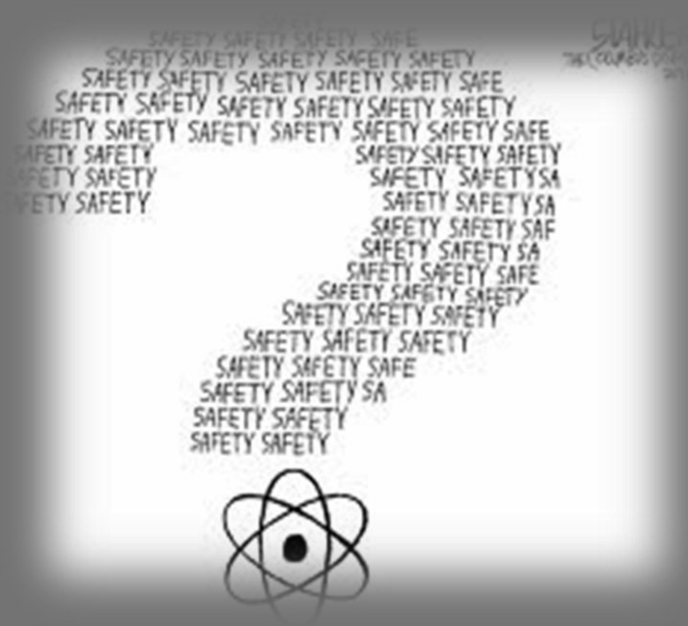
2013

IAEA 2013 Background Guide

MIT Model United Nations Conference V



iaea20132mitmunc.org

Letter from the Dais

Greetings Delegates,

My name is Abdulhamid Haidar, and I will be chairing the IAEA session of MITMUNC V with Ethan Bates. I am an 2nd year undergraduate student studying computer science and economics. I am from Syria, and am passionate about international politics. I am particularly interested in the political dynamics that surround nuclear energy and weapons. I participated in several MUN conferences while in high school. I was also a co-chair in MITMUNC IV.

Ethan Bates is a 2nd year Ph.D student in the nuclear science and engineering department at MIT. He is a passionate advocate for nuclear power and truly believes in its potential to help improve the world. His participation in MUN in high school and debate of global issues such as climate change helped draw him into the engineering and clean energy field. He hopes that you find this experience as valuable and insightful as he did. We are both very excited about chairing the IAEA this year, and are looking forward to the event.

Sincerely,

Abdulhamid Haidar

Ethan Bates

IAEA Chairs,
MITMUNC V,
iaea2013@mitmunc.org

Topic 1:

Nuclear Security: Preventing and Dealing with Danger

Introduction

Nuclear technology, if abused, can become a threat to safeties of host countries, neighboring ones, and the world. The two most critical examples are the threat of terrorists' acquisition of nuclear weapons - which could then be used anywhere - , or the development of nuclear weapons research based on technologies developed for peaceful uses of nuclear energy. These dangers are very real today, but the path towards dealing with them is unclear. Is the IAEA doing enough to prevent failures like theft of nuclear material, for example, in countries that are not as developed? In other cases where the IAEA is aware of present dangers, such as the issue of Iran, and where previous attempts of resolutions have passed - what happens next?

Nuclear technology and nuclear materials, when combined appropriately, can be a very beneficial source of energy. However, if exploited, both technology and materials can prove to be very dangerous. In its efforts to make Nuclear Energy accessible and safe, the International Atomic Energy Agency must make an effort to prevent such misuse of technology and material. Misuse can occur in many ways, and although the causes and effects differ, any misuse has the capacity of becoming very dangerous.

Misuse of Nuclear Technology

Nuclear power is a reality today due to decades of dedicated research in the field, and the world has amassed lots of knowledge and experience relating to nuclear power that is not made available to everyone. Sharing of such knowledge and technology is crucial in the process of promoting nuclear energy. However, there is a thin line between nuclear energy and nuclear weapons, and technology needed for the former can play a large role in the creation of the latter. Thus, if the technology falls in the wrong hands, this could very well lead to the creation of nuclear weapons programs. It is important to note that such misuse of nuclear technology – ie, usage for purposes other than peaceful nuclear energy – can come as a result of several violations. First, countries given access to this technology (on the premise that it will only be used for peaceful purposes) could decide to use it to develop nuclear weapons capability. An example of such a case is Iran, which is accused of doing just that – illegally pursuing nuclear weapons under the cover of peaceful nuclear energy program.

However, nuclear technology can also be ‘stolen’ and provided to any number of unknown groups that can then choose to use it as they wish. It is very realistic for technological secrets to find their way to parties that would not use it peacefully. It is not too difficult to imagine terrorist groups, such as Al-Qaeda, getting their hands on the necessary technology for building nuclear weapons. Needless to say, the consequences of such an event would be devastating and would be pose prime threat to world peace and security. Fortunately, though, even with all the technological knowledge in the world, without nuclear material, little danger can be posed.

Misuse of Nuclear Material

Nuclear material – such as Uranium – is made available to dozens of nations and organizations. Some use it for peaceful nuclear power sources, such as Springfield. Others use it for medical research. However, nuclear material can always be used destructively, in the form of nuclear weapons.

Of course, in most cases, nuclear material requires significant refining and processing before it can be used in nuclear bombs, and this requires significant resources and funding that are not made available to most groups. However, nuclear missiles in ready-to-use format can themselves be stolen.

In the hands of a terrorist organization, or even an unstable individual, the dangers associated with possession of ready-to-use nuclear weapons cannot be understated. While it is unlikely for ready-to-use nuclear missiles to fall in the wrong hands, many have gone missing and/or are in unknown locations. It is estimated that a large amount of nuclear material and warheads are unaccounted for, and the world is lucky that no one has successfully used them to blow us all up.

Having explored scenarios that the IAEA must work to prevent, the following questions must be answered. What should the IAEA do – and what can it do – in preventing such measures?

Right now, the IAEA cooperates with member nations to ensure that adequate safety procedures are in place and in effect. However, consider the case where the nation does not have the capacity or willingness to cooperate fully. Clearly, the IAEA has no authority to force anything in any nation, so direct intervention cannot be the solution. The United Nations Security Council, on the other hand, can effectively intervene. However, Is it realistic to expect the UNSC to intervene whenever a country has an infraction?

The Threat is Real

Consider the case of Iran. The IAEA cannot establish with relative certainty that its nuclear program is purely for peaceful purposes. Iran claims that it has no intentions of ever pursuing nuclear weapons, and that its nuclear program is strictly aimed at a peaceful nuclear power generation, which is needed in the country. Other countries, such as the US and Israel, have accused Iran of working towards nuclear weapons, and do not trust its incentives. This issue has been a source of global tensions for years, and the world seems to be running out of patience (Dahl 2012).

A variety of negotiations have taken place over the past years, and the west has resorted to using heavy sanctions against Iran, but efforts have been unsuccessful. The world still believes that Iran is years away from being able to make a bomb. Yet, Iran seems ready to accelerate (Al Jazeera 2012). To this day, there remains uncertainty regarding Iran's nuclear program which could possibly lead to militarization of the conflict, especially from Israel.

Consider now the case of rogue nuclear missiles. Over the course of the cold war, many nuclear weapons were lost. Today, as many as 50 bombs, missiles or warheads remain out there (Maack 2008). Most are in deep and inaccessible parts of oceans and seas. Others' locations are not clearly identified. Almost all are at risk of spontaneous detonation, although the likelihood of such an event is unclear.

There is also a real threat posed by nuclear weapons that are unaccounted for. There have been numerous allegations of different severity regarding unaccounted-for nuclear material and warheads, and we do not know any exact numbers. While most cannot be verified and have been denied by official resources, they give an indication of the seriousness and realness of the issue of nuclear material and weapons falling into the wrong hands – by falling out from official hands.

Perhaps the most extreme accusation comes from Senator Rockefeller, who hinted that half of all nuclear in Russia is unaccounted for:

"In the sense that half of the nuclear materials, pieces and parts of it, are unaccounted for by the Russians — and a lot of them, these places are in rural areas — I think you can legitimately look at North Korea and the unaccounted-for nuclear weapons parts in Russia and have a real debate as to which is more threatening to the world right now, because the point is that a lot of those people who protect those places can be bribed.

Terrorists can come in and buy part of those. And that's the theory that I think Porter was talking about, that a lot of those lost nuclear weapons can be out circulating in the terrorist community." (Fox News 2005)

Porter Goss, then director of the CIA, has supported such views, saying that ""There is sufficient material unaccounted for, so that it would be possible for those with know-how to construct a nuclear weapon." (ABC News 2005

In addition, up to 250 nuclear warheads are believed to have gone missing during Cold-War-Era transactions between Russia and Ukraine. Moreover, in 1997, a former Russian official claimed that over 100 'suitcase-sized' nuclear weapons had gone missing (Sublette 2002). There is also at least one account of a businessman that stores his own personal nuclear bomb near Moscow (Earley 2007). Clearly, the danger of nuclear material/weapons falling into the wrong hands is very real.

The IAEA's Role

The IAEA works closely with governments and maintains accurate records of all nuclear material and their locations. Furthermore, IAEA inspectors visit facilities to verify record accuracies, especially when the nuclear material can directly be used in the creation of nuclear weapons.

In the case of failure of compliance or breach of agreements, the IAEA Board of

Governors takes necessary action. Generally, in the most critical cases, the board reports to the United Nations Security Council and General Assembly.

It's Not Working

The system in place today seems to be ineffective on many fronts. In the case of Iran, the solutions that have been used by the United Nations (effectively, sanctions coupled with bilateral and multilateral negotiations) have failed. Soon, the issue will be out of the IAEA's hands.

Moreover, the world is not prepared for misuse of nuclear weapons. Terrorist organizations, especially Al-Qaeda, are actively seeking nuclear weapons. The threats of today, of course, could be the realities of tomorrow, and the IAEA is positioned at the forefront of combating this threat.

Dangers have materialized in the past – the IAEA has confirmed no less than 18 incidents of theft or loss of highly enriched uranium and plutonium.

Questions to Consider

How real is the threat of abuse or misuse of nuclear material?

If in the wrong hands, nuclear weapons can be used by anyone and against anyone (as they can be sold in the black market). Thus, shortcomings in one state places everyone at risk. In other words, the entire world has reason to be interested in the security of nuclear material globally.

How can these global interests in national projects be realized without interfering with host state's autonomy?

Should nations be accountable for all things nuclear within their borders? What if they don't have the required capacity but want to pursue nuclear weapons? Should they be stopped, and how would that be enforced? Or, is the world responsible for directly intervening whenever security concerns arise?

In some cases, different nations have different concerns which may or may not be well-founded. This is particularly true in an era where countries have their own intelligence agencies and sources of information. How can the IAEA account for these different opinions?

Required Reading

In addition to reading the articles that have been sited (links below), read the following speech by Yukiya Amano, IAEA Director General, which was given during the last IAEA Board of Governers meeting:
http://www.iaea.org/newscenter/statements/2012/amsp2012n021.html

ABC News. "Official: Enough Material Missing From Russia to Build a Nuke." ABC News. February 16, 2005. http://abcnews.go.com/WNT/story?id=506177&page=1#.UMKW8YMfgww.

Al Jazeera. "IAEA: Iran ready to boost uranium enrichment." Al Jazeers. November 17, 2012. http://www.aljazeera.com/news/middleeast/2012/11/201211170442883543.html.

Dahl, Fredrik. "U.S. gives Iran until March to cooperate with IAEA." Reuters. November 29, 2012. http://www.reuters.com/article/2012/11/29/us-nuclear-iran-usa-idUSBRE8AS0VS20121129.

Earley, Pete. Comrade J: The Untold Secrets of Russia's Master Spy in America After the End of the Cold War. Penguin Books, 2007.

Fox News. "Transcript: Sens. Rockefeller, Roberts on 'FNS'." Fox News. February 20, 2005. http://www.foxnews.com/story/0,2933,148192,00.html.

Maack, Benjamin. "A Nuclear Needle in a Haystack - The Cold War's Missing Atom Bombs." Spiegel Online International. November 14, 2008. http://www.spiegel.de/international/world/a-nuclear-needle-in-a-haystack-the-cold-war-s-missing-atom-bombs-a-590513.html.

Sublette, Carey. "Alexander Lebed and Suitcase Nukes." Nuclear Weapon Archive. May 18, 2002. http://nuclearweaponarchive.org/News/Lebedbomb.html.

Topic 2:

NUCLEAR SAFETY AND THE FUTURE OF NUCLEAR POWER

Introduction

In the aftermath of the Fukushima accident, some member states are withdrawing nuclear programs because of concerns about the safety of nuclear plants. In many cases, decline in public support is a driving force behind this. What can/must the IAEA do to keep nuclear power a safe, viable option? It is clear that the response to the Fukushima accident was chaotic, sluggish, and not optimal. How can the IAEA improve the emergency response preparedness of member nations? What frameworks can be set up in advance to improve communication and decision making clarity? Can evacuation recommendations be solidified and proceduralized to avoid conflicting or inconsistent recommendations between member states? Recognizing that the psychological impact of such accidents may exceed the health or physical impacts, what mechanisms can the IAEA implement to reduce the propagation of misinformation? Can better systems to share information among scientists and experts during the accident be put in place?

The primary purpose of this briefing document is to provide the delegates with a sound, scientific, fundamental basis upon which discussions of nuclear power and safety issues can be built. During their research, they may come across many sources of questionable accuracy, and it is important they are enabled to identify whether or not a statement or report is based on fact.

Introduction to Nuclear Power and Safety

Importance of Energy

Abundant energy is generally accepted as a necessity in raising standards of living and improving quality of life[1] across the world. Without cheap sources of energy (traditionally fossil fuels), the industrial revolutions and historically unprecedented increases in population and economic output that have occurred over the past 200 years[2] would not have occurred. In recent years however, the unsustainability, limitations, and health effects of fossil fuels have been recognized. Key developing countries (such as India and China) are undertaking their own revolutionary changes in energy infrastructure to adapt to this, promote economic growth, and combat climate change.

Advantages and Disadvantages of Nuclear Power

Nuclear power is a well-proven technology that can provide a stable source of baseload energy without emitting greenhouse gases. This is in contrast with other low-carbon sources of clean energy such as wind and solar which currently provide intermittent energy unless they are in some way connected to energy storage devices. The fuel used in nuclear reactors (certain isotopes or types uranium or plutonium) represent the most energy dense fuel forms in useful existence and thus only small quantities are required to be mined, enriched and disposed. Table 1 presents a comparison of the energy density of various sources (or stores) of energy.

From Table 1 (see Appendix A), it is seen that a given mass of uranium-235 may yield about million times more energy than any other chemical source of energy. Furthermore, the amount of fuel required to provide energy for an average person in a year from fossil or biomass sources is staggering.

Natural uranium (obtained from the earth or ocean) only contains approximately 0.7% uranium-235. Some reactors such as the Canada Deuterium Uranium (CANDU) reactor can use natural uranium as fuel. Most reactors which use regular "light" water as a moderator require some fuel enrichment (typically 3-5%) because light water absorbs more neutrons than heavy water (deuterium).

As a result of this low fueling requirement, in a typical reactor, only 10% of the costs of electricity are associated with the fuel.

This in contrast with fossil fuel plants, where 25-60% of costs are associated with purchasing fuel[5]. Most of the expense of a nuclear reactor and thus cost of electricity produced comes from the upfront capital cost of building the reactor, which includes a significant number of expensive safety systems and structures. The necessity of these large and redundant safety systems and high capital costs are a disadvantage of the current generation of nuclear reactors.

Typically the initial construction costs are paid for using a private loan, which is expected to be paid back during the lifetime of the plant. Since reactors may take longer than expected to construct or be forced to shut down at some point during their long lifetime (due to unforeseen setbacks or regulatory uncertainty), a certain amount of risk is associated with taking out the loan. This risk causes nuclear plant purchasers to experience higher interest rates (ie. a risk premium), which increases the cost of electricity[6].

Conversely, if the reactor has operated for a long period and the loan has already been repaid, nuclear electricity represents one of the cheapest sources of electricity, because it only requires paying for the fuel and maintenance costs.

Nuclear Reactor Basics

Fission

To begin an educated discussion of nuclear safety first requires understanding the basics of how a nuclear reactor operates. Commercial nuclear reactors derive energy from the splitting of atoms into smaller atoms, also known as fission reaction. The typical cause of fission is an incoming neutron, which destabilizes the heavy uranium-235 (or plutonium-239 atom) and causes it to break up into many pieces. A wide array of fission products are created as a result of this violent and random process, including approximately 2 additional neutrons which can act to continue fission in a sustainable, chain reaction process. Most byproducts are unstable atoms, which continue to radioactively decay and break apart into smaller pieces while releasing energetic particles of radiation. The time required for the byproducts to completely break down and reach a stable state varies from miniscule fractions of a second to millions of years.

Fission Products and Decay Heat

The fundamental phenomena that causes nuclear plants to have safety issues is that energy (in the form of radiation) continues to be released from fission products long after the original fission event occurred.

During normal operations, all the fission products are contained within the solid fuel structure (UO2) or metal "pins" or "cans" that surround the fuel. As fresh fuel is irradiated in a reactor and produces energy, the fission products build up in the fuel. When a reactor that has operated for a long period is "shut down" and the neutron chain reaction has been stopped, the fission products in the fuel will still continue to produce approximately 6% of the total operating power of the reactor.

For a typical large 1000 Megawatt(electric) nuclear plant, this heat output is equivalent to the energy consumption of 2 MIT campuses. One week after reactor has been shut down, the fuel will still produce ~2% of the original power. If this energy is deposited in the fuel itself (and not removed by a coolant), the fuel will start to heat up and may reach its melting point.

When the fuel and the cladding (the material that seals the fuel from the environment) reach their melting points, the radioactive products will be released into the reactor vessel. This is referred to as a core melt accident or nuclear meltdown. After this occurs; however, most fission products will be stuck in the coolant (dissolved) and/or deposit onto surfaces of pipes. The troublesome fission products that remain mobile (ie. are gaseous or insoluble) will buildup in the nuclear containment building.

Current water cooled nuclear reactors primarily use zirconium as a cladding material because it is transparent to neutrons.

When zirconium is heated up to 1000° C, it begins to react with water and oxidize, which releases hydrogen gas and significant amounts of additional thermal energy. The energy released from the oxidations can be comparable to the energy released from the fission products, and the reaction rate increases as the temperature goes up. If the hydrogen gas builds up in sufficient quantities in the reactor building, it may combust, causing damage to the containment boundary.

Other types of reactors (such as gas cooled) use a different approach to cladding. Instead of fabricating a large "can" to surround the fuel rod, uranium particles (the size of a tip of a pencil) are individually encapsulated with a strong and high melting point material composed of silicon carbide. Many safety issues are thus dependent on the specific design of the reactor being discussed, but the fundamental concerns of decay heat removal remains common to all reactor designs.

Safety Systems

Most reactors require some electrically driven pumps to maintain cooling of the reactor fuel during shutdown. As a result, systems of batteries, diesel and gas generators have been built at nuclear plants as a backup during power loss.

Some popular advanced designs that are currently being built (such as the Westinghouse AP-1000) do not require electricity, but have passive (gravity driven) systems that can cool the reactor for a few days in the case of power loss. From the previous introduction to nuclear reactors, we may note that there are 3 primary barriers preventing the release of radionuclides.

- Fuel Matrix
- Fuel Cladding
- Containment Dome
    - The containment may contain other engineered systems to prevent the release of radiation to the environment, such as:
- Containment sprays to reduce pressure and absorb radionuclides
- Hydrogen recombiners to eliminate combustible hydrogen
- Beds of sand and charcoal to filter and capture radionuclides.

Some argue that nuclear safety is completely driven by the humans that design and operate the plant (for a more direct statement of this argument and discussion of the Fukushima Accident, see the report[7]). The designers of the plant must fully understand the environmental conditions and probability of external events that can negatively affect the operation of the nuclear plant. Much of this work is completed during the siting process, but additional design decisions and modifications (such as a tsunami walls at many coastal Japanese nuclear plants) may occur after the plant is constructed. The proper functioning and activation of these safety systems depends on the training and preparedness of the operators of the plant.

Difficult decisions that can result in an extremely expensive loss of the nuclear plant (or prolonged shutdown) must be made quickly in the event of an unexpected accident. Thus, streamlined networks for making decisions and risk comparisons are beneficial. Some reactors safety components that are critical to safety are may not be maintained properly and deteriorate and due to a lack of strict safety culture at the plant. Maintaining an appreciation for safety and preparedness are crucial to preventing accidents from propagating.

Consequences of Radiological Releases

Radiation doses to humans inevitably occur, due to the cosmic rays from the sun, exposure to naturally radioactive materials (such as potassium, radon gas in basements, or certain rocks used in construction) and exposure to medical sources of radiation. Radiation doses due to cosmic rays increase with elevation and altitude, and approximate double for each mile of elevation gain.[8] The global average radiation dose per year from natural background sources is 2.4 milisieverts (mSv) per year, while man made and medical doses add ~1.2 mSv to that.

When brought in close proximity to human tissue, radionuclides release energetic particles which can penetrate cell walls, damage DNA, and disrupt the normal operation of the cell or cause it to die. At very high dose rates (rate of energy deposition in the tissue) such as those experienced during nuclear explosions, the loss of key cells in the body (bone marrow cells) can lead to death. At low dose rates and on long time scales, such as those experienced in proximity to a damaged nuclear plant, in a very small portion of these energy deposition events, DNA damage is the key concern. If the damage is not repaired by the body and the DNA altered in a very specific way, the cell can become tumorous, resulting in uninhibited reproduction and cancer.

The additional cancer risk of caused by low dose rates of radiation are extremely difficult to statistically measure because of the high natural occurrence of cancers in humans. The exact mechanisms for DNA damage and repair are still topics of significant research.

Past models for quantifying radiation damage simply assume that the damage is proportional to the total energy absorbed by the tissue, and assume no minimum threshold energy deposition rate may exist for the DNA to be damaged permanently. This is known as the "linear no-threshold" model, and is frequently used to compare radiological releases and create evacuation policies, although its scientific soundness is currently being questioned[9]. The newer research suggests that low doses of radiation of (up to 400 times background radiation) do not result in measurable changes to DNA.

IAEA's Role in the Future of Nuclear Safety

Important Past Conventions

Convention on Early Notification of a Nuclear Accident[10]- establishes a notification system for nuclear accidents which have the potential for international transboundary release that could be of radiological safety significance for another State. It requires States to report the accident's time, location, radiation releases, and other data essential for assessing the situation. Notification is to be made to affected States directly or through the IAEA, and to the IAEA itself.

The Convention on Nuclear Safety[11]- adopted in Vienna on 17 June 1994, it establishes broad guidelines for practices to follow in emergency preparedness, siting evaluation, design and construction, operation.

Some questions to consider

How much energy and electricity does your country use? What alternative energy sources are available? What kind of foreign dependencies does your country develop when using one source or another?

Is your country considering building nuclear reactors?

What is the public opinion of nuclear energy in your country?

How has it been affected by the recent nuclear events?

What kind of accidents are nuclear reactors susceptible to in your country (seismic, tsunami, hurricane, terrorist etc)?

What accident preparedness does your country require for nuclear plants?

What standards for evacuation in the event of a nuclear accident does your country use?

How does/has your country made recommendations for its own citizens to evacuate other countries in the event of an accident?

What radiological risk models are these evacuation recommendations standards built upon?

Can or should they be improved?

What are the largest consequences that your nation would be concerned with in the event of an accident (psychological, evacuation effects, loss of agricultural land, loss of tourism)?

What kinds of decision making frameworks (if any) have been established to complete the difficult cost-benefit analyses associated with accidents?

Can or how should these decisions be made on an international level in cooperation with other affected nations?

References

[1] http://www.unescap.org/drpad/publication/journal_8_2/aqeel.pdf

[2] Lucas, Robert E., Jr. (2002). Lectures on Economic Growth. Cambridge: Harvard University Press. pp. 109–10.

[3]http://en.wikipedia.org/wiki/Energy_density

[4]http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE/countries/1W-US?display=graph

[5]http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html

[6] For a full discussion of economics of nuclear power see MIT's "The Future of Nuclear Power" (2003) available at http://web.mit.edu/nuclearpower/

[7]http://warp.da.ndl.go.jp/info:ndljp/pid/3856371/naiic.go.jp/wp-content/uploads/2012/09/NAIIC_report_lo_res10.pdf

[8]http://www.colorado.edu/ehs/programs/safetyhandbook/introduction.pdf

[9]http://web.mit.edu/newsoffice/2012/prolonged-radiation-exposure-0515.html

[10]http://www.iaea.org/Publications/Documents/Conventions/cenna.html see pg 35 of http://www.iaea.org/About/Policy/GC/GC44/Documents/gc44inf4.pdf for a list of status of Safety Related Conventions

[11]http://www-ns.iaea.org/conventions/nuclear-safety.asp Check for review reports from respective member countries.

Appendix A

Table 1

Energy density of various fuels (see reference 3), and the amount required for the yearly average energy consumption of an average person. The United States' per capita yearly energy consumption is referenced because it represents the maximum all countries.

Fuel	Energy Storage Type	Energy Density (kW-hr/kg)*	Mass Required to provide energy for an average person in 2009(see reference 4)	Mass required to provide energy for an average person in the U.S. in 2009
Uranium-235	Sub-atomic forces	22,100,000	~1 gram	~4 grams
Gasoline or Propane	Chemical bonds	~12.7	~1,790 kg	~7,000 kg
Coal	Chemical bonds	6.6	3,430 kg	13,400 kg
Wood	Chemical bonds	4.5	5,082 kg	19,876 kg

*One kilowatt-hour (kW-hr) is the energy released from a 1000 watt heater (or boiler) in an hour.