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Nuclear Power and the Uranium Market: Are Reserves and Resources Sufficient?

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The increase of the use of atomic power in some emerging economies, in particular South Korea and China, has revitalized a discussion regarding the availability of uranium resources. Despite the fact that global uranium resources are more than sufficient to supply reactor-related demand for the rest of the century, some voices in the nuclear community expect a supply shortage for the upcoming decades, and the risk of prices tippling in the next 20 years. They argue with delayed construction times, untimely mining expansion and unfavorable market conditions. This Roundup takes a closer look at the arguments of the debate.

1. Future prospects of Nuclear Power

The use of atomic power for electricity generation and military purposes requires a natural resource: uranium. The uranium market has for a long time been surveyed quite suspiciously by many companies and governments, as the use of nuclear power is diffusing from the more advanced industrial countries to emerging economies, such as China, India, Brazil, and others. In addition to the issue of resource availability ("will there be sufficient uranium for everybody?"), and the role of the nuclear fuel cycle, corporate strategies (e.g. vertical integration) as well as future prospects for the nuclear industry, both on the demand and the supply side need to be considered. Forecasts of uranium supply, demand and nuclear power capacity are currently subject to uncertainty. In this context, this Roundup provides an overview of the discussion on the role of the uranium market. The next section introduces the nuclear fuel cycle, followed by a discussion of supply and demand at the global scale. Sections 4 and 5 discuss market structures, the role of long-term contracts and vertical integration; Section 6 presents future scenarios of nuclear fuel demand and supply, followed by a summary given in Section 7.

2. The nuclear fuel process

As with other raw materials, uranium has to undergo several stages of processing before it can be used as fuel for nuclear power plants. After mining, the uranium ore needs to be separated from waste material and milled. The resulting intermediate product is referred to as yellow cake (U_3O_8). This material has yet a low share of uranium-235 (~1%), the fissile isotope of uranium that is required to maintain the fission process. To increase the share of uranium 235 a high-tech enrichment procedure is required. It is preceded by the conversion of yellow cake to uranium hexafluoride (UF_6), which is nowadays mostly performed in specialized centrifuges. Commercial conversion services are available at plants in Canada, China, France, Russia, USA, and commercial enrichment services are provided at plants in China, Japan, England, France, Germany, Netherlands, Russia, USA (WNA 2015c) (see below Table 2 and Table 3). The by-product from the uranium enrichment is referred to as depleted uranium (DU) or enrichment tails and can be used in various ways: it can be stored as UF_6, de-converted back to yellow cake, used to dilute high-enriched uranium (HEU) or re-enriched (WNA 2015d). Continuing the nuclear fuel cycle, enriched UF_6 is then transformed into pellets (UO_2), the final nuclear fuel, and utilized to generate power. Fuel fabrication is widely distributed, with local plants in many countries where nuclear power is produced.

After three to four years of utilization in a typical Light-Water reactor (LWR) (MIT 2011, 20), the fuel rods are considered depleted. The resulting spent nuclear fuel (SNF), which contains about 96% of the original fissionable material, including depleted uranium and plutonium-239, that was created during the fission process, is discharged from the reactor and, in the context of the “open fuel cycle” or “once-through cycle” (top line in Figure 1), transferred to an interim storage. In the last stage of the fuel cycle, the radioactive waste is planned to be stored in a geological repository for long-term disposal. In the short history of the commercialization of nuclear power, this approach has been by far the most prevalent one and still dominates every alternative currently available.

Several advancements to this traditional fuel cycle have been developed or are currently in the development stage. The ”partly closed fuel cycle” (top two lines inFigure 1) involves the recovery of the plutonium as well as uranium contained in the SNF by separation from the radioactive waste and the reutilization in a nuclear reactor as mixed oxide (MOX) fuel (MIT 2011, 11). This technology has already been adopted in France, Great Britain and Japan. Although this method of recycling SNF could have an impact on the global uranium demand, this effect has not yet been observed, as only few reactors (35 or 8% of the world’s operating reactors in 2012) employ MOX fuel (OECD NEA and IAEA 2014, 116). Furthermore, the current reprocessing and reactor technology only allow a limited number of recycles due to the gradual accumulation of undesirable elements, in particular curium, and certain plutonium isotopes, which are not fissionable by thermal neutron spectrum found in LWRs (such as plutonium-240).

Back in the 1970s/80s, there used to be a discussion on so-called “fast-breeder reactors” (FBR), which are fast-neutron spectrum reactors that could convert fertile uranium-238 by absorbing neutrons to fissile plutonium-239 faster than they consume the fuel (MIT 2011, 27). As depicted in Figure 1, these reactors could be used in the context of the “closed fuel cycle” (note that this term is misleading since radioactive waste is still generated in this procedure and has to be disposed). Depleted uranium from enrichment facilities and SNF (both containing uranium-238) could theoretically be transformed to plutonium-239 and reused in fast reactors. Fast reactor SNF is then reprocessed to recover uranium and plutonium in order to create new fast reactor fuel assemblies with depleted uranium. This process raised hopes that the energy in the fuel would be used more efficiently (the traditional fuel cycle uses less than 1% of the energy value of the mined uranium (MIT 2011, 21)), but the fast breeder has not been further developed thus far and it is still highly uneconomic. Therefore, the anticipated drop in demand for uranium stemming from this utilization of uranium is negligible. The most prominent example for an alternative nuclear fuel is thorium, whose resources are estimated to be three times more abundant than uranium (WNA 2015d). Despite not being fissile, thorium-232 absorbs neutrons in a reactor to produce uranium-233, which will fission in the reactor. Consequently, it can only be utilized in conjunction with a fissile material that provides neutrons, such as uranium-233, uranium-235 or plutonium-239, and therefore does not represent a real alternative to conventional uranium fuel, and it is far from commercial utilization as well (WNA 2015d).

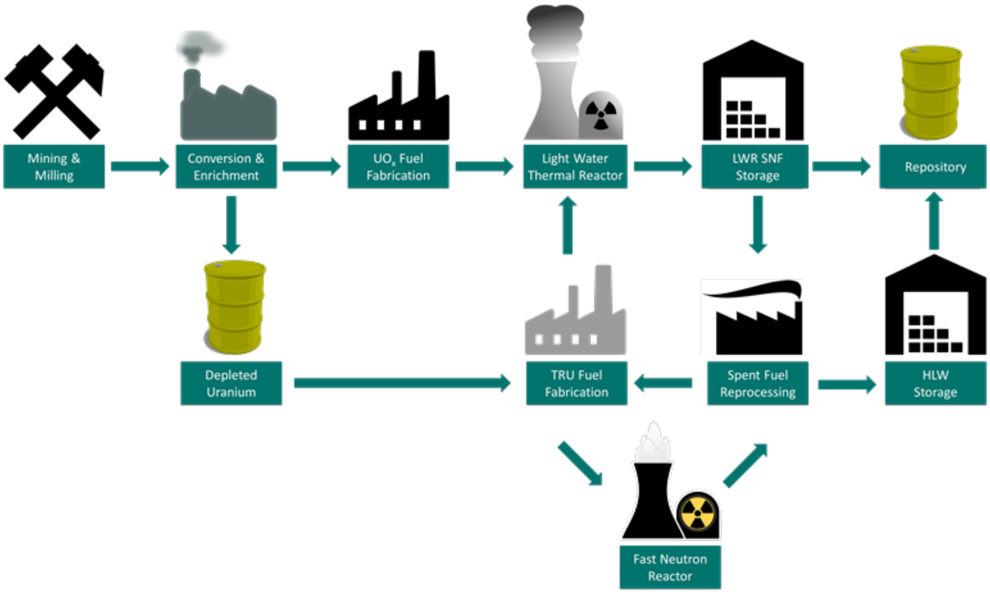

Figure 1: Alternative nuclear fuel cycles.
Source: Own illustration based on MIT (2011, 11).

Major proliferation concerns have been raised based on this scientific progress, since the modern fuel cycles provide (two lower lines of Figure 1) routes to nuclear weapon materials by extracting plutonium-239, which is predominantly used in nuclear weapons. Therefore, strong incentives exist to adopt fuel cycles that minimize the quantity of weapons-usable material.

3. Current Supply and Demand

3.1 Demand

Demand for uranium is primarily driven by installed nuclear capacity and military uses (much of which is confidential). Contrary to other sectors, where metals can be substituted (e.g. aluminum or steel to be used in construction), the atomic sector heavily relies on uranium due to limited alternatives. Demand estimates are complicated by the choice of fuel cycle technology of a country or firm; in case of a once-through fuel cycle, demand is proportional to the electricity produced.

Until the turn of the century, demand has been increasing, but has stabilized since (see Figure 2). In 2012, global reactor-related uranium requirements (defined as anticipated acquisitions, not necessarily consumption (OECD NEA and IAEA 2014, 98)) amounted to 61.6 ktU (with the U.S., France, China, Korea and Russia covering about 70%), supplying a total of 437 commercial nuclear reactors (371.8 GWe) in 30 countries (OECD NEA and IAEA 2014). 81% of the world's nuclear electricity (303.0 GWe) was produced in 18 OECD countries. Further 68 reactors (64 GWe) were under construction. Uranium reactor-related requirements have almost doubled in the Middle East, Central and Southern Asia regions, due to some new reactors, from 0.9 ktU in 2012 to 1.6 ktU in 2013.

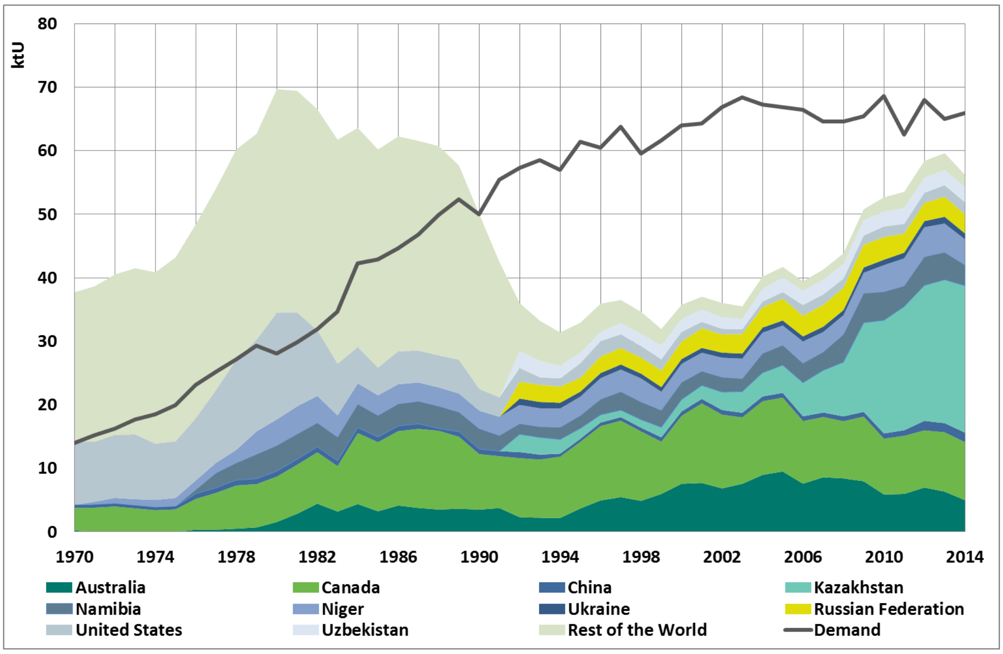

Figure 2: Uranium demand and primary production from 1970 to 2014.
Source: Own illustration based on OECD NEA (2006, sec. Appendix 7.1), and OECD 2004-2014.

3.2 Supply and Resources

In nature, uranium does not appear in its pure form, but in combination with other elements as uranium ores. Production methods include open-pit mining (20%) and underground mining (26%), and in situ leaching (ISL, 45%), it is also extracted as a co-product or by-product in gold, copper and phosphate production (7%) and others (2%) (OECD NEA and IAEA 2014, 69).

Reported uranium resources are subject to uncertainty since new resources are continuously identified due to exploration activities. They are classified into different categories, according to the degree of confidence in the respective estimated uranium resource. China's total uranium resources, for example, are expected to substantially increase in the near future due to high investment in exploration activities: In 2012, China spent $131 million (more than 14 times as much as in 2003) on uranium exploration, leading to a three-fold increase in identified resources from 77 ktU in 2003 to 266 ktU in 2012 (Zhang 2015). The global distribution of reasonably assured resources (RAR) – highest reliability in estimates, generally compatible with mining decision-making standards – were estimated to be 4.6 MtU in 2012: Australia, the U.S. and Canada currently own the largest share with 1.2 MtU, 0.5 MtU, respectively. (OECD NEA and IAEA 2014, 21). In fact, only a few countries possess a significant share (>1%) of the global RAR. However, the estimated amount of undiscovered resources that are expected to occur based on geological knowledge is equal to 7.7 MtU (OECD NEA and IAEA 2014, 33). In terms of actual production, a total of 58.8 ktU was produced in 2012, primarily in Kazakhstan, Canada and Australia with a share of 36%, 15% and 12%, respectively (OECD NEA and IAEA 2014, 62).

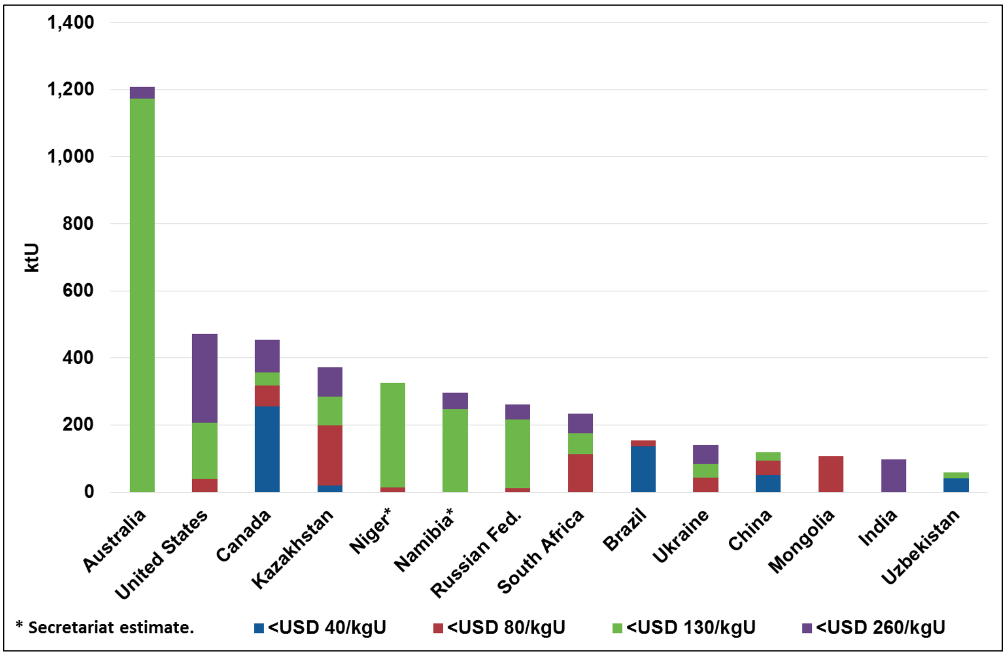

Figure 3: Distribution of reasonably assured resources (RAR) among countries with a significant share of resources.
Source: Own illustration based on OECD NEA and IAEA (2014, 21).

In addition to the aforementioned resources, referred to as "primary" sources of uranium supply, a significant portion of the global uranium demand has been supplied by "secondary" sources, particularly in the 1990s and the early 2000s (filling the gap between global primary production and demand in Figure 2). These include stocks and inventories of natural and enriched uranium, from civilian as well as military origin, which have been accumulated during times when production exceeded demand (until 1990 c.f. Figure 2). Another uranium resource that does not result from a direct mine output source originates from re-enrichment of depleted uranium tails and reprocessed spent nuclear fuel.

Among the secondary resources, the conversion of highly enriched uranium (HEU) from nuclear warheads to low-enriched uranium (LEU), suitable for nuclear power plants, is one of the most significant sources due to its large share (13% to 19% of world reactor requirements until 2013 (WNA 2014)) as well as its political importance. The process of converting HEU to LEU was primarily stipulated in various agreements between the United States and the Russian Federation such as the "Megatons to Megawatts" agreement (Centrus Energy Corp. 2015). Under these contracts, both countries agreed to reduce their nuclear arsenal by about 80% (WNA 2014). Over the last 20 years, Russia blended down 0.5 kt of its HEU, yielding approximately 14.4 kt of LEU, which is equivalent to about 150 kt of natural uranium or 20,000 warheads. The conversion rate is remarkably high as weapons grade uranium contains over 90% uranium-235. The U.S. committed to the disposition of 0.2 kt of fissile material and has further declared 0.2 t HEU as surplus in 2005 (OECD NEA and IAEA 2014). With the reduction of the conversion programs, e.g. the expiration of the "Megatons to Megawatts" program, the available secondary resources are likely to diminish (Zittel, Arnold, and Liebert 2013). In terms of supply of LEU within the International Atomic Energy Agency (IAEA), the IAEA and the Kazakh government agreed to open the first internationally controlled depot of LEU in Oskemen, Kazakhstan (IAEA 2015). The purpose of this agreement is to supply member states with LEU in case of a shortage on the global uranium market and to hinder countries from acquiring enrichment technology, which would increase the risks of proliferation. The physical reserve should provide capacity to store up to 90 metric tons of LEU. As this amount of LEU would satisfy only a fraction of the global requirements, the impact of such an establishment remains questionable.

4. Contracts and Prices

Although uranium has become one of the key fuels in many industrialized and emerging economies, a comprehensive body of empirical research examining the market conditions is lacking. This can partly be attributed to several characteristics of the commodity uranium and the uranium market. Trade in uranium is usually stipulated in fixed long-term contracts that are negotiated between uranium mine operators and consuming facilities for a timeframe of up to 10 years or more (Trieu, Savage, and Dwyer 1994). The prices set in the long-term contracts, whose terms are mostly confidential (OECD NEA and IAEA 2014), can be either fixed throughout the contract duration or variable, orientated towards the spot market price, which fluctuates according to current supply and demand. Only about 20% of all uranium has been sold on the spot market and the remaining 80% under long-term contracts (Auzans et al. 2014). Furthermore, Owen (1983) finds that the demand for uranium is price inelastic; this can be explained by the nature and function of nuclear reactors. As uranium is used to produce electricity in plants that feature long construction and operating times, buyers' highest priority is security of supply. Hence, buyers not only diversify their sources of supply, but they are also willing to pay higher prices for a secure supply of uranium (Trieu, Savage, and Dwyer 1994). In addition, military stocks made available for civil use modify the demand-supply balance. The fact that there is no substitute to uranium reinforces the singularity of the uranium market. Malischek and Tode (2015) find a substantial mark-up over marginal costs exists in the uranium price, which cannot be attributed to scarcity rents. This finding implies that market power is exerted in the uranium market and that pricing mechanisms do not reflect current cost of production.

Kahouli (2011) provides an overview of studies analyzing the uranium market. As mentioned above, uranium demand could not be met by primary production since 1990 (see Figure 2); additionally, there has been a large and unexpected decrease in primary supply from Canada and Australia; capacity predominately managed by AREVA was expected to come online but had serious delays due to the company's financial problems. This development of the relation between demand and supply of uranium resulted in changing market conditions. Kahouli (2011), in line with the papers analyzed in her study, finds that the uranium price is significantly correlated with the coal price but not with oil price. Moreover, she finds that the uranium supply is correlated with the price of by-products like copper and gold.

Figure 4 shows the average of uranium prices for spot and long-term contracts for the EU from 1980-2014, both nominal and real (deflating by the German producer price index since 1980 (Statistisches Bundesamt 2016)). Both the the spot prices and long-term prices in 2014 were significantly below the 1980 values. The drop of prices was particularly strong after 1986, year of the Chernobyl accident, which marked the end of the boom of civil nuclear power in the Western world. In the course of the resource boom after 2004, uranium prices increased quite significantly, with spot prices reflecting the volatility of other natural resources, such as oil. , Between 2006-2011, the price was driven by among others factors, problems in production centers, changes in the value of the US dollar (currency used on the uranium market), speculations and the general market perception concerning the future importance of uranium (OECD NEA and IAEA 2014,119-124). After 2011, year of the Fukushima nuclear accident, prices dropped again.

In 2014, the average uranium price in the EU was 40 USD/lb U_3O_8 and 38 USD/lb U_3O_8 for multiannual and spot contracts, respectively (Euratom Supply Agency 2014).

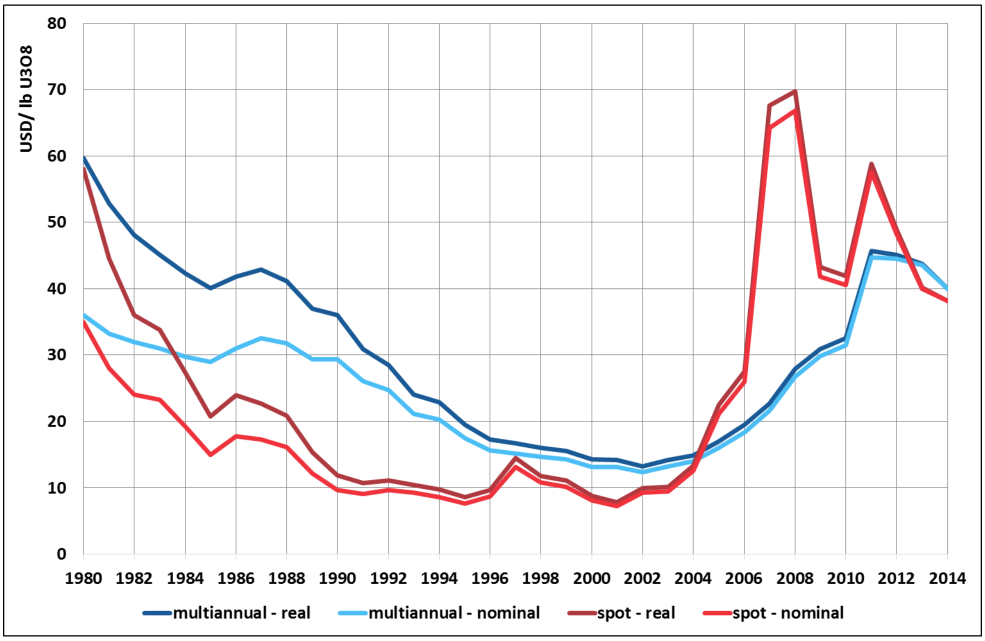

Figure 4: Average nominal and real uranium prices for EU spot and long-term contracts 1980-2014.
Source: Own illustration based on Euratom Supply Agency (2014) and Statistisches Bundesamt (**2016**).

5. Corporate Strategies in the Nuclear Fuel Cycle towards more Vertical Integration

Although the vast majority of globally traded uranium is processed by only few companies, the global uranium supply chain nevertheless exhibits a high level of complexity. The international companies involved are often joint ventures with many subsidiaries. There is also a discrepancy among the companies in terms of the level of vertical integration. Paladin Energy Ltd, for example, an Australian company, solely dedicates its business area to uranium mining and production, whereas Rosatom, a state corporation in Russia, covers all steps of the nuclear fuel cycle as well as the construction of nuclear power plants. Nevertheless, a tendency towards vertical integration by some international players is currently emerging, particularly in countries pursuing ambitions of nuclear expansion.

5.1. Uranium Mining

In total, uranium mines operate in 20 countries, but 85% of the world's mined uranium is supplied by the six countries included in Table 1. Only 10 mines accounted for more than 54% of the global uranium production in 2014.

Mine	Country	Main owner	Production (ktU)	% of world
McArthur River	Canada	Cameco	7.356	13
Tortkuduk & Moinkum	Kazakhstan	Katco JV/Areva, Kazatomprom	4.322	8
Olympic Dam	Australia	BHP Billiton	3.351	6
SOMAIR	Niger	Areva	2.331	5

Budenovskoye 2	Kazakhstan	Karatau JV/Kazatomprom, Uranium One	2.084	4
South Inkai	Kazakhstan	Betpak Data JV/Uranium One, Kazatomprom	2.002	4
Priagunsky	Russia	ARMZ	1.970	4
Langer Heinrich	Namibia	Paladin	1.947	4
Inkai	Kazakhstan	Inkai JV/Cameco, Kazatomprom	1.922	3
Central Mynkuduk	Kazakhstan	JSC Ken Data, Kazatomprom	1.790	3
Top 10 total			**29.075**	**54%**

Table 1: The largest producing uranium mines in 2014.
Source: Own illustration based on (WNA 2015f)

5.2. Conversion

The next step of the nuclear fuel cycle involves the conversion of yellow cake to uranium hexafluoride (UF_6); commercially operating conversion plants are located in the USA, Canada, France, Russia and China (see Table 2). Several companies such as Cameco, Areva, TVEL (which belongs to Atomenergoprom and is therefore part of the Rosatom State Corporation) are both involved in mining and conversion.

Secondary sources of conversion supply has been primarily provided by blending down Russian HEU and amounted to approximately 26 ktU in 2013. Due to the cessation of the Russian HEU supply, these sources are projected to account for less than 14 ktU by 2022.

Company	Nameplate capacity (ktU/yr as UF_6)	Approx. capacity utilization 2015	Capacity utilization 2015, ktU/yr
Cameco, Port Hope, Ont, Canada	12.5	70%	8.75
TVEL at Siberian Chemical Combine, Seversk, Russia	12.5	100%	12.5
Comurhex (Areva), Malvesi (UF_4) & Tricastin (UF_6), France	15.0	70%	10.5
Converdyn, Metropolis, USA	15.0	70%	10.5
CNNC, Lanzhou, China	4.0	Unknown	4.0
World Total			**46.25**

Table 2: World Primary Conversion capacity.
Source: Own illustration based on (WNA 2015a)

5.3. Uranium Enrichment

The technology utilized in the uranium enrichment process is very sensitive and always under international control due to risks of proliferation. In order to mitigate

the potential of proliferation as much as possible, the technology is not globally traded: about 90% of the world enrichment capacity is located in the five nuclear weapon states (Table 3).
"Separative work units" (SWU) is generally used as a measurement for the capacity of enrichment plants; it is a complex unit indicating the energy input relative to the quantity of processed uranium, the degree to which it is enriched and the level of depletion of the remainder (WNA 2015e). It measures how much of separative work has to be performed in order to enrich a given amount of uranium. In terms of numbers, the production of one kilogram of enriched uranium (5%) requires 7.9 SWU and 10.5 kg of natural uranium, assuming the facility is operated at a tails assay of 0.25%. Reducing the tails assay to 0.2% would require 8.9 SWU to yield the same amount of enriched uranium, but requires only 9.4 kg of natural feed (WNA 2015e). SWU is directly related to the energy consumption in the enrichment process. The enrichment costs are therefore highly dependent on the enrichment method; modern gas centrifuge plants require 50 kWh per SWU, whereas the gaseous diffusion method consumes approximately 2500 kWh per SWU (WNA 2015e).

Country	Company and plant	2013	2015	2020*
France	Areva, Georges Besse I & II	5,500	7,000	7,500
Germany-Nether-lands-UK	Urenco: Gronau, Germany; Almelo, Netherlands; Capenhurst, UK	14,200	14,400	14,900
Japan	JNFL, Rokkaasho	75	75	75
USA	Urenco, New Mexico	3,500	4,700	4,700
Russia	Tenex: Angarsk, Novouralsk, Zelenogorsk, Seversk	26,000	26,578	28,663
China	CNNC, Hanzhun & Lanzhou	2,200	5,760	10,700+
Other	Various: Argentina, Brazil, India, Pakistan, Iran	75	100	170
	Total SWU/yr approx.	**51,550**	**58,600**	**66,700**
*planned	Requirements (WNA reference scenario)	49,154	47,285	57,456

Table 3: World enrichment capacity – operational and planned, (in thousand SWU/yr).
Source: Own illustration based on (WNA 2015e)

In the last step before uranium can be used as nuclear fuel, it has to be turned into nuclear fuel rods in specialized fuel fabrication plants. In contrast to the universal applicability of some intermediate products of the uranium supply chain such as LEU, nuclear fuel assemblies are highly engineered products, constructed to each facility's individual specifications. These reach from the physical characteristics of the reactor to its reactor operating and fuel cycle management strategy and even to national licensing requirements (WNA 2015b). It therefore seems logical that most of the main fuel fabricators are also reactor vendors (e.g. Areva, Rosatomprom). The market for LWR fuel, however, is currently changing and becoming more competitive as many fuel types are now manufactured by several competing companies. Moreover, the global fuel fabrication capacity for all types of LWR significantly exceeds the demand (40% of the installed capacity met the demand in 2013) (WNA 2015b). Since China, India and South Korea are currently aiming at achieving self-sufficiency, thereby contributing to the overcapacity, ample supply will be guaranteed for the foreseeable future.

5.4. Tendencies towards vertical integration

Some international players are strongly working towards further vertical integration in their uranium supply chain. The Chinese companies (e.g. CNNC and CGNPG) have pursued a particularly active upstream integration; this includes long-term contracts with mining companies (e.g. Canada's Cameco and Kazakhstan's Kazatomprom, and Uzbekistan's Navoi Mining & Metallury), but also the acquisition of upstream assets (e.g. SinoU activities in Niger, Namibia, Zimbabwe, and Mongolia) in order secure the uranium supply for the projected increase in reactor-related uranium requirements (Zhang 2015). The Canadian company Cameco, which is predominantly focusing on uranium production, is currently exploring opportunities to add uranium enrichment to its uranium production portfolio (Cameco 2014). Kazatomprom, the Kazakh company whose uranium production has surged in the last decade, is planning on integrating uranium conversion to UF_6 in its business activities (Kazatomprom 2015). It has also just recently gained access to enrichment services in 2014.

6. Discussion of future scenarios

Zittel, Arnold and Liebert (2013) examine several supply scenarios provided by various organizations that participate in the global uranium market, such as WNA, Areva and AtomRedMetZoloto (ARMZ) and find that in none of the examined scenarios high growth demand can be met after 2030. The common base for the scenarios are resource and demand figures published by IAEA in 2011. Depending on the scenario, demand is expected to range between 90 ktU – 140 ktU in 2035, while uranium production is estimated between 70 ktU – 110 ktU. The authors conclude that timely development of mining projects is crucial in order to compensate for the predicted decrease in production, which is expected somewhere between the beginning and the middle of the next decade. Generally, these forecasts are subject to high uncertainty due to the dependency on few large deposits or mining projects such as the Olympic Dam in Australia or the Cigar Lake in Canada. Similarly, Liebert and Englert (2015) also doubt that uranium production will reach a sufficient level of output in case of a high demand scenario, and forecast reaching the high price uranium segment (USD 130/kgU by 2035).

However, the previous section has indicated that the global market for uranium is relatively relaxed, and that chances are high that it will remain so in the foreseeable future. In particular, the absence of a global nuclear comeback and the continued availability of secondary material indicate a lack of constraints. Consequently, the forecast presented in the newest edition of the IAEA Redbook (2014) show that, with the inclusion of planned or prospective production facilities, primary production capability will easily cover low demand case requirements and will meet most of the high demand case requirements throughout the period until 2035, even without secondary supplies (OECD NEA and IAEA 2014, 101): a demand of 72 ktU (low demand case) – 121 ktU (high demand case) and a production of 110 ktU is forecasted for 2035. It is worth mentioning that, compared to the scenarios in Zittel, Arnold and Liebert (2013), the projections are based on less restrictive assumptions: it is presumed that uranium mines produce at near production capability and that all planned and prospective production centers will be implemented. From a historic perspective, mine production is rarely more than 85% of the capability and delays in some mine developments have already been announced due to unfavorable market conditions, e.g. rising mining and development costs as well as low uranium prices. Thus, in order to narrow the gap between the demand and supply in the near future, strong market conditions are vital (OECD NEA and IAEA 2014, 126).

None of the reports puts sufficient long-term uranium supply in question. In fact, OECD NEA and IAEA "Red Book" high case scenario reactor requirements to 2035 would use up less than 40% of the identified resources (OECD NEA and IAEA 2014). In line with these findings, Rooney et al. (2013), conclude that uranium scarcity is unlikely to be an issue in the first half of this century, even in the case of high demand projections. The same line of argument is brought forwards by Hall and Coleman (2013) that identify potential for shortages in production but do not see a scarcity of uranium resources in the well beyond the middle of the century.

The argument is strenghthened if economic and technical obstacles to high-growth nuclear energy are taken into account, such as voiced by the World Nuclear Industry Status Report (Schneider et al. 2015), McCullough (2014) or Kemfert et al. (2015).

7. Summary

The production of nuclear power is solely dependent on one resource: uranium. It has to undergo various stages along the nuclear fuel cycle (mining, milling, conversion to UF_6, enrichment, fuel fabrication and finally waste disposal), when utilized for power generation. Uranium resources are concentrated in few locations around the globe, likewise are the facilities providing a nuclear fuel cycle service. As proliferation risks are always prevailing, the uranium market is under tight international control to impede a dispersal of enrichment technology. The uranium market, therefore, does not exhibit the features of a conventional commodity market: the demand for uranium, for instance, is inelastic to the price as security of supply is the highest priority for buyers. Furthermore, market participants follow individual strategies, ranging from an exclusive focus on one step of the fuel cycle to a complete vertical integration of the services required by the nuclear fuel cycle. Nevertheless, a trend towards vertical integration seems to be emerging.

Concerning the issue of uranium scarcity, it has become evident that the current base of uranium resources and reserves satisfies the projected reactor-related requirements for the foreseeable future. Although there might be a certain inertia in uranium production (mine exploration, construction, expansion, etc.), no high scarcity prices are to be expected. The situation will relax even more once current technical and economic obstacles to expanding nuclear power in industrial and emerging countries materialize (cf. Davis 2012; Lévêque 2014). Whatever the future of nuclear power may be, resource availability is unlikely to be a determining factor.

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