AMG Critical Materials NV

NewMOX®: Technology Leadership in nuclear (MOX) fuel from waste

At COP28 in Dubai, Countries Launch Declaration to Triple Nuclear Energy Capacity by 2050, Recognizing the Key Role of Nuclear Energy in Reaching Net Zero

In numerous countries globally, nuclear energy is considered an environmentally friendly power source aimed at curbing carbon dioxide emissions. Recently intriguing new reactor designs have been explored and refined, leading to the development of Small Modular Reactors (SMRs).

NewMOX, AMG's project to produce nuclear fuel (MOX, Mixed Oxide) from secondaries in the nuclear fuel cycle is likely to transform the way nuclear energy is produced by reducing the role of primary uranium. AMG extends its circular economy ambitions to nuclear power.

Nuclear power plants have been a reliable source of electricity for about 60 years and are a key factor in reducing CO_2 emissions worldwide. Figure 1 below shows the negligible amount of CO_2 per kWh of electricity generated compared to fossil fuels.

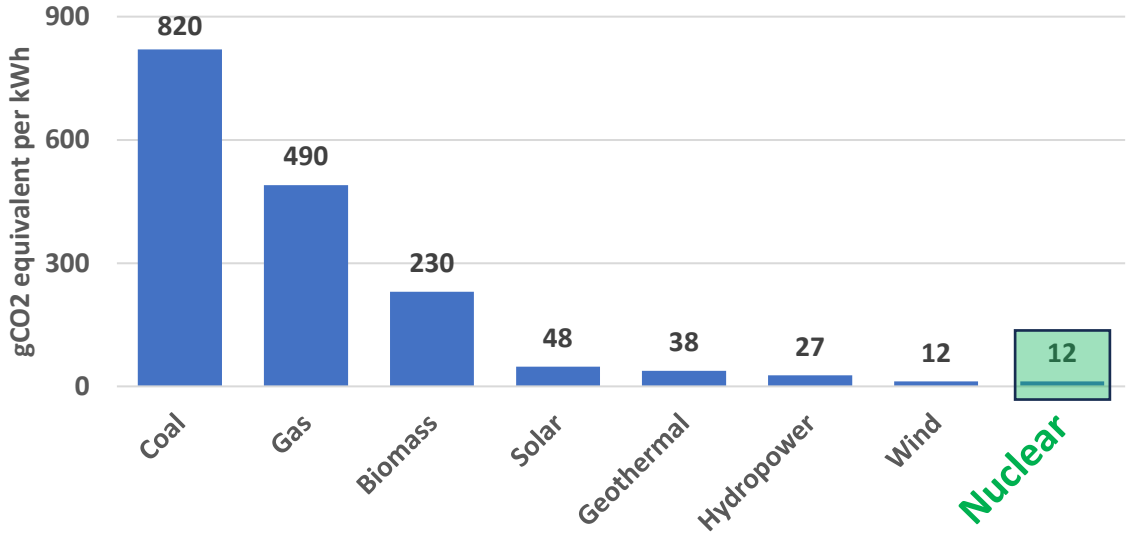


Figure 1: *Greenhouse gases by energy source in CO_2 equivalents g/kWh*
Source: https://www.world-nuclear.org

In many countries, SMRs are seen as a future solution to ensure a secure supply of electricity and process heat. Thanks to their flexible operation, SMRs are ideal for combined use in a power grid with renewable energy generators such as wind or solar energy. MOX fuel, while commonly associated with these SMRs, extends its applicability beyond these smaller units, finding utility in large-scale nuclear reactors as well.

The NewMOX® project: Closing the gap in nuclear fuel supply

The use of a secondary nuclear fuel, such as plutonium, is a huge step to introduce circularity into the nuclear industry. Plutonium is produced as a by-product when uranium fuel is used during the operation of a nuclear reactor. This plutonium is isolated from the spent fuel elements through a reprocessing process and then reused as new nuclear fuel as shown below in Figure 2.

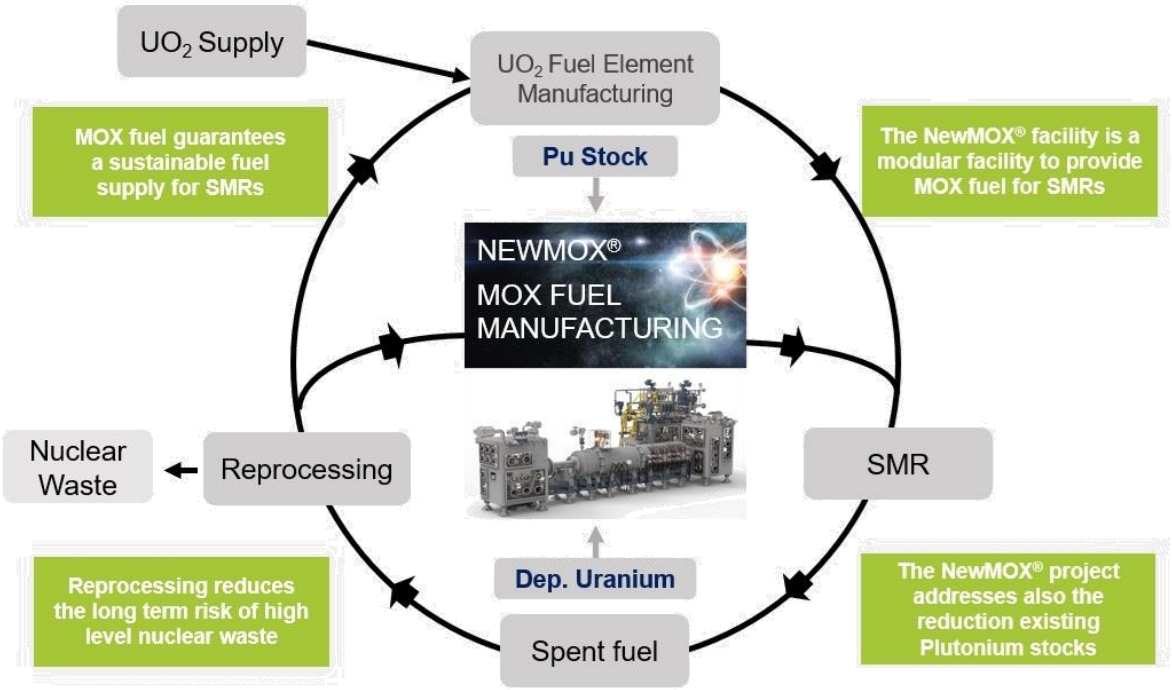


Figure 2: The NewMOX® fuel cycle

Modular Production Idea

More than 70 different SMR projects (with a typical size of 200-300MW electric) are currently being planned worldwide (around half of which can use MOX fuel). From smaller designs of current reactors to completely new reactor concepts, these developments offer great potential for the future. An overview of the main SMR types is shown in Figure 3.

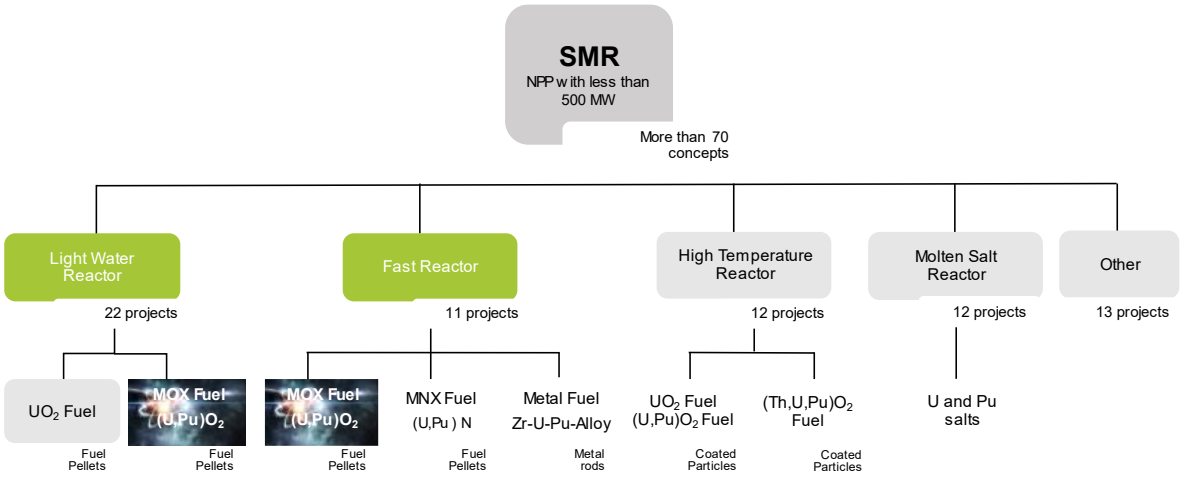


Figure 3: Overview of the main SMR types

Such reprocessing of spent fuel elements was carried out in the USA and Great Britain for a long time and is still the current process in France for managing the spent fuel elements produced there. A large amount of plutonium has been recovered in the process (see Figure 4). In France, a certain proportion of the plutonium is used for the production of MOX fuel elements. In the USA and Great Britain, the extracted plutonium is currently only stored at high cost.

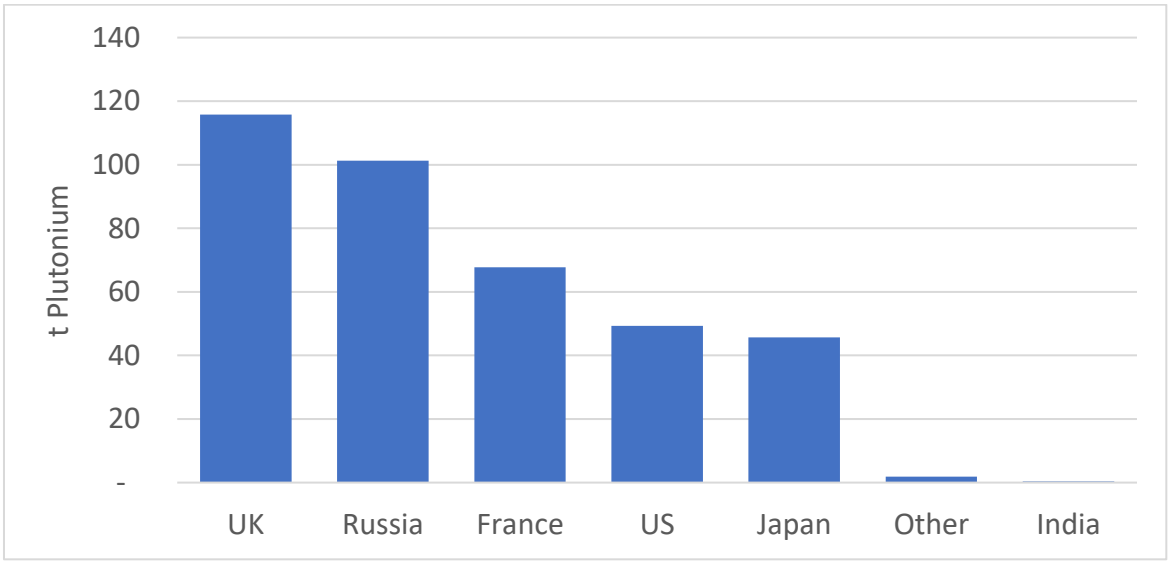


Figure 4: Plutonium quantities (non-military) stored

There are currently around 115 tonnes of plutonium stored at Sellafield Ltd. in the UK alone, which would ensure an operating time of around 40 years for 20 SMRs, each with a capacity of 200 MW. The British government estimates that storing the plutonium will cost around £7.3bn over the next 100 years.

It is precisely this plutonium that can be used to close the short-term and long-term supply gap of nuclear fuel for the SMRs.

Using the stored plutonium as a MOX fuel element in SMRs would allow them to be operated for many years and would also reduce the high costs for the safe storage of plutonium.

NewMOX®

NewMOX® is a special purpose company under AMG that will turn this idea into a business model. The aim of the project is to build and operate a factory for the production of MOX fuel elements being planned with an annual production of 20-40 tonnes of MOX in the basic version.

AMG is in the transition from reference plant design and business case (FEL1) using AMG experimented technology on sintering furnaces to MOX concept design and pre-feasibility study (FEL2).

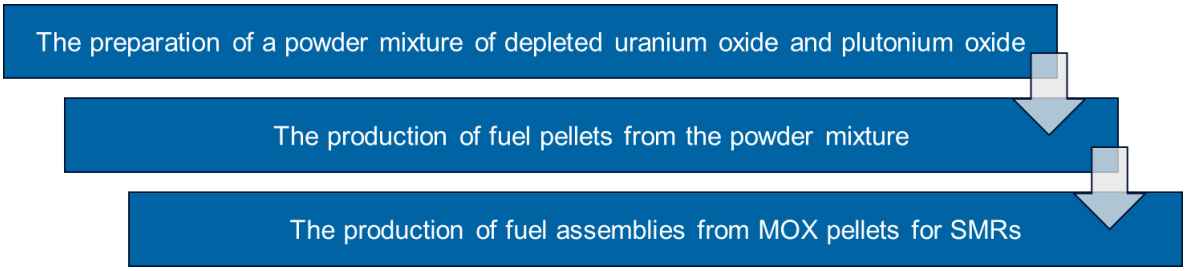
Initial considerations for the construction of such a plant have already been started and well-known engineering companies in the nuclear industry have begun initial rough planning of a building. Other potential partners for the NEWMOX® project include companies with extensive experience in the manufacturing of fuel elements for nuclear power plants.

Potential NewMOX joint venture partners include entities long in plutonium, entities short in nuclear fuel, and engineering companies. Apart from the quest for appropriate joint venture partners, a comprehensive study is underway to evaluate the technical and economic viability of a commercial MOX plant. Drawing upon AMG’s routine experience in feasibility studies and the successful execution of sizable industrial projects. This collaboration aims to consolidate expertise within AMG, maximizing the likelihood of transforming a vision into tangible reality.

Expected time to start FEL2 is Q3 2024.

How MOX fuel elements are produced

The production of MOX fuel elements essentially takes place in three stages:



To produce the MOX powder mixture, depleted uranium oxide is mixed with plutonium oxide in two steps. The powder mixture is then pressed into pellets, from which the MOX fuel pellets are produced using sintering furnaces (product of AMG Engineering). A sintering furnace specifically for the production of MOX pellets with a plutonium content of over 10% was developed by AMG Engineering and installed in China (Figure 5).

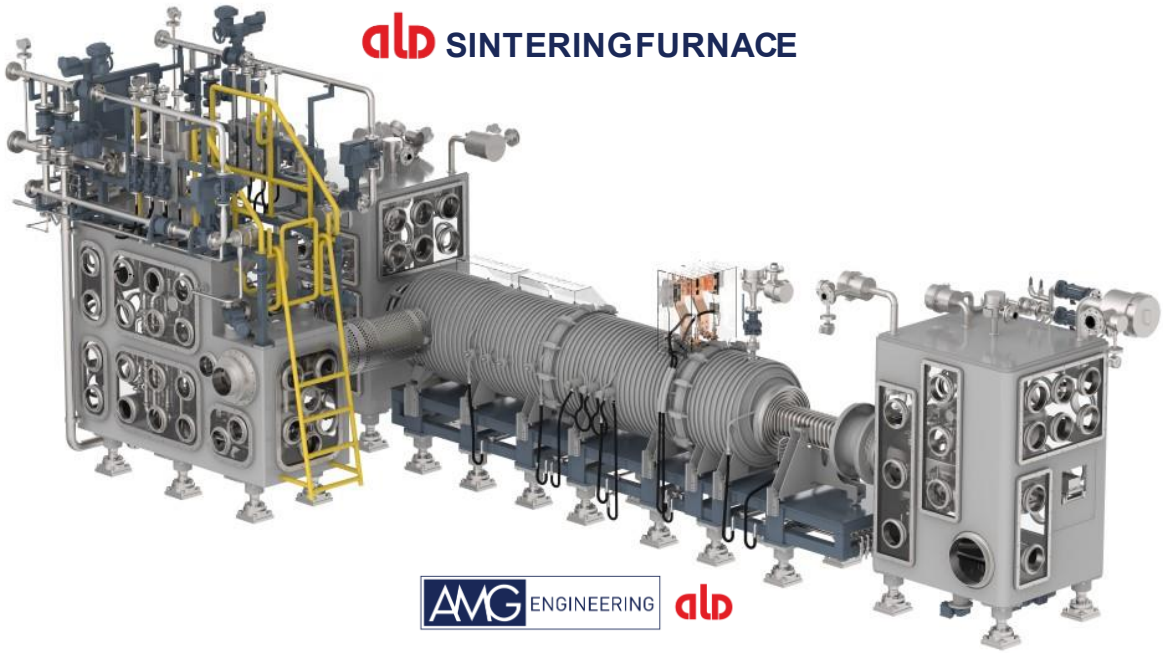


Figure 5: MOX sintering plant with reinforced glovebox walls for shielding at higher plutonium quantities

In total, AMG Engineering has manufactured more than 60 sintering furnaces for the production of fuel pellets, of which about 30 sintering furnaces were for the production of MOX pellets. (list in Appendix)

In the final step, the pellets are processed into the fuel elements. A system for filling and sealing fuel rods is needed and such a system was built by Leybold AG and successfully used in the cold testing phase of the Siemens MOX plant. The documentation for this system is still held by AMG Engineering. The individual fuel rods are then joined together to form a fuel element (Figure 6).

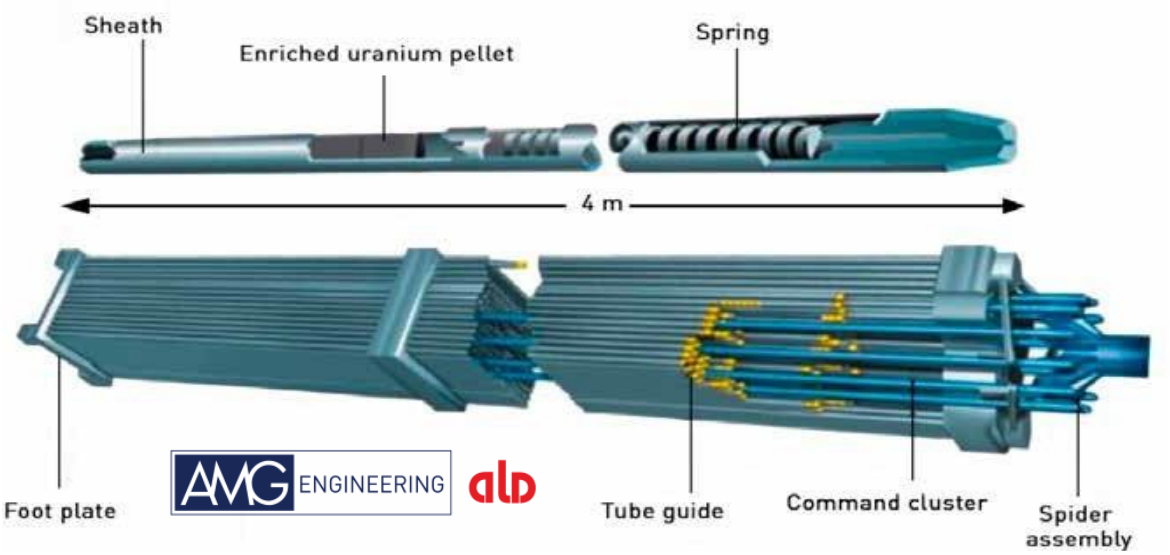


Figure 6: Structure of a fuel element

NewMOX fuel element manufacturing will require much greater flexibility than the production of fuel elements for large nuclear power plants.

The recurring need for MOX fuel is underpinned by its pivotal role in addressing ongoing challenges and contributing to a sustainable global energy landscape. As a key environmental success, MOX fuel plays a crucial role in the ongoing management of plutonium waste, offering a practical solution to repurpose this material and reduce the long-term environmental impact associated with nuclear waste.

Beyond its environmental benefits, the recurring demand for MOX fuel stems from its potential to lower carbon emissions, position it as a valuable component in the transition to a low-carbon energy future.

AMG Engineering has experience with MOX fuels from its sintering furnaces and has provided the sintering furnaces for MOX production sites in Belgium, France, the UK, China, and one for the U.S. (originated in the context of “Plutonium Management and Disposition Agreement” between the U.S. and Russia and discontinued when agreement was revoked)

Appendix

1.1 Reference list

Customer	Country	Quant.	Furnace Type
Metallurgie M.N., Mol	Belgium	3	GWSmo 16/14/150-Box
BN, Dessel	Belgium	1	GWSmo 16/14/150-Box
Alkem, Hanau	Germany	1	GWSmo 13/9/300-Box
Alkem, Hanau	Germany	1	GWSR 27/10/300-Box
PNC, Tokai	Japan	1	GWSmo 25/12/210-Box
PNC, Tokai	Japan	1	GWSR 25/12/300-Box
Alkem, Hanau	Germany	1	GWSmo 13/9/150-Box
Alkem, Hanau	Germany	1	GWSmo 13/9/150-Box
SIEMENS, Hanau	Germany	2	GWSmo 13/9/200-Box
SIEMENS, Hanau	Germany	2	GWHR 29/3/220 - Box
MELOX, Bagnols	France	3	GWSmo 21/10/300-Box
BNFL, Sellafield	United Kingdom	4	GWSmo 13/9/200-Box
MELOX, Bagnols	France	Several as spare parts	GWSmo 21/10/300
MOX SERVICES	USA	2	GWSmo 22/11/300
CNLR	China	3	GWSmo 17/15/150