Nuclear Energy – why all the fuss?

Our last function for 2007 was held at the premises of the Alliance Française in St Kilda, where AFAS-Vic members and guests gathered to hear the presentation by Dr Selena Ng, the Nuclear Business Development Manager from AREVA. After a welcome glass of bubbly (méthode champenoise, of course!), the President, John Acton, took the opportunity to introduce the newly arrived Cultural & Scientific Attaché in Melbourne, Sylvie Christophe and the new Director of the Alliance in Melbourne, Patrice Pauc.

Peter Tolé, Vice-President, then introduced our speaker, Dr Selena Ng.

Selena started her presentation with five questions:

- Who is AREVA?
- Where does nuclear power come from?
- What is the nuclear fuel cycle?
- Why nuclear?
- What about Australia?

Answering the first question, she explained that AREVA is an International Corporation, with its headquarters in France, which provides technological solutions for producing CO2-free energy, and for transmitting and distributing electricity. It is the only company to cover the entire nuclear fuel cycle and is also actively involved in the renewable energy sector.

To answer the second question, Selena gave a brief history of nuclear power, from the discovery of radioactivity, through the realisation of the equivalence of mass and energy and that the release of binding or “nuclear” energy in a nuclear reaction is a million times greater than in chemical reactions between atoms and molecules. The first application of nuclear energy used an exponential chain reaction to produce the hugely powerful explosion of an atomic bomb, which ended World War II. This led to the proliferation of nuclear weapons then finally the Non-Proliferation Treaty, signed by 189 States. However, work on controlling the chain reaction led to the development of nuclear reactors for producing energy for civil purposes. The first reactor to produce electricity in the world was in Idaho in the US in 1951. Dr Ng used the example of a pressurised water reactor (PWR) to show how a nuclear reactor works and some of the factors to be considered in building one (fuel, location, equipment, waste management).

The nuclear fuel cycle begins with the mining of uranium ore in an open pit or underground mines. As the mined ore has only about 1% uranium, the ore is crushed and milled into a fine powder (yellowcake), which contains around 80% uranium. When mining ceases, the mine site is reclaimed to make it fit for public use. However, natural uranium is unusable in a nuclear power plant and must be enriched via a process of chemical treatments then heated for the gaseous phase. In a centrifuge, the enriched gas modules are separated then cooled back to a solid where more chemical treatments are required to produce the nuclear fuel. Selena pointed out that only 1kg of enriched uranium is needed to supply as much energy as 80 tonnes of coal! After enriching, the powder is compacted into cylindrical pellets, fired in a furnace like industrial ceramics, inserted into long metal tubes (fuel rods) then bundled together in a rigid metal structure (fuel assembly). Some statistics: each pellet weighs 7 gm, around 300 pellets fit into a fuel rod, and 264 fuel rods make up a fuel structure for a PWR.

The fuel assemblies are loaded into a reactor core, where the energy is produced. The core is inside a reactor vessel, which is inside a cover, 13 metres high and weighing 400 tonnes. Selena told us that AREVA has built a quarter of the world's nuclear reactors (around 100). The fuel assembly stays in the core for at least 3 years, but when exhausted, it is sealed in a "cask" and transported to a reprocessing plant, for those countries that choose to recycle their used fuel. The used fuel is stored in a water pool for 5 to 7 years before reprocessing, where the waste is separated from uranium and plutonium, which are recycled in new fuel assemblies. The waste is incorporated into a glass matrix, which is then poured into stainless steel canisters and stored in air-cooled pits. Each country is responsible for managing its own final waste.

Now that we are all have enough background information, we can think about the answers to the next question – ***Why Nuclear?***

If we accept that climate change is caused by an increase in carbon dioxide, then we must consider all options as there is no silver bullet! In addition, we must be aware of the dramatic increase in the world demand for electricity over the next 30 years. Currently, 47% of the world's electricity is generated from fossil fuel (coal, oil) burning power stations, which contributes significantly to the increase in carbon dioxide levels. A nuclear power station creates minimal carbon dioxide (3 tonnes) when producing electricity compared to a coal fired power station (766 tonnes) or oil (774 tonnes).

But what about nuclear radiation?

The nuclear industry typically produces less than 1% of the radiation to which we are subject, by comparison with natural radiation (82%) and man made radiation (18%).

But what about a nuclear reactor disaster?

In 1979, there was an accident at the Three Mile Island Unit 2 due to a cooling malfunction and subsequent misguided intervention by the operators, which prevented the emergency core cooling system from functioning and led to a partial core meltdown. Although the reactor was destroyed, the containment building successfully contained the radiation. Unit 1 is still functioning with excellent operating efficiency. By contrast, the accident at Chernobyl in 1986 was as a result of major design deficiencies, the violation of operating procedures and the absence of a safety culture. To conduct a test, operators placed the reactor in an unstable setting then switched off all automatic shutdown mechanisms. The lack of a containment building in the reactor design meant that the force from the rupture of the fuel elements released fusion products directly to the environment.
The World Association of Nuclear Operators integrates all 115 operators in 34 countries to maximize the safety and reliability of nuclear power plants. The next generation reactors incorporate enhanced safety and security aspects, based on the "defence-in-depth" principle.

But is there a link between civil and military uses?

Civil nuclear power has not been the cause of or route to nuclear weapons in any country that has nuclear weapons, and no uranium traded for electricity production has ever been diverted for military use. The International Atomic Energy Agency (IAEA) was created in 1957 as an independent inter-governmental organisation within the United Nations system to promote and control the peaceful uses of nuclear energy and technology.

But what about nuclear waste?

The nuclear industry is the only energy-producing industry that takes full responsibility for all of its wastes, and bears the cost for this. In France, industrial waste per capita per year is 2,500 kg, compared with less than 1 kg of nuclear waste (including 10 gram of High Level Waste), coming from the 58 nuclear reactors, which produces 80% of its electricity needs.
However, in the long-term, appropriate disposal arrangements are required for HLW, due to its prolonged radioactivity. Disposal solutions are currently being developed for HLW that are safe, environmentally sound and publicly acceptable. The solution that is widely accepted as feasible is deep geological disposal, and repository projects are well advanced in some countries, such as Finland, Sweden and the US.

But are nuclear power plants economic?

They are the most expensive to build per unit of installed capacity (cost per kWh) and take the longest to build, but they generate electricity at the lowest cost (per kWh) if operating at baseload. In addition, they have much lower variable production costs than other thermal power stations (coal, oil, gas), as the price of uranium only accounts for 50% of the fuel cost and they have the lowest external costs (CO2).

So who is using nuclear power?

In 2007, there are 439 reactors and it is predicted that there will be 500-600 by 2030, taking into account expected plant shutdowns, lifetime extensions to existing plants and new plants. More than 20 new countries have expressed interest in nuclear energy, with China and India expected to account for at least 40% of the world's nuclear power plants by 2035.

Finally, we come to Australia!

While Australia's domestic greenhouse gas emissions may "only" represent 1-2% of the global emissions (for 0.3% of the population share), it has one of the highest per capita emissions, coming third just after the US and Canada.
But Australia is already a major actor in the nuclear industry, whether it likes it or not! Via the Australian Safeguards and Nonproliferation Office (DFAT), Australia is recognized internationally as being at the forefront of safeguards policy worldwide, with its stringent regulations associated to uranium export. It has the world's largest known reserves of uranium, but is currently only exporting around 10,000 tonnes per year, which represented $A658 million in exports in 2006-7. However, these uranium exports fuel annually the electricity production for more than 50 million people and save the emission of some 450 million tonnes of carbon dioxide.

Selena concluded that Australia has a significant role to play in global climate change mitigation, due to the export of its rich primary resources.

We would like to thank Selena and AREVA for this very interesting talk and the lively discussions, which followed over a glass of red.