NUCLEAR ENGINEERING FREQUENTLY ASKED QUESTIONS

Everything you wanted to know about Nuclear Engineering, but were afraid to ask...

ENERGY

What is energy?
From an engineering perspective, energy is a property of matter that defines the ability to do work. The automobile uses the energy during the combustion of gasoline to move it forward. Heat in steam is converted to electrical energy through a turbine.

What source of energy do we use today?
The major sources of energy in use today are: oil, coal, natural gas, hydro-power, nuclear and renewables such as bio-mass, wind and solar.

How much energy do we use?
In the US we use energy at 5X the per capita rate of the rest of the world average. Our rate of use globally is increasing rapidly. In the last 50 years, the population of the world has roughly doubled but energy usage has increased by a factor of sixteen (16). In the next 50 years the population of the world is projected to increase by ~70% but the energy usage will nearly triple.

Is there a shortage of energy?
There are limited resources of fossil fuels such as coal and oil. Over the next 20-30 years, the world demand for oil will be in excess of production capability. There will be adequate supplies of nuclear energy since it is sustainable. For renewables, such as wind, solar and biomass, space considerations will be limiting.

Is there a shortage of other natural resources that will affect energy supplies?
In addition to fossil fuels, several countries in the world are already experiencing a shortage of potable water. Unless major action is taken over the next decade, the availability of potable water may well become a world crisis. Engineers can help solve this problem—for example through desalination of sea water—but this will require a fair amount of energy. Adequate supplies of electric power will play a big role in avoiding a shortage of potable water.

How much of our energy do we import?
At the present time we import about 27% of our total energy (2001, 27% of 97 quadrillion BTU). This is projected to increase to 35% by 2025. For transportation, we import 66% of our total energy usage. This is projected to increase to 79% by 2025. Over the same time frame, the world consumption of oil is expected to increase by almost 60%.

NUCLEAR ENERGY

What is nuclear energy?
We are primarily focused here on energy resulting from fission. In current design commercial nuclear power plants, uranium 235 is the principal atom that fissions—that is the U235 absorbs a neutron, and decomposes into two atoms of lower mass—for example xenon and krypton—and in so doing releases energy in the form of heat.

How does uranium generate electricity in a power plant?
All current US reactors are of the light water reactor design. Heat from the fission process heats water in the reactor vessel. This heat is then transferred from the heated water to a steam turbine, similar to those used in conventional power stations, to generate electricity. The water flows over the fissioning fuel and through the steam generator as one continuous heating and cooling cycle.

What is the difference between fission energy for nuclear power and fission energy for bombs?
In commercial nuclear fuel, the U235 isotope is only slightly enriched. In naturally occurring uranium, U235 is at a level of about 0.7%. It is enriched to 5% or less for use in commercial power stations. Additionally, absorbers are used in power stations to assure a slow rate of fission and to assure decreasing fission rates with increasing temperature. In nuclear bombs, the uranium is highly enriched in U235—to 90% or greater—to provide a very high fission rate.

How does the energy of uranium compare to that of coal, oil or natural gas?
The energy out put from one pellet of uranium dioxide fuel -- about the size of the nail on your
small finger--is equivalent to about ¾ of a ton of coal, 150 gallons of oil, or 17,000 cu ft of natural gas.

**POWER PRODUCTION**

*What is the output of a typical nuclear power plant?*
Most nuclear power plants generate about 1 million kilowatts of electric power. That is sufficient electricity for about 800,000 homes.

*What is the US government position on nuclear power?*
A national energy bill is currently going through Congress—it embraces a balanced approach for all energy types. There is a need for nuclear power to be sustained at or above current 20% level. A congressional resolution, dated 6/4/04, stated that some 50,000MW of new nuclear capacity is required by 2020.

President Bush, in his state of the union speech on February 2, 2005, pressed for acceptance by congress of his comprehensive energy plan, which includes more production of clean, safe nuclear energy. The statement was heavily applauded on both sides of the house.

*What funding does the US Government provide for the advancement of nuclear energy?*
DOE has recently released the new budget for fiscal year 2006, which starts in October 2005. For the 2010 Nuclear Initiative, which is addressing the need for cost sharing of the regulatory process for a new power plant, it is seeking a 13% increase: $56M.

*What is the US demand for electricity?*
Electricity demand in the US is expected to grow at the rate of 1-2% per year. However, in developing countries it is expected to grow at a rate in excess of 4%.

*What sources of energy produce electricity in the world today?*
Nuclear: 16%; coal: 36.5%; natural gas: 16.7%; hydro: 21.3%, other: 9.5%.

US: coal 50.1%, nuclear 20.2%, natural gas 17.9%; hydro 6.6%, other 5.2%

*What is the future of renewable energy?*
A lot of engineering work is being done on renewable energy—wind, solar, bio-mass. These technologies have a large footprint—that is they use a large amount of land. They may contribute 5-10% of electricity in the next 20 years. Hydro plants in the US are near their limit.

*What is the current US dependence on nuclear power?*
Presently some 103 nuclear power reactors are operating in the US. In 2004 the electric output was about 20% of the total (786 Billion kw-hours).

*How much electricity in South Carolina is generated from nuclear power?*
In SC, some 56% of electricity is generated from civil nuclear power stations. This is the second highest in the US, Vermont being the largest (72%). Some 20 states generate more than the nations average (20%) while 20 states do not generate any nuclear power.

*If there are no new nuclear plants built in the US, when will they cease to operate?*
If nuclear plants cease to operate after their initial license expiration date, only about one half will be operating in another 20 years. None will be operating in another 30 years. Fortunately, because of research undertaken over the past half century, we are now able to better determine factors that affect the aging of plants, and a number of license extensions have been approved by the NRC. At the present time, some 30 plants have received license extensions and about 14 more applications are under review. Additionally, 25 plants have issued letters of intent. These extensions will add an additional twenty years to the useful life of a nuclear power reactor.

*What is the status of new nuclear plant orders?*
US DOE has taken the lead in streamlining the process of licensing a new plant through the NRC. The DOE has a plan to provide assistance to utilities (called Vision 2010) for studies on an early site permit and a combined construction and operating license (ESP & COL). A consortia of utilities, Westinghouse and General Electric called NuStart Energy Development LLC, a consortia headed by Dominion Power and a consortia headed by the Tennessee Valley Authority is currently studying ESP/COL applications and has asked DOE to provide cost sharing. By September of this year between 2-5 sites will be selected.
What are the goals for new nuclear plant construction in the US?
To meet near term future power requirements, 5 new plants of so called “Generation 3+ Passively Safe” designs are hoped to be operational by 2015. Thereafter 3-5 plants a year are required just to maintain the current mix of energy sources and replace retiring plants. Some 50 new 1000Mwe nuclear plants will be needed by about 2025. By 2030 new Generation IV advanced designs should be coming on-line.

Are there any plans for building new nuclear plants in SC?
In a recent article in The State newspaper, Representative Gresham Barrett R-SC believes the time is right for a new nuclear power plant to be built in SC. He believes a suitable site would be at Savannah River and plans on conducting hearings on this topic.

What plant designs are the “front-runners” in this new initiative?
GE has an advanced boiling water reactor operating in Japan that has been certified by the NRC. Westinghouse has recently had its new AP1000 pressurized water reactor certified by the NRC. There are other designs available, notably from France and Canada, but for the US it is probable that US vendors will be selected.

What are the advanced Generation IV nuclear power plants?
A total of 10 nations, including the US, are presently combining their resources to determine the best design for the next generation of nuclear plants. The design goals address improved thermal efficiency, increased safety and proliferation resistance, improved economics and sustainability. Significant engineering research and development will be required over the next two decades on these designs.

Will breeder reactors ever be used?
Breeder reactors are a major consideration for the Generation IV designs. The breeder reactors will use the Uranium 238 isotope, which is abundantly available, to breed plutonium 239, the fissionable isotope that generates the power. There are sufficient reserves of uranium 235 to provide sustainable power for thousands of years.

What is driving the resurgence of nuclear power?
Increased concern for global warming, increasing oil prices, Middle East turbulence, and competitive operating costs. Additionally, the high reliability and safety record of the US nuclear industry has played a major role in public acceptance.

How many nuclear plants are there in the world?
At the present time ~ 440 nuclear plants are operational in the world. Additionally about 35 new plants outside the US are on order or under construction.

How does the US compare to the rest of the world in nuclear capacity?
Presently we are the worlds #1 producer. We roughly equal the second and third highest producers combined. We produce roughly one third of the world’s nuclear generated electricity.

How reliable is nuclear power?
From 1993 to 2003, nuclear power stations increased in overall efficiency equivalent to an additional 18 power plants. Nuclear plants are currently operating at about 90% capacity.

ECONOMICS OF NUCLEAR POWER

What is the cost of producing electricity?
For nuclear and coal the operational and maintenance costs are comparable: ~1.7c kw-hr. For oil/gas: ~5-6c kw-hr.

What is the capital cost of a nuclear power plant?
The operating costs, which include maintenance, are low. But the capital cost is high, and the construction period is long, primarily due to licensing uncertainties. Since it is a long time since a new nuclear plant has been built in the US, the cost of first time design and construction is estimated to be about 60% higher than a coal fired power station. For a 1000Mwe nuclear plant the cost will be about $1.5Billion. For reasonable discount rates (10%) and equity interest rates (15%) this translates to a total cost of 6c/kw-hr for nuclear vs 4c/kw-hr for coal. The cost of subsequent plants, particularly with standardized designs, will gradually approach that of coal fired plants.

What can be done to make the cost of nuclear plants more attractive to investors?
There are several initiatives currently underway. First: a production tax credit of $18/ Mwt-hr for the first 8 yrs of production, similar to that given for renewable energy forms (eg wind/biomass) would have a big impact. This is
being studied by Congress Second: a 20% investment tax credit for first time plants is also being examined by congress. Third a carbon tax is being considered for fossil fuel power stations, and fourth: a cost share between industry, government and vendors is being considered for first time plants. Additionally, the government is seriously looking at federal loan guarantees to back up corporate bonds. All of these initiatives will substantially offset any investment uncertainty in nuclear power plants.

ENVIRONMENTAL CONCERNS

What is global warming?
Carbon dioxide emissions from burning fossil fuels create a greenhouse effect around the earth and traps heat from the sun. Other gases such as ozone also have an effect.

What is the effect of global warming?
Global warming will result in melting of the polar ice-caps which will gradually result in increased sea levels and climate changes. Over the past 150 years the sea level has increased by about 12 cm.

What are the carbon dioxide levels and how much global warming has occurred?
Prior to 1860, CO2 levels were steady at about 290ppm. Over the next 100 years, due to the industrial revolution, the CO2 levels steadily increased by about 10%. During the past 40 years, however, the CO2 levels have increased by another 17% to a total of 365ppm. This increase has resulted in a temperature rise of almost 2F. As a result of this temperature rise there are already signs of glaciers shrinking.

How does nuclear power effect global warming?
We can reduce CO2 emissions by use of energy sources such as nuclear, wind and solar. These sources of energy are good for producing electricity. In France, where about 80% of the electricity is from nuclear generation, CO2 emissions have been reduced over the past twenty years from 75 million tons to less than 20 million tons/year In the US, about 70% of all non-carbon electricity generation comes from nuclear power.

What about environmental pollution other than greenhouse gases?
Burning fossil fuels results in significant noxious gas emissions. Over the past 30 years, nuclear power plants have offset the following emissions from coal fired power stations: nitrous oxides—40 mtons, sulfur dioxide—80 mtons; carbonaceous gases—3btons.

What is the new government/industry initiative called Climate Vision?
Climate VISION (Voluntary Innovative Sector initiatives: Opportunities Now) is a Presidential initiative dated 2/03 to reduce greenhouse gas emissions per unit of economic output by 18% between 2002 and 2012. The nuclear industry has already contributed to ~1.5% (8% relative) of this goal through plant upgrades and improved capacity factors.

ALTERNATIVE TRANSPORT FUELS

How can we use nuclear energy to offset our need for oil?
Electricity can be used directly for transportation, as for example in batteries, but the technology is not well developed and batteries are heavy. The best approach appears to be to use either electricity or heat to generate hydrogen which is very light and can be used to replace gasoline. Significant engineering work is now being undertaken to accomplish design hydrogen powered vehicles during the next decade.

If we use electricity to generate hydrogen for vehicles, won’t this result in a shortage of electric power like there was in California a few years ago?
If we do not plan the transition correctly, there could well be a shortage of electric power. Furthermore, if all we do is use fossil fuels (coal, natural gas) to generate electricity, we will not help the greenhouse gas situation, which is the goal being addressed by the use of hydrogen. We must use a mix of renewables and nuclear to generate the hydrogen needed for vehicular transport.

Won’t the cost of hydrogen be greater than that of gasoline?
If we use current electrolysis technology, the cost of hydrogen is estimated to be about 70% greater than the cost of gasoline. ($2.5/kg, where 1kg=energy in 1 gallon of gasoline) With new technologies, however, such as high temperature steam decomposition, the costs are expected to become comparable. Furthermore, as the supply of gasoline becomes more limited, the price of gasoline will only increase beyond
current levels. In the past year, the price of oil has increased for ~$25/barrel to over $50/barrel.

NUCLEAR WASTE

What is nuclear waste?
There are two forms of nuclear waste: high level—which originates from nuclear fuel discharged from a nuclear reactor; and low level waste—which does not originate from spent fuel. High level waste disposal is the responsibility of the federal government while low level waste is the responsibility of states.

Doesn’t high level nuclear waste have to be stored for thousands of years?
The fission process creates a lot of new isotopes, some of which are very radioactive. Some of these isotopes have very long decay periods. After 10 years, the radio-activity in high level nuclear waste is reduced by a factor of 1000. After 500 years, the radio-activity is less than that of the original uranium ore.

What do we do with our high level nuclear waste?
The present US policy is to store high level nuclear waste in a deep geological repository. In the long term, it may be recycled—for example, some countries in Europe are already recycling spent fuel. Presently, spent fuel is being stored at reactor sites, but the government as been working for more than two decades to open a facility called Yucca Mountain in Nevada.

How is waste stored at reactor sites? Is it safe?
When fuel is freshly discharged from a reactor—which occurs once every one to two years—it is stored in the containment vessel of the plant in a special steel lined water tank, called a spent fuel pit, to keep it cool. The containment vessel is maintained under extremely tight security. After a few years, the fuel is sufficiently cool to be removed from the pool and stored on site but out of containment in specially designed casks weighing 50 tons. These casks are so dense that they are virtually impenetrable by unauthorized people (terrorists).

What is the status of Yucca Mountain? When will it be operational?
At his confirmation hearings, the new secretary for energy Dr. Bodmon, assure congress that he would give very high priority to Yucca Mountain. The issues are mainly legal and political. The technical issues have been very thoroughly addressed. Licensing acceptance will be pushed for this year. The facility is targeted for opening in the year 2012. Cost: about $7B to date.

Since no spent nuclear fuel has yet been stored for thousands of years, how can we be sure that it will be safe?
Actually, there is direct experience for millions of years with nuclear waste. It would appear that in the West African republic of Gabon, a uranium mine was discovered in 1972 that had up to 60% of uranium in the ore. The concentration was sufficient to sustain a nuclear chain reaction more than 200 million years ago. Scientists have determined that the chain reaction occurred intermittently over a period of 500,000 years! Despite being in a wet tropical region, the radioactive fission products remained locked in the natural repository and migrated only a few inches in millions of years. These radioactive fission products have long since decayed to stable isotopes.

Doesn’t spent nuclear fuel require a lot of space?
Nuclear fuel takes up a surprisingly small volume. All of the spent fuel in the US to date weighs about 50,000 tons. If all of it was stacked together it would take up a football field to a depth of about 16 feet.

Who pays for spent fuel storage?
When utilities order enriched uranium from the US government to refuel their nuclear plants a small surcharge is added for end use. These end use costs are intended to pay for long term government storage at a geologically mined underground facility such as Yucca Mountain. This cost roughly translates to 1c for every 10 kilowatt hours generated.

Why are some countries recycling nuclear waste?
During fission in a power reactor, not only are numerous highly radioactive isotopes generated, but more fissionable material such as plutonium is produced. If this plutonium, and the unused U235 is recovered, it can be recycled in a reactor to produce more power. In the process of recovering the fissionable material, the highly radioactive wastes are also isolated and converted into a stable compound with the properties of stable solid glass. These glasses make the radioactive isotopes very stable chemically. The glass like solid waste will also be eventually stored in deep geological repositories.
**How is spent nuclear fuel shipped?**
Spent fuel is usually shipped by road in a 25-40 ton cask with 1ft thick walls. If the shipment is by rail, the containers usually weigh 125 tons. The containers have to meet very strict design requirements to sustain natural disasters, fire and high-speed collisions. During the past 40 years more than 3000 shipments have taken place successfully in the US. In Europe, more safe shipments have already occurred than are planned for the total lifetime of Yucca Mountain (~175/year).

**What about waste from the military program?**
Nuclear waste from the military program has not been irradiated and is not highly radioactive. In the post cold war era, a major initiative has been taken to reclaim the highly enriched uranium and plutonium in bombs and to recycle these fissionable materials at greatly diluted levels in civil power reactors. While no military grade plutonium has yet been recycled in the US, a considerable amount of uranium has been recycled as a result of dismantling the bombs. Such action results in the world being a much safer place.

**When will plutonium be recycled?**
In Europe, plutonium from power reactors is being recycled already in small quantities. The US and Russia have a plan to build a high temperature gas cooled reactor in Russia, specifically for the purpose of reducing stockpiles of military plutonium. In the US, DOE have proposed a new processing plant to be built at Savannah River Site specifically for the purpose of recycling plutonium in current operating power reactors. Duke Power is presently pursuing a license to recycle low enriched plutonium in its power reactors.

**PROLiferATION**

**What is the concern with proliferation?**
The concern stems from the possibility of rogue nations or terrorists having access to nuclear materials that can be used for bombs. In the US, government policy on reprocessing of nuclear waste was reversed in 1977 during the Carter Administration for this reason. Other countries are reprocessing however –despite US policy. The international safeguards to prevent proliferation from recycling nuclear waste appear to be working well. Countries which are attempting to develop their own nuclear capability are generating their own plutonium.

**What is the risk of nuclear materials falling into the wrong hands?**
At the international level, a considerable amount of work is being done to prevent the proliferation of nuclear materials. In the post cold war era, for example, Russia has dismantled a large number of the earlier design highly enriched uranium bombs and diluted the U235 isotope for use in civil reactors. By the end of 2003, more than 200 metric tons of Russian weapons-grade uranium (enough for 8000 nuclear weapons) had been diluted and made into nuclear power plant fuel. Roughly one half of the uranium being used in US power plants today comes from this source.

**Will increased reliance on nuclear power lead to more atomic bombs?**
No. No country has ever used a commercial nuclear power plant to produce plutonium for an atomic bomb. The reason is that commercial nuclear power plants are very poor machines for producing weapons-grade plutonium and thus every country that has made nuclear weapons has built nuclear reactors specifically designed for that purpose. What history is telling us is that a country that wants to produce a nuclear weapon will produce a nuclear weapon, regardless of the existence of commercial nuclear power. Eliminating nuclear power will no more eliminate nuclear weapons than eliminating commercial aircraft would eliminate military fighter jets and bombers. Anti-nuclear activists try to equate nuclear power with nuclear weapons to turn the public against nuclear power, but their arguments are false.

**Can the used fuel from a nuclear power plant be used to make a bomb?**
Fuel discharged from a commercial nuclear power plant is very ineffective for making a nuclear weapon. That is why no country has ever done so. Even so, there are ways to make the used fuel even less attractive for use in a nuclear weapon such as adding materials to the fuel that disrupt the efficient chain reaction necessary for a nuclear weapon.

**Would outlawing nuclear power eliminate nuclear weapons?**
No. As history has shown, a country that wants to produce nuclear weapons will produce nuclear weapons without any involvement of commercial nuclear power. It is impossible to outlaw science and technology – the science and technology to create nuclear weapons exist and can’t be
eliminated by laws any more than the law of gravity could be outlawed by legislation. The only way to ensure that nuclear weapons won’t be manufactured or used is through diplomacy.

HEALTH

What exactly is radiation? Isn’t it harmful to people?
Radiation results from the disintegration of an atomic core to another atomic species. Radiation takes numerous forms---but the radiation of concern here is ionizing radiation and has electromagnetic wave like properties. Examples of radiation are: alpha and beta particles, and gamma rays which are similar to x-rays. Radiation possesses energy, which when absorbed in the body, is measured as a dose in rems. There are strict guidelines on the permissible rems a human being can be exposed to over a fixed period of time. (<1 rem/year).

For people living near a nuclear power plant, radiation levels from the plant are extremely low. According to health physics data, the population will receive a far larger dose of radiation from natural sources such as radon from granite, and radiation from cosmic rays. Radiation from a typical x-ray substantially exceeds that from living near a nuclear plant.

Doesn’t nuclear power generate a lot of harmful radiation?
During the fission process a large amount of radiation is generated. However, there are very strict requirements for the containment of radiation. Virtually no radiation goes beyond the containment vessel of the reactor. There are several levels of protection from radiation in a nuclear plant, the first being the nuclear fuel itself. Nuclear fuel in modern plants is made of a very stable oxide of uranium. Much of the radiation is actually trapped within the fuel itself. Secondly, the remaining radiation has a limited distance of travel and is absorbed within the pressure vessel which is made of steel plate 8 inches thick. And finally, the pressure vessel is enclosed in the containment structure which is made of four foot thick reinforced concrete. The accident at TMI provided us with some valuable lessons, one of which was to demonstrate that even for severely damaged fuel, the containment vessel served its design function and prevented radiation in harmful levels from reaching the public.

SECURITY / SAFETY

How secure are nuclear power stations from terrorist attacks?
Since 9/11 2001, the nuclear industry has spent more than $1B upgrading nuclear plant security. Nuclear facilities were regarded as the safest of all industrial sites even before 2001. Even greater security will be a major feature in the design of new power plants.

Could nuclear material be used in a “dirty bomb“?
In the US it would be virtually impossible for a terrorist to gain access to high level nuclear waste since this is contained in the fuel assemblies in storage. However, in the worst case, assuming a terrorist did get access to either high level or low level waste, the dirty bomb would use conventional explosives and as such the range would be limited. It is not possible for a dirty bomb to generate a nuclear reaction. Because nuclear material can be readily detected by instruments, it is probable that nuclear

Doesn’t plant maintenance result in workers being exposed to high radiation levels?
Plant workers are very carefully monitored for radiation. There is strict compliance with regulations. Additionally, today, considerable use is made of robotic technology which allows for maintenance in high radiation fields to be undertaken remotely.

Have people died as a result of radiation exposure from a nuclear power plant?
In the US no deaths have been attributed to radiation from commercial nuclear power plants. There are ~ 10,000 reactor years of safe experience with power reactors in the US. Even with the accident at TMI, no deaths were reported. Similarly, in the rest of the world, there are no reported deaths attributed to radiation exposure from LWR’s of the design used in the US.

Sadly, there are two limited incidents in other parts of the world where deaths have occurred not related to LWR operation. In the Ukraine, 34 people died from the Chernobyl accident in 1986. This type of accident is unique to the Chernobyl Russian RBMK design of reactor. In 1999, 2 Japanese technicians died as a result of violating a procedure for handling enriched uranium in a laboratory and created a critical mass which resulted in a high radiation field.
material would not be the substance of choice by terrorists for a dirty bomb.

How safe are nuclear power plants? Haven’t there been major safety issues in the past?
In the US there was a major accident at TMI unit 2 in Pennsylvania in March 1979. A partial core melt down occurred because operators incorrectly determined the water level in the pressurizer due to a stuck valve. However, because of the safe design of the plant, all radiation released from the partial melt down was confined to the containment building and the public was not exposed to abnormal radiation levels. In the Ukraine, a very serious accident occurred at Chernobyl in April 1986. The operators initiated an unauthorized experiment with the safety systems locked out. Because the reactor did not have a containment building-- as US plants do--a substantial amount of radioactive gas was discharged with serious consequences to the general public of the Ukraine, Russia and Belarus. An accident like that in Chernobyl is not possible in US designed plants.

Was the television show 24 realistic in its portrayal of a terrorist being able to take control of nuclear power plants via the internet and kill hundreds of thousands of people?
No, that show was absurd. For one thing, it is impossible to control nuclear power plants over the internet because their control systems are not connected to the internet. Moreover, a commercial nuclear power plant could not possibly cause the deaths of a large number of people. That is physically impossible and a paper in the prestigious journal Science said so. We also have actual history to back that up. The disaster at Chernobyl resulted in the near-term deaths of about thirty people. Since a commercial nuclear power plant could not possibly release radioactive material on the scale that occurred at Chernobyl, it’s impossible to cause the immediate deaths portrayed in 24.

Don’t the Chernobyl and TMI accidents prove that nuclear power is too dangerous?
Actually, they prove that nuclear power is not incredibly dangerous. The TMI incident was perhaps the worst possible thing that could happen to a commercial nuclear power plant and nobody was harmed. It was a financial disaster, but not a health disaster. As for Chernobyl, despite the repeated claims by the press that tens or hundreds of thousands of people were killed, according to a United Nations organization, only thirty to forty people died as a result of acute exposure to radiation. While an increase in thyroid cancer has been observed (1,800 cases), no other increase in cancers has been noted. And the real tragedy is that those thyroid cancer cases were largely preventable. Had the government response not been one of Soviet Cold War secrecy, the risk of thyroid cancer could have been reduced or eliminated simply by telling residents not to drink locally produced milk which contained radioactive iodine from Chernobyl.

Are today’s nuclear reactors safer than TMI?
YES! Many valuable lessons were learned from TMI. Today, reactor systems have redundant instrumentation which would have prevented the TMI accident. Additionally, regulators have now implemented industry wide significantly improved regulations, operator training and supervision practices. A new institute—INPO—Institute of Nuclear Power Operations—was formed in response to the Kemeny Commission recommendations. This institute is basically an industry watch dog which sets performance objectives, criteria and guidelines for the nuclear power industry. It also provides training for nuclear plant operators.

Have we had problems with power reactors in the US separate to the TMI accident?
The nuclear industry is highly regulated and all infractions are reported to the NRC and are a matter of public record. As instituted by INPO there has been a substantial and continuous improvement in operational standards over the past twenty years. Plants are subjected to frequent inspections and maintenance actions during refueling outages. For some of the older design nuclear plants, some operators have chosen to permanently shut down and decommission rather than extend the plant license. One of the reasons for this was the ageing and/or corrosion of materials used in the pressure vessel or piping. In later design plants, with more advanced materials, studies have shown that the ageing has stabilized and is acceptable. For a number of plants, major components such as new vessel heads and steam generators have been replaced to extend plant life. Welded joints on piping have also been upgraded to provide performance margin.

What is the major difference between current operating reactors and new reactors?
All of the lessons learned collectively within the nuclear industry will be applied to the new designs. For example, the new so called
generation 3+ designs will be designed for passive cooling in the event of a loss of coolant. That is, emergency cooling will be powered by gravitational feed to flood the reactor core rather than by back up electric generators. Additionally, the pressure vessels will be located underground to provide yet further deterrence to terrorist attacks.

PUBLIC PERCEPTION

What is the current public perception of nuclear power production?
In a recent survey, nationwide—67% of Americans favor nuclear power. For US college graduates—73% favor nuclear power.

EDUCATION

How many Universities have graduate NE programs?
Approximately 20 universities in the US have graduate nuclear engineering programs. The graduate program at USC is the first new NE graduate program in more than twenty years.

Does USC have an undergraduate NE program?
No, but an undergraduate NE program is now being offered by SC State University. Students from SC State will feed into the USC graduate program.

How many students are enrolled in NE programs, nationally?
Nationally, enrollment for undergraduate programs was about 1600 in the early 80’s. However, by the turn of the century, it had fallen to about 600 students. With the renewed interest in nuclear power during the past five years, undergraduate enrollment has more than doubled. Nationwide, graduate enrollment has been fairly flat at about 600 for PhD’s and 600 masters degrees over the past decade.

How many NE graduate students are enrolled at USC?
The USC graduate program was officially kicked off in the fall of 2003. At the present time we have a total of 16 graduate students enrolled in the NE graduate program. Nine of these students are on campus and seven are off campus and fully employed in industry. This semester there are a total of 34 course enrollments.

Why did USC decide to offer a NE graduate program?
South Carolina has a very large nuclear industry. Within a 120 mile radius of Columbia there is a total of 11 nuclear power reactors generating more than 10% of the nation’s nuclear electricity. While the nation consumes 20% nuclear energy on average, in South Carolina the nuclear electric production is 56% of total. Additionally, the Savannah River National Laboratory is within easy driving distance and one of the world’s largest nuclear fuel fabricators is on our doorstep. Being in the center of all this nuclear activity, we felt we were ideally positioned to serve the needs of this industry.

Why is the NE graduate program in the Mechanical Engineering Department?
The new NE program would fit in well with either the ME or the ChemE Departments—in fact research on the production of hydrogen from nuclear is being pursued cooperatively with both departments. Many disciplines, for example thermal systems, mechanics of materials, etc are major strengths in the ME Department.

What educational pre-requisites are needed to enroll in USC NE graduate program? Is a BS in NE required?
Because the NE program is a graduate program, candidates must meet the requirements of the USC graduate school. Normally a BS degree with a GPA of 3.0 or greater is a pre-requisite for graduate school. For the NE program, USC has made the decision that the undergraduate degree does not necessarily have to be in an engineering discipline. BS degrees in Computer Science, or Physics will be accepted. If the BS degree is not in engineering from an ABET accredited university, candidates will also be required to take the GRE exam.

What NE degrees are offered at USC and how long does it take to graduate?
For the masters degree a total of thirty credits are required. On campus students may take an MS degree requiring six of these credits to be a research thesis. For non-campus students a ME degree is offered exclusively through course work. Since we are offering six three credit courses a year, a graduate degree, in principle, can be earned in under two years. A PhD will take a similar period of time to complete, following completion of the masters program. We recognize however that not all students will complete the program this quickly and we allow up to seven years for those who need the extra time.
How do off-campus students receive course material?
We provide all course materials through our Distance Education program called APOGEE (A Program of Graduate Engineering Education). Students can download video streamed lectures of all courses and study the content at their leisure.

What funding does the US Government provide to universities for nuclear research?
For 2005 fiscal year the DOE budget for nuclear energy research is $510M. Of this, more than $24M is given to University research and reactor operation. DOE has recently awarded USC a grant of $1.5M to support the new graduate program.

Are scholarships and internships available for students?
YES! For full time students, scholarships are available. We have a number of funding sources available for research such as DOE, NANT, NSF etc. Also, our industrial partners are offering some internships.

Does USC have access to a test reactor?
YES! Through a cooperative program, one of our graduate courses makes use of the test reactor at NC State in Raleigh. For the long term, consideration is being given to designing a new test reactor for the SEC Universities to be housed at Savannah River.

Where can I find out more about USC NE graduate program?
You can visit us at our web site: http://www.me.sc.edu. There you will find hyperlinks to the NE graduate program.

CAREERS IN NUCLEAR INDUSTRY

What is the demand for graduates in NE?
Studies carried out by the Nuclear Engineering Department Heads Organization (NEDHO) have shown a major imbalance between the number of positions available and the number of NE students. For 2003, there were more than three times the number of positions available than the number of students. Since the nuclear workforce is ageing rapidly—a recent DOE study shows that 50% of the workforce could be retiring over the next 10-15 years—there will be a dire need for qualified nuclear engineers for a considerable period of time.