Uranium mining and (in)transparency: URENCO’s role in the nuclear fuel chain

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Introduction

Exploration and exploitation of uranium is the starting point of the nuclear fuel chain. Uranium mining can have a tremendous impact on environment and society in the respective regions.

Legislation concerning uranium mining in western countries is getting stricter and stricter. At the same time uranium mining exploration licenses in many developing economies are rapidly increasing whilst objective information provision on this type of mining & governance implications are strongly lagging behind. Fresh uranium comes from countries such as Niger, Namibia, and in the future potentially from Malawi, Mali, Cameroon and Tanzania. Full transparency over the whole fuel chain makes it possible to influence both end users (in this case Europe) and producers (in this case African countries) to take responsibility on environmental governance and security and civil society issues that are tied into nuclear energy and uranium mining, workers’ rights, empowering civil society organizations (CSOs) in the participating countries in Africa, democracy, health and fair prices.

The URENCO group (Uranium Enrichment Company) enriches uranium for around 50 utilities in at least 18 countries. ‘This means it fuels around 170 nuclear power stations worldwide.’

This report gives important background information on uranium mining and enrichment, the policy framework of the European Union, activities of URENCO, their transparency and corporate social responsibility, contract information, proliferation treaties and safeguards. With this report we want to encourage stakeholders like governments, the civil society, the private sector and international bodies, to engage in a debate on corporate social responsibility.

A first step could be to fully disclose the origin of the uranium that is enriched in the URENCO facilities.

World Information Service on Energy, March 2014

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1 URENCO Annual Report 2012, p. 4
Uranium mining and (in)transparency: URENCO’s role in the nuclear fuel chain
1. What is uranium enrichment?

Enrichment means the raising of the concentration of a certain isotope of interest in an element. Although not limited to uranium, the term is mostly used for the enrichment of the isotope U-235 in uranium (see simplified graph of nuclear fuel chain).

Natural uranium mostly consists of the isotope U-238, while the fissile isotope U-235 that is able to sustain a nuclear chain reaction makes up for only 0.72% of the atoms (or 0.711% of the mass). The use of natural uranium as a fuel is only possible in certain reactor types, such as Heavy Water Reactors (HWR), graphite moderated reactors (such as the Russian RBMK type), or Gas Cooled Reactors (GCR). However, 88.5% of the current net nuclear generating capacity in the world is from Light Water Reactors (LWR), such as Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR). In these reactor types, a nuclear chain reaction can only be obtained, if the fraction of the fissile isotope U-235 in the uranium fuel is raised from 0.72% to approx. 3% to 5%. The process of raising the fraction of the isotope U-235 in the uranium is called enrichment.

Commercially available enrichment technology is now almost exclusively based on gas centrifuges. In these centrifuges, a gaseous uranium compound (uranium hexafluoride - UF6) is exposed to strong gravity fields, separating the lighter from the heavier isotopes. As the enrichment obtained in a single centrifuge is not sufficient, several centrifuges are connected to so-called cascades. In commercial enrichment plants, many such cascades are operated in parallel to obtain the required throughput.

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3 Isotopes are atoms of the same element (e.g. uranium) that have the same atomic number but different mass numbers (for uranium for instance 233, 235, 238).
4 Nuclear Power Reactors in the World, RDS 2-33, IAEA 2013
In addition to the stream of enriched uranium, the enrichment process generates a by-product stream of uranium with a concentration of U-235 lower than in natural uranium, the so-called depleted uranium (DU), or tails, with typically 0.2% - 0.3% U-235. The depleted uranium represents more than 85% of the mass output of the enrichment plant.

The depleted uranium hexafluoride also is filled into cylinders, which are then stored in open cylinder yards next to the enrichment plant, awaiting a decision about their further fate. Over the decades, the USA alone have accumulated more than 700,000 t of depleted uranium hexafluoride.

Theoretically, it is possible to reintroduce the depleted uranium hexafluoride into the enrichment plant to extract more of the fissile U-235 still contained. Changes in the economics might make this feasible, such as an increase of uranium prices, and/or decrease of enrichment cost - possibly as a result of future technology advances. However, re-enrichment is not very effective as a means to reduce the mass of the stockholdings of depleted uranium, as it turns most of the material into secondary tails.

Ultimately, all depleted uranium that is not re-used must be disposed of. As the tails in the form of UF6 are not suitable for this, the companies now have begun to deconvert it to the less hazardous oxide form of U3O8. But there is no such repository in existence yet.

The disposal of depleted uranium presents unprecedented challenges, due to the sheer volume of concentrated alpha radiation-emitting material, and due to the unusual property that it becomes more hazardous with time: radioactivity starts to increase after 50,000 years, reaches its maximum activity after around 2 million years and remains at this level for a billion years.\textsuperscript{5}

\textsuperscript{5} http://www.wise-uranium.org, Peter Diehl, January 2014
2. General political framework of the EU regarding nuclear energy as well as uranium mining and import

One of the three treaties signed in Rome, Italy, in 1957, establishing the European Economic Community (EEC), was the Treaty to establish the European Atomic Energy Community (Euratom). The general objective of the Treaty is to contribute to the formation and development of Europe’s nuclear industries, so that all Member States can “benefit from the development of atomic energy”, and to “ensure security of supply”. It is important to note that Euratom’s powers are limited to civil uses of nuclear energy.

Unlike most of the EEC Treaties, no major changes have ever been made to the Euratom Treaty, which remains in force. The European Atomic Energy Community has not merged with the European Union (EU) and therefore retains a separate legal personality, while sharing the same institutions. The Treaty amending the EU and EC Treaties, which was signed in December 2007, changed certain provisions of the Euratom Treaty via its “Protocol No 12 amending the Treaty establishing the European Atomic Energy Community”. These changes are limited to adaptations to take account of the new rules established by the amending Treaty, particularly in the institutional and financial fields.

According to the Treaty, the specific tasks of Euratom are:

* to promote research and ensure the dissemination of technical information
* to establish uniform safety standards to protect the health of workers and of the general public and ensure that they are applied
* to facilitate investment and ensure the establishment of the basic installations necessary for the development of nuclear energy in the EU
* to ensure that all users in the EU receive a regular and equitable supply of ores and nuclear fuels
* to make certain that civil nuclear materials are not diverted to other (particularly military) purposes
* to exercise the right of ownership conferred upon it with respect to special fissile materials
* to establish joint undertakings

The Euratom Treaty establishes two specific bodies: the Safeguard Office (which carries out physical and accounting checks in all nuclear installations in the Community) and the Supply Agency (Article 2(d) and 52 of the Treaty). The Euratom Supply Agency ensures a regular and equitable supply of ores, source materials or other fissionable materials to EU users. The main task of the ESA is “to ensure that all users in the EU receive a regular and equitable supply of ores”. The ESA Rules set the manner in which demand is to be balanced against supply of ores and source materials. It has “an exclusive right to conclude contracts relating to the supply of ores and source materials coming from inside the EU or from outside”.

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

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As the market is becoming increasingly complex, the remit of the ESA 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. The Nuclear Observatory should provide the Euratom Community with expertise, information and advice on any subject connected with the operation of the market in nuclear materials and services.\(^9\)

But actual factual information about for example purchase of uranium by utilities is very limited. In many reports a Disclaimer says “ESA ensures confidentiality and physical protection of the commercial data.”

The Euratom Supply Agency has legal personality and financial autonomy and is under the supervision of the Commission, which issues directives to it and possesses a right of veto over its decisions.\(^10\)

Mining
The EU mining policy is determined by two Directorates of the European Commission: DG Transport and Energy and DG Enterprise. The first Directorate deals with the energy extractive industry and the second one with the non-energy extractive industry. Mining had been specifically excluded from much of the environmental policy developed by DG Environment. Reviews of relevant legislation show how the mining industry has been favourably treated compared to other industrial sectors.\(^11\)

Council Directive 96/29/Euratom requires that member states shall require prior authorisation in particular for the operation and decommissioning of any facility of the nuclear fuel cycle and exploitation and closure of uranium mining.\(^12\)

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3. History of uranium enrichment market

In the beginning all uranium enrichment was for the production of nuclear weapons. In the 1950’s the US expanded their World War II enrichment capacity to three huge diffusion plants with a total capacity of 17 million SWU. \(^{13}\) The British also constructed diffusion plants for their weapons programmes. The British plant at Capenhurst with a small capacity (400 tSWU) \(^{14}\) opened in 1953 \(^{15}\) and was dismantled in 1982. \(^{16}\) The Soviet Union also started a military uranium enrichment program. Export of uranium enrichment services (first exclusively to countries inside the Soviet-bloc) is performed by Tenex (founded in 1963). \(^{17}\)

In the mid-1950’s in the formative years of the EEC, the French proposed that the Community should embark upon an enrichment project. But the US stepped in with an offer Europa “could not refuse” of State-subsidized enrichment from the big US-diffusion factories. By accepting the US-offer collaboration on enrichment technology in EEC was postponed for another 15 years. \(^{18}\)

Breaking the US monopoly
From a virtual monopoly on enrichment services outside the Soviet Bloc throughout the 1960’s and most of the 1970’s, the US share of foreign demand had diminished to less than 60 percent by the end of 1982. \(^{19}\) France was the first country to break the monopoly and signed an agreement with Tenex in March 1971 for the supply of enriched uranium. \(^{20}\) In 1975 already 8.8% of imported enriched uranium in the Euro-9 \(^{21}\) came from the USSR.

The position of the US as the dominant world supplier of EU eroded fast in the 1970’s/early 1980’s for a number of reasons: \(^{22}\)
- the perception was important that the US was an unreliable source of enriched uranium fuel, due to closing its order books in 1974 because outstanding contracts exceeded US production capacity (for four years no new orders were accepted).
- as US policy moved toward the Nuclear Nonproliferation Act of 1978, more restrictions were placed on foreign buyers of the enriched uranium

These factors heightened foreign nations’ interests in developing their own enrichment facilities.

Multinational cooperation
Early in the 1970’s, the URENCO company was set up by the Federal Republic of Germany, the United Kingdom and The Netherlands and started construction of their own enrichment capacity. In September 1975 URENCO made its first commercial delivery of enriched uranium. While these deliveries were relatively small and came from pilot plants, URENCO gained importance. \(^{23}\) In 1977 the Almelo (Oct. 25) as well as the Capenhurst producti-
on plants (Sept. 15) were officially inaugurated," and production at the German Gronau plant started in August 1985."

Eurodif was founded in 1973 as a joint venture between then-five participating partners: Belgium, France, Italy, Spain and Sweden (in 1975 Iran bought Sweden's 10 %). In 1979, the Eurodif-gas diffusion plant at Tricastin, France, started production and expanded capacity rapidly to 10,800 tSWU a year, and became the world's second largest supplier of enriched uranium. "Currently Areva" owns in total directly and indirectly a majority of 59.65 % of the Eurodif shares."

Small number of producers
In 1976 only five nations had facilities larger than that of a pilot plant for the enrichment of U-235. These were US, United Kingdom, France, Russia and China. All of their existing plants were built initially for the purpose of fulfilling military objectives. Of the five, only the US and Russia had sufficient capacity beyond its own national needs to sell some toll enrichment services abroad."

In 1992, global production capacity (actual production was much less, due to chronic overcapacity) was 43,500 tSWU and still concentrated at a very limited number of producers:
the US (19,400 tSWU), Soviet Union (10), Eurodif (10,800) and URENCO (2,700) held approx. 90 % of total capacity. China, Japan and South Africa accounted for most of the other 5 %.

At present that situation is more or less the same: a small number of producers dominating the enrichment market. But important changes within those producers and technology have taken place: the US now totally lost its position as market leader. Further, the decennia long domination of the diffusion plants ended and the rise of centrifuge technology seems unstoppable. Areva closed the diffusion plant permanently on June 7, 2012 as replacement capacity at Georges Besse II (centrifuge) reached 1.5 million SWU/yr. And URENCO opened new centrifuge enrichment production plant in the US which reached a capacity of 2,700 tSWU/y end of June 2013."

25 URENCOcentecnews, n4, November 1977
26 atw, January 1986
28 The French Eurodif share was managed by CEA. A branch of this public research body Commissariat à l’Energie Atomique (CEA – Atomic Energy Commission), was created to manage all its industrial activities, mainly through the Compagnie Générale des Matières Nucléaires (Cogema – General Company for Nuclear Materials), a private company set up in 1976. In 2001 this merged with Framatome, the nuclear reactor builder, to create the Areva group. Source: Nuclear power, the great illusion. Promises, setbacks and threats, Global Change, October 2008, p. 35
30 Enrichment Supply and Technology Outside The United States, S. A. Levin & S. Blumkin, Union Carbide Corporation, Nuclear Division, 01-1977
31 Conversie en verrijking van Uranium, presentation drs. H.Rakhorst UCN, KVI Symposium 9-10-92, except figures URENCO: Jahrbuch der Atomwirtschaft 1993, p.58
34 Building and operating URENCO USA, http://www.URENCO.com/page/33/URENCO-USA.aspx
Table 1: Enrichment capacity end 2013 in tSWU/y

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity 2013</th>
<th>2020 (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russia (total)</td>
<td>26,000</td>
<td>37,000</td>
</tr>
<tr>
<td>USA URENCO</td>
<td>2,700</td>
<td>5,700</td>
</tr>
<tr>
<td>Netherlands URENCO</td>
<td>5,500</td>
<td>6,200</td>
</tr>
<tr>
<td>United Kingdom URENCO</td>
<td>5,000</td>
<td>5,300</td>
</tr>
<tr>
<td>Germany URENCO</td>
<td>4,200</td>
<td>4,200</td>
</tr>
<tr>
<td>France Areva GB II</td>
<td>3,700</td>
<td>8,200</td>
</tr>
<tr>
<td>China</td>
<td>2,500</td>
<td>8,000</td>
</tr>
<tr>
<td>Japan</td>
<td>50</td>
<td>1,500</td>
</tr>
<tr>
<td>Iran</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>USA Global Laser E.</td>
<td></td>
<td>3,000</td>
</tr>
<tr>
<td>USA Areva</td>
<td></td>
<td>3,300</td>
</tr>
<tr>
<td>various (Brazil/Pakistan/Iran)</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49,659</strong></td>
<td><strong>83,400</strong></td>
</tr>
</tbody>
</table>

36 Compiled from different sources, Laka Foundation, Jan. 2014
37 June-December 2013
41 URENCO Group – Half-Year 2013
42 URENCO Group – Half-Year 2013
43 URENCO Group – Half-Year 2013
44 Low Enriched Uranium From France, Daniel W.Klett, Capital Trade Incorporated, September 10, 2013
46 IPFM, p.18
47 WNA
Overcapacity & Costs
According to Euratom enrichment capacity is still way too much. In 2012, the industry put demand for enrichment services at below 50,000 tSWU. However, capacity reached 65,600 tSWU that year. According to the latest – still optimistic – forecasts of growth in nuclear power production, the SWU oversupply situation will not be resolved before 2020 at the earliest.  

One of the important reasons for the rapid change towards centrifuge enrichment is the costs: and especially the high power consumption of diffusion compared to centrifuge enrichment. The gaseous diffusion process consumes about 2500 kWh (9000 MJ) per SWU, while modern gas centrifuge plants require only about 50 kWh (180 MJ) per SWU. About 140 tSWU is required to enrich the annual fuel loading for a typical 1000 MWe light water reactor at today’s higher enrichment levels.  

Price of SWU constantly decreased over the past few years after relatively high prices in period 2007-2010. The January 2014 spot price of 1 SWU is about US$99 (72 euro). 

48 http://ec.europa.eu/euratom/observatory_segments_e.html
4. Advantages, disadvantages and dangers of uranium enrichment

Advantages:

- The use of enriched rather than natural uranium allows for the use of light water rather than heavy water as a reactor coolant.
- The use of enriched uranium rather than mixed oxide (MOX) avoids all the problems connected to the use of plutonium (higher radiation hazard for workers, proliferation hazard, etc.).

Disadvantages:

- Current commercial uranium enrichment technologies require the uranium to be in the form of a gas. The uranium compound used for this purpose is uranium hexafluoride (UF6). The uranium therefore has to be converted to UF6 first, and, after enrichment, converted back to an oxide form.
- The enrichment process has a considerable power consumption, although this is now sharply reduced by the replacement of old gaseous diffusion technology with much more efficient gas centrifuges.
- Enriched uranium presents a criticality hazard during transport and manufacturing processes.
- Approximately 30% - 40% of the fissile isotope U-235 remains in the depleted uranium stream, as it cannot be extracted economically.
- The depleted uranium hexafluoride generated in the enrichment process as a by-product has to be managed and ultimately disposed.
- Enriched uranium presents a proliferation hazard regarding classified centrifuge technology know-how and also concerning the enriched uranium product itself, as the separative work required to enrich a certain amount of reactor-grade uranium further to bomb-grade (> 90% U-235) is lower than that required to produce that reactor-grade uranium from natural uranium in the first place (see World Nuclear Association graph).

source: WISE Uranium Project, unless stated otherwise
Hazards from normal operation:

- gamma radiation from UF6 (whether natural, enriched, or depleted)
- neutron radiation from UF6 (originating from the interaction of the uranium’s alpha-radiation with the fluorine in the UF6); near cylinders holding enriched uranium, for example, up to 70% of the radiation exposure can be due to neutron radiation
- high gamma radiation from cylinders containing UF6 heels (residue left from unloading of cylinder by heating: the radioactive decay products grown in from the uranium do not form gaseous compounds with fluorine and therefore don’t sublimate, they rather stay in the cylinder, but now are no longer shielded by the uranium), the radiation from a cylinder containing heels is around 100 times higher than that from a full cylinder - the heels thus are responsible for the highest radiation fields encountered in an enrichment plant; the emptied cylinders still containing the radiating UF6 heels are sent back to the sender for cleaning and reuse

Hazards from accidents:

- toxicity hazard from accidental UF6 releases (contact with water - even atmospheric humidity - leads to formation of corrosive hydrofluoric acid (HF) and toxic uranyl fluoride (UO2F2).
- hazard of cylinder rupture, if, for example in a transport accident, a UF6 cylinder is engulfed in an externally fuelled fire; if the whole contents of a UF6 cylinder is released during a fire, lethal air concentrations of toxic substances can occur within distances of 500 to 1,000 meters,
- hazard of cylinder rupture, if an overfilled UF6 feed cylinder is erroneously heated for unloading,
- criticality hazard from enriched uranium (if the amount of enriched uranium present in one location exceeds the critical mass, heavy gamma and neutron radiation bursts from uncontrolled chain reactions can result in lethal radiation doses to persons standing nearby),
- accidents with depleted UF6 storage in open cylinder yards (leaks caused by corrosion, cylinder manipulation errors, plane crash...)
5. The URENCO company

URENCO’s principal activity is the provision of a service to enrich uranium to provide fuel for nuclear power utilities. Its enrichment service is mostly provided on a toll basis using customers’ uranium. URENCO’s shares are ultimately held one-third by the UK government (through Enrichment Investments Limited) one-third by the Dutch government (through Ultra-Centrifuge Nederland Limited) and one-third by German utilities (through Uranit UK Limited, owned by E.On Kernkraft GmbH and RWE Power AG (both 50%).

URENCO fulfils its customer requirements through its four operational enrichment plants in the UK (Capenhurst), Germany (Gronau), the Netherlands (Almelo) and the US (Eunice, New Mexico). In the four enrichment facilities a total of 1600 people are employed.

Since 1990 URENCO also utilises its centrifuge technology for medical and industrial purposes through its research unit Stable Isotopes (located in Almelo). Although this is not a major part of URENCO’s business in purely financial terms, it is considered by the company to be of great value from commercial, social and environmental perspectives.

Enrichment Technology Company Limited is a joint venture company owned in equal share by URENCO and Areva. ETC, formed in October 2003, has the exclusive responsibility to develop, manufacture, supply and install gas centrifuges. A drop in expected installation of new centrifuge capacity forced the company in October 2012 to announce massive lay-offs: up to two third of worldwide jobs will be lost in the coming years: 1400 of the 2000. For the Almelo plant this means a loss of 240 of total 800 jobs.

URENCO Netherlands:
Besides the state initially the following companies invested in URENCO by taking shares: Originally, 45% of Ultra Centrifuge Nederland was owned by industry: RSV & VMF Stork 7.5%; and Philips, Shell and DSM each 10%. After the decision in the late 1970’s to enlarge enrichment capacity, necessary to fulfil the giant and much criticized contract with the military regime in Brazil, the industry declined to invest in the company. Departing from the original intention of the government that the companies take over all shares in the long term, the government decided to invest 214 million euro and to give a loan guarantee. This larger financial involvement resulted in a larger state share in 1980: 98.9%.

In 2009 the Dutch State bought the remaining 1.1% shares for 17 million euro from the industry, making it a 100% state company.

Privatisation:
Less than four years later, in May 2013, the government published its intention to sell the entire Dutch stake in the URENCO Group.

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53 URENCO, Annual Report 2012, p4
54 Company website
57 Tweede Kamer, zitting 1976-1977, nr 2461, nr 2
58 Tweede kamer, zitting 1979-1980, nr 256, A-C
59 Tweede kamer, zitting 1979-1980, nr 256, nr 3
60 Minister van Financien, October 12, 2009: Betreft Uitkoop minderheidsaandeelhouders in Ultra-Centrifuge Nederland N.V. About buying out minority shareholders UCN.
Main reason to sell the shares in URENCO arises from changes relating to the control and the share ownership of the company. Since it was set up, the Netherlands, the United Kingdom and the German private shareholders have held URENCO’s shares indirectly and in equal proportions so that in practice the status quo surrounding the exercise of control over the undertaking has been maintained. But because the German private shareholders RWE and E.on decided to investigate the sale of their interests in URENCO and since the British government made its desire to sell its shares in URENCO known in April 2013, the Dutch government aired their intent to sell.

Doubts within coalition parties only grew after a round table debate early December 2013. The main argument for selling the Dutch part, loss of possibilities to exercise sufficient control to effectively safeguard the public interest due to minority share, surfaced another possibility: not selling but buying a majority shares or even the entire consortium. In its May 2013 letter the cabinet anticipated this possibility and “is of the opinion that acquiring shares in URENCO is not a realistic alternative, in terms of the accompanying budgetary effect alone.”

Table 2: URENCO SWU-production 1976-1990 (in 1000 SWU)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total capacity</th>
<th>Annual Production</th>
<th>NL</th>
<th>UK</th>
<th>BRD</th>
<th>USA</th>
<th>Total production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>75</td>
<td>40</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>1980</td>
<td>460</td>
<td>220</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
<td>410</td>
</tr>
<tr>
<td>1985</td>
<td>1500</td>
<td>780</td>
<td>480</td>
<td>50</td>
<td></td>
<td></td>
<td>1310</td>
</tr>
<tr>
<td>1990</td>
<td>2600</td>
<td>1100</td>
<td>800</td>
<td>400</td>
<td></td>
<td></td>
<td>2300</td>
</tr>
<tr>
<td>2000</td>
<td>^w^c^3^c^7^c^9^c^2^c^7^c^1^c^3</td>
<td>1500</td>
<td>1800</td>
<td></td>
<td>1200</td>
<td>4500</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>17400</td>
<td>5500</td>
<td>5000</td>
<td>4200</td>
<td>2700</td>
<td></td>
<td>17400</td>
</tr>
</tbody>
</table>

Customers and market share:
URENCO’s capacity reached 17,400 tonnes of separative work per year(tSW/y) at the end of June 2013. URENCO will continue with the capacity expansion programme in order to achieve a capacity of 18,000 tSW/a by 2015. URENCO Group has around 50 customers from 18 countries, proudly announcing its first contract in the United Arab Emirates. Customer countries are not listed anywhere (let alone a list of customer utilities), however a world map with customer countries is published in the latest Annual Report. The company’s order book extends beyond 2025 and reflects URENCO’s global customer base: 46% USA, 37% Europe, 17% Rest of World. Contracts are signed typically for 10 years or more. During 2012, URENCO’s market share increased from 29% to 31%.

--62 Letter Minister van Financiën, May 23, 2013
63 URENCO/UKN, Annual Reports 1976-1990
64 URENCO Annual Report 2000, p 57; figures Almelu, Capenhurst, Gronau are estimates of actual production figures
65 URENCO Group – Half - Year 2013 Unaudited Financial Results,
66 URENCO Group – Half - Year 2013 Unaudited Financial Results
67 URENCO Annual Report 2012, p. 4
68 URENCO Annual Report 2012, p. 13
69 URENCO Annual Report 2012, p. 4
70 URENCO Annual Report 2012, p. 17
71 URENCO Annual Report 2012, p. 2
URENCO SWU Deliveries by Region (%)

- Rest of the World: 3%
- East Asia: 13%
- North America: 40%
- Europe27 & Switzerland: 44%

Our operations and customers

- URENCO operations
- Customers
Turnover & other financial details

Financial reports are a part of URENCO’s Annual Reports. However, URENCO Group does not breakdown financial results per location. No results for the Almelo location are published, this is made possible by an exemption based on Art. 403 of Dutch taxation legislation (*personal communication Laka with URENCO Almelo, January 13, 2014). Article 403 provides that if the parent company formally declares it is liable for all obligations of its subsidiary, the subsidiary has no obligation to publish financial reports.

The financial results published in Annual Report of Ultra-Centrifuge Nederland NV, the holding company for the Dutch part, are (except the costs of the holding company) the URENCO Group results divided by three; it has no relationship with the results of the Almelo URENCO plant.

<table>
<thead>
<tr>
<th>Year</th>
<th>Turnover (x million euro)</th>
<th>Net income (x million euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>655.6</td>
<td>100.3</td>
</tr>
<tr>
<td>2011</td>
<td>1,302.4</td>
<td>359.1</td>
</tr>
<tr>
<td>2012</td>
<td>1,601.4</td>
<td>401.5</td>
</tr>
</tbody>
</table>

(source: URENCO website)

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72 Jaarverslag 2012, UCN NV, May 2013, p. 23
73 URENCO Annual Reports 2000, 2012
6. Accidents and incidents related to URENCO

Almelo, The Netherlands:
The most well-known ‘incident’ involving URENCO is of course the Khan-affaire. It is now well known that the ‘father’ of Pakistan’s nuclear weapons programme, Abdul Qadeer (AQ) Khan, had his scientific roots in the Netherlands in the 1960’s and 1970’s. At that time he had access to what was supposed to be highly secret uranium enrichment technology: the URENCO ultra centrifuge project. Thanks to security problems, as well as deliberate and unwitting help from former teachers and colleagues, he was able to build a global nuclear information network and business. From Pakistan, ultracentrifuge technology, knowledge and materials, were exported to Libya, Iran and North Korea. A mixture of legal and illegal transactions, involving businessmen from all over the world as well as individuals in the higher circles of the military and political elite in Pakistan allowed nuclear proliferation to proceed much faster than even those most familiar with the issue expected.⁷⁴

A selection of other incidents concerning URENCO’s Almelo plants

* **UF6 truck crashes on A1 motorway in the Netherlands:**
  On May 21, 2003, a British truck carrying UF6 crashed into a Polish truck carrying paraffin on A1 (Amsterdam-Hengelo) near Bathmen, The Netherlands. The UF6 truck was part of a convoy of 12 British trucks hauling uranium hexafluoride from Preston (England) to URENCO’s enrichment plants in Almelo (The Netherlands) and Gronau (Germany). The British driver was injured. There was no leakage of UF6.⁷⁵

* **Explosion in centrifuge manufacturing plant at Almelo site:**
  At approx. 22:30 hrs. on July 23, 2008, an explosion occurred at the centrifuge manufacturing plant of URENCO’s subsidiary ETC at Almelo. The approx. 25 employees present in the shop evacuated the building without problems.⁷⁶

* **Gas release causes death of two workers from asphyxiation in centrifuge manufacturing plant:**
  Two men died in an accident at the Enrichment Technology Company (ETC) in Almelo. On March 29, 2013, a release of the noble gas argon caused the asphyxiation of two workers; one of them died the same day, the other on April 2. ETC is a joint venture of URENCO with Areva for the development and production of gas centrifuges and the design of complete uranium enrichment plants.⁷⁷

* **In 2013, the enrichment plant at Almelo reported two incidents to the Dutch regulatory authorities** (Kernfysische Dienst), both incidents (on January 13 and July 27) were spills of wastewater in a working area.⁷⁸

A selection of incidents concerning URENCO’s Gronau plant

* **Worker exposed to uranium hexafluoride:**
  On Jan. 21, 2010, at 14:32 hrs., a worker at URENCO’s Gronau enrichment plant was exposed to uranium hexafluoride, when preparing a transport cylinder for a pressure test. The cylinder had been delivered as “empty and cleansed”. The amount of uranium hexafluoride released is unknown, but was only a few grams, according to URENCO’s estimates. The worker suffered contamination at arms and legs and was hospitalised. The contaminated area of the plant was isolated and the contaminated air released via the stack. The release to the environment was equivalent to one sixth of the permissible weekly amount. The

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http://www.laka.org/info/publicaties/Khan/Khan.pdf  
⁷⁵ De Twentsche Courant Tubantia May 21/22, 2003  
⁷⁶ NU.nl July 24, 2008  
⁷⁷ Westfälische Nachrichten April 2, 2013  
environmental monitoring around the plant detected no unusual features.\(^9\)

* **Small release of uranium hexafluoride:**
  On July 23, 2011, a small release of uranium hexafluoride occurred in an autoclave in the Gronau enrichment plant. UF6 concentrations in room air remained below acceptable limits.\(^{10}\)

* **Smouldering fire in switchbox:**
  On June 7, 2012, a smouldering fire occurred in a switchbox at the Gronau enrichment plant. The fire was automatically detected and extinguished. According to URENCO, the switchbox was implemented in multiple instances, allowing for a continued safe operation of the plant. No risks were expected for the employees or the environment, as there was no radioactivity present in the area concerned.\(^{11}\)

* **Fire on board of vessel Atlantic Cartier in Hamburg port - UF6 heels in the hold:**
  In the late evening of May 1, 2013, fire broke out on the lower decks of the vessel Atlantic Cartier, while berthed in the Hamburg port (Germany). The shipment comprised 4 cylinders of type 30B containing a total of 40 kg of UF6 heels from enriched UF6, sent from Areva Richland, Washington, USA, to URENCO Almelo in the Netherlands.\(^{12}\)

A selection of incidents concerning URENCO’s Capenhurst plant

* **Three safety related equipment items found out of operation, after URENCO forgets maintenance:**
  URENCO UK Limited - Capenhurst reported on 17th December 2009 that during a periodic review of the Plant Maintenance schedule, the licensee identified that some safety related equipment items had not been placed on to the Plant Maintenance Schedule; some since 2005. This potential shortfall related to extensions to the latest enrichment facility, which was actively commissioned over the period 2005 to 2009. Consequently, affected safety related equipment items may not have been maintained in accordance with the plant safety case. Urgent checks were made of the safety related equipment items, three were found to be out of operation but of low safety significance, and were promptly repaired.\(^{13}\)

* **Unexpected enhanced site perimeter radiation levels detected:**
  In late 2008 and subsequently confirmed in 2009, some unexpectedly enhanced levels of radiation were measured, at the boundary of the URENCO UK Limited licensed site, at levels still well below any regulatory limits, but nevertheless warranting further investigation.\(^{14}\)

* **Leakage of radioactive liquor:**
  Sellafield Limited - Capenhurst Works reported on 24 July 2009 the leakage of radioactive liquor from one of the uranium hexafluoride (“Hex Tails”) cylinders, currently stored inside a building. The leak was discovered during routine plant surveillance. The hole in the leaking cylinder was promptly sealed by the site fire brigade.\(^{15}\)

* **Fire at URENCO’s Capenhurst enrichment plant:**

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\(^9\) North Rhine-Westphalia Ministry of Economics, January 22, 2010
\(^{10}\) Ministerium Bauen und Verkehr des Landes Nordrhein-Westfalen, July 25, 2011
\(^{11}\) Westfälische Nachrichten, June 8, 2012
\(^{12}\) Advance Notification of Export Shipment, RSB Logistic, March 14, 2013, NRC ADAMS Acc. No. ML13214A187
\(^{13}\) HSE Office for Nuclear Regulation: Quarterly statement of nuclear incidents at nuclear installations; 2010, 1st Quarter
\(^{14}\) NI site inspector’s quarterly report to the local stakeholder group for 1st October to 31 December 2009, Jan. 25, 2010
\(^{15}\) HSE Office for Nuclear Regulation: Quarterly statement of nuclear incidents at nuclear installations; 2009, 4th Quarter
A nuclear scare was triggered at URENCO when a fire started in a non radiologically contaminated solvent degreaser tank, located within a pump maintenance workshop. The non-radioactive degreaser solvent fire led to evacuation of the enrichment facility control room for about an hour. The proximity of the fire to radioactive uranium meant a carefully prepared action plan was set in motion. Firefighters wearing breathing apparatus and staff from the plant put the fire out using a CO2 extinguisher. There were no injuries to personnel and the public were not affected. Monitoring of the perimeter of the site confirmed that there was “no significant release of radioactive material”.

86 HSE Office for Nuclear Regulation: Quarterly statement of nuclear incidents at nuclear installations; 2012, 1st Quarter
7. Future perspective of URENCO and the uranium enrichment market

Gas centrifuge is the winner on the global uranium market but the transfer from gaseous diffusion to centrifuge enrichment technology is now complete with the June 2013 shut down of the last large diffusion plant at Paducah in the US. With a market share of 31% URENCO is the second largest producer (after Tenex).

Despite the closure of the Paducah Gaseous Diffusion Plant, the enrichment market remains over-supplied by around 12% in 2013. It is estimated that 85% of 2020 requirements are already contracted.\(^7\)

The commercial outlook for URENCO depends on many factors, of which the expected capacity increase of nuclear power is the most important. According to IAEA 71 nuclear reactors are under construction, about 40% of those in China.\(^8\) However, many of the reactors outside China are under construction for 10 or more years,\(^9\) and it is unlikely that all those reactors will actually come online. The large majority of the existing nuclear reactor fleet is between 27 and 34 years old (see table),\(^10\) with 15% (64 reactors) 40 years or older!

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\(^7\) Nuclear Engineering International, October 9, 2013
\(^9\) Nuclear Power Status Report 2013, Annex7, p.137
\(^10\) http://www.iaea.org/PRIS/WorldStatistics/OperationalByAge.aspx (status January 2014)
\(^12\) Laka Foundation: Golf van sluitingen kerncentrales VS, Kernenergienieuws, 30 Augustus 2013
Scenarios for the year 2030 have been published by the World Nuclear Association (2030: high 700GW)\(^9\) the IAEA (2030: low 435 GW; high 722 GW)\(^1\) and the IEA (2035: 580 GW)\(^2\). The figures vary between roughly 300 and 750 GW. Given the many years usually required from planning to implementation and actual operation, doubling the installed capacity in the next 17 years is not very realistic. Therefore it is very likely that the existing trend (no growth of total installed nuclear capacity) will continue in the coming years.

**Table 4: Installed nuclear capacity 1960-2013**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of reactors</th>
<th>Total capacity MW (e)</th>
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<td>1960</td>
<td>15</td>
<td>1087</td>
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<tr>
<td>1970</td>
<td>84</td>
<td>17656</td>
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<td>375277</td>
</tr>
<tr>
<td>2014</td>
<td>438</td>
<td>374332</td>
</tr>
</tbody>
</table>

In addition, China’s apparent plan to rapidly increase enrichment capacity by utilizing indigenous centrifuge technology must be considered. China’s enrichment capacity is expected to mainly cover domestic needs until 2030, although there is currently already some modest export to Western-Europe and US. But, it is foreseeable that in the region with the largest growing nuclear power capacity the increase of enrichment capacity will be highest too. This leaves no or only minor market opportunities for URENCO in those regions.

Factors which will also influence the future of enrichment, but difficult to predict, are the use of thorium and plutonium (MOX) as fuel.

The conclusion of the above considerations should be that it is difficult to forecast the future of nuclear energy and the profitability of URENCO in 2025 or 2050. As shown by the downsizing of the centrifuge production plant ETC\(^3\), the market stagnates, with almost no orders after 2025. Consolidating its current market share (31%) seems likely, although the total volume of the future market is unknown.

One important factor for the commercial outlook of URENCO is innovation in enrichment technology. The only technology that will probably be able to compete with centrifuge enrichment is laser-technology. But, like nuclear fusion, the expectations of laser-enrichment are already many decades old and it never lived up to its expectations.

**Laser-enrichment**

Many sources expect laser-enrichment being the only technology capable of endangering the domination of gas centrifuge technology in the global enrichment market. However, laser-enrichment was seen as very promising way back in the 1970’s when it was expected to replace gas diffusion technology. Many countries have done
research on laser enrichment, but the technology is still not commercial viable. USEC suspended work on AVLIS (Atomic Vapour Laser Isotope Separation) in 1999 having spent US$ 1.9 billion\textsuperscript{99}. In 2003 France’s Commissariat a l’Énergie Atomique (CEA) ended research into laser enrichment too, having spent over 1 billion euro on the project\textsuperscript{100}. However, the Australian SILEX (Separation of Isotopes by Laser Excitation) technology is now looking most promising (although USEC stopped funding that in 2003 too)\textsuperscript{101}. Global Laser Enrichment -owned by GE (51%), Hitachi (25%) and Cameco (24%)\textsuperscript{102}- already has a licence to construct and operate a commercial uranium enrichment plant using SILEX technology in the US\textsuperscript{103}. However, actual construction of a full scale commercial laser enrichment plant is still a long way ahead.


\textsuperscript{100} Nuclear Fuel, January 19, 2004


\textsuperscript{103} World Nuclear News, February 26, 2013
8. Plans of mining companies to explore uranium mining, especially regarding Mali, Cameroon and Tanzania

Cameroon - new projects:

- **Kitongo, Lolodorf, Teubang (Mega Uranium Ltd)**
  Canada-based Mega Uranium Ltd, through its wholly-owned subsidiary, Nu-Energy Uranium Corporation, has a 92% interest in Mega Uranium Cameroon plc, which holds three properties in Cameroon: Kitongo (Poli and Salaki tenements), Lolodorf, and Teubang. In the 1980’s limited drilling by Cameroon/Foreign government agencies intersected significant uranium mineralisation in small portions of the Kitongo and Lolodorf properties. In 2008, Mega resumed exploration of the properties.

Mali - new projects:

- **Faléa (Denison Mines Corp.)**
  On April 26, 2010, Canada-based Rockgate Capital Corporation announced that it has commissioned environmental and social baseline studies on the Faléa Project.

  On Nov. 15, 2012, Rockgate Capital Corp. announced the commencement of a Pre-Feasibility study on its Faléa U-Ag-Cu project in south-west Mali. The project comprises 11,377 t U at 0.073% U in measured and indicated resources and 6,035 t U at 0.042% U in inferred resources.

  On Nov. 18, 2013, Canada-based Denison Mines Corp. became majority owner of the Faléa project. The project is opposed by 21 area villages (“Falea21”). France-based Foraco is cooperating with Rockgate and preparing the steps for the start of the exploration.

Tanzania - new projects:

- **Mkunjo river (Mantra Resources Ltd)**
  On Mar. 1, 2010, Australia-based Mantra Resources Limited announced that the Pre-Feasibility Study for the company’s Nyota Prospect, part of the wholly owned Mkuju River Project in Tanzania, has confirmed the technical and economic viability of the project and its capacity to operate with strong cash margins.

  In December 2010, Russia’s nuclear holding company Rosatom, through its subsidiary Atomredmetzoloto (ARMZ), acquired a majority in the shares of Mantra Resources Ltd.

  On May 6, 2011, Mantra Resources Ltd announced the completion of the Phase 1 Definitive Feasibility Study for the company’s Nyota Prospect, part of the wholly owned Mkuju River Project in Tanzania, “which confirms the robust technical and economic viability of the Project and demonstrates that Nyota will be a low cost, near term uranium producer”. The study assumes an annual production of 1,615 t U during steady state operation, based on average annual throughput of 5.2 million tonnes of ore at an average grade of 0.037% U, with an initial mine life of 12 years for Phase 1, with potential to increase further.

  In July 2012, the World Heritage Committee approved a boundary change of the Selous Game Reserve to excise the proposed uranium mine site from the World Heritage Site.

  On Oct. 15, 2012, the project obtained the environmental clearance, and on April 8, 2013, it was granted a mining license.

  In June 2013, the start of the development of the Mkuju River uranium mine project was still open due to

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104 All data from WISE Uranium Project, unless stated otherwise
“some pending issues”, according to Deputy Minister for Energy and Minerals, Stephen Maselle. He further said the new investor owed the Tanzania government millions of dollars in capital gains tax from the sale of the project from Mantra Resources Pty Ltd of Australia to a Russian company, ARMZ Uranium Holding. Atomredmetzoloto currently holds 93.25% in the project, partly through its subsidiary Uranium One Inc.

- **M kunjo river (Uranex Ltd)**
  In April 2012, Australia-based Uranex Ltd announced a maiden resource of 2,346 t U at a very low grade of 0.020% U for its Mkunju Uranium Project.

- **Manyoni (Uranex Ltd)**
  In June 2010, Uranex Ltd announced a resource of 11,154 t U at an extremely low grade of 0.012% U for its Manyoni Uranium Project.

- **Madaba Matra (East Africa Resources Ltd)**
  On Sep. 26, 2013, Australia-based East Africa Resources Ltd announced that it has obtained Prospecting Licenses for its Madaba property, where work carried out between 1979-1982 identified six anomalous uranium zones. The site is located within the World Heritage Selous Game Reserve. The company now has commissioned an Environmental Impact Assessment (EIA) to support its application for site access.
9. URENCO: customers, contracts and secrecy

It is very hard to track down from which mine the uranium used in a specific nuclear power plant is coming from. Or, the other way around, in which nuclear power plants the uranium mined in a specific mine is ending up as fuel. Information is scarce and scattered. Companies do not disclose this information, nor do governments. In most cases it is also almost impossible to track down the origins of the uranium enriched in a certain enrichment plant comes from. We will describe why that is the case and give examples of the failure and/or the unwillingness to disclose information by the URENCO governments.

Movement and ownership

The utilities running nuclear plants purchase the uranium ore concentrate directly from the uranium mining companies. There exists no official uranium market place: for long-term contracts, the utility concludes an agreement with a miner to purchase certain amounts of uranium in regular delivery batches over a certain time period, while for short-term requirements, the utility invites tenders from a number of providers and buys the batch from a provider of its choice.

Note: Due to the lack of a market place, there also is no official price quotation for uranium. The uranium price figures presented by UxC, TradeTech, and others, are based on polls sent out to the parties involved in recent purchasing contracts.

The utility then contracts conversion, enrichment, and fuel fabrication services for its uranium batch with the respective providers of such services (e.g., URENCO for enrichment).

Note: enrichment contracts usually transfer the ownership of the depleted uranium generated in the process to the enrichment company.

The details of all these contracts are subject to trade secret and thus are not public. For the European Union, the Euratom Supply Agency (ESA) collects all relevant information, but will not release it.

All uranium imported into the European Union is officially “owned” by the Euratom Supply Agency (ESA).

Most uranium trade is subject to IAEA safeguards; additional restrictions may apply, such as:
- further safeguards obligations imposed by the governments of uranium-producing countries (in particular Australia and Canada)
- Nuclear Suppliers Group (NSG) policy (e.g. ban for nuclear trade with NPT non-signatory India, lifted in 2008)
- Euratom Supply Agency (ESA) policies (e.g. diversification of sources of supply)

Confidentiality of the supply contracts

Transparency is very limited, even when governments reply to parliamentary questions the common answer is that data is commercial and will not be disclosed. Or, as put by the UK Secretary of State for Energy and Climate Change Mr Kidney in April 2010, “prohibitively expensive.”

German government also throws a cloak of secrecy over uranium imports.

In 2011, in a reply to a parliamentary question, the German government has denied to disclose the origin countries of the uranium used in Germany’s nuclear power plants.

In the same reply to another parliamentary questions the German government said it cannot disclose the origin

105 Daily Hansard - Written Answers 6 Apr 2010 : Column 1229W
106 Antwort der Bundesregierung auf die Kleine Anfrage der Abgeordneten Ute Koczy, Sylvia Kotting-Uhl, Hans-Josef Fell, weiterer Abgeordneter und der Fraktion BÜNDNIS 90/DIE GRÜNEN – Drucksache 17/5858 – Herkunft des Urans in deutschen Atomkraftwerken, Deutscher Bundestag, Drucksache 17/6037; June 1, 2011
Uranium mining and (in)transparency: URENCO’s role in the nuclear fuel chain

of uranium enriched at the URENCO Gronau plant, because of
a. the bilateral agreements between Euratom (Supply Agency) and third-countries (e.g. Australia, Canada, South Africa); and
b. confidentiality of the private supply contracts of the utilities. In the reply to a follow up parliamentary question, the German government explained that the origin of the uranium could not be disclosed due to the confidentiality of the supply contracts.

The Netherlands
In the late 1970’s, in a period that the possible import of uranium from Namibia (occupied by South Africa) was an issue in mainstream media, the government denied access to data about the origin of the uranium used in Dutch reactors. Answering parliamentary questions the Dutch minister of Economic Affairs replied on December 1, 1977 said that “for economic considerations, the origin of uranium purchased by NV SEP cannot be communicated”. In the same response the minister explicitly claims that the Dutch government has no power to determine the origin of the uranium offered to URENCO for enrichment.

In July 1979 the Dutch government refused to try to change the Treaty of Almelo in a way that customers had to disclose the origin of the uranium offered for enrichment.

Available data: ESA and EIA reports
How difficult it is to find exact data is may be best symbolised by the official disclaimer, printed in most of Euratom Supply Agency’s documents: “ESA ensures confidentiality and physical protection of the commercial data”. However, there is data published by the Euratom Supply Agency as well as the US Energy Information Agency, but only in very general terms.

In 2012, demand for natural uranium in the EU represented approximately one third of global uranium requirements. EU utilities purchased a total of 18 639 tU in 127 deliveries under long-term and spot contracts, 807 tU or 4.5% more than in 2011.

Natural uranium supplies to the EU continued to come from diverse sources. In general, the origins of natural uranium supplied to EU utilities have remained unchanged since 2011 (except for Ukraine, which made no deliveries in 2012). However, the relative shares of the four big uranium-producing regions (the CIS, North America, Africa and Australia) have shifted substantially.

Russia and Canada were the top two countries delivering natural uranium to the EU in 2012, providing 44% of the total. Uranium originating in Russia (including purchases of natural uranium contained in EUP) represented the largest proportion, with 5 102 tU or 27% of total deliveries, which was 13% up on 2011. It was followed by uranium of Canadian origin, with a 17% share or 3 212 tU, a year–on-year decline of 3%. In third place, uranium mined in Niger amounted to 2 376 tU or 13%, a strong 38% increase over 2011. Australia and Kazakhstan accounted for 12% each in 2012, an increase of 28 % and a 15 % decrease, respectively.

A breakdown of ESA imports of natural uranium is shown in Table 5.

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107 Antwordt der Bundesregierung auf die Kleine Anfrage der Abgeordneten – Drucksache 17/5858; Question 21
109 Tweede Kamer, zitting 1977-1978, Aanhangels, Answer to question nr. 372; December 1, 1977
110 Tweede Kamer, zitting 1978-1979, Aanhangsel, Answer to question nr. 1617; July 20, 1979
The other publicly available data is from the US (the US Energy Information Administration). In 2012 17% of the \( U_3O_8e \) delivered in 2012 to owners and operators of US civilian nuclear power reactors, was US-origin uranium. Australian-origin and Canadian-origin uranium together accounted for 35 percent of the 58 million pounds. Uranium originating in Kazakhstan, Russia and Uzbekistan accounted for 29 percent and the remaining 19 percent originated from Brazil, China, Malawi, Namibia, Niger, South Africa, and Ukraine. Owners and operators of US civilian nuclear power reactors purchased uranium for 2012 deliveries from 32 sellers, the same number as in 2011. For a breakdown of uranium purchased by owners and operators of US civilian nuclear power reactors by origin country see Table 6.

The physical movement of the uranium is as follows
What happens with uranium when it is mined? Which transports are needed before the uranium can be used in a nuclear reactor?

1. from the mine to the contracted conversion plant (as uranium ore concentrate in 200-litre-drums), then
2. to the contracted enrichment plant (as UF6 in type 48Y cylinders), then
3. to the contracted fuel fabrication plant (as enriched UF6 in type 30B cylinders), and finally
4. to the nuclear power plant for which it is intended (as enriched UO2 in fuel elements).

Additional transports are required:
- where conversion is performed in subsequent process steps at different locations, such as Malvési (U3O8 to UF4) and Pierrelatte (UF4 to UF6) in France, or Blind River (U3O8 to UO3) and Port Hope (UO3 to UF6) in Ontario, Canada,
- if the deconversion of the enriched UF6 to UO2 is not performed at the location of the fuel fabrication plant,
- to return the “empty” but strongly radiating 48Y and 30B cylinders with UF6 heels to the respective originating plants, where they are cleaned and reused,
- to send the depleted UF6 from the enrichment plant to a deconversion plant (e.g. Usine W in Tricastin, France) to process it into the less problematic oxide form of U3O8, and then back to the originating enrichment plant, or on to some designated storage facility (e.g. Bessines in France, COVRA Vlissingen in the Netherlands) or disposal site.

While there are only a limited number of nuclear facilities, uranium is transported often over extremely long distances, as can be seen from the Koeberg-fuel example.

**Box 1: The example of Koeberg Nuclear Power Plant, South Africa:**

- uranium mined in Namibia (so, either Rössing or Langer Heinrich)
- conversion to UF6: location unknown, but likely at Areva’s Malvési and Pierrelatte plants, France
- enriched in the European Union (so, either Areva’s Georges Besse II Tricastin plant in France, or one of URENCO’s plants in the UK, The Netherlands, or Germany)
- production of fuel pellets at Areva’s Richland plant, Washington, USA
- fabrication into fuel rods at Areva’s ANF Lingen plant, Germany
- fabrication into fuel assemblies at Areva’s FBFC Romans plant, France

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112 uranium quantities are expressed in the unit of measure U3O8e (equivalent). U3O8e is uranium oxide (or uranium concentrate) and the equivalent uranium-component of hexafluoride (UF6) and enriched uranium

113 Uranium purchases and price, http://www.eia.gov/uranium/marketing/#1

114 A December 2013 NRC-document sheds some light on where the fuel for the Koeberg NPP comes from: http://pbadupws.nrc.gov/docs/ML1334/ML13345A552.pdf
For some of these transports, information is available in the public domain, in particular for cross-boundary shipments to and from the USA, where details are released by the Nuclear Regulatory Commission (NRC) some months after the transport has reached its destination; however, information about the mine of origin is only given for transports of uranium ore concentrate (if at all). As URENCO provides enrichment services, only the conversion plant of origin, or the fuel fabrication plant destined for further processing, respectively, can be identified for material processed at URENCO, if at all. For UF6 export shipments from the USA, the country of origin of the uranium ore concentrate (from which the UF6 was produced) can in some cases be tracked down in the applicable export licence, but often there is quite a number of possible origin countries listed.

In some cases, information is available for transports through certain ports (e.g. Hamburg and Bremen in Germany, as obtained from the state governments in response to parliamentary questions).

The example of Borssele nuclear power plant
EPZ, the operator of the Borssele nuclear power plant, discloses the origin of the uranium it uses on its website:\footnote{115 http://epz.nl/kernenergie/hoe-werkt-de-kerncentrale/de-brandstof/de-oorsprong-van-epzs-uranium}  
- 2000 - 2002 and 2004 - Re-enriched tails
- 2003 and 2007 - Reprocessed uranium and ex-military high enriched uranium
- 2005, 2006 and 2008 - 2011 - Kazakhstan
- 2012 - Reprocessed uranium and ex-military high enriched uranium

However, the origin of the re-enriched tails are unknown.
In the 2011 Annual Report, EPZ announced a new enrichment contract “for the coming years” (no exact period is mentioned) with URENCO. The origin of the uranium enriched at URENCO, is Canada (no mine or mining company is mentioned).\footnote{116 EPZ, Jaarverslag 2011 (Annual Report), p.17}
Table 5: Purchase of Natural Uranium by EU utilities by origin, 1992-2012 (tU$_3$O$_8$)

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<td>Niger &amp; Gabon</td>
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<td>South Africa + Namibia</td>
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Total: 11,790

Source: European Supply Agency

Disclaimer: The statistics and data analysis provided by ESA are for information purposes only. ESA does not bear legal liability for making use of them. ESA ensures confidentiality and physical protection of the commercial data.
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W = Data withheld to avoid disclosure of individual company data. -- = Not applicable.
Notes: Totals may not equal sum of components because of independent rounding. Weighted-average prices are not adjusted for inflation.
10. URENCO’s Corporate Social Responsibility

Companies are required by law to report on a wide range of aspects related to the financial performance of their operations. Reporting on non-financial aspects (such as social and environmental impacts) of corporate activity, on the other hand, is largely left to voluntary initiatives and ‘soft law’ guidelines and recommendations.

URENCO’s website states that the company “understands that it cannot act in isolation of its local community. The company must take responsibility for the outcome of its operations by understanding how it impacts on neighbouring communities and how it can make a positive contribution.”

All employees are made aware of clear codes of conduct, including anti-bribery and corruption policy and the (zero-tolerance) consequences of its implementation and key requirements. URENCO also has a whistle blowing policy in place which provides all employees with a route to report any concerns regarding fraud, corruption or professional misconduct.

One of the corporate responsibilities URENCO mentions specifically is sustainability. The companies 2012 Sustainability Report starts as follows: “Acting responsibly throughout our business and endeavouring to be a good corporate citizen is a critical aspect of our leadership in the industry.” The SR 2012 has been created in line with the Global Reporting Initiative (GRI) and URENCO commissioned DNV Two Tomorrows Limited to undertake independent assurance. The GRI-checklist is available at the company’s website.

The GRI is a multi-stakeholder process that aims to develop a common global framework for sustainability reporting. The sustainability reporting guidelines developed by the GRI are globally acknowledged to be an important voluntary tool that companies can use to facilitate and improve reporting on non-financial aspects of their operations. URENCO has published a sustainability report according to the GRI guidelines since 2005.

URENCO is not a member of the United Nations Global Compact: the largest corporate sustainability initiative in the world – with 10,000 signatories based in more than 140 countries, and Local Networks existing or emerging in over 100 countries.

URENCO focuses on four key areas of sustainability:
- Managing health, safety and security
- Minimising our environmental impact
- Developing our position as an employer of choice
- Supporting education and cultural projects

All this is applicable only to the four URENCO enrichment facilities: “URENCO will encourage and expect commitment to good health, safety and environmental practice from all of its employees and others undertaking work at UEC locations.” No mention is made of uranium mining as such. There is no indication that chain responsibilities (other than at the URENCO locations) plays any role in URENCO’s policy. This is not surprising since URENCO’s policy is that it is only selling enrichment services. It does not mine uranium nor do they own the uranium at any time. And therefore it has no responsibility for other than matters at their facilities (and transporta-
Uranium mining and (in)transparency: URENCO’s role in the nuclear fuel chain

However, is it responsible for the by-product of enrichment - depleted uranium - because enrichment contracts usually transfer the ownership of the depleted uranium generated in the process to the enrichment company. Currently URENCO stores DU at the enrichment facilities pending further re-enrichment or conversion to a chemically stable form – uranium oxide (U3O8) – for long-term storage.124

In the years 1997125 – 2009126 depleted uranium from the URENCO consortium was transported for re-enrichment to Russia under a contract signed with Tenex in 1995.127

Many argued this was export of radioactive waste, but URENCO denied all accusations. URENCO simply stated it had a contract for re-enriching the uranium to natural levels, but fact is that almost all material stayed behind at the enrichment plants in Russia. According to the Dutch environmental minister the depleted uranium is not waste but a commodity. Twenty percent of the material is transported back to URENCO in the form of re-enriched (to the natural level of 0.7% U-235) uranium.128 This means, 80% of the material was left behind and has to be stored indefinitely in Russia. Currently a special storage hall (VOG2) at the Dutch central radioactive waste storage facility (COVRA) is being built for the URENCO depleted uranium.129

124 URENCO Annual Report 2012, p.7
125 Nuclear Fuel, October 19, 1997
126 Rosatom says uranium tail contracts will not be renewed, citing economic infeasibility; Bellona, June 1, 2009
127 Letter Tenex to URENCO Enrichment Co., May 31, 2005
128 Tweede Kamer, answers to parliamentary questions nr. 1429, February 23, 2007
129 COVRA, December 2013: COVRA dient aanvraag in voor wijziging Kernenergiewet vergunning
11. URENCO: proliferation treaties and safeguards

The URENCO facilities are subject to national law. Dutch nuclear installations are subject to permits under the 1963 Nuclear Energy Act and the equivalent legislation is in existence in the United Kingdom and Germany. The ETC plant is not considered to be a nuclear facility by Dutch law, but for proliferation reasons is most important, because it holds the proliferation-prone technology to manufactures the centrifuges.

The URENCO installations are also subject to a number of special safety instructions, and positions held by members of staff are designated as positions involving confidentiality. Technology, know-how and products are subject to specific permit obligations arising from the Strategic Goods Decree, the 2012 Strategic Services Act and Council Regulation (EC) No 428/2009 of May 5, 2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items.

Treaties of Almelo, Washington, Cardiff and Paris

The most important treaties concerning URENCO are of course treaties establishing the cooperation between United Kingdom, Germany and The Netherlands, and later with France (Areva). URENCO’s corporate structure is based on the legal foundation provided by the Treaty of Almelo, signed on March 4, 1970. The treaty contains provisions regarding non-proliferation, nuclear safeguards, information protection, withdrawal from and termination of the treaty, and a defined decision making process. Significantly, the treaty established a supervisory Joint Committee comprised of representatives from the three governments that must make all its decisions – including on any sale of shares – by consensus.

In 2005, the three URENCO governments and France signed the Treaty of Cardiff, which provides for both URENCO’s and Areva’s 50 percent ownership in the ETC and their use of ETC know-how at their uranium enrichment plants. The uranium enrichment know-how that URENCO developed for over three decades was transferred to the ETC, and both URENCO and Areva were licensed to use the technology to sell enrichment services to the world market. The parties to the treaty must make sure that present or future ETC shareholders do not obtain classified information beyond that necessary for the safe operation of enrichment plants.

Two additional government-to-government treaties have been put in place to accommodate the expansion of ETC technology into the United States. The 1992 Treaty of Washington between the three URENCO governments and the United States permitted the construction and operation of the enrichment plant in New Mexico. And the 2011 Treaty of Paris opened the way for the construction, which is still pending, of an enrichment facility in the United States that would be owned by Areva and outfitted with ETC-supplied centrifuges.

In principle, all centrifuge enrichment plants operating in Europe and the United States using ETC technology are so-called black boxes; that is, the technology inside the plants is not available to the enrichment firms – URENCO and Areva – that operate the plants. In practice, these projects have a few “grey” areas, where the ETC has shared a limited amount of compartmentalized classified information with nuclear regulators seeking assurance that the plants are safe and with individuals who are building centrifuges that will be installed in the plants.
Non-Proliferation Treaty and safeguards

Under the 1968 Nuclear Non-Proliferation Treaty (NPT), non-nuclear-weapon states’ obligations on centrifuge manufacturing fall under two IAEA safeguards regimes: those with Comprehensive Safeguards Agreements (CSAs), and those who further implement the strengthened measures of the Additional Protocol to their CSAs. All URENCO countries (UK, G, NL, France and USA) have signed, ratified and put into force the Additional Protocol.

Though each non-nuclear-weapon state’s CSA is individual, all follow the form and content of a standard text, ‘INFCIRC/153’, (INFCIRC is the IAEA abbreviation for “Information Circular”) which obliges a country to provide information on all nuclear material and facilities, and to allow agency inspectors to verify these declarations. The resulting verification regime focuses largely on nuclear material accountancy to check the accuracy of declared materials in declared facilities. As such there are no requirements regarding centrifuge production facilities. CSAs were designed in an age when centrifuge enrichment technology was still in its infancy. The underlying assumption was that the production of HEU through conspicuous gaseous diffusion plants would be readily detectable, and that the proliferation risk came instead from the diversion of material from declared facilities.

The Additional Protocol is a legal instrument that provides the IAEA with more information and wider access rights, thereby strengthening its ability to verify that a country is not producing material for nuclear weapon purposes. The document ‘INFCIRC/540’ describes the standard obligations required under an AP. In contrast with INFCIRC/153, this document specifies in Article 2.a.(iv) that the participating state must provide the IAEA with a description of the scale of operations involved in centrifuge production.

INFCIRC/540 (the model Additional Protocol) makes an important contribution by outlining a system of ‘Complementary Access’ to inspectors. This expands the rights of the Agency to make visits to centrifuge manufacturing plants. There is no need to obtain agreement from the party and notification of a visit can be as short as 24 hours.

While the Additional Protocol relates primarily to non-nuclear-weapon states party to the NPT, the foreword to INFCIRC/540 affirms that nuclear-weapon states and “other states” may also conclude an Additional Protocol. All the nuclear-weapon states have an Additional Protocol. Because the nuclear-weapon states have nuclear material and activities outside safeguards, which they are under no obligation to declare, clearly the purpose of the Additional Protocol is not to strengthen the IAEA’s capability to detect undeclared nuclear material and activities in those states. Accordingly, their Additional Protocols vary from the INFCIRC/540 model. The nuclear-weapon states’ Additional Protocols operate so as to increase the information available to the IAEA regarding nuclear cooperation with and transfers to non-nuclear-weapon states.

Another agreement the URENCO facilities are subject to (Article V, Treaty of Paris) is the IAEA Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.4). Principles of physical protection are realized through administrative and technical measures, including physical barriers. The measures for the physical protection of nuclear material in use and storage and during transport, and of nuclear facilities presented herein are recommended for use by States as required in their physical protection systems. These measures are based on the state of the art in physical protection hardware and systems and on the types of nuclear material and nuclear facilities.

138 Mikael Shirazi and Andreas Persbo, Trust & Verify 133, April-June 2011
Uranium mining and (in)transparency: URENCO’s role in the nuclear fuel chain