COMMONWEALTH OF AUSTRALIA

Official Committee Hansard

HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

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

THURSDAY, 2 MARCH 2006

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

Thursday, 2 March 2006

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 Cadman, Mr Haase, Mr Hatton, Mr Katter and Mr Prosser

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

BRAY, Prof. Igor, Private capacity.. 1

Committee met at 11.40 am

BRAY, Prof. Igor, Private capacity

CHAIR (Mr Prosser)—Welcome. I am pleased to declare open this 13th public hearing of the House of Representatives Standing Committee on Industry and Resources in 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. Professor Bray, thank you for taking the time to appear before the committee. I understand that you wish to give a presentation. Do you have any comments to make on the capacity in which you appear?

Prof. Bray—I am a professor of physics at Murdoch University. I am also chair of the Western Australian branch of the Australian Institute of Physics.

CHAIR—Thank you for that. 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. I further 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. Please proceed with your presentation.

A PowerPoint presentation was then given—

Prof. Bray—Thank you very much for the opportunity to speak to you today. It has been rather sudden. It was suggested to me yesterday that I do so. At the Science Meets Parliament get-together, I suggested that another process worth considering is the fission based process based on thorium and that it might be of interest to the committee. The first thing a person like me should declare is that I have no conflict of interest in this area. Physicists are renowned for supporting fission research. However, I am in a slightly different department. As you can see from the slides, we are interested in energy studies and we do a lot of renewable energy research into areas such as solar energy out of amorphous silicon and also we work with fuel cells. That is our primary focus. I feel I have no conflict of interest in putting forward fission as a source of research. It is not part of my research.

I am a professorial fellow employed by the Australian Research Council to do pure research. I am also deputy director of the ARC Centre of Excellence in Antimatter Studies. You are aware that fission is based on the equation $e=mc^2$. This is how you get energy by losing a little mass. This is an area that is particularly relevant to our area of research where we work in the atomic physics scale. The slide shows that we interact positrons, which are anti-electrons, with electrons. To give you an idea about how much energy you can get out of such systems, from one milligram of positrons you get enough energy to take a one megatonne spacecraft and put it about 30 kilometres above the earth's surface. This is why there is just so much energy associated with mass, and why it is worthwhile to consider using this for peaceful energy generation.

I have published over 250 papers and I have some awards. We are consultants to NASA and the International Atomic Energy Agency. We also work with industries such as Osram-Sylvania.

The problem, according to me, is that costs associated with choice of energy production are typically very difficult to estimate and often we do not do a very good job of it. A typical example is coal, the use of which generates carbon dioxide.

If you sometimes have difficulty convincing people that global warming is a problem, you need to remember that ice melts at an absolute temperature of 273 degrees kelvin. We typically use Celsius, so we call it zero degrees Celsius, but it really is 273 degrees kelvin. We live at a room temperature of around 300 degrees kelvin. A one degree movement might seem a lot if you are working from nought to 30 degrees, but in 273 degrees it is not such a big movement. This is why man-made activities—man-made gases—are able to influence climate. It just so happens that we are living quite close to the melting point of ice and so a small movement can be quite significant.

Also associated with coal are things we do not talk about, such as radioactive emissions. Much of the uranium and thorium that I will be talking about gets emitted from coal powered stations. There are also health risks from mining. Someone was saying yesterday that in China they lose almost 20,000 people. I am not sure whether that is accurate. It is an extraordinary suggestion.

Other factors are more political, for instance a dependency on Middle East oil. The Iraq war is going to cost the United States in the trillions of US dollars. Imagine if all of us were driving cars based on electricity, with that electricity being provided from renewables or fusion. If that were so I do not believe we would have had a war in the Middle East.

Other means of energy generation include wind and water based turbines and solar; those are a bit closer to our areas of research. Many of those sources are very diffuse; you have to have many of them to provide energy, and so there are going to be large maintenance costs. Those are unknown because these things will need to be running for many, many years.

Last but not least there is nuclear energy. With that, you have Chernobyl-style problems; there are also problems with the waste and problems with weapons-grade plutonium proliferation. And, of course, Homer Simpson reminds us about the dangers of working in nuclear power plants.

I have been very heartened by what I heard yesterday during the energy forum. You people clearly know that the solution to the problem is basically to cast the energy production net very widely. I am here to suggest that nuclear energy does deserve careful evaluation. One of the areas I am involved with is fusion.

It has been announced that the International Thermonuclear Experimental Reactor, or ITER, is going to be built. It is going to cost around $20 billion. It is going to be built in Cadarache in France. We are consultants and will provide underlying atomic collision data for the project. This project is going to come online in about 2015. Note that the ‘E’ stands for ‘experimental’—it does not mean that this is for production mode energy production. It is certainly something worthwhile for Australia to be involved in on the research front, but it is not something at this point that will lead to abundant energy for households.

I turn now to fission. It is important to appreciate that historically it has been uranium based due to the ability to create plutonium. That was done at Los Alamos. First and foremost its primary purpose was to create the atomic bomb. Since that time, much research has been done to address proliferation and long-lived radioactive waste concerns within the pure uranium cycle. I have checked some of the submissions to this committee and many of them accord with the terms of reference and deal with the uranium issue, so I will not go into those areas very much. What I would like you to consider is thorium based fission.

I was not sure at what level of detail to make this presentation so I will give an executive summary, then go through in a tiny bit more detail, then give my conclusions and allow you to ask me questions at the level of detail that you would like me to go into.

First, I will give some background. Thorium is three times more abundant in nature than uranium. Australia is the No. 1 repository of thorium. It has more thorium than the United States and Canada combined. I have some numbers here to illustrate that. In terms of thousands of tonnes, Australia has about 300; India is next with 290; Norway has 170; USA has 160; Canada has 100 and it drops off very rapidly after that. So Australia really has the world's major resources of thorium.

The key issue of thorium usage is that the fuel cycle leads to much less plutonium—weapons grade material—and other transuranic elements. 'Transuranic' means elements that are like uranium and heavier. In this field, you can think of fast and heavy as bad things, things that are going to lead to more radioactivity. Things that are small and light are good things. Thorium has an atomic number two less than uranium. There are many reactor concepts based on thorium fuel cycles under consideration. I will outline just a couple for you. I will go from the more speculative through to something that is currently being built. The source I am using for this information can be found at http://press.web.cern.ch/Public/Content/Chapters/AboutCERN/ResearchUseful/Future/Future-en.html.

The first one is called energy amplifier. It was invented at CERN, which is the world's premier accelerator facility, by Nobel Prize winner Carlo Rubbia. The idea is to combine a particle accelerator with a nuclear reactor. Firstly, they use thorium as fuel rather than uranium. The particle accelerator is used to produce slow neutrons. It is important that they are slow; you do not have excessive energy and the problems associated with fast neutrons. These slow neutrons will provide fission. CERN have done an experiment to show that the energy produced from such fission is 30 times more than the energy you need to put into the accelerator.

That is an important point. It is feasible. There is absolutely no possibility of meltdown, a Chernobyl-like runaway reaction, the reason being that as soon as you stop putting those slow neutrons in, the system stops. You lose your power to your reactor and it stops. If you have slow neutrons, there is no way you can have a runaway reactor. So it is inherently totally safe. It also has the interesting capacity to incinerate existing nuclear waste. The Russians, at the moment, are trying to get rid of about 150 tonnes of plutonium in similar ways. But there are some questions. From my reading, I am not sure how the neutrons are being created or of the cost. If you are to have a reactor then you have to build an accelerator. Is it going to be a commercial venture? It is not yet, no.

The next one I would like to talk about is more of a conventional style. The point that needs to be made is that, unlike uranium, all of the mined thorium is potentially usable in the reactor, compared with 0.7 per cent of natural uranium. So you have about 40 times more energy per unit mass available. Here, the thorium-232—232 stands for the mass number—absorbs a neutron that will come from some other source to become thorium-233. It then decays to another element called protactinium-233 and then to uranium-233, not to the 235 or 238 that are commonly used. This last uranium is separated and fed back into another reactor, and you have a closed recycled fuel cycle. That is basically the idea behind it.

Such a concept has been successfully demonstrated in the USA in the 1970s. It is currently being developed in a more deliberate proliferation resistant way, and India is currently building two reactors. I mentioned earlier that there is about three times more thorium than uranium, but in India it is six times more. India has lots of thorium, 10 per cent or so less than Australia, and it is seriously interested in this technology. There are also problems with this technology in terms of cost. There is a high cost of fuel fabrication, and there are technical problems in reprocessing. So there are issues there as well.

In conclusion, the thing I would basically like to communicate is that the thorium fuel cycle has potential for breeding fuel without the need for fast neutron reactors. It is inherently going to be safe. It should lead to considerably less weapons grade material. Waste will be much more manageable, with a shorter half-life. So there is considerable potential. I believe it could be a key factor in the sustainability of nuclear energy.

CHAIR—Some submitters to our inquiry are opposed to the use of thorium because thorium reactors, as you just mentioned, would produce uranium-233, which is said to be fissile. How do you respond to that?

Prof. Bray—You need to get energy out. Is uranium-233 better than uranium-235? The answer is that it is. I can read you a paragraph from the material I am using. It says:

> In one significant respect U-233 is better than uranium-235 and plutonium-239, because of its higher neutron yield per neutron absorbed ...

Later on it says that U-233 is ‘separated from the thorium, and fed back into another reactor as part of a closed fuel cycle’. Basically, yes, you will have radioactive substances involved. I do not want to suggest that there is no uranium involved or that there are no problems here. If there were no problems this issue would have been solved. It just leads to fewer waste products with very long half-lives. That is basically the response. We do need some version of uranium that will produce the energy that comes from fission.

Mr HATTON—Just following on from that, regarding its fissibility though, how much plutonium is produced as an end product? If we look at U-233, there is a plutonium output potential.

Prof. Bray—There is, yes.

Mr HATTON—How easy is it, compared to the current situation using U-235 or U-238, to get that plutonium output? Do we know in relation to this?

Prof. Bray—Yes. This is now getting into rather technical aspects of proliferation problems. It is addressed in the literature that I have been investigating. Basically, the idea is that the kind of plutonium that you generate has a mix of isotopes that makes it unworkable in weapons. The material I have says:

Plutonium produced in the seed will have a high proportion of Pu-238, generating a lot of heat and making it even more unsuitable for weapons than normal reactor-grade Pu ..

So, yes, plutonium gets generated, but it is a different isotope and in smaller amounts. The mixture makes it difficult for nuclear material to be separated out. It makes it very difficult to create weapons grade plutonium.

Mr HATTON—That is part of the argument about the current uranium based reactors. If you look at the civil programs, it is extremely difficult to get that. You cannot get a fast enough breed. The output is meant to produce power. It is not a fast breeder reactor and it is not meant to produce plutonium. We have had that argued generally. Is there that big a difference between the two processes?

Prof. Bray—I am not sufficiently educated in this area to know how well the new technologies operate. As I showed in one of the slides, there are technologies trying to minimise proliferation problems with pure uranium based systems. How they will compete with thorium I do not know, because these are research projects. I am not really able to answer which one will be more efficient than the other.

Mr HATTON—So is the output given the title U-233 because it is two down in terms of the atomic number?

Prof. Bray—Yes.

Mr HATTON—Thorium is two down from uranium, so that is why you get 233 instead of 235?

Prof. Bray—Yes.

Mr HATTON—I hope I am not pinching Mr Haase's question but I wanted to ask about mineability. With uranium, we have an existing capacity in Western Australia in particular and in other places where there is not much mining. In South Australia, certainly, there is the biggest uranium mine in the world, there is well-established practice and people know what they are doing. They also know how much it will cost them to extract it. In relation to thorium, how much has been mined? Given that you can use a great deal more, you get 30 times the output and you can use the whole of the thorium that you have been able to mine, rather than just 0.7 per cent, how easy is it to get it? How dispersed within the rock is it? Do you know anything about the cost of extraction?

Prof. Bray—I don't know enough of the details of the mining process. The figures I have here are from the US Geological Survey of January 1999, and it labels them as economically extractable—'world thorium resources economically extractable'. I am aware that it occurs basically everywhere, and one of the ways to get thorium out is from coal. When you burn coal, thorium comes out. It says here that it occurs in several minerals. It is quite a stable element. There is no suggestion here that it is difficult to mine. But there are problems that people talk about, in the vast literature that is available, with respect to making fuel. I think I mentioned in a previous slide that making fuel from thorium was a costly issue. It is a research project.

Mr HATTON—I would like to go on to the fusion aspects. Recently, a number of scientists were trying to get Australia involved in the project in France—to be one of a multinational consortium that is investing in it. Given that your fundamental speciality is with collision of electrons with atoms and what they get up to, I imagine you have some metallurgical experience.

Prof. Bray—No, not really. My experience is at the atomic physics level. What happens is that they ask us to calculate the kind of processes that will go on deep inside their plasmas. They will then combine that with the work of those people who have metallurgical experience in surfaces analysis, to let them know what sort of particles they can expect and in what densities to come against the walls and those sorts of issues. To give a specific example, the question is: when you built this large toroidal chamber, what do you build it from? It is a simple, fundamental question. So about three or four years ago they asked us to come to Vienna and we discussed these issues and then they asked us to perform electron collisions with boron, beryllium and various irons. In the end, it was decided that we would use a lot of beryllium and boron for these walls.

Mr HATTON—So at the moment it is part of the project; it is untested and it is based on your best guess. There seem to be two fundamental problems: one is the unknown medium-term and long-term reaction of that chamber, given the amount of heat that is generated within it, where you are trying to replicate the core of the sun, and we don’t have any experience with that because it has not been done before. But there is also the related question in terms of the amount of potential radiation and the amount of heat generated. Could that in itself be a problem?

Prof. Bray—The break-even point has already been reached in existing fusion reactors, which means the amount of energy you put in and the amount of energy you generate. The idea is that we should generate a lot more energy than we put in, and we have to have the means of extracting it. That, as far as I understand, is still a problem in material science: how do you get that energy out from the toroid in such a way that you can boil some water?

Mr HATTON—So that is still fundamentally what this experiment is about. The argument that was put to us was that when the decision was made, because of the weapons based approach to go with uranium and to produce weapons firstly and then go to the simple cycle, they could have gone to fusion then, despite the fact that most of what I had read or heard about was that it was still many decades off. They argue it is primarily a matter of will rather than the technical problems. Do you still think those technical problems have to be played out in this practical agenda?

Prof. Bray—It is a research project, there is no doubt about that, otherwise it would not be called an experimental reactor but there is enough reason. They have managed to convince Japan and the European Union to put in $20 billion worth. There is enough hope that we will make something worth while out of it. It has been on the cards for maybe 10 or 15 years. I have been giving public lectures on this facility for about 10 years and saying, ‘It is going to be built; it is going to be built.’ Finally, they have convinced enough people that there is good underlying science to pursue this route. I do not expect it will contribute to everyday household energy needs within 15 or 20 years.

Mr HATTON—Given your preference for what is not fully tried in terms of thorium reactors, which I think is based on the fact that they generate less heat, so they operate in a cooler fashion, they produce slower neutrons and do not have as much waste coming out of them, can you compare the third and fourth generation current nuclear reactors that are being produced, particularly the fourth generation pebble bed reactors? Given that they are an extension of what is being done, why would you still prefer the thorium?

Prof. Bray—I do not want to go on record saying that I prefer thorium, I would like to say on record that it deserves consideration, particularly in an Australian context. The reason is we have no infrastructure invested to go down purely the uranium route. We are starting anew and that is the difference. The US or Russia are doing a lot of research in this area. They are doing it as a way of getting rid of plutonium as they are trying to find ways to incinerate nuclear waste and that is a really important issue. So having invested very heavily in infrastructure associated with the uranium based cycle for them it makes sense to stay in that cycle as much as they possibly can to utilise existing infrastructure.

In an Australian context, it may be a little bit different. Let us consider what India is doing. India is an interesting in-between case. They have a lot of thorium and not as much uranium as Australia. I said it was a factor of six to one there. They are in both camps. I do not know enough about the details of these reactors to answer your question accurately. I cannot compare a fourth generation uranium based reactor against some of these others such as the one combined with an accelerator. They are so different and I would imagine costs associated with the accelerator would be enormous.

Mr HATTON—The question was a bit unfair given nothing has developed in the thorium area.

Mr HAASE—I think you have answered the question but let me be sure about that. Are there any thorium reactors operating today anywhere in the world in a producing role?

Prof. Bray—That is a tricky one. There are plenty which have started, had their life cycle and completed, so they have left them alone because they were experimental reactors. There was one in 1970, I think I mentioned it earlier. There is quite a large history of them. Between 1967 and 1988 an experimental pebble bed reactor was built at Julich. I worked with people at Julich on fusion but this is fission with thorium. That is a fairly early one. There was one in the United States in the 1970s. In India, both Kakrapar-1 and -2 units are loaded with 500 kilograms of thorium fuel when newly started. I think these two are currently running.

Mr HAASE—Where is that thorium being sourced presently?

Prof. Bray—For India, it would be from India.

Mr HAASE—Is Australia mining any thorium presently?

Prof. Bray—I do not believe we are utilising it. I think we cannot help picking it up from all our sands and soils but it is not being utilised.

Mr HAASE—When you say sands, do you mean mineral sands mining in Western Australia?

Prof. Bray—Yes, absolutely. There are huge reserves in Western Australia.

Mr ADAMS—Whereabouts is it, other than in Western Australia? Is it in any other locations?

Prof. Bray—It is fairly uniformly spread, as far as I understand. It is in sandy soils, typically. That is my understanding. I am not a miner. You are asking me many questions. Forgive me; I have to be honest.

Mr HAASE—So you are perhaps saying that we are producing it as a by-product but not deliberately.

Prof. Bray—And we are not looking for it.

Mr HAASE—So is anyone presently buying a thorium product from Australia because it is thorium, to your knowledge?

Prof. Bray—Not for the purpose of fission but for the purpose of making high-quality lenses and for lighting and other things. It is in small quantities. Thorium has been used quite extensively by industry for quite a long time but not in the kinds of quantities we are talking about.

Mr HAASE—You say it is used in high-quality lenses. Can you describe for our benefit the nature of this product? Is it exported as a powder or as a metal? What is it?

Prof. Bray—It certainly is a metal. The World Nuclear Organisation says:

Thorium is a naturally-occurring, slightly radioactive metal discovered in 1828 ... named ... after Thor, the Norse god of war. It is found in small amounts in most rocks and soils, where it is about three times more abundant than uranium. Soil commonly contains an average of around 6 parts per million ... of thorium.

In answer to how it has been used, the World Nuclear Organisation says:

... thorium has found applications in light bulb elements, lantern mantles, arc-light lamps, welding electrodes and heat-resistant ceramics. Glass containing thorium oxide has a high refractive index and dispersion and is used in high quality lenses for cameras and scientific instruments.

But I am not able to answer in what quantities or to put a dollar value on it.

Mr ADAMS—I will start off with a very simple question, Professor, which you should be able to answer very easily. What is the difference between fusion and fission?

Prof. Bray—In fusion you start with light elements, typically hydrogen or what is called heavy hydrogen, and you combine them. You fuse them. You bring things together and you get more energy out.

Mr ADAMS—So you bash them together and out of that comes energy.

Prof. Bray—Yes, because they stick together. Because these are light elements, the way quantum mechanics works is that you get excess energy out. I should say that we were all created inside the cores of stars by the fusion process, so every element in our bodies that is lighter than iron was created as a result of fusion in the cores of stars. They have blown up and spread around the universe, and that makes us. Fission, on the other hand, involves very heavy elements. With elements that are much heavier than iron, if you break them up you have excess energy coming out. So fusion is for light elements and you bring things together; fission is for heavy elements and you break them apart.

Mr ADAMS—So the experiment in France that a lot of countries have signed up to is fusion.

Prof. Bray—Yes.

Mr ADAMS—I thought that one of the issues was to do with having to build a wall around the container for that much energy. But you think that we already have that solved and it is about getting the energy out of the process.

Prof. Bray—Yes. The idea is that you are trying to reproduce the core of the sun inside this chamber, with very light particles. The very light particles fuse together and heat comes out somehow. How do we get that heat out?

Mr ADAMS—You think we can contain that okay. You do not think it is necessary to build a wall around it?

Prof. Bray—Containment is okay because of the high energy involved. You are working with charged particles, and charged particles can be maintained via magnetic fields.

Mr ADAMS—So they can stay there and be controlled.

Prof. Bray—That is right. They can go around the magnetic field lines, so they can stay. But you cannot always guarantee that everything will always be charged. As soon as something becomes neutralised it goes out and hits the wall. That is why it is important to know what you have made your wall from.

Then the excess energy has to be somehow channelled out, and that is a materials problem. But people believe they can get on top of it. A lot of written material and research is currently being done. You hear about hard coatings of all sorts of materials constantly being developed. Look at the alloys in our cars. They are only a few years old, most of them. So a lot of materials research is ongoing.

Mr ADAMS—Are there a lot of people in the world working on this science?

Prof. Bray—Fusion science is very expensive. We are talking about billions. So in that science there are not that many areas but they are highly prestigious, and certainly the big countries—the United States, the UK, Japan—and the European Union all have very large investments in these areas. Fission is not quite so expensive. There is a lot more history there. France is fiercely independent, a huge investor in fission. South Africa, through the apartheid era, had to go towards fission for survival because they could not guarantee oil. So there is a lot of expertise there.

Mr ADAMS—How much have we got in Australia and how much university-level expertise is there?

Prof. Bray—Please forgive the political answer: not enough. We certainly do not have a great deal. We have a wonderful facility here at the ANU and there are very good theorists, and then of course there is ANSTO and you have had submissions from there. But they are unique facilities in Australia and they could use some real competition.

Mr ADAMS—Are there students wanting to go into this area? Are there people who are interested?

Prof. Bray—It is a bit of a catch-22 situation. Without visibility it is difficult to attract students. But as soon as the world says that the nuclear option has to be considered very seriously you will see an enormous change. I am very confident you will, because this is very interesting science—it always has been very interesting science—and primarily physicists get excited by the science and applications are wonderful bonuses. A lot of our work has application, but the joy is really in the pure science and everything else is just icing on the cake.

Mr KATTER—In my home area of Cloncurry-Mount Isa, which is arguably the biggest mineral province in the world, I have heard the rare-earth thorium phosphate mineral monazite mentioned many times. Is north-west Queensland one of the areas where there are deposits?

Prof. Bray—I am sorry; I do not know the geographical distribution of that.

Mr KATTER—Don't worry. It also has the eight biggest phosphate deposits in the world.

Prof. Bray—From what I read, you are likely to have heaps as well.

Mr KATTER—When you separate the thorium from the U-233, the U-233 goes back into the breeder reactor operation. Is the thorium that is left over at that stage dangerous? How dangerous is it and how do you deal with it?

Prof. Bray—The thorium itself comes predominantly in one major isotope, which has a half-life three times the age of the earth—so it is very stable. As it says here:

… thorium isotopes occur in its and in uranium decay chains. Most of these are short-lived and hence much more radioactive than Th-232, though on a mass basis they are negligible.

They destroy themselves relatively quickly.

Mr KATTER—But is the thorium itself dangerous? You are saying it has a long half-life, but—

Prof. Bray—No—

Mr KATTER—It is not like uranium, where you can get cancer from radiation?

Prof. Bray—It depends on which uranium. People mine uranium. Certain isotopes are much more dangerous than others. Plutonium is particularly the nasty one.

Mr KATTER—But what about thorium?

Prof. Bray—It is my understanding that thorium will quickly be dominated by its most stable isotope. There are a few that are dangerous. They are stable in the reactor, but as part of the waste cycle you will end up with some isotopes that are dangerous but they become not dangerous very quickly.

Mr KATTER—What is 'very quickly'—100 years, 10,000 years?

Prof. Bray—No. It is tens of years, as opposed to hundreds of thousands.

Mr KATTER—Is it cheaper than conventional breeder reactor nuclear energy?

Prof. Bray—I cannot answer that question, because there are so many different combinations and suggestions. At the moment, we have a lot of experience with pure uranium based reactors and relatively little with thorium. India has gone both ways. At some stage, they will make a decision as to whether one is going to be particularly more efficient than another. It is a research project; I do not want to suggest—

Mr KATTER—The paper we have here from the World Nuclear Association does not make clear to me whether the energy is coming from the thorium or whether the thorium is like ethanol in petrol—it just gives you a better burn in the petrol.

Prof. Bray—The purpose of thorium is to produce uranium-233. You start with thorium and then, through the decay chain, by introducing some slow neutrons, you end up with uranium-233, which then in turn becomes a typical fission—

Mr KATTER—That is good as far as energy goes.

Prof. Bray—That is right. That is the fissionable material, and that is how you get the energy in the end.

Mr CADMAN—What is our base of nuclear scientists in Australia? Do we have sufficient to enter into any serious expansion, research or industry?

Prof. Bray—Yes, we do. The reason I can answer that question reasonably well is that I was on a committee of the Australian Institute of Physics awarding a medal to a person who has made the greatest contribution to Australian physics, which is internationally renowned. A couple of years ago, it was a nuclear physicist. And it is never one great person; they usually have a very good group around them. I have also worked for the Australian Research Council for the last three years, and we have awarded a number of grants to people who are competitive on the world stage in the area of nuclear physics.

CHAIR—There being no further questions, thank you for appearing before the committee today. If the committee has any further questions, we will contact you. Is it the wish of the committee that the presentation of slides provided by Professor Bray be received as evidence for the committee? There being no objection, it is so ordered.

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

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

Committee adjourned at 12.22 pm