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STORY ARCHIVE

Thursday, 11 October 2012

Next Generation Nuclear Power

Dr Graham Phillips investigates next generation nuclear reactors to find out what makes them safer than previous models.

TRANSCRIPT

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NARRATION
We know the greenhouse gas message. More extreme weather, more acidic oceans, more flooded coastlines. There is a remedy - switch to more carbon-free nuclear power.

Prof Per Peterson
It's difficult for me to see how we can transition away from fossil fuels and not use significant amounts of nuclear energy.

NARRATION
Even environmentalists have put this energy option on the agenda.

Prof Tim Flannery
I can't see an alternative to nuclear power, at least as part of that generation of base load.

Dr Graham Phillips

But then came the Fukushima disaster in Japan, and that in turn reminded us of the Chernobyl accident a couple of decades earlier, and, in many people's eyes, nuclear was back off the agenda. It was just too dangerous.

NARRATION
We still don't know how many years it will take to decontaminate this area, and for the thousands of displaced people to be able to return home.

Prof Derek Abbott
My view is that nuclear power in any form is not sustainable on a global scale.

NARRATION
After Fukushima, Japan is now talking about phasing out its nuclear reactors. Germany too is moving away from nuclear in favour of renewables.

Prof Barry Brook
I think the consequences of ignoring nuclear energy or shutting it down worldwide would be severe from a climate-change perspective.

NARRATION
Should we embrace nuclear or not? Historically, our love hate relationship with the power of the atom goes back a long way. In the beginning, Marie Curie, who invented the word 'radioactivity', could see the great potential of nuclear for medicine. But in the 1940s, some big nuclear negatives exploded onto the scene. After the war came a push to love the atom again. Some peaceful uses never caught on, like using nukes for engineering.

Man
New harbours, big dams, canals, passes through rugged mountainous terrain.

NARRATION
Others - food irradiation - are used today, although in a limited way.

Man
The gamma rays are as fresh after 18 months as when they were dug.

NARRATION
But what did take hold was nuclear energy generation. The first commercial power plants appeared in the 1950s. These generation I reactors were pretty crude, but safety standards have been improving.

Prof Per Peterson
If you think about automobiles, a car that you would buy today is going to be intrinsically better designed and safer than one you would've bought 30 years ago. We're doing the same thing with nuclear plants.

NARRATION
And that's the Fukushima defence - these are older generation II reactors, built in the '60s and '70s, not the much safer generation III of today.

Prof Per Peterson
So what we need to do is to develop reactors that are increasingly safe, so that as we continue to use fission as an energy source, the safety level and therefore the risk of getting radioactive material into the environment is kept acceptable.

NARRATION
But can that be done? We went to California to get a glimpse of the next wave of reactors, generation IV. These are the nuclear engineering labs at the University of California, Berkeley, where they're developing a reactor they say is much safer. Its radioactive fuel is sealed and can't escape into the environment.

Dr Graham Phillips
In a conventional reactor, the fuel comes in the form of little cylinders, about that big. Now, they have no protective coating. But this reactor, however, has two layers of protection. One, the fuel pellets are

housed inside spheres like this - spheres of graphite. There's thousands of them in there. In fact, we've got a simulation of them here. They're so tiny, you can barely see them. And for a second layer of protection, each one of those has a protective coating as well. So if there were an accident, it's very unlikely the fuel could escape into the environment.

NARRATION
Those spheres are simulated here by coloured balls. They're testing how they'll flow slowly but continuously through the reactor's reaction vessel. And made out of tough graphite, they're supposedly meltdown-proof.

Prof Per Peterson
Once we go to reactor fuels that essentially are impossible to melt, then we've got reactors which have an even higher level of intrinsic safety.

NARRATION
Already, a pebble reactor is operating in China. But the Berkeley design will step up the safety yet another notch, by using a new coolant. In a nuclear reactor, the coolant is the fluid that flows over and absorbs the heat from the hot radioactive fuel. The electricity's then generated from this heat. In this Chinese reactor, the coolant fluid is helium gas. In standard reactors, it's just water. But Berkeley's is very different.

Dr Graham Phillips
This reactor doesn't use water to flow through the fuel elements and extract the heat - it uses melted salt. Now not table salt, sodium chloride, but the related substances lithium and beryllium fluoride. Heat these guys to about 450 degrees Celsius and they turn into a clear liquid.

Mike Laufer
One of the big advantages of the salt is that it's very effective in moving heat around, but it's at low pressure.

NARRATION
Low pressure means a less accident-prone reactor. Today's generation IIIs run at a staggering 70 times atmospheric pressure.

Prof Per Peterson
If we switch to liquid coolants, like these fluoride salts that we're using, then we can build much more compact, high power density systems that operate at atmospheric pressure, and that gives us a system which is intrinsically safe, because there's no source of pressure to disperse radioactive material.

NARRATION
For another safety innovation, I went to the eclectic labs of General Atomics in San Diego. Here, they research everything from magnetically levitated trains to algae for car fuel. For nuclear reactors, they're planning to replace the fragile metal parts.

Dr Graham Phillips
One of the problems with high-temperature reactors is things can melt. For example, in today's reactors, the fuel is held in place by metal rods. Now, metal melts relatively easily. So the researchers have developed this amazing material, silicon carbide, that can withstand temperatures of up to 2,500 degrees Celsius.

NARRATION
At Fukushima, the metal rods did indeed break down. Silicon carbide would've prevented that. Could generation IV reactors be made fail-safe?

Prof Barry Brook
No-one can guarantee you 100% of the time, for a million years in the future, you'll never have another meltdown. But the probability of that type of accident that occurred at Chernobyl or Fukushima is virtually zero.

Prof Derek Abbott
Because a nuclear station is such a complex beast, there are always pathways to accidents, either

through human incompetence, through human error, components rusting, corroding, or through natural disaster, as we well know.

NARRATION
And beside safety, Derek says there's another little mentioned problem with nuclear. Today's high-tech gadgets underline it. Building products like these requires increasing amounts of exotic metals, like hafnium and tantalum. The problem is these same metals are used in great quantities to build nuclear reactors, and they're lost to the world when the reactors are decommissioned and their waste buried.

Prof Derek Abbott
It's not that these metals can then be re-used and recycled - if they were recyclable, that would be different, but what happens is they become radioactive and you bury them for 100,000 years. So what we're essentially doing is making more and more elements extinct via nuclear power, and that's reducing elemental diversity.

Prof Barry Brook
I think he's making a mountain out of a molehill. The problem with Derek Abbott's viewpoint is he's trying to look a billion years into the future and say, 'What's the ultimate sustainability of different energy sources?' whereas I'm trying to think about how we solve a problem on the 100 to 1,000 year timescale.

NARRATION
Derek says we should skip nuclear and go straight to its great competitor.

Prof Derek Abbott
The amount of solar energy that hits the surface of the planet is 5,000 times the amount of energy we currently use. So we only have to tap solar energy at less than 1% of that and we've got our energy needs in the bag.

NARRATION
Like nuclear, big solar power stations could be built in the desert.

Prof Derek Abbott
If you add up all the solar energy that hits all the deserts of the world, that amount of solar energy over six hours is enough to power the whole world for a year.

NARRATION
The trouble is, unlike nuclear, sunshine is intermittent. It varies with the weather and seasons, and disappears completely at night.

Prof Derek Abbott
What is needed there are many solar farms all interconnected together on a grid and so you balance out that intermittency.

NARRATION
But nuclear's great attraction is it can slot straight in to today's grid.

Prof Barry Brook
It provides what I call a 'plug and play' alternative to coal. You can take out a coal-fired power station, you can put in a nuclear power station and you have something that has replaced coal.

NARRATION
Since we discovered the power of the atom, there's been great optimism for nuclear. We'll have to wait and see how this long-time love hate relationship works out.

Topics: Technology, Environment, Maths & Physics

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Related Info

Generation IV: Technology Roadmap

Gen IV (US Department of Energy)

Nuclear Power Plants - Now Safer and Cheaper (ABC Science Show)

YOUR COMMENTS

Comments for this story are closed. No new comments can be added.

William - 18 May 2013 10:46:22pm

Hi Graham, I've been thinking about the Fukushima disaster & some of the details that led to the meltdown of multiple reactors. In one report that I read from Dec 2011, it's been estimated that the time-frame for decommissioning the nuclear power station at Fukushima is 40 to 50+ years!!....

Mid & Long Term Roadmap towards Decommissioning Fukushima Daiichi;
http://pbadupws.nrc.gov/docs/ML1210/ML12103A108.pdf

In regard to the meltdown details of the reactors at the Daiichi plant, I recently found some really informative online documentaries that explained how rapidly the meltdown situations developed & why they occurred....

Fukushima NHK Documentary - Meltdown;
http://youtu.be/ixjlSsUlNBw
http://youtu.be/vpA0TOgB9-o
http://youtu.be/ps8PBh197pg

Corium â€“ The Most Dangerous Man-made Lava Flow;
http://www.wired.com/wiredscience/2013/04/the-most-dangerous-manmade-lava-flow/

Thorium Reactors: Back to the Dream Factory;
http://www.ccnr.org/Thorium_Reactors.html

William - 12 May 2013 11:03:10pm

Iâ€™ve been pondering over a question that Dr Graham presented about the generation IV reactorsâ€¦

"At Fukushima, the metal rods did indeed break down. Silicon carbide would've prevented that. Could generation IV reactors be made fail-safe?"

I guess new material technology might help prevent a nuclear fuel melt-down, but how do you eliminate

the accident risk that gets created through unethical decisions & reckless management?

As an example of the specific choices that were made with material technology surrounding a high-energy fuel source, I couldnâ€™t help thinking back to the Space Shuttle Challenger Disaster in 1986. It is time well spent reading the detailed commentary from former Morton Thiokol Engineer, Roger Boisjoly;

Ethical Decisions â€“ Morton Thiokol and the Space Shuttle Challenger Disaster;
http://www.onlineethics.org/Topics/ProfPractice/PPEssays/thiokolshuttle.aspx

In regard to some of the past decisions that were made using nuclear fuel, it's now 27 years since the Chernobyl catastrophe that occurred on April 26th 1986 at 1:23am.

May the choices we make for the future be very sensitive to the past & presentâ€¦

Chernobyl 3828
http://youtu.be/0xavqHI33QE

Arthur Robey - 17 Oct 2012 7:24:01pm

I went to ICCF17 in Daejeon Korea.
Professor Hagelstein has created a model for why Cold Fusion works. He used his model to predict collimated x-rays from the surface of the metal Mercury.
This was his 282nd attempt over 20 years. He shows how nuclear and phonon energy can be coupled. The process can operate in both directions. Nuclear energy can be extracted from the nucleus. And energy can be transmitted into the nucleus where it is store as mass. Transmutation.
And how many of the Main Steam Media were there? None. Your reputation is deserved.
Here is my report.
http://coldfusionnow.org/updates-from-iccf-17/

Myopic dystopia - 14 Oct 2012 11:53:40pm

Barry Brook: "The problem with Derek Abbott's viewpoint is he's trying to look a billion years into the future and say, 'What's the ultimate sustainability of different energy sources?' whereas I'm trying to think about how we solve a problem on the 100 to 1,000 year timescale."

I wonder who has the "problem". Yes let's get 100 years (one human generation) of profligate energy and leave 100,000+ years (half of all human existance) of concentrated nuclear waste for future generations to deal with (if they can still exist after we're gone.)

Pete Blurg - 14 Oct 2012 12:33:12pm

Has anyone considered that the preferred molten cooling salt mixture is toxic? Beryllium Flouride is VERY toxic and very soluble in water. Lithium Flouride is toxic. Both salts emit toxic fumes when heated.

Bob Fernley-Jones - 14 Oct 2012 10:32:05am

Part of the narration:

â€œAfter Fukushima, Japan is now talking about phasing out its nuclear reactors. Germany too is moving away from nuclear in favour of renewables.â€□

Seems to be more than a tad misleading. For instance:

According to Forbes in an article entitled:
Germany -- Insane Or Just Plain Stupid?
http://www.forbes.com/sites/jamesconca/2012/08/31/germany-insane-or-just-plain-stupid/

Germany plans to build over twenty new coal (brown lignite) fired power plants.
Other sources say much the same.

Elsewhere it is reported that Germany is moving away from renewableâ€™s subsidies because of cost concerns and German industries moving offshore for cost savings

Frosty - 12 Oct 2012 5:36:47pm

How about an update on Solar Thermal around the world and the rapid growth of wind power, perhaps in separate segments?

Solar PV is going ahead in leaps and bounds as well, what about an update on that?

Jack Walker - 12 Oct 2012 3:02:13pm

Dr Phillips, I found last night's program on nuclear power reactors gen 1V very interesting. Were you aware that the AAEC(Lucas Heights) was researching Pebble-Bed nuclear reactors in the early 1960s. In this concept, the U fuel was encased in Beryllium oxide and the pebbles would circulate through the core, the coolant was removed by liquid sodium. Be is an excellant neutron moderator and as the core is ceramic high operating temperatures can be achieved. However, ongoing irradiation studies in HIFAR proved that the BeO did fracture over time and this major project was terminated about 1968. I was at AAEC from 1957-91. (See "The Australians"(Rigby) 1966,pp 204-9, by Goodman and Johnston.)

Levi - 11 Oct 2012 10:54:06pm

Are you serious Catalyst?

Another story on Nuclear Power, another failure to mention Thorium and the LFTR...
Perhaps you guys have forgotten what you said on a post last year?

Catalyst - 29 Apr 2011 11:20:11am

"Dear Graham,
Thanks for your post. We have been planning to do a story on Thorium for several years âå¬â€œ it is intended that the subject be covered early in the 2012 series.
Thanks for watching Catalyst."

Maybe it's time you followed it up?

Alan - 12 Oct 2012 4:06:48pm

Totally agree with you levi,
not just LFTR, but also WAMSR and TWR as well.

Hayward - 11 Oct 2012 8:46:55pm

No Nuclear Generation System in the world runs without almost total taxpayer support from scoping to decommissioning.

US nuclear reactor development was part of the USN nuclear submarine programme. Those that became involved were told that nuclear generated power would be so cheap there would be no need to meter it!

US nuclear power, together with Defense are some of the greatest consumers of US government largesse, really the tax payerâ€™s. Christopher Crane, Senior Vice President of Exelon, April 2007 in address to the US Congress said that loan guarantees for new power plants must cover 100% of project debt, as otherwise financing of new power plants would be extremely difficult. Then there are the insurance costs...

Nuclear power is competitive only if the financial/insurance costs are assumed by the public purse.

Which is exactly what has happened with the Japanese government taking a controlling stake in Tokyo Electric Power (TEPCO) in return for a one trillion yen ($12.5bn; £7.8bn) taxpayer bailout.

For TEPCO faces huge clean-up and compensation costs from that disaster follwing the earthquake and tsunami last year that affected Fukushima

Such nationalisation is to avoid a collapse of the company. Just one more case of socialise the losses while letting the profits be privatised.

TCO including energy, environmental, infrastructure and finance for the materials, construction,

maintenance of the plant/s THEN the big one decommissioning.

True ROI costs from start up to shut down and decommissioning?

Will a plant be energy positive within its payback period?

Extraction of more uranium ore/enrichment for fuel. Energy, environmental. infrastructure and financial costs for more mines which also need vast quantities of fresh water. With costs to rise as ore grades decrease.

WOL energy, environmental and financial costs?.

Australia does not have the numbers of academically/technically trained to do the work. Even better, outsource it all to our US friends. That will not come cheap, even if we get â€œmateâ€™s ratesâ€□ Viz. Abrams Tanks, not so Super Hornets, Wedgetail, F 35....

It is the grid that is the real problem. With only c.25% of the energy input providing consumable energy ito the end user. This coupled with badly designed commercial buildings and private dwellings means we still have a 19th century supply and consumer model running in the 21st. C.

We have abundant LNG. So abundant that we sell it to China for c. 5c/litre.For the costs of the aany nuclear programme, and without the waste problem, it should be possible to put in place an LNG pipeline network running smaller more local power generation plants. This should result in much greater energy efficiencies.

While we should, as the developed country with the greatest amount of insolation, use solar in bot

brendan - 12 Oct 2012 12:46:36pm

what a load of unsupportable rhetoric. Unreliable "renewables" are supported with feed in Tarrifs, preferential purchase schemes, outright grants the last of which was I recall A$5Billion. They have done nothing but prove themselves uncommercial http://thingsworsethannuclearpower.blogspot.com.au/2012/10/big-energy-part-1.html without political support from the totally unscientific anti nuclear lobby, no one would waste their time, particularly when you consider the waste problem from solar panels, which is around forever after they have expended their 20 year life

Pro-Nuke - 13 Oct 2012 2:48:14am

Maybe. But at least with these so called taxes, you get something of value in return...clean air and minimum disturbance of land. Solar and LNG don't offer these benefits.

Richard horobin - 11 Oct 2012 8:16:40pm

Nuclear is not just uranium-plutonium based. You ignored Thorium, proposed for gen iv. Could you explore Thorium soon, please, like you did in 1987?

Terry Krieg - 17 Oct 2012 8:11:27am

I missed the programme but Barry Brook is on the ball. Prof Abbott isn't. He's just plain anti-nuclear. Prof Flannery surprised me. He seems to vaccilate between pro and anti-nuclear. I wish he'd make up his mind. Regardless of all the technical stuff and cost and safety fears the fact is, there are currently 31 countries using nuclear power and another 17 countries are building reactors as I write. 443 reactors operating now will grow to 552 within the next 10 years. Australia should get it's head out of the sand and join the growing list of countries with nuclear power. If we haven't got a reactor within the next 10 years, we'll rightly be regarded as technologically backward and irrelevant.

Ted Small - 19 Oct 2012 6:09:21pm

Why can't Australia be at the forefront of Thorium technology and generation. The advantages are mindblowing.

Ted Small - 19 Oct 2012 6:07:01pm

Absolutely correct. China is now working on Thorium generators, we should have been working on this technology since the first document was produced all those years ago. Australia has a large proportion of the worlds Thorium. Thorium generators can supply the base load, produces no weapons grade material, uses almost all the radioactivity amongst other big advantages. How I would love to organise a consortium of people interested in Australia and not personal greed.
