COMMONWEALTH OF AUSTRALIA

Official Committee Hansard

HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

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

FRIDAY, 16 SEPTEMBER 2005

SYDNEY

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

Friday, 16 September 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 Hatton, Miss Jackie Kelly, 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 9.01 am

CALDICOTT, Dr Helen Mary, President, Nuclear Policy Research Institute

CHAIR (Mr Prosser)—I welcome you to the fourth public hearing of the House of Representatives Standing Committee on Industry and Resources of its 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.

Thank you for agreeing to appear before the committee to give evidence to the public hearing today. 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 and that the giving of false or misleading evidence is a serious matter and may be regarded as a contempt of the parliament. I also remind you that the committee prefers all evidence to be given in public. However, if at any stage you request that evidence be given in private the committee will consider that request. I now invite you to make a short opening statement before we proceed to questions.

Dr Caldicott—Thank you. If I may, I will use the white board during my presentation. I come as a physician, a paediatrician, concerned about the medical implications of uranium mining and the whole nuclear fuel cycle. I am currently writing a book called *Nuclear Power is Not the Answer to Global Warming*, and I can answer questions about that later. In fact, the whole nuclear fuel cycle, from the beginning to the end, produces large quantities of carbon dioxide, the major global warming gas, plus CFC gas, which is used as a coolant in the enrichment of uranium and is a potent global warmer and ozone depleter, and large quantities of fluorine gas, which is used in the enrichment of uranium. I can get onto that later. However, I would like to walk you through why, as a physician, I am so concerned and what uranium mining really means.

There are four forms of radiation: X-rays—we have all had X-rays—gamma rays given off by radioactive material like uranium and all the materials produced in nuclear power plants, alpha particles and beta. These here on the board are particulate, and these here are non-particulate and go straight through you the moment you are impacted by them. An alpha particle is composed of two protons and two neutrons which is shot out from the radioactive nucleus. It is large in mass. You can hold an alpha emitter like uranium or plutonium in your hand. The alpha particle travels such a short distance that it does not penetrate the layers of dead cells to impact the living cells in the dermis. However, if you swallow or inhale an alpha emitter like plutonium or uranium it can damage a cell and later cause cancer. A beta emitter is just an electron shot out from an unstable nucleus. It too is particulate and can damage you.

How does radiation cause cancer? Our body is composed of trillions of cells. In every cell there is a nucleus; in the nucleus there are 46 chromosomes and arranged on the chromosomes are the genes. In every cell of the body is a gene that controls the rate of cell division; it is called the regulatory gene. What happens is that if radiation, be it gamma, X-rays, alpha or beta, strikes a cell and hits the regulatory gene by chance, the DNA molecule, which is a double helix molecule, can be damaged biochemically.

The cell will sit there for anywhere from two years to 60 or 70 years. That is the incubation time for cancer. If I were to sneeze on you, you could be sneezing in two days. The incubation time for a cold is two days, for measles it is three weeks, for mumps it is three weeks, but for cancer it is a long time. That is the silent period—the cryptogenic period; it is called the latent period of carcinogenesis. Then one day, instead of the cell dividing in a regulated way to produce two daughter cells, it goes crazy and produces trillions of cells—and that is a cancer. So all it takes to produce cancer and possibly kill you is a single mutation in a single gene in a single cell.

When a cancer arises, however, it does not wear a little flag saying, 'I was made by some strontium-90 that you ate in a Hershey's chocolate bar 20 years ago.' Why strontium-90 and Hershey's? Because Hershey's is 13 miles from Three Mile Island, which had a major meltdown. Not all the evidence about Three Mile Island has come out yet but in my book—and I have submitted it as evidence—is a chapter on Three Mile Island.

There are other cells in the body that are more important than ordinary bodies cells: the sperm and the eggs. In the sperm and the eggs are half the number of chromosomes or genes in a normal cell so when the two unite you get a normal complement of genes. Mr Adams, I cannot talk to you while you are not listening.

Mr ADAMS—Sorry, please carry on. I will do what I have to do, and you do what you have to do. Okay?

CHAIR—Dr Caldicott, please proceed.

Dr Caldicott—Every gene in the sperm and egg is important: we are who we are because of our reproductive genes. They control everything about us: eye colour, hair colour, personality, why we are like our father, our mother, and the like. However, there are genes in our sperm and eggs that cause disease. My specialty is cystic fibrosis, and one in 25 of us carry that gene. And it is not unless two people with the same gene mate so you get a pair of genes for cystic fibrosis that the child is born with the fatal genetic disease. All these children die—many before the age of 30, but many in childhood. They are 3,000 diseases, or more, caused by genetic abnormalities. Many of them are heartrending, including diabetes, phenylketonuria, dwarfism and cystic fibrosis.

What radiation does is damage the genes in the egg and sperm, inducing an increased incidence of genetic disease, which may not show up for 20 generations or more, until two recessive genes get together to form cystic fibrosis or a similar disease. Blue eyes are the result of a recessive gene; you can only have blue eyes if you have two blue-eye genes. You can have brown eyes if you have one brown-eye genes and one blue-eye gene, or two brown-eye genes. If a mother and father both have blue eyes and they have a brown-eyed baby, the question is: where did the brown-eyed baby come from? Probably the milkman, because there is no chance that those two people could have produced a brown-eyed baby.

Uranium is radioactive. When you mine it, gamma radiation is emitted from the ore face. The men who mine uranium are exposed to gamma radiation, like X-rays, all the time, which can damage the ordinary bodies cells, to cause cancer, and damage the sperm. Uranium decays to a series of daughters, one of which is radon, which is an alpha emitter, like that very highly

carcinogenic material that I told you about. If you inhale radon into your lung, it lands in the terminal air passage and can irradiate a few cells for many years—such that one-third of men who have, in the past, mined uranium around the world have died of lung cancer. None of our uranium miners have ever been followed up—from Rum Jungle, Mary Kathleen or anywhere else—to see, epidemiologically, if they have an increased incidence of cancer, and that is irresponsible on the part of our governments.

The other daughter that is emitted from uranium is radium. Years ago, women used to paint the dials of watches with radium-enriched paints so they glowed in the dark. They used to lick the brushes, so they swallowed a lot of radium. The body thinks radium is calcium. It is a calcium analogue and it goes to the bone. So many of those women died later of bone cancer and leukaemia. The white blood cells are made in the bone marrow. If a white blood cell in the femur is irradiated by an alpha particle, that white blood cell becomes malignant. Leukaemia is a cancer. The blood gets full of immature white blood cells and the patient dies of massive haemorrhage or infection in the way an AIDS patient dies. A bone cancer can also be produced if the bone cells become malignant.

That is uranium mining. I do not have time to go into the rest of the fuel cycle except to say that uranium is enriched to three per cent. Uranium 235 is the fissionable isotope. Uranium 238 is non-fissionable and that is what they are making the weapons out of in Iraq—it is called depleted uranium. Uranium is enriched to three per cent for nuclear power. It is packed into fuel rods 12 feet long and half an inch thick, and 100 tonnes are put into a reactor core. They start fissioning. The uranium fissions and boils the water, producing tremendous heat. The steam is taken off, which turns the turbine and generates electricity. All nuclear power does is boil water.

The uranium becomes one million times more radioactive than the original uranium when it fissions. Two hundred new elements are made, all of which are much more dangerous and radioactive than the original uranium. That is nuclear waste. Some last for seconds and decay. Some last for millions of years. I will go through four of them and then I will stop this presentation and you can ask me questions. One of the nuclear wastes is radioactive iodine. It has a half-life of eight days so it is poisonous for about 16 weeks. You multiply the half-life by 20 to get the total radioactive life of something. ‘Half-life’ means that in eight days the radioactive iodine decays so that you have half a pound of radioactive iodine. You start with a pound and in eight days you have half a pound. In eight more days you will have a quarter of a pound and so on. So it takes a while before it becomes non-radioactive. A lot of radioactive iodine got out at Chernobyl. Two thousand children in Belarus and the Ukraine have had their thyroids removed because of thyroid cancer and up to 7,000 people have developed thyroid cancer. Thyroid cancer is pretty malignant. It spreads. When you have your thyroid out, you cannot survive without having thyroid replacement every day. Those children are at great risk of dying of the cancer itself or because they cannot get their thyroid replacement.

Strontium 90 has a half-life of 28 years. It is poisonous for 600 years. It is a bone seeker like calcium. It causes bone cancer and leukaemia, like radium did with the watch dial painters. Caesium 137 is very carcinogenic. It has a half-life of 30 years and is around for 600 years. A lot of the food in Europe is still radioactive from Chernobyl and there are 120 sheep farms in England that cannot sell their lambs because they are full of caesium 137. We should not be buying radioactive food from Europe. I rang the man in Melbourne who tests the food from Europe. I asked him, ‘How do you test the food to see if it is radioactive?’ A lot of the herbs

from Turkey are very radioactive. It came down in various hot spots around Europe. He said, 'We do random spot checks.' I asked, 'How do you pick out the batches of food to check?' He said, 'The computer does it.' I asked, 'What do you do when you find radioactive food?' He said, 'We dilute it with non-radioactive food.' The solution to pollution by dilution is fallacious with radiation because when you eat food containing radioactive material the strontium concentrates in the bone.

If strontium gets into the water, it bioconcentrates in the algae and crustaceans and then, thousands of times at each step, in the big fish. That is why big fish are full of toxins and radioactive substances if they are near nuclear power plants. You cannot taste strontium 90 in a fish. You do not say, 'I can taste this,' because our senses do not pick up radioactive material. It is silent. You do not know what is going on when you get cancer. Cancer is increasing in frequency but it does not say what it was made by.

Last, but not least, is plutonium. It is named after Pluto, the god of the underworld, not Pluto the dog. It is an alpha emitter, described by its discoverer as the most toxic substance known to the human race. There are more toxic ones, but that is one of the most toxic ones. Less than one-millionth of a gram is carcinogenic so, hypothetically—you cannot do this really—if you took half a kilo of plutonium and distributed that amount amongst every person on earth, that would be a carcinogenic dose for everyone on earth. You cannot do it, but that is a hypothetical scenario. Each reactor makes 500 pounds, or about 200 kilos, of it a year. It has a half-life of 24,400 years, so it is around for half a million years. It has one very nice property, in that about five kilos is the amount you need to make yourself a nuclear weapon. You can make nuclear weapons from reactor grade plutonium. They have made them and blown them up.

So plutonium is fuel for nuclear weapons. It is highly carcinogenic. The body thinks it is iron, so it causes lung cancer, bone cancer and leukaemia. It crosses the placenta into the developing embryo, where it can kill a cell that is going to form the right half of the brain or the septum of the heart or the left arm—like the drug thalidomide did years ago. Thalidomide gave babies terrible deformities, because they were born without limbs. And plutonium has a predilection for the testicle. It tends to deposit next to the little cells that are going to form the sperm.

So the alpha particle can be damaging the genes in the sperm which are passed on from generation to generation, for the rest of time. Meanwhile, the plutonium lives on for half a million years. When that body is cremated, the plutonium goes out through the chimney to be breathed in by someone else, for the rest of time. So we have genetic abnormalities passed on, plus the plutonium, for the rest of time. Every male in the Northern Hemisphere has a small amount of plutonium in his testicles from the weapons-testing days of the British, the Americans, the Russians and the Chinese, when they were testing in the atmosphere.

The incidence of testicular cancer is rising. The incidence of cancer in general is rising. We spend millions of dollars trying to cure cancer. We spend countless hours caring for our patients, and then they often still die of cancer. If you have ever sat with a child dying of cancer, you will know that the parents never recover.

The nuclear industry is about cancer. We are talking about nuclear waste that lasts for up to half a million years, which at the moment is seeping out of containers all over the United States. I have documented it here. The incidence of cancer in those areas is increasing. You cannot cure

cancer, generally—not adult cancer. We can cure a lot of childhood cancers. That is the legacy that this industry will bequeath to all future generations, and we are not the only creatures that have genes. All creatures have genes, all creatures get cancer and all creatures get genetic disease, and so do the plants. We inhabit the planet with 30 million other species.

So I would say as a biologist that the nuclear industry is medically contraindicated. That is what we say when we give a patient a drug that has bad side-effects. We should not be mining uranium, because what we are actually doing is exporting disease. That is a very brief summary.

CHAIR—Dr Caldicott, your revised edition of *Nuclear Madness*, published in 1994, which you have presented to the committee, states that 5,000 to 10,000 of those in the Chernobyl clean-up are known to have died so far. The United Nations Chernobyl Forum, comprising representatives of some eight UN agencies as well as the governments of Ukraine, Belarus and Russia, recently issued a definitive report entitled *Chernobyl's legacy: health, environmental and socioeconomic impacts*. I note that the report found that there have been fewer than 50 deaths directly attributable to radiation from the disaster to date. How can you account for this wide variance between the UN figures and your claims?

Dr Caldicott—My claims come from a book written by Medvedev. He is a Russian. Those claims by the UN come from the IAEA, the International Atomic Energy Agency, which has a very close relationship and a contract with the WHO, the World Health Organisation, such that the WHO is not allowed to publish anything or do any epidemiology on radiation victims unless the IAEA, which promotes nuclear power, agrees. That report is considered by many of my colleagues throughout the world as a whitewash. Number one, I told you that the latent period of carcinogenesis is up to 70 years, for as long as people live.

CHAIR—And the three governments?

Dr Caldicott—Yes.

CHAIR—So the three governments have been involved in the whitewash as well.

Dr Caldicott—Yes. There have been very few studies funded—none by WHO—to assess the incidence of cancer in those countries. That is the first point. Number two, we are going to see much more cancer. It is only 20 years post Chernobyl. It is too early to do a report yet, except that we do know there are over 7,000 cases of thyroid cancer, and many of the men who came in to clean up the radioactivity from Chernobyl—

CHAIR—The forum said that there was only 4,000 cases—

Dr Caldicott—Well, that is wrong.

CHAIR—and all have recovered, with the exception of only nine deaths.

Dr Caldicott—They have not recovered. When you have cancer, you do not know till you die if you are going to die of cancer. That is the problem with cancer: one cell can escape to the brain, and 20 or 30 years—

CHAIR—But some of those people would have died of cancer anyway.

Dr Caldicott—No, they are mostly young people who imbibed or ingested the radioactive iodine and, as they grew up, they developed thyroid cancer. They are mostly young people. Are you challenging me that radiation doesn't cause cancer?

CHAIR—I am asking you to explain the wide variance in your claims from the claims of the—

Dr Caldicott—I think it is a whitewash. From my experience with the IAEA—and I have been in touch with ElBaradei—

CHAIR—So you are saying that the UN's claims are a whitewash and the three governments' claims also are a whitewash.

Dr Caldicott—Yes. I think that the people who came from those governments worked with the IAEA, which promotes nuclear power, and I would not trust an organisation that promotes nuclear power. It was interesting when it came out. I read it with great interest. I then investigated and found that the data they had is not accurate and many more people died. I was just going to finish this point: they brought in thousands of people from the military in Russia to clean up Chernobyl. Men were picking up pieces of spent fuel—incredibly radioactive fuel—with their bare hands and putting them in buckets. Within two days, those men developed radiation tan—they went all brown—their legs swelled so much their skin split, and within two or three days they died of acute radiation sickness. And it was not just 30 or 50; there were many more that died. It is documented here and documented further. I can bring you the evidence and refer you to the papers.

Mr HATTON—Your autobiography has an interesting title and indicates a desperate passion. It is indicative of the approach you have taken. On page 21 of the revised version of *Nuclear Madness*, you say this:

… I have grown up with the fear of imminent annihilation by nuclear holocaust.

Would you say, given the conjunction of the fear of a nuclear holocaust and the driving passion that developed in relation to campaigning against nuclear energy and its use, either in thermonuclear weapons or nuclear energy in the nuclear fuel cycle, that that has been the key motivator for the latter part of your life, say, the last 35 years?

Dr Caldicott—What is the question?

Mr HATTON—Has the drive to stop the use of any kind of nuclear energy whatsoever been dominated by the fear of nuclear annihilation that you grew up with?

Dr Caldicott—No, the two things come together. Nuclear power is an offspring of the nuclear weapons industry and, in fact, is still funded to a degree by the weapons industry in the United States: $13 billion in its last energy bill went to nuclear power. I am a physician. I took the Hippocratic oath when I was 17—'do no damage'—and I have spent my life trying to save lives. That is who I am; that is my vocation. If you have seen people dying of cancer, helped them die

of cancer or had relatives dying of cancer, it is a very painful, humiliating disease. I, however, have spent many years treating other diseases too, and my goal as a physician is to cure people: that is what I do.

It is not just the nuclear industry; I have written a book, called *If You Love This Planet*, about the 80,000 chemicals in common use today, many of which are carcinogenic and act synergistically with radioactive materials. So there are two tracks in the nuclear industry. One goes off to nuclear weapons—and America is currently building new nuclear weapons—and one goes off into nuclear power. But they are the same thing: they fission the atom. It is all medically very dangerous. I founded a group called Physicians for Social Responsibility. We got the Nobel Peace Prize in 1985. I led that movement to try to teach the people of America and the world about the medical consequences of the nuclear age.

Mr HATTON—What do you think the social and educational impact of your book *Nuclear Madness* has been? What was your intent?

Dr Caldicott—Education, which is why I gave that talk today. That is what I do; I educate. It has been used by a lot of colleges in the United States in their curricula. It is about education. The book is all fully referenced.

Mr HATTON—How would you sum up the fundamental message that you gave to students at school in the 1980s? What call did you make to students at school with regard to the impending nuclear catastrophe and what their first duty should be as world citizens?

Dr Caldicott—It was about the holocaust, about impending nuclear war at that stage during the Cold War. That is what I mostly talked about in the eighties as I led the nuclear weapons freeze in the United States. It was that nuclear war is bad for your health—I am being facetious. Physicians for Social Responsibility—PSR—wrote two articles in the *New England Journal* in the early seventies about the medical effects of a nuclear weapon dropping on Boston. And we used the data to translocate a weapon dropping on Seattle, in California or wherever and taught the American people that nuclear war is medically contraindicated. When I first started in 1978, most Americans said, 'It's better to be dead than Red.' We said, 'You'd rather be dead?' and they said, Yes.' So we said, 'Do you know what happens if a nuclear bomb drops on Boston?' and they said, 'No.' So we would hold symposia at Harvard, the University of California, Stanford. We got a lot of media and we taught a lot of people about the medical effects of nuclear war such that in five years 75 per cent of Americans rose up and said nuclear war is not a good idea. That helped to lead to the end of the Cold War.

Mr HATTON—I actually would not have thought that would have been too difficult an argument to win—

Dr Caldicott—It was not difficult.

Mr HATTON—when it was in the sixties. Like you, I lived through that period. Like you, I am a person who was born in the atomic age. Like you, I lived through a period of mutually assured destruction. It is not a really difficult argument to win, and I do not think too many people needed to be won over too hard to that point of view.

Dr Caldicott—It was not hard but the fact is that when I first started in 1978 people were oblivious; they were unaware. So what we did was bring it back into their consciousness again and teach them what a nuclear war could mean and that there were thousands of nuclear weapons targeted on the US 'right now'. Robert McNamara and I wrote an article—

Mr HATTON—Yes.

Dr Caldicott—McNamara, the former Secretary of Defense. The article was published in the—

Mr HATTON—I know who Robert McNamara was—

Dr Caldicott—or is.

Mr HATTON—I know what he did.

Dr Caldicott—There are 70 nuclear weapons targeted on New York as I speak because the Cold War is not finished. Russia and America still have each other on hair-trigger alert and we are also targeted because of US bases.

Mr HATTON—I know all that and understand that.

Dr Caldicott—Okay—good.

Mr HATTON—I want to go to a different point: the social and educational impact on students at school by your campaign to emphasise the nuclear holocaust and the fact that we were only minutes from midnight and your call to those students effectively to put their studies aside and to campaign against this as the single most important thing that they could do.

Dr Caldicott—I did not ask them to put their studies aside.

Mr HATTON—That is how it was interpreted. You made calls that were of that nature. Do you have any comprehension of how much damage has been done to students worldwide, including students in Australia, by the manner in which your campaign, your crusade, was taken up?

Dr Caldicott—I find it extremely offensive that you should say that to me.

Mr HATTON—I am asking that question—

Dr Caldicott—I will not take an offensive question—

Mr HATTON—Why not?

Dr Caldicott—like that to say that about the education I did during the eighties, and not just me but 23,000 of my colleagues in America and many thousands around the world—medical

people talking about the final epidemic of the human race. If people were not concerned about that and are not now something is very seriously wrong.

Mr HATTON—Dr Caldicott, have you ever been in a situation where you have taught children in years 7 to 10?

Dr Caldicott—Yes.

Mr HATTON—You have?

Dr Caldicott—Yes. I have been invited by schools and principals.

Mr HATTON—You have been invited, by schools and principals, to speak. You have not been in the position I was in, in the 1970s and 1980s, when you were arguing the way you were in *Nuclear Madness*. You were presenting a clarion call for people to have that as the single most important issue directly in front of their mind, and that effectively they should put other things aside to join you in that campaign. I saw the impact of that being taken up in schools, and in Catholic schools in particular—

Dr Caldicott—Where?

Mr HATTON—In Sydney. I saw the impact of that becoming central to the view that they had. It was taken up in an emotive way—not in a rational, scientifically based way, not in a way which was driven by the logic of what you presented in terms of the nuclear fuel cycle. It was taken up in an impassioned way, where they effectively replaced whatever guilt they had in the fifties—

Dr Caldicott—Did you ever hear me give a presentation at that time to children in a school?

Mr HATTON—No, I did not.

Dr Caldicott—Okay.

Mr HATTON—But I was a teacher in a school when that wave came through them, and that preoccupation, and I listened very closely to what you argued at that time.

Dr Caldicott—At that time, the American Catholic Bishops put out a pastoral letter about nuclear war, calling on all Catholics to attend to this, saying that it could produce the final epidemic of the human race and that this was a deep spiritual issue. Cardinal Bernadine, and many of the others in America, came on board because of the work that Physicians for Social Responsibility did. People would say that you must not be emotional about nuclear war, or that you must not be emotional about nuclear power, because that invalidates any rational argument. I would say that if you are not emotional about children dying of cancer—and one does get quite emotional when one treats a patient with cancer, or when the patient is your child—

Mr HATTON—There is a difference between being emotional and emotive.

Dr Caldicott—No, there is not. I am saying 'emotion'. If you are not emotional about the final epidemic of the human race, and care about that, there is something wrong. If I have two parents in my office and I tell them that their child has leukaemia or cystic fibrosis and they have no emotional response, I get them to see a psychiatrist, because it is very important that we have feelings as well as a rational neocortex to understand the issue. So to negate emotions is not appropriate.

Mr HATTON—I am not talking about negating emotions. I very well remember the temper of the times and the temper of the argument. It was emotive, above everything else. The 'minutes to midnight' campaigns, what was on TV—the fear that they instilled into children was extremely great.

Dr Caldicott—It was. But I spoke very rarely to young children, let me tell you; I did so about two or three times. I spoke a few times to high school students. On the whole, I spoke to adult audiences. My presentation was very factual, particularly to doctors, who cannot stand any emotion at all—you just bomb them with data. People have an emotional response to the data. That is their response. But the data is very factual.

Mr HATTON—I understand that the data is factual.

Dr Caldicott—And if you had not heard me speak—

Mr HATTON—I also understood the campaigns that were conducted at the time.

Dr Caldicott—According to the *Bulletin of the Atomic Scientists*, the 'Doomsday Clock' was then at three minutes to midnight. I met with Reagan for an hour and a quarter in the White House, when I had just written my book about the medical effects of nuclear war. It was very worrying because the man was a nice man but he was fairly ignorant. He said that people who worked for the nuclear weapons freeze were either KGB dupes or Soviet agents; he was reading straight from the *Reader's Digest*. At that time, 80 per cent of Americans supported the nuclear weapons freeze.

Mr HATTON—Further on in *Nuclear Madness*, at pages 28 and 29, you say this:

> ... first and perhaps most important, that we can no longer afford to entrust our lives, and the lives and health of future generations, to politicians, bureaucrats, "experts," or scientific specialists, because all too often their objectivity is compromised.

Why is your individualised response to nuclear holocaust and the dangers of using nuclear energy more powerful than that from people who actually have elected responsibility in regard to this area? I know what you argued in relation to Reagan. This does not leave anybody out, does it?

Dr Caldicott—I guess I was a little bit too comprehensive. David Suzuki did a survey of federal politicians in Canada and found that less than three per cent were scientifically literate. That does not negate the intelligence of politicians at all, but I think it is important on issues such as these, which have profound medical ramifications not just for this generation but for many future generations, that people do understand genetics, biology, medicine and the like or

read about them and learn about them, because decisions made on a purely economic basis, which I see our uranium industry and politicians doing, are inappropriate. It is very important to be educated.

Mr HATTON—It is also possible that campaigns that are fundamentally based on the psychology of fear and engendering that within populations from the very youngest to the very oldest can have deleterious effects as well.

Dr Caldicott—I think that, when people have a fearful reaction to the data and information presented, that is how people respond. If I give a lecture about the medical effects of nuclear war or, indeed, nuclear power, which I am about—

Mr HATTON—Can I bring you back—

Dr Caldicott—Can I just finish this?

Mr HATTON—If I can bring you back, I think you will get my point and yours. Can I bring you back to the 'minutes to midnight' stuff that I think was on Channel 7 during the early eighties—

Dr Caldicott—I did not see that. I was in the States.

Mr HATTON—and the impact that had on the population at large, based on your campaign. It was not reserved, scientific or logical. It had a strong emotional base. It was highly emotive and, I would contend, highly damaging.

Dr Caldicott—My dear, I had nothing to do with Channel 7. I was in the United States as President of Physicians for Social Responsibility. I was on *60 Minutes* in the States, *Good Morning America* and all the shows, as well as in the *New York Times*, and I spoke only as a doctor and only about the medical consequences. *The Day After* was made because of our work at PSR, but I had nothing to do with that. People's interpretation of the data will be variable, and I take no responsibility for what Channel 7 did.

Mr HATTON—Or the other filmic work based on this?

Dr Caldicott—No, because I did not make the films. I was teaching.

Mr HATTON—And as a teacher I observed the impact of those campaigns in schools. The level of emotiveness and the fear engendered by them were extraordinarily high, with the argument that students should effectively put aside preparing for their lives because it was just too late; there was only one thing they had to do.

Dr Caldicott—I guess you could put the blame or responsibility for that partly on the Catholic bishops and their pastoral letter, especially in Catholic schools.

Mr HATTON—Or taking too much to heart the fundamental drive of the argument. I do not think they invented that. I think it was inherent in what you and others were arguing.

Dr Caldicott—They were very intelligent men who wrote a very intelligent document, as did the Methodist bishops in America who wrote a similar pastoral letter.

Mr HATTON—So their intelligence is related to whether or not they agree with you and the fundamentals of the campaign.

Dr Caldicott—I did not say that. Are there any other questions?

Mr TOLLNER—Dr Caldicott, you have outlined your concern very well. Thank you very much.

Dr Caldicott—Thank you.

Mr TOLLNER—I suppose that, with all things nuclear, many people see and have concerns about the dangers of nuclear products and that sort of stuff. On the other hand, there are people who see the benefits of it. I think even you would admit that there are benefits, but your view is that they are outweighed by the dangers. To give you an example, most people these days would say that nuclear bombs are extraordinarily dangerous, but there is still a view among some people in the community that nuclear bombs actually save lives—for example, in the Cold War build-up, it never actually came to nuclear war. The deterrence factor was there. That is an argument, you would admit, that some people make; they do see that as a benefit. The benefit is that, of course, without nuclear weapons those two Cold War countries would have been at war constantly and would have killed people everywhere.

An obvious benefit of nuclear power generation is electricity production. Your concern is that the dangers outweigh the benefits of electricity production. We benefit from a whole range of other uses of nuclear technology. Fire detectors and the like, which contain a small amount of radioactive isotope, need to be made at a nuclear facility. I am curious as to what you see as the alternatives. I understand what you mean when you say that we can generate electricity with coal, wind and a whole range of other things, but in other areas the answers do not seem so obvious. For instance, in medicine, if you completely do away with anything nuclear, how do you treat existing cases of cancer? And how do you make fire detectors?

Dr Caldicott—In 1976 I testified before the New York Fire Department when they were deciding whether they should use photovoltaic cells for fire detectors or use americium, which is, in fact, much more dangerous than plutonium, which is a by-product, a spin-off, of nuclear power. I begged them to use not americium but photovoltaic cells. However, they went in the direction of americium, which is extremely dangerous and lasts for hundreds of years. It is in a plastic container and, if a place burns down, the americium gets into the air, people can inhale it and they will almost certainly develop lung cancer. Then, of course, when the fire detectors go to the rubbish tip—they are only plastic—the americium can leak out. So this puts into the environment a lot of americium, which is very dangerous and will bioconcentrate in food.

In medicine we use X-rays a lot—and sometimes injudiciously. Each dose of radiation you get adds to your risk of getting cancer. Doctors use X-rays for legal purposes; they should not do that. We do treat cancer with X-rays—very high doses—because rapidly dividing cells are killed by radiation. Children, who are so sensitive to radiation, get cancer much more readily than adults because their cells are rapidly dividing and they are very vulnerable. We hope to kill all

the cancer cells—sometimes we do, but we usually do not—but sometimes patients who have been cured of the primary cancer develop a second cancer, related to their radiation therapy, some 20 years later. That is now very well documented in the medical literature. Normal cells adjacent to the cancer have had their regulatory gene damaged and they get another cancer. We, I admit, are the main irradiators of the public at the moment. In nuclear medicine they say, 'We need nuclear power plants for radioactive isotopes'—for thallium scans or whatever. You can make every radioactive isotope that you need in medicine in a cyclotron, which is not a nuclear power plant and does not produce nuclear waste.

Mr TOLLNER—But it certainly produces radioactive materials.

Dr Caldicott—You can make specific isotopes for medicine in cyclotrons, and you do not make radioactive waste. That is what we should be doing.

Mr TOLLNER—And what about other areas such as drill-pipe testing?

Dr Caldicott—They use caesium 137 in capsules for that, which has very high radiation. I will tell you an anecdotal story. A hospital in Brazil was using caesium for radiation therapy for cancer. They did not need the capsule anymore so they sent it to the local rubbish tip. A family found it—and it was magic: if they put it on their faces, they glowed in the dark. They ate it and they hid it under the bed and watched it in the dark. The whole family died of radiation sickness. In fact, the whole village was contaminated for the rest of time, because it lasts for 600 years.

I would like to get back to the idea that having nuclear weapons prevented nuclear war, so we had to build nuclear weapons. We are in a very dangerous situation at the moment. The Russian early warning system is breaking down and none of their satellites work. America still has a policy to fight and win a pre-emptive nuclear war against Russia—that is from a Pentagon document—and there are thousands of nuclear weapons on a hair-trigger alert on both sides.

In January 1995, Yeltsin, who was not very often sober, got a message that America had launched its nuclear weapons. In fact, a Norwegian satellite set on an American missile had been launched to monitor the weather near where the Trident submarines, the American submarines, roam. They picked it up and said, 'My god, we're under attack,' because they are always nervous that it might happen. Yeltsin gets three minutes to decide whether or not to press the button, and so does George Bush. The computer—the football—was open for the first time in history in Russia. Never before had it—with the computer codes—been opened. His generals, standing over his shoulder, said, 'Mr President, press that button.' Ten seconds before the end of that three minutes had elapsed the missile veered off course, and they did not destroy the planet. That was a major full-page story in the *New York Times.*

I had a Russian colonel, who was desperate, saying to me: 'Helen, we're so scared we're going to blow up America and the rest of the world by accident because our early warning systems are faulty and degraded. Please help us. Please hold a conference with the CCCI—the command, control, communications and intelligence—people from both sides to work this out and take the weapons off hair-trigger alert.' The danger now is greater than it was during the height of the Cold War simply because people's attention is not on the risk anymore.

Mr ADAMS—I have a couple of points. One is: is using isotopes in medicine an acceptable process?

Dr Caldicott—Yes. You often get a lower dose from using isotopes than you do with using, for instance, an intravenous pyelogram with normal X-rays, so they are very useful in medicine and they have very short half-lives.

Mr ADAMS—I take it that splitting the atom was a mistake, in your opinion.

Dr Caldicott—I think it was inevitable. But it was Einstein who said the splitting of the atom changed everything save man's mode of thinking, 'thus we drift towards unparalleled catastrophe'. We use it for the wrong purposes.

Mr ADAMS—I think you argue that nuclear reactors put out a percentage of radioactive isotopes into the air and water at some level of measurement—

Dr Caldicott—Routine releases, yes.

Mr ADAMS—and that that is doing harm. That is what you have given us today. Is there any reputable scientific evidence that backs up that claim?

Dr Caldicott—Yes, there is a large literature on tritium and the very dangerous effects that tritium has. The nuclear industry does not know what to do with it and has allowed radioactive releases continuously from all the reactors around the world. Tritium is radioactive hydrogen that makes a water molecule that combines in the DNA molecule. There is a huge literature on tritium because the nuclear industry is very worried about it. Routine releases of noble gases—xenon, krypton and argon—are dangerous too. They are fat soluble. They are inhaled through the lung. They tend to deposit in the fatty tissue of the abdominal fat pad near the genitalia. They are high-energy gamma emitters like X-rays. That is an issue that the nuclear industry has not coped with; it still does not. There is a quite large literature on that.

Mr MARTIN FERGUSON—You have said we should not export uranium because we would be exporting potential illness and death. Given that there is a comparison by volume of the toxicity of the waste produced by energy sources which establishes that fossil fuels emit more than 24 billion tonnes of CO_2 each year and that the burning of coal also includes toxic metals such as arsenic, cadmium, lead and mercury, which are also pretty long lasting, should we also walk away from the export of coal?

Dr Caldicott—I think that we should be thinking about coal seriously. Our coal is very dirty. It is responsible for a lot of global warming and CO_2 production. Here we are a nation bathed in sun. Israel pretty well runs a lot on solar power. We should be developing solar power. It would employ many more people. It would improve our economy and we could export it to an energy-hungry world just to the north of us which is bathed by sun. As for the money that is going into nuclear power at the moment in subsidies, certainly in the United States—$13 billion—it could be used for the development of alternative and renewable energy sources. Wind power is now cheaper than coal by far and cheaper than nuclear. There is enough wind west of the Mississippi to supply the whole of the United States with energy.

Mr MARTIN FERGUSON—Do you believe therefore that renewable energies are the solution to the world's base load power requirements?

Dr Caldicott—Yes, and to global warming. The money that is going into nuclear energy will not solve anything, even if all existing electricity plants are replaced by nuclear plants. There is only two years supply of uranium left in the world. There is not a lot of high-grade uranium ore left and, as that is degraded, they are using lower energy ore. I have the whole life cycle study which was done by a Dutchman and an American, whom I am flying over for my symposium in Washington on nuclear power and global warming. At the moment, a nuclear power plant produces three times less CO_2 than a gas-fired plant. It is just three times less but that is a lot of CO_2 and, as the uranium ore declines in concentration, you will get very much less energy from nuclear power and a lot of CO_2 will be produced. There is not enough uranium in the world to make the slightest bit of difference to global warming. Global warming, as we know, is a very serious issue.

Mr MARTIN FERGUSON—Have you done some research on why as a nation we should stop exporting coal?

Dr Caldicott—Yes. It is self-evident, isn't it? Coal produces carbon dioxide and, you are right, it produces mercury—it does not actually produce it; it is in the coal itself. But by orders of magnitude, it is not nearly as dangerous as the nuclear waste that is produced that lasts for half a million years.

Mr MARTIN FERGUSON—How many people were killed in the nuclear industry last year?

Dr Caldicott—You cannot ask me that question. Those workers are not followed up epidemiologically and it takes them up to 50 or 60 years to get their cancers, whereas when people are killed in coalmines you know because they are killed that day.

Mr MARTIN FERGUSON—Do you accept, for example, that in China alone last year there were over 6,000 coalmining deaths?

Dr Caldicott—Yes. It is a very dangerous industry in China, and they do not have many safeguards for their workers. But we are talking about something that is going to affect people and other species for the rest of time. As I said, when a cancer arises it does not denote its origin. This material is highly carcinogenic. There is a huge amount of medical literature on it, as there is on coal.

Mr MARTIN FERGUSON—There is also a difference between nuclear power and nuclear weapons.

Dr Caldicott—What is the difference?

Mr MARTIN FERGUSON—It is an entirely different debate. We as a nation have a major greenhouse problem.

Dr Caldicott—Not as a nation—as a planet.

Mr MARTIN FERGUSON—As a planet and as a nation.

Dr Caldicott—We are in very serious trouble.

Mr MARTIN FERGUSON—My oath, we are.

CHAIR—Thank you, Dr Caldicott, for appearing before the committee today. If the secretariat have any further follow-up questions, we will contact you.

[9.53 am]

BROINOWSKI, Professor Richard Philip, Private capacity

CHAIR—Welcome. Would you please state the capacity in which you appear.

Prof. Broinowski—The capacity in which I appear is as a private citizen, but I am a professor at the University of Sydney and I am a former Australian diplomat.

CHAIR—Thank you for agreeing to appear to give evidence before the public hearing today. Although the committee does not require you to give evidence under oath, I should advise you that committee hearings are formal proceedings of the parliament and remind you that the giving of false or misleading evidence is a serious matter and may be regarded as a contempt of the parliament. I also remind you that the committee prefers all evidence to 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 give a short opening statement.

Prof. Broinowski—Thanks very much. Like many others, I am sceptical that nuclear energy can be a solution or even a part solution to the growing problems of greenhouse gas emissions and global warming. The most compelling reasons are that: firstly, electricity generation accounts for only approximately one-third of greenhouse gas emissions; secondly, at least 1,000 nuclear reactors of at least 1,000 megawatts each would have to be constructed, beginning immediately, to make any dent on the contribution power generation makes to global warming; and, thirdly, these would in turn generate enormous quantities of hydrocarbon emissions in the mining and enrichment of the additional uranium, rapidly exhaust economically significant deposits of uranium and significantly increase the problems of disposal of spent nuclear fuel.

Gentlemen and madam, I know that others would have covered this matter with you in this committee. What I want to concentrate on is the inadequacy of Australia's bilateral safeguards on uranium exports. I go back—and Mr Ferguson might remember this, although he would have been very young—to July 1975, when Prime Minister Whitlam commissioned Mr Justice Russell Walter Fox to undertake the most comprehensive environmental study ever undertaken in the Commonwealth of Australia about mining and exporting uranium from the Northern Territory. He gave a guarded approval. He said, 'Yes, we could do it, but it's fraught with dangers.'

In 1975, Mr Fox's study and findings hung like an incubus on the incoming Prime Minister, Malcolm Fraser. He went ahead, and in May 1977 he introduced what my fellow bureaucrats in the Commonwealth government claimed to be the most comprehensive bilateral safeguards in the world. Candidate states must be signatories to the NPT. Government-to-government safeguard agreements must be concluded before the negotiation of commercial agreements. Australian uranium must be in a form to attract full-scope IAEA safeguards by the time it leaves Australian ownership, and all facilities using Australian uranium must be accessible to IAEA and Australian inspectors. There must be no transfer or enrichment beyond 20 per cent U235 or reprocessing of any Australian uranium without express prior Australian government consent

and, finally, every commercial contract must acknowledge that the transaction will be subject to the bilateral safeguards agreement.

Then, with a moralistic flourish, which I have heard today from the present government and from members of the opposition, Mr Fraser declared that Australia was only selling uranium to give Australia the capacity to influence peaceful nuclear technology and discourage the development of nuclear weapons. His trade minister, Doug Anthony, added that under the terms of the NPT Australia had a legal obligation to sell it. It did not. Both of these statements were in fact inaccurate. Commercial considerations governed the whole deal, such as the creation of 100 jobs in Queensland that people talk about today. The treaties section of DFAT determined that article IV of the NPT did not oblige Australia to sell its uranium to a particular customer or at all.

What has happened since then is that these safeguards, imperfect as they were, have been modified through commercial pressures. I will mention just a few of them. We began immediately by selling uranium to France, which had not signed the NPT. In October 1977 Australian uranium no longer had to attract IAEA safeguards when leaving Australian ownership, because we could not make uranium hexafluoride, which was the first stage at which it had to attract safeguards. We were exporting yellowcake. In October 1977 we told Japan that we would not insist that uranium contracted for supply before May 1977 must be subject to prior consent on transfer, enrichment and reprocessing.

Then, in January 1981 we dropped the provision altogether in favour of a program or toll approach. In other words, with a nod and a wink we said to our customers, 'We'll trust you not to transfer, reprocess or enrich our uranium because we now have that agreement.' We allowed them to do as they wished. In January 1979, the government overrode the objections of DFAT to allow contracts to be negotiated before the negotiation of bilateral safeguards agreements, therefore cutting the ground from under the negotiators of the bilateral agreements. Finally, by November 1982, we were allowing sales of uranium from offshore warehouses outside Australian jurisdiction and through offshore brokers.

The Hawke government compounded the problems. Firstly, in May 1986 it introduced the principle of equivalence, by which Australian uranium could in practice be used in all manner of unauthorised ways, provided only that an amount of uranium equivalent to the original shipment from Australia could be seen to be used in approved activities. Secondly, in 1986 the Hawke government introduced the concept of flag swaps or book transfers, by which Australian originating uranium could become American or French or some other nationality to save transport costs.

I mention these facts because the erosion of our safeguard standards has increased the likelihood that Australian nuclear material will find its way into nuclear weapons. In fact, in my book *Fact or Fission?*, published in 2003, I say that it is absolutely clear that some of it has already done that. We have exported tens of thousands of tonnes of uranium in various forms. The Japanese nuclear industry is one of our largest customers. They have admitted that some of their plutonium has gone missing. Right now in north Asia we have a situation where if North Korea does not have nuclear weapons already they surely will. I can assure you that my professional judgment is that if they do, Japan is going to declare that it has them too, South Korea will as well, and Taiwan probably will too. This is not a joke. This is really serious; these are our most important customers for uranium.

In the context of this committee and the Australian government's intention to expand uranium mining and exports, we have several other problems to consider. First is the legitimisation of India's and Pakistan's illegal nuclear weapons programs by the United States. Second is the fact that Australia is even contemplating selling uranium to India, which is not a member of the NPT, and to China, which has said that it will not allow some of its facilities to be open for international inspection. Third is the goading of North Korea by the United States and other powers into making its own nuclear weapons. Fourth is the possibility that Japan and South Korea, as I said, may become nuclear states as well. And last is the failure of the non-proliferation review conference in New York in May 2005 to reach any substantial agreement about anything, including in particular agreement about realising the bargain inherent in article VI of the treaty, which says that the nuclear weapons states will promise to begin the process of reducing their nuclear arsenals if the non nuclear weapons states promise never to develop or obtain nuclear weapons of their own. Gentlemen, in this context, where we have a non-functioning nuclear non-proliferation regime, how on earth can we suggest that we keep exporting uranium? Thank you.

CHAIR—In your book you suggest that before the 2001 terrorist attack in New York Australian authorities could not accurately quantify how much radioactive material was missing in Australia. Are you aware of whether any steps have been taken by the Australian government to impose stricter controls and to develop an accurate inventory of radioactive material? If not, would you recommend that such activities be undertaken?

Prof. Broinowski—I am aware that there has been a tightening of the Nuclear Non-Proliferation Treaty, especially since the uncomfortable discoveries of the weapons program in Iraq. That is the NPT-plus, and Australia has signed on and agreed to it. I am not personally aware, though, of any initiatives taken by the Australian government. They are always talking sanctimoniously about being terribly much in favour of nuclear non-proliferation, but when you look at the record you find that not a great deal has been done. There are claims made by the government, by John Carlson of the Australian Safeguards Office and others, that we have the best, most leak-proof safeguards in the world, but we do not. So my answer is yes.

Mr HATTON—The introduction of your book states that you once supported the development of the whole nuclear fuel cycle in Australia, in which fuel fabricated domestically would be leased to power companies in other countries then returned as spent rods for reprocessing and disposal in Australia. You state that not only would this create an enormously valuable industry but also it would be a responsible and foolproof way of preventing the diversion of Australian uranium into nuclear weapons. Do you still believe that the creation of that domestic fuel cycle industry and the leasing of fuel elements would have non-proliferation and economic benefits?

Prof. Broinowski—No, Mr Hatton, if you would read the rest of what I said, I say that on balance I find that it is extremely dangerous to be selling this stuff. But let me follow that up. One thing that has always disturbed me, after 34 years as a foreign service officer doing a lot of work on trade, is that Australian governments and Australian industry are content to sell unenriched, unprocessed commodities. We still do it. We still have the mentality of a colony. In that sense, I was putting uranium in the same context. We are selling yellowcake. Yellowcake is the lowest form of beneficiation of uranium. Enormous value could be added to it if we had even a uranium hexafluoride plant, if we could fabricate it into fuel rods and if we could lease the

rods, not sell them—this was put twice to the Fraser government as something we should seriously do, and they turned it back.

The United States is worrying about Russia selling uranium to Iran. Russia have always had—when they were the Soviet Union and now as Russia—a policy of leasing their rods. The only country they never did that with was China, and that was out of an efflorescence of brotherly, Soviet type comradeship. All the other countries, they have leased to. If we had done that—if we had the whole cycle and we bought back, as a morally conscientious people should, the spent fuel that we have so happily sold to the world—we could have developed a very important and powerful industry here in Australia. That would give us a greater say in the international community about nuclear matters, and that would safeguard Australian uranium from entering the fuel cycle. My feeling now, though, is that because we have such a mess in our international nuclear safeguard systems it is most unwise, most inappropriate and most dangerous for Australia to be adding to the problems of the world.

Mr HATTON—I had looked at the rest of your material. The point was to take what your position was then and ask why you had changed it, which you have partly answered.

Prof. Broinowski—I hope I have answered that.

Mr HATTON—But I also understand that in your original argument you were driving at the moral and ethical responsibilities of what we were doing. Are there are other factors that would lead to us not crossing that bridge now? Is it just too hard to take on those responsibilities?

Prof. Broinowski—It is certainly too hard, when I look at the way politicians run for cover when it is suggested that we have a nuclear spent fuel storage regime in this country.

Mr TOLLNER—Not all of them.

Prof. Broinowski—Well, not all of them. That is good. Mr Tollner, I am not familiar with your views. Quite frankly, we need right now an above-ground repository for low-level waste. But let us also be certain of our terms. Helen Garnett, the former head of ANSTO—and she was not a nuclear physicist any more than I am—kept confusing intermediate- and high-level waste. She kept calling high-level waste intermediate-level waste. That is where we run into a huge problem. We also do so with low-level waste. Until we can sort that problem out, why on earth are we building another reactor at Lucas Heights? That is another question.

CHAIR—Professor, you would be aware that an additional protocol has now been negotiated to strengthen the IAEA safeguards, and the Australian government has indicated that it will be a precondition for the supply of uranium to non-nuclear weapons states. What is your assessment of the value of the additional protocol? Do you think it goes far enough?

Prof. Broinowski—My assessment is that it was a step in the right direction. I also believe it does not go nearly far enough, because of one principal fact—that so-called peaceful uses of nuclear power and weapons uses of nuclear power are the same technology. There has always been this Janus face about the nuclear non-proliferation regime; one leads to the other. Iran right now are acting perfectly legally under the NPT and the extended protocol in developing an enrichment plant. Indeed, they are encouraged to do that by the terms of the NPT and its

extensions. Yet that could lead immediately to weapons-grade plutonium or uranium being developed in Iran. All you have got to do is go beyond a 20 per cent 235 to up to 90 per cent and it is the same process.

So, no, I do not believe the system works. I believe there are double standards inherent in the treaty. Under article VI, the weapons states are supposed to reduce, and then do away with, their arsenals as a bargain for the non-nuclear weapons states saying, 'We will not possess, develop or acquire nuclear weapons.' In my view, we are going to see one or two extra nuclear states every year because they are absolutely sick and tired of having to follow their part of the bargain while the superpower and the other nuclear weapons states have no intention of reducing their armaments. Indeed, the United States has new programs to make new weapons.

Mr MARTIN FERGUSON—For your information, this week in the Senate there was an endeavour by the government, with the opposition, to reaffirm the policy of no sales to India. That resolution of the Senate was blocked by the Greens and the Democrats. It was just a political game, but there was a genuine endeavour by the government and the opposition to reaffirm that India, because it is not a party to the nuclear non non-proliferation treaty, cannot purchase Australian uranium.

Prof. Broinowski—I understand that.

Mr MARTIN FERGUSON—You understand the significance of that?

Prof. Broinowski—Yes. It is logical and legal, and that is how it should be.

Mr MARTIN FERGUSON—Whether any of us like it or not, the export of uranium from Australia is going to expand, without any new mines, because of the potential expansion of Olympic Dam.

Prof. Broinowski—Yes, I know that.

Mr MARTIN FERGUSON—In terms of the Nuclear Non-Proliferation Treaty and also the future capacity for some of those countries to walk away from those responsibilities, what should Australia do both domestically and internationally to try and strengthen international safeguards? That is one of the fundamental issues that has to be confronted.

Prof. Broinowski—I would like to see Australia taking a leading role, for once, in looking honestly at the hypocrisy of the present nuclear non-proliferation regime and, as we have done in the past, join with other like-minded countries such as Sweden, Denmark, Holland and New Zealand in saying: 'The system is broken and it needs fixing. What can we do to begin a new process?' This process will have to be on the basis that we get rid of double standards—no more, 'Do as I say, not as I do'—and get back to fundamentals and see if we can reduce and get rid of nuclear weaponry. The first thing we would have to do is abolish from the NPT the encouragement that developed from President Eisenhower's Atoms For Peace program, which rewarded them by saying, 'We will give you access to nuclear technology for peaceful purposes'. We should say to them that that is no longer valid because nuclear technology has reached such a level, the wealth of countries has reached such a level and the ambitions and motivations of subnational groups have reached such a fierce determination that we now face the

most likely problem, I think, not so much of a nuclear exchange between the great powers but of a nuclear terrorist attack. That is the ghost that is hanging over our considerations right now. If Australia were brave and fearless and wanted to do something about it, and was not so much echoing what Washington wanted, that is what we would do.

Mr MARTIN FERGUSON—In practical terms what should we as a nation seek to do? The Minister for Foreign Affairs has stated that the non-proliferation regime is remarkably successful and that the IAEA has only found four non-compliant countries—Iraqi, Romania, North Korea and Libya. What should we be doing internationally to try to bring this to a head?

Prof. Broinowski—I think we should reverse what Mr Downer has said because, quite frankly, it is based on a fallacy. We should say, 'This doesn't work, it hasn't worked, let us be honest and get back to basics.' Diplomatically, we should lead a push and encourage other countries. In Latin America, Mexico, Argentina and Brazil have done away with any option of having nuclear weapons for the time being through the Treaty of Tlatelolco—a very good thing. South Africa is another country that has done the same thing. Let us get together with some of those countries and have an initiative. It could be done discreetly; it does not have to be something we score brownie points for. Maybe it is being done—I am no longer a diplomat, but I am pretty sure it is not. That is what needs to be done. No more triumphalism and no more linking, as we have done in the past, commercial considerations to self-righteousness about our safeguards agreements. Let us say: 'That is flawed. Let us get back to basics here.' Sadly, I have to acknowledge what you say. Olympic Dam and BHP Billiton—that mine that Mr Hawke rationalised his way and allowed a three-mine policy because it was producing gold and copper as well as uranium—are going to cause—

Mr MARTIN FERGUSON—I do not question the history; it is a fact of life.

Prof. Broinowski—I know.

Mr MARTIN FERGUSON—You are effectively saying that you accept the reality of uranium mining in Australia, it is going to continue and our responsibility, to a large extent, is to look at the international safeguards.

Prof. Broinowski—In practical terms, that is what I think. In idealistic terms, I would like to see a return not to the pathological fear that Australians had but to the concerns we had that were called the Palm Sunday syndrome. It is why Mr Hayden appointed my colleague Richard Butler as the first ambassador for disarmament. Bob Hawke was worried about public feeling at the time. We seem to have lost that and I am not quite sure why, except for the nuclear analogy nimby—not in my backyard—'We won't have any waste in our backyard.'

Mr MARTIN FERGUSON—Not even a low-level repository.

Prof. Broinowski—That is right; not even that.

Mr ADAMS—You are arguing that we should redo the non-proliferation treaty and use that as a bargaining chip to eliminate some nuclear weapons. Is that your point?

Prof. Broinowski—Yes, of course, because that is the stated intention of the present Nuclear Non-Proliferation Treaty, which does not work under article VI. It simply does not work. We have to get back to a situation where countries, nations and diplomats look honestly at the situation and say, 'This is really disastrous and it is leading to further and further problems.'

Mr ADAMS—As in Iran.

Prof. Broinowski—I am not so sure the Iranians are not to be believed. I spent two years on a posting in Teheran. I have many Iranian friends. I spoke a bit of Farsi at that stage. Even then, the Shah had a nuclear program. He was saying to all and sundry, 'I don't want our oil to be used to drive motor cars; I want it to be used in a petrochemical industry.' Even then, they had a nuclear program and they still do. To tackle Iran in the way you tackle Iraq would be a huge mistake. Iran is a far more powerful country, with greater self belief and it is far more unified. They had better not try it.

Miss JACKIE KELLY—You mentioned that the Fraser safeguards have been watered down. Can you provide some examples of that?

Prof. Broinowski—Yes. I have a paper here which has them all in it. That is for distribution. The most important watering down has been of the original safeguard, which said, 'We will not permit Australian uranium to be enriched, transferred or reprocessed without our express permission'—and that meant for every shipment. After a mission of diplomats went overseas to test the temperature on Australian safeguards—it was led by Sandy Hollway, another colleague of mine who went on to greater things—they came back and told Mr Fraser, 'Listen, Prime Minister, there is no way that countries are going to accept this, particularly the Japanese.' The Japanese had sidetracked them in the corridors and said, 'You understand that the Japanese diet would never pass a safeguards agreement that said we had to come to you cap in hand each time we wanted to enrich, transfer or reprocess.' Other people said of the Japanese diet: 'We want to have nuclear weapons. We are not going to do this. We must not let go that possibility.' That safeguard was immediately done away with.

Another most important thing was, as I said, the doctrine of equivalence and flag transfers. For example, France has two lots of uranium in different forms: one is in the United States and one is in France. The French lot has an Australian flag on it because it comes from Olympic Dam. The French say to us: 'It's going to cost an awful lot of money to take that uranium and ship it to the United States and have it enriched and fabricated into fuel rods. Can't we simply take the flag off that lot and put it on this lot which we got from Algeria?' We have said, 'Yes, you can do that.'

Uranium is a fungible commodity. It is like sugar or wheat or any other bulk commodity. It is very hard to trace once it leaves our country. It is subject now to so many technicalities—so many different forms of working it, enriching it, doing whatever you like with it—that, in this book, I have challenged the government to justify or to explain how it is that they keep claiming they can track every single gram of Australian uranium. They cannot. It is not possible. These safeguard modifications—all because of commercial considerations, all to make our own uranium more attractive to clients—have weakened the whole system. That is my point.

Mr HATTON—What was your view of the work done during Mr Keating's Prime Ministership, particularly work that Gareth Evans took as the leading part in the Canberra group

and so on—the attempt to re-energise policy dealing with nuclear weapons and trying to come to grips with the fact that for a long period of time that really had been left in abeyance? Since 1996 that has been a fundamental problem, particularly because of the changed nature of the Soviet Union and its passing away. We now have a Russia that still has an immense number of nuclear weapons, as does the United States and other nuclear countries. We do not have any concerted program to pull that back and to dismantle that entire apparatus.

Prof. Broinowski—My response is that the Canberra conference was a good idea but then we had a change of government and, although Mr Howard and Mr Downer gave lip service to the recommendations of that Canberra conference, nothing was done. It was buried. Mr Keating himself has said that when the Cold War ended we all breathed a sigh of relief and thought that this is it—that we could now go about our business, we could disarm, because who the heck is the United States or Russia going to fight anymore? But that was an illusion, as the previous witness has said, and I think she is absolutely right from what I can gather from my own research. You still have in place these two arsenals on hair-trigger alert. My own view is that there is a lot more understanding and communication between the Russians and the Americans than there ever has been before. For example, before the Americans invaded—illegally, in my view—Iraq, the Russians knew what was going on. They were not going to interfere with that. Nevertheless, I think it was an opportunity lost that the Canberra conference findings and recommendations were not taken forward.

Mr HATTON—Going from a bipolar world to a multipolar one, it is my view that in fact it has become much more dangerous, much more uncertain, much less predictable. That is without taking into account the terrorism situation. What is the proper vehicle for an Australian government to take up the charge or the mission, if you like, as you have argued should be done in relation to the Nuclear Non-Proliferation Treaty? Or do we need a broader thing for it to be attacked at the UN and for a country like Australia to take the initiative?

Prof. Broinowski—I would like to see the Australian government give greater support to the International Atomic Energy Agency. I would like the Australian government to take up with alacrity the suggestion by Mr ElBaradei that some sort of leasing system should be introduced and that uranium should be enriched and fabricated through the International Atomic Energy Agency. I would like to see Australian diplomacy coalesce with other likeminded countries—not trying to say, 'Let's start something completely new,' but to say, 'Let's use the International Atomic Energy Agency to work on developing a new treaty'. Almost every government knows that the treaty is broken. The May 2005 review in New York came up with absolutely no conclusion or agreement on any point. People representing countries that are threshold nuclear powers left that conference, I know, with enormous feelings of cynicism and of being let down.

I would not be surprised, if things do not start picking up in the way I suggest, if some of these countries—Argentina, Brazil and perhaps Mexico, which has two nuclear reactors of its own, and I am not sure about South Africa—make renewed efforts to dust off their old systems. In the Middle East there is a mare's nest of countries. Syria is further advanced than we give it credit for. I do not know what happened to Muammar Gaddafi—I do not know who put some drug in his coffee to make him do what he did, but it was a surprise. Egypt is a nuclear threshold country. It is really coupled, as well, with the Palestinian problem, I think. Until that is solved, we are going to have all sorts of tensions that will inevitably lead to subnational groups having the motivation to get hold of nuclear weapons.

Mr TOLLNER—Professor, can you just outline your views on trading in nuclear waste? My understanding is that currently there are some fairly hefty checks on countries trading in nuclear waste. I would have thought that, particularly with high-level waste, certain countries would have certain problems in safely storing that. Do you think that maybe the trading of waste should be revisited?

Prof. Broinowski—Only to the extent that this should be part of the international effort to coordinate and cooperate on a safer international regime. It is not just high-level waste that has left reactors. It is not just the waste left after reprocessing. There are 440-odd reactors around the world, most of which are rapidly filling up their co-located swimming pool cooling ponds. No-one knows what is going to happen to that. The regime that the United States had set up in Nevada—I think it is Nevada—is not working at this stage. If the United States cannot solve their own problems, this problem of trading in waste is going to continue.

Mr TOLLNER—The French and the Danes are saying that they have the solution in their countries.

Prof. Broinowski—I do not think they have. Here is a very quick story. We were selling uranium to Finland. Finland was sending it to the Soviet Union—with which we did not have a treaty—to enrich it and then to reprocess it at the end of the process. Because it was not safeguarded, most of the products of the reprocessing were going back to Finland but the tails, which were not under safeguard, were going to France, and we did not have an agreement. There was a tremendous scandal in parliament about that, and Canberra very hastily went ahead and negotiated a safeguards agreement with the Soviet Union.

Trade in waste is a murky thing. Most of it stays where it is, and there is not a great deal of it yet, but, yes, it is a problem, and Australia should address that one too. Of course, we all recall the efforts by an international consortium called Pangea to set up an international waste regime in Australia. Objectively, I would have to say that Australia is one of the more suitable countries in which waste could be put. We already have the waste; let us not kid ourselves that it will go away. We have to try and stop any more waste, and we have to try and do something sensibly and internationally—as ElBaradei has said—with the waste that we have.

Mr TOLLNER—Do you think part of the problem with storing it in Australia is some of the public concern with nuclear waste and that the whipping up of public hysteria about anything nuclear has been a double-edged sword in some ways?

Prof. Broinowski—To suggest that one 'whips up public hysteria' is to be quite condescending and patronising to the Australian people. You politicians depend on the good judgment of your electors to be elected. Quite frankly, let us not underestimate the capacity of people to think problems through for themselves. I believe that what happened in the eighties, Mr Hatton, was richly understandable and justifiable. Emotion was involved, because at that stage we did have a nuclear confrontation, not just continent to continent. We had Pershing II missiles facing SS20**s** on a very short time fuse and a very short border across the Eastern European escarpment, and anything could have happened to set that off. Yes, it is true that nuclear weapons have discouraged war from happening, but there is always a mistake, and it is a wonder it did not happen there. I think people were quite right to be emotional.

Mr MARTIN FERGUSON—Do you accept the need for a national repository?

Prof. Broinowski—I do.

Mr MARTIN FERGUSON—Do you reject the emotive nature of some people suggesting that it is wrong to move low-level waste from different areas of Australia by road or rail to a national repository, that we are endangering the health of the Australian public at a time where, in the last eight months, there have been two container loads of yellowcake taken from Adelaide to Darwin?

Prof. Broinowski—No, I do not agree that this really should be an emotional argument. Let us be sure what we are talking about: we are talking about clothing and radiopharmaceuticals that have been finished—although a molybdenum generator is usually sent back like a book from the library to the place it comes from.

Mr MARTIN FERGUSON—From hospitals?

Prof. Broinowski—Yes. I think we have a most untidy and quite dangerous system now. When you have these radioisotopes floating around hospitals, mining companies and other areas, they should be pulled together. This is where I think the government and the opposition should be a lot more honest with the Australian people. They should say: 'This is low-level waste. Let's really look into this. It would be better if we pulled it all together and put it somewhere.' The irradiated fuel at Lucas Heights is another problem. That is where we certainly have a difficulty. I might be out of date but I think about one-third of the total number of irradiated fuel rods from the HIFAR at Lucas Heights have been taken off to Britain, and now France, for reprocessing. God knows what we are going to do with the waste when it comes back. A half to two-thirds are sitting in limestone drills, holes in rocks, out at ANSTO.

Mr MARTIN FERGUSON—At Lucas Heights.

Prof. Broinowski—It is not a very good thing. They are stymied; we do not know what to do. And yet we continue to go ahead to the point where we will be commissioning very soon this new Argentinian reactor. We have a problem there too. Like the problems around the world, we are looking at the short term, the expedient and the commercial; but we are not really looking at the longer term problems.

CHAIR—Thank you for agreeing to give evidence today. If the committee has any further questions, the secretariat will contact you.

[10.33 am]

WOODS, Dr Ian, Senior Research Analyst, Sustainable Future Fund, AMP Capital Investors

CHAIR—Welcome. Is it the wish of the committee that the document provided be received as evidence to the committee's inquiry and authorised for publication? There being no objection, it is so ordered. Dr Woods, thank you for agreeing to appear before and give evidence at the public hearing today. Although the committee does not require you to give evidence other oath, I advise you that the hearing is a formal proceeding of the parliament and remind you that the giving of false or misleading evidence is a serious matter and may be regarded as a contempt of the parliament. I also remind you that the committee prefers 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. Do you have any additional information you wish to add about the capacity in which you are appearing?

Dr Woods—Yes. The AMP sustainable future fund is one of AMP Capital's Australian equity funds. I am representing that fund and the investees in it and not necessarily those of AMP Ltd or other entities.

CHAIR—I now invite you to make a short opening statement.

Dr Woods—Thank you very much for the opportunity to present. Again, I would like to reinforce that the views I am expressing are those of the sustainable future fund and not necessarily those of AMP Ltd or the other entities. As a fund, we have a view of looking at issues from a sustainability perspective. When looking at uranium and nuclear power—

CHAIR—Are you happy to have this recorded by ABC radio? It is your call.

Mr MARTIN FERGUSON—You do not have to if you do not want to.

Dr Woods—I would prefer not to.

CHAIR—Please proceed.

Dr Woods—With the uranium and nuclear power industry we looked at three key questions: can it be demonstrated that the Australian uranium which is currently used and will possibly be used in the future is managed appropriately along all parts of its value chain; are the countries to which we export or may export uranium working towards the objectives of the non-proliferation treaty and is there confidence that this will be true in the time that Australian uranium has an effective life; and, in the bigger picture, are there no better options for Australia in contributing to the non-fossil-fuel energy industry? When looking at those three questions, there are some key issues: waste management disposal, the effectiveness of nonproliferation, safety issues, greenhouse gas emissions and cost.

On the issue of waste, it is important to recognise that, currently, no country has successfully implemented a long-term plan for dealing with waste. The industry has had up to 50 years to come up with a plan. At this stage, it is unlikely that anything will come up until 2020 at best, or, in the case of the UK, something like 2040. It is also worth noting that one needs to be cautious about whether 2020 is a reasonable time frame, given that in the US, the Yucca Mountains—which is their proposed facility—was originally proposed to happen in 1998, it was then postponed to 2010 and it is unlikely to be ready until maybe 2015 or 2020. So even a time frame of 2020 needs to be seen with some caution.

Another question is: what happens with growth within the industry, and what are the requirements for further waste management in the future? If the nuclear power industry expands so that it represents about the same percentage of the world's electricity as it does now, you would need about 13 of the repositories that have been planned in the US. This means that one would need to be built every three or four years. It is quite a challenge to find out exactly who is going to build that and where. Even more of a challenge is exactly where that expansion is going to occur. Generally, it is viewed that countries like India, China and other parts of Asia are going to be the areas of growth. It is my understanding that they have no concrete plans to develop sites for managing their waste.

There are other options—nondisposal, reprocessing et cetera—and they raise a whole range of other issues. I am happy to go into those, maybe under questions. There are some serious questions about the performance and cost of that. That was well illustrated in the MIT document which looked at the future of the uranium industry, specifically issues around Sellafield and its performance. With those three questions, when looking at waste management, you would have to ask what sort of conclusion you would come to in terms of the industry demonstrating that it has managed and will manage in the near future the value chain issues. It is a bit hard to come to the conclusion that they are responsibly managing it and can demonstrate that they will be able to responsibly manage it in the near future.

The next issue is safety. I again draw your attention to the MIT study which looked at safety and some of the challenges that occur with safety in the nuclear power industry and with uranium. I also draw your attention to the inquiry into the Sellafield spill that happened earlier this year and some of the questions that were raised. These were not about the engineering design of the facility but about the human factors, the fact that you are dealing with people in all these things. Most people who look at safety realise it is not an engineering issue per se—you can have terrifically designed aspects but you require people. That has been the history of problems in the nuclear power industry—and all industries, for that matter—that you are relying on people to do what they are supposed to do. They say that there are examples of where that has not happened. On the effectiveness of safety regimes, I guess a quote from the MIT study effectively sums up a view that I would share:

> The current international safeguards regime is inadequate to meet the security challenges of the expanded nuclear deployment contemplated in the global growth scenario. The reprocessing system now used in Europe, Japan and Russia that involves separation and recycling of plutonium represents unwarranted proliferation risks.

I would reinforce that sentiment. I think the discussions about the non-proliferation treaty that are happening now—or which have been happening over the last six months—reinforce the troubles that there are with the non-proliferation treaty, even though the objectives are perfectly

good objectives. But the watering down of those objectives in the discussions in the UN at the moment is a matter of concern. On top of that, we have the Australian obligated nuclear material requirements, which I think are a useful addition. But, again, under those requirements we have allowed the UK to reprocess uranium from Australia at a facility like Sellafield, where you have some processes in place, but do you have a system in place that checks that the facilities are good facilities to reprocess the materials that you have? Countries like Japan are developing fast-speed reactors. I am not sure whether the requirements relating to AONM state that Australian uranium cannot be put into fast-speed reactors. The development of plutonium through fast-speed reactors would, again, be a significant concern with regard to nonproliferation.

There are some real challenging issues for the non-proliferation treaty, and any sort of treaty, in this regard. I understand that the non-proliferation treaty requires acknowledgement of materiality of one per cent of their plutonium, which seems perfectly reasonable and it seems quite a stringent requirement. But if you look at Sellafield, for example, you will see that the accounts of their plutonium balance over the last five or six years state, 'We have not been able to account for something like 17 to 20 or maybe 30 kilograms of plutonium each year.' The argument is that it is a clerical error, and that may actually be true. I am not doubting that. We might believe that, in the case of the UK, that is appropriate, but would we believe that if some other country said, 'It's a clerical error, and it's only 30 kilograms of plutonium'? It is worth recognising that that 30 kilograms probably represents about 0.1 per cent of the amount of plutonium that something like Sellafield handles in a year. Even at that sort of level of accuracy you are still talking about a significant amount of plutonium which cannot be accounted for and I think, again, that is an issue.

I will conclude on the issue of greenhouse gas emissions and costs and the debate of the uranium nuclear power industry. Clearly, on the face of it, nuclear power looks like a good solution to the problems of greenhouse gas emissions and climate change, which is no doubt an issue. My question concerns the assumption that somehow it is a cheap solution to that issue. If you look at the costings of that, you would clearly not come to that conclusion. They are certainly low in terms of their operating costs, but they are certainly not low if you want a return on your investment, whether you are a government and/or an investor such as us. There is still the question, given the fact that the waste management issue is unresolved, of the cost of waste management. It is interesting that the British government has to subsidise British General Electric in the order of £184 million a year to deal with its waste management, which goes to British Nuclear Fuels. If you do the calculation, you find that is equivalent to a subsidy of about £2.50 per megawatt hour produced, or about $A5. The industry—BNFL—in its publication say that the cost of waste disposal is only £0.80, so already there is an inconsistency between what is required for the government to subsidise waste disposal as opposed to what a proponent of the industry says is required. I think they are critical issues.

If you look at how much the UK has to pay to dispose of its waste, which is something in the order of £56 billion, and you work out how much electricity has been generated from the British nuclear industry over 50 years, you would calculate that, if that amount of electricity has to pay for the £56 billion, that would be equivalent to about £12 or £13 per megawatt hour. That is equivalent to about $A35 just for waste disposal costs per megawatt hour, and the current price of electricity in Australia is less than $35. So the waste disposal costs in the UK, if I have done my calculations correctly, are equivalent to how much it costs to produce electricity in Australia currently.

I will go back to those three questions I asked about the uranium industry and the nuclear power industry. From our fund's perspective, can it be demonstrated that currently and in the future it is appropriately managed along the value chain? My conclusion is no. Are there appropriate safeguards for countries with regard to nonproliferation? My conclusion to that is no. One other point I would like to make there is that it is very easy in the discussion about non-proliferation treaties to think of the geopolitical situation as it is now, but you need to think about uranium and waste management in terms of the life span of the uranium, which is 100, 150, 200 or even more years. If you think of the geopolitical changes that have occurred in the world over the last 20 years, let alone over the last 50, 100 or 200 years, and that the good guys can easily become the bad guys and that these people may have control over uranium or a waste management issue which could become a fuel, then that is a challenge. You might set up a framework which works within the current view of the world, but you actually need something which can transcend that, given the changes that can occur in the political arena. So the answer to the second question is no.

The third question is: is there a better option? Given the cost of nuclear power and the fact that it is uneconomic currently and will continue to be unless a fairly significant cost of carbon is imposed, the question is: if we are going to develop non-fossil fuel energy use, is it best to put it into the uranium industry, where there are current problems of waste management, or into something else? I guess if you look at it from an opportunity perspective, you would say no to uranium but yes to some other non-fossil fuel energy resources that we have in Australia.

CHAIR—Dr Woods, you mentioned safety in your address. Advanced generation 3 reactor designs are said to incorporate passive or inherent safety features which do not require active control or operational intervention to avoid accidents in the event of a malfunction. Do you believe that engineering advances such as these could mitigate the risk in regard to reactor designs?

Dr Woods—It is certainly a good improvement in terms of engineering design, but I guess there are two other questions: what causes accidents at nuclear power plants and is it a result of engineering design; and what might be an acceptable risk? The acceptable risk question is a difficult one, because everyone will have their own particular view. So I am not sure that engineering design per se will address perceived risk issues. I was a risk consultant in my previous life, and the key to any safety issue—whether it be a power station or whatever—is the human factor rather than engineering design. That is not to say that good engineering design is not a good prerequisite, but it is not the end. In the example of Sellafield and the reprocessing, they had a very good design but the problem was that it was not built to the design. Again, that reflects good engineering that is not carried through.

Mr TOLLNER—I imagine that AMP Capital Investors is part of the AMP corporation, that the single highest priority of that organisation is to provide a return to their shareholders and that, ultimately, as part of that organisation you would require people to invest in your fund so that you can provide some sort of a commercial outcome for the shareholders of AMP. Would there be a view, at an AMP level, that this is a niche market in the community? You are an ethical fund inasmuch as you tend to be making some ethical decisions on how you invest shareholders funds. Are you after a specific segment of the Australian community? Finally, is it your fund's role to promulgate the idea that nuclear energy and the whole nuclear fuel cycle has some bad issues, in order to broaden the pool of potential investors out there? Are you appointed by AMP

as a gun for hire to promulgate the idea that the nuclear fuel cycle is inherently unethical and that people can invest in your fund as a way of avoiding having their money go into the nuclear fuel cycle?

Dr Woods—I will just clarify a few things. We do not actually invest AMP Ltd shareholder money.

Mr TOLLNER—But you make returns for AMP shareholders.

Dr Woods—That is correct.

Mr TOLLNER—So you are driven by commercial concerns.

Dr Woods—That is correct.

Mr MARTIN FERGUSON—What he is saying is that your appearance today is good for business.

CHAIR—Gentleman, let Dr Woods answer the question.

Dr Woods—It is good for business, because the objective of our fund is to engage on issues—one of the characteristics of our fund is that we say we engage on these issues. It is not just about passive investment; it is hopefully about constructively adding to the discussion. Ethics is a tricky issue. All decisions are ethical decisions about your values, so to pretend that one decision is ethical and another is not ethical ignores the fact that they are all underlying values. Our particular fund takes a view of looking at sustainability. That is why I said very clearly at the start that we should look at the three questions via which we looked at the industry. It was not an ethical issue. There are ethics questions there, but it is about looking at those three criteria, including safety and responsibility, which are very much sustainability issues. If you look at it within that context and use that as a lens through which you look at that issue, that is the conclusion you come up with. If I came up with different conclusions, we might have a different view on nuclear power. Again, that is why we have a nuclear fuel position paper, which discusses the issues. It talks about what uranium is, how it gets processed, what are the good aspects, what are the bad aspects and why we have come to the conclusion we have come to. That is our fund, and we obviously appeal to people who believe in that. It is also important to realise that our fund is put forward as a mainstream fund and not just as a boutique fund. We have mainstream investors who are investing in us purely because of the returns and not because of anything else.

Mr TOLLNER—I imagine that, like most managed funds in this country, you would have had some significant exposure to BHP. How did the decision on Olympic Dam affect the fund? I imagine you had some problems replacing a stock like BHP in your fund. How did you deal with that?

Dr Woods—Before the BHP and Western Mining Resources issue came up, we had, as I said, a position paper which outlined our position. It talks about how we decide whether we will invest in companies involved in this area. It stipulates a five per cent materiality with regard to investment in the industry.

Mr ADAMS—What does that mean?

Dr Woods—Five per cent materiality means—

Mr TOLLNER—What they are saying is that they have sold their uranium mine and they will not invest in them.

CHAIR—Let Dr Woods answer that the question.

Dr Woods—It means that if five per cent of their revenue and/or profit—or appropriate financial criteria—involves uranium mining then that would be inconsistent with the mandate of the fund. That is a hard limit and we can obviously choose below that if we so desire. But, in terms of saying to our potential investors what the issues are, that is what we say.

Mr ADAMS—It has to be 95 per cent non-nuclear.

Dr Woods—That is right. That was clear before the Western Mining and BHP issue came about. As a result of BHP taking over Western Mining—and I am trying to quote numbers off the top of my head—the revenue from uranium under the larger BHP is of the order of three per cent. Olympic Dam in total is maybe 1.3 per cent. So that is the copper, uranium and gold from Olympic Dam. Based on that, it would meet our strict criteria.

We are an investment fund, and we need to think of a whole range of issues. Given BHP's broader performance in this area and the size of its exposure, we thought it was consistent that the fund still invests in something like BHP even though it has its exposure. Having said that, the fund is about engaging with companies to encourage them to improve their performance. We have had discussions with BHP about presenting at things like this as an example of how we engage with them—not to get them to understand because I think they already understand to a great extent—on some of the concerns about the value chain and what they are doing and what can they do now that they have this position in the market.

Mr MARTIN FERGUSON—What do you want BHP and companies like Rio to do?

Mr TOLLNER—Are you saying that you have divested yourself of BHP shares?

Dr Woods—No. They met the criteria.

Mr TOLLNER—So what you are saying is that, if a little tiny company had bought Olympic Dam—which you had invested in—and that was 50 per cent of their revenue, you would have dumped them?

Dr Woods—That is correct.

Mr MARTIN FERGUSON—Further to BHP shares, do you hold Rio Tinto shares?

Dr Woods—No.

Mr MARTIN FERGUSON—What have you sought BHP to do in accordance with your policy on the uranium and nuclear industry?

Dr Woods—It is early days yet. We have talked about our need to discuss to them what they are doing. The issue that we have raised—

Mr MARTIN FERGUSON—What types of issues?

Dr Woods—The main issue is the value chain and what they might be able to do with regard to waste management.

Mr MARTIN FERGUSON—Where do you think they should improve it? What practical proposals do you have in mind?

Dr Woods—I do not know what the answer is. If I knew the answer, I probably would have put that in my submission.

Mr MARTIN FERGUSON—I would have thought this is all about good business. Attracting investment dollars for sustainable funds is now good business. It is pretty competitive, isn't it?

Dr Woods—Yes. I think, to BHP's credit, they realise it is an issue and something that they need to be aware of and manage.

Mr MARTIN FERGUSON—Your position paper argues that nuclear power is currently being subsidised by government. What is the nature of those subsidies?

Dr Woods—One example is the subsidy by the UK government to British Electric with regard to waste disposal costs in the order of £184 million a year.

Mr MARTIN FERGUSON—It is of no consequence to your investment strategy in Australia, is it?

Dr Woods—Not directly, no.

Mr MARTIN FERGUSON—Yet, by comparison, you believe that governments should subsidise the renewable energy industry in Australia?

Dr Woods—In the position paper, we talk about the circumstances under which you might want to support an industry from a government perspective. The position paper talks about how it might be worth it on the net clear environmental benefits as a result of that subsidy.

Mr MARTIN FERGUSON—Without those subsidies it would not be a good investment for your members, would it?

Dr Woods—That is correct. The other issue is whether the current market reflects all the costs. I think the issue with energy at the moment is that, except in the EU, it does not consider the greenhouse gas costs. It does not in Australia.

Mr MARTIN FERGUSON—What percentage of BHP's profits are from coal?

Dr Woods—I do not know off the top of my head.

Mr MARTIN FERGUSON—What discussions have you had with BHP about CO_2 emissions and what they should do to clean up their act?

Dr Woods—I have had in the order of eight discussions with BHP on the issue of greenhouse gas emissions.

Mr MARTIN FERGUSON—What practical proposals have you put forward to make an improvement?

Dr Woods—One of the issues is the mix of thermal coal, coking coal, and oil and gas in terms of strategy. One of the other things we have raised with them is the issue of stapling carbon credits to their thermal coal exports, which means you effectively balance your carbon dioxide emissions from your thermal coal in a market. So, although you are basically selling something which is going to release CO_2, that is offset by a carbon credit that has been generated in another area.

Mr ADAMS—It could be growing trees?

Dr Woods—It could be growing trees or it could be initiatives in developing countries. Also there could be possibilities within their various sectors, such as the aluminium sector. So there is a range of things we have tried to cover.

Mr MARTIN FERGUSON—Regarding base load power requirements, do you believe that renewable energy is the solution to those requirements, both in Australia and internationally?

Dr Woods—Currently, no. The question is: what do we need to move to in the future?

Mr ADAMS—Is it getting harder to answer ethical questions? Has this been a hard question to come to grips with?

Dr Woods—I am sorry, the issue of—

Mr ADAMS—Nuclear energy.

Dr Woods—Yes, it is. I think most questions are neither black nor white. It is always nice to think things are black and white but most ethical questions are not. That is why we put a position paper out to ask: what are some of the issues and how do you look at those and come to a conclusion?

Mr ADAMS—Has this become an issue of saying that some of the uranium in Australia will go to China because China is industrialising and that without nuclear energy to help them industrialise and improve their lot they would probably use large dams, like they have done, or coal fired power stations? Has that come into the equation at all?

Dr Woods—Yes, it does.

Mr ADAMS—That must be a difficult—

Dr Woods—Yes, it is a challenging issue. I am not going to say I can provide a solution to China's energy problems; that would be presumptuous of me.

Mr MARTIN FERGUSON—You would be a very wealthy investor if you could!

Dr Woods—That is true, but I might not say it here in public if that were the case. It is complex and I think there are other opportunities for Australia. For example, we are already exporting LNG to China and, if you compare the greenhouse gas emissions from a coal fired power station with those from a combined cycle power station, it is 380 kilograms per megawatt hour for a combined cycle gas turbine, depending on what technology you use, compared with 700 or 800 from a coal fired station. It is a step in the right direction in addressing greenhouse gas issues and still allowing China to manage what is a perfectly legitimate desire for economic growth. In the meantime that, hopefully, will provide us with a breathing space in which we can then develop the renewable energies which can provide the base load—but that requires investment. Or it could be hydrogen, yes.

Mr ADAMS—Do you take into consideration that there are some leading conservationists now saying that maybe we need this hole in the energy cycle from nuclear to get us another 30 years down the road until we get the hydrogen energy cycle up?

Dr Woods—Yes, certainly there are. I have not spoken to those people personally, but they have probably looked at the same issues I have and have put different emphases on different things. That is the challenge of weighing up a whole range of different issues.

Mr ADAMS—Do you think it is getting harder? That was my original question.

Dr Woods—Yes.

Miss JACKIE KELLY—You have been in operation since 2001?

Dr Woods—Yes, that is correct.

Miss JACKIE KELLY—So before then there were not many ethical or triple bottom line options for investors concerned about those issues, about that third bottom line?

Dr Woods—Not within AMP, but there were a number.

Miss JACKIE KELLY—BT and a few others.

Dr Woods—BT, I think, for a year or two before that, and Australian Ethical Investments.

Miss JACKIE KELLY—It is a relatively new thing. In your position paper from 2004 you said you had an investment of $220 million; then by 2005, in your covering letter to us, it was up to $800 million. You have had fairly rapid growth?

Dr Woods—That is correct.

Miss JACKIE KELLY—Do you see that growth continuing?

Dr Woods—I certainly hope so.

Miss JACKIE KELLY—When you look at $67 billion overall, it is still a 'poofteenth' of what AMP are doing. What do you see as the future for this type of investment vehicle?

Dr Woods—I am quite encouraged by the future. One of the things that not only our fund but other funds have done is to demonstrate that you can match financial objectives and personal values in your investment. The returns of not just our fund but most of the funds have been as good as, if not better than, normal active funds. Given that, you have something with which you can differentiate yourself in a market so that people do not feel that there is a disconnect between what they personally believe, in terms of their values, and their investment options. There are some options.

Miss JACKIE KELLY—The model for this type of vehicle is still a cherry-picking model: you pick a winner in terms of what your investors believe in. We have just heard from the previous witness here today, Professor Broinowski, about a concept where, for all the uranium exports in Australia, we should be producing the rods for the reactors, shipping them to China and India and then taking them back and disposing of them so that we have complete control of the entire life cycle of the uranium, if we are going to market it at all. In the future when your investment capacity in this area gets so large that you look for those who are progressing their ethical issues, would you look to a source of venture capital so that you can bring those rod processing factories to Australia and get that type of investment and development happening here, or do you just not see it ever getting to that stage?

Dr Woods—I cannot see that happening in the foreseeable future. The other thing is that for our particular fund we invest in listed entities, so we would not be able to contribute to venture capital. Our mandate is to just invest in entities listed on the ASX. It is a possibility but I cannot see it happening next—

Miss JACKIE KELLY—You do not see that as a future—

Dr Woods—It might be in five or 10 years time. In five or 10 years time we would have a look at it and review it, based on the same sorts of frameworks, to see what it looked like then.

Mr HATTON—This is probably a moot question, but is there an AMP capital investors unsustainable fund?

Miss JACKIE KELLY—All the rest!

Dr Woods—I will let that pass.

Mr HATTON—When I get to the next question, you will find that it is a serious question.

Dr Woods—The focus of this fund is to use sustainability concepts in looking at companies and their approaches and adding the information we gain from that into the investment decision-making process. Our other funds do not necessarily explicitly consider, as we do, the sustainability issues in the investment decision-making process.

Mr HATTON—Ipso facto those other funds which are much larger could be categorised in that way, because they do have that specific marketing—capital niche marketing, as Mr Tollner pointed out. They are not going to present themselves as that, but, by implication, if you are not setting out to say that it is specifically on a sustainable basis, you could say, 'It's not a consideration in the other regard, and if you look at the rest of the ASX they're not in the game.'

Dr Woods—As you are probably aware, there is a requirement under the Corporations Act in terms of funds being able to disclose how they consider those environmental and social issues. There is a distinction between those that have a formal process of looking at those issues, which are the socially responsible investing funds, of which we are one, and the other funds who actively manage equities. They might be value or growth style, and they will consider those issues on an ad hoc basis, depending on what they think the materiality is. That is not to say they do not consider those issues; that is to say they consider them in a different framework from ours. Certainly our mining analyst for our other funds looks at the safety record of the mining companies which he invests in. He is not going to say it is a sustainability fund, but I am not going to say that it is unsustainable either. He just has a focus and he thinks about those issues within the context of his approach.

Mr HATTON—I now want to go to the second part of that and address the question of what sustainability is about. Your paper argues quite strongly that the nuclear industry is toxic, yet we have already heard you say that, in terms of the ethics and morality—or whatever else you want to call it—of sustainability, because the total value of BHP Billiton's investment in the uranium output from Olympic Dam is 0.3 per cent and the total investment for all of the activity at Olympic Dam is 1.3 per cent, that could be incorporated because it is part of an extremely large entity. Do you invest in Rio Tinto?

Dr Woods—No.

Mr HATTON—Why not? Is there a difference between BHP Billiton and Rio Tinto?

Dr Woods—In our assessment there are differences and those differences are to do with environmental issues, occupational health and safety issues and a whole range of other issues. Our conclusion is that Rio Tinto would not meet our requirements from an environmental and social perspective.

Mr HATTON—Across the broader range of investments, apart from BHP Billiton, given that you have gone from $200 million to $800 million—you are quadrupling the investment and that makes it more significant—what kind of minerals are you investing in?

Dr Woods—Mineral sands is one of the things we are investing in. It is very difficult in the Australian market, given the nature of the mining companies, and depending on whether you have a large capital fund or a small capital fund. Principally, our investments are in mineral sands but we have some gold exposure and investment with BHP Billiton.

Mr HATTON—Given BHP Billiton's activities in the coal area and so on, as Mr Ferguson alluded to, and the amount of CO_2 that is produced by them, and given that we are looking through this funnel at greenhouse effects and the relationship with the nuclear industry and other non fossil fuel alternatives, how sustainable does your fund see the coal industry in Australia as being? What relative toxicity is there, with regard to its activities and what we export worldwide, in terms of creating greenhouse effects and therefore planetary effects that we have to deal with? Also, what is the general toxicity of the particulates that are produced by the company and introduced into the atmosphere? What is the toxicity of the refined products that they make, particularly diesel, which is demonstrably carcinogenic? In fact, those refined products may be even more carcinogenic than the levels of toxicity involved in the nuclear industry.

Dr Woods—I will have to unpack all of those questions. When we looked at BHP's environmental performance we considered all the issues that you talk about—releases to the atmosphere et cetera—and we came to the conclusion that, while there is always room for improvement, it is acceptable within the mandate of the fund. For example, the company are doing some interesting work with regard to their green lead program. Lead is an issue and they are looking at that. The company are doing some really interesting things with regard to the life cycle of diamonds—given the relationship of diamonds to wars in Africa—and making sure that it there is an appropriate life cycle so that you can track ethical diamonds. They are doing some really interesting stuff in that area.

We also distinguish between coking coal and thermal coal because of the nature of what they get used for. It is a bit hard to make steel without finding a reductant such as a carbon source, so we make a distinction between coking coal and thermal coal. We look at the company's policies and strategies in terms of their emphasis on oil, gas or coal et cetera. Probably one of the key things for us is the issue of how they are stapling credits to their thermal coal exports to Europe, which counteracts their greenhouse gas emissions. That does not make them sustainable, however you define that, but it was considered acceptable for the purposes of our fund, in terms of investing in companies, having a return and looking at what companies are doing.

Mr HATTON—How much of this is patina? How much is it providing a covering for activities that are inherently dangerous, that could be inherently toxic in a range of ways? How much are you are recasting or refocusing on those activities that are not so inherently dangerous, or trying to look through a particularly lens at a company like BHP, which has such a broad range of activities, in order to look at that only through a fairly narrow focus? I understand why the funds have been set up. I have concerns about just how fundamentally deep the realities are. When you look at a whole series of activities which can have deleterious impacts and you look at stapling or going into other activities just to match them up, it looks good to people in terms of what they are doing. People get a warm glow about what is happening. But it may not materially change the fundamentals. If you are dealing with our coal, coal being the largest product exported from Australia, the drivers for producing much cleaner coal that has a less detrimental impact on the world at large are still not great enough. Or is part of your function as a company and what you are trying to sell to people the fact that we should be concentrating on doing those sorts of things?

Dr Woods—That is a big question. Our fund is about encouraging people—not only people but also companies—to think about those issues. I got lost in the question.

Mr HATTON—The key thing is that you are presenting a product. The patina of that product, its covering, is that people should feel comfortable, relaxed and happy that this is an environmentally driven approach and it is sustainable, and they should not look too much at the actual activities of those companies. But you would see your part, as an ethically driven company, to try to drive the companies towards those better ends?

Dr Woods—That is right. Transparency is an important issue for our fund, so we put all the companies we invest in on our web site, so that information is up there for whoever wants to know who we invest in. They may or may not agree with those, but at least it is there. We are not saying, 'Don't you worry about that; we'll just look after these companies,' et cetera. There is an openness there about our policies on issues and the companies we invest in. We say it is about investing. It is about managing, both getting investment returns and also considering sustainability, and you can do that through who you invest in and also how you relate to the companies you invest in and encourage them to improve their performance.

It is not just environmental. I know sustainability is generally considered just in terms of environmental issues, but the other things we look at are occupational health and safety issues, workplace practices, ethics and governance within companies, relationships with communities et cetera. So we look at quite a broad range of issues when we are looking at companies.

Mr HATTON—As with all good circularity, I will return to the first and second questions. In relation to sustainability and unsustainability, what are your investment horizons in terms of longevity? With a number of things that you are investing in, you could argue that fundamentally they are unsustainable. Even if they run for a couple of hundred years, in the end they may be far more unsustainable than investments in non-fossil fuel alternatives which are relatively much poorer performing at the moment.

Dr Woods—Primarily our money is for superannuation for people, so the returns are for the longer term because people are getting their money in 20 or 25 years, so the requirements are there for conceptually longer term returns. In terms of how we are assessed on our performance—because that is how we are assessed through the reinvestment fund—we get assessed the same as everyone else, for better or for worse, and that is on our monthly, three-monthly, yearly, three-yearly and five-yearly returns. As we are in a marketplace where that is how people are judged, we are assessed on those same criteria in terms of time frames that are investment returns.

Mr HATTON—I know about those. It is the longevity of the sustainable resource, whether it is coking coal or gas or whatever else. What is the horizon there?

Dr Woods—It really depends on the issue. It is an interesting question, and I do not have a rule of thumb that it is three, five or 30 years. On the issue of greenhouse, it is probably of the order of 20 to 30 years. So we will favour more a company with gas than one with oil or coal, given that that is the time frame. That is not to say that gas is going to be the solution for the whole world but, within that time frame of the issues of greenhouse gas emissions, there is a significant opportunity for gas to be a solution. Coal may well be too, if they can get geosequestration up. The problem is that, at the moment, they have not. When that is up, when it is implemented and the drivers are there for it to be implemented, it may well change the view we have on coal. So it is a dynamic.

Mr HATTON—Given your sustainability mix and those horizons, do you think Australian companies and Australian government policy should drive towards a substantial gas to liquids industry in Australia?

Dr Woods—I am not know much about gas to liquids per se.

Mr HATTON—We have a lot of gas and we have a great deal of energy need. Could we be meeting that need in lots of other ways? We could have a great deal of import replacement if we used natural gas and then liquefied natural gas, if we went to liquids, to provide other energy sources. We could use that to drive our own economy, rather than importing a great deal.

Dr Woods—I am not sure what Australia's current oil dependency is. I think it is somewhere in the order of 60 or 70 per cent. Someone else might be able to help me on how much oil we produce domestically as opposed to otherwise.

Mr ADAMS—It is about 50 per cent, and I understand that it is going down.

Dr Woods—I do not have a particular view per se about whether we should be independent of oil and whether it is needed for transport fuel. I think gas certainly has a significant opportunity with regard to power generation, which gives a third of our greenhouse gas emissions. That is at $3 a gigajoule, which is the current price on the east coast. You could probably produce electricity at $40 to $42 a megawatt hour, which is still more expensive than coal, but it does seem as though there are some real opportunities there.

Mr HATTON—Thank you, Dr Woods.

Mr ADAMS—I want to ask you one of the ethical questions we have got. You have come to grips with it and I appreciate that, which is why I want to ask you this question relating to producing steel. People will support steel over timber—and there was a push for this. Coal is used to produce steel but trees are renewable. I know there is some argument about old-growth forests, but I could not understand the ethics of that. We are using coal to produce steel, but trees and timber can be a renewable resource. What is the ethical question in that? People will invest in steel, in BHP, but will not invest in a forestry company.

Dr Woods—I guess it comes back to what steel can be used for. Steel can be used for infrastructure, and that is where a lot of the steel in China is going to at the moment. In terms of infrastructure—the roads, transport et cetera—that is probably a positive thing. If you are going to weigh up how you are going to use the steel and you get greenhouse gas emissions from it, that is probably the best place to put it. It might not be such a good idea for cars, for example.

Mr ADAMS—But what about plantation timber? Is there no problem?

Dr Woods—There are issues that certainly need to be considered for plantation timber, but it is considered better than others. But you are not going to be able to build a bridge out of timber, unfortunately.

CHAIR—Thank you for appearing before the committee. If the secretariat requires anything further they will contact you. It is moved by Mr Ferguson that the document entitled 'The

nuclear fuel cycle position paper' be accepted as an exhibit. There being no objection, it is so ordered.

[11.25 am]

BROUGH, Mr James, President, Australian Nuclear Forum

FREDSALL, Mr James Richard, Secretary and Treasurer, Australian Nuclear Forum

MOORE, Dr Philip William, Committee Member, Australian Nuclear Forum

CHAIR—Thank you for appearing. Do you have any comments to make about the capacity in which you appear?

Mr Brough—I am a microbiologist by profession. My working life was spent in the pharmaceutical industry and, latterly, in radiopharmaceuticals.

Mr Fredsall—I am a nuclear engineer. I have spent time in the nuclear industry in the US and in Australia.

Dr Moore—I worked in the nuclear industry for 30 years and was for a time the Counsellor Nuclear for Australia in London and Australia's representative at the OECD's Nuclear Energy Agency.

CHAIR—Thank you for agreeing to give evidence at this public hearing today. 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 and 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 all evidence to 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 an opening statement.

Mr Brough—I have already dealt with some of the parts in my statement. We do not wish to add too much more to what we already said in our submission, but we have some comments to reinforce what we said. The US Department of Energy estimates that by 2025 total world energy use will grow by over 50 per cent and electricity consumption will increase by 80 per cent. A significant amount of this predicted electricity demand will occur in developing regions of the world. Seventeen per cent of current electricity generation is nuclear. The International Atomic Energy Agency estimates that nuclear capacity will increase from about 368 gigawatt hours electrical to 427 by 2020, an increase of 16 per cent over the current. World uranium requirements will also rise by 2025 by 15,500 tonnes of uranium a year.

Although Australia does not have a nuclear electricity generation industry, nor any plans for establishing one, it has a part to play as a major supplier to those countries that wish to reduce their CO_2 emissions by an expansion of nuclear electricity. The committee will recall that nuclear electricity has the lowest CO_2 emissions per kilowatt hour of the alternatives for base load generation. In those countries that are serious about global warming, nuclear will expand and will need fuel. We think that the greatest contribution Australia can make to the global reduction of CO_2 is to maximise the export of uranium to responsible countries. We also submit

that Australia should seize the opportunity to maximise the financial return by not only selling more uranium but also adding value to the product by getting involved in other steps in the manufacture of nuclear fuel. Above all, we should sell enriched uranium to reactor fuel quality rather than simply selling uranium as yellowcake.

Do we have the expertise? Australia ran a successful enrichment project which was cancelled in the early 1980s. The Silex enrichment project, or process, is being developed and it is looking good. So, given time, we could develop the domestic commercial system or we could work with an overseas producer to establish a plant here. We believe that Australia would be an ideal location for a fuel enrichment plant operating under multinational safeguards control such as recently suggested by the IAEA director-general. In relation to the central issue of this inquiry, we ask the committee to consider this question: if Australia stopped exporting uranium, what would be the effect on the world's nuclear power programs, nuclear proliferation, public health and safety, the environment and national economies?

We believe that world nuclear programs would continue via an early introduction of breeder reactors, so nothing else would change—except that this country would miss out on a considerable export income and would probably lose influence in world nuclear affairs. Consequently we in the ANF believe the opposite should occur: Australian uranium exports should be governed primarily by market forces, but consistent with non-proliferation constraints. Has Australia the political will? In Australia opposition to nuclear activities has been vociferous but clearly not too numerically strong. I say that as a former member of the Labor Party. This has led to governments adopting antinuclear positions and enacting legislation prohibiting certain nuclear related activities. We trust that politicians will revise this legislation in the national and the global interest.

Finally, if decisions are made to move forward with our uranium industry, we submit that governments must prepare the population by giving them clear and simple information on matters of uranium and radiation safety. For too long—for a generation at least—the nuclear industry has suffered from myth and misinformation in the media and the schools, leading to fear in the public mind. There always will be some controversy, but governments have a duty to inform and to lead. On that point I will close, and we await your questions.

CHAIR—I want to pick you up on that last point, which you echo in your submission, where you state:

> The ANF recognises the political difficulties in this country associated with objective discussion of nuclear power.

How can the public's perception be addressed?

Mr Brough—I will speak with experience of nearly 14 years as a tour guide on behalf of the AAEC and then ANSTO. In that role, until I retired this year, I met over 80 groups a year, people from all walks of life: high school students, university students, Probus groups, senior cits, Rotary. And it struck me as highly unusual that, in this clever country, almost 110 years after we discovered radioactivity in the natural environment, 98 per cent of the people that I talked to in general were not aware of the fact that the world is radioactive. They tend to think it only comes from nuclear reactors and nuclear bombs. I can assure you that, when they are given a bit of simple information—it is not expensive; it is easy and it sets their minds at rest—they can

understand and make their decisions on their own. They can actually say, 'But we've been told that there's no safe dose of radiation.' But, of course, radiation has been around since the world began. Once they understand that, the road is clear for them.

This is only what has been done by ANSTO, the government organisation I used to work for before and after I retired, and it is effective, but it needs to be expanded in some way. How you do it, I do not know, but you have to take the public into your confidence, and I am sure it will work.

Mr HATTON—Is the nuclear industry as mad as a two-bob watch, as some in Australia would have us believe?

Mr Brough—Of course not.

Dr Moore—A very sober group of people, actually. To make an extra point about what Jim has just said, we do not underestimate the difficulty of the task of changing public opinions in relation to nuclear power, uranium and everything related to that. I have had quite some international experience and I would say that, of people from all the countries I know, Australians are the most antinuclear in their sentiment. It comes, first of all, from the schools and, second of all, from the news media. A recent survey showed that the most antinuclear people in our community are television and news journalists, and this is where the public get their information.

Mr HATTON—I had the joy of asking some questions of Dr Helen Caldicott this morning. As a teacher in a Catholic school in the 1970s and 1980s, prior to going to work for Mr Keating for over a decade, my experience was that there was immense psychological damage done to entire generations of Australian children. Firstly, the 'minutes to midnight' argument scared the wits out of them. Secondly, there was a fundamental point made that they should put aside their education—here, I think, my memory is not faulty; it may be that the memory of others is—and be out there campaigning against nuclear weapons and the nuclear industry as a whole. I felt that very deeply. Psychologically, this penetrated them so heavily. You have alluded to that in your experience. Can you tell me a bit more of what you came across among the student population, among the people at large and among the journalists who, as you averred, were all of those things prior to that?

Mr Brough—How long have we got!

Mr HATTON—We have got a little while.

Mr Brough—My colleague James Fredsall is going to pull me down when he thinks I have gone too far. As I said, you must give people the facts on background radiation; once they can understand that, it is easier. But, again, the only people supplying that information are ANSTO, the Australian Nuclear Science and Technology Organisation, and ARPANSA, the Australian Radiation Protection and Nuclear Safety Agency—although I have a criticism of their web site—and one or two organisations such as ours. So there is not much there.

In relation to what is happening in the schools, I was asked to visit a Catholic school to talk about nuclear bombs, how dreadful they were and things like that. My boss at ANSTO said, 'We

shouldn't be doing that.' I said, 'If we don't do it, Greenpeace will do it.' So I went along, and it was about a novel for year 10 high school students called *Z for Zachariah*. It is No. 15 on Amazon's list of top-selling books—and it was first published in 1975! It is a dreadful tale. We have analysed it and it is grossly inaccurate, except in its description of radiation sickness. All the rest of it essentially is terribly inaccurate. This is what is in the school system. There are 25 copies in the Sydney region. It is listed as an education resource in all of the universities which teach high school teachers and it is very popular overseas. So here we have a book which is gross science fiction, but it is still very much in the public domain and it is being fed through the schools.

Mr HATTON—If you look at the geography curriculum, the commerce curriculum and the associated religious studies stuff, what was embedded within the approach from the late 1970s through to the 1980s onward, particularly in Catholic schools, was effectively that guilt over sexuality should be replaced by guilt over the fact that we lived in advanced industrial societies in the West, that because we were developed we should take on guilt and responsibility for those who were underdeveloped and that we had two great moral imperatives. One was the issue of nuclear activity, primarily nuclear war, and the second was general green activities. So it is not just in individual texts but embedded in the curricula and embedded in the psyche.

Mr Brough—And I think it is embedded—although I cannot prove it—within the teacher training institutes. Phil mentioned the media. I have a case in point. I subscribe to what used to be called the *Manchester Guardian* and is now the *Guardian*; I get the *Guardian Weekly*. Four weeks ago they had a full page in the *Guardian Weekly* on the topic of nuclear. It was a very contentious report put out by an anti-nuclear group—and it was in the section of the paper that focuses on learning English. So you can see what I mean—we have got problems here. I do not mind people getting the facts so that they can discuss them and make decisions upon the facts, but the problem is that there is far too much ill-informed opinion and, quite frankly, lies being spread around in the media. You can try and get a letter published in the *Herald* or, for that matter, in the *Australian*—I have written dozens of letters; we have all written dozens of letters—to counteract some of the gross misinformation you find in an article by someone who has appeared before the committee today, but you will not get in there. So this is what is embedded in the media.

My wife did a degree as a mature age student at the University of Technology, Sydney in the communications department. She was terrified that they would find out that I worked at Lucas Heights. It would have been the end of the story. I may be biased but, again, this is what has been happening for a long time. I may sound extreme but I do not think I am. Jim and I did a little bit of revision work on the science curriculum. We have not had an answer in a year, have we?

Mr Fredsall—That is right. There was an interesting question on the 1997 HSC physics exam in New South Wales that had to with Robert Oppenheimer, who you all know was the father of the A-bomb. The question was:

Give one reason why some people think Oppenheimer should be held accountable for the harmful effects of nuclear energy.

Why would you ask a question like that on a physics exam?

Mr Brough—That is a political responsibility.

Dr Moore—I found that the misinformation my son was getting at school was through his English teacher as well as his science teacher. Apart from schools, the other place where people get their information is basically from the television. They do not study it. Perhaps you have noticed that, if there is a nuclear story on television that explains what is happening, it is usually followed up by a nuclear opponent, who has the last word, where there is no chance for a rebuttal of what he says. If there is a story about renewable energy, for example, it is treated in a totally different fashion. It is treated uncritically and glowingly, as if it were a promise of new things to come.

So we really have to get back to examining where we can substitute this kind of information. It is not going to be easy. One thing that they have discovered overseas in trying to influence public opinion is that the information must come from a respected source. It should not necessarily come from somebody like us, where people would say, 'We would expect you to say that—you are a nuclear scientist.' It needs to come from some authoritative people that the public has respect for and will accept what they say.

Mr HATTON—Such as the Australian Academy of Science or CSIRO?

Dr Moore—Something of the kind, yes.

Mr HATTON—But we have no equivalents here to the institutions in the United States that are invested with some of that kind of moral and scientific authority.

Dr Moore—The NHMRC could possibly say something about the health aspects, and the Australian Academy of Science could say something about the role of nuclear in world electricity generation.

Mr Brough—Phil has just mentioned the NHMRC. I have got a little bit of stuff from an NHMRC—the National Health and Medical Research Council—document, RHS No. 32, published in 1990. Its title was *Intervention in emergency situations involving radiation exposure*. It said:

> Public health authorities should develop programs to educate and prepare communities living in a potential near-field situation. The type of education and training should take account of existing levels of knowledge and attitudes in the community. In addition, special training programs should be developed for emergency and medical personnel.

I could go on, but you see the point I am making. This was an NHMRC recommendation made 15 years ago. I have not looked at the latest ARPANSA edition of this, but it is probably not in there because nobody wants to do the job. Who is going to do it? ANSTO? No way. ARPANSA? Possibly. Helen Caldicott? No way. You have to, as Phil said, get some well-respected organisation to do it because, if you do not do it, you are going to be living with fear. If you will take the time to look at the latest World Health Organisation report on Chernobyl, it says that 20 years after the accident people are still without adequate information.

I am sorry if I push it, but it is absolutely important that you do it, not merely for the uranium industry and the nuclear industry but because this affects every part of your life. Radiation from

power wires, mobile phones, telephone towers—it is all radiation. We are spending many millions of dollars because of this insensible fear of radiation. I get a radiation dose of two millisieverts a year from the natural background. Last year I had a bad problem with my back. I got seven millisieverts in one CAT scan. Over the last 15 years, my medical radiation dose doubled what I got from working at ANSTO. What is our problem? You guys do a lot of flying, don't you? I have a little bit for you in here. Melbourne to Sydney is a one-hour flight. These guys calculated the dose, and it is two microsieverts.

Mr TOLLNER—Do you want to table that?

Mr Brough—You can check it!

CHAIR—The witness is tabling it. You have to thank him!

Mr MARTIN FERGUSON—With your science backgrounds, what do you think is the state of nuclear research in Australia and our existing nuclear expertise?

Mr Brough—I will ask Phil to answer that, certainly on the scientific side, and Jim on the power side.

Dr Moore—Our group is really a group of old reactor engineers and other scientists. I think that the experience that the AAEC once had in these areas—and we are thinking particularly of nuclear power—has really disappeared with the retirement of people like us. Certainly ANSTO is engaged in various areas of nuclear technology, but there are very few people there these days who understand much about reactors, and nuclear power is just not an area that I think—is it by legislation?—

Mr Brough—It is not government policy.

Dr Moore—They are just not allowed to do any further work on that at the present time.

Mr MARTIN FERGUSON—In terms of waste disposal, did you work on synroc?

Dr Moore—We know about synroc.

Mr Brough—We know about synroc.

Mr MARTIN FERGUSON—What is your attitude to synroc in terms of the best available method of waste disposal in the world?

Mr Brough—It is the best available method. Yes, I would say that without a doubt. But, again, it is a bit more expensive than glass. Is glass good enough? I am being honest here, because ANSTO has spent a lot of money and time doing this. It is an excellent technology, without a doubt. But, again, do you want to spend extra money to make it safer than glass?

Dr Moore—I was in the Harwell research establishment some years back, where they were testing samples of some very fine slivers of various materials—synroc and other ways of waste immobilisation. I asked, 'Is the synroc doing better than the glass and the others?' and they said,

'Yes, it is. But it's really only necessary if you're going to put your waste repository at the bottom of a hot waterfall.' In other words, it is much more than is really required. Although it will find a place in the future for special applications, Australia should remember that both Britain and France have the equivalent of about a £5 billion investment in their present way of doing things, and they are certainly not going to just shut that down so they can embrace synroc. There will come a time when the plant becomes obsolete, and that will be the time when these people will be making decisions about synroc. However, if we were to use one of the processes in Australia, synroc is probably the one we would choose.

Mr Brough—I will add a comment here. Last year, I did a tour of the waste facilities at ANSTO. Some of the molybdenum waste—they call it 'moly waste'; it is actually uranium waste and fission product waste—from the medical process is being dried off right now, and it will eventually go into synroc. They have made a mock-up of the cell. I do not know how far they have got with it now. You saw it as well when they took us round?

Dr Moore—Yes.

Mr Brough—So that will eventually be used locally. But it is only a tiny amount of waste compared with what you have overseas in power reactor waste. This is tiny.

Mr MARTIN FERGUSON—To your knowledge, where is synroc being commercially considered at the moment, and what have been the barriers to its utilisation?

Mr Brough—It is being considered right now in the UK because they have five tonnes of what the industry calls intractable plutonium waste. You can recycle fuel to extract plutonium to make new fuel elements with it, but you get to the stage where you have plutonium which is mixed with so many other things that it is not economic to start separating it out. This is what I understand. As far as I know, the British have contracted with ANSTO to use synroc to deal with five tonnes of the stuff. That is a significant move, to my mind, but I suggest you check that with ANSTO, because I finished work there in May.

Mr TOLLNER—That is my understanding.

Mr MARTIN FERGUSON—I have no problem with Lucas Heights, because I used to represent workers there, just so you know.

Mr TOLLNER—You talked about the enrichment of products. I am curious. Is there sufficient capacity globally for the conversion industry to develop? I have never heard of any applications in Australia to start a conversion industry here. For a start, is it a commercially viable industry? Is there demand for it? Are companies saying that Australia is an ideal location? You have talked about the political and educational issues stopping it. I am interested in some of the other issues.

Mr Fredsall—There are a couple of issues here. One is that the main source of uranium for reactors nowadays comes from down-blending high-enriched uranium from the Russian and US weapons programs with depleted uranium. I think that is taking up, say, 10 to 15 per cent of the total market at the moment, so the need for enrichment is not as great but, when that runs out and the US finally shuts down its last diffusion plant, there is going to be an increasing demand for

enrichment. The US will probably then go to a centrifuge enrichment plant. In our view, as far as enrichment is concerned and in concert with the recommendation of the Director-General of the IAEA, Australia would be an ideal place to have an enrichment plant, because it is a safe country relative to many other countries, such as Iran, for instance. Conversion is a small part of the business; enrichment is a large part of the business. Fabricating fuel is the final step. We would have the expertise here, or we could develop it if required. Again, it may have to be developed in conjunction with an overseas vendor or overseas supplier.

Mr TOLLNER—Are you aware of any potential companies who want to do this?

Dr Moore—Overseas companies.

Mr TOLLNER—I imagine you would have to get them from overseas, import the labour and all that sort of stuff.

Dr Moore—I think it would be silly for us to try to reinvent the wheel. I was certainly spoken to on numerous occasions by a group of representatives from Eurenco, which is part of the British, Dutch and German consortium that has development the centrifuge process. They were very eager to come to some cooperative arrangement with Australia, possibly in Australia, to get further involved in the centrifuge enrichment process, because there is no question that it is far more economical that the old gaseous diffusion plant. Most of the US DOE plants, which had more than half the business a few years back, are now closed.

Mr Fredsall—They were the quick way to get enriched uranium for the weapons program during the war. That is what they were developed for.

Dr Moore—They are largely shut now, and the only gaseous diffusion plant that is available to the Western world is the plant in France. We think that there is an opportunity there. As Jim said, the situation is changing, and we would go into partnership with somebody who already had experience in the field.

Mr TOLLNER—Where do you reckon would be the best location for it? Right next to the Port of Darwin, where all the uranium goes out of?

Mr Brough—First of all, you need a supply of electricity.

Mr TOLLNER—All right. So it could not be Darwin!

Mr Brough—Now we go around in circles! But we are not supposed to mention the word ‘nuclear’ in terms of reactors! Let us face it: 14 per cent of our electricity goes to exporting refined aluminium. That is what is was in 1998. I do not know what it is now. I do not think uranium needs as much as that.

Dr Moore—Certainly it does not need anywhere near as much as the old gaseous diffusion.

Mr HATTON—This question might be one for the next group as well. In terms of what are now pretty much the demonstrable effects of the greenhouse effect, and given the problems we had previously with chlorofluorocarbons and given the significant problem we have with the

ozone layer, what is the broader danger here in terms of gamma radiation and other radiation from our biggest nuclear source, the sun, because of the atmospheric effects that we have been experiencing and, going forward, the fact that they seem to be happening with a great deal more rapidity?

Mr Brough—As far as the effect of climate change on what happens to the radiation coming through from the sun, I cannot answer that. You would have to ask someone with far more physics knowledge than I have. I do not know if Phil can answer that. So that is an imponderable right now. But it is a possibility, yes. One of the things we have about nuclear power is that it is going to take all these thousands of nuclear reactors to replace what you are doing now. This is not what is being proposed. If you are serious about global warming and you know what is causing it then you do your little bit to prevent it. By having nuclear reactors you certainly could do something to ameliorate it. It is not going to solve your problem by itself. We never say it, but everyone wants to jump on the nuclear industry and abolish it. Strange, isn't it?

Mr HATTON—But you feel guilt free?

Mr Brough—I feel guilt free, yes. Well, I do not feel quite guilt free. I feel guilty that I have not done more in the past.

CHAIR—Gentlemen, thank you for your evidence today. If the committee requires anything further, the secretariat will contact you. Could I have Mr Hatton move that the graph as presented recording the millisieverts exposure be accepted into evidence?

Mr HATTON—I tremble to do so, with the amount of travel we do! I so move.

CHAIR—Is it the wish of the committee that the graph be accepted as evidence? There being no objection, it is so ordered.

Proceedings suspended from 11.58 am to 12.31 am

HARDY, Dr Clarence James, Honorary Secretary and Public Officer, Australian Nuclear Association

CHAIR—I welcome Dr Hardy from the Australian Nuclear Association. Please state the capacity in which you appear.

Dr Hardy—I am here to present a brief submission on behalf of the Australian Nuclear Association. By way of background, I spent some 35 years in national nuclear laboratories in the United Kingdom, the USA and Australia, of which 20 years were spent working for the Australian Atomic Energy Commission and for ANSTO—up to 1991 when I took early retirement. Since then, I have been a consultant to the industry, and I am also a member of two non-profit, non-government associations in this nuclear field.

CHAIR—Thank you for agreeing to appear and give evidence at this public hearing today. Although the committee does not require you to give evidence under oath, I should advise you that the hearing is a formal proceeding of the parliament and remind you that giving 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 all evidence to 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 the committee proceeds to questions.

Dr Hardy—The requirement was that you should look at four specific matters, so we have limited our fairly brief presentation to those matters: firstly, the global demand for Australia's uranium resources; secondly, what we see as the strategic importance of these uranium resources and any developments; thirdly, the potential implications for greenhouse gas emission reductions from export; and, finally, our views on the current structure of the regulatory environment. I will take each one of those briefly.

It is a proven fact that there is a global demand for Australia's uranium. This is obvious from the fact that we are exporting around 10,000 tonnes of yellowcake each year to a number of countries overseas who are using it for nuclear power. We give a few figures on the first page of our paper, and I will quickly mention those: 4,500 tones a year to the USA; 2,500 to Japan; 1,000 to Korea; and 2,600 to the European Union. This adds up to 10,600 tonnes. These contributed significantly to a large number of those 307 reactors listed there that were operating in those countries. I think that is all we need to say: there is a global demand. Of course, the reason for this is that we are considered by the world's nuclear power users to be a stable country both politically and economically, and we can sell high-quality uranium to the world market. We have many advantages which have led to that global demand for our resources.

You have to recognise that this is a very significant amount of uranium we are talking about. We are talking about 10,000 tonnes a year. Our figures indicate that the whole world's nuclear industry is using about 80,000 tonnes of yellowcake a year but, of this, only about 40,000 tonnes a year is provided from new mine production. As was mentioned earlier today by another witness, a large part of the present supply of uranium is from secondary sources. For example, this quite important agreement between the United States and Russia to downgrade uranium and

plutonium weapons means that a lot of stuff will be down-blended to three per cent uranium and fed into the civil nuclear program. This is to be applauded, but it will not last forever and perhaps in 10 years time this source of secondary uranium will be used up. Unless another agreement between America and Russia is entered into involving more uranium warheads being decommissioned then there will be a requirement for more uranium from mines. This is where Australia comes in.

Obviously, we have about 38 per cent of the world's low-cost resources—that is our estimate—and therefore we have an opportunity to exploit these resources and increase production. Can we do this? The supply issue is whether Australian companies—present or possible future companies—can expand their production to meet this expected increasing demand and also whether they can export uranium to rapidly developing markets in China and India. From what we read, the government is currently negotiating suitable agreements to allow it to export uranium to China.

We point out in our brief submission that India is not a signatory to the MPT and therefore the Australian government may not be willing at this time to negotiate a safeguards agreement to enable uranium to be exported to that country. But, while it is often said that a day or a week is a long time in politics, a week or a month is a long time in the nuclear industry. We have seen only recently that the United States has changed its attitude to India with regard to the supply of nuclear materials, equipment and technology. So who knows—perhaps there will be changes in the Indian political situation that might make it a suitable recipient of Australian uranium in the future. Only time will tell. That has dealt with the first point.

The second point is: what is the strategic importance of these resources and any developments? It is almost self-evident that if a country owns around 40 per cent of the world's resources, whether it be uranium or nickel or copper, that must have great strategic importance in the world's thinking if that is a material which is an important resource for energy production—in this case, mainly electricity production. Even 25 per cent production of the world's low-cost uranium sold to the world is a very important strategic amount. It is likely that this percentage will increase even more, and therefore it will become even more strategically important to many countries that have invested large amounts of money in putting in place nuclear power programs in their own countries. It is almost self-evident that it must have great strategic importance.

What about the possibility of expanding production? The most likely short-term expansion, we believe, is with the BHP Billiton takeover of Western Mining Resources. Before the takeover and since the takeover the owners have said they are seriously considering an expansion of there three-fold resource: copper, uranium and gold, all of which contribute to the bottom line. I believe that, unless there are some unforeseen eventualities, the company will probably proceed with that expansion plan, if it can obtain environmental approvals, state approvals, government approvals of exports and so on.

Recently, we opened an in situ uranium mining venture in the Beverley deposit in South Australia. All the necessary approvals have been approved by the South Australian and the Commonwealth governments, but it only produced a modest 1,000 tonnes last year. It is very likely that additional in situ uranium mines will be developed in the next few years if they receive the necessary approvals. There are benefits and risks attached to this in situ mining technology. The benefits are that you do not have very large requirements to dig holes in the

ground or build expensive mining tunnels and tunnel systems like those in Olympic Dam. But, on the other hand, there is a concern of the public—and a concern of the regulatory people—as to whether there can be leakage of the liquid pumped into and out of the ground. So there are benefits and risks. I do not believe that in situ mining will become a major industry in this country. It is very suitable for some deposits but not suitable for others. It can certainly add to Australia's future resources and exports, but not to the major extent that, say, a 5,000-tonnes-a-year expansion of uranium at Olympic Dam could add to our resources. That deals with the strategic importance. I think it is self-evident that it is important in the world scene, and there are some very prospective industry developments coming along.

I now turn to the controversial topic: what are the potential implications for global greenhouse gas emissions? As an example of the importance of our export of uranium, in 2002 exports then fuelled the electricity production for about 33 million people and saved an emission of 290 million tonnes of carbon dioxide. I have taken these figures from the Uranium Information Centre briefing paper on uranium mining in Australia. Quite a lot of work has been done by experts in many countries overseas on the relative amounts of carbon dioxide emitted by different sources of energy—including coal, gas, solar, wind, nuclear and hydro. The results that I have provided here are from people who were involved in the nuclear industry, but there have been very similar tables of results produced by people who you could say are not involved in the nuclear industry, who are maybe working in universities and so on, so there is a broad pattern.

In very broad numbers, you all know that coal produces the most carbon dioxide per kilowatt hour of electricity, and gas—particularly combined cycle gas plants—produce almost half as much CO_2 per kilowatt hour, so they are a cleaner source of energy than coal. Solar photovoltaic produces perhaps only 10 per cent of that amount and nuclear is usually down near the bottom of the list—as is hydro. Why does nuclear power produce any at all? Some people like Dr Helen Caldicott, and other people who are opposed to nuclear power, would say that these are not reliable results because they do not take everything into account. For example, nuclear is low on this list, because it makes various assumptions, including the assumption that the enrichment sector here is produced from centrifuge enrichment, not from the old gaseous diffusion plants, which have been factored in as an assumption in some other studies that other people have cited.

The difference is that enriched uranium produced by infusion plants to feed into a reactor takes an enormous amount of electrical energy. They are the dinosaurs of the nuclear age. They are being replaced by what are called centrifuge plants, which can produce enriched uranium with less than one-tenth of the electricity previously required. If you put those assumptions in, then you get these very low figures. Why is there any figure at all for CO_2? Because the power station, while it is operating, does not produce any CO_2 or any particulates out of the stacks. The CO_2 comes from the fuel cycle—that is, mining the uranium, digging it out of the ground, enriching it, processing it, feeding it into the plant, making the metal cladding of the fuel elements, then treating the waste when it comes out and again digging holes in the ground to bury it. When you add up the CO_2 emissions of the conventional industry in the assessments done by these people, it is a very low figure compared with coal or gas. Some figures have been quoted to your inquiry, particularly a set of figures from a Dutch study some years ago which claimed that these figures were much higher. You have to look at the fine print and the assumptions that went into them. I believe that these are as reliable as anyone else's.

So it is clear from these figures that, if you are operating 400 or so nuclear power stations around the world, you are producing less CO_2 per unit of electricity than if you were operating coal or gas stations. Nuclear power, in that sense, can contribute to reducing the greenhouse effect but, as other people have said to you today and in other meetings, nuclear power is not the solution to the greenhouse problem because it can only contribute a small amount as one of several energy resources. In general, we in the world are unfortunately very reliant on fossil fuels. We cannot possibly phase them out over a short period, and possibly not even over 20 to 50 years. We will be dependent on them, but we can do everything possible to conserve electricity and use more efficient end-use applications. We can conserve it in that sense and we can supplement it with new base load and distributed generation from nuclear and renewables which have much lower contributions. That is the point.

CHAIR—Can I suggest we go to questions, as otherwise we are going to run out of time.

Dr Hardy—I was going to say a couple of sentences on the regulatory side. We believe—and I have said this many times in papers—that Australia's uranium industry is one of the most highly regulated mining industries in the world, and we believe that it is satisfactorily controlled by the Commonwealth and the states with respect to environment protection safeguards. Of course we would like to see the international safeguard system strengthened, and we believe the Australian government has that same aim. I think we have covered your four major points, and I would be very happy to cover any other topics, including anything you would like to ask me on the very controversial topics of uranium, radiation, plutonium and all these other things that you have been given evidence on.

CHAIR—Thanks for that. I note that on page 3 your submission provides the tables with estimates of the amounts of carbon dioxide produced by different types of fuel sources in selected countries. The figures for Japan place nuclear emissions even below wind power, and only marginally about wind in Sweden and Finland. How would you account for this difference?

Dr Hardy—Wind is a very low concentration of energy. At my public speeches I am asked: how is it possible that solar and wind, when they are free, cost more than fossil fuels and nuclear? There are two answers to that. The first one is that they are very diffuse sources of energy. The amount of solar energy per square metre is not very high. Even if you put hundreds of thousands of square metres together, you do not get a very dense energy source like burning coal or burning uranium. It is a very dilute source.

The second important thing—you all know it; it is simple—is that the sun does not shine all day. So you get a very low capacity factor. So solar power is very dilute, it is fairly expensive to build solar cells and they all produce CO_2 in the production processes. If you look at wind power—you have seen the photographs of the massive concrete structures with massive turbines on top of them—a lot of energy and CO_2 emissions come from producing the concrete, the electrical generators and so on for a relatively small amount of energy. Okay, you get one megawatt or perhaps 2½ megawatts from one tower, but that is very small for its capital cost. You also have to maintain it, and they are very expensive to maintain. Although the source is free, when you add it all up and do a lifetime analysis of the cost of the electricity, it is more expensive than coal and produces more CO_2.

These are not just my figures. In fact, two years ago the government had some consultants put together for Australia a comparison like this for all the energy sources under the national hydrogen study. These figures reflect very similar figures to what those independent consultants came up with by discussing it with experts. These are not just figures produced by nuclear experts and fudged; they are mirrored in independent studies, including the government's own study two years ago.

Mr MARTIN FERGUSON—The bipartisan view in Australia is that we should only export uranium to countries that are parties to the Nuclear Non-Proliferation Treaty. India is not a party to it. You have raised developments in the US. Do you think that Australia should walk away from the requirement to be a party to the NPT?

Dr Hardy—I am a conservative traditionalist and I believe that the non-proliferation treaty has made a major contribution to world peace and world stability over many years. I have always had the view that if countries do not wish to join it—even though it may not be perfect—they should not be given very many benefits. This has been the philosophy with countries such as India and North Korea for many years. I would like to see diplomatic initiatives to try to bring some of these nations that have not signed it into the NPT, as well as improving the NPT, before we relax regulations in this case. That is my view.

Mr MARTIN FERGUSON—Given the potential growth in energy demand, do you see nuclear power as only a part of a mix of initiatives to solve our greenhouse problem and not as the solution?

Dr Hardy—Yes. We are so dependent upon fossil fuels in the whole world—developed and developing countries, and particularly in Australia with our high use of fossil fuels—that there is no conceivable way that we can replace them in the short term, and by that I mean 20 years. We talk about renewables coming in, but they are only making a very small impact and they do require considerable government subsidies to get over that initial impact until they can get large-scale production and bring the cost down. So they inevitably need government subsidies, I believe, otherwise they will not be brought in at all by industry.

If we look at, say, hydrogen use, hydrogen is not a resource like coal or nuclear uranium. Hydrogen is just a method of getting from A to B, like electricity. It is a transmission system. So you have to produce hydrogen and then you have to use it at the end. The end use is brilliant. You can use it and only produce water at the end of it in a fuel cell or in a car—just burn hydrogen and produce water. But it is the production and distribution of hydrogen that is its big problem. If you are going to make hydrogen from fossil fuel feedstocks like gas, which is the cheapest and cleanest, you are not solving the CO_2 problem with hydrogen because you release all that CO_2 in the production process. The only way that hydrogen could help to solve the CO_2 problem worldwide is if you produced it from water. So you produce it from water, you end up with water and it is a way of transforming energy along the way. To do that, you mainly need electricity to electrolyse it. Then you are back to where you get the electricity from. It is no use making the electricity and using gas to produce hydrogen, because you do not solve the CO_2 problem.

Mr MARTIN FERGUSON—I have one final question. What do you say about suggestions from the environmental movement that base-load energy requirements throughout the world can be solved by reducing energy use and by reliance on renewables?

Dr Hardy—The conservation of energy is vitally important. It is far more important to save a dollar's worth of electricity than to produce a dollar's worth. We all accept that but we are faced with the question: would you or I put in a light bulb which is 10 times more efficient if it cost 20 times as much? I face this every day I buy a new light bulb. They cost 50c each imported from China, whereas these beautiful new, low-energy ones are something like five, six or seven dollars each. Okay, it says they last 20 times longer, but they cost 20 times as much. Unless you are fairly wealthy and have a disposable income you do not buy these new developments. If you mandate them—for example, all new refrigerators must have a five-star rating or whatever—then you can influence the public's choice by putting regulations on it. But until somebody regulates that you must buy the better light bulbs—or perhaps subsidises people to do it—then you will not get people doing it.

Renewable comes into the next category. At the moment it is too expensive. Unless governments subsidise it, it will not get off the ground. If they do subsidise it, one day soon they may break that commercial barrier and then you can put solar energy on your roof. The simple thing is that I could put a solar water heater on my roof in Sydney today for a certain amount of money but it would take me seven or eight years to recover the capital. In Darwin, though, it might only take you a couple of years to recover the capital. So in some parts of the country you have a different set of circumstances. Unless you mandate it and encourage it, you cannot bring it in.

I am all for conservation and more efficient end use in industry and residences. I am also all for bringing in renewables, but I do not believe they can make a major impact until one thing is done: we need a clever person like Mr Edison to invent a brilliant new electricity storage system that is not as expensive as a lead acid battery—and it has worked brilliantly for 100 years but you cannot scale it up to 1,000 megawatts; it is just not on. If someone comes along with an energy storage battery that is relatively cheap, you could couple it to all these intermittent renewable sources—solar, wind and wave—which only work 50 per cent of the time and produce a smooth, efficient source at a reasonable cost. That is the key to renewables.

In the meantime, I think the government is right: you have got to have better, cleaner technology for coal. Everybody is trying to do this and everybody is trying to capture the CO_2 and bury it underground. If you think it is going to be difficult to find a site anywhere to bury radioactive waste deep underground, I think it is going to be equally difficult to find a site underground in any developed country where you can dig holes and put highly liquefied CO_2 under pressure and guarantee that it will not leak out. The gas is toxic to humans—it is perfect for plants but not for humans. We are going to face the same problems with sequestration of CO_2—which countries are spending billions of dollars on research on—when it comes to 'not in my backyard' for an underground repository.

CHAIR—Don't they sequester CO_2 in Norway?

Dr Hardy—They do. But again it is a half-truth. So many people against nuclear tell you half-truths. The half-truth is, 'We do it in Norway in the gas industry and the petroleum industry.' It is

very different extracting the CO_2 coming out from a gas well in Norway or in the North Sea. You have got methane and CO_2 coming out at pressure and you can easily separate them. It is cheap. But it is a different matter when you have got a 1,000 megawatt coal fired power station putting out a million tonnes of CO_2—hot gases diluted with air. It is very difficult and very expensive to take that CO_2 out, then compress it and liquefy it, which takes more energy. When we have totally solved the technical problems with gas and coal fired power stations and solved the 'not in my backyard' problems with putting it underground, what will you get? A higher cost. Are you prepared to pay double the cost for your electricity to clean up the coal in order to get your children and grandchildren a cleaner planet? I do not think we are at the stage where we are prepared to accept 50 per cent on the cost of electricity to clean up coal.

Mr ADAMS—One of the questions that has not been answered is: how much of the bulk load is coming from renewable energies at the moment?

Dr Hardy—So there was another problem. To use these windmills and solar generators you normally have to have a distributive system, not a centralised system. You have to look at the facts. The facts are that the population is increasing from, say, six billion—it is going up and up and up—to maybe 10 billion by 2050. A lot of those people are in the developing world and some of them do not have electricity. Thirty per cent of Chinese people in the countryside do not have electricity, or clean water for that matter. They will all want to use electricity in the future because it is so convenient; so electricity demand is going up—everybody accepts that.

The other thing to remember is that we are an urban society and we are moving more and more into big cities. The field workers in China are trying to get into the cities and earn more money and have a better standard of life, and in India too. In this country we are not going to suddenly put all our new immigrants out in the country, are we? We cannot get them to do it. We are going to stick with big cities all over the world, so we have got to have base load electricity for convenience—at a cost. The cost is that the greenhouse gas problem could be more dangerous in the future, for your grandchildren, than the risks of radioactive waste if we use nuclear power. They are different risks and it depends how you perceive them. What is the most important, not for you but for your grandchildren? Is it the risk of the world becoming warmer and of some land going under water if the sea is a metre higher, or do you want to have a small risk of underground nuclear waste going wrong?

Mr TOLLNER—You mentioned centrifuge enrichment and gaseous enrichment processes, and you said the centrifuge system was 90 per cent more efficient than the gaseous system. Can you give me an idea of what sort of energy levels we are talking about there?

Dr Hardy—Yes. Normally you would describe enrichment plants in terms of their output in SWUs: separative work units—it is just a kind of number. As an example of what that number means: in order to feed a 1,000-megawatt nuclear power station—a big, standard nuclear power station—you need to put in 30 tonnes of uranium fuel every year. To make that fuel at three per cent enrichment from natural ore you would need at least 100,000 separative work units, and they cost you $100 per unit. So those are the ballpark figures.

A big plant today could produce as many as 10 million units a year. In the past these big plants have been based on gaseous diffusion. Gaseous diffusion, typically, might use as much as 2,000 kilowatt hours of electricity to produce one separative work unit. For example, a big plant in the

United States would be taking almost all of the production from two big power stations in the Tennessee Valley Authority, if it was at Oak Ridge, for example, so it is using an enormous amount of electricity. The problem with the present US diffusion plant, which is being virtually run down and is going to be replaced shortly, is that they cannot get that vast amount of electricity from the US grid system near the plant and so they are not running that plant at full capacity all the time, which is wasteful and uneconomical.

These big plants are being replaced gradually with centrifuge plants, which are more efficient by a factor of between 10 and 20. Instead of using 2,000 kilowatt hours per unit of production, they only require between 50 and 100 kilowatt hours per unit of production. They are very much more efficient. The difference is the mass production of lots of these little centrifuges in a mass production factory—as in a factory for motor cars, gearboxes or whatever—and putting them all in and connecting them up. The other big advantage they have is that you can build them in modules. You do not build one enormous plant producing 10 million units; you build a plant producing one million units. In three years, it will be operating and you will be getting revenue coming in. Then you build the next one and the next one, and in perhaps 10 years you would build the 10 million-unit plant, but you would have cash flow coming in to do that. That is why they are so attractive to investors today.

One of the leading companies in the world is Eurenco—you have heard that name mentioned. That is the European equivalent. They have plants in Britain, Germany and the Netherlands and are now planning to build a new plant in America in competition with the government supported plants. They are building a first module of this new plant. Similarly, the French have just recently licensed that technology to completely replace their enormous gaseous diffusion plant in the south of France. The difference with this plant in the south of France is that it is an enormous plant—10 million units of production; it will supply all the French and some of the other countries they sell to—and it has four dedicated nuclear power plants alongside it. It is a diffusion plant with four dedicated nuclear plants. This is one of the plants that, although it is using 2,000 kilowatt hours per unit, is not producing any CO_2 from the coal-fired plants because they are nuclear. That is a slight difference from the American plants, which are very big and use coal.

The Russians are operating centrifuge plants. I have never been told where they get their electricity from—whether it is partly nuclear or partly coal—because they do not always disclose the details in Russia. The Russians are using centrifuges. The French are trying to replace all of their plants with centrifuges. The Americans are going to replace their plants with centrifuges. In perhaps 10 years time there will be no gaseous diffusion plants working in the world. They will all be centrifuge enrichment plants.

Mr HATTON—Thank you for the arguments you put with regard to geosequestration of CO_2. I think too few people understand just how geologically unstable the planet is. There have been instances in geological time where there have been major escapes of CO_2 that have killed existing animal life. My question, which I also asked of the previous group, goes to the fundamentals of what ionising radiation is and the fact that it can change the molecular processes within animals. We have already seen some changes. There has been the campaign to get rid of chlorofluorocarbons, which are produced by those kinds of large gaseous diffusion plants, as I understand it. The campaign to reduce chlorofluorocarbons in the atmosphere has been generally fairly successful. There are significant problems over the Antarctic in particular with the increase

in the porosity, effectively, of the ozone layer and the fact that the hole in the ozone has become so much larger. That of course has an impact on Tasmania and on the radiation levels in Tasmania. During this period of industrialisation, we have had a thinning of the atmosphere. Is the problem of ionising radiation directly from the sun and from gamma rays greater than that produced from civil nuclear energy?

Dr Hardy—I am not quite clear what your question is. Is it: would expanding the nuclear industry affect the radiation approaching the earth from space? Is that your question?

Mr HATTON—No. Is the radiation emitted by nuclear power generation a more significant problem than the climatic changes that have occurred over the last few decades with the ozone layer and our greater exposure to ionising radiation directly from the sun? You may not be an expert in that area.

Dr Hardy—I would not call myself an expert in climatology by any means, but I certainly have a broad background in radiation. I would say that there is so much radiation coming from the sun—and from the whole universe, not just the sun; cosmic rays and so on—to the earth. There is a radiation field entering the earth. There is also basic radiation coming from the earth, from all of the radioactive materials in the earth. That amount of radiation on the earth is so significant that any tiny amount from the uranium industry is absolutely insignificant. You are getting all of this solar radiation—I forget the number of watts; it could be 75 watts per square metre on every square metre on the earth—from the sun, plus all of the cosmic radiation and gamma radiation, as well as visible radiation. That flux on the earth is so enormous that the amount that any uranium mine or nuclear power plant is generating is totally insignificant. I do not think it is a factor to be taken into account at all.

Mr HATTON—Yet, if you would believe the evidence we heard earlier today and the arguments that have been put in Australia as indicated by the previous group, the Australian Nuclear Forum, throughout the eighties in particular, led by Dr Caldicott and others, they are almost a reversal of that—that is, radiation is a fundamental problem and always will be, and that it should be done away with wherever possible.

Dr Hardy—There is so much radiation in the earth and around the earth—it is called background radiation, wherever it comes from. As Mr Brough explained, the general public does not understand that the world is radioactive and we are all exposed to radiation naturally. You cannot stop it in any way whatsoever unless you live in a lead house. It is inevitable. What Dr Caldicott in particular has said repeatedly for 25 or 30 years in my experience is that all radiation—it does not matter what it is—is harmful to human beings and to all living cells. That is what I call a half truth.

There is evidence that if you give enough radiation to a human being you will kill them instantly. If they got hold of a spent nuclear fuel rod in their hand, they would die horribly within an hour or two. So it is well known that high radiation levels given in a dose will kill you. It is also known that, if you keep giving people medium-low doses for a long period of time, it can have harmful effects. Where there is great controversy is whether the line on the graph which runs from high dose, high effect through medium dose, medium effect extends down to the origin, so that any tiny little dose will give you a tiny little effect. That is not proven. If Dr Caldicott were sitting here I would say that that is totally unproven theory.

There has been great controversy for many years as to whether it could be the opposite—that is, a tiny dose may give a beneficial effect. So the line on the graph, looking at it from your viewpoint, would actually go below the origin into the beneficial area and then come up to what is called a threshold. Then it would become linear—that is, every dose above that threshold gives you more risk of harm. You can prove the middle bit by animal experiments. You cannot prove it on humans very well because we are not allowed to do experiments of that kind on humans. You can prove the top bit with atom bomb survivors and so on. There are atom bomb survivors living today who have had quite serious irradiation and they are still living 50 years later. Helen Caldicott would say, I am sure: 'The effects could happen next year—it takes a long time to happen.'

It is the same with Chernobyl. We know the results of the United Nations study by eminent experts. They are not all working for the IAEA. These eminent experts looked at all of the figures and said, 'We think the initial estimates have been grossly overestimated. This many have died, this many have had thyroid cancer and this many may die, but it is in the thousands, not the hundreds of thousands.' She disputes that by saying that we have not waited long enough. If we wait another 20 years there will be many more. You cannot prove her wrong because we have not got there yet.

Similarly, there is evidence that there are beneficial effects of a very low dose of radiation. This is called the hormesis effect, and some of your submissions may have dealt with that. A very tiny amount of something has a beneficial effect. This is well known in many other systems—toxic elements, for example. A tiny amount of zinc and copper is essential for your wellbeing but, if you have more than that amount, you can have very serious problems. This is well proven in non-radioactive systems and there is a lot of information now on radioactive systems. The evidence is there; it is just that some people will not accept it.

Mr HATTON—You were speaking about a storage problem with renewables and the fact that we need someone to get a way of doing it on a localised basis. Have you seen any of the work that CSIRO and some other Australian agencies have been doing with storage ponds using different layers of salt?

Dr Hardy—Yes, I have seen that. There has been some very useful work done by the University of New South Wales, which I understand they patented, called the vanadium redox battery, which you can build in quite big batteries. It has a solution of a vanadium salt in it in which you put energy, convert it from one form to another and then get it out. It is like a superior form of lead acid battery. That has very great promise, but whether you could ever scale it up to hundreds of megawatts or even a megawatt I am not quite sure. But there are promising inventions coming along.

You can store energy in water. This has been used for years: you have a dam and when you are not using it you put the water into a storage pond and then drop it down through turbines. That is technology that is 100 years old, but it is not particularly cheap. It has very specific applications, say in the Snowy River. What we need is something that can be scaled up to take megawatts of power in intermittently and put megawatts of power out smoothly to feed into the grid.

CHAIR—Thank you for your presentation today. If there are any further questions that the committee has, the secretariat will contact you.

[1.18 pm]

HUMPHREYS, Dr Malcolm, Executive Director, Compass Resources NL

CHAIR—Welcome. Do you have any comments to make on the capacity in which you appear?

Dr Humphreys—I am representing the views of Compass Resources NL as a resource company in Australia.

CHAIR—Thank you for agreeing to give evidence at this public hearing. Although the committee does not require you to give evidence under oath, I should advise you that the hearing is a formal proceeding of parliament and 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 invite you to give a short opening statement before the committee proceeds to questions.

Dr Humphreys—As I said, I represent Compass Resources, which is a publicly listed company with approximately 2,000 shareholders. Its business is the exploration and development of mineral resources, including uranium. I have worked in this industry for over 35 years, both in Australia and overseas—included in that experience is uranium exploration and development. My submission basically comes from the supply end of the business, as Compass Resources is interested in developing uranium resources in the Northern Territory.

I guess we would not be having this inquiry if it were not for the fact that the demand for uranium for new nuclear power plants is creating something of a bloom and that Australia has large resources of that metal. I believe, however, that it would be a mistake to think that failure to meet the supply of uranium from Australian sources would somehow disrupt the growth of the nuclear power industry. Uranium is, after all, not a scarce or rare commodity, and, in the absence of Australian production, alternative supplies will make their way onto the market from countries well endowed with uranium resources, such as Canada, south-west Africa, west Africa and former Soviet republics, such as Kazakhstan. Logic would seem to argue that Australia, with its strong regulatory environmental position for mining operations and the adherence to the Nuclear Non-Proliferation Treaty, would be encouraging new uranium operations to meet the increased demand. In that way, we believe that Australia has an opportunity to exert world's best practice on mining operations and will play an important role in monitoring uranium through the nuclear fuel cycle.

Within Australia many in our industry are somewhat mystified as to why some states have selected uranium as a metal to black-list but at the same time are content that other states should continue with uranium mining and processing. With the exception of uranium, however, the states have done an admirable job of regulating mineral developments. They are closest to the action, and that tends to result in more streamlined yet issue-focused approval processes. As I said, this is not necessarily the case for uranium, and it varies very much between states. At the

moment, we have a number of potentially commercial deposits which have been left in limbo on what appears to be an emotion-driven rationale.

Our company believes that, if a state government has issued an exploration right to a company for uranium, subject to compliance with environmental and other regulations, that company should be entitled to proceed to mining. Otherwise the right to the uranium should have been specifically excluded from the exploration licence and would not have diverted scarce capital into searching for that commodity. We know Australia has a great reputation as a low sovereign risk country; however, if states issue exploration rights to companies without the intention of approving developments, that national reputation will be called into question.

Compass holds its uranium interests in the Northern Territory, where a recent conflict existed between Territory government and federal policy in regard to development approvals. The decision by the federal government to take responsibility for approving uranium projects in the Territory has removed that uncertainty and is a welcome development. Ideally, however, state governments will continue to administer approvals of uranium projects in the same way that they do for other commodities, without blanket bans being imposed on some such metals. This would seem to be the most efficient way of proceeding to monitor the progress of developments in the mining industry.

In summary, Compass shares the view that, driven partly by high fossil fuel costs and the greenhouse gas reduction imperative, it seems likely that nuclear energy will play an increasing role in meeting the growth in world energy demand. Australia and resource companies like Compass are well positioned to benefit commercially from that growth and also to play a positive role in ensuring the peaceful use of the increased uranium production and a lowering of greenhouse gas emissions.

Mr TOLLNER—Dr Humphreys, in relation to your company's prospects, my understanding was that your Browns site, the cobalt mine that you are trying to get off the ground, is facing some issues with the provision of electricity and the particularly high cost of electricity in the Northern Territory. I am also aware that right next to Browns is the old Rum Jungle site, where you have some still significant uranium resources. Is that uranium subject to the same commercial problems that you have with your cobalt in regard to the provision of electricity, or is it a different process?

Mr MARTIN FERGUSON—Where is the Browns site?

Dr Humphreys—It is about 80 kilometres south of Darwin.

Mr TOLLNER—It is Batchelor—the old Rum Jungle site, Martin.

Mr MARTIN FERGUSON—You have a cobalt salt and a potential—

Dr Humphreys—Yes, there is copper cobalt mineralisation, which we are planning to bring into development next year, and adjacent to that is uranium. In answer to your question, the increases in oil prices and so on have driven up electricity costs considerably. Compass had originally looked at diesel generation of power for the copper cobalt operations we are proposing. We have been forced to revert from that to supply from the grid system at a higher

price than we had originally built into our plans. The production of copper, in particular, to a metal utilises quite a high amount of energy and therefore it is a key part of operating costs. A uranium treatment plant is actually a very simple type of processing plant and uses much less electricity, so the impact of rising oil prices would have had a lesser impact in the case of a uranium development there, and we might not have had to go to grid power. We could equally have gone with diesel generation.

Mr TOLLNER—Does that signal that you are much more keen to develop that uranium resource there now?

Dr Humphreys—Given that the price projections for uranium are sustained—and spot prices are now about $40 per pound—there is a big margin between operating costs and revenues for uranium deposits. Eventually, we believe the market will come into a much better supply-demand balance, and uranium prices will fall. But certainly, if we looked at the straight economics, it would probably be a lot more profitable to use the capital and develop a uranium operation than a copper cobalt operation at this time.

Mr TOLLNER—I do not know whether you can answer this question, but when would you look at getting a uranium mine running? Has any thought been given to that? Do you have a time line?

Dr Humphreys—Yes. We are looking at it all in our planning. We are looking at a sequential development, with the first cab off the rank being the copper cobalt oxide project, which we anticipate having in production at the end of next year. At the same time, we will be drilling out our uranium resources in that area to more detailed standards than in the past, and then we will be going through the engineering process and the permitting, such that we would expect to be producing from those operations in about four years time, given that we get the necessary approvals.

Mr TOLLNER—So John Earthrowl's in work for a while yet!

Dr Humphreys—John has been working extremely hard over this dry season.

Miss JACKIE KELLY—do you know the amounts of uranium Australia is currently exporting?

Dr Humphreys—I do not have those figures in detail, but Ranger have been producing around 5,000 tonnes and Olympic Dam in the 5,000- to 10,000-tonne range.

Miss JACKIE KELLY—And do you know what the worldwide waste each year is in uranium?

Dr Humphreys—The waste?

Miss JACKIE KELLY—The waste products from the 400-odd reactors.

Dr Humphreys—No, that is not an area that I am familiar with other than that, if one compares the general energy efficiency of uranium to that of coal, for example, uranium is

substantially more efficient. Therefore the amount of waste that is generated is minuscule compared with that of coal operations.

Miss JACKIE KELLY—We have had evidence that 12,000 tonnes of high-level waste is generated per annum world wide and that there is currently 270,000 tonnes of high-level waste in the world.

Dr Humphreys—I am not able to dispute or confirm that.

Miss JACKIE KELLY—What amount of that waste would you have to take back to make sure you were getting back the amount of uranium you had exported? Would you be able to do that figure?

Dr Humphreys—The amount we are talking about is really miniscule. The efficiency of uranium when you split an atom is so high that it generates the same energy as burning 50 million carbon atoms. If you export a million pounds of uranium oxide a year, which would have a revenue of say $40 million, only 0.7 of one per cent of that is the uranium-235 isotope, which is the one that has to be enriched to three per cent in order to make fuel. So you are talking about 0.7 of one per cent from the production, which then becomes depleted and of which some proportion would be high-level waste.

Miss JACKIE KELLY—You are basically saying that Australia is a low-cost generator of uranium and that it would be cheaper to mine uranium than to mine copper. But, if you had to put into your costs of development, into your business plan, an enrichment process and then a lease-back of rods so that you were guaranteeing you were getting it back, would it be uneconomic?

Dr Humphreys—The world just does not operate that way. The suppliers supply a product, yellowcake, which is straight uranium oxide. The uranium oxide has to go to an enrichment facility. The last speaker was talking about centrifuges and things like that, where the isotope that you are interested in gets concentrated. By the time you are in that stage, you are well away from the mining section of the business.

Miss JACKIE KELLY—So you are only interested in mining yellowcake and shipping it off overseas?

Dr Humphreys—We are interested in supplying a commodity to a market to the specifications it requires to make the wheels of industry continue to go round.

Miss JACKIE KELLY—Given that we are currently supplying 25 per cent of the world's uranium, do you think there is an opportunity for an Australian company to corner the worldwide market in terms of total take-back and control of the entire life cycle of uranium? Could a company say, 'We will get back what we produce and store that for you,' so that there was huge international pressure to use Australian sourced uranium because people would know it was all coming back?

Dr Humphreys—No, I do not think that is a likely eventuality at all. Deposits will—

Miss JACKIE KELLY—It is a model put up by Professor Broinowski.

Dr Humphreys—We are working in a commercial world on a supply and demand basis. The companies that can supply product to the market at a lower price, given the quality—

Miss JACKIE KELLY—So you just want supply at the cheapest price and you will not build into that price anything about final waste disposal?

Dr Humphreys—I am not sure I am in a position to answer that.

Mr MARTIN FERGUSON—Is the uranium export industry any different to the coal industry, in the sense that both supply a product? Is there any requirement for our coal exporters to also build in the cost of cleaning up greenhouse damage?

Dr Humphreys—Again, I am not an expert on the coal industry.

Mr MARTIN FERGUSON—Uranium exports are no different to coal. At the moment you supply a raw material, and neither of the exporters has to factor in potential long-term storage or environmental consequences.

Dr Humphreys—Correct.

Mr MARTIN FERGUSON—Is your exploration around Batchelor in the Northern Territory virgin exploration or did you buy existing uranium leases?

Dr Humphreys—It is an exploration program that has been going on for about 15 years. They were straight exploration licence applications, in the main.

Mr MARTIN FERGUSON—For uranium?

Dr Humphreys—For all metals, including uranium. There had been past uranium production from that area, so we knew the potential existed there. Our priority had been copper, cobalt and nickel, which was the thing we had focused on. Only recently have we seen the uranium price rise from about $7 to $10 a pound to $40. That makes one rework the numbers and look at what developments might go ahead.

Mr MARTIN FERGUSON—Have you had to seek any exploration approvals in the last 4½ years from the NT government? If so, is it commonly known in the Northern Territory government that you are pursuing uranium exploration?

Dr Humphreys—Yes, I believe it is very well known. We are, of course, seeking approvals for our copper, cobalt and nickel project. The Territory government have had a reputation for being very efficient in reviewing and going through those programs. They have an excellent reputation in the industry and we are happy to work with them. They are quite aware of our uranium activities.

Mr MARTIN FERGUSON—What have you spent on exploration in the last five years?

Dr Humphreys—We have probably spent $20 million to $30 million.

Mr MARTIN FERGUSON—There have been environmental problems at Rum Jungle relating to the failure to initially clean up. What was the cause of the environmental damage from the old Rum Jungle mine?

Dr Humphreys—Uncontrolled mining, as was a common approach in those days, whether down at Queenstown in Tasmania or in the Rum Jungle area. Mines did not go through the normal approval process because of the requirement for uranium for the UK nuclear program. Even if it had gone through the normal approval process, in those days the regulations were very flimsy.

Mr MARTIN FERGUSON—If you were to be given approval, why would the environmental concerns about operations and rehabilitation be different now from when Rum Jungle closed in the early seventies?

Dr Humphreys—There are substantially higher standards to meet, many more hurdles to get through, many more justifications as to how you handle and control products and safety requirements both for the occupational health of employees and the products that you treat in and dispose in. There is a requirement for the reclamation plan to take a position at the forefront of the approvals process whereas in the early days it tended to be an afterthought at the end of operations.

Mr MARTIN FERGUSON—What commitments do you think you as a company should have for Indigenous employment and training and community development?

Dr Humphreys—We have close contact with traditional owners in the area. I think it is very desirable to improve the employment and training opportunities for Indigenous people. Our company would strongly support that. In relation to our copper, cobalt and nickel project, even though we would not have requirements in that area we will certainly be working with the NLC and the communities to present those employment opportunities.

Mr TOLLNER—I want to clarify a question that Martin asked you. Is the current Northern Territory government aware that you were not only exploring for uranium but also possibly looking at some stage to develop a uranium mine?

Dr Humphreys—We deal with the mines department. We put up a mine management plan which covers our exploration program each year. As part of that, we identify where our activities are going to go. There is a reporting requirement which comes forward with the licences that you are granted and we produce reports that summarise our activities. In that regard, the mines department is our main point of technical communication as to what we are doing with uranium vis-a-vis base metals or cobalt.

Mr HATTON—Dr Humphreys, you had a little trouble with some questions on the whole issue of adding value to Australian resources and whether or not we could take a larger part of the cycle in. We heard a vision where we could take uranium from digging it up to enriching it and then sending a product with much greater value overseas. By using the way the Russians have done it—taking leased rods—we would have responsibility for those throughout the cycle,

and we could create a much bigger and stronger industry that would return much more to Australia. I want to go back to your end of it, the digging it up and flogging it bit, and the parts that we had trouble understanding. At page 2 you said:

One reason why the supply from Australia ... is not vital to the uranium supply demand balance is the concentration factor required to convert the uranium mine product into a fuel.

What do you really mean by that? Is it having to go and enrich the thing and concentrate it that is the fundamental problem? We are still struggling to understand that.

Dr Humphreys—Let me go back a step. When the ore comes out of the ground, it may average one pound or two pounds per tonne of U_3O_8. The U_3O_8 is not 100 per cent uranium. There are different isotopes in it. Uranium miners will send that product, and that is the general product that is sold from uranium mines throughout the world. The requirement to build the isotope U-235 up to three to five per cent in terms of concentration is the major capital step which is involved and you could not do it on a mine-by-mine basis. The scale of the investment and the amount of materials that you would need to process would be substantial. It may be possible, for example, to build a centrifuge plant in Australia to treat all Australia's production, but if Compass were producing two to three million pounds of uranium per year it would be grossly uneconomic for us to consider it.

Mr HATTON—But, in terms of your extra input and Australia's increased input, there is that balance. The evidence we have had so far is that, once you get beyond the existing range of contracts and the existing use of warheads under the agreement between the United States and the USSR, then unless there is another set of agreements to say, 'We'll take these 1,000 warheads and reuse those,' the expectation is that demand will greatly increase and that production from Australia should increase commensurately as well. That would then add to world supply, and Australia's total percentage might increase from 38 per cent or so to a higher amount.

Dr Humphreys—I would not necessarily expect the percentage to increase, but it will be bigger cake that will be shared around, and so the volumes of material should substantially increase, given the low-cost nature of Australia's uranium resources. I apologise in that I did not quite answer your other question fully. I got to the point of drawing the analogy with the enriched uranium. By the time you have a fuel pellet to put in a rod in a nuclear reactor, most of the cost has come from the enrichment process. Whether you are selling uranium for $12 a pound or $40 a pound, by the time you come to the extra enrichment process it has made very little impact upon the cost of that fuel.

Mr HATTON—Because of the total cost, it is the cost of production in the enrichment process that is the really big whack.

Dr Humphreys—Exactly.

Mr ADAMS—In your submission you mention the Commonwealth Environment Protection and Biodiversity Conservation Act. If you get approval at your site through that act, will you also have to get Northern Territory approval as well, or is it one or the other?

Dr Humphreys—There is an overriding requirement for the Environment Protection and Biodiversity Conservation Act to be met. There are requirements for other agencies, but this is a Commonwealth requirement. I think what I was alluding to in the submission is that, as far as possible, avoiding duplication between federal regulations and Territory regulations is certainly desirable for efficiency. But we recognise that the oversight of the biodiversity conservation act sits with the Commonwealth, and we are quite happy to go through it in that regard.

Mr ADAMS—But the Territory would not expect you to go through their own biodiversity or environment act, would they?

Dr Humphreys—Obviously there are issues in relation to the environment which overlap in those areas, so you could be doing things which—

Mr MARTIN FERGUSON—You do a joint exercise.

Mr ADAMS—You do a joint exercise, though, don't you?

Dr Humphreys—Part of the information you are using could involve flora and fauna. It might be for a purpose which is not necessarily under the real constraint of the biodiversity conservation act, but you are required to know what you might be impacting upon.

CHAIR—Thank you for giving evidence to the committee today. If committee members want any further information, the secretariat will contact you.

[1.47 pm]

LOY, Dr John, Chief Executive Officer, Australian Radiation Protection and Nuclear Safety Agency

CHAIR—Welcome. Dr Loy, are you happy for ABC Radio to tape your conversation?

Dr Loy—Yes.

CHAIR—Thank you for agreeing to appear and give evidence at the public hearing today. Although the committee does not require you to give evidence under oath, I should advise you that the hearing is a formal proceeding of the parliament and remind you that giving 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 camera and the committee will consider your request. I now invite you to give a short opening statement.

Dr Loy—I am pleased to appear before the committee today and give evidence flowing from the role of the Australian Radiation Protection and Nuclear Safety Agency, ARPANSA. Our submission goes principally to term of reference d. of your inquiry, about the regulatory environment of the uranium industry, but it also bears on some of the advice sought by members of the committee about health risks to workers and the public from exposure to ionising radiation from uranium mining. The office of CEO of ARPANSA is created by the Australian Radiation Protection and Nuclear Safety Act 1998. Principal functions given to the CEO include promoting national uniformity in radiation protection amongst the Commonwealth, the states and the territories; and providing advice, undertaking research and providing services related to radiation protection.

ARPANSA becomes involved in the regulation of the uranium industry at second remove, rather than directly. Our only direct involvement is in fact to regulate the work of Parks Australia North in dealing with some mining legacy issues in the Kakadu park. The national regulatory framework for radiation protection in uranium mining rests upon codes of practice and related documents that are drawn up through a Commonwealth and state process overseen by the Radiation Health Committee which has been established under the ARPANS Act. This process has just completed the production of a code of practice and a safety guide on radiation protection and radioactive waste management in mining and minerals processing. I made available copies of this document to the committee. At the time of my submission that document was still in preparation; it has now been completed.

The code and guide are intended to replace separate codes for radiation protection and for radioactive waste management that were drawn up under the old Environment Protection (Nuclear Codes) Act. The new documents reflect current best practice in radiation protection philosophy and standards. It is hoped that the code and the safety guide will be adopted by states and territories through being included in a document called the *National Directory for Radiation Protection*, the second edition of which is being prepared. The transport of radioactive materials, including uranium, is covered by the code of practice for the safe transport of radioactive

material. This code, which adopts international transport requirements, replaced an earlier code drawn up under the nuclear codes act.

ARPANSA's submission describes briefly the state of knowledge about the health effects of ionising radiation, leading into the basic tenets of a radiation protection system. These are the need for justification of any practice involving exposure to ionising radiation; the optimisation of protection to ensure that exposures are as low as reasonably achievable, economic and social factors being taken into account—and this is called ALARA in the trade—and the limitation of individual doses. These tenets are reflected in the new code and safety guide. The submission goes on to indicate what is known about radiation doses to workers in Australia in uranium mining and in the context of the nuclear fuel cycle as a whole. Finally, we comment that the security classification of uranium ores and concentrates is very low in terms of risk abuse as dirty bombs. I am happy to respond to questions from the committee.

CHAIR—Thank you for that, Dr Loy.

Miss JACKIE KELLY—The critical things that concern the general public are waste management disposal, possible diversion to military use, the health of workers and the safety of reactors. Do you see those key things as part of ARPANSA's role in terms of Commonwealth users of radiation?

Dr Loy—Yes. In terms of a direct regulatory role, we regulate the Australian government's use of radiation and nuclear facilities. To do that we keep up with knowledge on international best practice about all of those issues. In terms of directly applying it, we apply it to the Commonwealth.

Miss JACKIE KELLY—Is it fair to say that a fair amount of the public's confidence in nuclear issues in Australia comes from the state and federal government agencies set up to regulate the industry?

Dr Loy—I think that is certainly a very important part of giving confidence to the public about—

Miss JACKIE KELLY—Do they have any other means of measuring it or of regulating it or knowing what is going on?

Dr Loy—I think in all cases the proponents and the operators of nuclear facilities need to work in an open and accountable manner and to be able to directly present their record and their case. Certainly the involvement and the oversight of effective regulatory agencies is very important and is a way in which I hope the public can be assured that their interests are being protected.

Miss JACKIE KELLY—Six months ago the Auditor-General did a review of ARPANSA. As far as audits go, it was not a very satisfactory audit. You have had six months to respond to all of the failings that they found. Do you want to update the committee as to where you are at in responding to the Auditor-General's review?

Dr Loy—There is a slight sense of deja vu. We had an encounter at the Joint Committee of Public Accounts and Audit on this subject this week.

CHAIR—If you are not in a position to answer it, you may decline it.

Dr Loy—I am. I just wanted to start at the beginning regarding the ANAO report. The audit report was certainly critical about the way we managed our regulatory function. I think some of that was historical, when we were faced with licensing and assessing the entire Commonwealth. We put in all our applications on the one date, so we were faced with a considerable management issue and did not perform that as well as we could have. I hope we are past that. Regarding some of the issues about building a better cost recovery framework, we have put out policies on that and they are out for comment. Certainly, regarding the regulatory policy and the whole approach that we take, we have also explicitly written about that and, again, we are receiving comments on that. In general, the Auditor was saying that, while he was not in a position to comment on our decisions, we were not managing in a way that demonstrated clearly enough the basis upon which we took our decisions.

We are moving to remedy that, and I hope we will have completed that at the end of the year. Regarding the decisions themselves, I would still strongly defend the decisions that we have taken as being appropriate and based upon international best practice in terms of radiation protection and nuclear safety.

Miss JACKIE KELLY—One of the things that really disturbed me about that report was the ad hoc way in which site inspections were done to make sure people were complying with licence conditions. There just seemed to be this old boy network, no particular time frame of notice and no follow-up. Are you moving towards standard operating procedures where there are regular checks on licence conditions?

Dr Loy—I think the criticism of the Auditor-General was that our inspection program was not demonstrably based upon an assessment of the risk of particular licence holders, and that is true. That is not to say we did not judge the priority of inspections on that basis, but we did not have a systematic way of demonstrating that. That is not necessarily an easy thing to do. It is easy in one sense. Obviously, people with lots of radiation activities have a higher priority than people with fewer and smaller sources and so on. In terms of ensuring that we are addressing the people who are not necessarily managing as well as others—as priorities need more intelligence and information analysis to demonstrate that we are doing that, more than has been applied to date—that is certainly something we are pursuing very actively.

Miss JACKIE KELLY—In your submission to this committee, you list as one of your activities:

> … to promote uniformity of radiation protection and nuclear safety policy and practices across jurisdictions of the Commonwealth, the States and the Territories…

In your evidence to the Public Accounts and Audit Committee, there was very little discussion with the other states and pretty limited information as to what they were doing. There had not been any Auditor-General reports of the state bodies and it seemed as though this audit report was the first look at how the regulation of radiation within Australia was done. They were also

some loopholes between when things left Customs and ended up in the states' control. There was a real gap there as well which would, I think, be of concern to this committee.

Dr Loy—To me, I do not think there is any such gap at all. I am not sure how you gained that impression.

Miss JACKIE KELLY—You are quite confident that, when something leaves Customs control and comes under the control of a state licensed body, that they just show the licence and it moves through and that that is good regulation?

Dr Loy—Radioactive materials are prohibited imports.

Miss JACKIE KELLY—No; radiation sources, nuclear medical—

Dr Loy—All radioactive materials are prohibited imports and a person requires—

CHAIR—I know that, as an ex-Customs minister. Jackie, can we pull the questions back to the case in point?

Miss JACKIE KELLY—The case in point is about the population—

CHAIR—I mean in terms of our inquiry.

Miss JACKIE KELLY—having some concerns about nuclear issues, looking to government to regulate the industry and about giving them some confidence in the process, yet the regulators do not stand up to Auditor-General reports and, in fact, are not even subject to them in the case of the states.

Dr Loy—I am sure that state auditors-general review state practices from time to time. I am not familiar with their practices, but they are all subject to auditors-general. We talk to the states constantly through the Radiation Health Committee about how to regulate and oversee the safety of radiation sources and radioactive material throughout Australia.

Miss JACKIE KELLY—And you are confident that you move in some sort of uniformity across Australia?

Dr Loy—Yes. We have created a document called the *National Directory for Radiation Protection*. The idea behind it is to put within that publication all the guidance, the codes of practice and the standards and then for the states, the territories and the Commonwealth to pick up that document within their own legislative frameworks. Rather than to try and make the legislation in each state and territory identical, which is the labour of Hercules, we thought it would be better to have a commonly agreed structure that each jurisdiction could adopt, using whatever legislative framework was favoured by them.

Miss JACKIE KELLY—It has been argued that, before the events of 11 September 2001, Australian officials could not accurately quantify how much radioactive material—such as discarded caesium, strontium, cobalt and americium used to treat patients, monitor oil wells and so on—was missing in Australia. Is that accurate? Do you have such an inventory?

Dr Loy—All the states have good regulatory systems and good knowledge of the location of the sources in their states, as does ARPANSA for the Commonwealth. I would not ever say that it is perfect. Certainly, as part of our current review of security issues, we are looking at how we might pursue a systematic way of looking for what is called in the trade 'orphan sources' that have come out of control in some way. My gut feeling, and I think it is shared by the state regulators, is that it is not a big problem, but that is not to say that it does not exist and that it should not be given attention.

Mr HATTON—I think we just heard a mobile phone tone which almost sounded like a geiger counter. It might be bringing us closer to where we are. The question of how adequate our control of the substances americium, cobalt, strontium 90 and so on was prior to 11 September 2001 was posed by one of the presenters today, Professor Richard Broinowski, in his book *Fact or Fission* 2003. Prior to his evidence, his sister Dr Helen Caldicott, in one of the exhibits she presented to this committee, asserted—and this is extremely local and I would appreciate, if you can, your answer to it—that Lucas Heights discharges more radioactive waste into the air and water than bigger, more powerful plants overseas. This reactor has discharged more radioactive iodine 131 into the air than the huge and dangerous nuclear fuel reprocessing and power plants at Sellafield in England. How accurate do you believe those claims are?

Dr Loy—Let me give the most considered answer I can on that. Obviously we have a regulation about discharge from the Lucas Heights site. The way we do that is the way that people do it throughout the world, which is basically by saying: 'You cannot discharge more than would give people nearby a radiation dose of 20 microsieverts.' That is a very tiny radiation dose. We then take each discharge point and, together with ANSTO, do some figuring about what that particular point may discharge so that the total does not discharge more than this dose of 20 microsieverts. There are levels set for each discharge point. If those levels are exceeded—they are not legal levels; they are notice levels—that means something has changed and it needs to be looked at and examined but it is not necessarily a problem. Overall is this constraint of the 20 microsievert dose. I would think that is in line with international best practice. It is not exceeded. In fact, I do not think they even go close to it. So I would be very surprised if the first parts of the statement you quoted were factual.

Mr HATTON—So you do not have any specific knowledge of the output of iodine 131 at Lucas Heights?

Dr Loy—No, not on me, but obviously I could follow that up.

Mr TOLLNER—Do you have any idea what happens at Sellafield?

Mr HATTON—It might be useful to have a considered response to that, if it is possible, given that the claim is very strong. It might be useful to compare Sellafield with Lucas Heights which is a research reactor. One is local; the other is not. One is a major power production plant; the other is a research reactor. Having an alternative view on that could be useful.

CHAIR—We will send you the context of that question in writing and the committee would appreciate a response.

Dr Loy—Okay. Firstly, I will just make the quick point that we regulate in terms of dose, not necessarily in terms of specific radionuclides. Secondly, different plants have different inventories. Iodine 131 has a relatively short half-life. You would not expect to find it in a reprocessing plant. That is just by the by.

Mr HATTON—We may still have a chance to talk to the relevant people from Lucas Heights; I think they will be making a presentation later. I would like to ask you one other question. It again goes to something that Dr Caldicott has put in an exhibit to the committee. She said:

During their operation nuclear power plants and reprocessing facilities are known to emit some radioactive gases: for example, krypton, xenon and argon.

It has been submitted that these emissions are not regulated and may cause genetic diseases. However, other evidence from the Uranium Information Centre's submission suggests that:

The net effect of their release is too small to warrant consideration in any life cycle analysis and that, in any case, the gases have short half lives and their radioactivity is diminished by delaying their release.

What is your view on this debate? Should these emissions be more closely regulated in Australia and elsewhere, or is it the case that, faced with the same scientific data, these two different groups—one a person, one an entity—came to completely different scientific assessments?

Dr Loy—Certainly there can be emissions of noble gases from any nuclear activity. If you know your chemistry you will know that noble gases are pretty hard to contain, but they can be trapped and delayed. There are certain filters, but noble gases would be contributors to the dose that people receive from the operation of nuclear facilities. In the attachment to our submission there is a discussion of the radiological consequences of nuclear power production. That has been taken from the work of the United Nations Scientific Committee on the Effects of Atomic Radiation. It goes through in pretty agonising detail all parts of the nuclear fuel cycle and the emissions and doses that are emitted. The noble gas emission, as shown in a rather colourful diagram on page 3 of the attachment, is a very small part of the emissions of nuclear power plants, but it is there.

Mr HATTON—Do you think that the relatively short half-life of those gases is a significant factor in regard to their potential for causing harm to people?

Dr Loy—We, and every other nuclear regulator, regulate on the basis of what dose you will give to people nearby in terms of determining what emissions you could give. Whether that dose comes from noble gases or from some other emission is a lesser point. Provided the total dose is of a trivial level then that is the fundamental regulatory parameter.

CHAIR—You have noted in your submission that the codes have been revised due to major changes in recent years in radiation protection and waste management philosophies and standards. Can you describe what these major changes have been in relation to radiation protection and waste management?

Dr Loy—The codes, when they were originally written, preceded the current standards based upon a document called *ICRP Publication 60: 1990 Recommendations of the International*

Commission on Radiological Protection, 60. It established dose limits for occupational and public exposure for any practice involving radiation. It also established very clearly this structure of a radiation protection program of justification, optimisation and limitation. That was buried in the previous codes; it did not come through as clearly and as strongly as it does in the revision. The revised dose limits were applied to the mining industry by adoption of a general document that said that everybody needs to observe these dose limits but nonetheless the specific code applying to uranium needed to be addressed that way. In terms of radioactive waste management, there has been a significant number of publications by the International Atomic Energy Agency. I would not describe them as in any way fundamental changes, but there were refinements and improvements to the system and approach.

Mr MARTIN FERGUSON—In terms of uranium mine workers and ANSTA workers et cetera serious questions have been raised about the lack of long-term follow-up of the monitoring of their health. You have supplied material on Australian mine workers for the period 1991 to 1994. Are there any more recent figures? Do you think we should be leaning more on the long-term monitoring of health?

Dr Loy—First of all, on the Australian mining figures, we do not presently have up-to-date data for total dose. We are trying to gather that for our own knowledge and also to contribute to UNSCEAR's new report on total doses worldwide. We need to gather that from the mining companies.

Mr MARTIN FERGUSON—Why isn't that part of our ongoing work?

Dr Loy—The reason is that the dose a uranium miner receives is made up of the direct dose from the gamma rays from the radioactive material, which can be measured simply by the thermoluminescent dosimeter badges. Second, there is the dose from inhaling radon gas and from inhaling or ingesting dust. Those are internal doses that are difficult to measure, but there are techniques for estimating them. It is not simply a case of passing out a badge and getting back the full dose that a worker has received. You need to know where they have been working, for how long and the conditions. The companies obviously collect that data and knowledge. We as the Commonwealth regulator do not have that data but we approach them every five years or so to collate the data so that we do have a handle on it.

Mr MARTIN FERGUSON—How long are companies required to keep that data for?

Dr Loy—I am not sure of the time, to be honest. Certainly all the state regulators would demand that they keep it for a period of time. I will have to check and let you know.

Mr MARTIN FERGUSON—Was their a proposal to establish a national radiation dose register for occupationally exposed workers? I think ARPANSA opposed such a proposal. Given the potential growth in the uranium mining industry in Australia, do you think you should reconsider your view on that? Also, due to the sensitive nature of the industry, putting aside the potential need for additional resourcing of your organisation, do you have any other practical suggestions for our consideration in terms of what should be done to more rigorously monitor workers in the industry?

Dr Loy—Possibly the long-term issue, which I talked about in answer to Mr Ferguson's first question.

Mr MARTIN FERGUSON—I raise this, for example, in the context of more recent concerns over asbestosis and how long it took to see some of these problems emerge.

Dr Loy—Certainly the recommendation that there be a national radiation dose register came forward, amongst other occasions, in a Senate committee in the nineties. We looked closely at whether and how you could establish such a thing. There was a reasonable attempt to try to set one up.

We discussed it with the states in the Radiation Health Committee because their input was necessary to get a complete picture, particularly to get the data that was not measured directly. In that discussion, the states recommended through the Radiation Health Committee that we not proceed with such a register. I think fundamentally their view was based upon the fact that what we know of the doses is such that they are not likely to lead to any further knowledge of the effects of radiation on human health because the level of dose is low and the number of workers is relatively small. So from that point of view, which I guess is one view of what a national dose register is about, they saw it as not being worthwhile.

On the other hand, you could argue that, for a sense of security and support for workers in the uranium mining industry, a dose registry would be something that would be appropriate. We would certainly be open to the suggestion that we should go back and revisit that, focusing on mining workers and perhaps some other workers who receive small but measurable doses, rather than having a national dose register for people who work very briefly with radiation and do not get very much exposure at all. I think we need to narrow down the terms of reference a little bit to make it manageable.

Mr ADAMS—There is some scientific uncertainty about the effects of low radiation. Can you summarise the competing views of the risks to health and the effects associated with that?

Dr Loy—How many hours do you have? The submission contains the kind of approved statement that appears in all the codes of practice and so on. Basically what it is saying is that for doses down to something like 100 millisieverts—I would argue a bit below that—there is clear, strong, epidemiological evidence of the relationship between radiation dose and health effects. Here I am talking about delayed health effects—cancer. Obviously, if you have received an enormous dose of radiation you can have very direct and immediate health effects.

Mr ADAMS—We know all that.

Dr Loy—At doses down to a bit below 100 millisieverts, the epidemiology seems to me to be very clear, based particularly upon the atomic bomb survivors. There is epidemiological evidence that that continues to lower doses. For example, there has been recent work by the International Agency for Research on Cancer that published a very large pool study of nuclear workers throughout the world which indicated a continuing level of health effects. The average dose there was about 20 millisieverts. Getting down into that kind of range, it seems to me there is pretty reasonably evidence.

If you start looking at the day-to-day doses that you get from background, obviously, and that nuclear workers now get with current practices—say, three, four or five millisieverts—then there is no epidemiological evidence, and you would not expect there to be because the effects would be very difficult to see. So you are looking at radiobiology—the effect of irradiating the cells and animals and so on. Certainly, the evidence there is difficult to interpret. Some people can interpret it in such a way that they believe radiation in low doses is good for health. I think the majority of people do not interpret it that way, and there is certainly some puzzling things that seem to go on. The safest view is that the effect is linear with doses down to very low levels.

There is a group of people in the United Kingdom, particularly, who have seized upon the uncertainties in the effects of, or the damage done by, internal emitters of radiation—the radiation you breathe in or ingest. In order to be sure about the radiation doses, you have to do some modelling of the effects and make some modelling assumptions. There are uncertainties in each of those steps. We are uncertain about the impact of internal emitters. The view of the group of people—perhaps to caricature them a bit—is that all the uncertainties go in the direction of being bad and that there is a gross underestimate of the impact of internal emitters of radiation. The broader view is that, yes, there are those uncertainties and they might be reasonably significant, but they are equally as uncertain in the downwards direction as in the upwards direction. Such epidemiological evidence as there is is consistent with it being more or less at the level of that linear threshold hypothesis. I hope I have not confused you too much.

Mr ADAMS—No.

Mr TOLLNER—Dr Loy, I am not very well informed on what ARPANSA does, but can you explain to me the relationship between ARPANSA and the Supervising Scientist? What are the differing roles, how does the relationship work and where might there be some crossover?

Dr Loy—In one sense, there is no relationship in any legal or formal way. The Supervising Scientist is given a statutory role in relation to the Alligators Rivers Region, particularly to the Ranger mine, and carries out that role. It is not a direct regulatory role, but it does research, gains knowledge and monitors the impact of the mine on the national park. Regulation of the Ranger mine is to be done by the Northern Territory authorities, and they would be working with the code of practice and so on that ARPANSA developed. The relationship between us and the Supervising Scientist is quite separate in terms of formalities. Obviously in terms of working together and exchanging information and knowledge—a collegiate role—we work closely with people in the Office of the Supervising Scientist and the ERIS research group. Dr Johnston is a member of the Radiation Health and Safety Advisory Council that was established under the ARPANS Act. We have taken up some roles. For example, in the follow-up to his report on the incidents at Ranger, we have undertaken some audits of the radiation protection arrangements adopted by the company. That was done at the direction of the minister. Other than in that sense of working together in a collegiate way, we do not have a formal or legal relationship.

Mr TOLLNER—What was your involvement in the prosecution of ERA in the last case of a spill? Did you have any role there?

Dr Loy—No.

CHAIR—Your submission provides the current national and international standards for limits on radiation doses, listing the effect of equivalent dose limits. Would you care to explain what is meant by 'equivalent dose'?

Dr Loy—Firstly, radiation affects different tissues of the body differently, so some are more radiosensitive than others. Secondly, different forms of radiation, whether they be gamma rays, X-rays, alpha particles or electrons, do more or less damage. So you take the dose that you calculate from the energy given to a tissue of the body. You weight it for the tissue-weighting factor as to whether it is more or less radiosensitive and you weight it for the type of radiation. Having done that you get something called the effective dose. The idea of that is to be able to compare doses received in different circumstances and given to different tissues, but in a consistent way. So when I say an effective dose of one millisievert, whether that is derived from a very small dose from alphas or whether it is derived from gamma rays does not matter; I have taken all that into account by talking about the effective dose.

Mr MARTIN FERGUSON—There have been some community accusations about re-machined fuel rods from the Danish government being used in HIFAR at Lucas Heights. Have these accusations been brought to your attention? If so, do you think there are any concerns related to problems of exposure because of swelling or blistering of the rods, which is another accusation?

Dr Loy—ANSTO some time ago applied for agreement to use low-enriched uranium fuel that they were buying from the Danes from a shut down reactor that was a sister reactor of the HIFAR reactor—so it was a DIDO class reactor built in Denmark years and years ago. They had shut it down and they had some fuel left. ANSTO were anxious to extend their supplies of fuel for HIFAR. This was low-enriched fuel which took them out of using higher enrichment fuels, with all the proliferation issues and so on that are relevant there. So they applied for that modification and, after assessment, I agreed to it.

Mr MARTIN FERGUSON—Have any concerns been raised, or have concerns come through your monitoring, since these rods were introduced?

Dr Loy—No.

CHAIR—There being no further questions, Dr Loy, I thank you for appearing before the committee today. If the committee has any further questions the secretariat will contact you. Is it proposed that the document entitled 'Radiation protection and radioactive waste management in mining and minerals processing' be accepted?

Mr ADAMS—I so move.

CHAIR—There being no objection, the motion is carried.

[2.29 pm]

ALDER, Mr Keith Frederick, Private capacity

CHAIR—Mr Alder, would you advise the committee of the capacity in which you appear today.

Mr Alder—I appear before the committee as a former nuclear scientist and engineer, retired 23.9 years.

Mr HATTON—Almost a half-life!

Mr Alder—Near enough.

CHAIR—Thank you for agreeing to give evidence before the hearing today. Although the committee does not require you to give evidence under oath, I should advise you that the hearing is a formal proceeding of the parliament and 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 all evidence to be given in public. However, at any stage you may request that your evidence be given in private and the committee will give consideration to your request. I now invite you to give a short address to the committee before we proceed to questions.

Mr Alder—Thank you for having me appear. I hope I can be helpful to you. Briefly, I worked in atomic energy research and development for over 30 years—two years in England for the British and 28 years with the Australian Atomic Energy Commission, commencing with four years at Harwell in England doing research on power reactor fuel. I have inspected many nuclear plants overseas. I have climbed all over all classes of reactor in use in the Western world, both during construction and in operation, and I have also inspected all types of industrial plants in the nuclear fuel cycle, including uranium enrichment plants of all types in the US, the UK, Holland and France. I was director of Lucas Heights for 10 years and commissioner of the commission for 13. I was responsible for the technical management of the aborted Jervis Bay nuclear power program. I set up the uranium enrichment research project at Lucas Heights in the mid-1960s and directed it for its first few years. That project, regrettably, was terminated by the government in about 1986, which I think was a tragic loss. That is a summary of what I did. I retired in February 1982. I have endeavoured to keep up with the general information and progress in the nuclear industry since. I do read a lot of literature.

I have a few points of emphasis I would like to make in relation to the submission I gave. Uranium is for electricity generation. Lots of its opponents put great emphasis on alternatives, and they particularly prefer solar energy and wind power—the renewables. There is a lot of urging that the use of these be increased—looking for subsidies, of course—from the present one or two per cent up to about 20 per cent. I think this is a very laudable objective. However, these technologies have their limitations. One of my regrets is that the limitations are very seldom pointed out. You get a lot of media publicity for solar energy and wind power, but very seldom are you told the limits.

That figure of 20 per cent is one of the limits, I believe. I do not think you can put more than about 20 per cent of renewable energy such as solar and wind into a major electricity grid, for the simple reason that it is unreliable. Renewables, regrettably, are unreliable. If the wind does not blow or the wind blows too strongly, your wind generator drops out and, if the sun does not shine—and it certainly does not shine at night—you lose your solar energy. There is a natural limit to what the grid can stand. If it drops out and you do not want blackouts, then something else has to pick up the load. No electricity generating authority in the world which believes it can supply reliable energy will tolerate more than about 20 or maybe 30 per cent, at the most, of its input in one piece of machinery. This is why there is a natural limit on the renewables, renewables being also unreliable.

Therefore, we are concerned with where we get the other 80 per cent. That is where uranium comes into the picture. As far as I can see, there are only two possible ways to generate that 80 per cent, or the base load—which is more than half and, more likely, 70 per cent—of that 80 per cent. The two alternatives are coal and nuclear; there is nothing else. It is an absolutely inescapable fact that you have to burn coal or use nuclear reactors to generate base load electricity. You can use oil or gas, but they are both very desirable resources to be retained for other purposes. At the moment, oil is newsworthy. Nuclear power is eminently suitable for base load generation. Indeed, there is more to it than that. Nuclear reactors should not be operated any other way than continuously at full power. They are not suitable for load-following. You can load follow with them, but it may shorten the fuel life. The way to operate a nuclear power reactor is to bring it up to full power, when it is ready, and run it flat out until such time as you have to do a shutdown for a fuel change. If you cycle the reactor you run the risk of shortening the fuel life in terms of the megawatt days per tonne you can get out of it and, therefore, you also put up the price of the electricity. So nuclear power is ideal for base load.

What is happening in many parts of the world that have gone for nuclear power is that they do run them like that and, therefore, occasionally, if there is a drop in the load consumption—the load curve—there is surplus power. This can help industrial development because there are certain industries which can use that electricity—for example, aluminium smelting, copper refining, zinc refining and, dare I say, desalination plants. So there is a possibility that replacing fossil fuel with nuclear energy can assist in other industrial development.

Another point I would like to make is that a tremendous amount of rubbish is talked and published about the disposal of radioactive waste. The technical and economic problems of this were solved many years ago. The remaining problems are in public relations—the nimby syndrome, or ‘not in my backyard’; that has been amply illustrated in Australia in the near past in looking for a national repository for radioactive waste—and, of course, politics. I firmly believe the solution is to put it back where you got it from—which is deep in the ground. That has been done in France and Sweden, and they are well advanced towards doing it in the United States. Australia has very many suitable locations to do this. I can never understand why people get so worked up about the possibility of a few atoms from somewhere in Central Australia finishing up in your breakfast milk or your breakfast egg. It seems so unreasonable that this could happen, but people get very worked up about it.

The media reports constantly that we can only make use of nuclear power to fill the gap from now until all the wonderful developments in renewables and other alternative energies. The reason they give is that there are limits to the supply of uranium. When nuclear power first

arrived, in 1955 or 1956, there was concern about uranium supply. There was a tremendous urge to get to the development of the fast breeder reactor, because that would extend the useful energy you got from uranium by a factor of maybe as much as 50. That has notably slowed down in the last couple of decades. There is not nearly as much R&D on fast reactors as there was. It is still going on. The Russians have been running a couple of them for quite a few years. There is still R&D on fast reactors, but it has slowed down because it turned out that there was plenty of uranium and there was not the incentive to go for the much higher utilisation factor. Fast reactor research and development is a pretty expensive exercise. It is not quite as expensive as fusion research, but that is another subject.

The antinuclear people often say, 'It's a stopgap exercise because we will run out of uranium.' That is absolute rubbish. There is an awful lot of uranium still to be discovered, particularly in Australia. I draw your attention to the Northern Territory. There is not a deep mine for uranium in the Northern Territory, and there is not a lot of deep drilling either—they have not had to do it, with open-cut mining at Ranger. It was to be open cut at Jabiluka for Pancontinental but now it is shallow underground. But nobody has really had an extensive look very deep underground in the Northern Territory, and that is just one part of Australia.

My reading shows me that at the moment there are about 15 companies throughout Australia anxious to start up new uranium mines since the price went up. It does not look to me as if uranium supply is going to be a problem. In any case—and this may sound like levity but it is true—during the time that I was still working the Japanese built a plant in the Sea of Japan to extract uranium from sea water. It was about eight to 10 times the cost of uranium at that time, so they did not go on with it commercially, but they calculated that there is 4,000 million tonnes of uranium in the sea. I cannot see this world running out of uranium fuel. I simply do not understand this stopgap philosophy.

Even if it did cost five to 10 times the price of uranium, if you look at the cost of the uranium that goes into the production of a kilowatt hour you see that it is negligible. If you multiplied the cost of uranium in the kilowatt hour by 10, the householder or the small industrial user would face a very small increase in power price. There is too much rubbish talked about the availability and price of uranium. Price is not nearly as important in nuclear energy as the other benefits that come from it, particularly environmental benefits.

I did point out in my submission that the strategic significance of Australian uranium worldwide was negligible, because if we decided to leave it in the ground it would not make any difference at all, in my view, to the development of nuclear power anywhere; there is plenty of other uranium. I said in my submission that the Canadians would continue laughing all the way to the bank because they have far less uranium than we do but they export far more than we do. Australian uranium could become of major strategic importance if we were to develop into a major nuclear fuel supplier later this century, particularly for nuclear developments in Asia. If you look at where all the new nuclear reactors are being built, you will find that six countries are outstanding. China, Japan, Korea, Taiwan, India and Pakistan all have advancing nuclear programs. The Chinese one, of course, is tremendous, and for a long time now the Japanese have had a big program.

Australia had an opportunity 35 years ago to build a uranium enrichment plant. Four of our biggest companies got together to form a group called the Uranium Enrichment Group of

Australia and were on the point of reaching full agreement with the tripartite of Germany, Holland and the UK on centrifuge enrichment, which we had been researching in Australia at that time for 20 years. Unfortunately, that project was terminated shortly after the election of a Labor government in 1983. We lost an enormous opportunity then, which was a tragedy for Australia.

The opportunity to do that is still there, and the attraction of Australia as a place in which to do it is still there. In fact it is higher now than ever before because the demand for uranium is going up and Australian resources have increased. Australia is a very attractive place to overseas partners who want to go into the industry, just as they were attracted by our resources in 1982-83, when that enrichment study was done. It was not Australian science or Australian engineering that attracted the Americans, the French and the European tripartite. They came to Australia in droves trying to sell us the idea that their technology would be used in Australia. The background for that has not changed, so we still have the opportunity.

I will make one final, contentious point. Some people think you should leave it in the ground in the Northern Territory. I think there would be a very great strategic danger for Australia in the long term if we decided to do that. If you look at the hordes of Asia getting hooked on nuclear energy, and look south at those bountiful fuel resources in Australia, don't you think there is a possibility they would try to take it away from us? Obviously you would hate to think that that would happen.

CHAIR—Thank you for those statements. Your submission makes the argument that an expansion of Australia's uranium exports has no potential to reduce global greenhouse gas emissions. Would you explain your reasons for that view? Secondly, you mentioned base load power and you excluded gas. Are you aware that in Western Australia the state government has just signed a contract for the next base load power station to be gas fired?

Mr Alder—There are two questions there. In answer to the first one, what I said in my submission was that if we chose not to increase our uranium exports it would not make any difference to nuclear power programs in other countries. Our decision to sell or not sell them uranium would not change their attitude to nuclear power and therefore it would not change the amount of emission. That is what I meant by saying we are negligible in terms of effect. In answer to your second question, about gas, I think it is wicked to turn gas into electricity. We make electricity so we can reticulate energy to our homes and factories and light our streets. We do not light our streets with gas anymore, but you can reticulate gas as a form of energy to houses. We do this all over our cities, all over Australia. It used to be coal gas made in retorts in gas plants; it is now a natural gas and we export it as well. But it does not make sense to turn one reticulated type of energy into another, losing half or maybe two-thirds of it in the process. When you turn gas into electricity about 60 per cent of the heat goes up the stack. It is polluting; it is not as polluting as coal but if you burn 12 grams of carbon in coal or in gas you get 44 grams of CO_2—it does not matter where you burn it. So I think it is wrong. I do accept that for peak power a gas turbine is a very useful thing because you can start it up at short notice and bring it to full power without having to spend reserves—without having to have a big boiler fired up and a big turbine idling.

Mr HATTON—This will sound provocative—it sort of is. Given the way the Australian public have perceived the nuclear industry over the last 35 years in Australia, and given what

you refer to here as the public campaigns, do you feel that you have been seen as being mad as a two bob watch because you have been part of the nuclear industry? Looking at the reaction of the Australian public at large and the underlying political drivers being conditioned by that atmosphere, why did an Australian nuclear industry of the magnitude that you are talking about effectively not get off the runway?

Mr Alder—I have been shot at many times during my career and subsequently. I have given many talks to Rotary clubs, Probus clubs, mothers clubs and the like. You will always find a lot of anxiety and quite a lot of anger among people. At the time I retired—which was February 1982—we counted up the number of active bodies in Australia promoting antinuclear feeling. There were 37. There were two organisations promoting the positive side: the Australian Atomic Energy Commission and the Uranium Information Centre, which started then. Of the 37—with respect to Mr Ferguson—more than half were trade unions. It was a very interesting situation. At Lucas Heights we had 18 trade unions represented among the staff, of which 16 were antinuclear. Some of those people had slight difficulties in their careers but they were very good and faithful workers, I might add. That was a curious situation.

A lot of those organisations have amalgamated, so there are now fewer. There are still some very prominent individuals delivering antinuclear talks: Friends of the Earth, the Australian Movement Against Uranium Mining, the Australian Conservation Foundation, Greenpeace—need I go on? Who is putting the positive side to the population today? The Atomic Energy Commission used to be promotional; ANSTO is not. The Uranium Information Centre, to my knowledge, is the only organisation that is presenting a positive line on uranium. From the public point of view, the public look at the federal opposition and see that it is antinuclear. They look at the federal government and what do they see? That nuclear energy is not on the agenda. Do you wonder that they are confused and that they are anti? Everything is pointing them in the wrong direction.

Mr HATTON—It is part of the cowering that has taken place over a couple of decades. It has been driven very strongly by the media and by some very sensational presentations—documentaries like *The Day After* that Dr Caldicott mentioned this morning—and other very heavy campaigns that were highly emotive. I would typify them as exceedingly irrational as well. That has created a context where there has been a great deal of fear about taking what I would see as a more balanced and rational approach, trying to sort out the real from the unreal.

Mr Alder—I agree with you. One of the worst things has been the teachers. One of the organisations that I could have mentioned among the 37 that were prolifically antinuclear in 1982 was the Teachers Federation. At Lucas Heights we had the experience of sending literature to high schools and it coming back, sometimes torn in half. I went to a couple of high schools and, on one occasion, I met the then President of the Teachers Federation. We went into the library and it was covered in antinuclear literature. They would not have what we sent them, which originated from Vienna from the International Atomic Energy Agency, because it was loaded. The librarian would not have it and the teachers would not have it.

I am afraid, from what I hear from my own family, grandchildren and so on, that that attitude is still there in much of the teaching profession. I am not quite sure how you fix that. This may be a radical thought to you, but I do believe that some of the big organisations such as Greenpeace deliberately stimulated antinuclear feeling in Australia. It was a sensible thing to

do—this was told to me by two prominent members of Greenpeace who changed their minds. They said that it was quite deliberate because if you want to stop something you cut off the fuel. Therefore, Australia was made a target. Just how organised and implemented that was I think is impossible to find out. But I do think that the Australian population became the most antinuclear population on earth because of the constant antinuclear propaganda which was put to them. We did the best we could, from the AEC, in running educational programs. We used to have a touring caravan that went around schools and so on. I have no more to add.

Mr HATTON—I very much agree with you in terms of the teaching unions. The religious fervour with which this was taken up has been embedded not only in the teachers but in the educational process. That is one of the significant problems in dealing rationally with this. But isn't there a further series of problems? Looking at the key generation of the debate in the 1960s, the period of mutually assured destruction and the nuclear holocaust that people thought there would be, in the outline that you have given us and also in the book that you have done you say that Australia at one point conceivably could have had that 500 megawatt reactor and it could have had an enrichment plant at various different stages in the cycles. I cannot remember whether it was Sir Philip Baxter or, more particularly, Sir Macfarlane Burnett who pushed the idea of us going towards nuclear weapons. That was used very strongly in the campaign against nuclear energy use in Australia. Would you like to comment on that?

Mr Alder—Yes, I would like to comment on that. I knew Baxter very well indeed, from the day he arrived in Australia. I worked with and for Sir Philip Baxter for over 30 years. Baxter never advocated building an Australian bomb. He advocated two things: first, that Australia should not irretrievably give away the option should we ever wish to build a bomb and, second, looking for a nuclear competence in Australia which would shorten the lead time if we did want to make a bomb. But he never—I repeat: never—advocated building a bomb. There have been documentaries made which implied, firstly, that Lucas Heights was involved in bomb thinking—that is a complete and utter falsehood—and, secondly, that Jervis Bay was conceived as a source of military plutonium. I was in charge of the team that wrote the specification for that and I was in charge of the team that did the tender analysis. We never thought in writing the spec of going for a reactor which specifically could make military plutonium. Are you gentlemen aware of the difference between civil and military plutonium? There is a big difference, and there is a big difference in the sorts of reactors in which you can make the two things.

Mr HATTON—If you could expand on that, that would be particularly useful. In previous evidence to the committee we have had allegations and averments that you can use civil reactors to effectively produce weapons grade plutonium.

Mr Alder—That is a load of absolute garbage. Military plutonium is produced by irradiating uranium in a reactor, bombarding it with neutrons. The fissile material is a very small component of the fuel. It is uranium 235. The rest of it is uranium 238. Natural uranium is 0.7 per cent 235. Modern reactors use enriched uranium, which is three to four per cent 235. All the rest is U238. You hit it with neutrons, the neutrons are absorbed and the weight goes up and it turns into neptunium. Neptunium throws out some radiation and turns into plutonium 239.

If you leave the fuel in the reactor and go on irradiating it, two things happen to that plutonium. One is that it captures another neutron and goes bang. So halfway through the life of a nuclear power reactor fuel, you are getting just as much energy, sometimes more, from the

plutonium that you have made and are now burning than you are getting from the uranium 235. Not always does the tacking on of another neutron lead to fission, so it becomes plutonium 240. Plutonium 240 builds up in the reactor fuel. Plutonium 240 is not a fissile isotope. But it will caption neutrons and go up to 241. Plutonium 241 is a fissile material. Then you gone on and make transuranic elements. You start making americium, californium, berkelium and so on, as you go further up.

It is sufficient to say that after a certain radiation dose you have quite a mixture of plutonium isotopes in the fuel. The ones that are non-fissile will capture further neutrons; therefore, they are a neutron absorber in the reactor—they are a poison. They are turning into a fissile thing but in doing so they do not contribute to the neutron economy of the reactor. If you want to make a bomb, you do not want all those poisons. You want low burn-up plutonium, plutonium 239, without the additional 240, 241 and 242, which are poisons.

If you do try and make a bomb out of that stuff, you have a problem—you are going to need a much bigger lump because of the neutron absorbers in it and you are going to have to know absolutely and precisely the isotopic concentration of the various isotopes of plutonium. If you do not, you run a better than 99 per cent chance that either it will just fizz and will not go off or you will kill yourself putting it together, because of the uncertainty. The hardest physical measurement I know in science is to measure the isotopic ratios of plutonium 239, 240, 241 and so on. There is no machine in Australia that will measure that. All this talk about a terrorist getting hold of civil plutonium and making a bomb in his backyard or his cellar is absolute rubbish.

Mr HATTON—There is also a lot of talk about—

Mr Alder—I have not quite finished.

Mr HATTON—Sorry.

Mr Alder—To make military grade plutonium, the burn up, the amount of energy you take out of the uranium when you put it in the reactor, used to be a very highly classified number: 400 megawatt days per tonne. You leave the fuel in for that time. The target burn up today in nuclear power stations is between 50,000 and 60,000 megawatt days per tonne. In other words, it is 400 megawatt days per tonne to make bomb material and 60,000 megawatt days per tonne to burn it in a nuclear power plant, which takes 18 months to two years. What comes out when you reprocess the plutonium is an awful mixture of 239, 240 et cetera.

The Americans, very unwisely at one stage of the game, about 20 years ago, did actually make an explosion with civil plutonium. It is very difficult, but they did it, and I think it was a stupid thing to do because it made people feel that if a terrorist got hold of that stuff he could do that. Don't you believe it. The enormous sophistication that goes into a bomb is far beyond the capability of a terrorist organisation.

I spent two years on the first British bomb. That was my two years with the British Ministry of Supply. As I say, I remember subsequently the tremendous sophistication of what was put into it to make it go. If you make a bomb out of TNT, if you trigger it, it will all go off. It will all burn—bang, a tremendous explosion, half a tonne of TNT. If you make a bomb out of

plutonium, it will only burn while it is compacted and it is in a subcritical condition. As soon as it starts going off, it blows itself to blazes. As soon as it gets beyond critical size, the reaction stops. The plutonium bomb that destroyed Nagasaki was 60,000 tonnes of TNT equivalent. It burnt six per cent of the plutonium, at which stage it stopped burning, and the rest went into the atmosphere.

So the sophistication of that device is not just the nuclear side but how to implode it, to make it hold together to burn for long enough to make a significant bang. To try and do that with commercial plutonium, without all the resources, all the instrumentation and so on of a major national laboratory—the mind boggles. How could that happen? The idea of a terrorist snooping in with a suitcase with a bomb he has made in his cellar is crazy.

Mr HATTON—Thank you very much for that explanation. It is very important. You also have access to experience at Lucas Heights. It is important for the committee in terms of some of the allegations that have been made about a current program that is in development and one that was developed over quite a period of time at Lucas Heights. In Melbourne, I think, we had evidence that there were serious problems with the Silex project, that there were a lot of underhanded things being done and that significant questions should be asked. Specifically, in the separation of isotopes by laser extraction at Lucas Heights, do you think there is the potential to form the basis for an enrichment industry in Australia using that technology, given that that and centrifuge were the last two areas of exploration at Lucas Heights? Are you aware of any of these allegations about underhanded things or difficulties associated with the Silex project, or great question marks that we should have about it?

Mr Alder—No, I am not aware. Laser enrichment has been on the research agenda for 25 or 30 years. If you look at the history of the enrichment industry you will see that it began with the Oak Ridge diffusion plants. Incidentally, there is still a lot of confusion about enrichment in terms of the energy that is needed for it. I have heard people like Dr Caldicott, for example, say that you do not get any net energy because you have to put so much into the nuclear fuel cycle. Sixty years ago enrichment was done with gaseous diffusion, first in America. Until about 1971 all power reactors were looking to Oak Ridge, Paducah, Portsmouth, Ohio in the United States, to the three big diffusion plants for their supplies of enriched uranium. It has all changed since.

Gaseous diffusion went two steps further. The British had a plant at Capenhurst which went as far as bomb material—of course, you can also use pure 235, or 92 per cent, as a bomb, as no doubt you know—and the French had a diffusion plant. In the Western world, other than the Chinese and the Russians, the French built the only commercial gaseous diffusion plant, and that was in the south of France—and I have been through that several times, when it was being built and since it started. It was a major improvement on the American technology—not surprisingly, because it was 30 years later—particularly the compressors. The problem with the original gaseous diffusion was the enormous energy consumption. There was a building a mile long full of diffusion barriers and great big compressors, all with an enormous electric motor with a belt drive onto a very inefficient compressor with a very high friction seal so that nothing leaked out. You pressurise the seal with nitrogen so that the nitrogen blew into the plant and you got the nitrogen back at the top of the cascade and so on.

The French built much better compressors by Hispano-Suisse, and the efficiency of the industry and the use of energy decreased markedly. It came down by a factor of 20 when you

went to centrifuges. One of the beauties of the gas centrifuge is that it uses only a very small amount of energy compared with gaseous diffusion. There is still quite a lot of energy. The French gaseous diffusion plant on the Rohn canal in the south of France near Marcoule is still in operation—and I have another point to make on that in a minute, if I may—and it is powered by four nuclear reactors. It amazes me that people can say that you get a net energy loss by using nuclear power. France is 80 per cent nuclear electricity. It is propping up Germany by exporting electricity to Germany, and it is running its diffusion plant to feed its own reactors and selling enrichment services to the rest of the world. How you can equate that with a net energy loss, I do not know. Have I answered your question?

Mr HATTON—The question was about Silex.

Mr Alder—People have been trying it with lasers. Two possible ways are known to me by which you could enrich your own in using a laser. It relies on molecular excitation. You have to make a difference between the 235 molecule or the 235 atom—exploit a difference or make a new difference between the U235 and the U238. Bombarding it with exactly the right frequency of laser excitation could excite one molecule and not the other and then you could separate them. You could do that by having uranium as a metal in the vapour form. Obviously you have to do it with a gas. The gas could be uranium vapour or a uranium compound. The only really suitable uranium compound is the one you use in diffusion plants and the one you use in centrifuge plants, and that is uranium hexafluoride, UF6—or 'hex', as it is called. But there is a possibility of doing it with uranium metal. The trouble is that, to make uranium vapour, you need a very high temperature and you have to contain it in something, and uranium metallic vapour at a high temperature is very destructive material.

Both of these approaches have been tried, and most people who have tried them have given up. We never got anywhere in the Lucas Heights labs while I was there. Arthur Pryor was the scientist involved, and a chap whose name I have now forgotten—it begins with G—has been working with Silex ever since. In the Lucas Heights labs we did not achieve anything significant. I know that Pryor became a thorough cynic about it ever working. As far as I am aware, there has been no success leading to commercial utilisation anywhere in the world. I know nothing in detail about Silex. They have been very good with their classification, and I believe that is a good thing, because the technology of uranium enrichment should be kept secret; it is not the sort of thing you should talk about.

Mr HATTON—My vague memory is that of the degree of transportability. You decrease by orders of magnitude the size of the process by going through to laser. That is if you can get it work, I suppose.

Mr Alder—Theoretically, if it worked, you could have a very small unit producing a fairly high yield per stage. One of the problems with gaseous diffusion is that you get a very small gain per stage, so you have to have a gigantic plant cascade with many stages going up one step at a time. With centrifuges, you have a lot less. You get a bigger separation per stage of the centrifuge than you do with a gaseous diffusion. The theory is that you get a much bigger separation with lasers. Whether they have achieved that in such a way that you could run a commercial plant, I do not know.

Mr TOLLNER—Mr Alder, it is fantastic to have you here. I do not think we have had many people with the sort of experience in the industry that you have. You mentioned that at one stage there were 37 organisations that were putting out misleading information in regard to the nuclear industry, uranium and that sort of stuff. My view is that the nuclear industry, the uranium mining industry and all of those organisations involved somewhere along that chain, have been extraordinarily poor in promoting their own case. ANSTO say: 'No, we cannot run a public education campaign. People will say, "You have a vested interest".' Miners say the same thing: 'We can't.' It seems to me that nobody is putting money into some sort of effort to contradict some of these arguments that are being put. Ultimately, we are just reaping the results of the other side's argument.

Mr Alder—Yes, you are right. Let me tell you something—a short anecdote. I have forgotten his name, but there is a professor in the United States who writes—or he used to write; he may still be doing so—an energy paper. He came out to Australia shortly after the Fox inquiry—Mr Justice Fox's environmental inquiry into the Ranger mine. We entertained the professor at lunch, and he asked: 'How did the inquiry go? What did the witnesses say?' We said, 'There were many who were very outspoken about the dangers of uranium to the environment and so on.' He asked, 'What did you people say?' I said to him: 'We told the truth. We played an absolutely straight bat. We answered the questions and we told them what was what.' He asked, 'Did you win?' and I said, 'No, I don't think we did.' He said: 'Right. You did the wrong thing—you fight fire with fire.'

We did not fight fire with fire. You cannot make scientists do that. We were trained to tell the truth, and that is the problem. Engineers can maybe go a little closer to the edge, but you will find that trained scientists refuse to tell lies. It is against all your training to fight fire with fire, and that is one of the problems. The sorts of things that these 37 antinuclear organisations were saying—and some of them are still saying it; you have heard some of them, I am sure—

Mr TOLLNER—Of course.

Mr Alder—They are pretty emotive things. I could be emotive about the other side, but I will not tell the lies that they tell.

Mr TOLLNER—No. The point is that you do not have to tell lies. You just have to promote the case. For instance, I have not heard anyone from the medical profession anywhere saying, 'We need Lucas Heights to continue to make radioisotopes.' In this whole debate about where we site a nuclear waste repository, there has not been one single medical organisation of any nature that has stepped up to the plate and run a few ads on the television, put something in the newspaper or done anything of any sort of public nature to say why we need nuclear energy.

Mr Alder—It is worse than that. There was a lot of argument for years about getting a new research reactor. We are getting a new research reactor. I had retired by the time all this started, but one of the things I tried to do was whip up some enthusiasm in the universities. I have some friends who are vice-chancellors, or ex-vice-chancellors. One of the main uses and benefits to Australia of HIFAR, the old reactor, has been neutron beams, neutron diffraction and their application to biological sciences. Every university in Australia has used the resources of the HIFAR reactor neutron beams for neutron diffraction. I do not know if neutron diffraction means anything to you, but you can study solid state with X-rays. You can bounce X-rays off metals;

you can bounce electrons off them. You cannot study molecules containing hydrogen with any of these technologies. What neutron beams have done for biological science is to allow people to study structures of biological organic compounds using neutron beams. Neutron diffraction has become a tremendous thing in university and medical research in Australia. I wanted some of the vice-chancellors to speak up and say, 'We need neutron beams in Australia because of the benefit that we get from it.' Nobody would say a word. They did not want to get involved.

CHAIR—Is this, in part, the same technology used to measure stress fractures in bridge beams?

Mr Alder—No. A metal is crystalline. You can look at the structure of the metal and measure the interatomic spacing and measure some of its properties by bouncing X-rays off the lattice. The wavelengths of the X-rays happens to be about the right wavelength to bounce. But you cannot do it with very light atoms like hydrogen. You cannot study the structure of DNA and all sorts of organic compounds that are a part of your body. You cannot do those structural studies with X-rays or with electrons, but you can do them with neutrons. That is the major benefit of nuclear science and it is done at Lucas Heights. The old research reactor, HIFAR, is entirely surrounded—

CHAIR—To take your response to my colleague further, the structural engineers of this world also did not step up to the plate to say, 'We couldn't X-ray big, welded plates and whatnot if it weren't for the information—

Mr Alder—The cobalt-60.

CHAIR—That is right. Is that true?

Mr Alder—I am not sure that that would have been as forceful because I believe that cobalt-60 and iridium—they are the industrial radiological sources—are not nearly as commonly used now. There have been so many advances in X-ray tube design and so on. There is still some industrial radiography with iridium and cobalt. As I was going to say, dear old HIFAR is entirely surrounded by neutron spectrometers. Nearly all of the workers with those are university personnel and some are from the CSIRO. But nobody wanted to speak up and say, 'This is a benefit of a reactor.'

Mr TOLLNER—I just want to go off on a bit of a tangent now. Put yourself in the hypothetical situation that we all go to bed tonight and wake up in the morning to a massive change in public opinion. We all become French overnight and there is bipartisan support in government for nuclear energy and that sort of stuff. How long do you think it would take us, starting from scratch, to create a nuclear energy industry in Australia, create regulation, find a work force and do everything that has to be done? As I said, leaving aside public opinion, if we were to start today, how long would it take us?

Mr Alder—There are two or three separate parts to that question. I personally believe that Australia should get into the front end of the nuclear fuel cycle as soon as possible. That is, instead of exporting yellowcake, we should get into conversion to UF6 and enrichment. Those are two steps into the nuclear industry. I think that could be done fairly quickly under the wonderful conditions you envisaged.

Mr MARTIN FERGUSON—Ideally, where should that section of industry development occur in Australia?

Mr Alder—Where geographically?

Mr MARTIN FERGUSON—Yes. You need cheap electricity, don't you?

Mr Alder—No.

Mr MARTIN FERGUSON—You don't?

Mr Alder—No. The first thing you would need in Australia is a much greater production of fluorine, because to make UF6 you need hydrofluoric acid. There is a fluorine plant in Australia, or there was. I am out of date on this; I do not know if it is still there but certainly all of Australia's fluorine was made in a plant at Camellia in Sydney, mainly because it was used in refrigerants. So we had a capability already and we had a location for fluorine.

Hydrofluoric acid is the nastiest substance involved, by the way, in the nuclear fuel cycle. I would be much more scared of HF than ever I would be scared of plutonium or uranium. I got one tiny drop the size of a pinhead on my thumbnail at Harwell and had a fortnight of agony. Hydrogen fluoride is a nasty substance. Fluorine is a nasty element. But we already do that industrially, or we did in Camellia in Sydney near Rosehill racecourse. The UF6 plant is no more hazardous than that, nor is an enrichment plant.

When we were looking, with the Australian companies, at the partnership potential with Eurenco in the British-Dutch-German trination project, which we wanted to become a quadripartite arrangement with Australia, we were looking to site the plant at Caboolture in Queensland, in the pine forest. There was one important factor in selecting a site, apart from chemical thinking, and that was seismic. One of the things you do not do with centrifuges is shake them. When they are going at 60,000 RPM, you do not give them a good shake, so you keep away from earthquake areas.

Mr TOLLNER—What about the time frame?

Mr Alder—As soon as you could form a partnership with one of the overseas firms. We have lost our own expertise, of course. We had all the know-how of how to do it 20 years ago. With regard to the reactor, as you say, you have to develop the regulation and licensing procedure and so on. One of the main incentives for Jervis Bay, as you probably know, was to develop that whole framework for Australia before state generating bodies really were looking to go nuclear. When we did Jervis Bay in the 1960s everybody knew, including the electricity authorities of the states, that Australia was going to go nuclear in the 1970s. It was common knowledge. ETSA, the Electricity Trust of South Australia, had their own study group. They had done all their own estimates for a 250 megawatt plant on Kangaroo Island. The Victorian SEC had their own study group. New South Wales, of course, were our partners when we did the Jervis Bay thing. Queensland had their own study group. ETSA from South Australia had three engineers seconded to Harwell looking at nuclear power for South Australia when I was there in 1954. It is not a new idea. But it all fell by the wayside.

I would think the reactor would take an absolute minimum—if nirvana arrived and there were no public opposition and there were bipartisan agreement in government and so on—of 10 years but more likely 15 before you had a nuclear power plant operating. Construction time is not less than six years and is more likely 10 on a new site in a new country. There would be a lot of design work, contracting, specification, calling for tenders and so on. So I think you are looking at 12 to 15 years for a nuclear power station.

Mr MARTIN FERGUSON—The issue I raise is one you have partly touched on. Put aside the issue of when Australia might go nuclear. We were a leading country in terms of our skills base for research and development. There is going to be an ongoing greenhouse debate and this is going to be part of that debate. How should we go about starting to rebuild our scientific and engineering nuclear skills base and how can the uranium industry help? Should we seek, for example, a strategic relationship between a university and ANSTO? What do you think we as a nation should do?

Mr Alder—Before I came in today I was seated at my computer replying to an email message sent to all fellows of the Australian Academy of Technological Sciences and Engineering. Do you know of that academy?

Mr MARTIN FERGUSON—Yes, of course.

Mr Alder—The academy is beginning to look at it. It sent a questionnaire to all fellows—and I am one—asking us a whole series of questions exactly along those lines. I have just replied by putting my humble thoughts into their questionnaire. I do not think the academy is a suitable organisation to try to start a public education program. I think it could well start a government education program and perhaps try to provide help towards having bipartisan support for nuclear in the country. How do you set about educating the public? I do not know. I wish I did.

Mr MARTIN FERGUSON—It is not just about educating the public. Our skills base in engineering and nuclear science has been dissipated. How do we set about rebuilding it?

Mr Alder—You are asking the wrong person.

Mr MARTIN FERGUSON—You, for example, spent a couple of years in the UK. That is how we started in the fifties and sixties—with strategic relationships with the Brits and things like that.

Mr Alder—I would certainly suggest that one of the things should be a broadening of the program of ANSTO so that it is involved not only in paper study but also in physical laboratory research, even if it is a long way off, on the treatment of uranium and uranium fuels. One of the reasons for the choice of dear old HIFAR in the first place, you know, was as a test reactor so that we could test things that we made in Australia. When we set up Lucas Heights, Charles Watson-Munro, who was the first boss—he was the chief scientist and I was head of metallurgy—said to me, 'You ought to set up laboratories at Lucas Heights in metallurgy so that we can make anything we need.' He had already been through the mill in Canada and later in the UK because of having bits of nuclear fuel and control rod and all of that sort of thing—nuclear hardware—made by industry. He found out that, because there were different problems, different standards of purity and different standards of health control and so on, industry was very slow to

do these things in the early days. So, if you look at Lucas Heights today, you will see that there is a rolling mill, an extrusion press, a vacuum press, a melting furnace and so on. We had the capability there—and it is still there, but I think it is largely unused—to make bits and pieces.

I think if you are going to rebuild scientific confidence, you have to put back into the scientific program research and development on the things you want to know about. That is a good start. There is still the AINSE—the Australian Institute of Nuclear Science and Engineering—which we started, or Baxter and I had a good hand in it. It was formed between all of the then Australian universities—there were seven in those days—and the AAEC. That still exists. It has a council consisting of a member from each university and a number of members from the AAEC and I think now from ANSTO. As far as I know it is still going. AINSE is a very good body for cooperation between the government research institutions and the universities. You can use that too. When research contracts, research sums and research grants are handed out by AINSE, perhaps they could be slanted more towards the nuclear industry and not just to neutron diffraction and the other things. Then, if you can get university staff interested in and working on matters associated with the nuclear fuel cycle and reactive theory and so on and teaching them, perhaps you are away. But it is going to take a very long time.

CHAIR—Thank you for agreeing to appear today.

[3.30 pm]

KEMENY, Visiting Professor Leslie George, Private capacity

CHAIR—Welcome. Do you have any comments to make on the capacity in which you appear?

Prof. Kemeny—At the moment I am Managing Director of L&M Kemeny and Associates, Consulting Engineers and Physicists based in Lithgow. My past connections have been with the University of London's school of nuclear engineering, the Massachusetts Institute of Technology's school of nuclear engineering and the University of New South Wales's school of nuclear engineering.

CHAIR—Thank you for agreeing to appear to give evidence at the public hearing today. Although the committee does not require you to give evidence under oath, I advise you that the hearing is a formal proceeding of parliament and remind you further 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 if you request to give evidence in private the committee will consider your request. I now invite you to make a short opening statement.

Prof. Kemeny—I have prepared an A4 sheet on which I invite questions. I will pass these around. By strange coincidence, SBS has invited me to participate in the filming of an *Insight* forum on nuclear engineering and nuclear energy for Australia on Monday evening. I cannot participate in that, but the three questions they have asked me to address are on that sheet of paper, which I would like to address for five to 10 minutes. The questions are as follows. First, should we use nuclear power to generate electricity and produce potable water and hydrogen in Australia? Second, should we accept nuclear waste from other countries that buy Australian uranium? Thirdly, should we export Australian uranium to China? This is what I would like to speak to you about.

I fully believe that we should accept nuclear power as a mature technology, legitimate for Australia's use. My own experience overseas—in the last 20 years, anyway—is that we have in a sense not lost time by making this commitment. I believe that Generation Four nuclear power designs, nuclear plant designs, at MIT Boston, in the USSR and in China are extremely interesting to Australia. We have a gas-cooled reactor, as opposed to a water-cooled reactor, which is eminently suitable for electricity generation, producing potable water by desalination and also hydrogen if we want to have hydrogen as a potential fuel.

As far as the second question is concerned, yes, we should accept nuclear waste from other countries. This is politically the most difficult area, I know that full well. I have been very much involved in some of the discussions in Western Australia and South Australia in this area. But there is nothing really horrendously dangerous about nuclear fuel.

The hydrocarbon technology has never accepted the handling of their waste products as being a legitimate cost to their fuel cycle. I believe the nuclear industry is the only one that has looked

at its waste properly. I believe Australia, as a potential major supplier of uranium to an energy-hungry world should take on this responsibility as financially lucrative, as a sunshine industry and as a place which is geologically and in every way suitable for acceptance of so-called nuclear waste.

On the third point—should we export Australian uranium to China?—I have had the privilege of visiting China several times during very difficult times. The United States government and the Australian government have chosen me—I am not being presumptuous or anything—to represent them in lecturing in Beijing, in Tsinghua University and in Szechuan province at their pressurised water reactor centre. In the 1970s, when no-one else could approach China, I believe that the Chinese—and this is what I am working on at the moment with the International Nuclear Energy Academy—have always obtained their weapons uranium from their slave states, Tibet and, to some extent, Mongolia. They are not using Australian uranium for weapons programs. I know this full well. I had the privilege of sharing thoughts on this with Li Peng in Beijing at a world nuclear energy congress many years ago. Australian uranium sales to China would not be compromised. If you have seen my submission to this inquiry, you will see that, in the 1970s and 1980s, I submitted proposals for leasing Australian uranium to countries like China. They do not require Australian uranium for weapons programs. If they go on with weapons production—and I must be quite frank about this: we have to watch that—they have access to uranium.

So the answer to all three questions, which SBS will ask on their *Insight* forum which will be filmed on Monday evening and to which I will not be able to go, because I am far too committed, is—as I have told them—yes, yes and yes. I am the foundation member of the International Nuclear Energy Academy as far as Australia is concerned. We advise the International Nuclear Energy Agency in Vienna on their major programs. I believe that the agency would not be worried by Australia submitting uranium sales to China. They are the three points that I would like to address, and I am now ready for any questions.

CHAIR—Your paper, 'Nuclear Energy and Greenhouse Problems', makes comparisons between nuclear, coal and gas power plants. Would you summarise how these sources of electricity generation compare in terms of the types of volumes and waste they emit?

Prof. Kemeny—I would be pleased to do that. Two countries that have possibly up to 20 years of experimental records on this—France and Japan—show quite clearly, having adopted nuclear power plants as their major source of electricity and a significant source of primary energy, a decrease in their greenhouse gas production. Only France and Japan can clearly show that their greenhouse gas production is back to the baseline date of 1990, I think it was, and that they will be able to meet their 2012 targets.

Mr HATTON—Thank you very much for not only a very good presentation today but also the wealth of materials that you have provided to the committee for consideration. One of the key points you make, given your experience at New South Wales university, is that it was the only school specialising in nuclear engineering and the teaching of that, but that it closed its doors. We do not have any facility, apart from the ANSTO research facility, which has a minor provision in relation to this. How do you think we could restart this process? Where is the entry point—at the governmental level, the administrative level or in our tertiary sector, in terms of getting a kick start?

Prof. Kemeny—Thank you for that question. I do not get paid for promoting nuclear energy; you understand that. I had the good fortune of having close links with the University of Chicago and MIT Boston. It is through those people that I was elected to the International Nuclear Energy Academy. In the last month I have had the privilege of meeting with the new Dean of Engineering at New South Wales university, Professor Brendan Parker. I have started consulting with him on the possibility of a school of nuclear engineering. New South Wales university is an obvious place. It has relatively close geographical links with Lucas Heights and with ANSTO.

I have had 22 pleasant years sitting on top of the HIFAR reactor and doing all sorts of experiments. My specialty is in the control and surveillance of nuclear power stations. We produce many technical papers in that area as a link between the University of New South Wales and Lucas Heights. I believe that other states I have consulted are very interested in this technology for the Northern Territory government. I will put politics to one side: I am aware of the interest in Western Australia and South Australia, which are uranium geographical regions. Also, three weeks ago I was at Hayman Island at the Australian Leadership Conference and spoke to all the premiers, including Premier Beattie. I sense that there is a resurgence of interest in uranium mining. I believe it is very important that nuclear education should take off again in Australia.

We have to face facts. Historically, military engineering was the first—mechanical engineering, civil engineering and electrical engineering all started off in the 19th century due to the Industrial Revolution. Much of it is due to the United Kingdom and Europe. Unfortunately, we have lost nuclear engineering from this country, which is amusing to fellow Commonwealth countries like Canada, for instance, where there are plenty of schools of nuclear engineering and they are competing with us in uranium sales. They have their own nuclear industry; we have nothing here at the moment.

I have been an advisor to the Uranium Information Centre. When I came back from England I was the first technical consultant to the UIC in Melbourne. Then I was invited to all the meetings of the Uranium Producers Forum. My hope is that those who benefit from uranium sales might help us start up schools of nuclear engineering. It does not have to be a government funded enterprise; it could have some private input of funding.

At the University of New South Wales in the early days, in the 1960s and the 1970s, we had a school of metallurgy which was primarily devoted to the casing of nuclear fuel elements. Some mistakes were made at that time. Sir Philip Baxter was the vice-chancellor. He was a very keen advocate of nuclear energy. He also became the chairman of the Australian Atomic Energy Commission, as you well know. It was through him and a few others that I came back from Queen Mary College at the University of London to the University of New South Wales.

Mr TOLLNER—You mentioned consulting with the Northern Territory government. Can you tell me when that was? Were you referring to the resurgence in support for uranium mining? Do you believe that applies in the Northern Territory as well?

Prof. Kemeny—I believe so. I was adviser to Justice Fox when the Ranger uranium inquiries took place in 1976. Soon after that, in the early 1980s, I was an adviser to the Northern Territory. I was aware of Peko-Wallsend's development of Ranger uranium. I gave advice to the Northern Territory government at that time.

Mr TOLLNER—So it is not the current government.

Prof. Kemeny—Not the current government, no. I do not know how the present government of the Northern Territory looks at this, but I think they might be leaning towards uranium mining. I know all the difficulties of Indigenous people and their involvement in Kakadu National Park. Incidentally, I helped to make sure that the exclusion of the uranium region from Kakadu National Park took place. It is not actually in Kakadu, as you well know. Whether these Indigenous people are now beginning to be pro-mining, I do not know. I know what the attitude is of Rio Tinto—which has taken over from Peko-Wallsend, North Ltd and Energy Resources Australia—but I do not think it is relevant. That has to be worked out.

Mr HATTON—If I could bring you back to your fundamental expertise and the core of your lifetime experience, in point 5 you deal with the new Generation Four high temperature gas cooled meltdown and terrorism proved pebble or prismatic bed modular reactors. You talk about those as being optimal power sources. One of the things we have not had enough of, in terms of evidence given to the committee, is how reactors have changed over time. At the moment, we are taking a picture of what the situation is world wide. There are some countries that are on the cusp of either closing down or renewing. How much dramatic change has there been? Can you tell us a bit more about these pebble bed reactors, which were the subject of research at Lucas Heights back in the 1960s.

Prof. Kemeny—You are absolutely right. Just dealing with it in terms of chronology, Lucas Heights had a huge involvement. Their engineering and research division under Mr Kim Ford, a great friend of mine, was greatly involved in pebble bed studies. It phased out. Karlsruhe in West Germany took over. They took all the research reports from Lucas Heights in the 1970s back with them. The instrumentation which I worked on from the University of New South Wales was used in that study. Since then, there have been incredible developments. At MIT Boston, Professor Kadak has led a study on pebble bed reactors. General Atomics in San Diego, which built a prismatic pebble type fuel element as opposed to a rod type fuel element, has actually had some research reactors in operation in the United States.

Incidentally, my own work was on the Berkeley nuclear power station in Gloucestershire, which was the first commercial nuclear power station in Europe, was a gas cooled, carbon dioxide cooled, but rod type natural uranium reactor. It was not terribly efficient. It has just been shut down recently after 45 years of operation. I believe that the gas cooling system is ideal for Australia. In one sense, it is fortuitous that we have not gone into water reactors, which were reactors pressed by the United States mainly because of their interest in naval reactor strategies—submarine reactors, aircraft carrier reactors and so on. This has a gas cycle, a Brayton cycle, which has inlet temperatures at about 300 degrees centigrade when the reactor is operating at its normal power level and outlet temperatures over 900 degrees to 1,000 degrees centigrade. It is terrorism proof. It is meltdown proof, because there is no metal in the reactor core.

The pebble bed is an orange sized reactor element, which is carbon, uranium dioxide and silicon, which will not melt even if all the coolant is shut down. The whole reactor will shut down normally, there will be an interruption to the power supply, but there will be no Chernobyl type of incident. Professor Robert Uhrig of the University of Tennessee is my great friend and has been deeply involved in all this. If you look up ‘Mr nuclear energy’ in the United States on

the internet you will get Professor Uhrig. He has been involved in these developments, and I have been associated with MIT Boston in the last five years. I believe this is the sort of reactor which would be ideal for Australia. Surprisingly, South Africa is commercialising on this. They already have two new, big French nuclear power stations of a conventional type and I think the government of South Africa has committed funding to a Generation Four pebble bed reactor.

It is the only power system presently available which is suitable for electricity generation and the desalination of brackish or seawater and is also ideally suited for the production of hydrogen if we want to switch to hydrocarbon fuels. That is why I am enthusiastic about that. I am not commercially involved at this stage, but General Atomics would very much like to collaborate with possibly a group in Lithgow, which has had a huge share of industrial development in New South Wales, in a plant which would look at certain aspects of Generation Four pebble bed reactor development.

Mr HATTON—Because we have such massive resources in coal, because we make so much money out of selling that coal overseas and because the chance to establish a 500 megawatt reactor at Jervis Bay was lost, how do pebble bed reactors equate in terms of the cost of electricity output from prior generations of nuclear reactors and the cost of electricity output normal coal-fired generators, such as we have predominating in New South Wales?

Prof. Kemeny—They would be the real breakthrough in capital costs. With Professor Kadak, we have been working on a factory produced unit for the pebble bed reactor which would come down an assembly line, which would ignore specialised needs of clients wanting to buy nuclear energy and which would be transported to site in 21 lorry loads for a 250 megawatt thermal unit. Because they are so efficient—45-plus per cent efficient—they would produce, let us say, 120 to 125 megawatts of electrical energy, which could be built up to gigawatts of energy by connecting a single control unit with up to 10 modules. This would bring down the capital cost to compete fully with base load coal-, gas- or oil-fired stations.

Going back to America's 103 nuclear power stations, the water type and with high capital costs of $US3 billion or $US4 billion, all of them which have passed the 30-year operation cycle—and many of them have—are being licensed to operate for another 30, 40 or even 50 years and their capital costs have been amortised. I published quite recently—it will come out shortly in many newspapers—that nothing can compete with the cost in cents per kilowatt hour or dollars per megawatt hour of electricity. I will stand by that. I have gone through the calculations. I have had a close link with the University of Florida and Florida Power and Light company. Florida is almost a completed nuclear powered state. There are about 10 million people receiving all their energy from nuclear power. The four nuclear power stations are now producing electricity which nothing can compete with. Their capital costs have been amortised.

We are aware of the high capital cost of generation 4 reactors, which is mainly because nuclear power vendors have been listening to their clients and trying to comply with local, geographical and other situations. So there is no cost decay as you have numbers 1, 2, 3, 4, 5, 6, 7, 8 power stations rolling down the line. I believe the nuclear industry will look at factory production and then supply to site to bring down the costs. I do not believe any other base load power will compete with this—and I am not against coal; I live in Lithgow. I have close contacts with Delta and I do speak to the top people in Delta, and I feel that they agree with me.

Mr HATTON—In terms of the implementation of that pebble bed technology, are there any extant reactors around the world? Alternatively, how long will it be before those can be implemented?

Prof. Kemeny—Surprisingly, the UK had the Dragon reactor at Winfrith Heath when I was still over there, and that was one of the prototypes. In a sense you could say that all the magnox reactors—Berkeley, Bradwell and about eight others in Britain—are the prototypes of the gas-cooled reactors. They were not anticipating the energy cycle as being the Brayton cycle at that stage. Germany has had a high-temperature gas-cooled reactor, and General Atomics of San Diego, who are very interested in Australia, have built at least three gas-cooled reactors in the United States using helium cooling. They would be prismatic fuel elements, not the orange sized—they are bigger than golf ball sized—fuel elements which MIT is working on. I believe there are commercial and political pressures in the nuclear industry itself which want water reactors to go on—and there is nothing wrong with that; that is the world we live in. Does that answer your question?

Mr HATTON—Yes, it does. Thank you.

Mr TOLLNER—I am fascinated by this assembly line production of reactors. Do you have a time line for when that sort of stuff will come along? Could you say, 'I expect that within the next five years we will see production line reactors being used around the world'?

Prof. Kemeny—Yes; within five years, I think. Surprisingly; the American component and Tsinghua University, which is linked with mainland China's interest in nuclear energy, and also a Russian consortium are working together, which is, I think, wonderful. On the campus of Tsinghua University in Beijing, where I have lectured, there is a 10 MW pebble bed reactor in operation now, and I think within five years the production line concept could well be commencing.

Mr TOLLNER—You have mentioned 10 MW. In your submission you say, 'the modules of, say, 250 MW'—is that what you are talking about?

Prof. Kemeny—That is thermal energy; yes. But once you have a 10 MW unit going—and HIFAR at Lucas Heights is 10 MW—upgrading is not all that hugely difficult.

Mr TOLLNER—I am just thinking of this in the context of, say, a place like Rockhampton. I would imagine that you would use about 100 MW or 150 MW of electricity to power a town of that size.

Prof. Kemeny—I gave a seminar on this in Boston, and you are absolutely right. I see no reason why any size—from 10 MW up to the commercial power station size, the base load energy size, for the electricity grids of New South Wales or Queensland, even perhaps a major hotel or a commercial industrial site—could not be supplied by nuclear energy using the pebble bed helium-cooled concept.

Mr TOLLNER—Are there economies of scale? When it comes to, say, building a 10 MW reactor compared to a 250 MW pebble bed production line unit, are there economies of scale, such that one is significantly cheaper in the end?

Prof. Kemeny—By the way, Bechtel Engineering is looking at linking into this; as you would know, Senator, Queensland has some Bechtel input. I believe that basically the economy of scale is focused on 250 MW thermal, which is 125 MW electrical but, once these are in operation, I see no major problem in downgrading to a smaller size. When I first came back to Australia from working in England, and went to Lucas Heights from the University of New South Wales, there were experiments on the HIFAR reactor to supply thermal energy to heat the offices, and that is a 10 MW reactor. That was a bit of a trial project, and I do not know whether it has been maintained.

The moment you get down below three Australian cents per kilowatt hour with nuclear energy, you have a whole host of options, both industrial and domestic, for nuclear sources. One problem we face in this country is that we are very risk-conscious; we do not want to try anything new. The paradigm shift is very hard to take. I can understand that.

My first student at the University of London was a gentleman—I will not mention names—who was a brilliant person. He did his early work in the United States; he came to London to do his PhD; he then went on to Siemens, which is a nuclear corporation, and then he went back to Indonesia and became secretary of state for energy. Under Dr Habibie it looked as if—

Mr TOLLNER—I don't think it would be too hard to track down who you are talking about by now!

Prof. Kemeny—We meet quite often. He comes to Canberra sometimes, and when I go there we have a picnic in Bogor. It seems that many of our neighbours overseas are far more willing to try new technologies than we are. We seem to have been pioneers, and we paved the way. First of all Japan, then South Korea, then Taiwan and then mainland China are now pressing ahead. Recently, I have been to Malaysia, and I think they have great aspirations for nuclear energy too.

Mr HATTON—There are those who would say that nuclear power is the problem, not the solution to the greenhouse issue. I think you would say, as you do in your third point, that a lot of what they are positing is 'pseudoscience, media hype or sociopolitical manipulation'. Given the crisis we are now confronted with in not only the width and depth of greenhouse gas induced changes but also the challenges that a state like New South Wales has in contemplating committing to a desalination plant, as well as the question of how you get to a hydrogen economy—and it has been posited that the best way to do that is to go nuclear in order to produce the hydrogen that could then change the way you do other things—do you think these new pebble bed reactors and the fact that you could do them on the scale you are positing could be almost a one-size-fits-all solution to a bundle of problems and that Premier Iemma should be having a look at it?

Prof. Kemeny—I believe so. I had the privilege of attending the Hayman Island Australian Leadership Retreat—that is what it was called, for what it is worth—three weeks ago. On my panel were Bob Carr, Paul Davies and the head of AGL, and they were all pronuclear.

Mr MARTIN FERGUSON—I thought that was Chatham House!

Prof. Kemeny—Chatham House—all right, I am sorry.

Mr MARTIN FERGUSON—But, having said that, I know it was discussed.

Prof. Kemeny—But I had not seen more enthusiastic advocates for nuclear energy than those people. Paul Davies is an astrophysicist, but he did his PhD with Fred Hoyle in the United Kingdom. Fred Hoyle was one of the greatest UK enthusiasts for nuclear energy. He wrote a book about why we should go nuclear in the UK. Bob Carr was absolutely committed, I think—I must not think for him; that would be wrong.

Mr MARTIN FERGUSON—He has been public about the need for the debate.

Prof. Kemeny—I believe that desalination, as you have mentioned, would be best done by nuclear power plant without greenhouse gas emission. I believe that those who say that nuclear energy is not an answer to climate change and greenhouse gas production are actually very foolish. They have not done their homework. I was with the world nuclear societies council and the International Nuclear Energy Academy in Paris some two years ago. We penned a letter to Kofi Annan saying that, looking at this problem from the United Nations point of view, it is absolutely ridiculous if you do not give credit to nuclear energy. I think I have in my presentations the French experience of increasing value-added production in France but decreasing greenhouse gas production as the answer to their nuclearisation of that country. I think the same holds for Japan. Sorry, what was the other part of that question?

Mr HATTON—It was about moving to the hydrogen economy and producing the hydrogen that you would need to form the basis of that economy.

Prof. Kemeny—I am not against other energy forms: wind, solar and hot rocks—the University of New South Wales is involved in all those technologies From an engineering point of view, the only basic, engineered device which produces the right thermodynamic cycle for producing hydrogen is nuclear energy. There is nothing comparable to Brayton cycle, gas cycle, with helium cooling—minimising water use, by the way; we do not necessarily want too much water to be used with nuclear power plants in Australia unless they are along the coast. We could build a prototype pebble bed reactor in the middle of Woomera for South Australia and show that it works with an absolute minimum of water consumption. If there is an aquifer there—and I think there is—we could produce potable and irrigation water from that aquifer using nuclear energy and a pebble bed system.

Mr MARTIN FERGUSON—Given your international experience, there has been talk of a white paper on energy in the UK. Where do you expect the UK to go on the nuclear debate?

Prof. Kemeny—That is interesting. It has been on again, off again.

Mr MARTIN FERGUSON—Correct; and the election is over!

Prof. Kemeny—At the Hayman Island retreat, the British High Commissioner, who is—

Mr MARTIN FERGUSON—I have met her.

Prof. Kemeny—One of her concerns was that she would like to have Australia involved in the fuel cycle for Great Britain. I think that, like Germany and Sweden—my last major international

conference was in Gothenburg in Sweden—the change back to nuclear energy could come with the next election. In Britain it is slightly different. The British Prime Minister has been on again, off again on this matter, but with about 20 nuclear power stations in Britain and the fact that Britain is already looking at the next generation of reactors, the decision is a political one. I think it will be made fairly soon. I do not know when that white paper will come out. I do get emails from London.

Mr MARTIN FERGUSON—It is fairly important where these reactors go.

CHAIR—Professor, thank you for agreeing to give evidence today. If there are any further questions, the secretariat will contact you.

Prof. Kemeny—I would be happy to provide anything in writing, with references.

Committee adjourned at 4.12 pm