Nuclear in Australia

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In recent months, the question of using nuclear power as an energy source has been increasingly under debate. In particular, Australian political and scientific groups are involved in an exchange of opinions following the visit of the Australian Foreign Minister Alexander Downer to Beijing last year. On that occasion, the vice-president of "China's National Development and Reform Commission" Zhang Guabao explicitly demanded the Australian Government's approval for a possible uranium supply, which will soon be needed as a consequence of the development of the Chinese nuclear system (at the moment China has nine operable reactors, two under construction, eight planned and 19 proposed for the coming years).

As shown in Chart 1, Chart 2 and Chart 3 (source: Uranium Information Centre Ltd – Melbourne Australia- Nuclear Power in the World Today - Nuclear Issues Briefing Paper 7 – January 2005), the clear and remarkable Chinese nuclear policy is in line with some of the most developed and underdeveloped countries. 16% of world electricity is produced from nuclear, whilst 39% from coal, 19% from hydro, 15% from gas and 10% from oil. Lithuania produces 80% of its electricity from nuclear, in France 78% of electricity comes from nuclear, some countries such as Belgium, Bulgaria, Hungary, Switzerland, Sweden and South Korea produce approximately 30% of their energy from nuclear, 25% is the percentage produced in Japan and 20% in the USA.

Chart 1

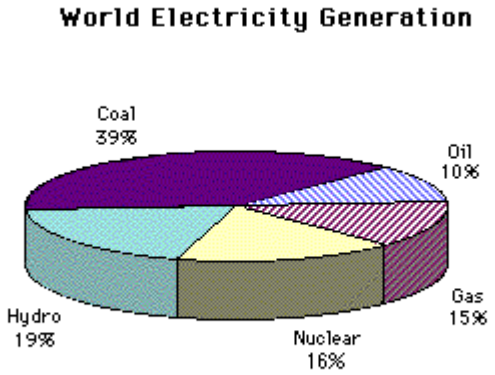
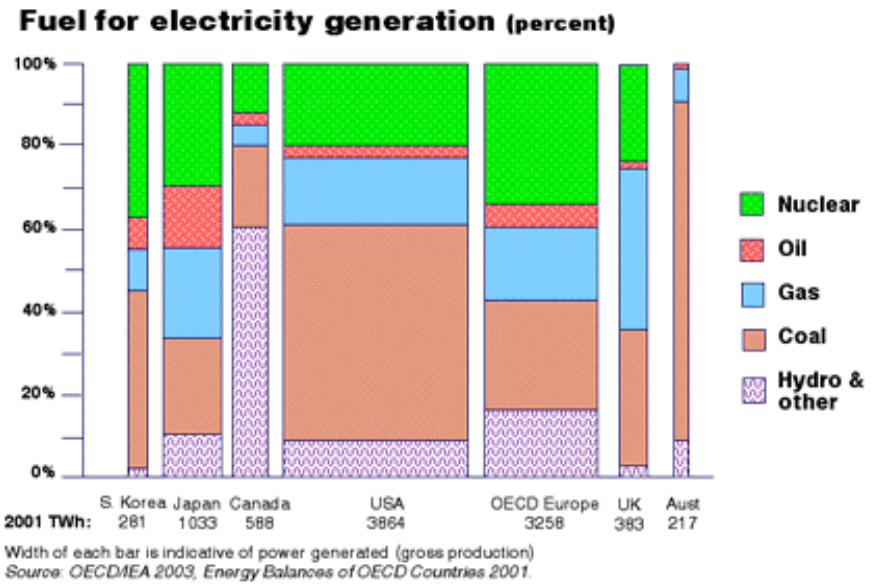
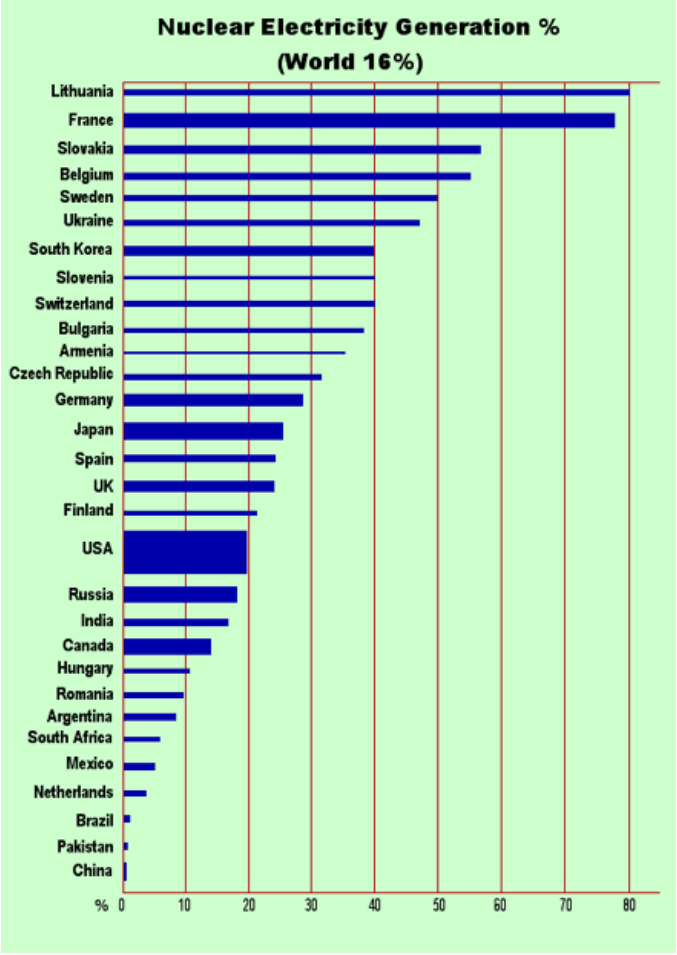


Chart 2



Width of each bar is indicative of power generated (gross production)
Source: OECD/IEA 2003, Energy Balances of OECD Countries 2001.

Chart 3



In 2000-01 (source: IEA/OECD) raw materials extracted for energy production in Australia (approx. 15,237 Pj) were 60% fossil fuel (50% coal and 10% oil), 30% uranium and about 8% natural gas. 120,000 people were employed in the energy sector and the economic yield in export amounted to 24 billion Australian dollars. Furthermore, still in 2000-01, national consumption for electricity production was approximately 2173 Pj, distributed as follows: coal 77.2%; oil 1.3%; natural gas 12.6%; hydro 8.1%; refuse and biomass 0.8%. This clearly shows Australian dependency on coal (77.2%) and fossil fuels in general (91.1%) to produce electricity, which is the factor that induced the Australian government to disagree with the Kyoto Protocol.
Australia is largest producer of uranium (owing approx. 30% of the world resource). Australian uranium export represents about 22% of world market. In the last five years, Australia exported around 46,600 tons of uranium oxide to 11 countries (USA, Japan, South Korea, Canada, Spain, France, UK, Sweden, Germany, Belgium and Finland) with an economic yield of about 2.1 billion Australian dollars. In the last year, the three Australian mines produced 10,964 tons of U_3O_8 overall: 5,544 tons from Ranger mine in the Northern Territory; 4,356 tons from Olympic Dam mine in South Australia and 1,064 tons from Beverley mine in South Australia.
As shown in Table 1, in the last year (2004-05) the 441 operable nuclear reactors in 31 countries generated 2,619 billion KWh of electricity in the world by using 68,359 tons of U_3O_8, 10,964 tons of which were from Australia.

Table 1 Nuclear reactors in the world and uranium requested (year 2004-2005)

	NUCLEAR ELECTRICITY GENERATION 2004		**REACTORS OPERABLE Sept 2005**		**REACTORS under CONSTRUCTION Sept 2005**		**REACTORS PLANNED Sept 2005**		**REACTORS PROPOSED Sept 2005**		**URANIUM REQUIRED 2005**
	billion kWh	% e	No.	MWe	No.	MWe	No.	MWe	No.	MWe	tonnes U
Argentina	7.3	8.2	2	935	1	692	0	0	0	0	140
Armenia	2.2	39	1	376	0	0	0	0	0	0	55
Belgium	44.9	55	7	5728	0	0	0	0	0	0	1163
Brazil	11.5	3.0	2	1901	0	0	1	1245	0	0	311
Bulgaria	15.6	42	4	2722	0	0	0	0	1	1000	345
Canada*	85.3	15	18	12595	0	0	2	1540	0	0	1796
China	47.8	2.2	9	6587	2	1900	8	8000	19	15000	1352
China: Taiwan	37.9	21	6	4884	2	2600	0	0	0	0	955
Czech Republic	26.3	31	6	3472	0	0	0	0	2	1900	474
Egypt	0	0	0	0	0	0	0	0	1	600	0
Finland	21.8	27	4	2656	1	1600	0	0	0	0	540
France	426.8	78	59	63473	0	0	0	0	1	1600	10431
Germany	158.4	32	17	20303	0	0	0	0	0	0	3708
Hungary	11.2	34	4	1755	0	0	0	0	0	0	274
India	15.0	2.8	15	2993	8	3638	0	0	24	13160	351
Indonesia	0	0	0	0	0	0	0	0	2	2000	0
Iran	0	0	0	0	1	950	2	1900	3	2850	125

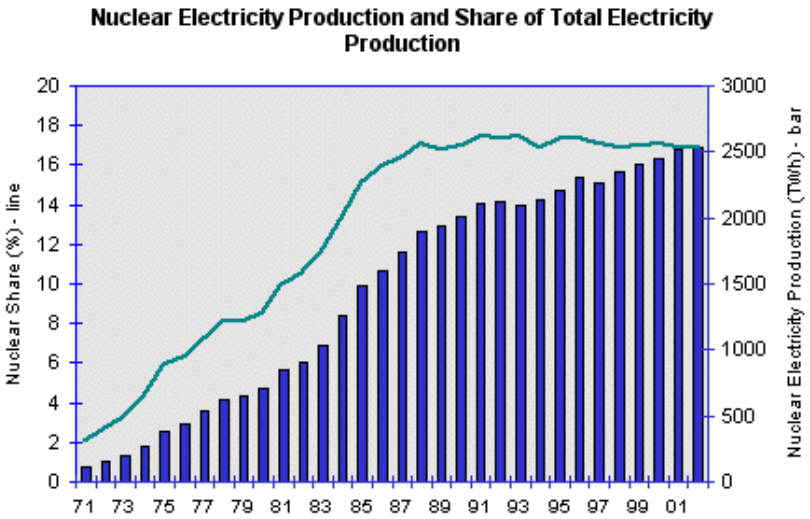
Israel	0	0	0	0	0	0	0	0	1	1200	0
Japan	273.8	29	55	47700	1	866	12	14782	0	0	8184
Korea DPR (North)	0	0	0	0	1	950	1	950	0	0	0
Korea RO (South)	124.0	38	20	16840	0	0	8	9200	0	0	3011
Lithuania	13.9	72	1	1185	0	0	0	0	0	0	290
Mexico	10.6	5.2	2	1310	0	0	0	0	0	0	237
Netherlands	3.6	3.8	1	452	0	0	0	0	0	0	112
Pakistan	1.9	2.4	2	425	0	0	1	300	0	0	57
Romania	5.1	10	1	655	1	655	0	0	3	1995	90
Russia	133.0	16	31	21743	4	3600	1	925	8	9375	3409
Slovakia	15.6	55	6	2472	0	0	0	0	2	840	373
Slovenia	5.2	38	1	676	0	0	0	0	0	0	128
South Africa	14.3	6.6	2	1842	0	0	1	165	24	4000	356
Spain	60.9	23	9	7584	0	0	0	0	0	0	1622
Sweden	75.0	52	10	8904	0	0	0	0	0	0	1536
Switzerland	25.4	40	5	3220	0	0	0	0	0	0	595
Turkey	0	0	0	0	0	0	0	0	3	4500	0
Ukraine	81.1	51	15	13168	0	0	2	1900	0	0	1531
United Kingdom	73.7	19	23	11852	0	0	0	0	0	0	2409
USA	788.6	20	103	97838	1	1065	0	0	2	2850	22397
Vietnam	0	0	0	0	0	0	0	0	2	2000	0
WORLD	**2618.6**	**16**	**441**	**368,246**	**23**	**18,516**	**39**	**40,907**	**98**	**64,670**	**68,357**

Sources: Reactor data: WNA to 29/9/05.
IAEA - for nuclear electricity production & percentage of electricity (% e) 7/7/05.
WNA: Global Nuclear Fuel Market (reference scenario) - for U. Operating = Connected to the grid
Building/Construction = first concrete for reactor poured, or major refurbishment under way
Planned = Approvals and funding in place, or construction well advanced but suspended indefinitely;
Proposed = clear intention but still without funding and/or approvals.
TWh = Terawatt-hours (billion kilowatt-hours), MWe = Megawatt net (electrical as distinct from thermal),
kWh = kilowatt-hour

NB: 68,357 tU = 80,613 t U_3O_8

It is interesting to observe in Chart 4 the increment in nuclear electricity production over the last thirty years.

Chart 4.



In consideration of Australian national potential thanks to its uranium reserves and the current world trend, Australia is seriously thinking of reconsidering nuclear as an energy source. The issue is based upon the following remarks:

1. the new process technologies and the new materials used ensure the construction of reliable and safe nuclear plants for electricity production (during the last decades, just one serious incident took place, Chernobyl, due, among all, to an old project and insufficient monitoring). Furthermore, due to the considerable increase in fossil fuel prices (oil price increased by 60US$ per barrel), costs of nuclear electricity production are very competitive and, at the same time, costs for building a nuclear reactor are totally comparable to the costs for other power stations (in particular the ones which use coal and gas);
2. the current vitrification techniques for nuclear waste, thanks to SYNROC process currently used in the UK and USA although resulted from studies carried out in Australia by the ANSTO (Australian Nuclear Science & Technology Organization), offer a deeper knowledge on how to treat nuclear waste;
3. the fact that nuclear plants do not produce carbon dioxide CO_2, which is the main responsible for greenhouse effect and global warming. A pro-nuclear campaign would lead Australia to reconsider its position towards the Kyoto Protocol and supporting a stronger environmental policy.

1.During the last decade, nuclear electricity production costs significantly reduced; about two third of production costs are linked to the transformation process of the uranium. A recent report by OECD Nuclear Energy Agency and the International Energy Agency Agency (OECD/IEA NEA 2005 Projected Costs of Generating Electricity up date) outlined that in 1998 electricity costs from nuclear became more competitive than gas and coal. In fact, in the 13 countries analysed, nuclear costs were inferior to gas costs and in 7 countries out of 13 nuclear costs were inferior to coal ones. It was also calculated that nuclear electricity costs are on average 0.4 euro cents/KWh (including transformation process of uranium, waste disposal and reactor decommissioning), whilst coal costs are more than 4 euro cents/KWh and gas costs are between 1.3 and 2.3 euro cents/KWh.

Table 2 reports an analysis recently carried out in Australia on uranium transformation costs need to produce 1Kg of UO_2 fuel.
A quantity as in Table 2 gives rise to a thermic production of 3400 GJ, which can generate 315,000 KWh of electricity. Thus, unit cost is approximately 0.35 US$ cents per KWh (approximately 0.29 euro cents per KWh).

Table 2. Estimated Uranium transformation process costs estimated (referred to 2004)

Product/process	Quantity	Unit Cost	American Dollars
U_3O_8 :	8 kg	$45	360
conversion:	7 kg U	$9	60
enrichment:	4.3 SWU	$105	450
fuel fabrication (per kg):			240
total, approx:			1110

A further element which makes uranium a highly competitive solution at the present time is the cost and the time needed to build a nuclear plant. According to OECD/IEA NEA 2005 data, average costs to build a nuclear plant vary between 1000 US$ per KW in the Czech Republic and 2500 US$ per KW in Japan, whilst costs to build a coal plant changes from 1000 to 1500 US$ per KW, those for a gas plant from 500 to 1000 US$ per KW and finally for an wind power station costs may vary from 1000 to 1500 US$ per KW. At the end of the '90s less than 4 years were required to build a last generation Japanese plant of 1300 MW was. Average costs for electricity production by using nuclear power, coal and gas in 2010 can be estimated by processing the above mentioned data, which refer to 2003. As show on Table 3, estimates refer to different countries and take into account an yearly inflation rate of 5% on average and a plant lasting approximately 40 years on average.

Table 3. Estimated costs for electricity production in 2010 (US$ cents per KWh)

Country	Nuclear	Coal	Gas
Finland	2.76	3.64	-
France	2.54	3.33	3.92
Germany	2.87	3.52	4.90
Switzerland	2.88	-	4.36
Holland	3.58	-	6.04
Czeck Rep.	2.30	2.94	4.97
Slovakia	3.13	4.78	5.59
Romania	3.06	4.55	-
Japan	4.80	4.95	5.21
Korea	2.34	2.16	4.65
USA	3.01	2.71	467
Canada	2.60	3.11	4

Source OECD/IEA NEA 2005

Another factor to consider is the low cost of uranium transportation, being uranium a very compact material. One kilogram of uranium produces 20,000 times more energy than the same amount of coal.

2. ANSTO (Australian Nuclear Science and Technology Organization) is the main Australian research centre completely sponsored by the Federal Government, which is actively involved in the development of new materials for the immobilization of nuclear waste proceeding treatment of nuclear fuel used in last-generation reactors. Despite the national antinuclear policy, ANSTO, which runs the small nuclear reactor HIFAR (High Flux Australian Reactor) situated in Lucas Heights in New South Wales, carries out important research activities in the sector, proof of the active and continuing involvement of the Australian scientific community in the nuclear sector. ANSTO also participates in the EUROPART project (EUROpean research program for the PARTitioning of minor actinides from high active wastes issuing the reprocessing of spent nuclear fuels), which is part of the Sixth Framework Programme of the European Union, whose main task is to give support in relation to its specific expertise on materials called "SYNROC".
   Furthermore, as part of its research activities, ANSTO collaborates with Italy, in particular with ENEA (Institute for New Technologies, Energy and Environment) and the University of Modena and Reggio Emilia, Department of Materials and Environment Engineering. The activities jointly carried out concern treatment of nuclear waste, among which thermic treatment by using radiofrequency in the so-called cold crucible, warming in traditional ovens and in microwaves. Activities carried out specifically by ANSTO in ENEA's laboratories in Bologna are related to the selection and synthesis of new materials to condition chloride-based saline waste, derived from electroraffination processes of irradiated fuel in fused salts.

3. The Australian Government undertook specific initiatives in order to promote future research activities in the energy, environmental and weather changes sectors, also due to the connection with the drought problem.
   At the moment, Australian policy is not oriented at nuclear neither within its own national research programme Backing Australia's Ability 2, for the period 2004-2010, nor within the energy planning programme Securing Australia's Energy Future. From a political point of view, the liberals (thus the federal government in charge) are in favour of reconsidering nuclear as energy source, while the labourists (in power in all the Australian states) are against it.
   Nuclear as an energy resource could represent an alternative to the current position of the Australian government towards the Kyoto Protocol. The Government is firm on its decision of not signing the Protocol, justifying its position with the lack of limits in gas emissions in developing countries (China, India, etc.), considered by the Government of Canberra to be the main producers of greenhouse gas.

In 1970 the Federal Government approved the construction of a 600 MW nuclear plant in Jervis Bay, New South Wales, for electricity production. In 1971, when a new Prime Minister came to power, the Australian position towards nuclear changed and in 1972 the initiative was interrupted, in this way definitively nullifying the governative programme envisaging national development of nuclear. At the moment, there is a reactor in use, HIFAR. Located in Lucas Heights in NSW (30 km south of Sydney), it is used for research

activities and to create isotopes for diagnostic and therapeutic purposes in medicine. It has a power of 10 MW and exploits an heavy water moderator enclosed in an alluminium container. HIFAR has been working for the last 40 years and will be replaced (probably next year) with the new nuclear reactor, OPAL (Open Pool Australian Ligh-Water Reactor), to be used for the same purposes.

At this point, a question on which kind of actions Australia will undertake in the next future should arise. Considering Australian electricity consumption per year of 2173 PJ, that is about 201 billion KWh, the construction of three nuclear plants of 1300 MWe each, as those built in Japan in 1996 and 1997, with an overall cost of 7 billion US$ and consuming about 800 tons of uranium per year, would produce approximately 30 billion KWh in total, in other words 15% of national production, perfectly in line with world trends.

The recent Chinese demand for Australian uranium supply again raised an heated debate in Australia, focusing particularly on the actions of the Australian Federal Government aimed at increasing uranium exportation and at opening new mines. These actions have been opposed by the labourist state governments, responsible for the concession of licences to explore and open new mines. Nonetheless, some important members of the Labour Party recently affirmed that the party might change its position in relation to the nuclear, opening up new prospects for a political and scientific debate on a new Australian power strategy and on a possible use of nuclear for electricity production, in the light of the new international trend.