COMMONWEALTH OF AUSTRALIA

Official Committee Hansard

HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

Reference: Developing Australia's non-fossil fuel energy industry

THURSDAY, 13 OCTOBER 2005

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

Thursday, 13 October 2005

Members: Mr Prosser *(Chair)*, Mr Hatton *(Deputy Chair)*, Mr Adams, Mrs Bronwyn Bishop, Mr Cadman, Mr Martin Ferguson, Mr Haase, Mr Katter, Miss Jackie Kelly and Mr Tollner

Members in attendance: Mr Adams, Mr Martin Ferguson, Mr Haase, Mr Hatton, Mr Katter, Mr Prosser and Mr Tollner

Terms of reference for the inquiry:

To inquire into and report on the development of the non-fossil fuel energy industry in Australia.

The Committee shall commence its inquiry with a case study into the strategic importance of Australia’s uranium resources. The case study shall have particular regard to the:

a) global demand for Australia’s uranium resources and associated supply issues;

b) strategic importance of Australia’s uranium resources and any relevant industry developments;

c) potential implications for global greenhouse gas emission reductions from the further development and export of Australia's uranium resources; and

d) current structure and regulatory environment of the uranium mining sector (noting the work that has been undertaken by other inquiries and reviews on these issues).

WITNESSES

Committee met at 11.40 am

CAMERON, Dr Ronald Francis, Chief of Operations, Australian Nuclear Science and Technology Organisation

SMITH, Dr Ian Oswald, Executive Director, Australian Nuclear Science and Technology Organisation

MATHER, Dr Dennis William, Scientific Secretary, Australian Institute of Nuclear Science and Engineering Inc.

O'CONNOR, Prof. Brian Henry, Vice President, Australian Institute of Nuclear Science and Engineering Inc.

CHAIR (Mr Prosser)—I am pleased to declare open the seventh public hearing of the House of Representatives Standing Committee on Industry and Resources inquiry into the development of the non-fossil fuel energy industry in Australia. The committee has commenced its inquiry with a case study into the strategic importance of Australia's uranium resources. The inquiry was referred to the committee by the Minister for Industry, Tourism and Resources, the Hon. Ian Macfarlane, on 15 March 2005. The committee has advertised the inquiry nationally and sought written submissions from interested parties and organisations.

The committee is pleased to welcome representatives from the Australian Nuclear Science and Technology Organisation and the Australian Institute of Nuclear Science and Engineering. Thank you for agreeing to appear. Although the committee does not require you to give evidence under oath, I should advise you that the hearings are formal proceedings of the parliament. I remind you that the giving of false or misleading evidence is a serious matter and may be regarded as a contempt of parliament. I also remind you that the committee prefers that all evidence be given in public. However, at any stage you may request that your evidence be given in private and the committee will consider your request. I now invite you to make a short opening statement before we proceed to questions.

Dr Cameron—We have combined our talks into one, and we intend to give a presentation and then take follow-up questions.

A CD-ROM presentation was then given—

Dr Cameron—Ian and I will team-tag on this presentation. Our intention is to cover the question of: what is nuclear power development in the world today? We will then look at some of the advantages of nuclear power in terms of cost, safety, security of supply and emissions. Ian will cover energy demand and carbon dioxide mitigation, I will come back and talk about what the future development will be in nuclear energy and then finally Ian will deal with the issue of waste management.

As you are probably well aware, there are 440 nuclear power plants worldwide. The main clusters are located in the United States and Europe and the other cluster is in Japan. However, in terms of growth, clearly the Asian region is the fastest growing region in the world. There are currently 31 nuclear power plants under construction around the world and they are listed in the table I am showing now. You can see that, of those 31, 22 are in the Asia region, which means that 70 per cent of the current growth of nuclear energy is in the Asia region. When we project out you will see that the plans for that region are much more extensive.

If we look at nuclear's share of electricity production around the world, we can see that the country where nuclear has the highest share is Lithuania, where about 80 per cent of electricity comes from nuclear power; nuclear's share in France is about 78 per cent, and this percentage decreases until we get to countries like China, Pakistan, India, Russia et cetera, where its share is much lower; in fact, nuclear's share in China is just a few per cent, but clearly that is a country with a large energy demand. Worldwide, about 16 or 17 per cent of electricity comes from a nuclear energy source. But clearly there is quite a variation between countries.

The United States is fairly typical of countries that have a nuclear power program, in terms of its mix of energy sources. Nuclear energy contributes about 20 per cent, coal about 52 per cent, and then there are gas, hydro, oil and renewables; those are the United States' current sources. If we were to translate that into emission-free sources—that is, sources that produce little or no carbon dioxide—you would see that nuclear would be about 72 per cent of the total, hydro about 26 per cent and there would be small amounts from wind, geothermal and solar. Clearly, if you take the fossil fuel side out of it then nuclear forms a big part of the ability to have emission-free generation.

We already know that growth in Asia will continue. China has announced plans for 15 new nuclear plants over the next 10 years. We are expecting the same number for each 10 years after that. Clearly, China is a country with few indigenous resources and a very rapidly growing demand for energy due to industrialisation. In terms of other countries in the region, Indonesia is planning its first nuclear plant by 2016. They are currently investigating a site for that, and plans indicate that five more plants are under consideration. India, of course, is the second-largest populated country in the world and has a very big issue with energy supply. There is a large number of people in the country who have no electricity at all. Their plans are to increase their current use of nuclear power by a factor of 100 times, which will be a very large number of plants. Plants are also being considered in Vietnam and Malaysia. Projections for the other countries often depend on how they have looked at the issue of CO_2, but these are really driven by energy demand and have not really factored in the need to mitigate the CO_2. It was interesting for all of us that, for the first time, the latest United States energy bill has a very strong advocacy of nuclear energy.

What are the advantages of nuclear power? Clearly the main advantages are generating costs, carbon dioxide emissions and safety and security of energy supply. I will just deal with generating costs at this point. Ian will deal with carbon dioxide emissions and then we will come back and look at safety and security issues later on. I think it is interesting to put this into context. This next image shows production costs in the United States, which we often take as an example, over the last 20 to 25 years. You can see that the production costs continue to decline. The industry has put a lot of effort into reliabilities and efficiencies and reducing those costs. You can see now that the generation costs in cents per kilowatt hour are about 1.7c per kilowatt hour.

Mr KATTER—Is that Australian cents?

Dr Cameron—No, that is US.

CHAIR—Why was it so high for that particular period around 1998?

Dr Cameron—You can see that in the United States there were a number of years where they had large legal challenges to what they were doing, and that involved additional costs. Of course 1986-87 was the Chernobyl era. A lot of people put effort into looking at plants and making sure that they put in mitigations. So a lot of back fitting happened in that period. Since then, there has been that gradual decline as they have just focused on efficiencies. If you look at the US electricity production costs, again, in constant 2003 cents per kilowatt hour, you can see that both coal and nuclear had declined relatively over that period of time. But there are very big increases occurring in oil and gas. This was only to 2003, of course; the situation in the last few years has made that much worse. We know that, for example, in the United Kingdom we are now talking about 10p per kilowatt hour for gas, which would be A25c per kilowatt hour. So gas is becoming a very difficult technology.

Mr KATTER—How much?

Dr Cameron—It is 10p, which is about A25c per kilowatt hour. So gas is becoming—

Mr KATTER—Not 2.5c, 25c.

Dr Smith—Gas has increased in price five times. While oil has doubled, gas has increased five times.

Dr Cameron—You will see later that, because of the availability—

Mr KATTER—That is in Great Britain.

Dr Cameron—That is in Great Britain. And of course Great Britain had North Sea oil, so they had access to gas fields et cetera, so they had an indigenous source. Elsewhere you can see that the cost of importation also adds to that. But this is not expected to decrease. Essentially, gas is one of those technologies that will be factored out over the next few years because of its cost.

Comparative electricity costs around the world for nuclear, coal and gas—and these figures are produced by the International Energy Agency in Paris—vary for different countries, depending on whether they have indigenous supplies or not, the cost of importation and the cost of their regulatory systems. But you can see that already, without any additional factoring in of carbon dioxide credits or any emissions issues, in countries like France they are down to 2.54. Even in countries like Japan, which has the largest import costs, they already have costs which are lower than those of coal and gas. Again, you can see that gas continues to increase relative to the other sources.

Mr HAASE—I hate to interrupt, Dr Cameron, but I need to know the basis of these costs. What do they include?

Dr Cameron—These are generating costs. This is life cycle. You take the 40 years of the plant. You add up all the costs for that process. There is a discount rate—

Mr HAASE—The capital cost for the plant?

Dr Cameron—No, the capital cost is not in there.

Dr Smith—It will be in there at the discount rate of five per cent.

Dr Cameron—Yes, discounted at five per cent, correct.

Mr KATTER—Can we get copies of these tables?

Dr Cameron—I think they have been supplied to you.

Mr MARTIN FERGUSON—Why are the costs in Japan so high relative to those in other countries—for example, when seen against those in South Korea?

Dr Cameron—South Korea has its own coal and Japan does not. Japan imports everything in the process, but also Japan's whole regulatory system and—we would have to say—a more bureaucratic process mean that its overhead costs are fairly high.

Dr Smith—That is certainly true for nuclear in Japan. Everywhere I have heard, it is regulatory oversight which is adding the premium for nuclear in Japan.

Mr TOLLNER—Where does Australia sit on that?

Dr Cameron—We have not got nuclear.

Mr TOLLNER—That is obvious! We do have coal and gas, don't we?

Dr Cameron—Yes.

Mr HAASE—It would be an interesting answer, though. In Australia, we could circumstance coal and gas—

Dr Cameron—We could certainly do that with respect to Australia's coal and gas.

Mr KATTER—It was almost exactly three for coal and about nine to 12 for gas.

Dr Cameron—Yes. It is about three or 3½, which are the figures we have seen for coal. Gas is just becoming increasingly expensive all around the world.

Mr MARTIN FERGUSON—Canada's has uranium supplies, and France would import most of their source, wouldn't they?

Dr Cameron—Yes, France would.

Mr MARTIN FERGUSON—Is that regulatory too?

Dr Cameron—I think it is just that the French have so many plants that they really get economies of scale that the others do not get, whereas Canada is much lower in terms of those comparisons.

Dr Smith—And probably France have more efficient reactors. The reactors in France are now producing for nearly 95 per cent of the operating time, whereas the CANDU reactors in Canada are not able to match that. And that is one of the factors. Down there, you can read '85 per cent load factor'. The American nuclear industry is now closer to a 95 per cent load factor.

Dr Cameron—And that was reflected in those costs, obviously.

Mr MARTIN FERGUSON—In terms of those countries, the most efficient technology and advanced reactors are in France?

Dr Smith—Yes.

Dr Cameron—Just going back to the issue about emissions: of course in the United States, even with their current electricity production, if they had not gone nuclear, there would be 29 per cent more emissions of CO_2 than there currently are. So their current nuclear program is saving about 30 per cent emissions.

Finland have looked at this issue quite a lot and have made quite a lot of progress in going forward with a nuclear program. These are the costs with and without emissions trading put into the situation. You can see that this is in euros per megawatt, which is a slightly different unit. At generating cost, nuclear is about 20. Coal is next, then gas, and wind is the most expensive at about 50. If you put the emissions trading, the carbon credits, into that you can see that of course wind and nuclear do not change but there is a significant upward change in coal particularly. That was one of the reasons that has persuaded Finland that they need to go forward with a fairly large nuclear program.

Dr Smith—I wanted to talk about the CO_2 load that is going into the world. I do not know whether any of you have had the opportunity to see the lecture last night by Sir David King, the Chief Scientific Adviser to the United Kingdom government. He gave a lecture last night in which he talked about the effects of atmospheric carbon dioxide on climate change. That was a very interesting talk.

What I really want to point out is that atmospheric CO_2 throughout the history of the world—600 million years—has changed quite a bit. During that time the world average temperature only changed between 12 and 22 degrees. But there has been a lot of change. From that geological time the shape of the earth is completely different—the continents were in different places. At some stages, around this time, Antarctica was a tropical forest and the rest of the world was practically uninhabited. So we are in a dynamic situation. We have seen the last 12,000 years as the civilisation of the climate of the earth. But there are tools that give us very good views of what has been happening.

If we come back, 50,000 years ago we had around 200 parts per million CO_2 in the atmosphere. You can see that, up until about 100 years ago, we stayed in that range—around 260, 270. Since the Industrial Revolution has come in and we have burnt so much fossil fuel this rate is rising at an unprecedented rate. There have been cycles in carbon dioxide in the world before but they have occurred over hundreds of thousands of years. We have compressed that change to 100 years.

This graph is an example showing the effect of temperature, which is the yellow curve at the bottom, and the CO_2 level determined from ice cores. Taking ice cores in Antarctica they have now gone back 750,000 years. We know that the world has a cycle between glacial and warm of about 150,000 years. In that cycle the sea level changes by about 120 metres and the temperature changes by about five or six degrees. We are now dealing into a cycle that has been going on for a period of 150 years. We are making the kinds of change in CO_2 level that triggered that change happening in just 100-odd years.

Mr KATTER—What was this up around 140,000 years ago?

Dr Smith—This area here will be a warming period for the earth. So the glacial period ended here and suddenly the earth warmed up. There is a lot of feedback in here because, as you change the temperature of the ocean, it is a very complex model of what happens. There is a cycle there, which has been determined in Antarctic ice and in ice on Russia, which shows a 150,000-year cycle. This change is triggered by about 180 parts per million CO_2 to 260 parts per million CO_2. We are now at 380 heading for at least 450, some people think 550. So this is a serious problem in terms of predicting what will happen; and of course it happens on a long time frame.

If you measure it more accurately you get curves like this. These are curves that are taken from the observatory at Hawaii, where they get good mixing of the atmosphere. You can see that there is a distinct upwards curve. To show you the resolution on the curve: that sawtooth is nothing to do with inaccuracy; it is actually seasonal—it happens each year. The bottom corresponds to the growing period in the Northern Hemisphere where more CO_2 is taken from the atmosphere by the plants in the northern summer. It happens that in the Southern Hemisphere most of the plant life is near the tropics and you do not get such a seasonal effect. There is no doubt that CO_2 is going up. There are another two graphs there showing CO_2 heading up and temperature going up. Sir David was able last night to attribute half of the severity of the 2003 heatwave in Europe, which killed 30,000 people, to global warming with a 90 per cent statistical certainty.

This is a diagram which shows that we have put a lot of CO_2 into the atmosphere. At the top of the graph, the darker colour shows emissions from fossil fuel; the lighter colour shows changes in land use—cutting down forests and the like. Down the bottom, the red shows what has gone into the atmosphere, and the green shows what has gone into the ocean—and there is CO_2 going somewhere else, which people have not really identified for certain; it is a complex biological system, which of course is what made oil reserves and coal reserves, but now we are testing it in zones in which we have not been able to test before. But certainly we are changing the amount of CO_2 in the ocean, which acidifies the ocean and has potentially disastrous effects on coral reefs and those sorts of things, as well as putting it into the atmosphere, which changes the temperature. So we have already made a lot of change.

What is going to happen with energy? This is a diagram that British Petroleum put out. The darker the colour, the greater the intensity of energy use. It is not meant to be area specific; it is country specific. All of Russia does not use electricity at that rate. The issues are those three wide areas where most of the world's population is. They have very little energy and therefore very little CO_2 emission now but, as they develop, we are going to have an interesting situation. If you take Nigeria, for instance, the average electricity consumption per person is 70 kilowatt hours per year. If you want to quantify it, that is the equivalent of leaving your television set on stand-by for the year. The average use in Europe is 8,000 kilowatt hours per person. So as these people develop, we are going to have a greater energy demand. If energy is produced by producing CO_2, we are going to push the CO_2 level up.

Mr HAASE—Did that slide indicate that Northern America, Europe and Australia had the same level? I could not differentiate the colours, that is all?

Dr Smith—Yes, that is right. They are done in bandings, really, just to show the very low against the high. On the left here shows what has happened in world energy production in the last 30 years. You can see that 31 per cent of the growth was in the OECD, 10 per cent was in the transition economies from the former Soviet Union and 59 per cent was in the developing world. In the next 30 years, three per cent will be in the OECD, 12 per cent in the transition economies and 85 per cent in the developing group. The issue really is: how does China get its energy? You heard Ron talk about a tremendously ambitious nuclear program. At the end of that program China will produce four per cent of its electricity from nuclear sources. This is not good news. If you are an Australian, this shows the tonnes of carbon emitted per person. You can see the United States, but Canada, Australia and New Zealand are right up there with them, followed by Russia, Japan, Western Europe and, of course, Africa, where you have a fraction. I do not know what the solution will be for the world, but one assumes that that curve will have to flatten out if there is to be a stable political situation in the world.

Where does the primary energy demand come from? You can see nuclear power down the bottom; it is very small. The interesting thing is: how much of the power projected into the future is still going to come from coal, oil and natural gas? The most difficult part of this curve is what the oil companies believe is happening to oil, because this is a plot of the 2004 scenario from the petroleum industry, and all the colours indicate the US, then Europe, Russia, other and the Middle East. Then you come to these areas where you have much more speculative sources like polar oil and deepwater oil, which are included. You can see that we are about at the time when the maximum production is possible. I have put some oil prices on there. In the first oil crisis, when there was a cut in production imposed by the producers, oil went to $70 a barrel in equivalent money. Now it is up to $60 a barrel, but we are going to have an imposition of production cuts due to a lack of supply.

What is happening to CO_2 emissions? These are millions of tonnes of CO_2. You can see the yellow again as the transition economies, the green as the developing economies and the red as the OECD. You will see that by 2020 the developing countries will have produced more CO_2 than the OECD. If you add them up, that comes to about 36 billion tonnes of CO_2 that will be emitted each year by this process. In his talk last night, Sir David speculated that if we stay on this path this would eventually produce CO_2 levels of over 1,000 parts per million. How do we avoid it? If we take just one of those 36 billion tonnes of CO_2, what do we have to do to avoid one of the 36 billion? For coal—

Mr KATTER—Is that 36 billion tonnes now?

Dr Smith—It is projected for 2030. To avoid one billion tonnes, you would have to replace 300 conventional 500-megawatt coal power stations with zero emission coal, so somebody has to invent the zero-emission coal fired station. You can use carbon sequestration, but you will have to install 1,000 Sleipner plants, which are in the North Sea, where the Norwegian state oil company currently sequesters a lot of CO_2. It is the only production plant in the world. It costs $US59 a tonne to do it, but they are doing it. With wind, we would have to install 200 times the current US generation. For solar, we would have to have 1,300 times the current US generation or we would have to build 140 nuclear power stations, which would make a difference of three per cent. It is a huge problem. The outcome is that I believe you have to do all those things; you cannot do just one of those things. This next one is the carbon sequestration in the North Sea. This is how it happens. They are producing. The producing wells produce a lot of CO_2 with the oil and gas. They then pump the CO_2 back into the saline aquifer under the ocean. It is a very good system and a very secure system, but operating costs are $US59 a tonne at the moment.

What is the relationship between generation, method and CO_2? This shows the grams of CO_2 that you produce per kilowatt hour of electricity. This is being done extensively by three countries—Japan, Sweden and Finland—so the numbers are different because they take different things into account. You can see that in countries with coal-burning power stations you are producing about a kilogram of CO_2 for every kilowatt hour. If you use gas, you produce less, except in Sweden. By their calculation, Sweden have incorporated all the CO_2 produced in getting the gas to Sweden. So transportation is in that one and has made a big difference.

The most efficient gas is down around 500, so it is about half coal. Solar is around 50. The real problem is making silicone from silicone dioxide, which produces quite a bit of carbon dioxide. With regard to wind, there are variations in that the Swedish number is low and the Japanese number is high. On nuclear, again there is some variation, and that variation comes from the way in which the uranium is enriched, whether diffusion enrichment or centrifuge enrichment is used and whether the power comes from nuclear sources or from fossil sources. Hydro is down the bottom. That is the menu we have to play with.

The people at Lucent Technologies looked at the unit cost of various pollutants in US dollars in 1999. They are saying that the effective cost of CO_2 is $US30 a tonne in 1999 dollars—carbon monoxide, lead et cetera. The reason for putting that up is, really, for the next slide, which says, 'If you look at these technologies you can then ask what the damage is to the environment per kilowatt hour in dollar terms'. Wind is clearly the best, nuclear is pretty good, hydro is pretty good and solar has some problems but is much better than, obviously, fossil fuels.

In terms of capital costs, I want to show you some diagrams which have come from the Royal Academy of Engineering. I want you to look at the blue colour, which is the capital cost, and the yellow colour, which is, effectively, the fuel costs. This is for a coal-generating plant. You can see that capital is relatively small and operating is relatively high. If you go to gas the cost of building the plant goes down; the cost of operating it goes up greatly. These numbers will not be correct now, because the price of gas has changed so much since they were done. But it means that you are very sensitive to the price of gas, because the operation cost is high. That is likely exactly why gas is used for peak load. You can build it cheaply and have it there to use when you need to use it. If you go to more efficient gas you get much the same thing. The point I wanted to make is that once you go to nuclear, the cost is upfront. The cost is in the capital; the operating cost is small. We pick up later in the discussion as to how the Americans are trying to address that problem of initial capital cost, but with a low operating cost, which is not very sensitive to the price of uranium. Most operators would not have a problem with uranium being $100 a pound. It would not make very much difference to the cost of electricity at all.

When you go to wind, the capital cost is high. The only reason that Denmark can have so much wind power is that they can sit on France's nuclear grid. When the wind does blow they pick up their electricity from the nuclear base load. Most people would not want to have more than five per cent of fluctuating power on top of their grid.

Dr Cameron—The whole issue of capital cost has been one of the big issues for the nuclear industry: what can we do about capital cost? As Ian pointed out, the fuel and operating costs are very controllable. That is why countries that go nuclear have a security of supply. Throughout the lifetime of the plant the fuel cost is not going to change very much, so they can guarantee some values for their electricity costs over that period. But we have to deal with the fact that the capital cost is high.

In the United States they are trying now to get to more efficient processes to license nuclear—to do the engineering et cetera. That makes the approval process much easier, which will bring the cost of nuclear down to the same level as coal and gas. That will be a significant issue economically for nuclear in the United States. If they were to go further and say, 'Because of the CO_2 we ought to give some investment credits to nuclear,' it would drop down below the cost of coal and gas. That is dealing with what is probably the biggest issue putting people off investing in nuclear—the capital cost. So, people say that the capital cost is too much but, as you can see, there are things that can be done about it.

The second issue that is often talked about is that nuclear is not safe. In fact, when you look at the safety record of the nuclear industry you see that it far surpasses any of the others. The left-hand side of the graph in this slide shows fatalities per terawatt hour. You can see that the figure for nuclear is much lower than for LPG, hydro, natural gas, oil, coal et cetera.

Mr TOLLNER—What is the relationship between injuries and coal compared to nuclear?

Dr Cameron—The nuclear industry use a very conservative calculation that says that if there is an amount of radiation exposure then there is a probability that a person may contract cancer. They factor that into the process as if it was an injury, even though in many cases there is no evidence that it has actually occurred. That is why it is a slightly different calculation.

Mr TOLLNER—You do not have wind represented in that graph.

Dr Cameron—No. There is not enough data on wind. Wind is a relatively new industry in terms of all of this. These are longstanding numbers that you can average over time with some certainty. Clearly, in terms of fatalities, nuclear is by far the safest of all those industries. People often ask, 'What about Chernobyl?' Chernobyl was a tragic accident in the nuclear industry. In occurred with a reactor which would never have been built in a Western country. I know that because when I was in the United Kingdom we did an assessment of the Chernobyl RBMK reactor. The conclusion in the report was that we could never license such a reactor in any Western country. The comparison between that and Three Mile Island, which was a Western design, is that they both had a meltdown but there were no injuries or deaths to go with Three Mile Island. That is because it had a strong container building et cetera.

The latest report on Chernobyl has just been produced, which is after 20 years. The estimate is now 56 deaths after 20 years. That was 31 immediate deaths and a number of people have died since. There have been 4,000 cases of thyroid cancer, but thyroid cancer is a very survivable cancer. Only nine people have died. So that takes the number up to 56 after 20 years. They say that the worst case they could predict—taking into account even the most conservative assumptions and people who got very small doses but have a certain probability of dying—would be that you might get 4,000 over the whole lifetime.

If you compare that with Bhopal, which was the chemical accident in 1984, just two years before Chernobyl, that killed 4,000 people immediately and 15,000 people within two years. In 1996, nearly 3,500 people died in China as a result of mining accidents. If you take Australia, which probably has the safest mining industry in the world, 281 coalminers have died since 1902; in New South Wales, 112 have died since 1979. That helps to put it into context.

Mr MARTIN FERGUSON—Have you got any figures for deaths in uranium mining for the post-1979 period? For example, there were a couple this year, including the Olympic Dam underground blast. It would be good to have them supplied if they are available. That is just in mining. That does not include construction of the mines, does it?

Dr Cameron—No. That is just operations.

Mr MARTIN FERGUSON—If you could make figures available for operational activities post-1979, that would be good.

Dr Cameron—I do not want to go on about safety, but I just wanted to put into it context with the nuclear industry that, despite what is said out there, the actual numbers are very low for the industry. The issues people raise about nuclear energy are capital cost, safety, proliferation—can this material be used for weapons?—and waste. What is happening internationally in these areas? In the United States the Nuclear Power 2010 Initiative is to have a standardised process for licensing and approvals, to reduce those costs. They are moving towards the concept of producing hydrogen by nuclear means, because we do have to think about what is the next transportation fuel when it is not oil. Hydrogen is obviously the way to go, so nuclear contributes there as well. But the two most important issues I wanted to talk about are the Advanced Fuel Cycle Initiative—which deals with the whole concept of proliferation—and generation IV, which is where the new reactors are going. It is a development in design that seeks to deal directly with issues of proliferation and waste.

If you look at it over a period of time, you can see how the nuclear industry has moved from generation I up to generation IV. We are currently at around generation III, and two of those advanced reactors have been built in Finland and France. That has taken account of all the efficiencies and improvements in safety that they have been able to put in. But what we are really looking for are the new designs which include, firstly, recycling of uranium and, secondly, getting a fuel cycle which is proliferation resistant—that is, it does not produce plutonium, which could be diverted for any weapons process.

Mr ADAMS—How advanced is that?

Dr Cameron—You can see the dates that we are talking about. Generation III is where we are now. Generation IV is about 2030. So by Generation IV designs, we will have a proliferation resistant cycle and we will be able to deal with the waste problem. Ian will talk about that later.

You can see here the American plan that assumes that Yucca Mountain opens in 2010. The difficulty with the American cycle is that it is a once-through cycle. They create the uranium for fuel elements, they burn it up, and then they dispose of it with the uranium still in there. If we did that, we would use up all the uranium in the world in 50 years. That would really preclude nuclear as a long-term solution. So we have to go to recycling, and we have to go to a process of reprocessing and using—

Mr KATTER—Are you talking about a breeding reactor?

Dr Cameron—We are talking about both reprocessing to extract uranium and use it again and we are talking about breeders too, eventually. You will see on the slide that they need to go to fast reactors. The commercial fast reactor operation will start in 2040-ish and the next stage is to go to the actinide burning.

Dr Smith—India now has a 500-megawatt fast breeder reactor commercially operating.

Dr Cameron—You can see that by 2030 they are expecting to start producing hydrogen using nuclear energy as well.

Mr ADAMS—Tell me about fast breeder reactors.

Dr Cameron—A fast breeder is a reactor with a very small, dense core. It produces fast neutrons out of that, so it needs to be cooled by a very efficient cooling system. In the core, you have both material that is undergoing fission to produce the power but also the material outside the core is breeding, so it is becoming fissionable material that can be used the next time around. You are fissioning some material to use immediately and changing the properties of some other materials so it becomes the next lot of fuel.

The goals of generation IV, which is a big process, are sustainability, economic competitiveness, safety and reliability and proliferation resistance. The participants currently in generation IV are Argentina, Euratom, Brazil, Canada, France, Japan, South Korea, Switzerland, South Africa, the USA and the UK. The United States currently have a once-through cycle, which is to use it and then dispose of it. They know that cannot work, because if they kept going like that in expanded nuclear they would have to build a Yucca Mountain every eight or nine years. That obviously does not work, so most European countries are reprocessing—they extract the uranium plutonium and reuse it. It obviously has to be done, but the proliferation resistance cycles are, first of all, producing a reprocessing system that does not separate out plutonium and, secondly, looking at faster access to the—

Mr KATTER—Do they separate that out from spent rods?

Dr Cameron—Yes. At the moment the uranium and plutonium is separated out and the fission products become waste products. You can reuse that, but people get concerned about the possible diversion of plutonium and so they are looking at cycles where you will not be able to separate out the plutonium in a way that it might be diverted. The issue then is what to do with the waste. Because that is so important, we have a few slides.

Dr Smith—The first question is whether waste management is a technical or political problem. The answer is that it is a political problem. The technology exists. It is safe. There are international guidelines. Everything is in place. The problem is political, and that is evidenced by there being a lot of social scientists in Europe now being employed by people in this business to try and provide the community with the assurance that it needs that the technology will work.

Basically, we wanted to talk about the disposal of low and short-lived intermediate waste, the encapsulation of intermediate-level and high-level waste—where we have our own process, synroc, as well as the standard process of vitrification—how Finland have tackled the problem and, as Ron mentioned, the opportunity to reduce the volumes of waste and to make that waste far less aggressive.

The reason that I say that it is not a technological problem is that the Champagne district in France is the host of a low-level and short-lived intermediate waste dump and it has not affected its sales, tourism or any of those things. Perhaps the people in the Northern Territory can feel more comfortable that it does not cause those sorts of problems. These wastes are just compacted and stored in concrete—

Mr Tollner interjecting—

Dr Smith—You can have champagne instead. The other point is that people talk about the transportation—and I can give you a comparison. In the OECD countries in the last 30 years more than 2,000 people have been killed in transportation accidents shifting LPG around the country. For the nuclear industry 20 million packages have been sent 30 billion kilometres without an accident. This is not an area where the facts indicate that there is a problem, though I guess there is a perception of a problem.

We have heard Ron talk about spent fuel. The components of spent fuel themselves are interesting. Ninety-five per cent of spent fuel is uranium, which is not a problem to store or worry about. You can actually reuse it. Four per cent is radioactive fission products—generally caesium and strontium are the major ones there—and they require treatment in isolation for about 200 years before they are back to background levels. One per cent of the components of the spent fuel are the materials that require hundreds of thousands of years of storage. So the idea of separating out this material and selecting processes to minimise the amount of the material as shown on the right hand side are very important for the future.

As for the encapsulation—and in the picture you see an example of synroc, where the material is made into a synthetic mineral which has been demonstrated in nature to contain uranium, thorium, plutonium et cetera for millions of years—it goes into this can which is pressed at high temperature and with high pressure and the material is sealed. It is a ceramic, resistant to leaching by water and capable of being stored safely in deep underground repositories.

These are the approaches. The International Atomic Energy Agency has all this material codified so that countries are able to deliver safe storage of the waste management. There is a question about how much monitoring and closing of wastes there should be. Some of the social investigation in Europe has shown that people are more disinclined to accept a repository which is closed than to accept a repository which remains open and is monitored. So that is an issue. Ron mentioned Finland, Sweden and the United States. Finland and Sweden have made positive decisions about disposing of spent fuel as waste. I do not think that the United States have made that decision. I think that they understand that the fuel value of spent fuel is quite enormous. Twenty per cent of the fuel load of the new generation of reactors will be spent fuel from the current reactors.

Mr KATTER—How much?

Dr Smith—Twenty per cent. The waste management in Finland is an excellent example of how to manage it and to get a politically acceptable solution which is accepted by the people. You can see that they have had interim storage of spent fuel. They have built their final repositories for low and short-lived intermediate waste and they have got a final geological repository which they are building simultaneously with the new reactor program.

Then there is the advanced fuel cycle initiative, which Ron mentioned. I think that the most important thing for the world here is the non-proliferation ability that is available. In this sort of area we are talking about reactors being developed that need to have their fuel changed once every 20 years. Obviously, fuel changes are a point at which diversion can occur but, if you go to reactors with fuel change-outs once every 20 years, the material that comes out is very unacceptable for diversion to military processes. So a whole lot of technologies are being built here.

You saw this slide before. The current cycle that you have in Europe has reprocessing in which you end up with solutions which contain plutonium and uranium. I have here in my hand a simulated result—the waste that France produces—of making 75,000 kilowatt hours of electricity. That is the amount for the average French household for 20 years. That is the volume of high-level waste. If they had made 75,000 kilowatt hours of electricity from coal they would have eight tonnes of solid waste which would contain uranium, thorium and heavy metals. According to the EPA in the United States, it would be quite a toxic substance with treatment times of about 10,000 years. This would have produced 1.5 kilograms of CO_2 and the coal would have produced 75 tonnes of CO_2.

When you look at this, you can understand why France is a country whose CO_2 per dollar GDP is half the world average. This route, which people are nervous about because it does offer the opportunity for proliferation, nonetheless minimises waste and maximises the use of the uranium. Deep burn technologies are the hope for the future. You get down to having less than 10 per cent of that one per cent of nasties, so that you have a much smaller volume produced in a way which has much less potential for diversion for military purposes. That is certainly the program the Americans are very keen on. As you know, global threat reduction is very important for them.

The graph I am showing you shows you the change in that result. The top line shows the activity of spent fuel if you do not do anything with it. You can see that it is a million or 300,000 years or so before you get back to the natural radiation from uranium, which is represented by the red line on the graph. If you do the advanced fuel cycles, you reduce that to 300 years, which is very manageable by society. We rely on history to prove we can do 300,000 years.

Mr HATTON—I want to ask you about linking in with the generation IV stuff and evidence we had at the last public hearing about pebble bed reactors. Can you tell us what you think about those and how effective you think they are?

Dr Smith—The pebble bed reactor is a generation IV reactor. There are two designs. There is pebble bed, which the South Africans are quite advanced in and are looking for investors at the moment. The other design is a prismatic design, which effectively uses very similar materials but arranged in a carbon block prism. They are both generation IV reactors.

Mr HATTON—I think we were told that originally there was Australian work done on pebble bed many years ago.

Dr Smith—Yes.

Mr HATTON—So it is an area where we have lost an advantage because of the degradation of nuclear science in Australia?

Dr Smith—I think the advantage of pebble bed reactors is that they are modular. The South Africans call them pebble bed modular reactors. They can be of various sizes, and there is a lot of potential for reactors that need little intervention to supply power in remote communities without any pollution activity or needing to have a lot of control. The Americans have a 180- or 190-megawatt reactor which they have designed to run with a 20-year fuel change-out time. The Japanese and Koreans have similar reactors being designed and built.

Mr KATTER—How much do they cost?

Dr Smith—I do not know, to be honest.

Dr Cameron—I think the cost is almost relative to the power. You would expect a 1000-megawatt reactor to cost you about $1 billion and the smaller ones to cost a fraction of that. The smaller ones are ideal, as Ian said, for particular applications like desalination plants. You can build a small 100-megawatt reactor that would do that, and that would cost around $250 million.

Mr HATTON—The laser enrichment process, Silex, that is going on at Lucas Heights has come up a number of times. We had some interesting evidence about it at the last public hearing. We had some pretty wild accusations about deep, dark things that were happening there. Can you comment on that program?

Dr Smith—Silex is a tenant of ANSTO at our Lucas Heights site, but we have nothing to do with the project at the moment. My knowledge of the project is public domain knowledge. My understanding is that it is a potential project to produce levels of enrichment of four or five per cent, which is what is needed for power reactors. It is well short of anything of any interest for military purposes.

Dr Cameron—I think it is worth saying, in terms of enrichment, that you can buy enrichment technologies which cannot go beyond a certain level. As Ian said, if people are concerned about the possibility of weapons, you can actually install enrichment technology that will only take you to four or five per cent and will have no capability of getting to these higher numbers needed for weapons.

Mr HATTON—The argument that was put to us in Melbourne was that it did have the capacity and that, because it was relatively more portable, there was a greater danger of proliferation as a result of that: you could build one in the garage. Evidence that we had last week indicated that that was not on because to produce plutonium and fissile materials you really need to go to large centrifuges and that the laser enrichment process really was not capable of doing that. Would you agree with that?

Dr Smith—I think that is what we are saying. The limitation on the level of enrichment is quite low.

Mr TOLLNER—Ian, thank you publicly for the tour of ANSTO last week—incredible! It was well conducted. Can you explain the science versus the politics of the three sites that are nominated in the Northern Territory? Scientifically, what are your requirements for a nuclear waste repository? Where can you put such things? Politically, I know that is another issue all over again. Are they the only three sites at which you could store radioactive waste in Australia for scientific purposes, purposes based on science? Do you understand what I am trying to get at?

Mr MARTIN FERGUSON—And as part of that could you also define what is low- and medium-level waste.

Dr Cameron—Okay. The answer is you can store waste anywhere in the world. If you just have an above-ground monitored store, there is no difficulty. The question is about what sites are suitable for a repository where you actually bury the waste. Low-level waste is the type of material you produce when you handle radioactive material—so it is gloves and pipe work and glassware and materials of that type. Generally, it is contaminated, rather than being radioactive. The waste gets compacted down into drums and then those drums are sealed. Other material that is slightly more active—maybe because it is due to spent radioactive sources—would get mixed with concrete and put in a drum.

In either case the whole concept of radiation protection is that the container provides the necessary shielding that you need to be able to handle it safely, so as activity goes up you need a higher integrity container. But the fact that you can just put low-level waste that has been compacted into a 200-litre drum and it is safe to handle shows that the activity levels are actually very low in that waste. That means that the material is one not suitable for dirty bombs at all and it would be a waste of time trying to use waste for that process. But it means you can handle it safely in terms of transportation and it means the material only has to be stored for relatively short periods of time before the activity decays away to what are background levels.

In terms of choosing a site for a repository, Australia has some of the best geology in the world. Many countries have much bigger problems than ours. Even so, we would say that there are hundreds of sites in Australia which would be suitable for that purpose. Generally, there are desired criteria but most of the criteria you can engineer around almost anywhere. The desired criteria are that it is in an area which is such that it is a distance from a water table—so that it provides another level of protection—and that the container itself and how you put it into a repository with a clay cap will provide the necessary protection, but there is another layer of defence: it is useful to have a geology such that even if the waste migrated out it would migrate so slowly that it would take thousands of years to reach any area. Certainly, as for the site which was in South Australia, it would be tens of thousands of years before radioactivity would reach any water table. By that time there is almost no radioactivity left. So the concept is that the package provides containment, that the way you seal it in the repository provides containment and that the geology provides containment as well. All of those mean there is essentially no risk from doing that.

Mr HATTON—There was a startling allegation made by Dr Helen Caldicott in evidence given to the committee, which I think ANSTO need to answer. I cannot remember the exact wording, but the argument was that the HIFAR reactor had produced a range of noxious substances beyond what is produced by other reactors producing energy overseas and that the level of radioactive iodine produced at Lucas Heights was significantly greater than that produced by a large commercial reactor at Sellafield in England. Can you answer that charge based on the history at Lucas heights?

Dr Cameron—There are two issues to answer. The key one for everyone is: what is the dose that people might receive from discharges? The whole process of radiation protection says: we know what the isotope is and we can work out what dose that gives. If you stood on the boundary of Lucas Heights for 24 hours a day, 365 days a year and breathed it all in, you would get about the same dose as flying from Sydney to Melbourne. You would get about four to five microsieverts. We have that data. It is measured data, and it has been around for years.

The other issue—and the reason she makes that claim—is that nuclear power plants do not produce iodine because they do not produce radioisotopes for medicine, and iodine is one of those. So it is a spurious type of argument. The key issue is: what dose might people receive? The whole concept of radiation protection takes into account where it comes from, and you can compare it dose for dose—and dose for dose Lucas Heights produces almost nothing.

Mr HATTON—And it is inappropriate to compare research reactors with—

Dr Cameron—We irradiate tellurium targets to make iodine-131, which ends up treating thyroid cancers in people in Australia, New Zealand and the region. It is a product we make for the purpose of using it. Iodine-131 is the radioactive isotope of choice for doctors wishing to deliver therapy from radioisotopes. It is a product which we make and which the Canadians and the South Africans make in some quantity to satisfy the medical need for this material.

Mr TOLLNER—Following on from where we were before, a range of low and intermediate level waste is stored around Australia at the moment in hospitals, in industrial sites and the like. How dangerous is that? Is it dangerous? We are hearing from the Northern Territory government that this is all safely stored and there is no need for a repository. Is that the case?

Dr Cameron—The argument for a central repository is that you end up with a purpose-built area which is designed to take the material. The second plus is that for people to send it there, they have to package it properly. At the moment, this material is scattered around. It is not packaged properly; it is not secure. People could go in and get it. Also, it is really not in a form that guarantees long-term stability. When you produce a centralised facility you require people to pack it up properly, according to international best practice. It gets transported to an area where you can secure it, you can monitor it all together and you can build a purpose-built, designed facility to deal with it. It is the standard international best practice way of dealing with waste rather than having lots of areas where you do not know its state. You do not know how well it has been looked after. You do not know whether it is secure. Certainly we know that it is not packaged well in many of these areas.

Mr TOLLNER—I have been trying extraordinarily hard to find out the quantities of waste and where it is being stored at the moment. Is there a central register? Is there a definitive view on how much is stored and the locations at which it is being stored in Australia? Where this stuff is located seems to me to be shrouded in a lot of secrecy.

Mr MARTIN FERGUSON—If you put that question on notice you will get the same answer that I got back. The government has answered that question, which I put on notice. There are over 100 locations in Australia. The Commonwealth government knows where all its deposits are and they are properly regulated. They do not have knowledge of all the state and territory locations for waste and how it is stored. If you look at the *Hansard*, you will find an answer on that from the department.

Mr TOLLNER—ANSTO may well have an understanding of that.

Dr Cameron—I will just agree with what has been said. Some states and territories have better knowledge than others.

Mr MARTIN FERGUSON—The truth is that there is a very thorough process of putting it in drums et cetera, but there are questions as to whether the process pursued by state and territory governments is as thorough in terms of containers in hospitals et cetera. That is a serious question, isn't it?

Dr Cameron—That is correct.

Mr MARTIN FERGUSON—You are obviously doing good research on waste disposal. What is the expectation of synroc being commercially pursued in the foreseeable future?

Dr Smith—At the moment we are building a pilot plant with Nexia Solutions, which is part of the British Nuclear Group. That is part of the large clean-up of the Sellafield site. Synroc has been identified internationally, I think, as being the disposal route of choice for plutonium-contaminated material. At Sellafield back in the 1950s and 1960s, when the UK was making as much plutonium as it could, there was a large amount of material contaminated with plutonium, which now has to be cleaned up. The cost of that is very large, and they are looking for the most secure method of putting that material into a form which will not be able to be leached out by water for geological time, virtually. The method chosen is synroc, and we are building a pilot plant with them at the moment. We are pursuing the opportunity of having this material used for the three sites in the United States, which have similarly large clean-up programs.

Mr MARTIN FERGUSON—Commercially developed, then, that is potentially an export earner.

Dr Smith—Yes.

Mr MARTIN FERGUSON—Do you have any understanding with the government as to how those earnings are to be allocated if that is achieved in the future? For example, would it go to research and development?

Dr Smith—All we can say at the moment is that the government has not taken money back from ANSTO. I guess we would hope that might be the case and that we can continue to develop the technology with the money coming from it.

Mr MARTIN FERGUSON—Turning to your mandate for research, obviously waste disposal is permissible. We have received evidence from a former head of the Australian Atomic Energy Commission that you no longer have a mandate to properly investigate issues of nuclear power. Is that true?

Dr Cameron—The ANSTO Act allows us to maintain an understanding of and expertise in the nuclear fuel cycle generally. However, we have not had an active program in any research in nuclear energy since ANSTO was formed.

Mr MARTIN FERGUSON—For what reason?

Dr Cameron—Part of the change in the act was to move ANSTO towards research into nuclear science and technology and its applications rather than into nuclear energy.

Mr MARTIN FERGUSON—But, historically, we were ahead of the field on the pebble option?

Dr Cameron—We were, back in the 1970s.

Mr MARTIN FERGUSON—Further, and still related to research, we also received detailed evidence that we as a nation have gone backwards in our expertise and in the training and education of people in the fields of nuclear science and engineering. Do you have any comment about that, and do you think that as part of this report we should be thinking about some strategic relationship—for example, between ANSTO, AINSE and a university?

Dr Smith—The first thing I would say is that there is an international problem with finding people with the skill sets for the nuclear industry at the moment. You saw in our presentation that the current program of building nuclear power stations is probably as large as it has ever been and that it is mixed up with the development of generation IV reactors, and so there is another group of people working on the fusion reactor. So there is a lot of research going on and there is a lot of building going on, but there is a great shortage. That was the hottest topic for most of the people whom I spoke to at the International Atomic Energy Agency board meeting in Vienna: where do we get the human resource to be able to deliver what is required? So I think there is an international problem, but that only heightens the Australian problem, because we do not have an indigenous source of people coming out with that training. ANSTO's reaction to that is to institute its own training program now to recruit graduates and send them to international destinations.

Mr MARTIN FERGUSON—What about the capacity to set up a strategic relationship in Australian universities? Is that worth exploring?

Dr Cameron—We actually currently do that in some of our areas like radiation chemistry with some of the universities, but there has not been an overall plan to do that, and I think it would be of some value. We have been fortunate in that the very sensible decision to permit ANSTO to build a replacement reactor has allowed us to bring in a technology transfer through that process. So that has refreshed a number of our areas again, but of course that is a one-off opportunity. To maintain that I think it would be sensible to have a program with some universities and an overseas company or university to work with.

Mr MARTIN FERGUSON—At the moment, what is the date of the commissioning of the new reactor?

Dr Cameron—We are certainly hoping to load fuel next year, around March or April, and then it will be fully commissioned by the end of next year.

Mr KATTER—All of us get a lot of sales chat on this. It is very hard to read. Can we have it in full print?

Dr Smith—Yes, you can get a full black and white or a full colour.

Mr KATTER—No, full sized—for me anyway that is very important. I have all that Valhalla area. Does a breeder reactor produce plutonium at the present? You were not using the words ‘breeder reactor’ up there. You were using ‘retreatment’ and other words. Was there some reason you were dodging around it?

Dr Smith—No, I think that there was a design for fast breeder reactors which was around in 1970 where there was a uranium blanket which went around and those fuel rods were then put into the major core. I think the idea has probably matured a little bit now and people are looking at having things much more integrated into the core.

Mr KATTER—Our information from Dr Teller at the time was that it does produce weapons grade plutonium—my notes say that anyway. Have I misinterpreted that?

Dr Smith—The fission of uranium does produce plutonium of the right isotopic area. The idea now is to not have this material taken from the reactor but to leave it in the reactor and have the fuel burn progressively through the life of the fuel element.

Mr KATTER—You leave it in for 20 years. So anyone who tries to get in gets radioactive poisoning?

Dr Smith—One of the safety features is the intense radiation of the core.

Dr Cameron—That means you do have to build a reprocessing plant as well if you want to extract that.

Mr KATTER—There is something here I do not understand. At Nagasaki and Hiroshima people were back in there two months later. It was a fully occupied city again within about four or five years. There were not people dying of radiation poisoning. What is the difference between that and Chernobyl where it is still radioactive?

Dr Smith—Twenty-eight people died on the site at Chernobyl. They were firemen generally, and they know the doses that they received. Three others I think subsequently died in hospital from other doses.

Mr KATTER—I understood there is still a problem in Chernobyl.

Dr Cameron—The issue is that we have followed the people from Nagasaki and Hiroshima for 40 years and we have seen an excess cancer risk among those people, and that is how we get our figures as to what is the probability of contracting cancer from radiation exposure. That has become the case study.

Mr KATTER—My understanding of Nagasaki and Hiroshima is that the risk was very, very low—not for the people who were not exposed at the time but for the ones who went back a year or two or three years later it was really very hard to establish a link. I am wrong there, am I?

Dr Cameron—Yes. It became a case study that has been followed over that period of time. There is a committee of the United Nations called UNSCEAR, which is the United Nations Scientific Committee on the Effects of Atomic Radiation. It has followed those people through all that period of time. It has been able to estimate how many would have died from cancer and it has used that to give us a better understanding of what is the risk from exposure to radiation. It is much lower than people thought and Chernobyl is another example of how, despite the claims which were made at the time of tens of thousands of people dying, that just has not occurred.

Mr KATTER—But Nagasaki and Hiroshima were huge cities. People obviously are not worried. You are missing my question here. They are obviously not worried in Japan about the long-term effects of radiation, or not at least at Hiroshima and Nagasaki—they went in there and live there. The increased incidence must be very low.

Dr Cameron—It is, but it is a scientific program that has gone on and they have detected excess cancer rates for the people who were exposed and that has given us a lot of understanding. It is why there can be a lot more certainty in how to protect people because those studies gave us the risk factors.

Mr KATTER—What are we talking about: one per cent, half a per cent, a thousandth of a per cent?

Dr Cameron—It is a function of how much exposure you get. Essentially, with an exposure of something like one sievert there is about one chance in 200 of dying from that. One sievert is a very big dose. They say that, with one millisievert, there is about one chance in 20,000 of dying from that. We have been able to work out the excess cancer rate from exposure to radiation above background levels as a result of the work that has gone on there for 40 years. It gives me a lot of confidence that there is no evidence, at the levels of exposure that we are talking about in Australia or from nuclear power stations or anything, of any risk at all.

Mr KATTER—I am still not getting a clear picture, with all due respect. I will rephrase the question: in, say, a two-kilometre radius of Chernobyl, what are their increased chances of getting cancer now? If I go and live two kilometres from Chernobyl power plant, what are the increases in my chances of getting cancer now?

Dr Cameron—You could go back and live at Chernobyl now, and it would be similar to background levels.

Mr KATTER—That is what I am after.

Dr Smith—In Hiroshima, the Japanese advised people to return to the city. The first reaction was that the Japanese authorities did not understand what had happened, and they advised people to return to the city and look for their relatives.

Mr KATTER—I thought it might have had something to do with the kamikaze culture! I will move on quickly. We have 440 plants in the world; how much waste by volume are we generating per year here which has to be dealt with by your synroc?

Dr Cameron—We would need to give you that on notice.

Mr KATTER—Just roughly.

Dr Cameron—There are very different volumes: a low level, an intermediate level and a high level. It is all a function of how many plants you have. We could supply you with rough estimates of the figures.

Mr KATTER—Let us say a 500 megawatt or 1,000 megawatt plant. Are we talking about volume of the size of this room every year?

Dr Cameron—It is interesting if, for example, you take 40 years of spent fuel out of the Lucas Heights reactor, then all of that waste would come back in two large cylinders about three metres high.

Mr KATTER—Forty-four gallon drum size?

Dr Cameron—No, these cylinders are about three metres high. That would contain 40-years worth.

Mr KATTER—How big in diameter?

Dr Cameron—They are about half a metre in diameter. So it is about 0.6 cubic metres per year.

Mr KATTER—What power are you generating at Lucas Heights?

Dr Smith—It is only 10 megawatts.

Mr KATTER—That is what I am after. I have another couple of questions. As I understand it, lead stops the radiation from moving through. If you have a membrane such as lead, it will stop the radiation. Let us forget about water taking contaminants away or air taking contaminants away. Is it correct that a substance such as lead will stop the radiation?

Dr Smith—It depends. There are three kinds of radiation.

Mr KATTER—We are talking about that one per cent that you referred to.

Dr Smith—A lot of that material is alpha particles. This piece of paper would stop it. For beta, you would probably need a piece of perspex to stop it. For gamma, you may need quite a thickness of lead because it is more energetic, or heavy concrete.

Dr Cameron—The way to think of it is that essentially radiation comes out and it collides with other materials. So the denser the material, the more collisions you get and it stops it. It is a bit like me running against that wall. I have a lot of energy but the wall absorbs it all and I lose my energy. That is what radiation does. It comes out, it bounces against materials and so the denser the materials the more bouncing you get and the more energy gets lost. So you can protect against gammas, either by lead or concrete or steel. Lots of things can do it.

Mr KATTER—You said there was a fast breeder reactor now working in India. Are there no other fast breeder reactors in the world?

Dr Cameron—There is a fast breeder reactor in Russia. The United Kingdom had a fast breeder reactor up until 1980.

Mr KATTER—Why did they close it down?

Dr Cameron—Because it was a research reactor. It worked very well. It had a 25-year life and worked extremely well. However, the UK decided not to build a commercial one, so they closed it down.

Dr Smith—I think the Indian one is a commercial power generating reactor. It is not a research reactor; it is a commercial power generating reactor.

Dr Cameron—The Japanese have a fast breeder reactor at Monju, which has been working for some time.

Mr KATTER—I have one final question. My home town is Cloncurry, which is 30 kilometres away from Mary Kathleen. They have the area completely sealed off. I would love tourists to go there. There is a huge hole in the ground that looks like a very spectacular tourist attraction, but we are told—whether or not it is correct—that the area is contaminated and that there are dangers to you if you go and have a look at this beautiful site. Whether that is just a story being told by the mines department, I do not know.

Dr Cameron—It is a little difficult for us to comment without—

Mr KATTER—Let us forget about Mary Kathleen. If you obviously are mining a product, there will be very low ore areas that are not viable to mine. So you leave them behind. But because you crush them and break them, you are exposing a new face on them which enables radiation to get away from the newly created face—that is from the cracked rock.

Dr Smith—If you look at some of the international sites where there has been contamination, it is often contamination of water, because of what you have said. Exposing the material to water you can get uranium carried in to streams and swamps etcetera around it—not that that is a terrible problem with Mary Kathleen. The Germans have just rehabilitated the East German mining site where the Russians extracted a lot of uranium. When you see the pictures of that, there are people living very close to the site. But they have gone through and tested it. They have done a complete survey of the radiation and, where the radiation was high, they have rehabilitated and covered the material.

Dr Cameron—So I think the answer probably is that it is possible to rehabilitate those sites. The technologies do exist and are in use. Any minerals industry concentrates radioactivity, whether it is lead or zinc or copper, because you are taking ore out of the ground and because of the process you go through you have naturally occurring radioactive material.

Mr KATTER—Radioactive material?

Dr Cameron—Yes, because it is in anything you mine. But the technologies to deal with that are known. I think the issue early on with some of the mine sites is that they were not mined in a way that made it easy to rehabilitate. Nowadays—certainly in the uranium industry—the idea of rehabilitation is in the design of the plant so that it makes it easy to—

Mr KATTER—Your problem is you have a half-life of 250,000 years, whereas with cyanide, for example, you have a half-life of about half an hour.

Dr Smith—By a long half-life you actually mean low activity, usually.

CHAIR—Thank you for appearing here today. If any further matters need to be canvassed, the committee will contact you. Mr Adams, will you move that the slide presentation be included in the committee's records as an exhibit, and that the supporting paper be accepted as a submission.

Mr ADAMS—I so move.

Resolved (on motion by **Mr Adams**):

That this committee authorises publication of the evidence given before it at public hearing this day.

Committee adjourned at 1.03 pm