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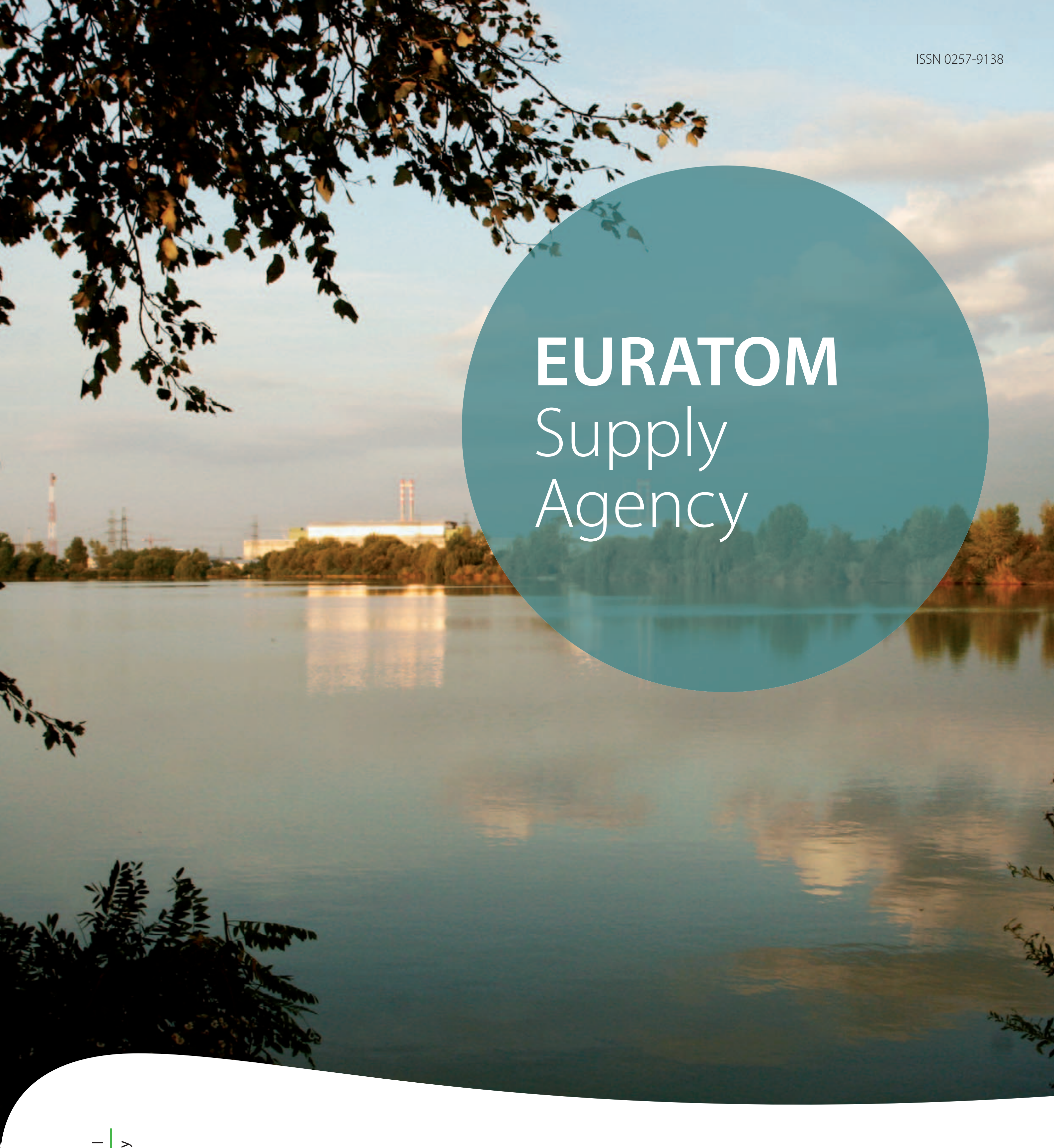

EURATOM
Supply Agency

Directorate-General for Energy

ANNUAL REPORT 2009

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EURATOM
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Contents

Foreword

In 2010 the European Atomic Energy Community (Euratom) is celebrating the 50th anniversary of the Euratom Supply Agency (ESA). During this half-century ESA has witnessed remarkable developments in the nuclear industry, not only in Europe but also all over the world.

On 25 March 1957 two of the founding treaties sealing European integration were signed: the Treaty establishing the European Economic Community (EEC) and the Treaty establishing the European Atomic Energy Community (Euratom).

This marked the beginning of development of civil use of nuclear technology in Europe. Two fundamental objectives set in the Euratom Treaty in 1957 — and still of key importance today — are to ensure that all users in the Community receive a regular and equitable supply of ores and nuclear fuels and to exercise the right of ownership over special fissile materials.

On 1 June 1960 the task of achieving the key objective of securing the supplies of nuclear fuel was assigned to ESA. For 50 years the Agency has been performing this mission in close cooperation with its Advisory Committee, which gives essential advice for conducting the supply policy and assists with analysing developments on the nuclear market.

By virtue of its exclusive right to conclude supply contracts for nuclear materials, the Agency has closely followed the development of the civil nuclear industry while promoting security of supply of nuclear materials in the EU, based on the principle of diversification and avoiding excessive dependence on any one source.

The Treaty of Lisbon which entered into force on 1 December 2009 left the substance of the Euratom Treaty unchanged. ESA's mandate to ensure a regular and equitable supply of nuclear fuels for users in the Community is in line with the Treaty of Lisbon which aims, in a spirit of solidarity between Member States, to ensure security of energy supply in the Union.

Moreover, the energy policy promoted by the Europe 2020 Strategy [1] in turn stresses the importance of mechanisms guaranteeing solidarity between Member States and of diversification of sources of supply — two principles that have driven ESA's action since it was established.

Finally, as the nuclear market is becoming increasingly complex, guaranteeing security of supply for the Union calls, more than ever, for monitoring and observing market trends. The development of a nuclear market observatory to assist nuclear players in the Community by providing expertise, information and advice on any subject related to nuclear materials and the nuclear services market is now one of the new priorities of the Agency.

(1) COM(2010) 2020, 'Europe 2020: A strategy for smart, sustainable and inclusive growth', 3 March 2010.

Executive summary

Economic development worldwide and the growing need for energy in the developing countries combined with the challenge of climate change are leading to an increasing interest in the nuclear energy option. The resulting rise in demand for uranium could lead to worldwide expansion of existing mines and new exploration. Improvements in *in-situ* mining technology could minimise the environmental burden and deployment of fast-neutron reactors and thorium-fuelled reactors after 2030 will also alleviate the pressure on uranium resources.

Natural uranium resources are widely distributed around the world, including in many countries where geopolitical risks are limited. Uranium costs make up only around 5 % of the total cost of generating electricity with nuclear power.

The latest data from the industry on global uranium production show an increase by 15 % in 2009 compared with 2008 to approximately 51 000 tonnes of uranium (tU). The bulk of this increasing production again came from Kazakhstan (27 %) — which in 2009 became the world's leading producer of uranium for the first time — followed by Canada (20 %) and Africa (17 %). Natural uranium production is expected to increase in the years ahead; however, delays in development and adverse economic conditions could have a negative impact on growth in uranium production in the medium term.

The European nuclear fuel market makes up around one third of the global market. Its largest suppliers of natural uranium are Australia, Russia, Canada and Niger, which cover almost three quarters of the EU's total needs. No major changes were observed in the pattern of nuclear fuel supplies during 2009. As in previous years, uranium mining in the EU meets under 3 % of the EU's needs.

In 2009 deliveries of natural uranium under long-term contracts to EU utilities accounted for 94.8 % of total deliveries. ESA's long-term average natural uranium price for 2009 was € 55.70/kgU (US$ 29.88/lb) contained in U_3O_8 (yellow cake), 18 % up from 2008, whereas ESA's average spot price was € 77.96/kgU (US$ 41.83/lb) contained in U_3O_8, a substantial decrease of 34 % compared with 2008. ESA's long-term average uranium price calculated on the basis of contracts and relevant amendments concluded in the last three years (MAC-3) in 2009 was € 63.49/kgU (US$ 34.06/lb) contained in U_3O_8, mirroring the latest developments on the nuclear market.

In 2009 the enrichment services (separative work) contained in the fuel supplied to EU utilities totalled 11 905 tSWU, delivered in 2 176 tonnes of low-enriched uranium (tLEU) which contained the equivalent of 16 497 tonnes of natural uranium feed. Enrichment service capacity in the EU in 2009 stood at around 23 000 tSWU, which is substantially higher than the EU's needs.

Chapter 1

Nuclear energy developments in the EU and ESA activities

EU nuclear energy policy in 2009

At a time of renewed and growing interest in nuclear energy, both at global level and in several EU Member States, the Commission is continuing to emphasise the positive contribution which nuclear energy can make to achieving the key objective of European energy policy, which is to ensure that European consumers and enterprises obtain safe, secure, sustainable and low-carbon energy at competitive prices. This is particularly true of the developments brought about by the Strategic Energy Technology Plan(2) (SET Plan) which identified a set of competitive low-carbon energy technologies to be developed and deployed in Europe, one of which is nuclear fission. In 2009 the Commission set out its vision of the financial needs for the SET Plan, calling for additional investment of € 50 billion in energy technology research over the next ten years(3).

Nuclear Safety Directive

A Council (Euratom) Directive N° 2009/71/Euratom establishing a Community framework for nuclear safety was adopted on 25 June 2009(4), with the full support of all 27 Member States. It builds on work that Member States have carried out already and transposes into Community law the IAEA Safety Fundamentals and the obligations imposed by the Convention on Nuclear Safety. The Directive sets binding principles for enhancing nuclear safety to protect the general public, workers and the environment. It substantially strengthens the role of the national regulators, confirming licence-holders' prime responsibility for nuclear safety, and improves transparency on safety issues. In this way the Directive brings legal certainty by clarifying responsibilities and provides greater guarantees to the public, as demanded by EU citizens.

The European Parliament and the European Economic and Social Committee overwhelmingly endorsed this approach. As the EU-27 account for around one third of world nuclear capacity, this unique safety framework could serve as a model for other regions too to make international safety standards legally binding.

Safe management of radioactive waste and spent fuel

Management of radioactive waste and spent fuel is another aspect of nuclear energy which is currently under the Commission's scrutiny. Considering that nuclear energy has a trans-border impact and that all Member States generate nuclear waste, a Community framework establishing the basic principles for radioactive waste and spent fuel management is needed. Support for a Community approach was also voiced in a recent Eurobarometer survey(5): 8 out of 10 respondents considered EU legislation useful. Another survey(6) showed that 4 out of 10 of those opposed to nuclear energy might change their mind if permanent and safe solutions for waste management were in place. The Council's conclusions of 10 November 2009 called on the Commission to continue to work towards a Community approach in this field. On this basis, the Commission is preparing a revised proposal for a Directive on management of spent fuel and radioactive waste which is expected to be adopted in autumn 2010.

(2) COM(2007) 723 final, 'A European Strategic Energy Technology Plan (SET Plan): Towards a low-carbon future', 22.11.2007.
(3) COM(2009) 519 final, 'Investing in the Development of Low-Carbon Technologies (SET Plan)', 7.10.2009.
(4) OJ L 172, 2.7.2009, p. 18.
(5) Special Eurobarometer 324, 'Europeans and Nuclear Safety', European Commission, March 2010.
(6) Special Eurobarometer 297, 'Attitudes towards Radioactive Waste', European Commission, June 2008.

Communication on nuclear non-proliferation

In March 2009 the Commission adopted a Communication on nuclear non-proliferation(7) setting out how the EU could strengthen its contribution to international efforts to reduce the risk of nuclear proliferation while providing emerging nuclear countries with assurances of fuel supplies. The Communication suggests closer cooperation with key nuclear countries and offers thoughts on possible Commission involvement in developing an international system to guarantee nuclear fuel for countries willing to develop nuclear energy without having their own nuclear fuel cycle facilities.

Bilateral nuclear cooperation agreements

Australia, Canada and the USA

Implementation of the nuclear cooperation agreements between the European Atomic Energy Community (Euratom) and Australia, Canada and the USA continued throughout 2009 to the satisfaction of all involved. Regular consultation meetings were held.

In July 2009 the Council issued directives to the Commission for renegotiation of the agreement between Euratom and Canada for cooperation on peaceful uses of atomic energy. The initial agreement between Euratom and Canada for cooperation on this subject was signed in 1959 and, due to the continuous development of nuclear trade between the Parties, has been amended five times. Revision and simplification of the agreement were therefore necessary.

Preparatory work has also started on renegotiation of the Euratom-Australia agreement, since the current agreement will expire in 2012.

Mandate for negotiating a Euratom-Russia nuclear agreement

In order to enhance mutual cooperation with the Russian Federation by providing a stable legal framework for political and industrial relations in this field, in April 2009 the Commission adopted a proposal for a revised mandate for negotiations with the Russian Federation, aiming at a broad cooperation agreement on peaceful uses of nuclear energy. The Council gave its green light to the new mandate on 22 December 2009.

Nuclear Energy Technology Platforms

As part of the SET Plan, the Sustainable Nuclear Energy Technology Platform (SNETP) was officially launched in 2007 to promote research, development and demonstration of the nuclear fission technologies necessary to achieve the goals of the SET Plan. Looking ahead to 2020, these goals for nuclear energy are (i) to maintain competitiveness in fission technology and (ii) to provide long-term waste management solutions. Taking a longer term perspective, the goals by 2050 are (i) to complete demonstration of a new generation (Gen IV) of more sustainable fission reactors and (ii) to expand applications of nuclear fission beyond electricity production. During 2009 the SNETP organised and participated in 27 actions.

On 12 November 2009 the Technology Platform for Implementing Geological Disposal (IGD-TP) of nuclear waste was launched with the support of the European Commission. The IGD-TP will define and then implement a strategic research agenda that will coordinate the efforts needed to address the remaining scientific, technological and socio-political challenges. Its aim is to ensure geological disposal of nuclear waste while maintaining the highest levels of safety and environmental protection. It will also further enhance public confidence in geological disposal and promote development of disposal solutions across the EU.

(7) COM(2009) 143 final, 26.3.2009.

European Nuclear Safety Regulators Group (ENSREG)

The European Nuclear Safety Regulators Group (ENSREG) is an independent group of experts made up of senior officials from the national regulatory or nuclear safety authorities of all 27 EU Member States. The objective of ENSREG is to further a common approach to the safety of nuclear installations and to safe management of spent fuel and radioactive waste.

In July 2009 ENSREG submitted to the Commission its first Activity Report(8), presenting the Group's discussions and recommendations covering nuclear safety, waste management and transparency aspects. In 2009 it held four meetings. A large part of ENSREG's work focused on drafting a proposal for a legal instrument on sustainable management of nuclear waste and spent fuel as a contribution to the Commission's forthcoming initiative on this subject.

European Nuclear Energy Forum (ENEF)

ENEF, established in November 2007 as a platform to promote a broad discussion among all relevant stakeholders on the opportunities, risks and transparency of nuclear energy, held its fourth plenary session in May 2009 in Prague. The debate in Prague confirmed that more European Member States are considering nuclear energy as an important contributor to the low carbon energy mix and security of supply. Strong support was expressed for developing in the EU the most advanced framework for nuclear safety, security and non-proliferation. The Forum welcomed in particular the finalisation of the nuclear safety directive.

Between plenary sessions, ENEF's work is divided between three working groups focusing on the opportunities, risks and transparency of nuclear energy respectively. The ENEF Working Group on Risks contributed to the proposal for a Nuclear Safety Directive and completed a roadmap on waste management, including towards successful geological disposal of radioactive waste and spent fuel.

The Working Group on Opportunities started an analysis of energy scenarios as well as strengths and weaknesses of nuclear energy. The Transparency Working Group presented 22 Recommendations on information, communications, participation and decision-making. The conclusions of the fourth plenary session made recommendations on such important aspects as a common approach to the design licence process for new reactors, an impact assessment on the state of nuclear liability at EU level, new investment-related aspects, transparency measures and education and training. One practical step taken was the conclusion of an agreement between the energy companies Areva, EnBW, URENCO, NOK, Vattenfall and E.ON to establish a 'European Nuclear Energy Leadership Academy' to provide theoretical and practical education on nuclear management.

Main developments in the EU Member States

Today there is growing recognition that nuclear power can produce competitively priced base-load electricity, essentially free of greenhouse gas emissions, and contributes positively to energy security. This was echoed in favourable statements made by several Member States in 2009 on nuclear energy and by the plans announced by others to enhance existing capacity or the clear commitments made to maintaining nuclear power as a significant component of their energy mix. The political announcement about resumption of nuclear power production in Italy, the hypothesis of extension of the operating life of nuclear power plants in several Member States and the projects announced for construction of a number of new reactors were just a few of the developments in the nuclear energy field in the EU in 2009.

(8) http://ec.europa.eu/energy/nuclear/ensreg/doc/2009_ensreg_report.pdf

As shown in Table 1, in 2009 a total of 144 nuclear power reactors were in operation and six under construction.

Table 1: Nuclear power reactors in the EU in 2009

Country	Reactors in operation (construction)	Nuclear electricity as % of total electricity generated
Belgium	7	51.7
Bulgaria	2 (2)	35.9
Czech Republic	6	33.8
Finland	4 (1)	32.9
France	58 (1)	75.2
Germany	17	26.1
Hungary	4	43
Lithuania	1 (reactor shut down on 31.12.2009)	76.2
Netherlands	1	3.7
Romania	2	20.6
Slovakia	4 (2)	53.5
Slovenia	1	37.9
Spain	8	17.5
Sweden	10	34.7
United Kingdom	19	17.9
Total	144 (6)	

Sources: IAEA and WNA.

The Belgian government has proposed extending the operating life of the three oldest reactors — Doel 1, Doel 2 and Tihange 1 — by 10 years, until 2025, in order to avoid energy shortages. The draft law also imposes on utilities to pay annually a 'nuclear rent' (fixed at € 215 - 245 million for the period 2010-2014). Furthermore, Electrabel said to be ready to invest € 500 million in renewables until 2015.

The Bulgarian government is seeking to develop a new financial framework to build the Belene nuclear power plant (NPP).

In the Czech Republic, a draft State Energy Plan called for a significant increase in the share of nuclear power in electricity production. A public tender was launched by ČEZ to select a contractor to build two additional reactors at the existing Temelin site, including an option to build up to three additional units later at other sites (not yet specified).

During 2009 France announced that the Atomic Energy Commission (CEA) will be given an extended remit and be renamed the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (Atomic and Alternative Energy Commission). It will remain France's leading energy research and development establishment, with a civil budget of € 2.6 billion for 2010. EDF's Flamanville-3 reactor is still scheduled to start up in 2012 as a first-of-a-kind unit, after settling differences with its main civil works contractor, Bouygues Travaux Publics. EDF together with Areva have agreed to notify UK regulators of all changes to the Areva EPR reactor design.

In Hungary, the government and parliament both voted in favour of doubling nuclear capacity by 2020-2025. Feasibility studies for one or two units of about 2000 MWe in all at the Paks site have been launched.

The adoption of new energy legislation by the Italian parliament in July 2009 officially ended the moratorium on nuclear energy and cleared the way for planning new nuclear power plants, with the long-term goal of providing 25 % of Italy's total electricity production.

After the closure of the last light water graphite-moderated reactor (RBMK) unit (1 500 Mwe) at Ignalina on 31 December 2009, Lithuania is no longer producing nuclear energy. The government is considering plans to build a new reactor by 2018.

In June 2009 the Dutch utility Delta announced plans to construct one or two nuclear power plants (maximum: 2 500 MWe) next to its existing Borssele plant. However, it will be up to the next Cabinet to be set up after elections in June 2010 to take a decision on possible new nuclear build in the Netherlands.

Poland has announced plans to build two nuclear power plants. A partnership between Polska Grupa Energetyczna (PGE) and EDF will conduct joint feasibility studies on construction of two NPP in Poland, each with individual capacity of 3 000 Mwe. The first of these units is to be completed by the end of 2020. The reactor technology has yet to be chosen.

In Romania a company (EnergoNuclear) was established in March 2009 to implement the project on units 3 and 4 of the Cernavoda NPP, with the aim of operating as an independent power producer delivering energy for its shareholders. In addition, the authorities are planning construction of a new nuclear power plant in the western part of Romania. A suitable site is to be found during 2010.

Work is continuing in Slovakia to complete construction of two reactors at the Mochovce site. The government has also proposed construction of two additional reactors, possibly located at the Bohunice site, for which the Czech power company ČEZ has been selected to form a partnership.

In Slovenia construction of a second reactor at the Krško site is seen as a major long-term energy policy objective. The State-owned energy company Gen Energija is waiting for approval to build its second nuclear power plant, to be completed by 2020 with a operating life of 60 years, while also trying to extend the operating life of the existing Nuklearna Elektrarna Krško plant by 20 years.

The Spanish government has authorised extension of the operating life of the Garona NPP until 2013. In its report 'Energy Policies of IEA Countries — Spain 2009,' the International Energy Agency states that Spain needs to clarify its long-term nuclear energy policy for the period up to 2030, especially its nuclear phase-out plans, by developing a strategy for replacing nuclear units, which could lead to cost-effective decision-making to ensure a secure electricity supply in the country.

In order to assist decision-making on energy infrastructure, the United Kingdom released new documents on nuclear energy policies. The UK is expected to need an additional 60 GWe of new net capacity by 2025, which could partly be covered by nuclear energy.

ESA operations

Mandate and core activities

A common nuclear market in the EU was created by the Euratom Treaty. Article 2(d) and 52 of the Treaty established ESA to ensure a regular and equitable supply of nuclear fuels to EU users. To perform this task, ESA applies a supply policy based on the principle of equal access to sources of supply.

In this context, ESA focuses on enhancing the security of supply of users located in the European Union and shares responsibility for the viability of the EU nuclear industry. In particular, it recommends that EU utilities operating nuclear power plants maintain stocks of nuclear materials, cover their requirements by entering into long-term contracts and diversify their sources of supply.

ESA's mandate is, therefore, to exercise its powers and, as required by its statutes, to monitor the market to make sure that the market activities of individual users reflect the values set out above.

The Euratom Treaty requires ESA to be a party to supply contracts for nuclear material whenever one of the contracting parties is an EU utility, an operator of a research reactor in the EU or a producer/intermediary selling nuclear material. When exercising its rights of co-signature ESA implements the EU supply policy for nuclear materials (imports into or exports from the EU, plus intra-Community transfers). ESA also has a right of option to purchase, with the right of first refusal over nuclear materials produced in the Member States.

On the basis of the Euratom Treaty, ESA also monitors transactions involving services in the nuclear fuel cycle (conversion, enrichment and fuel fabrication). Operators are required to submit notifications giving details of their commitments. ESA verifies and acknowledges these notifications.

In 2009, ESA processed 316 transactions, concluding 117 new supply contracts and amendments to existing contracts and acknowledging 199 notifications and revisions of notifications. In this way, ESA ensured security of supply of nuclear materials.

Activities of the Advisory Committee

The Advisory Committee assists the Agency in carrying out its tasks by giving opinions and providing analyses and information. This assistance also extends to preparation of various reports and analyses. It acts as a link between ESA and both producers and users in the nuclear industry.

As the market is becoming increasingly complex, the remit of the Agency was widened by the Council Decision of 2 February 2008 amending ESA's statutes which entrusted the Agency with a new task: the creation of a nuclear market observatory. This new task also influences the activities of the Advisory Committee.

In 2009 the Advisory Committee held two meetings — one on 13 March, the other on 23 September. The main items on its agenda were:

- analysis of developments on the world nuclear fuel market;
- discussions on the nuclear observatory;
- opinion on ESA's 2008 Annual Report;
- opinion on ESA's 2009 Work Programme;
- monitoring the progress made in the activities of the Working Groups;
- assessment of ESA's budget situation in 2009;
- review of ESA's 2008 balance-sheets and accounts.

In 2008 two working groups were created: (i) a Working Group on Prices to develop new methods for calculation of natural uranium prices by ESA to increase the transparency and efficiency of the natural uranium market; and (ii) a Working Group on Security of Supply Scenarios to assist the Agency in carrying out its analyses of security of supply in the EU.

During 2009 working groups held four meetings. The main results were to advise ESA on which directions to take to elaborate its reporting system for EU utilities, to advance the methods of current price indices and to create a new quarterly long-term natural uranium price index. This index would be the first ESA long-term forward-looking natural uranium price index, published on a quarterly basis.

International cooperation

ESA continued its cooperation with the two major international organisations in the field of nuclear energy: the IAEA and OECD/NEA. During 2009 ESA took part in discussing and preparing several OECD/NEA publications, namely on electricity generation costs, on trends in the nuclear fuel cycle and on global uranium resources.

ESA is closely following international activities relating to multilateral approaches to the nuclear fuel cycle. In November 2009 the IAEA Board of Governors adopted a resolution approving the proposal by the Russian Federation to establish on its territory a reserve of 120 t LEU for the IAEA Member States. Maintenance and storage of the 120-tonne stockpile are to be covered entirely by Russia and located at the newly founded International Uranium Enrichment Centre at Angarsk. The idea is that any IAEA member country would be able to draw on the reserve if it were denied supplies from the normal routes — apart from for technical or commercial reasons. In other words, any country using civil nuclear power and fulfilling its IAEA safeguards obligations would not suffer any disruption of its nuclear fuel supply for political reasons.

Market observation

Besides its Annual Report, ESA also launched a new publication back in 2008, based on its market observation activities: the *Quarterly Uranium Market Report.* Since the end of 2009 this report has been regularly published on the Agency's public website.

ESA publishes different types of natural uranium prices on an annual basis that are converging with other traditional price indicators. Furthermore, ESA is striving to improve its various calculation and estimation methods to enhance sectoral transparency for the benefit of market players. This is in line with the expectations of the European industry to have better insight into market developments.

The reliability of market analyses depends largely on the accuracy of the data collected. This is ensured by requiring European users and producers to provide information on their estimated future requirements, contracted purchases and the quantities of nuclear materials actually delivered (*ex-ante*, current and *ex-post* market data) and by screening open source information.

Management and internal control systems

Implementation of the budget

Following the European Parliament vote on the EU budget, the Commission's budget covered ESA's administrative expenditure for the 2008 financial year. The same approach has been taken for 2009 and 2010. The 2009 balance-sheet is available on ESA's website at:
http://ec.europa.eu/euratom/index_en.html

Quality assurance

In mid-2008 ESA introduced a programme to tighten up its internal control and quality management systems. As a result, the first quality management project has been initiated and the 'Euratom Supply Agency Quality Manual' was implemented during 2009.

Quality management tasks at ESA include:
- monitoring implementation of rules, regulations and procedures established within ESA;
- advising management and sectors on the validity of procedures and on their compliance with the rules and regulations in force; and
- ensuring the effectiveness and efficiency of procedures within ESA.

Evaluation by the Court of Auditors

The Court of Auditors audits ESA's operations on an annual basis. ESA has taken due account of the opinions expressed by the Court.

Chapter 2

World market for nuclear fuels

Competitiveness of nuclear energy and foreseeable technological developments

Worldwide there is growing recognition that nuclear power can produce competitively priced base-load electricity, essentially free of greenhouse gas emissions, and can contribute positively to energy security, as recently shown by the OECD-IEA/NEA study(9). Other potential drivers influencing positions on nuclear power are the volatility of fossil fuel prices and its overall operational performance. As a result, nuclear power will continue to play a major role for the foreseeable future.

The same OECD-IEA/NEA study demonstrates that nuclear technology is fairly competitive for base-load power generation. The study brings together the latest data from 190 power plants in 17 OECD countries plus Brazil, China, Russia and South Africa on the costs of electricity generation using a wide variety of fuels and technologies, including coal (with and without carbon capture and storage or CCS), natural gas, nuclear, hydro, on-shore and off-shore wind, solar, biomass, wave, tidal and combined heat and power (CHP). Assuming a carbon price of $ 30/tCO_2 in OECD countries, the study provides results for two real interest rates of 5 % and 10 %. When financing costs are low (5 %), nuclear energy followed by coal with CCS are the most competitive solutions. With higher financing costs (10 %), coal-fired generation followed by coal with carbon capture in countries where coal is cheap and combined cycle gas-fired turbines (CCGTs) are the cheapest sources of electricity. Strong government action, however, can do much to reduce the financial risks. The study says that nuclear energy delivers significant amounts of very low-carbon base-load electricity at stable costs over time.

The nuclear energy technology mix beyond 2020 will probably combine current Generation II reactors with their operating lives extended and their power output further uprated with the current Generation III and Generation III+ reactors offering significant advantages in terms of economics, safety, deployment time and supply chain, mainly due to standardisation, modularisation and new construction methods. Furthermore, until 2020 to 2030 small and medium-sized reactors could be deployed for small decentralised electricity markets and non-electricity applications, e.g. co-generation. Beyond 2035 to 2040, Generation IV(10) reactors, marking a quantum leap in development of nuclear energy, should start to come on stream. Generation IV reactors aim to close the nuclear fuel cycle, leading to higher energy usage per unit of uranium or recycled fuel, less nuclear waste due to more efficient burning of plutonium and other highly radioactive actinides, lower capital costs, higher nuclear safety and less risk of weapons proliferation. These reactors could transform the energy (electricity and heat) market, as they might be suitable for polygeneration (electricity, heat, hydrogen, synthetic fuels and desalination).

Supply of nuclear fuels

This chapter presents a short overview of the main developments affecting the global supply and demand balance and security of supply at different stages of the fuel cycle in 2009. An established market for the different front-end services exists. Most of the activities are performed under long-term contracts. Spot-market activities play a far more limited role.

Natural uranium production

Uranium is mined in 18 countries, seven of which account for 90 % of world production (Australia, Canada, Kazakhstan, Namibia, Niger, the Russian Federation and Uzbekistan). The relatively diverse geographical distribution of uranium resources and fuel fabrication activities allows confidence that the risk of disruption is low.

(9) 'Projected Costs of Generating Electricity', OECD-IEA/NEA, Paris 2010.
(10) Generation IV (or Gen-IV) reactors are a set of nuclear reactor designs currently being developed in the research cooperation within the 'Generation IV International Forum'. Current reactors in operation around the world are generally considered second- or third-generation systems.

As can be seen from Table 2, in 2009 natural uranium production increased by 15 % to 50 519 tonnes of uranium (tU). The bulk of this increasing production came from Kazakhstan (27 %), which became the world's leading producer of uranium for the first time in 2009, followed by Canada (20 %) and Africa (17 %). Natural uranium production is expected to increase in the years ahead; however, delays in development and adverse economic conditions could have a negative impact on growth in uranium production in the medium term.

Table 2: Natural uranium production in 2009 (compared with 2008, in tonnes of uranium)

Region/ Country	Production 2009 (tonnes)	Production 2008 (tonnes)	Share in 2009 (%)	Share in 2008 (%)	Change 2009/2008 (%)
Kazakhstan	13 820	8 521	27.36 %	19.43 %	62.19 %
Canada	10 173	9 000	20.14 %	20.52 %	13.03 %
Africa	8 536	8 053	16.90 %	18.36 %	6.00 %
Australia	7 928	8 430	15.69 %	19.22 %	-5.95 %
Russia	3 564	3 521	7.05 %	8.03 %	1.22 %
Uzbekistan	2 429	2 338	4.81 %	5.33 %	3.89 %
USA	1 453	1 430	2.88 %	3.26 %	1.61 %
Others	2 616	2 560	5.18 %	5.84 %	2.19 %
Total	50 519	43 853	100.00 %	100.00 %	15.20 %

Source: WNA.

From a security of supply point of view, uranium resources and fuel fabrication are very different from fossil fuels: one big advantage of nuclear power is the extremely high energy density of the fuel, combined with the diverse distribution of uranium resources and fuel fabrication facilities and the ease with which strategic stockpiles of fuel can be maintained.

In the medium term worldwide supply of natural uranium is sufficient to meet the requirements at each stage of the nuclear fuel cycle. Present resources could, however, be multiplied by a factor of 30 when Generation IV fast-neutron reactors with a closed fuel cycle are introduced. This scenario is shown in Table 3.

Table 3: Lifetime of uranium resources (years of supply based on 2006 requirements)

	Identified resources	Total conventional resources	Total conventional resources plus phosphates
Present reactor technology	100	300	700
Introduction of fast-neutron systems (Gen IV)	> 3 000	> 9 000	> 21 000

Source: Nuclear Energy Outlook 2008 (OECD Nuclear Energy Agency).

Secondary sources of supply

The natural uranium market persistently shows a wide gap between demand and production which is presently closed by secondary supplies. In 2009 secondary supplies covered approximately 25 % to 30 % of worldwide demand for nuclear fuel. Secondary supplies include: low-enriched uranium (LEU) derived from highly enriched uranium (HEU) and from re-enrichment of tails; inventory material in multiple forms; and re-enriched reprocessed uranium (RepU) with plutonium in the form of mixed-oxide fuel[11] (MOX).

Currently some 20 000 tU of secondary supplies are available worldwide per year, but this could decline to some 10 000 tU beyond 2013, mainly for two reasons: the Russian military HEU downblending programme is due to end in 2013 and Russian re-enrichment of western tails is expected to end in 2010.

(11) In order to recycle plutonium, mixed-oxide fuel (MOX) is fabricated where plutonium oxide (PuO_2) is mixed with depleted uranium oxide (UO_2) to form fresh fuel. MOX fuel typically contains 7 % to 9 % of Pu mixed with depleted uranium, equivalent to a normal enriched uranium fuel with a product assay of about 4.5 %.

In order to stimulate further Russian military HEU downblending, in the USA the Domenici amendment to the Russian Suspension Agreement was adopted in 2008. This amendment introduces the flexibility to raise the yearly quota of direct Russian LEU imports into the USA to 25 % (from 20 % under the Suspension Agreement), if additional HEU is downblended. However, until now Russia has not explicitly expressed any intention to use the flexibility allowed.

ESA closely follows worldwide and European discussions on security of supply issues. During 2009 it therefore continued to assign tasks to the working groups of its Advisory Committee, in order to conduct a wide-ranging analysis of all aspects of security of supply in the nuclear fuel cycle, particularly on the EU supply situation, including commercial stockpiles.

Conversion

During 2009 uranium conversion facilities continued to operate in France, the United Kingdom and the United States. Operations in Canada were restarted after a six-month shutdown owing to a contract dispute with a major supplier. Renewal of conversion capacity continued in France.

Table 4: Major uranium conversion companies

Company	Capacity in 2009 (tU as UF_6)	Share of global capacity (%)
Atomenergoprom (RUS)	25 000	32.9 %
Cameco (CAN + UK)	18 500	24.3 %
ConverDyn (USA)	15 000	19.7 %
Areva (FR)	14 500	19.1 %
CNNC (China)	3 000	3.9 %
World total	76 000	100.0 %

Source: Estimates based on data published by institutions and the industry.

Enrichment

Uranium enrichment is an extremely sensitive and strategic technology, possessed by a few companies in a small number of countries. The availability of the technology is carefully controlled for reasons of national security and non-proliferation. Enrichment is subject to safety and environmental regulation, including on radiological protection, similar to that for other comparable nuclear fuel and chemical processes.

From an economic point of view, it is worth mentioning that this segment of the nuclear fuel cycle accounts for over one third of the cost of nuclear fuel and about 5-6 % of the total cost of the electricity generated. The annual world demand for enrichment is about 45 million SWU[(12)], but there is currently significant overcapacity in enrichment worldwide due to the very large capacity in Russia, which is mainly a legacy of the Cold War.

Worldwide, construction of new uranium centrifuge enrichment plants continued. One is being developed at Areva's Georges Besse II facility in France (the full capacity of 7 500 tSWU will be reached in 2016), where rotation of the first cascade occurred in December 2009. The other two projects are in progress in the USA: the first at the Louisiana Energy Services' National Enrichment Facility (the capacity of 5 900 tSWU will be reached in 2015) and the second at the Eagle Rock plant in Idaho Falls (the capacity of 3 300 tSWU will be reached in 2019). In 2009, the US Enrichment Corporation suspended development of its new plant (with initial capacity of 3 800 tSWU) using the American centrifuge design. However, in March 2010 the development was re-launched. The GE-Hitachi Global Laser Enrichment project continued, with an application for the last part of the licence now awaiting approval. This laser enrichment plant would be located in Wilmington, North Carolina, and could start in 2012 with an annual capacity of between 3 500 and 6 000 tSWU. Tenex (Russia) has announced plans to increase its enrichment service capacity beyond 30 000 tSWU in the next few years.

(12) SWU stands for 'separative work unit' which measures the effort made in order to separate the fissile, and hence valuable, U-235 isotopes from the non-fissile U-238 isotopes, both of which are present in natural uranium (see the Glossary for further details).

In January 2009 the US Supreme Court took a unanimous decision in the Eurodif case after the Department of Commerce decided that enrichment contracts should be considered 'production contracts' under the anti-dumping law. The Supreme Court decided that the Department of Commerce was legitimate to adopt this interpretation within the limited scope of implementation of the anti-dumping legislation. Another important decision on enrichment was the decision of the European Court of Justice (ECJ) on a similar problem in the EU, in 2006, when the ECJ ruled that enrichment contracts must be considered, under the Euratom Treaty, as contracts for 'processing, conversion or shaping', as referred to in Article 75. The short-term impact of the US Supreme Court decision is rather limited, as Areva is constrained by the available capacity due to the closure of Georges Besse I. This ruling does not end the litigation over antidumping duties on the Areva LEU sold into the USA. Nor will it influence the Russian LEU trade in the USA.

Table 5: Major enrichment companies with approximate 2009 capacity

Company	Capacity (thousand SWU)	Share of global capacity (%)
Atomenergoprom (Russia)	27 000	45.00 %
Urenco (UK-DE-NL)	12 200	20.33 %
Eurodif (France)	10 800	18.00 %
USEC (USA)	8 000	13.33 %
CNNC (China)	1 300	2.17 %
JNFL	150	0.25 %
World total	60 000	100.00 %

Source: Estimates based on data published by institutions and the industry.

Fabrication

Fuel assemblies from different suppliers are not easily interchangeable, although many utilities do periodically change suppliers to maintain competition. The main fuel manufacturers are also the main suppliers of nuclear power plants or closely connected to them. The largest fuel manufacturing capacity can be found in France, Germany, the Russian Federation and the USA, but fuel is also manufactured in other countries, often under licence from one of the main suppliers.

Information supplied to the IAEA identified 40 commercial-scale fuel fabrication facilities in operation in Argentina, Belgium, Brazil, Canada, China, France, Germany, India, Japan, Kazakhstan, Korea, Pakistan, Romania, the Russian Federation, Spain, Sweden, the United Kingdom and the USA.

European fabrication facilities continued to cover the EU utilities' needs adequately. The bulk of the needs for fabricated fuel are covered by EU producers for the western type reactors. On the market for Russian design (VVER) fuel, the Russian supplier TVEL maintained its dominant position, holding a market share of nearly 100 %. Entering the fabrication market is especially challenging because the fuel assembly itself is a highly engineered, technologically specific product with significant intellectual property embedded in it. In addition, the fuel assembly is a component affecting the overall safety of the plant and requires extensive licence approval.

Reprocessing

Globally around 15 % of all spent fuel is reprocessed to recover and recycle uranium and plutonium. Today there are reprocessing plants in France, Japan, the Russian Federation and the United Kingdom, but only about 50 % of their capacity is used due to uncertainties about the future use of the reprocessed material. Uranium and plutonium (as MOX) are currently re-used mainly in light water reactors (LWRs), but in order to make maximum use of uranium resources in a closed fuel cycle, use of fast breeder reactors or other advanced systems is being actively considered in a number of countries (i.e. Generation IV reactors).

Worldwide, reprocessing continues to be regarded as an economically attractive solution, since it not only reduces natural uranium requirements but also can considerably decrease the quantities of radioactive waste which have to be safely stored (down to 4 % of ultimate high-level radioactive waste).

Chapter 3

Supply and demand for nuclear fuels in the EU

Fuel loaded into reactors

This overview of supply and demand for nuclear fuels in the European Union is based on information provided by the EU utilities or their procurement organisations concerning the amounts of fuel loaded into reactors, estimates of future fuel requirements and the quantities, origins and acquisition prices of natural uranium and separative work.

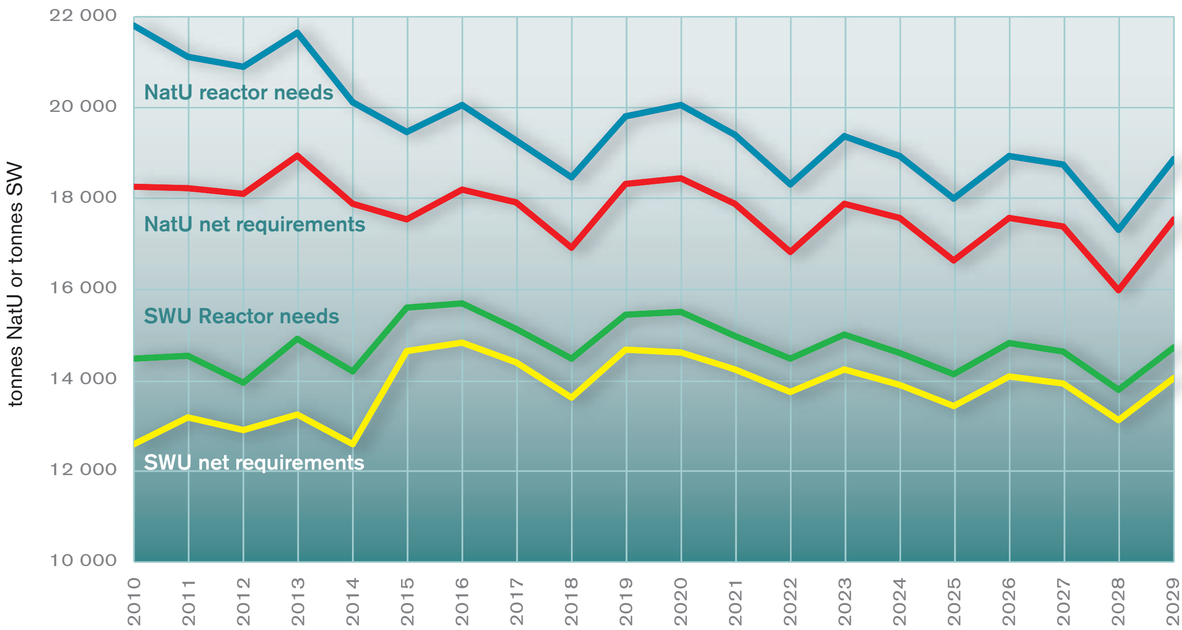
During 2009, 2 807 tU of fresh fuel were loaded into commercial reactors in EU-27 containing the equivalent of 19 333 tU as natural uranium and 13 754 tSWU. In comparison with 2008, the quantity of fresh fuel loaded increased by 187 tonnes of natural uranium. The quantities of fuel in 2009 entailed slightly more separative work, equal to an increase of 693 tSWU. The overwhelming majority of utilities put their tails assays in the range of 0.20 % to 0.30 %.

Reactor needs/net requirements for the next 20 years

Estimates of future EU reactor needs and net requirements for uranium and separative work, based on data supplied by all EU utilities, are shown in Figure 1 (see Annex 1 for the corresponding figures). Net requirements are calculated on the basis of reactor needs minus the contributions from currently planned uranium/plutonium recycling and taking account of inventory management communicated to ESA by utilities.

For EU-27 average gross reactor requirements for natural uranium over the next 10 years are forecast to be in the order of 20 249 tU/year and average net requirements 18 014 tU/year, while these values would be 18 776 tU/year and 17 355 tU/year respectively for the period between 2020 and 2029. The average gross requirements for enrichment services over the next 10 years are forecast to be 14 824 tSWU/year and net requirements 13 656 tSWU/year. These values would be 14 655 tSWU/year and 13 911 tSWU/year respectively for the period between 2020 and 2029.

Figure 1: Reactor needs and net requirements for uranium and separative work (EU-27)



Due to enhanced cooperation with the industry, in 2009 ESA was able to collect more data from EU utilities, especially relating to future estimates of needs. Compared with the aggregate requirements reported last year, the estimated future requirements for both natural uranium and separative work show a significant upward shift. The best example of this meaningful change is the fact that the estimated needs for the next decade (2020 to 2029) are significantly higher than the forecasts made before.

From the point of view of nuclear capacity, this fact could confirm a more realistic view on forecasts about the future of nuclear in Europe for the next two decades, including a possible change in nuclear policy in some Member States, with others considering expanding existing sites or building new reactors.

Supply of natural uranium

Conclusion of contracts

In 2009 ESA processed 52 contracts and amendments relating to ores and source materials (essentially natural uranium). Table 6 gives further details of the type of supply, terms and parties involved.

Table 6: Natural uranium contracts concluded by or notified to ESA (including feed contained in EUP purchases)

Type of contract	Number of contracts concluded in 2009	Number of contracts concluded in 2008
Purchase/sale by an EU utility/user	15	17
- multiannual[1]	8	3
- spot[1]	7	14
Other purchase/sale	13	18
- between intermediaries[2] (multiannual)	2	5
- between intermediaries[2] (spot)	11	13
Exchanges and loans[3]	8	11
Amendments to purchase contracts[4]	16	7
Total	52	53

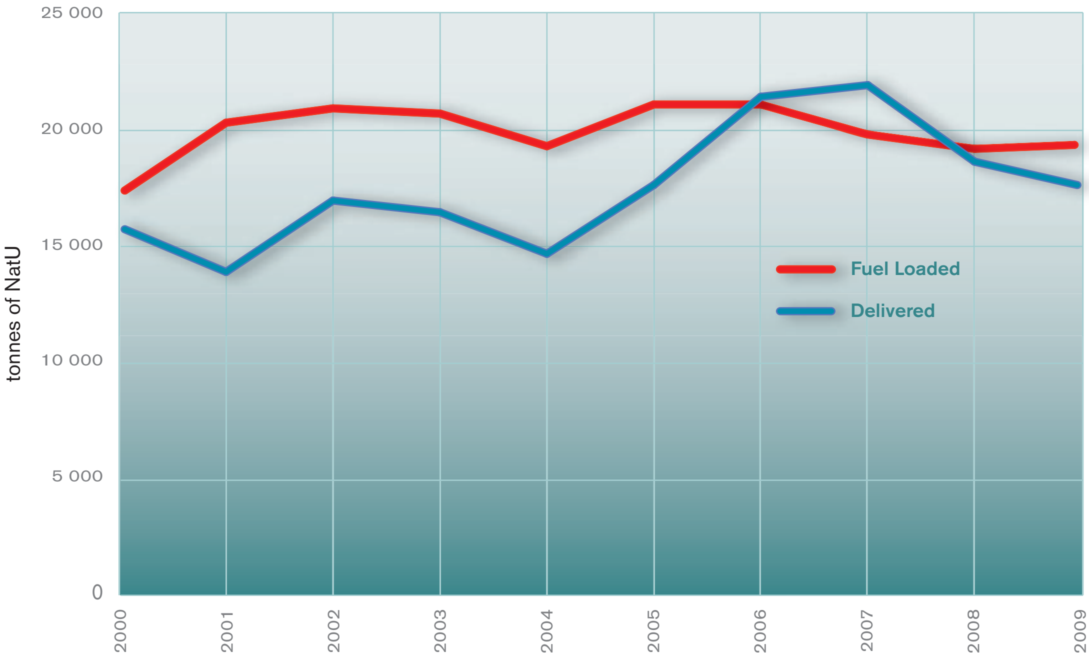
(1) Multiannual contracts are defined as contracts providing for deliveries extending over more than 12 months, whereas spot contracts provide for either only one delivery or for deliveries extending over a maximum of 12 months, whatever the time between conclusion of the contract and the first delivery.
(2) Purchase/sale contracts between intermediaries – neither the buyer nor the seller are EU utilities/end-users.
(3) This category includes exchanges of ownership and U_3O_8 against UF6. Exchanges of safeguards obligation codes and international exchanges of safeguards obligations are not included.
(4) The net increase (or decrease) in material for which contracts have been concluded.

Volume of deliveries

The deliveries taken into account are those made to EU-27 utilities or their procurement organisations in 2009, excluding research reactors. They also include the natural uranium equivalent contained in enriched uranium purchases. Deliveries and fuel loaded into reactors by EU utilities since 2000 are shown in Figure 2 (see Annex 2 for the corresponding table from 1980 to 2009).

Quantitative analysis shows that 17 591 tU were delivered to EU-27 utilities during 2009, i.e. a further decrease of 1 031 tU or almost 6 % down from 18 622 tU in 2008 and well below the 19 333 tU loaded into reactors. This means that the quantities delivered and loaded are not in balance — there is still a substantial difference of 1 742 tU or 9 %.

Figure 2: Natural uranium feed contained in fuel loaded into EU reactors and natural uranium delivered to utilities under purchasing contracts (tU)



Average prices of deliveries

The European nuclear market makes up around one third of the world market. In 2009 deliveries of natural uranium under long-term contracts to EU utilities accounted for 94.8 % of total deliveries and only 5.2 % of all uranium deliveries to EU utilities were purchased under spot contracts. The increase in spot contracts — almost twice as many as in 2008 (2.9 %) — could be attributed partly to the level of natural uranium spot prices throughout the year. However, there is a strong trend to prefer long-term over short-term supplies.

Relatively, the spot uranium price is the most transparent on the market. The quantity of uranium traded on the spot market is usually less than 15 % of the total quantity of uranium traded worldwide.

Definitions for uranium prices

Until 2008 ESA had been publishing two categories of prices on an annual basis: (i) the ESA natural uranium multiannual price and (ii) the ESA natural uranium spot price. 'Multiannual' contracts are defined as contracts providing for multiple deliveries extending over 12 months. This price index reflects the average long-term price paid by European utilities. In turn, the ESA 'spot' index reflects the most recent developments on the uranium market. Contracts provide for either only one delivery or deliveries extending over a maximum of 12 months.

As stated in ESA's previous Annual Report, ESA introduced a new category of average prices, the ESA long-term historical average uranium price (MAC-3), which is based on the prices of the natural uranium delivered under long-term contracts concluded during the last three years, including relevant amendments to the price levels.

ESA considers that the new index increases transparency on the market and widens the knowledge about the latest prices paid by European utilities. The MAC-3 price index is now considered a significant market indicator since the Working Group on Prices of the ESA Advisory Committee has validated its method and recommended annual publication and backwardation over the previous decade (in progress).

Furthermore, the validity of MAC-3 has been confirmed on various occasions where ESA presented this new index (e.g. international symposia, working groups and specialised press).

In order to provide reliable objective price information, comparable with previous years, only deliveries made to EU utilities or their procurement organisations under purchasing contracts are taken into account for calculating the average prices. In order to ensure statistical reliability (sufficient amounts) and the confidentiality of commercial data (no individual contracts revealed), ESA price indices are calculated only if there are at least five relevant contracts.

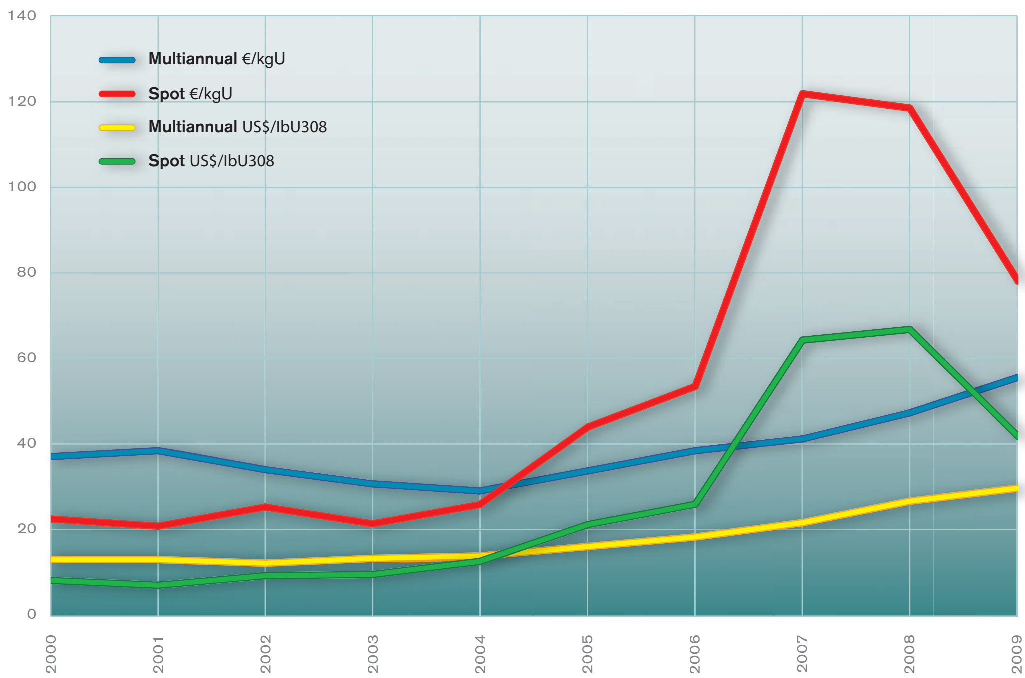
To calculate the average price, the original contract prices are converted, using the average annual exchange rates published by the European Central Bank, into € per kilogram of uranium in the chemical form U_3O_8 and then weighted by the quantities covered by each contract. To establish a price excluding the conversion cost, if it was not specified, in 2009 ESA applied a rigorously calculated average conversion price of € 7.92/kgU (US$ 11.04/kgU), up from € 6.86/kgU (US$ 10.09/kgU) for the previous year.

The average price of deliveries under multiannual contracts in 2009 was € 55.70/kgU contained in U_3O_8, 18 % up from the € 47.23/kgU in 2008 (or US$ 29.88/lb U_3O_8 v. US$ 26.72/lb U_3O_8 in 2008). This index is an average of contracts in force and, as such, shows relatively smooth price changes compared with spot or MAC-3 indices. During the last three years average long-term prices for uranium originating in the Commonwealth of Independent States (CIS) were higher than for non-CIS origin uranium.

The average spot price for natural uranium delivered in 2009 was € 77.96/kgU or US$ 41.83/lb U_3O_8, a substantial decrease of 34 % compared with the 2008 price of € 118.19/kgU or US$ 66.86/lb U_3O_8. The ESA value for the spot price of natural uranium was consistent with other spot price indicators available on the market. For example, in 2009, the yearly average uranium spot price indicator derived from data published by Ux Weekly, a market consultancy based in the USA, was US$ 46.27/lb. Some utilities took advantage of the low prices to purchase uranium on a discretionary basis. During 2009 natural uranium spot prices stayed relatively lower than last year due to the overall expectations of lower prices and buyers choosing to wait.

Figure 3 shows the ESA average prices for natural uranium since 2000. The corresponding data is presented in Annex 3.

Figure 3: Average prices for natural uranium delivered under spot and multiannual contracts 2000-2009 (in €/kgU and US$/lb U_3O_8)



The MAC-3 average price in 2009 (including eligible amendments) was € 63.49/kgU contained in U_3O_8 or US$ 34.06/lb U_3O_8 (see Annex 3 for detailed price information and Annex 4 for the price calculation method).

The ESA long-term natural uranium price indices are substantially lower than the forward-looking long-term price indicators published by the market consultants Ux Weekly and Trade Tech. The forward-looking long-term natural uranium indicators are estimates of the natural uranium prices which would be paid in future years, if the contracts were concluded now. In turn, ESA publishes historical long-term price indices which show the value of uranium delivered under historical long-term contracts in the year in question[(13)].

European utilities are not very exposed to temporary price fluctuations on the market, as they are well covered by existing long-term contracts and hold adequate stocks. This is also proved by the fact that over the last few years, when the forward-looking long-term uranium price remained relatively high, very few new long-term supply contracts for natural uranium were concluded by EU utilities (see Table 6).

Since 2007 the forward-looking long-term natural uranium price indicators have normally been higher than the spot prices. This tendency indicates that the current value of natural uranium to be delivered in the distant future is higher than that of uranium delivered now. The natural uranium purchasers are willing to commit themselves to a rather high natural uranium price in future years for security of supply reasons to minimise market-related risks and avoid uranium storage costs.

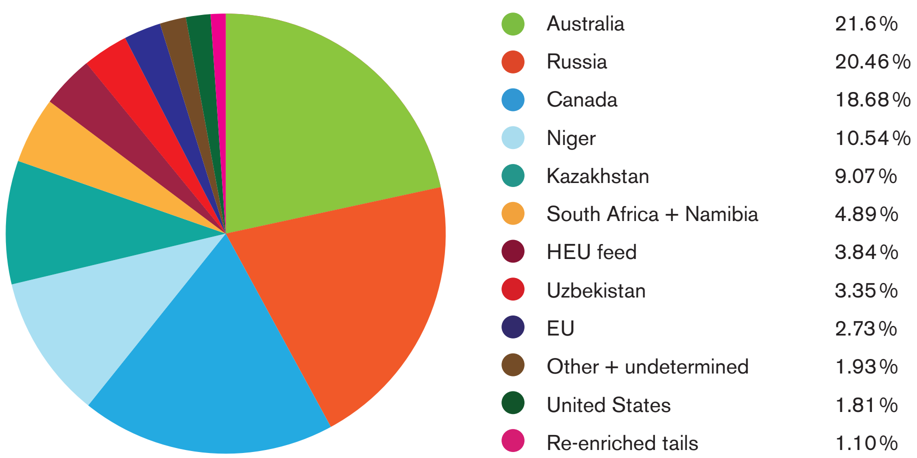
Origins

Canada's position as the leading supplier of natural uranium to EU utilities had already been challenged by Russia and Australia in previous years. After a substantial increase of 27.1 % in its uranium deliveries, Australia became the EU's primary source of natural uranium, supplying 3 800 tU or more than a fifth of the total deliveries to the EU in 2009.

Russia retained its place as second biggest supplier of natural uranium with approximately 3 600 tU in 2009. However, it is worth mentioning that this amount could also include other CIS material, HEU and other secondary sources.

Canada delivered almost 3 300 tU during 2009 to become the third biggest supplier of EU utilities. In addition, direct purchases from Kazakhstan further increased this year but remained relatively low at some 1 600 tU, especially considering Kazakhstan's production and capacity levels as number one uranium producer in the world. Given the potential of both Kazakhstan and Uzbekistan, the amount of uranium from these countries is expected to increase in the years ahead. Figure 4 shows the origins of uranium deliveries to the EU in 2009.

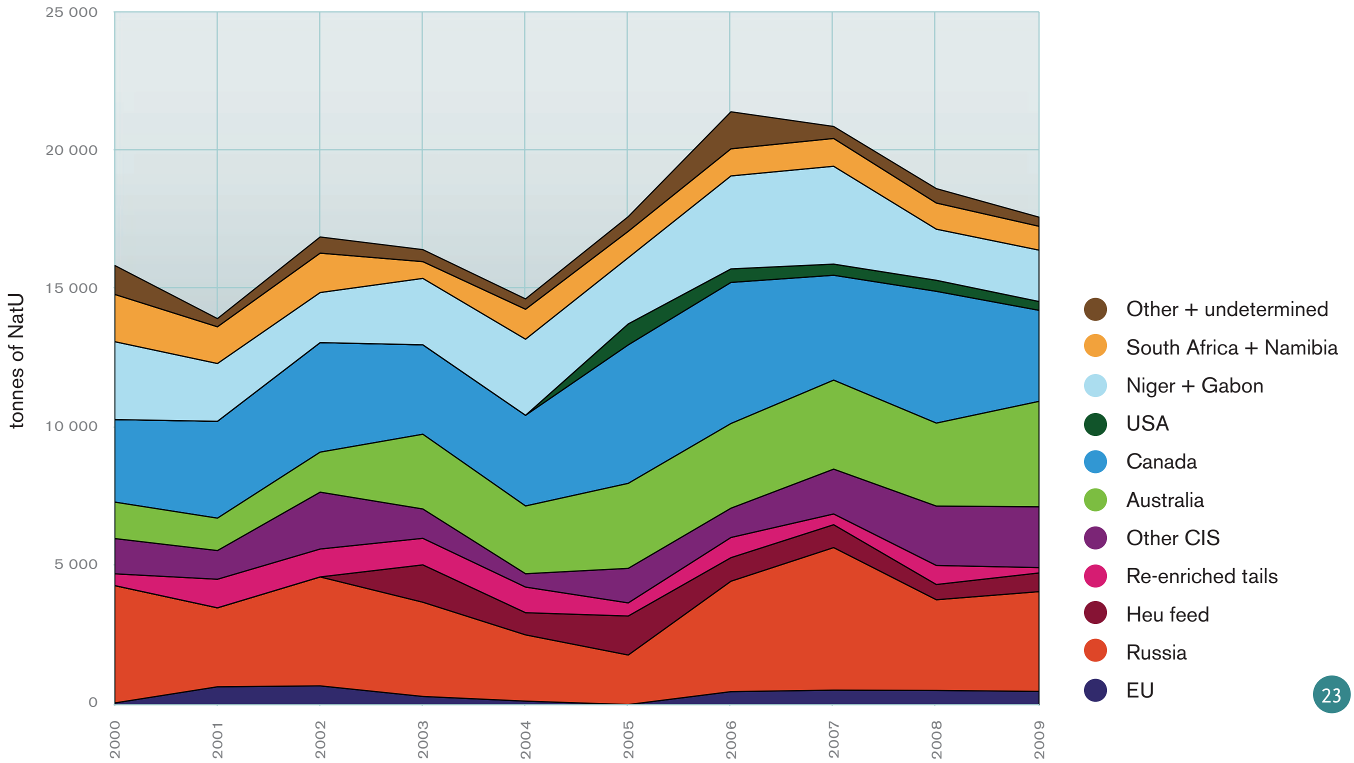
Figure 4: Origins of uranium delivered to EU utilities in 2009 (% share)



(13) For example, in 2009 the ESA long-term natural uranium price was € 55.70/kgU, while at the same time the average of the forward-looking price indicators published by Ux Weekly and Trade Tech was € 109.0/kgU.

European uranium delivered to EU utilities originated from the Czech Republic and Romania and covered just below 3% of the EU's total needs (a total of 480 tU). In 2009 the amount of re-enriched tails material totalled 193 tU, down from 688 tU in 2008, while the amount of HEU feed used increased by 125 tU to 675 tU in a year.

Figure 5: Purchases of natural uranium by EU utilities by origin, 2000-2009 (tU)



Special fissile materials

Conclusion of contracts

Table 7 shows the number of contracts and amendments relating to special fissile materials (enrichment, enriched uranium and plutonium) dealt with during 2009 in accordance with ESA's procedures.

Table 7: Special fissile material contracts concluded by or notified to ESA

Type of contract	Number of contracts 2009	Number of contracts 2008
A. Special fissile materials	65	72
Purchase (by an EU utility/user)	13	10
Sale (by an EU utility/user)	10	8
Purchase/sale (between two EU utilities/end-users)	4	3
Purchase/sale (intermediaries)	15	17
Exchanges	10	16
Loans	0	2
Pool	6	9
Total(1)	58	65
Contract amendments	7	7
B. Enrichment notifications(2)	18	11
Notifications of amendments	23	8

(1) In addition, there were transactions for small quantities (Article 74 of the Euratom Treaty) which are not included here.
(2) Contracts with primary enrichers only.

Deliveries of low-enriched uranium

In 2009 the enrichment services (separative work) contained in the fuel supplied to EU utilities totalled 11 905 tSWU, delivered in 2 176 tonnes of low-enriched uranium (tLEU) which contained the equivalent of 16 497 tonnes of natural uranium feed. In 2009 enrichment service deliveries to EU utilities decreased by 12.2 % compared with 2008.

The tails assay used to calculate the natural uranium feed and separative work components has a significant impact on the values of these components. An increase in the tails assay increases the amount of natural uranium and reduces the amount of separative work required to produce the same amount of enriched uranium. The optimum tails assay is dictated by the prices of natural uranium and separative work. For its calculations ESA used the contractual tails assay declared by the utilities or, when this was not available, a standard 0.30 %.

As regards the providers of enrichment services, almost two thirds of the EU separative work required was carried out by the two European enrichers (Areva-Eurodif and Urenco).

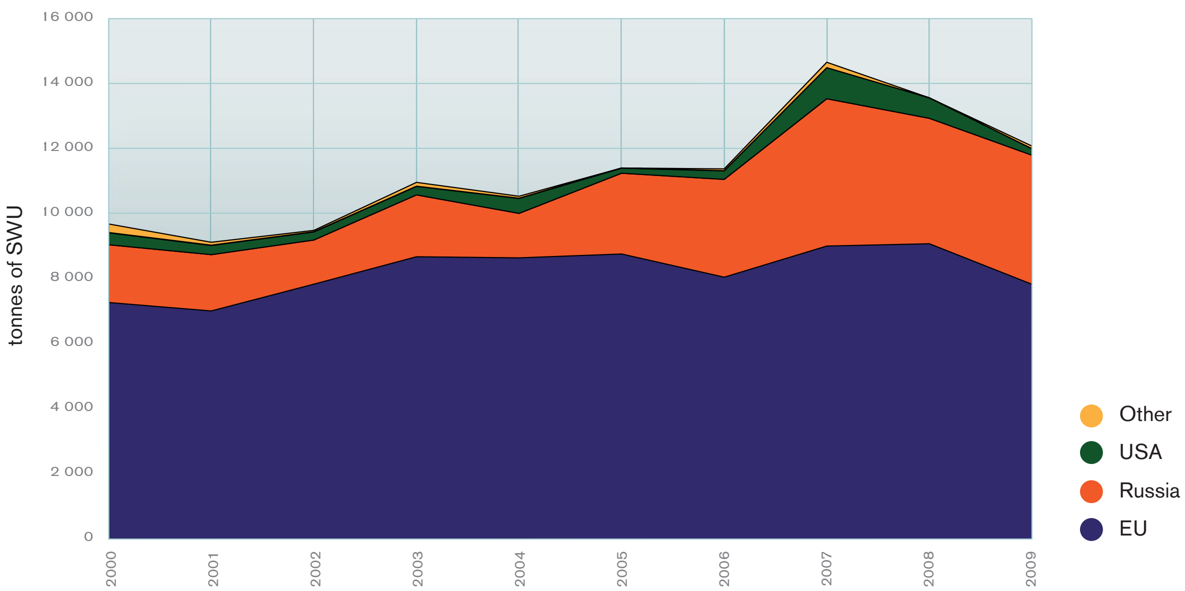
Table 8: Providers of enrichment services delivered to EU utilities

Enricher	Quantities in 2009 (tSWU)	Share in 2009 (%)	Quantities in 2008 (%)	Share in 2008 (tSWU)	Change over 2008 (%)
EURODIF+URENCO (EU)	7 833	65.80	9 078	66.95	-13.71 %
TENEX (Russia)	3 619	30.40	3 856	28.43	-6.15 %
USEC (USA)	195	1.64	626	4.62	-68.85 %
Others(1)	258	2.17	0	0	
Total	11 905	100	13 560	100	-12.21 %

(1) Including reprocessed re-enriched uranium.

Deliveries of separative work from TENEX (Russia) to EU utilities under purchasing contracts totalled 3 619 tSWU, a decrease of 237 tSWU compared with 2008 but still around 30 % of the total enrichment services supplied to EU utilities.

Figure 6: Supply of enrichment to EU utilities by provider, 2000-2009



Enrichment services provided from USEC totalled only 195 tSWU and accounted for about 1.64 % of the total enrichment services supplied to EU-27. Figure 6 shows the enrichment services provided to EU utilities by origin since 2000.

Plutonium and mixed-oxide fuel

Use of mixed-oxide fuel (MOX, see footnote 11) is attracting more attention, as it is seen as a viable option in both economic and waste management terms. Some nuclear countries consider this option beneficial for both the nuclear community and society, for at least two main reasons:

- MOX fuel is manufactured from plutonium recovered from spent fuel;
- MOX fuel also provides a means of burning plutonium to produce electricity, thus contributing to non-proliferation.

Plutonium (Pu) is an inherent by-product of operation of nuclear reactors and worldwide stocks might exceed 250 tonnes today. MOX fuel is expected to supply about 5 % of the fuel requirements for the world's nuclear reactors. At present MOX fuel provides about 2 % of the new nuclear fuel used worldwide.

Transactions involving plutonium mainly related to use for MOX fuel fabrication: ESA co-signed four such contracts in 2009. Reprocessing of irradiated fuel continued at the La Hague plant in France, which was able to reprocess all the material offered for reprocessing and even has some spare capacity. Reprocessing restarted during 2008 at the THORP plant in the United Kingdom.

The quantities loaded into EU reactors and the estimated savings from use of MOX fuel are shown in Table 9 (no MOX fuel is used in the EU-12). The quantity of MOX fuel loaded totalled 10 282 kg Pu in 2009, down from 16 430 kg Pu in 2008.

Table 9: Use of plutonium in MOX in EU-27 and estimated natural uranium (NatU) and separative work savings

Year	kg Pu	Savings	
		tNatU	tSWU
1996	4 050	490	320
1997	5 770	690	460
1998	9 210	1 110	740
1999	7 230	870	580
2000	9 130	1 100	730
2001	9 070	1 090	725
2002	9 890	1 190	790
2003	12 120	1 450	970
2004	10 730	1 290	860
2005	8 390	1 010	670
2006	10 210	1 225	815
2007	8 624	1 035	690
2008	16 430	1 972	1 314
2009	10 282	1 234	823
Grand total	131 136	15 756	10 487

Note that the published figures on natural uranium and separative work savings could vary, depending on the calculation method. In this report ESA assumed that one tonne of plutonium saves the equivalent of 120 tonnes of natural uranium and 80 tonnes of separative work.

ESA findings, recommendations and diversification policy

The overview of EU utilities' supply policy for the next ten years, produced by ESA on the basis of information received at the end of 2009, points to the conclusion that European utilities cover their current and future requirements mainly by means of long-term contracts. This approach is in line with ESA recommendations. On the basis of the results of the same survey, ESA also observes that the aggregate level of stocks and the contractual coverage are adequate to meet the needs of utilities.

In 2009 natural uranium continued to be supplied to the EU by trustworthy suppliers and from diversified sources. Altogether there were more than 10 different sources of supply.

Regarding diversification of sources of supply of enriched uranium to EU utilities, almost two thirds of the separative work required was performed by the two European enrichers (Areva-Eurodif and Urenco).

One external source of supply of SWUs is the US enricher USEC, though its share of the LEU supply was only 1.64%.

However, the bulk of external supplies of separative work come from TENEX (Russian Federation) which supplies 30.40% of enriched uranium delivered to EU. For EU-15 direct dependence on Russian enrichment services stood at 23.75 % of those countries' needs, whereas for EU-12 this dependence was as high as 95.90%.

The significant differences in supply patterns and, therefore, in diversification of sources of supply are due to the fact that utilities with western technology traditionally obtain uranium and services (for example, enrichment) under separate contracts from diversified sources, whereas utilities using Russian technology usually purchase fabricated fuel assemblies under the same contract (including supply of uranium and enrichment) with a single supplier.

In addition, supply contracts signed before EU-12 Member States joined the EU have been 'grandfathered' under Article 105 of the Euratom Treaty. In practice, grandfathered contracts sometimes keep certain EU utilities entirely dependent on a single external supplier.

The Euratom Supply Agency continues to recommend that EU utilities maintain an adequate level of strategic inventories and use market opportunities to increase their inventories, depending on their individual circumstances. It also recommends that utilities cover most of their needs under long-term contracts with diversified sources of supply.

The Supply Agency continues to monitor the market, especially supplies of natural and enriched uranium to the EU, in order to ensure that EU utilities have diversified sources of supply and do not become over-dependent on any single source. This is performed by validating or refusing to sign contracts and regularly exchanging information with the industry. One key goal for long-term security of supply is to maintain the viability of the EU industry at every stage of the fuel cycle.

As regards enrichment of reprocessed uranium by downblending HEU or by re-enrichment (in the Russian Federation), ESA generally welcomes reprocessing of spent fuel and considers that the availability of recycled uranium is increasing the security of supply of Community users. Furthermore, blending recycled uranium with HEU of military origin is beneficial for nuclear disarmament and non-proliferation of nuclear materials. Therefore when implementing its diversification policy ESA takes into account these positive aspects of use of reprocessed fuel. In 2009 some 2% of the EU's total enrichment needs were covered by using reprocessed uranium.

Chapter 4

ESA work programme for 2010

In line with the tasks conferred on it under Chapter 6 of the Euratom Treaty and its new statutes, ESA built its 2010 work programme around four major objectives:

1) **Maintaining the policy of promoting diversification of sources of supply.**
   The limited production of nuclear materials within the EU itself creates a need to diversify sources of supply to a satisfactory degree in order to guarantee security of supply of nuclear fuel to utilities in the Community. By participating in the process of evaluating and signing supply contracts for nuclear materials and acknowledging the transactions covering provision of the entire cycle of nuclear fuel services, ESA will continue to guarantee security of supply.

2) **Developing a nuclear observatory.**
   This task confirmed in ESA's statutes in 2008 was implemented during the second half of 2009. The first measure taken by ESA in this area was to ask the Advisory Committee to think about ways to obtain more accurate and timely information about developments on the nuclear market. In parallel, the Agency will continue its efforts to improve data processing methods.

3) **Intensifying international relations.**
   In order to carry out efficiently its tasks of nuclear observatory and guarantor of security of supply, ESA has to develop relations with international entities.

4) **Closely monitoring technological developments.**
   ESA will closely monitor developments in nuclear technology in order to acquire the latest available knowledge on possible changes in demand for nuclear fuel and, thus, be able adequately to evaluate the impact on security of supply of nuclear fuels to EU utilities.

Promoting diversification of sources of supply

Since the Agency was established in 1960 its main task has been to put into practice the principle of equal access to supplies of nuclear materials for EU Member States, paying particular attention to diversification of sources of supply.

This is one of the key priorities of EU energy policy, as confirmed in the Commission's 2006 Green Paper(14), in the Second Strategic Energy Review(15) and, finally, in the Europe 2020 Strategy(16). ESA's task is also in line with the Treaty of Lisbon which aims, in a spirit of solidarity between Member States, to ensure security of energy supply in the Union.

By signing the supply contracts for ores, source materials and special fissile materials produced within or outside the Community (Article 52 of the Euratom Treaty) ESA monitors diversification of sources. Notifications to ESA of contracts for processing, converting or shaping materials (Article 75 of the Treaty) also give the Agency an overview of needs and industrial capacity in the Union.

However, there is one exemption from the principle of diversification: it applies to Member States equipped with Russian design reactors and which had concluded long-term supply contracts before they joined the EU. Article 105 of the Euratom Treaty protects the rights acquired under these contracts until they expire.

Specific objective N° 1

1) Exercise ESA's exclusive rights to conclude supply contracts in order to continue to guarantee security of supply of nuclear materials to users in the EU.

(14) A European Strategy for Sustainable, Competitive and Secure Energy, COM(2006) 105 final.
(15) COM(2008) 781 final.
(16) COM(2010) 2020.

2) Acting in compliance with the principles established by the Euratom Treaty and with the guidelines developed by the Council and the Commission, strive to optimise the Agency's signature and acknowledgement procedures for contracts in the light of developments on the nuclear market.

Developing a nuclear market observatory

As part of its drive for optimisation, the Agency must make sure that it has the necessary information at its disposal in order to carry out the function of nuclear market observatory. This new task given to the Agency by its statutes entails developing analytical capacity and forecasting skills based on timely and accurate information relating to all stages of the nuclear fuel cycle.

The main and the most accurate source of information for the Agency are the supply contracts for materials and services plus the complementary data transmitted by the industry annually about execution of these contracts.

ESA has already started to upgrade its data processing methods which should allow it to fine-tune its market observation capacity and respond to the expectations of operators better. On the basis of this upgrade, in 2009 ESA was able to publish a new multiannual natural uranium price index (MAC-3) which reflects the latest market developments. Furthermore, in this context, ESA intends to publish the indicative price of natural uranium on a quarterly basis.

These measures will also lay the foundation for building up comprehensive overviews of the situation and trends on the nuclear cycle market. ESA's Annual Report and quarterly reports will remain the main ways to present the analyses by the nuclear market observatory.

Finally, the ESA website will include a special page presenting the activities of the nuclear observatory with direct access to information about market developments.

Specific objective N° 2

ESA will boost its market observation and monitoring activities by:

1) Monitor general trends on the nuclear market and publish an overview of market developments in ESA's Annual Report and quarterly market reports with the support of the Advisory Committee.

2) Intensify analysing capacities about developments in the price of natural uranium in close cooperation with the Advisory Committee.

3) Gradually widen the range of data processed by the nuclear observatory available on the ESA website.

Intensifying international relations

This activity is essential for ESA in order to accomplish the nuclear observatory tasks entrusted to the Agency in 2008.

The quality and neutrality of the analyses of the nuclear cycle market provided by ESA are being sought more and more by groups of international experts. In order to raise the profile of its activities as a market observatory and to carry out its other tasks efficiently, ESA will maintain regular contact not only with international nuclear organisations such as the IAEA and the OECD's Nuclear Energy Agency (NEA) but also with a number of market players outside the EU.

Specific objective N° 3

1) Intensify the frequency of exchanges with international organisations and the nuclear industry.

2) Intensify contacts with key players on the nuclear market located outside the EU.

3) Intensify relations with the Advisory Committee and develop common action in working groups.

Closely monitoring technological developments

ESA will actively monitor research and development activities especially within the Sustainable Nuclear Energy Technology Platform and the Technology Platform for Implementing Geological Disposal, launched with the support of the Commission, and also in other Community or international R&D fora which will have an impact on nuclear fuel cycle management — i.e. reprocessing waste, reducing the volume of waste, improving reactor efficiency, etc. — and thus directly influence the nuclear fuel market.

Specific objective N° 4

1) Review the latest technological developments related to fuel cycle management in Advisory Committee meetings or at specifically organised events.

2) Take account of the knowledge acquired from the latest technological developments in the security of supply policy applied by the Agency.

3) Take part in relevant R&D activities.

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A limited number of paper copies of this report may be obtained, subject to availability, from the above address.

Further information

Additional information can be found on Europa, the European Union server, at http://europa.eu/index_en.htm. It provides access to the websites of all European institutions and other bodies.

The Internet address of the European Commission's Directorate-General for Energy is http://ec.europa.eu/energy/index_en.html. This website contains information on, for example, security of energy supply, energy-related research, nuclear safety and liberalisation of the electricity and gas markets.

Glossary

CIS	Commonwealth of Independent States
ESA	Euratom Supply Agency
Euratom	European Atomic Energy Community
IAEA	International Atomic Energy Agency
(US) DoE	United States Department of Energy
(US) NRC	United States Nuclear Regulatory Commission
USEC	United States Enrichment Corporation
EUP	Enriched uranium product
HEU	Highly enriched uranium
LEU	Low-enriched uranium
MOX	Mixed-oxide fuel (uranium mixed with plutonium oxide)
RET	Re-enriched tails
RepU	Reprocessed uranium
SWU	Separative work unit (see below for detailed definition)
tSWU	1 000 SWU
tU	Metric tonne of uranium (= 1 000 kg)
BWR	Boiling water reactor
EPR	Evolutionary/European pressurised water reactor
LWR	Light water reactor
NPP	Nuclear power plant
PWR	Pressurised water reactor
RBMK	Light water graphite-moderated reactor (Russian design)
VVER/WWER	Pressurised water reactor (Russian design)
kWh	kilowatt-hour
MWh	megawatt-hour (= one thousand kWh)
GWh	gigawatt-hour (= one million kWh)
TWh	terawatt-hour (= one billion kWh)

MW stands for megawatt or one billion watts, which measures electric output. **MWe** refers to electric output from a generator, **MWt** to thermal output from a reactor or heat source (e.g. the gross heat output of a reactor itself, typically around three times the MWe figure).

Generation IV (or Gen-IV) reactors are a set of nuclear reactor designs currently being developed in the research cooperation within the 'Generation IV International Forum'. Current reactors in operation around the world are generally considered second- or third-generation systems. The primary goals of Gen-IV are to improve nuclear safety, improve resistance to proliferation, minimise waste and consumption of natural resources and decrease the cost of building and running such plants. These systems employ a closed fuel cycle to maximise the resource base and minimise the high-level waste to be sent to a repository. Most of them are fast neutron reactors (only two operate with slow neutrons like today's plants) and they are not expected to be available for commercial construction before 2030.

SWU stands for 'separative work unit' which measures the effort made in order to separate the fissile, and hence valuable, U-235 isotopes from the non-fissile U-238 isotopes, both of which are present in natural uranium. As a standard indicator of enrichment services, the concept of SWU is very complex, as it is a function of the amount of uranium processed and the degree to which it is enriched, i.e. the extent of increase in the concentration of the U-235 isotope relative to the remainder. The unit is strictly ‘kilogram separative work unit’ or kg SWU (but in graphs is usually shown as SWU or tSWU for thousands) and measures the quantity of separative work (indicative of energy used in enrichment) when feed and product quantities are expressed in kilograms.

To **produce one kilogram of uranium enriched** to 3.5 % U-235 typically **requires 4.3 SWU** if the plant is operated at a tails assay of 0.30 % or 4.8 SWU if the tails assay is 0.25 % (thereby requiring only 7.0 kg instead of 7.8 kg of natural U feed).

Between **100 000 and 120 000 SWU are required** to enrich the annual fuel loading for a typical **1 000 MWe** light water reactor.

Enrichment costs are related to the electrical energy used. The gaseous diffusion process consumes some 2 400 kWh per SWU, whereas gas centrifuge plants require only about 60 kWh/SWU.

Annexes

Annex 1

EU-27 reactor needs and net requirements (quantities in tU and tSWU)

(A) From 2010 until 2019

	Natural uranium		Separative work	
Year	Reactor needs	Net requirements	Reactor needs	Net requirements
2010	21 805	18 252	14 473	12 600
2011	21 090	18 203	14 518	13 169
2012	20 871	18 070	13 912	12 880
2013	21 627	18 945	14 902	13 225
2014	20 102	17 872	14 176	12 595
2015	19 439	17 532	15 569	14 625
2016	20 036	18 187	15 693	14 830
2017	19 253	17 891	15 116	14 392
2018	18 459	16 884	14 464	13 582
2019	19 804	18 302	15 416	14 662
Total	202 486	180 138	148 239	136 561
Average	20 249	18 014	14 824	13 656

(B) Extended forecast from 2020 until 2029

	Natural uranium		Separative work	
Year	Reactor needs	Net requirements	Reactor needs	Net requirements
2020	20 039	18 444	15 482	14 600
2021	19 375	17 863	14 971	14 217
2022	18 295	16 801	14 471	13 735
2023	19 362	17 865	14 982	14 211
2024	18 903	17 541	14 596	13 872
2025	17 982	16 620	14 120	13 396
2026	18 924	17 562	14 795	14 071
2027	18 724	17 362	14 625	13 901
2028	17 314	15 984	13 791	13 091
2029	18 841	17 511	14 721	14 021
Total	187 760	173 554	146 553	139 114
Average	18 776	17 355	14 655	13 911

Annex 2

Fuel loaded into EU-27 reactors and deliveries of fresh fuel under purchasing contracts

Year	Fuel loaded			Deliveries		
	LEU (tU)	Feed equivalent (tU)	Enrichment equivalent (tSWU)	Natural U (tU)	% spot	Enrichment (tSWU)
1980		9600		8600	-4	
1981		9000		13000	10	
1982		10400		12500	<10	
1983		9100		13500	<10	
1984		11900		11000	<10	
1985		11300		11000	11.5	
1986		13200		12000	9.5	
1987		14300		14000	17.0	
1988		12900		12500	4.5	
1989		15400		13500	11.5	
1990		15000		12800	16.7	
1991		15000	9200	12900	13.3	10000
1992		15200	9200	11700	13.7	10900
1993		15600	9300	12100	11.3	9100
1994	2520	15400	9100	14000	21.0	9800
1995	3040	18700	10400	16000	18.1	9600
1996	2920	18400	11100	15900	4.4	11700
1997	2900	18200	11000	15600	12.0	10100
1998	2830	18400	10400	16100	6.0	9200
1999	2860	19400	10800	14800	8.0	9700
2000	2500	17400	9800	15800	12.0	9700
2001	2800	20300	11100	13900	4.0	9100
2002	2900	20900	11600	16900	8.0	9500
2003	2800	20700	11500	16400	18.0	11000
2004	2600	19300	10900	14600	4.0	10500
2005	2500	21100	12000	17600	5.0	11400
2006	2700	21000	12700	21400	7.8	11400
2007	2809	19774	13051	21932	2.4	14756
2008	2749	19146	13061	18622	2.9	13560
2009	2807	19333	13754	17591	5.2	11905

Annex 3

ESA average prices for natural uranium

	Multiannual contracts		Spot contracts		New multiannual contracts (MAC-3)		Exchange rate (year average)
Year	€/kgU	US$/lb U_3O_8	€/kgU	US$/lb U_3O_8	€/kgU	USD/lb U_3O_8	€/US$
1980	67.20	36.00	65.34	35.00			1.39
1981	77.45	33.25	65.22	28.00			1.12
1982	84.86	32.00	63.65	24.00			0.98
1983	90.51	31.00	67.89	23.25			0.89
1984	98.00	29.75	63.41	19.25			0.79
1985	99.77	29.00	51.09	15.00			0.76
1986	81.89	31.00	46.89	17.75			0.98
1987	73.50	32.50	39.00	17.25			1.15
1988	70.00	31.82	35.50	16.13			1.18
1989	69.25	29.35	28.75	12.19			1.10
1990	60.00	29.39	19.75	9.68			1.27
1991	54.75	26.09	19.00	9.05			1.24
1992	49.50	24.71	19.25	9.61			1.30
1993	47.00	21.17	20.50	9.23			1.17
1994	44.25	20.25	18.75	8.58			1.19
1995	34.75	17.48	15.25	7.67			1.31
1996	32.00	15.63	17.75	8.67			1.27
1997	34.75	15.16	30.00	13.09			1.13
1998	34.00	14.66	25.00	10.78			1.12
1999	34.75	14.25	24.75	10.15			1.07
2000	37.00	13.12	22.75	8.07			0.92
2001	38.25	13.18	21.00[(1)]	7.23[(1)]			0.90
2002	34.00	12.37	25.50	9.27			0.95
2003	30.50	13.27	21.75	9.46			1.13
2004	29.20	13.97	26.14	12.51			1.24
2005	33.56	16.06	44.27	21.19			1.24
2006	38.41	18.38	53.73	25.95			1.26
2007	40.98	21.60	121.80	64.21			1.37
2008	47.23	26.72	118.19	66.86			1.47
2009	55.70	29.88	77.96	41.83	63.49	34.06	1.39

(1) The spot price for 2001 was calculated on the basis of an exceptionally low total volume of only some 330 tU under four transactions, one of which accounted for two thirds of this quantity. Some 300 tU were delivered as UF6 without a price being specified for the conversion component. To establish a price excluding conversion costs for these deliveries, ESA applied an estimated average conversion price of € 5.70/kgU (or US$ 5.10/kgU).

Annex 4

Calculation methodology for ESA U_3O_8 average prices

ESA collects two categories of prices on an annual basis:

- ESA weighted average U_3O_8 price for multiannual contracts, paid by EU utilities for their deliveries in a given year.
- ESA weighted average U_3O_8 price for spot contracts, paid by EU utilities for their deliveries in a given year.

The ESA weighted average U_3O_8 'MAC-3' price index is calculated using natural uranium deliveries under new multiannual contracts in the reporting year, i.e. contracts concluded between 1 January 2007 and 31 December 2009, with deliveries made during 2009. In this context, ESA regards amendments which have a direct impact on the prices paid as separate contracts.

The difference between multiannual and spot contracts is that:

- 'multiannual' contracts provide for deliveries extending over more than 12 months;
- 'spot' contracts provide for either only one delivery or for deliveries extending over a maximum of 12 months, whatever the time between conclusion of the contract and the first delivery.

Methodology

Prices

Prices are collected directly from utilities or via their procurement organisations from:

- contracts submitted to ESA;
- end-of-year questionnaires backed up, if necessary, by visits to the utilities.

Data requested on natural uranium deliveries during the year

The following details are requested: ESA contract reference number, quantity (kgU), delivery date, place of delivery, mining origin, natural uranium price specifying the currency, unit of weight (kg, kgU or lb), chemical form (U_3O_8, UF_6 or UO_2), whether the price includes conversion and, if so, the price of conversion, if known.

Deliveries taken into account

The deliveries taken into account are those made under purchasing contracts to the EU electricity utilities or their procurement organisations during the relevant year. They also include the natural uranium equivalent contained in enriched uranium purchases.

Other categories of contracts, such as between intermediaries or for sales by utilities, purchases by non-utility industries or barter deals, are excluded. Deliveries for which it is not possible reliably to establish the price of the natural uranium component are excluded from the price calculation (e.g. uranium out of specification or enriched uranium priced per kg of EUP without separation of the feed and enrichment components).

Checking

ESA compares the deliveries and prices reported with the data collected at the time of conclusion of the contracts, taking into account any subsequent updates. It compares, in particular, the actual deliveries with the 'scheduled deliveries' and options. Where there are discrepancies between scheduled and actual deliveries, clarifications are sought from the organisations concerned.

Exchange rates

To calculate the average prices, the original contract prices are converted into EUR per kgU contained in U_3O_8 using the average annual exchange rates published by the European Central Bank.

Prices which include conversion

For the few prices which include conversion but where the conversion price is not specified, given the relatively minor cost of conversion, ESA converts the UF6 price to a U_3O_8 price using an average conversion value based on its own sources and on specialised trade press publications and confirmed by discussions with the converters.

Independent verification

Two members of ESA staff independently verify spreadsheets from the database.

Despite all the care taken, errors or omissions are discovered from time to time, mostly in the form of missing data, e.g. on deliveries under options, which were not reported. As a matter of policy, ESA never publishes a corrective figure.

Data protection

Confidentiality and physical protection of commercial data are ensured by using stand-alone computers, which are neither connected to the Commission Intranet nor to the outside world (including the Internet). Contracts and back-ups are kept in a secure room, with restricted key access.

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