Nuclear Energy

Nuclear Energy

The wrong answer to energy needs

Desert Energy Project

Nuclear Energy

Paul Watkiss

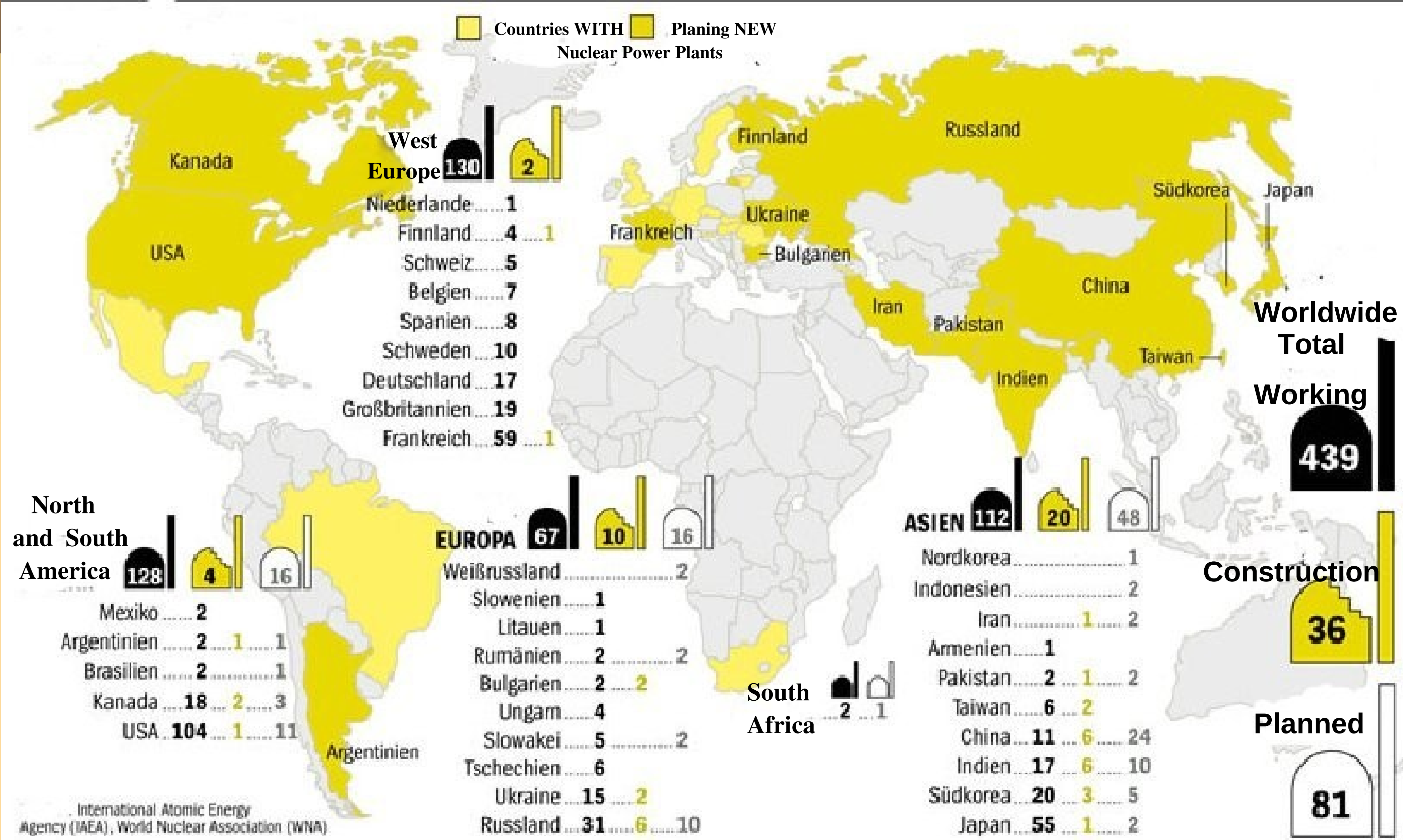
Employment Effects, Trade and Competitiveness
The effects of environmental legislation on employment, trade and competitiveness remain the subject of debate. A number of studies (OECD, 2004) have shown that effects from existing environmental legislation are low, and far less important than the effect of labour prices. However, there have been concerns that such effects might be more important for climate policy, given the large structural changes that would be required.

Lifestyle Changes
The move towards a low carbon society could possibly lead to changes in lifestyle. For example aviation costs could rise. Lifestyle changes could also involve more focus on communities and improvement in the local environment.

Technology Specific
Many of the low carbon modelling studies have shown relative increases in the use of nuclear power. The widespread adoption of this option, particularly in new countries without existing nuclear generation, might raise concerns over waste disposal, safety and (potentially) proliferation. These issues do not arise with carbon capture and storage, which might emerge as a significant option for large-scale power generation.

[1] Paul Watkiss, David Anthoff, Tom Downing, Cameron Hepburn, Chris Hope, Alistair Hunt, and Richard Tol: The Social Costs of Carbon (SCC) Review – Methodological Approaches for Using SCC Estimates in Policy Assessment. http://www.google.de/url?sa=t&source=web&ct=res&cd=31&ved=0CAcQFjAAOB4&url=http%3A%2F%2Fsocialcostofcarbon.aeat.com%2Ffiles%2FFinal%2520Report_7.doc&rct=j&q=Clarkson,+R.+and+Deyes,+K.+(2002),+Estimating+the+Social+Cost+of+Carbon+Emissions,+The+Public+Enquiry+Unit+-+HM+Treasury,+London,+Working+Paper+140.&ei=2F0rS_fWLIKt4QaFjNCBCQ&usg=AFQjCNGx-dBY9xZqdrGFC_JoBeAxr8nynw

Nuclear Power Plants



Nuclear Energy

Uranium mining contaminates ground water with alfa and beta radionuclides in Bahia, Brazil [1]

Alfa and beta radiation was found in drinking water and lakes of municipalities, Caetité, Lagoa Real and Livramento de Nossa Senhora in the state of Bahia, Brazil. The Ministry of Heath advises to stop drinking water or to use it in the kitchen. Safe drinking water will be supplied to the population by the municipalities.

Uranium mining involves deep geological encroachments setting free materials with adverse environmental consequences. Waste rock was often processed into gravel or cement and used for road and railroad construction. VEB Hartsteinwerke Oelsnitz in Saxony has processed 200,000 tonnes of material per year into gravel containing 50 g/t uranium. Thus, gravel containing elevated levels of radioactivity were dispersed over large areas. [2]

[1] Jornal do Pará. 10.11.2009.

[2] Uranium Mining and Milling Wastes: An Introduction. By Peter Diehl
http://www.wise-uranium.org/uwai.html

Nuclear Energy

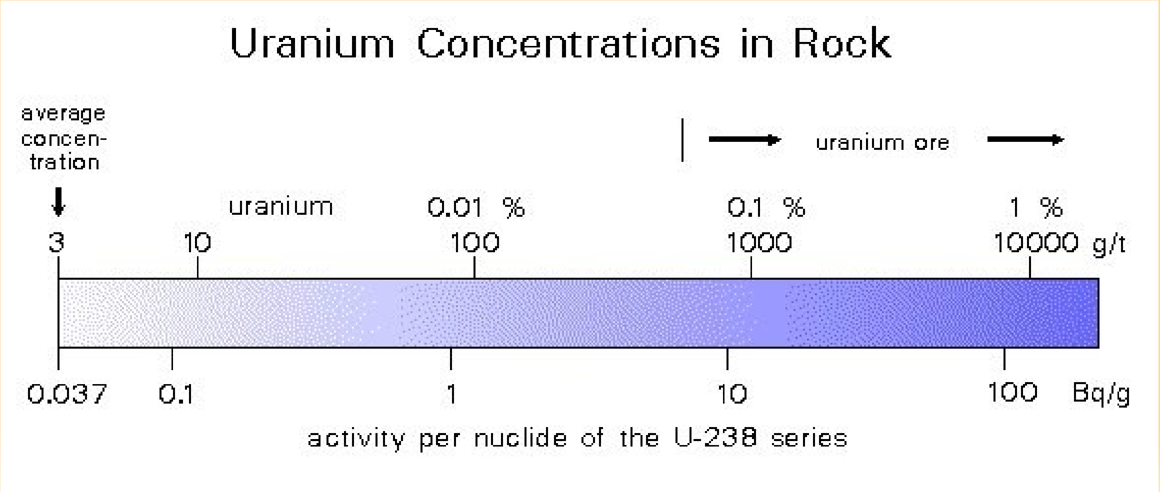
Caetité: A fragil ecosystem, contaminated by nucleids of uranium mine in Bahia/Brazil. Last drinking water reservoirs are unsafe.

http://www.ambienteja.info/imagem_full.asp?par=1419

Waste rock

Piles of so-called waste rock often contain elevated concentrations of radioisotopes compared to normal rock. Other waste piles consist of ore with too low a grade for processing. The transition between waste rock and ore depends on technical and economic feasibility.

All these piles threaten people and the environment after shut down of the mine due to their release of radon gas and seepage water containing radioactive and toxic materials



Nuclear Energy

Ranger uranium open pit
Canada

Lodève uranium open pit
France

To keep groundwater out of the mine during operation, large amounts of contaminated water are pumped out and released to rivers and lakes. When the pumps are shut down after closure of the mine, there is a risk of groundwater contamination from the rising water level.

Nuclear Energy

RIO TINTO

Rössing is one of the largest open pit uranium mines in the world, with solid reserves which will continue to serve the world nuclear energy industry. The mine currently produces about 7.55 per cent of the world's uranium. It is situated in Namibia, south-western Africa and started operations in 1976.

It is located close to the town of Arandis 65 kilometres inland from the coastal town of Swakopmund in the Namib Desert in the Erongo Region in Namibia.

Nuclear Energy

Nuclear Danger

The local mining company INB (Indústrias Nucleares do Brasil) says that there is no problem related to their company. However, it seems that INB is connected with the contamination of the surroundings of Caetité [1]. The search for the cause of the widespread contamination of public waters will take some time.

Mining, disturbing geologic stratifications with constructions of roads or reservoir dams may have freed nuclides leading to the contamination of the public waters of the region. Once again, mistrust rises against the proliferation of nuclear power plants which do not provide a safe disposal of the nuclear waste. Germany used the old salt mine Asse 2 as a repository. The mine is now being flooded by ground water and the caverns are collapsing. The Ground water of the surrounding region is in acute danger of contamination comparable to the municipalities in Bahia/Brazil.

[1] Vazamento de solvente orgânico com urânio em Caetité, Bahia. Ag Solve 27/11/2009. http://www.agsolve.com.br/noticia.php?cod=2693

Nuclear Energy

Environmental impact of runoffs from constructions and other soil disturbances [1]

Construction activities like clearing, excavating and grading significantly disturb soil and sediment. If that soil is not managed properly it can easily be washed off of the construction site during storms and pollute nearby water bodies. Soil runoff from construction has also reduced the depth of small streams, lakes and reservoirs, leading to the need for dredging.

The U.S. Environment Protection Agency EPA issued a rule which requires construction site owners and operators that disturb one or more acres to use best management practices to ensure that soil disturbed during construction activity does not pollute nearby water bodies. Owners and operators of sites that impact 10 or more acres of land at one time will be required to monitor discharges and ensure they comply with specific limits on discharges to minimize the impact on nearby water bodies.

Soil and sediment runoff of construction sites is one of the leading causes of water quality problems. Rin sediment discharges to surface waters resulting from the regulation will enhance or protect aquatic ecosystems currently under stress.

Total costs of U.S. water treatment and drenching are estimated by EPA to be USD 1 billion/year.

[1] Environmental Impact and Benefits Assessment for Proposed Effluent Guidelines and Standards for the Construction and Development Category. EPA November 2008.
http://www.epa.gov/waterscience/guide/construction/proposed/proposed-env-20081120.pdf

Nuclear Energy

In situ leach uranium mining
Water infused with sodium bicarbonate, or baking soda, is pumped underground and into the formation containing uranium.

The uranium is dissolved in the sodium bicarbonate solution as it is pumped through the ore and then to the surface, where the solution is processed and the uranium is recovered.
The U.S. Nuclear Regulatory Commission issued a report which found most of the in situ mines' operations would take at most a small toll on the groundwater, depending on specific geologic conditions unique to each site. The report did find, however, the mines' impact on deep aquifers could be large depending on site-specific conditions.

[1] Uranium digs up major players. Other companies closely watching Powertech USA
http://www.coloradoan.com/article/20091221/NEWS01/912210315/1002/CUSTOMERSERVICE02

Nuclear Energy

Several studies analysed the potential of CO2 reduction using nuclear energy. The Environment Instituite of Munich found that tripling the capacity of nuclear power stations until 2050 will avoid the generation of five billions of tons of CO2 from coal and natural gas power plants. Environmentalists say, however, 20 to 40 billions must be spared until 2050.
Tripling nuclear power stations can provide only12.5 to 40 percent of the needed change of the energy market. To rely on nuclear power plants several thousand of them would have to be built in a very short time. This is not feasibly and there is insufficient uranium to fuel these plants.

Thorium is no alternative to Uranium. It never worked in the Thorium High Temperature Reactor of Hamm-Uentrop/Germany. Other technologies also failed as seen with the fast breeder reactor of Kalkar/Germany, which remained stuck in trial operation.

Nuclear Energy

Nuclear Economy

The German party CDU (Party of the chancelor Merkel) isued a strategy paper according which nuclear energy is advantageous compared with other energies.

The Environmental Institute Munich contradicts saying:

Electricity from nuclear power plants have a seeming advantage to be a comparable low CO_2 emitter.

Nuclear power plants: produce only electricity.

Crude oil: is mainly used as fuel for transportation.

Natural gas: is mainly used for heating.

Fossil energy sources are not in direct competition with nuclear energy. The global share of nuclear energy of the total energy economy was in 2005 only 2 to 3 per cent, meanwhile solar, wing and other renewable energies hat a share of 20 per cent.

The future market will be strongly influenced by lobbying of the the different energy sectors and the reaction of politicians.

Nuclear Energy

Nuclear Danger

The fast breeder or fast breeder reactor (FBR) is a fast neutron reactor designed to breed fuel by producing more fissile material than it consumes. The FBR is one possible type of breeder reactor.

The reactors are used in nuclear power plants to produce nuclear power and nuclear fuel.

Nuclear Danger

Natural uranium: > 99.2% U-238 and 0.72% U-235
Low enriched uranium (reactor grade): 3-4% U-235
Highly enriched uranium (weapon grade) 90% U-235

Military use
To build a bomb plutonium or highly enriched uranium (HEU) is necessary. A simple bomb following the priciple of cannon tube 20-25 Kg of HEU 90% are needed.
Using the implosion principle only 3 – 7 Kg nach dem Implosionsprinzip nur noch 3 – 7 kg HEU are needed. Using 50% enriched Uranium the tripple amount is needed.

A concentration below 20 % is considered as not suitable for nuclear weapons.

Nuclear Energy

Nuclear Weapons

	Total	Today
USA	70.000	10.656
Russia	1.200	10.000
China	600 / 1964	402
France	1. 300 / 1984	346
Israel	1.967	< 200
Great Bri	1.200	185
Pakistan	Since 1998	65
India	Since 1998	40
	Today total	21.894

New START (for Strategic Arms Reduction Treaty) which is supposed to be signed in late 2010 says that the number of nuclear warheads should be reduced to 1.675 for each side and launcher systems reduced to 1.100.

Nuclear Energy

Most measures already taken to combat global warming are beneficial also for current explanation. However, $CO2$ sequestration and subsequent storage will have very little effect on the global warming. It is also concluded that nuclear power is not a solution but part of the problem.

GLOBAL WARMING IS GLOBAL ENERGY STORAGE
Bo Nordell and Bruno Gervet

Nuclear Energy

Water Cooled Reactor

Common Water Pressure Reactor such as the EPR use only 1% of the uranium to produce energy. Cooling water is heated to 300°C. The heat generates steam which is used to produce electricity. Danger come up when cooling system fails and temperature increases uncontrollable.

High Temperature Reactor

Thousands of spherical fuel assemblies heat helium gas up to 1000°C which drives the turbine directly. Efficiency ist booted. Failure of the cooling system does not cause core melting.

Quick Reactor

It works with quick neutrons and is 60 times more efficient compared with other reactors. Some use sodium and other use helium as coolant. However, this reactor type produces high amounts of polonium which is extremely dangerous.

Nuclear Energy

Nuclear power plants need enormous amount amount of cooling water. Therefore they are built near rivers. The temperature of the river rises by 2 to 3 degrees centigrades.

In 2005 a drought forced German nuclear plants to reduce their power. The low volume of the rivers could not provide sustainable cooling.

Nuclear power plants also have to discard their waste.

Nuclear Energy

Waste enquiry for 2007 (not including spent fuel elements)

The largest part of radioactive residues and radioactive waste produced in Germany arise:

* in connection with energy generation in nuclear power plants,
* in research and development,
* in medicine and industry and through the decommissioning or
* dismantling of nuclear installations.

Type of residue	With negligible heat generation	Heat-generating
Untreated residues (utilisable residues and primary waste) *Stock at the end of 2007*	18,506 m^3	63 m^3
Interim products *Stock at the end of 2007*	8,541 m^3	1,252 m^3
Conditioned waste *Stock at the end of 2007*	91,077 m^3	544 m^3
Waste produced in 2997 (reported amount)	2,383 m^3	0 m^3
Amount of waste prognosticated for 2008	4,736 m^3	56 m^3

Total Waste stored in Germany 2007 = 119,983 m^3

(Not including spent fuel elements)

The amount of waste arising in the medical field, however, is negligible with less than 0.5 percent by volume. Furthermore, radioactive waste resulting from the treatment of fuel elements from German nuclear installations in French and British reprocessing plants is returned to Germany as agreed in the relevant contracts. Apart from this waste, there are spent fuel elements which will be disposed of directly, i.e. without reprocessing, and which are considered as high-level radioactive waste.

Nuclear Energy

GERMANY

In Germany, radioactive waste intended for disposal is divided into heat-generating radioactive waste and waste with negligible heat generation. The group of heat-generating waste comprises mainly spent fuel elements and liquid high-level radioactive waste (fission product solutions) from the reprocessing of spent fuel elements. This liquid waste is concentrated and melted into glass blocks (vitrified waste canisters).

The group of waste with negligible heat generation includes other primary waste such as cleaning cloths, disused tools, used filters or residues from waste water treatment.

Germany started radioactive waste management in 1967 with dumping 80 drums filled with radioactive waste into the Atlantic Ocean around 800 km from the Portuguese-Spanish coastline. However, the waste management options explored in Germany ever since have exclusively concentrated on the emplacement of all types of radioactive waste in deep geological formations so that the waste is kept away from the biosphere as long and as safely as possible.

Nuclear Energy

Finnland
In 2020 operation of a repository could be started. It is planned to seal the repository by 2130 (110 years of operation.
http://www.posiva.fi/englanti/tutkimus_olkiluoto.html

USA
For the disposal of spent fuel elements the Yucca Mountain site in Nevada/USA has been investigated and planned in greatest detail so far.
http://www.ocrwm.doe.gov/ym_repository/index.shtml

Japan
The repository is to start its operation between 2033 and 2038. Cost of planed repository of vitrified material
33 Billion USD
http://www.numo.or.jp/en/faq/main1.html

Great Britain
Site-selection is to be carried out on the basis of voluntariness and local partnerships. 20 to 30 years are scheduled for the period starting when the decision about the site-selection procedure has been made until the repository will be taken into operation.
http://www.corwm.org.uk/default.aspx

Canada
Canada plans to handle a repository in thee phases, starting with the preparation of the site-selection procedure and ending with the sealing of the repository after a monitoring phase. The entire procedure has been scheduled for a period of up to 120 years altogether.

France
France will create new storage capacities above ground until 2015.

Nuclear Energy

No safe repositories for nuclear waste

Two German nuclear waste repositories are unsafe
Repositories Asse 2 and repository Morsleben in Germany are a global demonstration that there are no safe repositories of nuclear waste. Nuclear power plants produce deadly waste for million of years.

Asse 2: The Heimholt institute had been commissioned with the task to look for a disposal of nuclear waste of the German nuclear power plants. The institute stored the metal drums containing low and middle radioactive waste, together with highly poisonous polonium and chemical waste of pesticides in a salt mine called "Asse 2".

The salt mine is collapsing endangering anyone who tries to assess special sections of the repository. Faulty recordings during storage make it difficult to decide on how to contain the radioactive spill leaking from defective drums and contaminating groundwater which enters the repository.

The Heimholt Institute transferred the maintenance of Asse 2 to the Environment Department of Germany.

The German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz (BfS)) recommended to recover 126.000 drums from the collapsing salt mine Asse 2 and transfer them to the repository "Konrad" located 20 km from Asse 2. The costs of this transfer will be 2 Billion Euros, from the taxpayers. Politicians call for a nuclear fuel rod tax of 0,06 Euro/kW to pay for nuclear waste disposal costs.

Morsleben: Movement of tectonic plates caused leak of radiation of the Morsleben repository. There is no way to recover the stored nuclear waste,. The repository is therefore being filled with salt cement. This operation will take a decade.

http://www.spiegel.de/politik/deutschland/0,1518,672051,00.html

Nuclear Energy

Asse 2

All barrels have to be transferred to the "Konrad" repository.

It is going to be a hard job to get this mess cleaned up.

Costs: up to 4 Billion Euro

Nuclear Energy

Salt mine Gorleben/Germany

The mine will be used as repository for high radioactive nuclear waste.

Conditioning

Gorleben is filling quickly, so the volume of waste is being reduced with technology. Embedding the waste with specific materials is to keep temperature downof a critical point to avoid possible chain reactions:

Liquid waste: Is dried, cemented, bituminised or vitrified.

Solid waste: Is crunched, dried, burned, pyrolysed, melted, compacted or cemented.

Will it be safe for the next 1,000 Years?
Will it be sufficient to bear the nuclear waste of the next 200 years?

Bullflex seal system in Morsleben/Germany

This system is used to closes filled parts of repositories.

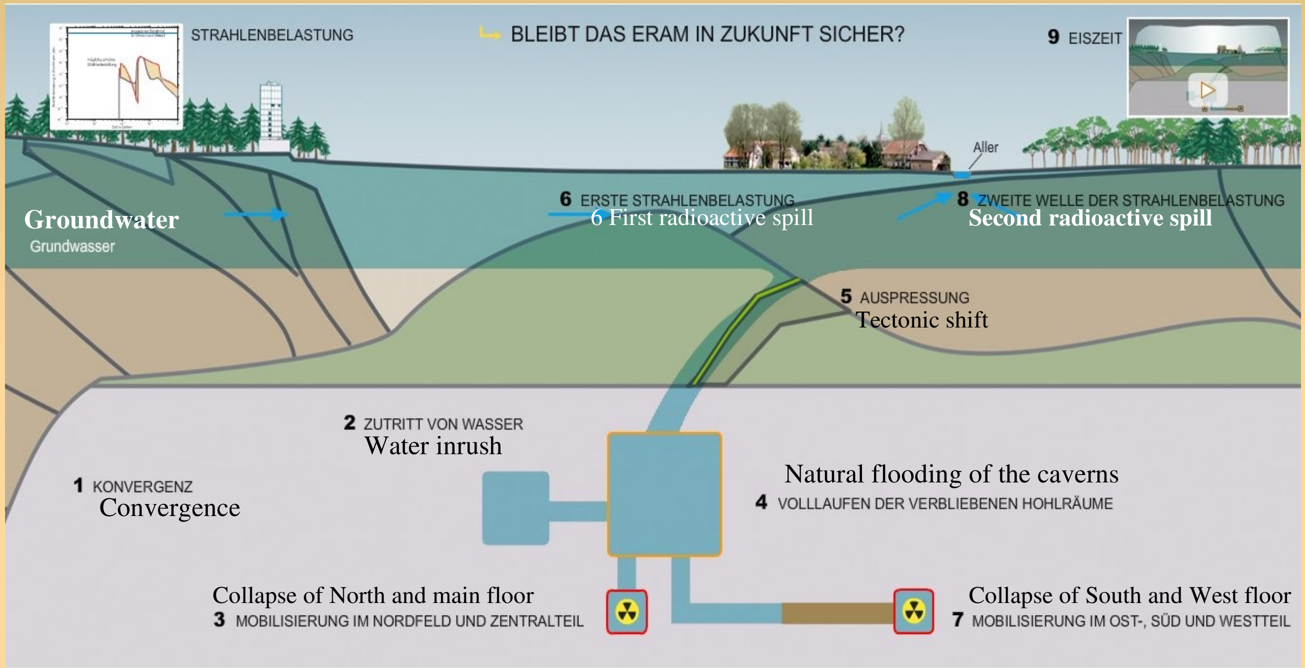
Salt cement is also used in Morsleben

Nuclear Energy

Leaking Repository "Morsleben" Germany

Tectonic plates of Morsleben/Germany

Movement of the plates caused water leak in the repository of nuclear waste. Two radiation contamination of ground water and the river "Aller" turned it necessary to fill the repository with salt cement.



http://www.bfs.de/en/endlager/morsleben.html

Nuclear Energy

Morsleben Repository

The whole repository must be filled with salt cement to avoid further radiation spills.

The needed amount of cement is so large that it wil take a decade to complete to work. Therefore best facilities and tubings are provided.

Movement of tectonic plates are not predictable.

Nuclear Energy

United States of America

Only one deep geological repository near Carlsbad, New Mexico is existent. Only special radioactive waste with interest in future recovery is stored there.
http://www.nuc.berkeley.edu/files/SingleGlobalRepos.pdf

There are no other deep repositories in USA. Storage is being done in free nature without ground water protection. Only some metres of soil cover is used to hide it.

USA stores nuclear waste unprotected.

Nuclear Energy

Deadly Inheritance

Global amount of high radioactive waste

	2007	2020
Total	300 000 Tons	445 000 Tons
Plutonium	2 000 Tons	3 000 Tons

IAEA, WNA, ISIS

If more nuclear power plants are build the prognosis for 2020 will increase significantly.

Nuclear Energy

Radiation hazard

Deadly radiation dose: a single dose to the whole body 600 rems (600.000 millirems) is lethal.

Radiation sickness: 100 whole body rems can cause radiation sickness.

Lymph nodes, spleen and blood cells: 10 rems may damage lymph nodes and spleen, decrease the bone marrow and the blood cells, although the symptoms are not felt.

Low radiation: Even a few millirems over a long period are considered as harmful. The radiation disrupts the DNA and RNA of the cells. If the repair potentials of the body are exceeded, illness, reduced life expectance and cancer may result. Human tissues of gonads, tyreoid and bone marrow are especially sensitive to radiation.

Some radioisotopes have particular affinities.
Strontium 90 is bone seeker. Iodine concentrates in the thyroid.

Nuclear Energy

Conclusions on Deep Geological Repository
By The Uranium Institute
Twenty Fourth Annual International Symposium 1999

The deep geological repository is the only ethically correct solution in the long term which gives passive protection to far future generations. It allows retrievability, if needed, for a certain time before final closure. The deep repository is in all cases an unavoidable solution. Separation and transmutation could be a partial, and very expensive, solution. It could only be a complementary solution to a deep repository.

Surface or shallow storage is a temporary solution. It could never be considered a permanent solution. The do nothing option, i.e. to leave the waste indefinitely in scattered surface storage locations, is not ethically acceptable. Our generation must prove that a solution does exist to provide passive protection to far future generations against nuclear waste.

Our generation must provide the financing, make all the studies, and create a consensus to demonstrate the feasibility of deep repositories. Our children will have the responsibility to take the decision to implement or not to implement such repositories. Our grandchildren will have the responsibility to keep such repositories open for a certain period of time, and eventually to close them to assure long term passive protection.

Deep Geological Repository: an Unavoidable and Ethically Correct Solution. By The Uranium Institute. Twenty Fourth Annual International Symposium 1999
http://www.world-nuclear.org/sym/1999/allegre.htm

Nuclear Energy

Nuclear power phase-out in Germany [1]

In 2000 German government decided the nuclear power phase-out on regard of safety concerns and the uncertainty related to permanent disposal of nuclear waste. The lifespan of nuclear power plants is limited to 32 years.

Nuclear plant of Muelheim-Kaerlich was closed and its 107.25 Terrawatt hours concession may be transferred to other plants of EWE.

For Biblis A the maximal production of 62 Terra Watt hours. The company wants to transfer 30 Terra Watt hours to Biblis A, aligning its lifetime with Block B to use the synergistic effect between both.

[1] RWE Power kaempft weiter um Biblis. 26. March 2009, RWE AG
http://www.rwe.com/web/cms/de/2320/rwe-power-ag/pressemitteilungen/?pmid=4003204

Nuclear Energy

Germany: Safety of Nuclear Power Plant Biblis Block A

Biblis Block A

The power plant is located at the river Rhine from which it take the cooling water.
Several cases of malfunction compromising the safety of the plant leaded to a series of upgrades and repairs on the system

Nuclear Energy

The EU is dependent on uranium suppliers

EU Dependence on Uranium

Russia	24.65 %
Canada	18.15 %
Niger	16.92 %
Australia	15.38 %
South Africa + Namibia	4.81 %
Uzbekistan	4.50 %
United States	1.93 %
Kazakhstan	2.67 %
EU	2.52 %
Other + undetermined	2.07 %
Ukraine	0.59 %
HEU feed	3.95 %
Re-enriched tails	1.86 %

Nuclear Energy

Three Mile Island
Harrisburg nuclear power plant

The Three Mile Island accident of 1979 was a partial core meltdown in Unit 2 (a pressurized water reactor) of the Three Mile Island Nuclear Generating Station near Harrisburg.

It was the most significant accident in the history of the American commercial nuclear power generating industry, resulting in the release of up to 481 PBq (13 million curies) of radioactive gases, but less than 740 GBq (20 curies) of the particularly dangerous iodine-131.

The nuclear power plant
Muelheim-Kaerlich

The site was planed to be build in a earthquake region and the building licence was withdrawn. After an incidence comprising the safety of the plant, its demolition was decide and will be completed in 2012. The plant worked only 100 hours.

Nuclear Energy

URENCO/Germany

Zentrifuges at the Uranium enrichment plant in Gronau

Endproduct with 7% U^{235} is returned to fuel rod production.
Depleted Uranium and Uranium hexafluorid is not considered nuclear waste. It can be transported and stored anyhow and anywhere.

Urenco stores this radioactive waste in its buildings without special safety
In January 22, 2009 an employee was contaminated with Uranium hexafluorid.

Abu Dhabi gets into dependence of the USA
The Emirates Nuclear Energy Corporation (ENEC) anounced that it signed a deal with South Korea of four blocks of nuclear reactors planed to deliver 1.4 GW/h each. The dealt mounted up to 20 billion. The power plant ist scheduled to work in 217.

The french offer was 36 billion. ENEC decided to take the South Korea offer.

Abu Dhabi imports already heavy amount of natural gas, also from Iran to satisfy its demand of 15,000 Megawatt/Year, which will increase to 40,000 Megawattin 2020.

Dependence: Abu Dhaby signed contracts for fuel rods from USA for its energy demands.

Disposal of nuclear waste: There is no way to get rid of it. USA will deposit it in the Deserts of Nevada.

http://www.spiegel.de/wirtschaft/unternehmen/0,1518,669140,00.html

Nuclear Energy

Nuclear armament
India launched its first nuclear submarin. It is build to carry nuclear warhead missiles. India becomes the sixst country with such armament.

India's rival Pakistan is in talk with the German submarine maker Howaldtswerke Deutsche-Werft (HDW) to acquire hydrogen driven submarines, also equiped with nuclear missiles.

The Government of India leases the newest Russian nuclear submarine “NERPA” for a period of 10 years. The leasing costs are 650 million USD.

In 2008 NERPA returned from the Japan sea after a first test voyage flying the flag at half mast following an incident which killed 20 crew members.

http://derstandard.at/1262209515849/Marine-mietet-russisches-Atom-U-Boot

Nuclear Energy

Pressurized Water Reactors

These reactors use a pressure vessel to contain the nuclear fuel, control rods, moderator, and coolant. They are cooled and moderated by high pressure liquid water. The hot radioactive water that leaves the pressure vessel is looped through a steam generator, which in turn heats a secondary (non-radioactive) loop of water to steam that can run turbines. They are the majority of current reactors, and are generally considered the safest and most reliable technology currently in large scale deployment.This is a thermal neutron reactor design, the newest of which are the Advanced Pressurized Water Reactor and the European Pressurized Reactor. United States Naval reactors are of this type.

Laguna Verde nuclear power plant

Boiling Water Reactors

A BWR is like a PWR without the steam generator. A boiling water reactor is cooled and moderated by water like a PWR, but at a lower pressure, which allows the water to boil inside the pressure vessel producing the steam that runs the turbines. Unlike a PWR, there is no primary and secondary loop. The thermal efficiency of these reactors can be higher, and they can be simpler, and even potentially more stable and safe. This is a thermal neutron reactor design, the newest of which are the Advanced Boiling Water Reactor and the Economic Simplified Boiling Water Reactor.

The CANDU Qinshan Nuclear Power Plant

Pressurized Heavy Water Reactor

A Canadian design, (known as CANDU) these reactors are heavy-water-cooled and -moderated Pressurized-Water reactors. Instead of using a single large pressure vessel as in a PWR, the fuel is contained in hundreds of pressure tubes. These reactors are fueled with natural uranium and are thermal neutron reactor designs. PHWRs can be refueled while at full power, which makes them very efficient in their use of uranium (it allows for precise flux control in the core). CANDU PHWR's have been built in Canada, Argentina, China, India (pre-NPT), Pakistan (pre-NPT), Romania, and South Korea. India also operates a number of PHWR's, often termed 'CANDU-derivatives', built after the Government of Canada halted nuclear dealings with India following the 1974 Smiling Buddha nuclear weapon test.

Nuclear Energy

The key to maintaining a nuclear reaction within a nuclear reactor is to use the neutrons being released during fission to stimulate fission in other nuclei. With careful control over the geometry and reaction rates, this can lead to a self-sustaining chain reaction, a state known as "criticality".

Natural uranium consists of a mixture of various isotopes, primarily 238U and a much smaller amount (about 0.72% by weight) of 235U. 238U can only be fissioned by neutrons that are fairly energetic, about 1 MeV or above. No amount of 238U can be made "critical", however, since it will tend to parasitically absorb more neutrons than it releases by the fission process. In other words, 238U is not fissile. 235U, on the other hand, can support a self-sustained chain reaction, but due to the low natural abundance of 235U, natural uranium cannot achieve criticality by itself.

The "trick" to making a working reactor is to slow some of the neutrons to the point where their probability of causing nuclear fission in 235U increases to a level that permits a sustained chain reaction in the uranium as a whole. This requires the use of a neutron moderator, which absorbs some of the neutrons' kinetic energy, slowing them down to an energy comparable to the thermal energy of the moderator nuclei themselves (leading to the terminology of "thermal neutrons" and "thermal reactors"). During this slowing-down process it is beneficial to physically separate the neutrons from the uranium, since 238U nuclei have an enormous parasitic affinity for neutrons in this intermediate energy range (a reaction known as "resonance" absorption). This is a fundamental reason for designing reactors with discrete solid fuel separated by moderator, rather than employing a more homogeneous mixture of the two materials.

Water makes an excellent moderator. The hydrogen atoms in the water molecules are very close in mass to a single neutron and thus have a potential for high energy transfer, similar conceptually to the collision of two billiard balls. However, in addition to being a good moderator, water is also fairly effective at absorbing neutrons. Using water as a moderator will absorb enough neutrons that there will be too few left over to react with the small amount of 235U in natural uranium, again precluding criticality. So, light water reactors require fuel with an enhanced amount of 235U in the uranium, that is, enriched uranium which generally contains between 3% and 5% 235U by weight (the waste from this process is known as depleted uranium, consisting primarily of 238U). In this enriched form there is enough 235U to react with the water-moderated neutrons to maintain criticality.
An alternative solution to the problem is to use a moderator that does not absorb neutrons as readily as water. In this case potentially all of the neutrons being released can be moderated and used in reactions with the 235U, in which case there is enough 235U in natural uranium to sustain criticality. One such moderator is heavy water, or deuterium-oxide. It reacts dynamically with the neutrons in a similar fashion to light water, albeit with less energy transfer on average given that heavy hydrogen, or deuterium, is about twice the mass of hydrogen. The advantage is that it already has the extra neutron that light water would normally tend to absorb, reducing the absorption rate.

The use of heavy water moderator is the key to the CANDU system, enabling the use of natural uranium as fuel (in the form of ceramic UO2), which means that it can be operated without expensive uranium enrichment facilities. Additionally, the mechanical arrangement of the CANDU, which places most of the moderator at lower temperatures, is particularly efficient because the resulting thermal neutrons are "more thermal" than in traditional designs, where the moderator normally runs hot. This means that the CANDU is not only able to "burn" natural uranium and other fuels, but tends to do so more effectively as well.

Nuclear Energy

The Ignalina Nuclear Power Plant - a still operating RBMK
Reaktor Bolshoy Moshchnosti Kanalniy (High Power Channel Reactor) (RBMK)
A Soviet Union design, built to produce plutonium as well as power. RBMKs are water cooled with a graphite moderator. RBMKs are in some respects similar to CANDU in that they are refuelable during power operation and employ a pressure tube design instead of a PWR-style pressure vessel. However, unlike CANDU they are very unstable and too large to have containment buildings, making them dangerous in the case of an accident. A series of critical safety flaws have also been identified with the RBMK design, though some of these were corrected following the Chernobyl accident. RBMK reactors are generally considered one of the most dangerous reactor designs in use. The Chernobyl plant had four RBMK reactors.

The Magnox Sizewell A nuclear power station

The Torness nuclear power station - an AGR
Gas Cooled Reactor (GCR) and Advanced Gas Cooled Reactor (AGR)
These are generally graphite moderated and CO2 cooled. They can have a high thermal efficiency compared with PWRs due to higher operating temperatures. There are a number of operating reactors of this design, mostly in the United Kingdom, where the concept was developed. Older designs (i.e. Magnox stations) are either shut down or will be in the near future. However, the AGCRs have an anticipated life of a further 10 to 20 years. This is a thermal neutron reactor design. Decommissioning costs can be high due to large volume of reactor core.

Liquid Metal
This is a reactor design that is cooled by liquid metal, totally unmoderated, and produces more fuel than it consumes. They are said to "breed" fuel, because they produce fissionable fuel during operation because of neutron capture. These reactors can function much like a PWR in terms of efficiency, and do not require much high pressure containment, as the liquid metal does not need to be kept at high pressure, even at very high temperatures. Superphénix in France was a reactor of this type, as was Fermi-I in the United States. The Monju reactor in Japan suffered a sodium leak in 1995 and is pending restart earliest in February 2010. All three use/used liquid sodium. These reactors are fast neutron, not thermal neutron designs. These reactors come in two types:

Nuclear Energy

The Superphenix, one of the few FBRs

Lead cooled

Using lead as the liquid metal provides excellent radiation shielding, and allows for operation at very high temperatures. Also, lead is (mostly) transparent to neutrons, so fewer neutrons are lost in the coolant, and the coolant does not become radioactive. Unlike sodium, lead is mostly inert, so there is less risk of explosion or accident, but such large quantities of lead may be problematic from toxicology and disposal points of view. Often a reactor of this type would use a lead-bismuth eutectic mixture. In this case, the bismuth would present some minor radiation problems, as it is not quite as transparent to neutrons, and can be transmuted to a radioactive isotope more readily than lead.

The Russian Alfa class submarine uses a lead-bismuth-cooled fast reactor as its main power plant.

Sodium cooled

Most LMFBRs are of this type. The sodium is relatively easy to obtain and work with, and it also manages to actually prevent corrosion on the various reactor parts immersed in it. However, sodium explodes violently when exposed to water, so care must be taken, but such explosions wouldn't be vastly more violent than (for example) a leak of superheated fluid from a SCWR or PWR. EBR-I, the first reactor to have a core meltdown, was of this type.

Pebble Bed Reactors

These use fuel molded into ceramic balls, and then circulate gas through the balls. The result is an efficient, low-maintenance, very safe reactor with inexpensive, standardized fuel. The prototype was the AVR.

Molten Salt Reactors

These dissolve the fuels in fluoride salts, or use fluoride salts for coolant. These have many safety features, high efficiency and a high power density suitable for vehicles. Notably, they have no high pressures or flammable components in the core. The prototype was the MSRE, which also used Thorium's fuel cycle to produce 0.1% of the radioactive waste of standard reactors.

Aqueous Homogeneous Reactor

These reactors use soluble nuclear salts dissolved in water and mixed with a coolant and a neutron moderator.

Nuclear Energy

India

Advanced Heavy Water Reactor
KAMINI
India is also planning to build fast breeder reactors using the thorium - Uranium-233 fuel cycle. The FBTR (Fast Breeder Test Reactor) in operation at Kalpakkam (India) uses Plutonium as a fuel and liquid sodium as a coolant. It can produce uranium for warheads.

Nuclear bomb tests

Nevada
Russia
In Algeria [1]: Starting in 1961, France conducted 17 nuclear test explosions at In Ekker, where it carried out underground blasts inside the mountain, and in the Reggane region of the Sahara desert, where it conducted surface explosions.
Nearly half a century later, local people - backed by Algeria's government - say the tests left a legacy of environmental devastation and health problems,
Hussein Dakhal, who lives in a village near In Ekker mountain,(2000 km south of the Algerian capital) is now 83. He remembers when, on May 1, 1962, the French conducted a test codenamed "Beryl.” It went wrong, letting radioactive material escape from inside the mountain. Since than nothing is normal. Infertility, cataracts are the problems that faced victims of nuclear tests in the region. Remember it is a remote area, and access to medical treatment is for many a luxury they simply can't afford.

[1] French nuclear tests in Algeria leave toxic legacy. Arab News March 5, 2010. http://arabnews.com/middleeast/article26049.ece

Nuclear Energy

Post Harrisburg nuclear power revival in USA [1]

“The Nation's approach, developed more than 20 years ago, to managing materials derived from nuclear activities, including nuclear fuel and nuclear waste, has not proven effective.

Scientists and engineers, meanwhile, learned a great deal about effective strategies for managing nuclear material. My Administration is committed to using this advanced knowledge to meet the Government's obligation to dispose of our Nation's used nuclear material.

Accordingly, I request that you establish a Blue Ribbon Commission on America's Nuclear Future (Commission) and appoint its members.

The Commission should conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of civilian and defense used nuclear fuel and nuclear waste. This review should include an evaluation of advanced fuel cycle technologies that would optimize energy recovery, resource utilization, and the minimization of materials derived from nuclear activities in a manner consistent with U.S. nonproliferation goals.” January 28, 2010.

[1] President Obama: MEMORANDUM FOR THE SECRETARY OF ENERGY
Blue Ribbon Commission on America’s Nuclear Future
http://theenergycollective.com/TheEnergyCollective/57855

Nuclear Energy

Molten Salt Reactor

A molten salt reactor (MSR) is a type of nuclear reactor where the primary coolant is a molten salt mixture, which can run high temperatures (for higher thermodynamic efficiency) while staying at low vapor pressure for reduced mechanical stress and increased safety, and is less reactive than molten sodium coolant. The nuclear fuel may be solid fuel rods, or dissolved in the coolant itself, which eliminates fuel fabrication, simplifies reactor structure, equalizes burnup, and allows online reprocessing.

In many designs the nuclear fuel is dissolved in the molten fluoride salt coolant as uranium tetrafluoride (UF4). The fluid becomes critical in a graphite core which serves as the moderator. Fluid fuel reactors have significantly different safety issues; the potential for major reactor accidents is reduced, while the potential for processing accidents is increased.

Members of the Blue Ribbon Commission are inclined to consider Molten Salt nuclear technology, and the thorium fuel cycle as potential remedies for the fuel cycle nuclear waste issue.
The Yucca Mountain approach to the nuclear waste issue is off the table, and it appears quite likely that the IFR is as well

Nuclear Energy

Integral Fast Reactor IFR

The Integral Fast Reactor (originally Advanced Liquid-Metal Reactor) was a design for a fast reactor (nuclear reactor using fast neutrons and no neutron moderator) distinguished by a nuclear fuel cycle using reprocessing via electrorefining at the reactor site itself.

In traditional water-cooled reactors the core must be maintained at a high pressure to keep the water liquid at high temperatures. In contrast, since the IFR was a liquid metal cooled reactor, the core could operate at close to ambient pressure, dramatically reducing the danger of a loss of coolant accident. The entire reactor core, heat exchangers and primary cooling pumps were immersed in a pool of liquid sodium, making a loss of primary coolant extremely unlikely. The coolant loops were also designed to allow for cooling through natural convection, meaning that in the case of a power loss or unexpected reactor shutdown, the heat from the reactor core would be sufficient to keep the coolant circulating even if the primary cooling pumps were to fail.

A safety disadvantage of using liquid sodium as coolant arises due to sodium's chemical reactivity. Liquid sodium is extremely flammable and ignites spontaneously on contact with air or water. Thus leaking sodium pipes could give rise to sodium fires, or explosions if the leaked sodium comes into contact with water. To reduce the risk of explosions following a leak of water from the steam turbines, the IFR, like other sodium-cooled fast breeder reactors, had an extra intermediate coolant loop between the reactor and the turbines. The purpose of this loop was to ensure that any explosion following accidental mixing of sodium and turbine water would be limited to the secondary heat exchanger and not pose a risk to the reactor. The requirement of such an extra loop significantly added to the cost of the reactor.

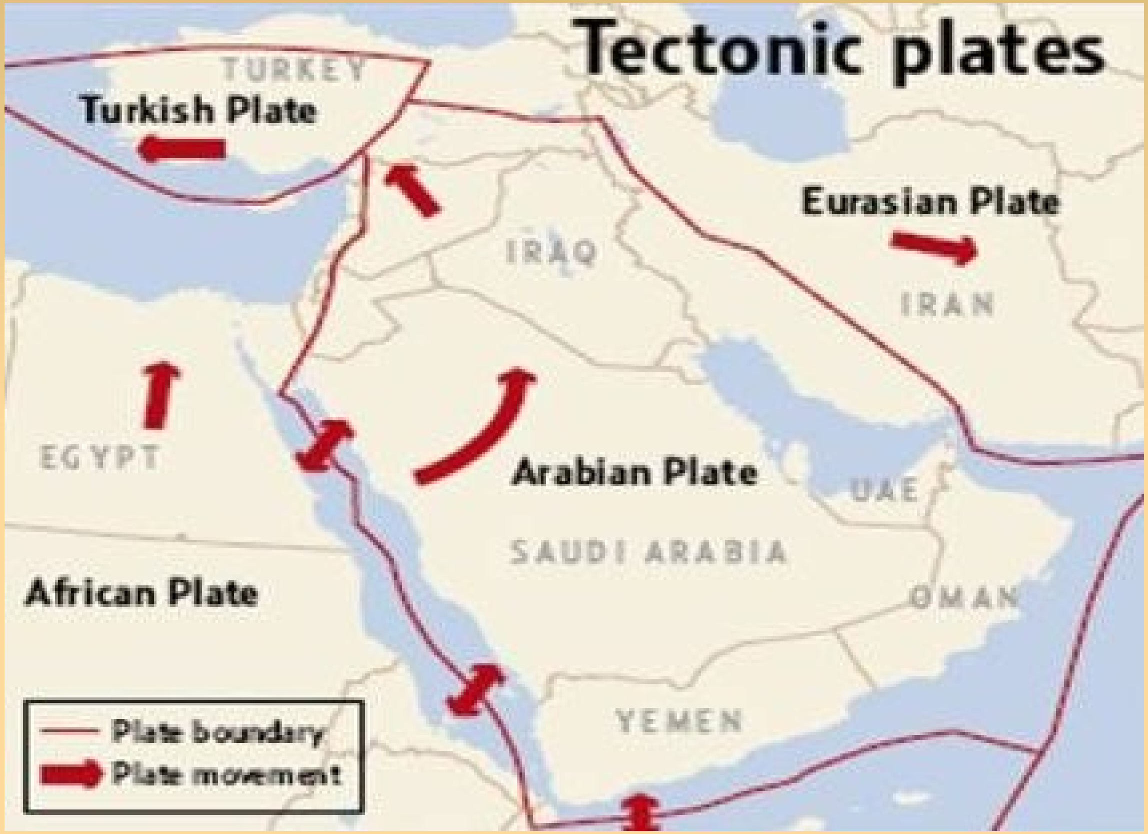
Nuclear Energy

Seismic threats to nuclear power plants and nuclear waste repositories [1]

The seismicity of the Arabian plate will become clearer with the establishment of the seismic networks in the GCC countries. These networks would provide a preliminary assessment of the seismic hazards in the region.

The region is affected by the tectonics of the Arabian plate, where earthquakes occur along the plate collision boundaries, said the statement. The northern and eastern boundaries formed and shaped by the folds of the Zagros Mountains of Iran and Turkey are known as one of the most seismically active areas in the world.

Earthquakes are common occurrences in the Makran fault, close to the borders of the Arabian Gulf region, and where earthquakes as large as magnitude 8 (in Richter scale) could occur.



[1] Gulf nations urged to link seismic networks. Gulf News. February 27, 2010. http://gulfnews.com/news/gulf/uae/environment/gulf-nations-urged-to-link-seismic-networks-1.589224

Nuclear Energy

Tremors affecting the UAE [1]

February 3, 2008: A series of tremors hit Ras Al Khaimah and Masafi area, which forced authorities to evacuate more than 800 students from two schools. The first earthquake measured 4.4 on the Richter Scale.

February 2, 2008: An earthquake measuring 3.4 on the Richter scale hit Dibba Al Fujairah at 5.44am. However, no injuries or damage to property was reported.

September 13, 2007: An earthquake hit Ras Al Khaimah and surrounding areas. It measured a magnitude of 4.6 on the Richter scale.

March 10, 2007: A moderate tremor and at least three aftershocks hit the UAE's East Coast, triggering panic and prompting residents in several areas of Fujairah and Ras Al Khaimah to run out of their homes.

June 29, 2006: A nighttime earthquake rocked southern Iran recorded as being between 5.4 and 5.6 on the Richter Scale jolted the Gulf region at about 1am and caused panic among many who felt the tremors. No damage was reported.

February 28, 2006: Residents in some high-rise buildings in Dubai and elsewhere in the UAE evacuated their premises after experiencing mild tremors at 11.31am.

Haiti earthquake

January 12, 2010: Deaths: 222,2512 Magnitude: 7.0

Chile earthquake

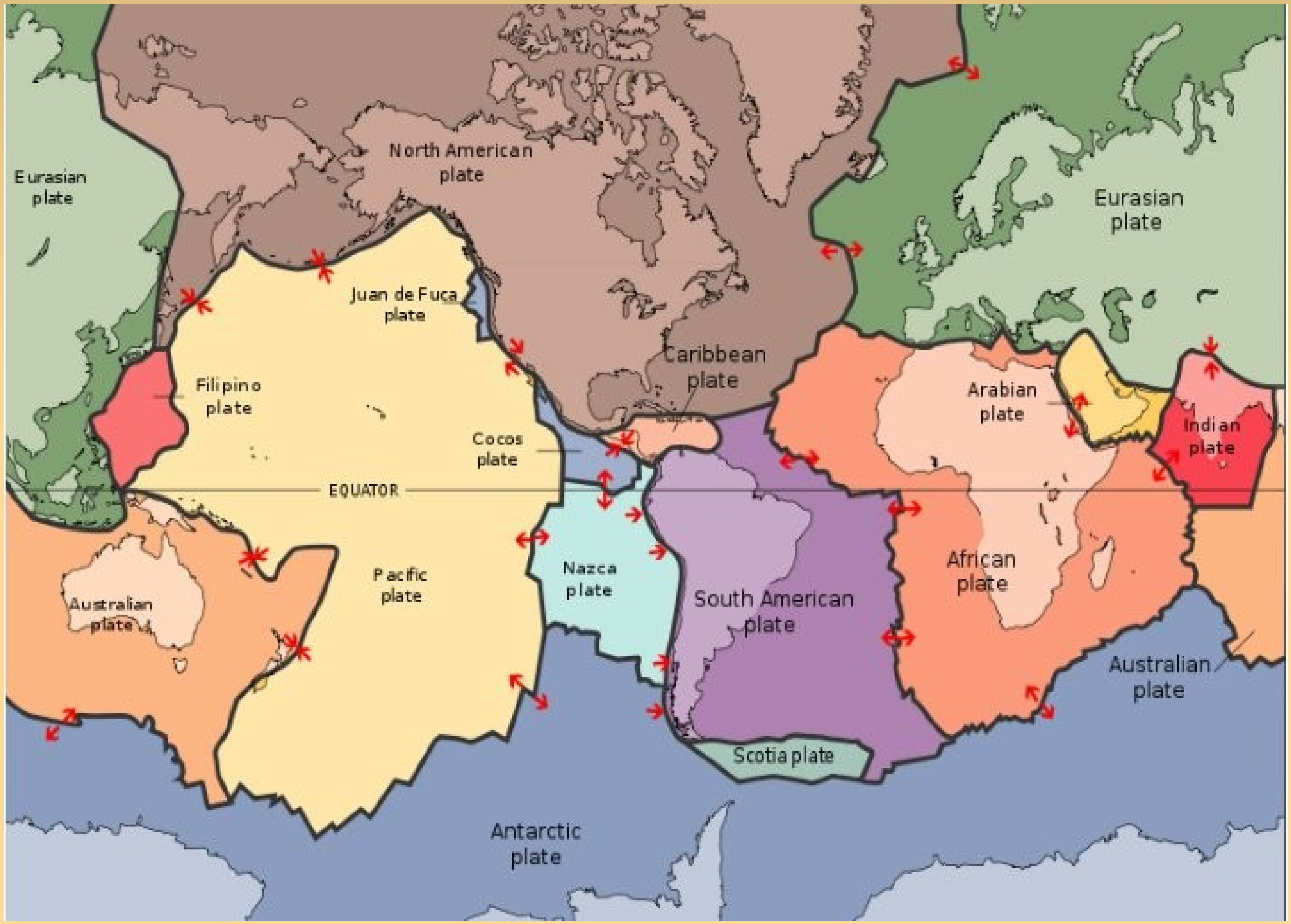
Febraury 27, 2010 : Magnitude 8.8

[1] Gulf nations urged to link seismic networks. Gulf News. February 27, 2010.
http://gulfnews.com/news/gulf/uae/environment/gulf-nations-urged-to-link-seismic-networks-1.589224

[2] http://neic.usgs.gov/neis/eq_depot/2010/2010_deaths.html

Nuclear Energy

Tectonic plates



Japan

1999 - Two workers killed in explosion at Tokaimura plant

2003 - 17 Tepco plants shut down over falsified safety records

2004 - Five workers killed by steam from corroded pipe at Mihama

2007 - Damage inflicted on Kashiwazaki plant from earthquake

Radioactive material leaked from the Kashiwazaki nuclear power plant

Nuclear Energy

Lowell Sachnoff

"Global warming is more of a threat than nuclear war."

http://www.newsdaily.com/stories/tre60d53x-us-nuclear-doomsday/

The End