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Status and Prospects for the Use of Nuclear Energy

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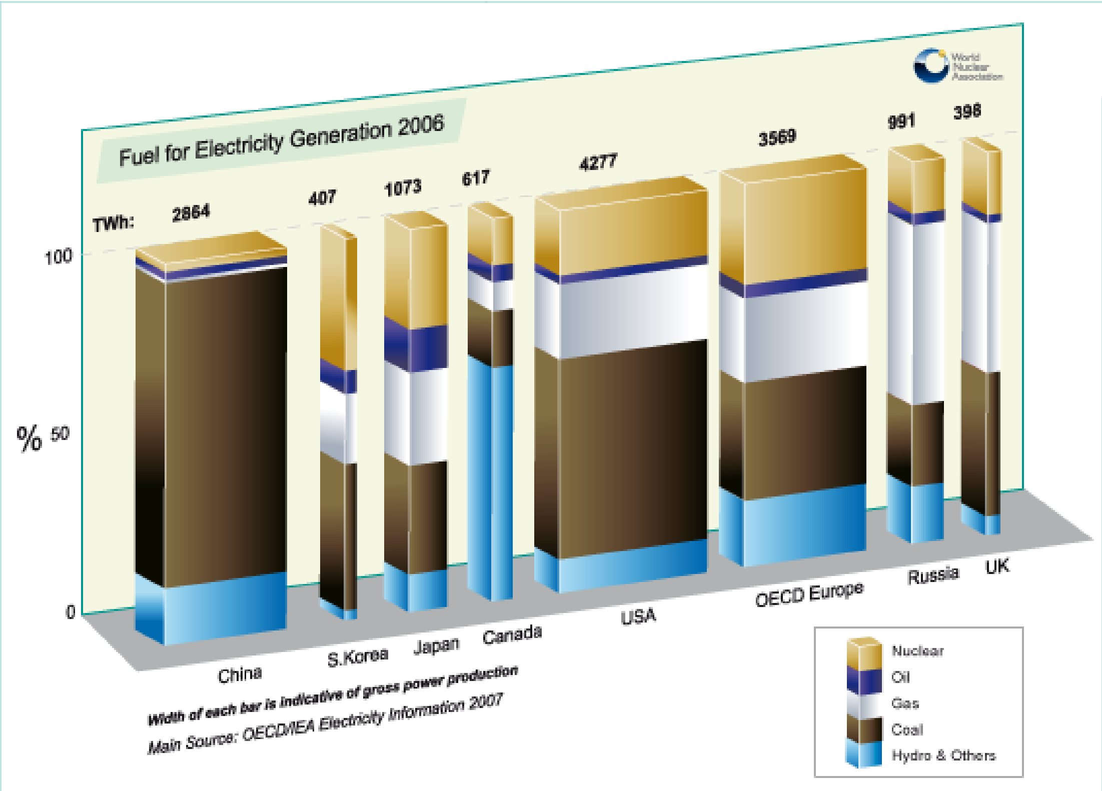
Most electricity today comes from coal (about 40%), natural gas (about 20%), hydro (about 16%) and nuclear (about 15%). The proportions in different countries vary. In the following Figure it can be seen that there is a lot of coal used in China, USA and Europe. This produces about one kilogram of CO2 per kilowatt-hour. Rather less electricity comes from gas, which is likely to become very expensive, and is better used for burning directly for heat, or making fertilizers. There is a lot of scope for expanding nuclear share.



World electricity demand is expected to double by 2030. The main technologies to achieve this will need to be low-carbon, and energy security is an increasing concern.
Nuclear power in world paper: http://www.world-nuclear.org/info/inf01.html
World energy needs paper: http://www.world-nuclear.org/info/inf16.html

Most electricity demand is for continuous, reliable supply on a large scale (known as base-load). This limits the possible contribution of non-hydro renewables, and hydro expansion is limited by natural endowment of water and mountains. Nuclear power is the sole well-proven source of zero emission power which can be expanded almost anywhere.

The main drivers for nuclear development are:
- **economics**: as fossil fuel prices rise.
Economics paper: http://www.world-nuclear.org/info/inf02.html

- **energy security**: uranium widely available from friendly countries, and easily and cheaply able to store a few years supply
- r**educing carbon emissions**: full nuclear fuel cycle emits about 2% of coal's CO_2
CO_2 emissions paper: http://www.world-nuclear.org/info/inf100.html
- **insurance against fuel price rises**: fuel is very small part of electricity cost
- **water use**: nuclear plants can readily be sited on coast, using seawater cooling, not evaporating fresh water.

But:
- **high capital cost** and delay in getting return on investment. Construction typically 4 to 5 years.
- **heavy engineering challenge**. Paper: http://www.world-nuclear.org/info/inf122_heavy_manufacturing_of_power_plants.html
- **wastes** have a bad press, but there is little of them, and civil nuclear wastes have been handled without incident for over 50 years.
Wastes paper: http://www.world-nuclear.org/info/inf04.html

Looking at particular parts of the world:

In **Europe**, while electricity demand growth is low, old plant needs to be replaced, and the EU has severe carbon emission restrictions. France, with 75-80% of its power from nuclear energy, is embarking upon a full replacement program over twenty years or so. All studies show nuclear as economically best option.
France paper: http://www.world-nuclear.org/info/inf40.html

Russia makes a lot of money and exercises a lot of influence selling gas to its neighbours, particularly EU countries. Two thirds of its own electricity is from gas, and this is the main driver of an ambitious program to build more nuclear capacity so as to export more gas. It also enjoys a technological advantage in fast reactor technology, and is selling this China.
Russia paper: http://www.world-nuclear.org/info/inf45.html

In **the USA** 17 licence applications have been lodged for 26 new nuclear reactors adding to the 104 now operating. Probably four of these plants will be built by 2020. Two new uranium enrichment plants are being built, two more are planned.
USA papers: http://www.world-nuclear.org/info/inf41.html
http://www.world-nuclear.org/info/inf41_US_nuclear_fuel_cycle.html

In **Japan**, 55 nuclear reactors provide 30% of the country's electricity (apart from recent Kashiwazaki Kariwa shutdowns), and this is expected to rise to 40% by 2017. Japan is unique among non-nuclear weapons states in having a full fuel cycle including enrichment, and reprocessing used fuel for recycling.
Japan paper: http://www.world-nuclear.org/info/inf79.html

China is on the way to a sixfold increase in nuclear generation capacity by 2020. It has nearly 20 reactors under construction and about 30 more ready to start building in the next two years. It is the first country to be building the most modern western reactor type - the Westinghouse AP1000, and it intends building many of them as well as its own CPR-1000 design (derived from a French one).
China paper: http://www.world-nuclear.org/info/inf63.html
http://www.world-nuclear.org/info/inf63b_china_nuclearfuelcycle.html

India has great ambitions, and now that trade is opening up with the rest of the world it is planning a big expansion of nuclear power using both indigenous and

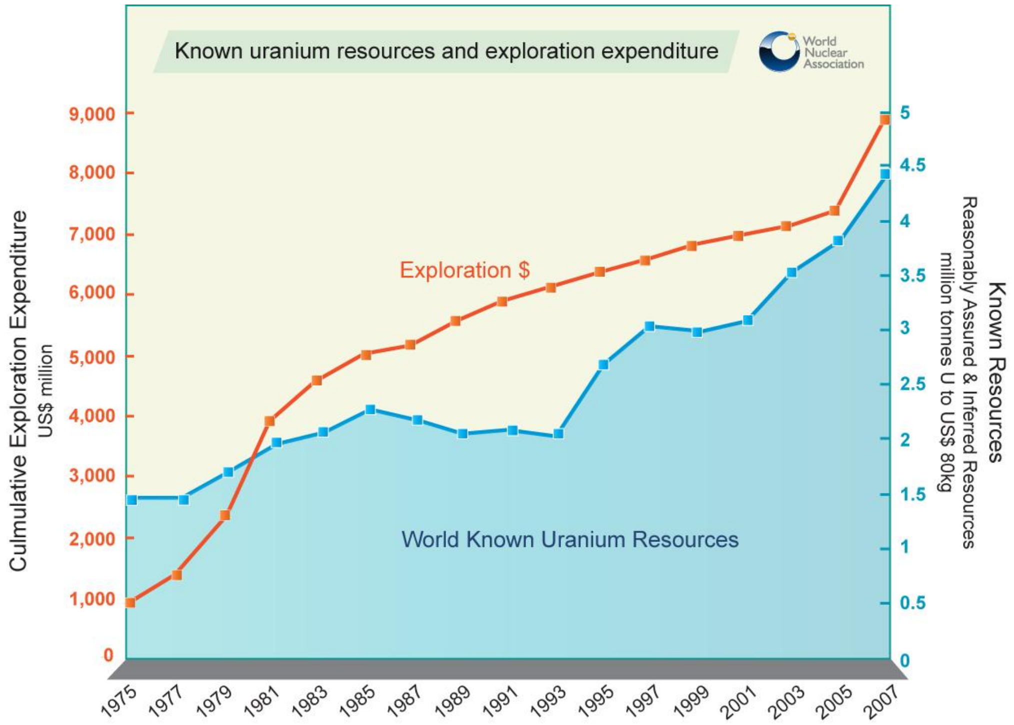
imported plants. It remains to be seen how fast these plans develop.
India paper: http://www.world-nuclear.org/info/inf53.html

I am not saying a lot about these countries here since you have hyperlinks to the country briefing papers, which I keep up to date. Several of them, such as China and Russia, are updated nearly every week, so we encourage people to access them on the web site when needed.

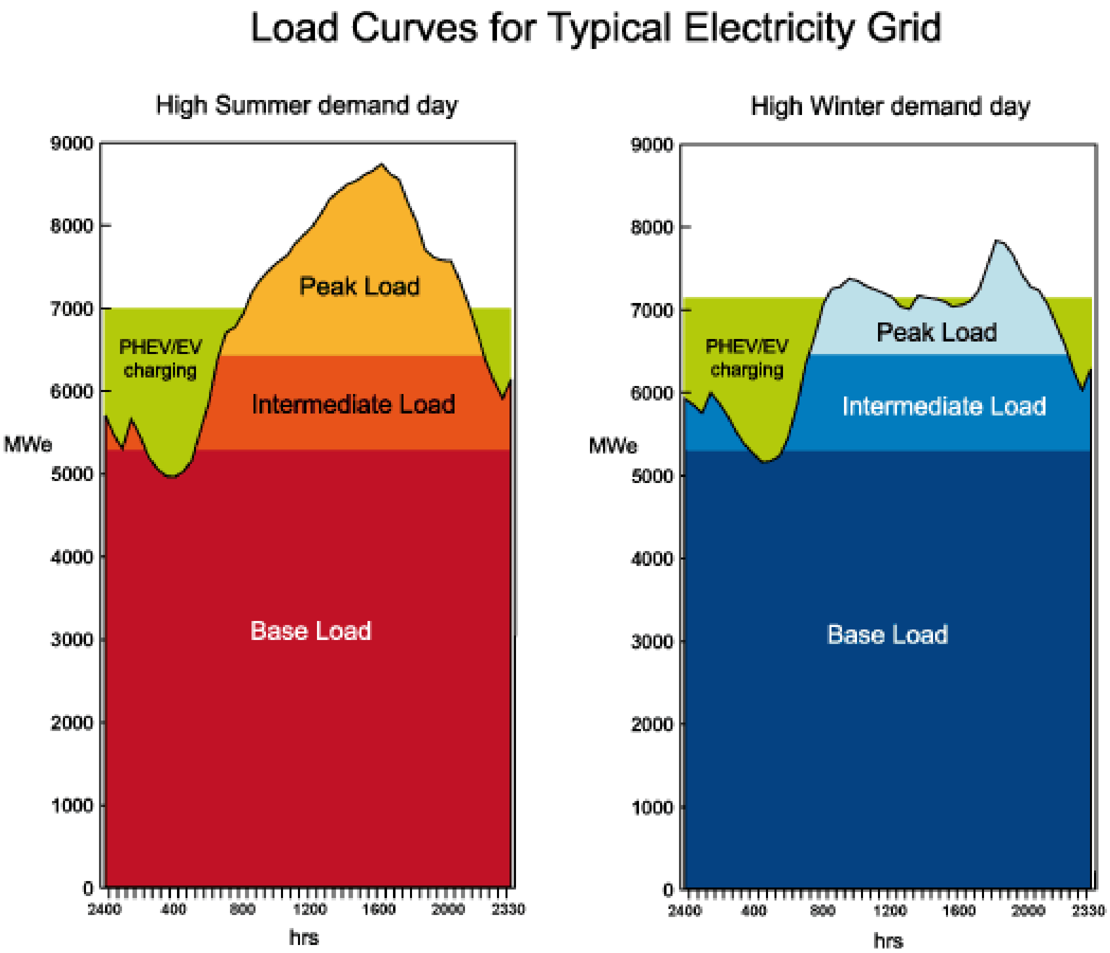
Apart from steady improvements in technology, involving both safety and durability, the main international development in the last few years has been the shift in thinking by the USA from treating used fuel as waste, to seeing it as a resource which should be recycled. This has both resource efficiency and potential non-proliferation benefits, as well as diminishing the amount and longevity of waste for disposal.
Safety of NP paper: http://www.world-nuclear.org/info/inf06.html
Reprocessing paper: http://www.world-nuclear.org/info/inf69.html

Giving more consideration to recycling used fuel (or at least 97% of it) is accompanied by moves towards greater use of fast neutron reactors. There are about 390 reactor-years of experience with these. The advantage of them is vastly greater use of uranium resources (including the 1.5 million tonnes of depleted uranium enrichment tails now stockpiled) and the ability to burn long-lived actinides which are currently part of wastes.

Uranium as fuel for much expanded nuclear power is plentiful. Quoted figures are only ever for *known* resources, thoroughly quantified. Proving them up costs money, and there is a clear correlation between exploration dollars spent and known resources, as with other metallic minerals. But newer technology – broadly, most Generation IV reactors - can utilize uranium some 50 times more efficiently. Most Gen IV designs are fast neutron reactors, and these are expected to be widespread after 2030.
Uranium supply paper: http://www.world-nuclear.org/info/inf75.html
Generation IV paper: http://www.world-nuclear.org/info/inf77.html



You will be familiar with the fact that major automotive manufacturers are preparing to offer electric and plug-in hybrid electric vehicles in a big way from about 2012. This will affect electricity demand, and in particular will mean that most demand can be met by base-load plant, thereby reducing average electricity cost. This gives major upside potential for nuclear power - some 35% - beyond simply the projected increase in electricity demand which is more in the order of 15%.
Electricity & cars paper: http://www.world-nuclear.org/info/electricity_cars_inf120.html



Beyond that, there is likely demand for nuclear process heat to liberate oil from tar sands, to make synthetic oil from coal, and further out, for making hydrogen. Hydrogen will require high-temperature reactors – 950 degrees C, and we are not far from having the first of those commercially.
Process heat paper: http://www.world-nuclear.org/info/inf116_processheat.html

Nuclear power for desalination is likely to become important in North Africa and the Middle East, using waste heat or electricity.
Desalination paper: http://www.world-nuclear.org/info/inf71.html

These are the developmental issues likely to bring very greatly increased use of nuclear energy in all its peaceful forms. There are also issues concerning how the nuclear fuel cycle is run.

First is ensuring that most countries and all sub-national groups do NOT have access to weapons-usable nuclear materials. The Global Nuclear Energy

Partnership (GNEP) is a recent initiative to limit the spread of two sensitive technologies - enrichment and reprocessing - and at the same time to guarantee fuel supply to countries which forgo the opportunity to host them. This is a further step than the well-established and very successful safeguards arrangements applying to those facilities (as well as much else) since 1970 under the Nuclear Non-Proliferation Treaty.
Safeguards paper: http://www.world-nuclear.org/info/inf12.html
GNEP paper: http://www.world-nuclear.org/info/inf117.html

Another aspect of limiting access to weapons-usable materials it the progress of US and Russian initiatives to convert all research reactors to use low-enriched fuel, and reclaim all high-enriched fresh and used fuel.
Research reactors paper: http://www.world-nuclear.org/info/inf61.html

A second issue is the possibility of fuel leasing, so that a utility simply leases its fuel for the three-year duration of its use and then returns it to the supplier, which would need to be based in one of the six countries with full fuel cycle facilities. At the front end of the fuel cycle this is straightforward and uncontroversial. But at the back end it raises the question of international high-level waste repositories. A variation of it at small scale is to lease entire reactors including their fuel, which are then returned to the supplier for refueling after 10-15 years service.

At present it is universally accepted that the legal and moral responsibility for wastes lies with those who generate them - in this case the reactor operators. This responsibility is accepted by the countries in which nuclear energy is used. But with fuel leasing the actual disposal of wastes, whether directly or after reprocessing, would need to be on some international basis, yet to be defined. Here is some precedent with depleted uranium, where the tails stay with the enricher, though whether these are classified as wastes or a future resource is sometimes debated.
International waste repositories paper:
http://www.world-nuclear.org/info/inf21.html

WNA information papers: http://www.world-nuclear.org > Public Information Service