Nuclear Fuel Cycle Video Script

In this video, we'll talk about nuclear nonproliferation and the nuclear fuel cycle. Get a little bit more in-depth into the fuel cycle itself.

Large concentrations of uranium in the ground are known as uranium ore. Uranium (U) is a common ore {_____} throughout the world. In its natural form, it is composed of about 0.1% uranium and 0.7% U-235, the isotope within the material that is responsible for the fission {_____} that {_____} heat for electricity in a nuclear power plant (NPP) or for an explosion in a {_____} bomb.

The {_____} fuel {_____} is the story of what happens to uranium from the time it is mined from the ground as ore to the point where it is stored as {_____} waste. This story of nuclear fuel is important for understanding our negotiation case. Why? Because {_____} fuel can be used for peaceful {_____} —for {_____} electricity or for producing radioactive isotopes used in {_____} diagnosis—and it can also be used for {_____} purposes—for building nuclear weapons. It can be both a commercial export and a material vulnerable to theft and use by terrorist organizations. This dual nature of nuclear fuel lies at the heart of our negotiation case.

The potential for uranium fuel to be used to construct nuclear bombs {_____} a proliferation risk. That is, there are certain points in the nuclear fuel {_____} when uranium fuel or plutonium can be transferred to a nuclear weapons program. This ability to transfer, or divert, {_____} material from peaceful use to weapons use is a proliferation risk. In addition, {_____} material and nuclear waste, if

not properly secured, can pose a risk of {_____} and proliferation to outsiders with malicious intent. Another proliferation risk is posed when a country with the technology to produce nuclear material for weapons passes that knowledge and/or material to another country that does not yet possess it. The risk of proliferation of nuclear {_____} know-how and material and equipment is an important factor in the negotiation over renewal of the US-South Korea {_____} agreement.

Efforts to prevent nuclear {_____} began in 1953 when US President Eisenhower began the Atoms for Peace Program. Nonproliferation efforts since then have included both {_____} and diplomatic measures, most notably the Treaty on the Nonproliferation of Nuclear Weapons (NPT), which has been signed by all countries of the world, with the exception of Israel, India and Pakistan. North Korea formally abrogated (withdrew from) the NPT in order to develop a nuclear weapons program. According to the treaty, all countries are entitled to nuclear {_____} for peaceful purposes, though not all are entitled to posses the complete nuclear fuel cycle because of proliferation concerns. So let's take a look at the nuclear fuel cycle and its implications for our negotiation case.

The World Nuclear Association {_____} the nuclear fuel cycle as a "{_____} of industrial processes which {_____} the production of electricity from uranium in nuclear power reactors." However, there is a darker side to the nuclear fuel cycle. Countries that have mastered the technological hurdles of the entire nuclear fuel cycle also have the {_____} to divert nuclear material from commercial use to a nuclear weapons program. The more countries that have this {_____} available to them, the higher the risk of more nuclear weapon states and more nuclear proliferation.

The nuclear fuel cycle has a front end and a back end. After uranium is mined and milled, it goes through the

{_____} of {_____}, enrichment and fuel fabrication—that's the front end. After {_____} three years in the nuclear reactor, the fuel is {_____} and either stored or reprocessed before ultimately being disposed—that's the back end of the {_____}.

The front end begins with mining. In mining uranium ore is mined through various {_____}, depending on the depth of the uranium ore in the ground, its composition, and safety and economic {_____}. Since the amount of U-235 is low in natural uranium, a large quantity of the material must be {_____}. Once dug out from the ground, the ore is milled. Milling is a {_____} that extracts natural uranium from the ore and produces uranium oxide, or yellowcake. This {_____} increases the level of uranium from 0.1% to more than 80%. The uranium oxide (U3O8) {_____} is dried, heated, and packed into drums before being sold for nuclear power reactors. The waste from this {_____}, known as tailings, contains radioactive materials and heavy metals, detrimental to the {_____} and populations near the milling facilities.

As I mentioned, only about 0.7% of natural uranium is made up of U-235, or the fissile material {_____} of undergoing fission—the process that {_____} heat in a {_____} or a nuclear explosion in a bomb. The remaining composition is U-238 (~99.3%), and U-234 (~0.0056%). All three isotopes are radioactive, with the most {_____} being U-238 and the most {_____} being U-235. In order to maintain a fission reaction in a nuclear reactor or a nuclear bomb, the concentration of U-235 needs to be increased. For a reactor, the concentration of U-235 needs to be between 3.5% and 5%; for a {_____} weapon it needs to be more than 90%.

Before the U-235 isotope can be increased—or {_____}—the yellowcake needs to be {_____} to uranium dioxide (UO2) or uranium hexafluoride (UF6), depending on the nuclear {_____} it is destined to fuel. For most light water reactors, the yellowcake is {_____} to

uranium hexafluoride gas and then shipped to the enrichment plant.

Enrichment is {_____} by separating the U-235 isotope in order to increase it relative to the other two isotopes. There are several {_____} for enriching uranium, the most common being centrifuge separation, {_____} thousands of spinning tubes, separating the isotopes by mass weight.

For a power reactor**,** enrichment of only 3.5%-5% is needed; this level is considered low-enriched uranium, or LEU. However, once a country masters the {_____} to enrich to this level, it is only a matter of time before it can {_____} higher levels of enrichment. For medical diagnosis, {_____} 20% enrichment is needed; nuclear weapons development {_____} highly enriched uranium, or HEU. That is more than 90% U-235. Most reactors today are light water reactors that {_____} enrichment.

Because it does not {_____} much more investment in {_____} and research to increase enrichment from 3%-5% to 90%, this stage of the {_____} fuel cycle is considered proliferation sensitive. At this stage, a country seeking to develop nuclear weapons could {_____}, or divert, highly enriched uranium to a weapons program, or make it {_____} to other states or non-state actors with terrorist intent.

Fuel fabrication

Fuel fabrication {_____} uranium oxide into ceramic pellets. The pellets are then {_____} into metal tubes known as fuel rods, which are arranged into a fuel {_____}. The fuel {_____} make up the core of the nuclear reactor. It is these {_____} that heat up from the fission of U-235, which boils water to generate steam, {_____}driving

the turbines that produce electricity.

Several hundred fuel {_____} make up the {_____} of a reactor. In the reactor core a U-235 isotope fissions or splits in a continuous process called a chain {_____}. The chain {_____} is controlled by a moderator material, such as water or graphite. Through fission, some of the U-238 in the nuclear fuel is turned into {_____}, another fissile material.

Once the fuel has been burned up in the reactor core, it can no longer efficiently produce a fission chain reaction and is known as spent fuel. About one-third of the spent fuel is {_____} every year or 18 months and replaced with fresh fuel. Although it is no longer useful as a nuclear fuel, the spent fuel is very hot and {_____}, requiring it to be stored in a large pool of water, known as the spent fuel pool or pond. After some three to five years in the pool, the spent fuel has lost enough radioactivity and heat to be moved into ventilated dry storage casks. This is known as {_____} storage, as the radioactivity decays to the point where it can either be moved into long-term {_____} or reprocessed.

Reprocessing

Whereas uranium is a natural ore found in the {_____}, plutonium is a fabricated material created by the fission {_____} in a reactor. Spent fuel contains about 96% of its original {_____}, about 3% waste products, 1% {_____} produced in the reactor, and less than 1% fissionable U-235. Reprocessing separates the uranium and {_____} from the waste products by chopping up the fuel rods and dissolving them in acid. The uranium and plutonium can be {_____} to be used again as reactor fuel. Reprocessing also reduces the amount of waste that needs to be stored. Both of these results of reprocessing are important for South Korea in our negotiation case. As you {_____} from our overview video, South

Korea needs fuel for its future nuclear power plants and for its plans to be a major nuclear {_____}. Reprocessing is also a way for South Korea to reduce its stores of nuclear waste. However, the plutonium and highly enriched uranium that are products of reprocessing can also be used in a nuclear weapons program. This {_____} is at the center of the US position in our negotiation case. Although the US does not suspect South Korea of developing a nuclear weapons program, the {_____} to produce plutonium is a proliferation risk, and it also sends the wrong message to North Korea and other countries that produce {_____} for nuclear weapons.

Used fuel and separated wastes: final disposal

Nuclear {_____} is also an important {_____} in our negotiation case. As of 2009, the amount of stored spent fuel in the world was 240,000 {_____} tons**.** {_____} of heavy metal, mostly uranium, spent fuel remains radioactive for thousands of years and {_____} a significant {_____}. Globally, {_____} 10,500 tons of heavy metal is {_____} each year. The US has 64,500 tons of spent fuel, and at the start of 2010, South Korea had 10,761 tons, which had filled some 80% of its total storage {_____}.

At the present time, neither South Korea nor the US has long-term {_____} facilities in operation. Geological {_____} of spent fuel or of high-level waste {_____} from its reprocessing is judged to be a safe solution by almost all countries, and also by international organizations such as the IAEA, the {Nuclear} Energy Agency (NEA) at the Organization for {Economic} Co-operation and Development (OECD) and the European {Commission} (EC). However, plans for siting deep repositories have {_____} opposition so that, today, {_____} have been selected only in Sweden and Finland (for spent fuel disposal) and in France (for high-level waste). The {_____} of developing suitable {_____} {_____} and of arriving at socially

acceptable {_____} has taken more than 20 years in these cases. Other countries, including the US and South Korea, are {_____} away from repository {_____}.

The US is committed to not reprocess nuclear spent fuel; however, South Korea sees it as a viable {_____} for reducing the amount of waste needing geological {_____} and for producing {_____} fuel for exports to other countries. This {_____} is central to South Korea's interests in this negotiation case.