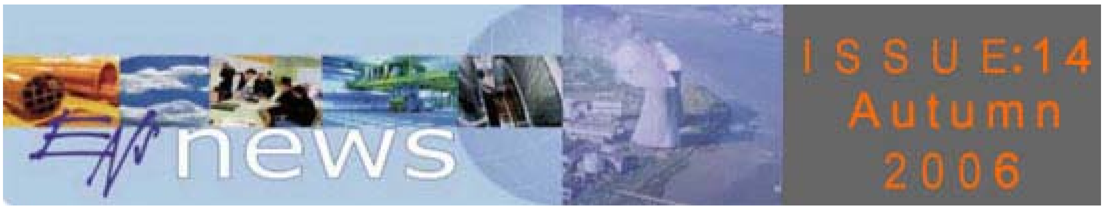


European Nuclear Society
e-news Issue 14 November 2006

ENS NEWS, N° 14: Sowing the seeds, securing the harvest

Hardly a week goes by without another disturbing report in the media confirming one of the most worrying socio-educational trends of recent years – the declining interest among young people in studying the natural sciences and, subsequently, pursuing a career in science. A BBC report recently highlighted how some colleges and universities in the UK have had to cancel certain courses or even close down departments because too few students are interested in gaining a qualification in physics, maths or chemistry. Sadly, this scenario is a familiar one in other European countries too. In France, for example, the sciences are still largely perceived by many young people as being too hard to grasp, divorced from the realities of everyday life and not the best option for cracking the job market. As a result, there are declining numbers of French students opting to pass a science-based baccalauréat and to take a science degree.

In a recent report, the IAEA stressed that the ageing workforce in the nuclear sector is a “growing concern”, adding: “A new generation of nuclear scientists and engineers is also needed in countries planning to expand the use of nuclear energy.” Well, what can we do to reverse the current trend and ensure that there is a transfusion of sufficient young blood to sustain and promote the nuclear revival?

This issue is by no means new. But the problem still persists. Is it because the world of scientific research still seems too distant for today’s youngsters, too stuffy and esoteric? Maybe it’s a question of image and positioning and science has quite simply not been “sold” effectively to young people? Science just doesn’t seem “cool” any more. Perhaps educationalists have failed to make the connection in young people’s minds between the natural sciences and the world we live in?

The anthropologist and biologist, Jacob Bronowski, might have put his finger on one aspect of the problem when he highlighted how hard work must go hand in hand with talent if science is to produce results, saying: “Nothing in the world can take the place of persistence. Nothing is more common than unsuccessful men with talent.”

But there are signs that the tide is turning. There are plenty of talented and committed young scientists out there to take up the baton, as the activities of the Young Generation Nuclear network regularly testify. Issue N°14 of ***ENS NEWS*** highlights the efforts that are being made in some countries to tackle the problem. It features a report on how the CEA, in France, is getting to grips with the problem thanks to a range of educational initiatives that put the emphasis on interaction, effective communications, multimedia tools and working closely in partnership with teachers and the government. In an exclusive interview for ***ENS NEWS***, the new Director

General of SCK-CEN in Belgium, Eric Van Walle, expresses his views on the subject (and several others) and highlights the training and exchange programmes that SCK-CEN offers at its Mol facilities to talented young scientists and PhD students from all over the world.

In Germany, industry in general is acutely aware of the problem and has launched a range of initiatives, including award schemes and grants, to tempt more young people to study maths, physics and chemistry.

So, it would appear that the corner is being turned in some countries, but much still remains to be done if science is to become a more attractive career option for young people today and for generations to come.

Whatever your take on the subject, ***ENS NEWS*** would like to hear your views and experiences on what is a crucial issue facing both the scientific community and industry.

ENS NEWS N°14 kicks off, as usual, with a word from the President. Frank Deconinck gives readers the low-down on the recent Annual General Conference (GC) of the IAEA, which featured a keynote speech from the IAEA's Director General and Nobel Peace Prize Winner, Mohammed ElBaradei. Bertrand Barré then gives his personal perspective on the GC.

In his regular column, Andrew Teller exposes some of the poor reasoning, factual inaccuracies and double standards that often underpin the arguments of the anti-nuclear brigade.

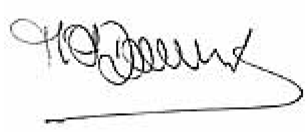
In the Events section of Issue N° 14, the reporting spotlight first falls on ENS TOP SEAL, where nuclear experts from Europe and beyond debated the latest research data and technological innovations related to radioactive waste management. Next the spotlight switches to Salamanca, Spain, where delegates at the "sold-out" ENS TOP FUEL conference focused on the current challenges and future direction of nuclear fuel management. The next ENS conference on the agenda is PIME 2007, which will take place in Milan, Italy, from 11-15 February - and ENS NEWS features the first in a series of teasers on the subject (please take note of the 2007 PIME Award information and send in your entries!).
Next up, in September, is the European Nuclear Conference (ENC 2007).

In this edition's Member Societies and Corporate Members section, there is a presentation by Frank Deconinck on nuclear medical imaging, which he gave at the IYNC (International Youth Nuclear Congress), in June. Our colleagues from SKI in Sweden have contributed an article on reactor kinetics equations related to the Ringhals NPP. The section also includes two reports on SCK-CEN that recently celebrated its 50th anniversary. The first is a general introduction on the activities of SCK-CEN and the other is the interview with Director General, Eric Van Walle.

The European institution section features three very significant developments: the first concerns the European Commission's announcement on the Joint Undertaking proposal on ITER; the second is a press release on the European Commission's approval of the investment plan for the EPR construction in Flamanville that was submitted by EDF and the third is another press release, this time outlining the European Commission's Recommendation on the management of decommissioning funds.

The World News section features an International Nuclear Energy Academy (INEA) statement by Bertrand Barré entitled ***HLW disposal: Status and Trends.***

Enjoy the read!



Mark O'Donovan
Editor-in-Chief

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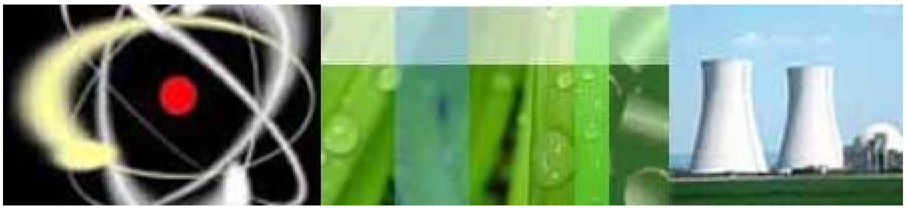
http://www.euronuclear.org/e-news/e-news-14/presidents-contribution.htm

ENS NEWS

Word from the President



Dear ENS members,

The 50th Annual General Conference of the IAEA (GC) was held, in Vienna, from 18-22 September, 2006. Because it was the 50th anniversary, the conference was attended by a larger than usual number of participants, many of them high-level state officials. Vladimír Slugen, President of the Slovak Nuclear Society and myself represented ENS.

Our former president, Bertrand Barré, attended the conference as chairman of INSC, the International Nuclear Society Council.

Here is a short report that I wrote, followed by an independent one written by Bertrand. The reports give two different but complementary views on the conference.

Frank Deconinck

The Annual General Conference usually starts with a few administrative matters, such as the election of officers – including that of a new president (on this occasion a South African) - and the accession of new member countries - Malawi, Montenegro, Mozambique and Palau. And this year was no exception. After the points of order, the Director General made his traditional opening statement. After a few more administrative matters were settled, such as the budget, each country then made a short statement.

In parallel with the main meeting, the so-called 'Committee of the Whole' began drafting and discussing proposals for resolutions to be adapted by the General Assembly at the end of the conference. This part of the proceedings was both highly technical and political.

Not surprisingly, the statements frequently addressed the issue of security of fuel supply and hinted at the ongoing situation in Iran. Both issues are, of course, closely related. The issue of security of supply was the subject of a 'special event' organised in parallel.

Director General Mohammed ElBaradei gave an overview of the Agency's different areas of competence. The full text of his statement is available at:
www.iaea.or.at/About/Policy/GC/GC50/Statements/index.html

On the subject of Iran, the Director General stated that:

"The implementation of the NPT safeguards agreement in the Islamic Republic of Iran has been on the agenda of the Board for more than three years and lately also on the agenda of the United Nations Security Council. On 31 July 2006, the Security Council adopted resolution 1696, in which it called upon Iran to take the steps required ... and the reestablishment by Iran of full and sustained suspension of all its enrichment related and reprocessing activities. In my report of 31 August to the Board and to the Security Council, regarding Iran's fulfilment of the requirements of that resolution, I stated that Iran had not suspended its enrichment related activities, nor was the Agency able to make progress on resolving the outstanding issues, due to the absence of the necessary transparency on the part of Iran. ... I remain hopeful that, through the ongoing dialogue between Iran and its European and other partners, the conditions will be created to engage in a long overdue negotiation that aims to achieve a comprehensive settlement that, on the one hand, would address the international community's concerns about the peaceful nature of Iran's nuclear programme, while on the other hand addressing Iran's economic, political and security concerns."

With regards to the nuclear fuel cycle, Mr. ElBaradei added: "The increase in global energy demand is driving a potential expansion in the use of nuclear energy. And concern is mounting regarding the proliferation risks created by the further spread of sensitive nuclear technology, such as uranium enrichment and spent fuel reprocessing. The convergence of the above realities points to the need for the development of a new framework for the nuclear fuel cycle.

I have been calling since 2004 for the development of a new, multilateral approach to the nuclear fuel cycle, as a key measure to strengthen non-proliferation and cope with the expected expansion of nuclear power use. The establishment of a framework that is equitable and accessible to all users of nuclear energy acting in accordance with agreed nuclear non-proliferation norms will certainly be a complex endeavour, and therefore in my view will be best addressed through a series of progressive phases:

- The first phase would establish mechanisms for assurance of supply of fuel for nuclear power plants
- The second phase would develop, as needed, assurances regarding the acquisition of nuclear power reactors
- The third phase would facilitate the conversion of existing enrichment and

> reprocessing facilities from national to multilateral operations, and would encourage limiting future enrichment and reprocessing to multilateral operations."

The US was, in my opinion, remarkably discreet about Iran. The only reference they made to it was:

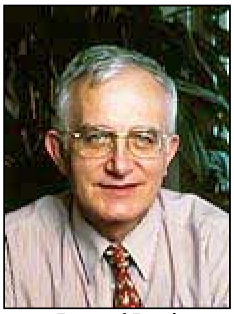
"The defiance and violations of Iran and North Korea, and the risk of catastrophic nuclear terror, must be addressed." However, the issues of terrorism and potential proliferation were a constantly repeated concern in their statement. With respect to security of supply, the US recalled their commitment to "encouraging reliable access to nuclear fuel for countries that forgo uranium enrichment and reprocessing activities..."

The Iranian delegation did not directly mention the US, but its allusion to the US was obvious in sentences such as '...the approach and behaviour of certain nuclear weapons states...' Iran holds the states that possess nuclear weapons responsible for the failure of the last NPT conference. It strongly argued against a monopoly on enrichment and fuel production by developed states and vehemently protested against the limiting of their country's inalienable rights to access to peaceful nuclear capabilities. Iran claims that the decision to refer Iran to the Security Council is illegal. The statement ended with a number of declarations, including: 'the Islamic Republic of Iran's intentions are exclusively peaceful" and "..the Islamic Republic of Iran is against nuclear weapons and is seeking the total elimination of nuclear weapons in the region and the world accordingly."

Let me conclude this summary by including an excerpt from the statement made by the Holy See, founding members of the IAEA (but not a member yet of the ENS!): "The truth of peace requires that all governments –those that openly or secretly possess nuclear arms or those planning to acquire them – agree to change course by making clear and firm decisions and by striving for a progressive and concerted nuclear disarmament".

Frank Deconinck

Back from Vienna (Bertrand Barré)


Bertrand Barré

IAEA, the International Atomic Energy Agency, recognizes INSC as a non-governmental organization (NGO). Member societies ANS and ENS, as well as the INEA (International Nuclear Energy Academy) enjoy the same status. As an NGO, INSC is invited to send one delegate and a few observers to attend the Annual General Conference (GC) of the Agency, which is traditionally held during the third week of September. Now that I am back from Vienna, allow me to share with you my personal thoughts on the conference.

This year, the IAEA celebrated both its 50th Anniversary and the Nobel Peace Prize that was won jointly by the Agency and its Director General, Mohammed ElBaradei. Even in a "normal" year, the GC is a very formal event, with a delegation from each country delivering a prepared speech in a vast auditorium. These speeches usually contain few surprises, but a lot of activity occurs behind the scene as the GC is a unique opportunity for bilateral meetings and negotiations. The GC is also an opportunity for the Agency to publicise its achievements and to spread information about the status of nuclear science, technology and politics around the world.

A number of countries, IGOs and NGOs had exhibition stands in the grounds of the Conference Centre. Iran was mentioned in many presentations, but because the matter had been referred by the Agency to the UN Security Council, the issue had moved from Vienna to New York.

From the Director General's report, I would like to highlight the following excerpts:

"There is no development without energy. Approximately 1.6 billion people have no access to electricity, and 2.4 billion continue to rely on traditional biomass, because they have no access to modern fuels."

Because of oil prices and fear of climate change, and owing to its safety record over the last 20 years, nuclear power is experiencing rising expectations throughout the world. Even though it is mostly used in industrialized countries, of the 28 reactors under construction, 16 are in developing countries, in Asia and Eastern Europe. Uranium reserves should suffice to fuel enhanced nuclear programs… provided activities in exploration mining and milling restart."

"New countries are expected to start developing nuclear power: it is paramount that this enlargement not results in increased proliferation. This is why IAEA has launched an expert study on multilateral approaches to the nuclear fuel cycle (Report issued February 2005) and a "special event" has been organized, in parallel to the GC, to study non-proliferation and assurances of fuel supply.
INPRO is about to start its phase 2, devoted to infrastructures. No serious reactor accident has occurred for the last 20 years, but a number of incidents underline that nuclear safety is never definitively acquired: it should always be viewed as "work in progress."

"Much of the Agency's scientific work is focussed on the transfer of peaceful nuclear technology in applications related to health, agriculture, industry, water management and preservation of the environment. The Nobel money was used to set up a "IAEA Nobel Cancer and Nutrition Fund". The PACT, Programme of Action for Cancer Therapy, has been boosted and successes have been obtained in the nutrition area (cocoa in Ghana, fruit fly control, tsetse fly eradication, etc.)."

"78 States have now Additional Protocols in force, but over 100 States, including 25 with significant nuclear activities, have yet to bring additional protocols into force. Worse: 36 non-nuclear-weapon States party to the NPT have not yet filled their obligation to bring Comprehensive Safeguards Agreements into force."

The special event that took place in parallel to the GC was primarily dedicated to examining possible mechanisms for ensuring supply at the front end of the fuel cycle and, more precisely, enrichment. The idea was to provide incentives for countries to voluntarily refrain from developing, on a national basis, sensitive enrichment technology. The six uranium supplier countries (USA, Russia, France and the URENCO troika) introduced a proposal last June called RANF (Reliable Access to Nuclear Fuel). Russia then added a proposal to turn one of its 4 existing enrichment plants into an International Uranium Enrichment Centre under IAEA auspices, and the USA announced they were about to downgrade 17.4 tons of military HEU to create a fuel reserve for civilian purposes. There were also German and Japanese proposals.

Several countries warned against creating a “new discrimination” between the “haves” and the “have nots” when it comes to fuel cycle technologies (in addition to the painfully accepted discrimination between NWS and NNWS). Canada pointed out that existing exporters of enrichment services were not exporters of natural uranium, therefore limiting the guarantee of supply that Canada can offer.
For us “old-timers,” it was somewhat reminiscent of INFCE, with one main difference: the main message was “multilateralization,” rather than denial.

Traditionally, on the first afternoon, the Agency holds a briefing session for NGOs and IGOs. Last year, for instance, the briefing was devoted to PACT. This year, the Agency asked NGOs to intervene rather than the reverse, as was usually the case. Accordingly, the INEA, in a joint move with the INSC, made an offer to support and assist the IAEA in its efforts to present nuclear energy in an impartial context at the various meetings of the Commission on Sustainable Development (CSD) and of the Conferences of the Parties to the UN Convention on Climate Change - the “COP.” This offer was politely rejected.

Bertrand Barré, Chairman INSC

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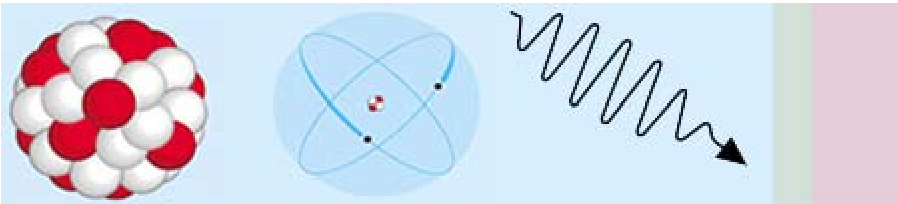
http://www.euronuclear.org/e-news/e-news-14/still-a-bad-idea.htm

ENS NEWS



“Still a bad idea”

by Andrew Teller

This is the judgment passed by Jeremy Rifkin, an American consultant, in the 29 September 2006 edition of the ***Los Angeles Times***. The subject of his judgment was, of course, nuclear energy and the subtitle of his article ran “Solar power is a better investment than a dated technology that’s too expensive and dangerous”. Cost and danger are well-known objections of the anti-nuclear crowd. But the reader’s attention should not be monopolised by the last part of the sentence, lest a third criticism go unnoticed. Is nuclear energy really a dated technology? The indictment sounds a bit weird. I’ve never heard anybody assert that the combustion engine is a dated technology. This is despite the fact that the first combustion engines were designed several decades before the first nuclear reactor. Why would nuclear reactors be the embodiment of a dated technology? To use his own words, the above-mentioned columnist concludes that “nuclear power represents the kind of centralized, clunky technology of a bygone era. In an age when distributed technologies are undermining hierarchies, decentralizing power and giving rise to open-source economic models, nuclear power seems strangely old-fashioned and obsolete.” So there we are: nuclear power would be obsolete because it is centralized. If the argument is worth anything, it should also apply to other energy sources, but this does not seem to be the case in practice. Wind machines have a well established tendency to grow bigger and bigger and wind farms also gain from being composed of as many machines as possible. At the turn of this century, 1 MW wind machines were at the forefront of wind technology. Today, the industry’s objective is to build 5 MW units. The trend is so well accepted that, in a Belgian newspaper, a local green politician was looking forward a couple of years ago to seeing wind machines delivering half the power of a nuclear power plant! To those who know that wind machines need twice as much concrete and three times as much steel per kW installed as a nuclear power plant, such statement can only appear ludicrous. The misconception would be funny if it did not betray a total lack of understanding of very serious matters. At any rate, this gentleman’s statement made it clear that centralisation was considered to be neither avoidable nor evil. We have here yet another example of double standards: centralised power generation is not worth mentioning if it comes with renewables and bad due to the use of nuclear power plants.

What is it then that makes a given technology obsolete? We just have to take a few examples from other industries to answer this question:

- At the beginning of the twentieth century, the British army set out to design the ultimate cavalry sword. The undertaking quickly fell into oblivion because it became apparent that horses were just about to be superseded by armoured vehicles, which represented more than a quantum leap in (military) technology; it was an actual paradigm shift. Not adopting it was a recipe for defeat in the short run and ultimately disappearance or domination in the long run.

- At about the same time, steam engines were gradually replaced by steam turbines for the generation of electricity. This was because the latter provided direct rotational force and, therefore, did not require a linkage mechanism to convert reciprocating to rotary motion. Furthermore, they produced smoother rotational forces on the output shaft. As a result they required less maintenance and generated less wear on the alternator than a comparable reciprocating engine. In the present case, a similar function was performed more efficiently by a different technology at a comparable cost.

- Today, digital photography seems to be poised to replace film photography. It allows instant viewing and many operations that are much more difficult or cumbersome with film photography. The price range of digital cameras overlaps to a large extent with the range of film cameras. One can reasonably assume that achieving the same level of picture quality will sound the death knell of the film camera.

The above examples indicate that the relevance of a given technology depends on factors such as fitness for purpose, relative cost, absence of other technologies providing competitive advantages at a similar cost and absence of paradigm shift. I would be tempted to say that all these factors apply to nuclear power generation. It certainly does fulfill its purpose; its cost looks more and more attractive in view of rising fossil fuel costs; each and every power generation technology has its own shortcomings; the paradigm shift many expect to take place with fusion is still some decades away.

At the end of the day, however, the relevance of a technology does not result from any one person's verdict. It emerges from the combined actions of all the actors who weigh the pros and cons of the different technologies available. So far, nuclear power generation has resisted remarkably well if it was as riddled with defects as its opponents claim. Self-appointed pundits whose judgments reflect more their personal wishes than a dispassionate analysis of facts won't change anything.

(The author wishes to acknowledge Wikipedia - en.wikipedia.org - as a source of information for the preparation of this article, in particular as regards steam engines and digital photography.)

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http://www.euronuclear.org/e-news/e-news-14/TopSeal2006.htm

ENS EVENTS

TopSeal 2006

17 - 20 September 2006, Olkiluoto, Finland

ENS TOPSEAL 2006: the European Nuclear Society puts the science and technology driving radioactive waste management under the spotlight

From 17-20 September 2006, over 100 nuclear scientists and engineers from across Europe, Canada, the USA, Japan and Korea converged on the Olkiluoto Information Centre in Finland to attend **TOPSEAL 2006**. This international topical meeting dedicated to the subject of radioactive waste management was organised by the European Nuclear Society (ENS) in co-operation with the Finnish Nuclear Society (ATS) and the OECD/NEA. The conference was hosted by TVO, Finland's largest power utility and POSIVA, a daughter company of TVO and the country's number one radioactive waste management specialist.

The main message that emerged from the conference is that a range of technological solutions exist and are currently being developed and applied across Europe - and beyond - to ensure the safe and efficient long term management of all categories of nuclear waste and spent fuel. Against the background of the nuclear revival, more and more countries are now looking closely at all available options.

TopSeal 2006

The **TOPSEAL 2006** agenda centred upon four main sessions devoted respectively to: international perspectives on radioactive waste management; research, development and demonstration of waste storage and disposal; existing experiences with low and intermediate level radioactive waste and deep geological and near surface repositories. The conference concluded with a panel discussion entitled Future Challenges in radioactive Waste Management and a visit of the waste management facilities in Olkiluoto.

Among the many issues discussed by TOPSEAL delegates was EU policy and legislation related to waste management, deep underground repositories, near surface storage, the experimental modelling of safety barriers, radiation shielding and research funding. Research and development programmes, benchmarking and long term strategies in several countries were also presented and discussed at length.

A recurring theme that underpinned the discussions was the need to increase public understanding and acceptance of nuclear waste management options. Recent public opinion polls have shown that more and more European citizens are in favour of nuclear energy – especially on account of its sustainability and environmental credibility as a non-CO_2 emitting energy source. Statistics also show that many more people would be in favour of nuclear energy if they knew that nuclear waste is managed safely and effectively. One major challenge for the nuclear community, therefore, is to communicate more effectively to the public how scientific excellence, operating expertise and cutting edge technology can ensure the safe long term management of all radioactive waste.

After the conference, Eero Patrakka, President of POSIVA and Chairman of the TOP SEAL Programme Committee, commented: “Nuclear new build can only happen if there is increased public acceptance that the safe management of radioactive waste is a reality. We, as people responsible for waste management, have a crucial role to play in this respect. I believe that **TOPSEAL 2006** has demonstrated that such a prerequisite will be fulfilled.”

As the nuclear revival gathers momentum, the nuclear community is well aware that its continued development is largely dependent upon showing how safe and effective waste disposal and management options are available and are being successfully implemented.

Have a look for the TopSeal 2006 Presentations and the Photo Gallery.

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http://www.euronuclear.org/e-news/e-news-14/TopFuel2006.htm

ENS EVENTS

TopFuel 2006

22 - 26 October, Salamanca, Spain

Brussels, 31 October 2006

TopFuel 2006: European Nuclear Society (ENS) puts international spotlight on nuclear fuel management

From 22-26 October, 340 researchers, nuclear engineers and scientists from across Europe and beyond congregated in the ancient university city of Salamanca, Spain, to discuss the challenges facing the developers and manufacturers of new high-performance nuclear fuels – fuels that will help meet current and future energy demand and reduce man's over dependence upon CO_2-emitting fossil fuels.

TopFuel is an annual topical meeting organised by ENS, the American Nuclear Society and the Atomic Energy Society of Japan. This year it was co-sponsored by the IAEA, the OECD/NEA and the Spanish Nuclear Society (SNE). TopFuel's primary objective was to bring together leading specialists in the field from around the world to analyse advances in nuclear fuel management technology and to use the findings of the latest cutting-edge research to help manufacture the high performance nuclear fuels of today and tomorrow.

The **TopFuel 2006** agenda revolved around ten technical sessions dedicated to priority issues such as security of supply, new fuel and reactor core designs, fuel cycle strategies and spent fuel management. Among the many topics under discussion were new developments in fuel performance modelling, advanced fuel assembly design and the improved conditioning and processing of spent fuel. During the week, a poster exhibition also gave delegates the opportunity to display and discuss the results of their latest work and to network with fellow professionals.

One important statement to emerge from TopFuel 2006 was that the world has enough reserves of uranium to support the large-scale and long-term production of nuclear energy. The OECD/NEA and the IAEA recently published a report entitled ***Uranium 2005: Resources, Production and Demand (the Red Book)***. The report, which makes a comprehensive assessment of uranium supplies and projected demand up until the year 2025, concludes by saying "…the uranium resource base is adequate to meet projected future requirements."

With the global nuclear revival gathering momentum, this event – which registered a record attendance for an ENS conference - provided a unique opportunity for professionals in the nuclear fuel industry to discuss the key issues of the day, to exchange experiences, to consolidate recent engineering and technological advances and to focus on the future.

Commenting on the tangible sense of purpose and focus shown by delegates, José Gutierrez, Nuclear Fuel Director at ENUSA Industrias Avanzadas and Chairman of the TopFuel 2006 Conference, said: "The ultimate goal for specialists involved in all phases and aspects of the nuclear fuel cycle is to develop the next generation of nuclear fuels that will help ensure security of energy supply and, help combat climate change combined with the highest standards of safety. The record attendance at TopFuel this year shows how the nuclear industry and research community is results-driven, single-mindedly focused on achieving its goals and on the right track to deliver."

After the conference, delegates visited the nuclear fuel manufactoring facility of ENUSA Industrias Avanzadas, in Juzbado, close to Salamanca.

TopFuel is a must for nuclear fuel and spent fuel managers, fuel manufacturers, engineers and designers, nuclear power plant operators, materials scientists and research experts from all sectors of the nuclear industry. Most of the world's major utilities were represented in Salamanca, as well as fuel manufacturers, several national nuclear organisations and research centres of excellence.

For more information on TopFuel 2006 - including copies of the papers – and other ENS conferences, visit the ENS website at:
www.topfuel2006.org, or contact Kirsten Epskamp, ENS Conference Manager, at + 32 2 505 30 54.

http://www.euronuclear.org/e-news/e-news-14/pime2007.htm

ENS EVENTS

PIME 2007

Make time for PIME!

Dear Colleagues,

Bringing together nuclear communications specialists from around the world to share experiences, exchange views and promote communications excellence – that is the aim of PIME, the annual **P**ublic **I**nformation **M**aterials **E**xchange.

Now in its twentieth year, PIME has established itself as a not-to-be-missed key event for nuclear communications professionals. The secret of PIME's success is the combination of a thought-provoking programme and an array of experts and speakers representing the industry, EU institutions and the scientific community.

The next edition will take place from **11 to 15 February 2007** in **Milan**.

Dare to share!

Play your part in the success of **PIME 2007** by submitting your proposal for a presentation to the Programme Committee by 1st October 2007. Share your expertise with fellow communicators and help fashion the nuclear industry's future communications strategy. The attached Call for Papers includes all the necessary details.

Help us spread the news about PIME and make sure your colleagues in the communications field get to know about the event through our website or via this e-mail.

We hope you will join us in Milan next year!

PIME 2007 Conference Secretariat
www.pime2007.org
pime2007@euronuclear.org

PIME AWARD 2007

As professional communicators we all know that knowledge is power - once people are empowered with the facts they can draw their own conclusions and form their own opinions. How skilfully we connect with our audiences - providing them with clear and easy-to-understand information, emphasising key messages, conveying core values - determines how positively we are perceived. The onus on professional communicators to deliver results is, therefore, great - especially with the nuclear renaissance gathering steam. But so too are the rewards that high impact communications can bring in terms of promoting understanding, enhancing public acceptance and fostering a positive image.

The 2007 PIME Award for Communications Excellence aims to recognise the achievements of professional communicators in the nuclear industry who have successfully connected with their audiences, helped to dispel myths and misinformation about nuclear energy and enhanced the image of our industry.

This year the PIME Award entrants will be required to provide some basic information on the campaign they are entering for the award: the campaign's objectives, the communications strategy adopted, the results that it achieved and why they think it should receive the award. As always, as much supporting documentation as possible should be sent it, like press articles, photos, DVDs, newsletters, web pages or promotional materials.

This information will help the jury – which will be made up of fellow communicators – to decide upon the winning entry. The focus will be on campaigns that show the most creative strategy, illustrative an innovative use of communications tools and can show tangible results. Multi-media packages backed up by sophisticated audiovisuals and glossy brochures can provide impressive results, but so too can a campaign that ran on limited resources. It's all about grass roots, creative communications that really reach out to their audience.

We hope that lots of nuclear communicators will take part in this year's award and that high impact communications will receive the recognition that it deserves.

More details regarding the 2007 PIME Award for Communications Excellence will be posted on the PIME web pages of the ENS web site. So, keep your eyes peeled and start preparing your entries now!

http://www.euronuclear.org/e-news/e-news-14/enc2007.htm

ENS EVENTS

ENC 2007

Mark your diary!

Sharing knowledge and providing insight on the latest developments in nuclear research and its applications - that is the aim of the **European Nuclear Conference (ENC).**

ENC2007 will take place in **Brussels** from **16 - 19 September 2007**. The conference will have a multidisciplinary approach, looking at nuclear applications in energy production and medical technologies, and giving special attention to how they impact on our society and vice versa.

Call for Papers

Share your knowledge with your colleagues by presenting a paper related to the following subjects:

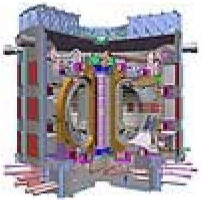
- new reactor and energy technologies;
- the nuclear fuel cycle (including waste, transport, dismantling and partitioning & transmutation);
- nuclear operations;
- medical applications;
- human resources and education and training; and
- socio-economic, political and ethical considerations.

In the spirit of the multidisciplinary approach of **ENC2007**, contributors are encouraged to send in work that appeals to crossover thinking and context exploring. Please submit your abstract by 31 of January 2007. The Call for Papers and abstract form can be downloaded from **www.enc2007.org**

Help us spread the news about ENC2007 and make sure your colleagues get to know about the event through our website or via this e-mail.
We hope to see you in Brussels next year!

http://www.euronuclear.org/e-news/e-news-14/iter.htm

MEMBER SOCIETIES



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Nuclear medical imaging

By Frank Deconinck

Among the may applications of nuclear energy and ionising radiation, medical imaging certainly is least subject to negative perception or outright opposition from the general public. Proponents of nuclear power correctly refer to it as an example of a very positive use of nuclear technology. Working in the field of medical imaging, it appeared to me that some misunderstandings or confusions exist as to the principles behind the different medical imaging techniques and their potential diagnostic role. This paper, which is a shorter version of an article entitled 'Nuclear Imaging in the Realm of Medical Imaging' (Nuclear Instruments and Methods in Physics Research A 509 (2003) 213–228), gives a general introduction to the subject.

1. The spectrum of medical imaging techniques

Medical imaging techniques can be classified according to a number of criteria. A particular classification scheme could use appearance, e.g. tomographic versus non-tomographic images and would group CT and MRI because of the similarity in image presentation. Another would classify the techniques according to the underlying physics. This is the classification scheme which is used here. Its basis will be the origin and nature of the radiation source that will carry the information about the patient to a detector.

1.1 External sources

When the radiation source is external, the body structures modulate the information through interactions with the radiation. In X-ray radiography or CT, an external point source of X-rays is used. The X-rays are partially absorbed when the rays pass through the body. The rays that are neither absorbed nor scattered move in straight lines between the point source and the detector (e.g. film), thus creating a shadow image of the bodily structures.

In ultrasound, an external source of pulsed sound waves is used. Both the time and direction of the pulse is known. Interfaces between different tissues will partially reflect the sound waves. By measuring the time span between the outgoing and incoming sound pulse, images can be reconstructed.

In endoscopy, an external light source illuminates internal organs through glass fibre. An ocular or small camera is used to observe the reflected light and hence the organ.

1.2 Internal sources

The body naturally and continuously radiates heat: its source is internal. In order to image the information carriers, some optics for infrared radiation are needed: a thermographic camera.

In MRI, the information is carried by radio waves emitted by hydrogen nuclei in the body. Although the body cxontains plenty of hydrogen nuclei, e.g. in water molecules, the nuclei do not naturally emit radio waves. In order for them to do so, they have first to be put in a magnetic field and then activated by means of well chosen radio wave pulses at specific frequencies. The nuclei then 'answer' by emitting radio waves of similar frequencies. In MRI the internal sources are always present but they only emit information when activated to do so.

In nuclear imaging, the information is carried by gamma rays emitted by internal radioactive tracers. The body is naturally radioactive. For physical reasons due to the nature of the radioactive decay of the radioactive body constituents, imaging them is too difficult to be of any use. Also, from the medical point of view, the information would not be of much help. Therefore, artificial radioactive tracers are administered. They are chosen in such a way that their radioactive decay allows for external detection and that their space/time distribution reflects clinical information.

Because of their particular importance, ultrasound, MRI, radiography and nuclear imaging will be discussed in more detail.

2 Ultrasound

The medical use of ultrasound is a spin-off from Japanese research on sonar. The first US scanners became available in the early fifties and the technique entered widespread clinical practice in the seventies.

The information in ultrasound originates from the reflection of sound waves emitted by an external source, typically a piezoelectric crystal resonance of between 1 and 10 MHz. Refraction, absorption and scattering also play a role, but mainly as factors that degrade the clinical information. The basic physical parameters of importance are the frequency of the wave, the speed of sound v and the density ? of the tissue.

The reflected fraction at a muscle/fat interface is about 1%. At a skin/air interface the reflected fraction becomes 99.9%, hence the use of a gel to decrease this undesired reflection.

Among many others, there are two typical artefacts in ultrasound. The first artefact is due to the coherent nature of the sound wave: the sound wave is a coherent pulse which will interfere with its reflected, refracted and transmitted components to give rise to speckling, similar to the speckling observed in laser light. The second artefact is due to the physics of reflection: interfaces between tissues that are parallel to the wave propagation will not reflect the wave and will therefore not be seen in ultrasound.

For some applications such as obstetrics or cardiology, the clinical information in the images is very high. Furthermore, the technique is safe and relatively inexpensive. Current research tends to eliminate artefacts, improve the image contrast and improve the presentation of the data. Many efforts are directed towards 3D or even 3D + time data acquisitions and representations.

FIGURE 1: 3D ultrasound (© 2000 General Electric,
www.gemedicalsystems.com)

3 Magnetic Resonance Imaging

The MRI technique stems from physics research carried out by Gorter, Rabi, Purcell, Bloch and many others that led to the discovery and development of nuclear magnetic resonance techniques just before and after world-war II. Medical applications and imaging were introduced in the seventies by, among others, Lauterbur, Damadian and Mansfield.

The basic information in MRI imaging relates to

- the magnetisation of hydrogen nuclei (their magnetic moment is called 'spin'), denoted as N(H)
- the energy transfer between the spins and tissue, characterised by a time constant T1
- the energy redistribution among spins with a time constant T2
- flow

Without an external magnetic field, the magnetic moment of the hydrogen nuclei will point at random in all directions. There will be no net magnetisation. In a large external magnetic field, the hydrogen nuclei in tissue will preferentially align their spin (1/2 or –1/2 due to quantum mechanical laws) along the magnetic field. More spins will align their spin in the direction of the field ('spin-up') than in the opposite direction ('spin-down') because the energy in spin-up direction is lower than in spin-down direction. The global energy of the spin system will, therefore, decrease while the magnetisation increases.

This magnetisation implies a transfer of energy from the spin system to another system: the 'lattice', or tissue in the case of MRI. This transfer of energy is characterised by an exponential relaxation law with a time constant T_1, also called spin-lattice relaxation time. In typical MRI field strengths (0.5 to 1.5 T), T_1 is typically of the order of 0.5 to 2 s, depending on the tissue type.

Next to interacting with the lattice, the spins can also interact among each other: as one spin flips from down to up, another spin can absorb the released energy and flip from up to down. This spin-spin redistribution of energy, internal to the spin system, is also characterised by a relaxation time, called spin-spin relaxation time and noted as T_2. Typical values for T_2 are 10 – 100 ms, again depending on the tissue type.

For a typical MRI field strength of 1.5 T the energy difference spin up/down corresponds to radio waves with a resonant frequency of 60 MHz.

By sending radio waves at resonant frequency some spins which were spin-up will absorb the energy of the wave and flip to spin-down, thereby increasing the global energy of the spin system. The energy of the spin system will now no longer be in equilibrium with respect to the tissue temperature and hence violate the normal Boltzmann distribution in equilibrium. The spin system will subsequently re-emit the extra energy as radio waves at resonant frequency. By varying local magnetic fields ('gradients'), fine-tuning the frequency, the polarisation and the duration of radio wave pulses to excite the spin system, and by modulating the delay after which the re-emitted waves (the 'signal') are measured, MRI images can be reconstructed. The contrast in the images then depends on the four following factors: N(H), T1, T2 and flow (any movement of nuclei during the imaging sequences).

The clinical value of MRI images is recognised in a large number of pathologies. Examples are the base of the skull and articulations such as the knee.

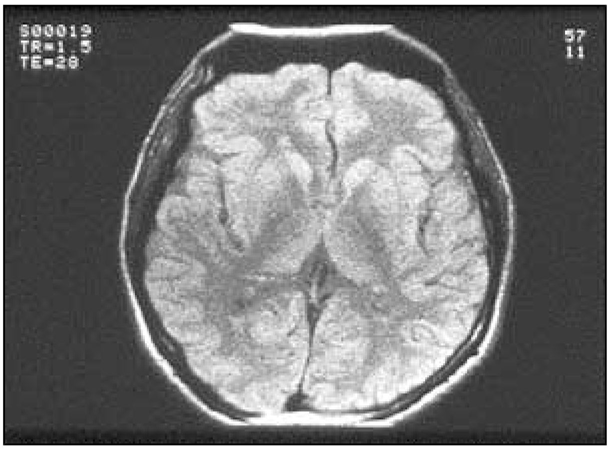

FIGURE 2: MRI image (1983) with Fourier reconstruction artefact (bottom folded to top).

Current research tends to widen the scope of information gathered. Examples are magnetic resonance angiography (MRA) to visualise the vascular structure without injection of contrast media, functional MRI to visualise areas of specific brain function, and diffusion imaging. Other ongoing efforts involve the shortening of the acquisition times that used to be tens of minutes and are now between seconds and a few minutes.

MRI is a rather safe technique for both patients and staff. Obvious precautions, such as removing metallic objects that could fly into the magnet due to the very high field strength should be taken. Patients with internal metallic objects such as clips should be excluded from the imaging procedure. The same is true for patients with pacemakers. Most other potential hazards are associated with the generation of heat due to induced currents.

4 Radiography

Radiography is imaging with an external X-ray source. X-rays were accidentally discovered but not recognised as such by Goodspeed at the University of

Pennsylvania in 1890. It is only after Röntgen's discovery in 1895 that radiography was born. Only weeks after the discovery, medical applications started as illustrated by figure 3.

The imaging process in radiography is based on the detection by film or other adequate detectors of the transmission of X-rays originating in a point source (the X-ray tube). Along their path from source to detector, the X-rays (photons with a mean energy in the range between 15 and 60 keV) undergo photon-matter interactions. Among the four classical interactions, the photoelectric effect, Compton scattering, coherent scattering and pair formation, only the first two are relevant because of the energy range.

The photoelectric effect is the main photon-matter interaction of importance in radiography; it creates the shadow image through absorption by the body structures, and allows the detection of the photons by the detector.

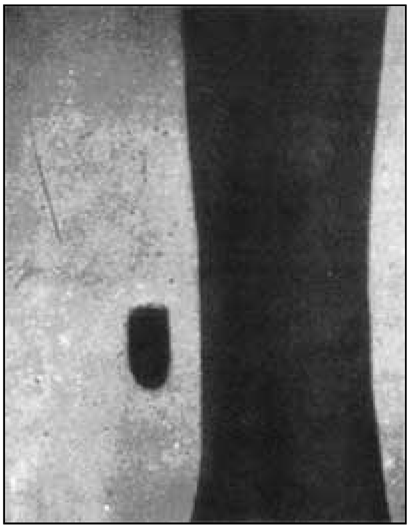

FIGURE 3: First Belgian military radiograph, April 1896.

X-ray film is still the most widely used detector. However, the characteristics of film are such that it is not very sensitive to X-rays. Therefore, a phosphor screen that transforms the X-ray in visible light is put against the film - thereby drastically increasing its sensitivity and allowing a similar decrease in radiation exposure to the patient. Today, large field of view semiconductor detectors gradually replace film.

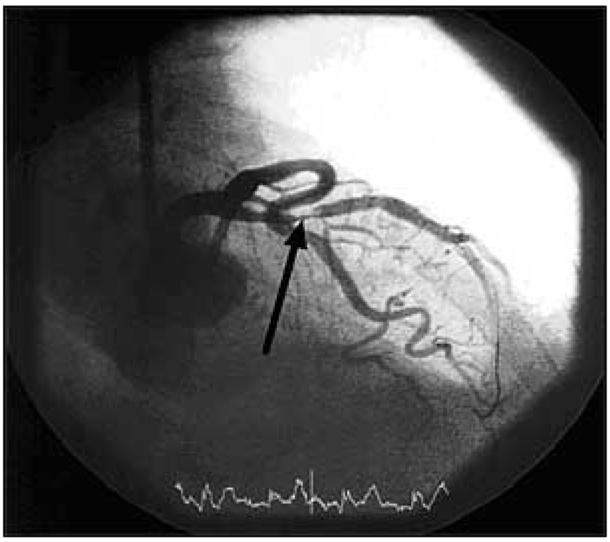

FIGURE 4: Coronarography of patient with LAD Stenosis

The spectrum of clinical applications of radiography is overwhelming, but inherently limited by the fact that it is a projection technique: the information along the path of the X-ray is integrated and information on changes in absorption along the path is lost in the image. This is the reason why X-ray computed tomography was developed.

Because of the ionising character of X-rays, a real health risk exists. Early radiographers paid a high toll as victims of radiation induced illnesses such as leukaemia.

5 Computed tomography

The loss of information due to the projection of a shadow in classical radiography limits its clinical value. Several methods have been devised in order to overcome this loss: tomography through blurring of out-of-focus structures by moving the X-ray source and film in opposed directions, stereoscopic views etc... The advent of powerful data processing allowed for new approaches and in 1972 Hounsfield introduced Computed Tomography (CT) following pioneering work carried out by Oldendorf and Cormack.

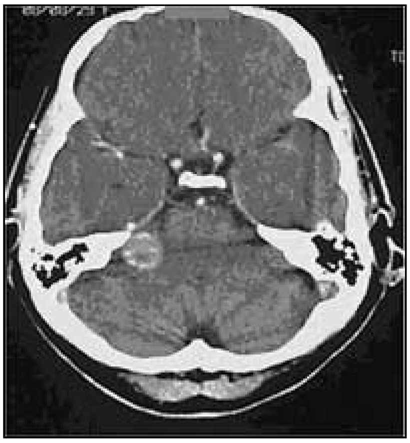

FIGURE 5: CT image with beam hardening artefacts

In order to have enough data to mathematically reconstruct virtual slices, one needs projections from different angles. Two angles allow the reconstruction of objects as squares. This is of course not satisfactory. As a rule of thumb, the quality of the reconstruction (shape, intensity...) and resolution in an image increases with the number of projections. However, for a fixed total acquisition time, the noise in each projection increases also with this number. Some optimum has to be found between resolution and noise. In today's CT scanners, thousands of fixed solid state scintillator detectors span a 2p arc, while a X-ray tube rotates at high speed (up to 1 revolution/s) over a full circle around the patient. Tomographic images are then reconstructed by means of analytical or iterative reconstruction algorithms.

As for projection radiography, a drawback of CT is the radiation burden to the patient, especially for young children. It is expected that the future switch from integrating detectors to counting detectors will allow a drastic reduction in patient dose for equivalent image quality, thus eliminating this burden.

6 Nuclear Imaging

The use of radioactive tracers that are introduced in the living system to study its metabolism dates from 1923 when de Hevesy and Paneth studied the transport of radioactive lead in plants. In 1935, de Hevesy and Chiewitz were the first to apply the method to the study of the distribution of a radiotracer (P-32) in rats.

The major development of nuclear imaging (also called scintigraphic imaging) started with the invention of the gamma camera by Anger in 1956. In parallel, positron imaging was developed. Both imaging modalities are now standard in the major nuclear medicine departments.

The tracer principle, which forms the basis of nuclear imaging, is the following: a radioactive biologically active substance is chosen in such a way that its spatial and temporal distribution in the body reflects a particular body function or metabolism. In order to study the distribution without disturbing the body function, only traces of the substance are administered to the patient.

The radiotracer decays by emitting gamma rays or positrons (followed by annihilation gamma rays).The distribution of the radioactive tracer is inferred from the detected gamma rays and mapped as a function of time and/or space.

The most often used radio-nuclides are Tc-99m in 'single photon' imaging and F-18 in 'positron' imaging.

Tc-99m is the decay daughter of Mo-99 which itself is a fission product of U. The half-life of Tc-99m is 6h, which is optimal for most metabolic studies but too short to allow for shelf storage. Mo-99 has a half-life of 65h. This allows a Mo-99 generator (a 'cow') to be stored and Tc-99m to be 'milked' when required. Tc-99m decays to Tc-99 by emitting a gamma ray with an energy output of 14O keV. This energy is optimal for detection by scintillator detectors. Tc-99 itself has a half-life of 211100 years and is therefore a negligible burden to the patient.

F-18 is cyclotron produced and has a half-life of 110 minutes. It decays to stable O-18 by emitting a positron. The positron loses its kinetic energy through Coulomb interactions with surrounding nuclei. When it is nearly at rest, which in tissue occurs after an average range of less than 1 mm, the probability of a collision with an electron greatly increases and becomes one. During the collision matter-antimatter annihilation occurs in which the rest mass of the electron and the positron is transformed into two gamma rays of 511 keV. The two gamma rays originate at exactly the same time (they are “coincident”) and leave the point of collision in almost opposite directions.

6.1 Single photon imaging

Because the source of the rays is no longer a point source, but distributed through the object, adapted 'optics' have to be used for image formation. There is no known material which refracts gamma rays the way that lenses do with visible light. One, therefore, has to rely on selective absorption of the rays based on geometrical criteria. The first, historical method but still used for particular applications, is based on the 'camera obscura' principle: a lead cone is placed over the detector and a pin-hole opening is made at top of the cone, perpendicular to the centre of the detector surface.

Only those rays which pass through the pin-hole form an image on the detector. The image is inverted and enlarged or reduced with respect to the object, depending on the distances between object, pin-hole and detector. The second method is based on the multiple hole collimator: a thick lead or tungsten sheet in which thousands of parallel holes are drilled (other manufacturing techniques exist). Typical hole sizes are a couple of cm in length with a diameter of a couple of mm. The collimator structure is an inherent limitation to the ultimate camera resolution. Furthermore, its geometric efficiency is very low (e.g. 10^{-4}).

Only those rays that hit the detector through the holes in parallel contribute to the image, which then corresponds to a one to one mapping of the radioactive distribution.

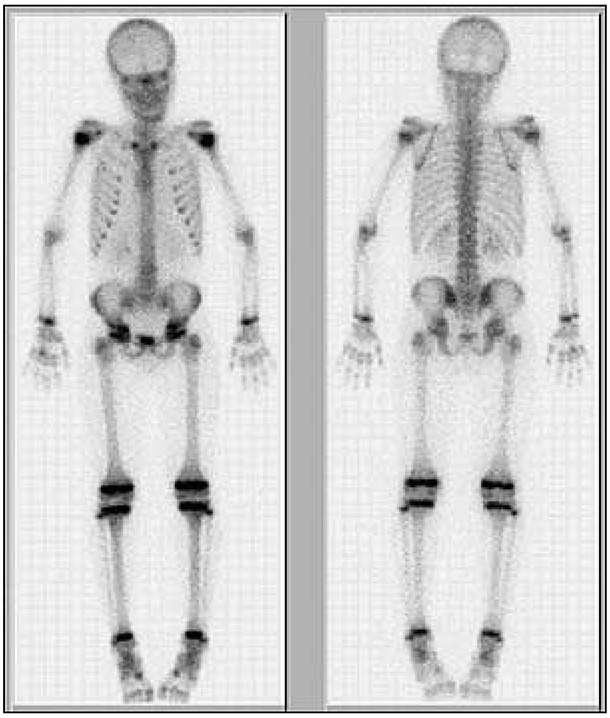

FIGURE 6: Bone scan, depicting bone metabolism in young patient.

In the Anger gamma camera, a large (e.g. 40x60x1 cm) NaI mono-crystal is used as the scintillation detector. The scintillations are detected by an array of about 100 photomultipliers. The distribution among the photomultipliers of the detected scintillation photons allows the place of detection on the crystal to be determined with a resolution of a few millimetres. The total number of detected photons allows their energy to be determined with a precision between 10 and 15%: the energy resolution.

In standard nuclear medicine practice, images are acquired during seconds to minutes. The spatial resolution of the images is between 0.5 and 1.5 cm and the contrast resolution is rather low. This is in part due to the fact that the images are projection images.

Although the number of photons per pixel may become extremely small, it may be of use to acquire series of images to study the dynamics of large areas in the image. The averaging effect over a large number of pixels, a 'region of interest', then compensates for the short acquisition time. An example of this is the use of nuclear imaging for the study of the heart function, in which a series of 8 to 16 images, representing one cardiac cycle, is acquired. Using specific processing techniques, such as temporal Fourier filtering, important clinical information can be retrieved.

By rotating the gamma camera around the patient and acquiring a large set of projections, enough data become available to reconstruct tomographic emission images. Kuhl developed emission tomography in 1964.

In tomographic imaging, the spatial resolution of the images is similar to planar imaging, but lesion contrast and, therefore, also detectability, is greatly improved.

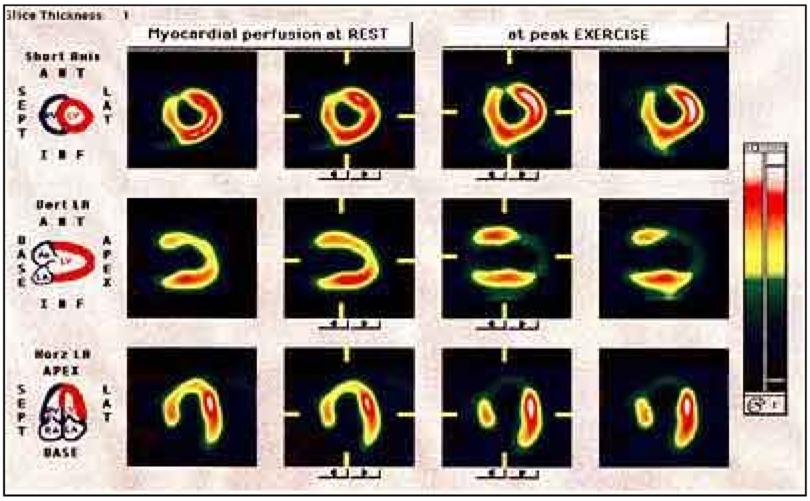

FIGURE 7: Tomographic image of myocardial perfusion defect at exercise

6.2 Positron Emission Tomography (PET)

In PET, the administered radio-nuclide decays due to the emission of a positron which in turn collides with an electron and is annihilated. In the process, two 511 keV gamma rays originate simultaneously and leave the annihilation site in opposite directions. Positron imaging was introduced by Brownell in 1951. Current ring PET cameras take advantage of the annihilation characteristics. A ring of scintillation detectors surrounds the patient. If two events are detected simultaneously in two opposed detectors, one assumes that an annihilation occurred somewhere on an imaginary line connecting the two detectors. By acquiring a large number of lines, e.g. 10^6, tomographic reconstruction methods can be used to reconstruct images of the tracer distribution.

The detectors used are scintillating detectors. Their stopping power should be high enough for 511 keV photons. Therefore, the detectors should be made out of high Z material and have a large enough detection volume. This last point however will reduce the precision of the localisation, as a precise spatial localisation requires small detectors. Furthermore, scattered rays should be rejected as they will generate lines that do not reflect the location of the annihilation. This requires a good energy resolution, which in turn requires large crystals. Finally, coincident detection implies a precise timing of events. The timing using scintillators depends on the temporal characteristics of the light generation in the detector. Therefore, finite coincidence time windows are set in order to accommodate for the detector response. This inevitably will lead to 'random' coincidences, in which two unrelated events are falsely attributed to the same annihilation. Blurring, scattered events and random events will therefore degrade the data sets. Current research is directed towards improving detector characteristics, geometrical configurations and reconstruction algorithms in order to improve the final image quality.

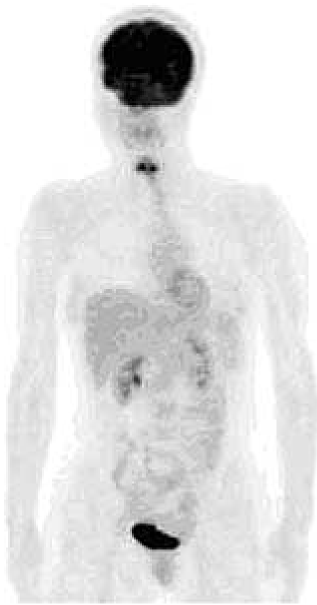

FIGURE 8: PET image of 18-FDG (DeoxyGlucose) metabolism

State-of-the-art clinical cameras have a spatial resolution of a few millimetres, which approaches the optimum given natural patient movements during acquisition times of the order of minutes. Small animal scanners reach the fundamental limit due to the positron range.

PET plays a major role in our understanding of biological processes at the molecular level.

7 How do you choose the optimal imaging modality?

Different imaging modalities generate images that correspond to different characteristics of the body or to different geometrical maps. They pose different short or long-term risks or concerns to the patient, the personnel and the working environment. The investment and running costs of the modalities differ, as do their availability.

The choice of an imaging technique is based on a balanced evaluation of the above stated factors. More than anything else, however, the following question should first be asked and answered: If the outcome of the examination is positive or negative, will it change the diagnostic or therapeutic pathway for the patient? If not, the examination should not be done.

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Reactor Kinetics Equations applied to the start-up phase of a Ringhals PWR

by Frigyes Reisch

Classical reactor kinetic equations with six groups of delayed neutrons (point kinetics) are not solved analytically. In the following programme the fuel and the moderator thermal dynamic equations are coupled to the reactor kinetic equations. The equation system is solved numerically with MATLAB and applied to a Ringhals PWR's start-up phase at zero power operation, when the fuel and moderator temperature increase is very modest. The results are presented graphically.

The programme can, of course, also be used for low power operation with some changed input data - and for various other reactors too.

This short programme with changed parameters is also suitable for nuclear engineering students to use when training at research reactors.

The calculations and the measured data are in agreement.

Fredrik Winge, a reactor physics specialist in Ringhals, supplied the chart with the measured data and was an invaluable partner.

The simplified neutron kinetics equations

$$\frac{dN}{dt} = \frac{\delta k - \beta}{l} N + \sum_{i=1}^{6} \lambda_i c_i \quad \text{or} \quad \frac{dc_i}{dt} = \frac{\beta_i}{l} N - \lambda_i c_i$$

Here

t	time (sec)
N	neutron flux (proportional to the reactor power)
δk	change of the effective neutron multiplication factor (k_{eff})
ß	sum of the delayed neutron fractions (here 0.006502)
$ß_i$	the i:th delayed neutron fraction
l	neutron mean lifetime (here 0.001 sec)
λ_i	i:th decay constant (sec^{-1})
c_i	concentration of the i:th fraction of the delayed neutrons' precursors, At steady state, when time is zero t=0 all time derivatives are equal to zero, all d/dt=0 and the initial value of the relative power equals unity N(0)=1, and also no reactivity perturbation is present δk=0

$$N(0)=1 \quad \frac{dN}{dt} = 0 \quad \delta k = 0 \quad \sum_{i=1}^{6} \lambda_i c_i = \frac{\beta}{l} \quad \frac{dc_i}{dt} = 0 \quad c_i(0) = \frac{\beta_i}{l\,\lambda_i}$$

Delayed neutron data for thermal fission in U^{235} is used as follows:

Group	1	2	3	4	5	6
Fraction $ß_i$	0.000215	0.001424	0.001274	0.002568	0.000748	0.000273
Decay constant λ_i	0.0124	0.0305	0.111	0.301	1.14	3.01

The initial values of the delayed neutrons' precursors are as follows:

i	1	2	3	4	5	6
$c_i(0)$	17.3387	46.6885	11.4775	8.5316	0.6561	0.0907

Using the MATLAB notations

x(1)=N x(2)=c_1………… x(7)=c_6

Fuel

The fuel temperature change (T_{Fuel}) follows after the power with a time delay (τ_{Fuel})

$$T_{Fuel} = \frac{c_{NF} N}{1 + p\tau_{Fuel}}$$

Where:

T_{Fuel}	Fuel temperature change
N	Relative neutron flux proportional to the relative power
	c_{FN} fuel temperature proportionality constant to relative power
p	Laplace operator d/dt, 1/sec
τ_{Fuel}	thermal time constant of the fuel, here 5 sec
t	time, sec

The differential equation form is

$$T_{Fuel} + \tau_{Fuel} \frac{dT_{Fuel}}{dt} = c_{NF} N$$

$$\frac{dT_{Fuel}}{dt} = \frac{c_{NF}}{\tau_{Fuel}} N - \frac{1}{\tau_{Fuel}} T_{Fuel}$$

At a steady state (equilibrium) d/dt=0 N(0)=1
Suppose that at zero power the fuel temperature changes by 0.001 ^{0}C when N=1 and,

therefore, c_{FN}=0.001

Suppose τ_{Fuel} =5 sec $\frac{1}{\tau_{Fuel}}$ =0.2 $\frac{c_{FN}}{\tau_{Fuel}}$ =0.00020C/sec

With the MATLAB notation x(8) = T_{Fuel}
and the neutron kinetics equations can be expanded to include the fuel dynamics

0.0002*x(1)-0.2*x(8)

The Doppler reactivity of the fuel is

$$\delta k_{Fuel} = k_{Fuel}(T_{Fuel} - T_{Fuel}(0))$$

Here

δk_{Fuel}	The reactivity contribution of the fuel temperature change, at the initial phase (t=0), at steady state (equilibrium) is zero: $\delta k(0)_{Fuel} = 0$
k_{Fuel}	Fuel temperature coefficient (Doppler coefficient) here is -3.1pcm/^{0}C

The reactivity of the Fuel's Doppler effect is

$$\delta k_{Fuel} = k_{Fuel} \left(T_{Fuel} - T(0)_{Fuel}\right) = -3.1\ 10^{-5} .(T_{Fuel} - 0.001)$$

with MATLAB notation

DeltaKfuel = – 3.1.10^{-5}*x(8) + 0.0031.10^{-5}

Moderator

The differential equation for the moderator is similar to that of the fuel, when the moderator thermal time constant is much bigger then the fuel thermal time constant:

$$\tau_{Moderator} >> \tau_{Fuel}$$

$$T_{Moderator} + \tau_{Moderator}\frac{dT_{Moderator}}{dt} = c_{NM}N$$

$$\frac{dT_{Moderator}}{dt} = \frac{c_{NM}}{\tau_{Moderator}}N - \frac{1}{\tau_{Moderator}}T_{Moderator}$$

$T_{Moderator}$	Moderator temperature change
$\tau_{Moderator}$	Moderator thermal time constant, here 100 sec
c_{NM}	Moderator temperature proportionality constant to the relative power, supposing that at zero power operation the moderator temperature change is only 0.0005 ^{0}C when the relative power N=1. Then c_{NM}=0.0005

Suppose $\tau_{Moderator}$ = 100sec $\frac{1}{\tau_{Moderator}}$ =0.01/seC $\frac{C_{PH}}{\tau_{Moderator}}$ = 0.0005.0.01 ^{0}C/sec =0.000005

With the MATLAB notation x(9) = $T_{Moderatorl}$

The neutron kinetics equations can be expanded to include the moderator dynamics too:

0.000005*x(1)-0.01*x(9)

Moderator reactivity contribution from temperature change

$$\delta k_{Moderator} = k_{Moderator}(T_{Moderator} - T(0)_{Moderator})$$

Here

$\delta k_{Moderator}$	the reactivity contribution of the moderator temperature change at the initial phase (t=0), at steady state (equilibrium) is zero $\delta k(0)_{Moderator} = 0$
$k_{Moderator}$	Moderator temperature coefficient here is - 0.6pcm/^{0}C

The reactivity contribution from the changing moderator temperature is as follows:

$\delta k_{Moderator} = k_{Moderator} (T_{Moderator} - T(0)_{Moderator})$ = -0.6.10-5.(TModerator – 0.0005)

with MATLAB notation
DeltaKmoderator=-0.6.10^{-5}*x(9)+0.0003.10^{-5}

Control Rods

δk_{CR} the reactivity contribution of the control rods' movement - here with the maximum value of 50 pcm (~8 cent, 1$˜650 pcm)
The movements of the rods and the corresponding reactivity changes are given in the first and third chart

The reactivity balance with the control rods, the fuel's Doppler effect and the moderator's temperature effect is

$$\delta k = \delta k_{CR} + \delta k_{Fuel} + \delta k_{Moderator}$$

The reactivity balance with MATLAB notation

DeltaK = DeltaKcr + DeltaKfuel + DeltaKmoderator

Comparison with Measured Data

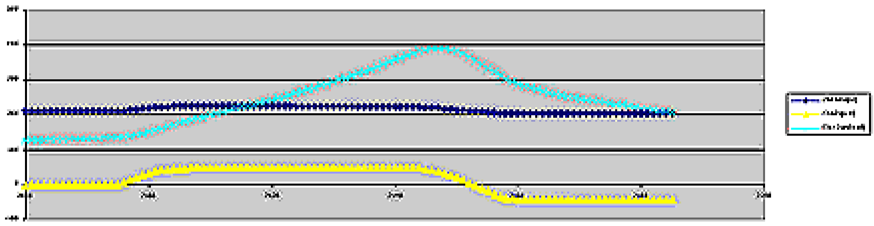
The **first chart** indicates the measured data, the neutron flux is shown by the light blue curve. The control rod reactivity is represented by the yellow curve. The dark blue dots indicate the control rod steps.

In the **second chart**, the calculated relative neutron flux is displayed and the curve is pretty much in agreement with the measured data.

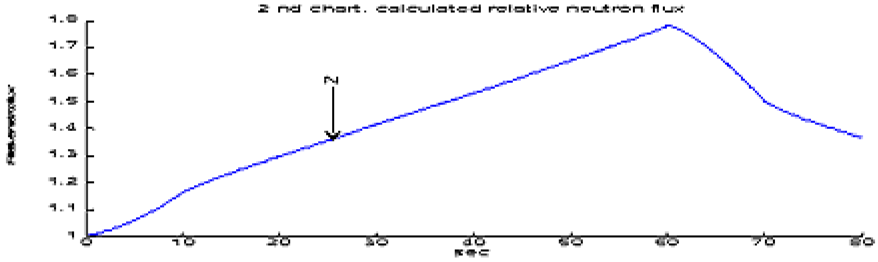
In the **third chart**, the schematic of the control rod reactivity used in the calculations is indicated.

In the **fourth chart**, the characteristics of the fuel and moderator temperature increase are shown. The values are very small as on this occasion the calculations are performed for zero power operation, when practically no power is generated in the fuel and transferred to the moderator. However, the curves clearly demonstrate that the fuel's thermal time constant is much smaller than that of the moderator's.

1st chart, measured data

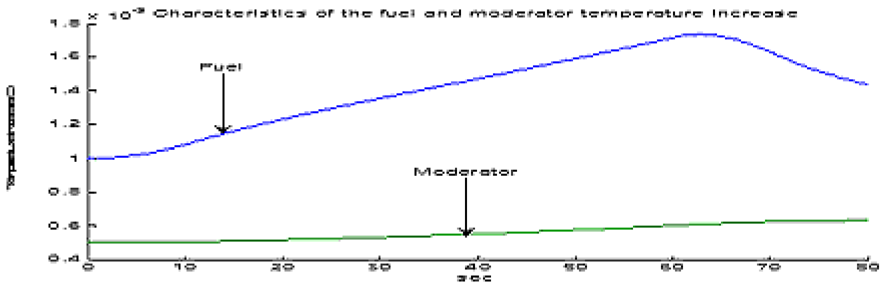


2nd chart, calculated relative neutron flux



3rd chart, schematic of the control rod reactivity

4th chart, characteristics of the fuel and moderator temperature increase



The code

The code contains two parts:

Part one

```
%Save as xprim9FM.m

function xprim = xprim9FM(t,x,i)

DeltaKcr=i*10^-5;
DeltaKfuel=-3.1*10^-5*x(8)+0.0031*10^-5;
if t>=0 & t<10
DeltaKcr=((i*10^-5)/10)*t;
end
if t>60 & t<70
DeltaKcr=(10^-5)*(i-8*(t-60));
end
if t>70
DeltaKcr=-30*(10^-5);
end
DeltaKmoderator=-0.6*10^-5*x(9)+0.0003*10^-5;
DeltaK=DeltaKcr+DeltaKfuel+DeltaKmoderator;
xprim=[(DeltaK/0.001-6.502)*x(1)+0.0124*x(2)+0.0305*x(3)+0.111*x(4)+0.301*x
(5)+1.14*x(6)+3.01*x(7);
0.21500*x(1)-0.0124*x(2);
1.424000*x(1)-0.0305*x(3);
1.274000*x(1)-0.1110*x(4);
2.568000*x(1)-0.3010*x(5);
0.748000*x(1)-1.1400*x(6);
0.273000*x(1)-3.0100*x(7);
0.000200*x(1)-0.2000*x(8);
0.000005*x(1)-0.0100*x(9)];
```

Part two

```
%Save as ReaktorKinFM.m

figure
hold on
for i=50 %i is the max Control Rod reactivity i pcm
[t,x]=ode45(@xprim9FM,[0 80],[1; 17.3387; 46.6885; 11.4775; 8.5316; 0.6561;
0.0907;0.001; 0.0005],[] ,i);
plot(t,x(:,1:1))
end
hold off
```

http://www.euronuclear.org/e-news/e-news-14/sck-cen.htm

MEMBER SOCIETIES

SCK•CEN: A centre of scientific excellence

In September 1951, Pierre Ryckmans, the then Belgian Commissioner for Atomic Energy and former Governor General of the Belgian colony Congo, commissioned a group of scientists to set up a new national organization to study the peaceful applications of nuclear energy. The founding members of that organisation came from various areas of the scientific world, as well as from academia, government and industry. They decided to set up a non-profit-making association called the "Research Centre for the Applications of Nuclear Energy". The choice for this kind of organisation shows that they wanted to stimulate the peaceful applications of nuclear energy in the best interests of the public.

Now, more than fifty years later, the post-war techno-scientific optimism that characterised societal thinking is balanced with an increased sensitivity for ecological and social aspects. But the aim of the founders of SCK•CEN, which is now called the "Belgian Nuclear Research Centre", remains the same: "Within the context of sustainable development…",

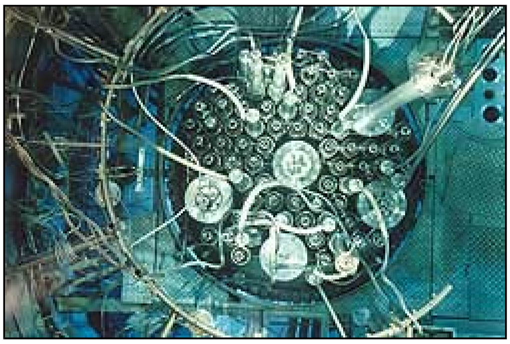
SCK•CEN states, "…our research aims to study new nuclear technologies, as well as medical and industrial applications, and to contribute to nuclear safety, radiation protection and the care for the backend of the nuclear fuel cycle".

About six hundred academic researchers and technical and administrative employees work in the laboratories and offices in Mol and Brussels, and their areas of expertise range in scope, quite literally, from the deep underground to outer space. SCK•CEN's research activities are concentrated into three main areas: 'materials sciences', 'advanced reactor systems' and 'health safety and environment'. In addition, the centre also aims to play a role in the ongoing debate on nuclear issues by serving as a 'platform for reflection' on risk governance issues and on policy related to the applications of radioactivity in general. This summary highlights some of those activities. A full overview and contact details can be found on the Centre's website at: www.sckcen.be

Research related to material sciences and advanced reactor systems

In the broad field of nuclear energy technologies, SCK•CEN focuses on the development and validation of materials and advanced fuel designs, for both fission (for present power reactors up to Generation IV) and fusion applications (ITER, DEMO). In addition to theoretical research, the Centre runs a variety of experimental programmes in its test reactors BR1, BR2 and VENUS in support of safety aspects relating to the present generation of NPP's. Within the context of the decision to build ITER in France and the future DEMO plant, the Centre concentrates its fusion research on the behaviour of materials under representative irradiation conditions. This entails research on the radiation resistance of materials for the first wall, the vessel assembly and the blanket, and on the radiation resistance of instrumentation components.

SCK•CEN also pays special attention to the optimisation of the back-end of the nuclear fuel cycle, in particular to the treatment of irradiated fuel or the separation of actinides and long-lived fission products from the residual waste that needs to be stored. The separated isotopes can then be transmuted into



short-lived or stable fission products in an accelerator driven system or a fast reactor. On the request of the Japanese IRI (Institute for Research and Innovation), SCK•CEN is testing a revolutionary new treatment project for the separation of actinides and long-lived fission products from the back-end fuel flows that are suitable for geological disposal.

MYRRHA, an Accelerator Driven System and a sub-critical installation that has to be fed with an outside source to produce neutrons in support of the nuclear reaction, is a demonstration machine operating within the framework of the European research programme EUROTRANS (EUROpean Research Programme for the TRANSmutation of High-Level Nuclear Waste in an Accelerator Driven System). The aim of this particular research project is to demonstrate that it is technically possible to transmute high-level and long-lived radioactive waste with an accelerator driven system.

Research related to health, safety and environment.

Meanwhile, the Centre is about to finish the dismantling of the BR3 reactor. This reactor was the first ever pressurised water reactor (PWR) in operation on the European mainland, and its dismantling can be considered as a reference ‘test case’ for developing the necessary experience for the future dismantling of commercial PWRs.

Last years, the PRACLAY experiments at Mol attracted wide attention from the scientific community and from politicians. They fit in well with the research currently going on into the suitability of Boom clay as a host formation for the secure storage of high-level, medium-level and long-lived radioactive waste. Tests with a source of heat that simulates the radiant heat of the waste will continue for more than 10 years and contribute to gaining a better idea of the impact that this heat has on the characteristic features of Boom clay.

As one of the world’s first ever nuclear research institutes dedicated to the peaceful use of nuclear energy, the Belgian Nuclear Research Centre was officially recognised this year as an "IAEA Collaborating Centre" by the International Atomic Energy Agency (IAEA). This reflects the close collaboration that exists between SCK•CEN and the Agency in the field of radioecology.

Materials and instruments are also tested for their cosmic radiation resistance qualities as part of space research. In addition, research on the stability of micro-organisms under extreme circumstances is still ongoing. Scientists at SCK•CEN examine whether the organisms that have been selected for the bioreactor – which has to transform human waste products into food and oxygen during long space missions – could mutate under the influence of cosmic radiation and, thus, put the bioreactor out of action. In the near future, SCK•CEN will study the effect of space on the behaviour of bacteria and will perform advanced biochemical and molecular tests on blood samples of astronauts working at the International Space Station. Radiobiology research is also performed 'on the ground': the Laboratory of Radiobiology is world famous for its studies on the effects of low-dose ionising radiation on the development of organisms. It has a special focus on female germ cells, the pre- and early post-implantation stages, and the embryonic developing brain.

Communication, education and the study of the social dimension.

When it comes to studying the human brain, research at SCK•CEN naturally goes hand-in-hand with education and training. In addition to its own education and training activities with regard to radiological protection, SCK•CEN also co-ordinates two education and training projects within the EURATOM Research Programme of the European Commission (Sixth Framework Programme, FP6). The ENETRAP project (European Network for Education and Training in Radiological Protection) aims at harmonising and integrating national education and training programmes in the domain of radiation protection. This will contribute to develop a European policy on radiation protection and a common safety culture. The FP6-BNEN project developed an evaluation methodology for the assessment of education and training programmes. This methodology is implemented in Belgium by a consortium of six Belgian universities and SCK•CEN, which is called the BNEN (Belgian Nuclear higher Education Network). BNEN has been organising a common education programme for nuclear engineers since 2002. The programme's aim is to share its accumulated experience with Belgium's European neighbours and to contribute to the realisation of the "European Research Area". Moreover, SCK•CEN grants on a yearly basis several PhD and post-doctoral projects to international researchers - in collaboration with Belgian universities.

Understanding the benefits and risks of radioactivity and its applications not only requires technical insight and training, but also an understanding of the context and a sensitivity for the social and philosophical aspects of a particular context. At SCK•CEN, societal aspects related to policy and decision-making in nuclear issues, such as risk perception and governance, and the involvement of local communities in the location of waste management facilities, are investigated in close collaboration with universities. The observations that can be made from these studies give nuclear researchers more insight into the complex social and ethical aspects associated with nuclear applications and also shed new light on how to organise - in a more effective way - dialogue and interaction with civil society.

Challenges and opportunities

Like most nuclear institutes and companies, SCK•CEN has to keep up with growing competition in what is a small but specific (research) market. At the same time, it has to respond to shifting public and political perceptions on nuclear by showing its openness to answer questions on hot topics such as energy policy, climate change and radioactive waste management. According to Eric van Walle, the new General Manager, the recent re-organisation of SCK•CEN will enable the Centre to fulfil, better than ever, its mission.

ENS NEWS recently interviewed Eric and here is what he had to say about the work, aims and future of SCK-CEN.

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http://www.euronuclear.org/e-news/e-news-14/eric-vanwalle-interview.htm

MEMBER SOCIETIES

Interview of Eric Van Walle, new Head of SCK-CEN

Q1*. The nuclear revival is in full swing, with some European countries reversing their nuclear phase-out policies and others expanding or opting for nuclear for the first time. Within this context, what are, in your view, the major challenges facing SCK•CEN? How do you see things evolving in the near future?*


Eric Van Walle

As you know, we have by law a nuclear phase out scenario in Belgium that will start with the closure of the Doel I/II and Tihange I power plants in 2015. We expect, however, that Belgium too will have to renounce its phase out and that the dossier will be high on the political agenda by next year. Although SCK•CEN tries to remain objective and not to take any position on the political dimensions of this dossier, we cannot hide the fact that reversing the current policy would have a positive impact on SCK•CEN's activities. It is clear that if a changed attitude towards nuclear were to be adopted this would have a positive impact on R&D in the nuclear energy domain and on the educational projects that we run as part of our portfolio of activities.

Q2. *As a state-run research institute, the work and objectives of SCK•CEN must, inevitably, be influenced by political change in Belgium. With elections in Belgium just around the corner, to what extent do you think that a change of government might impact upon the current work and future direction of research at SCK•CEN?*

First of all SCK•CEN is not a state-run business: we are government supported and need to fulfil certain obligations that are mentioned in our statutes. These statutes are rather well-defined but also allow us to carry out other activities as long as they are related to nuclear energy matters. SCK•CEN tries to be objective in its evaluations and communications: as such we are not influenced by political change, but we can be requested to look into extra matters (or the opposite). On the other hand we have our 'own income' from extra research or service related work. Here we have much more freedom to choose the directions in which we invest our resources.

Q3. *The research community in Europe is experiencing increasing competition from Eastern Europe. Is a more competitive marketplace a good thing or a bad thing for European research in general and for Belgian research in particular? Are they really competitors, or is it more a case of exploiting synergies, pooling resources and sharing experiences and expertise?*

We are not afraid of competition as long as it is fair competition. At present, the competition is unfair as far as money is concerned (especially when it comes to salaries!) but we can compete because of the quality and knowledge-based contributions we can make to the projects. It is clear that many of the former Eastern European countries are improving their overall standards and exploiting synergies will become increasingly more important: this is already apparent in many European projects. So, we will have to reach agreements as how to effectively pool resources and promote complementarity.

Q4. *SCK•CEN has been carrying out extensive research into the merits of Boom clay as a safe and efficient medium for the deep underground storage of radioactive waste. Do you think a European country will finally succeed in starting up a large-scale underground repository operation in the near future and isn't Belgium playing a leading role in making this a reality one day?*

Several projects are already well under way right now. In France, for example, work is ongoing 500m deep underground at the experimental gallery at Bure. However, Belgium has always had played a pioneering role in the research and development of waste disposal in clay formations and has set the standards in this area. The interest shown in this Belgian experiment is worldwide and has led to spin-offs both in the past and today (including research carried out by the IAEA and international consultancy). Will final disposal in clay ever happen? This is partly a political decision because retreated vitrified high level waste (HLW) still needs to cool down for at least 50 years before it can be put into a final repository. So, the final “reality” of Boom clay disposal may still be some years away … which does not mean that research has been finalised, on the contrary, it still keeps us busy.

Q5. *The medical isotope business continues to develop largely free of the controversy, public opposition and anti-nuclear NGO focus that have traditionally accompanied the nuclear power industry. How do you see research in the medical applications of nuclear technologies progressing in the short and medium term? The medical and diagnostic business should help enhance the overall image of nuclear energy, but is this the case?*

The medical radio-isotope business is an important business area for SCK•CEN in both the short and long term. There is an increasing demand for it, which will increase the capacity of our work in BR2 and help launch further research projects. We also believe that society should see in a better way the considerable healthcare benefits that can be gained from the medical isotope business. This can only be positive for the image of nuclear energy applications in general. Other applications not related to BR2 include, for example, "hadrontherapy," which we believe might deliver increasingly important healthcare benefits in Belgium in the years to come.

SCK•CEN (Belgian Nuclear Research Centre), Mol

Q6. *The continuing decline of interest among young people in studying the sciences and in pursuing a career in research is often highlighted in the media. Why do the sciences appear to be so unattractive to many young people? As a centre of excellence, SCK•CEN offers a number of education and training projects. Could you explain what the main objectives and activities of these programmes are?*

Well I think this situation is now gradually changing – and for the better. The natural sciences are beginning to make a come-back after a decline that was largely 'sponsored' by the loss of interest in nuclear energy issues. SCK•CEN together with 6 Belgian universities have put in place and organise at SCK•CEN the Belgian Higher Nuclear Education Network. Its purpose is to promote continuous education and applied training in a range of nuclear physics related applications and to develop the necessary bank of skills and technical expertise required to build a platform for talented young Belgians to pursue a successful career in nuclear engineering and related fields. SCK•CEN also offers an ongoing programme of training courses and exchange programmes with young PhD scientists and physicians from eastern European and emerging countries, who work in our Mol laboratories in a range of applied fields. These reflect the importance that we attach to training, education, sharing experiences and developing synergies with other countries. They also show the international network of contacts that we have developed and emphasise our international and forward-looking approach.

Similar initiatives are also being pursued in other countries. So, the "scientific education deficit" that has been so apparent across Europe in recent years is gradually being corrected. SCK•CEN's efforts in this area are bearing fruit. Only by refuelling interest in the natural sciences among young people through education - at all levels, from secondary schools to post-graduate university studies - can we ensure the reservoir of talent, commitment and youthful dynamism that will be needed to sustain and drive forward the nuclear revival.

Q7. *SCK•CEN is involved in societal research that aims to improve dialogue and interaction with local communities and stakeholders on nuclear issues – particularly with regard to safety, waste and risk management. Could you describe briefly what this work involves and the benefits it brings? To what extent do you feel that this work enhances public perception of nuclear?*

The PISA research programme that SCK•CEN is carrying out , which has concentrated on the integration into and impact upon nuclear research of social sciences and societal issues, focuses upon the involvement of key relevant actors and stakeholders - such as the local communities in Mol and Dessel- in the decision-making process relating to nuclear waste disposal. This combines risk governance approaches with enhanced dialogue.

PISA has also analysed the prevailing safety culture at our own installations, as well as liability issues linked to nuclear legislation. We also questioned our own experts and the public to learn more about risk behaviour patterns. A pre-condition for influencing public attitudes towards nuclear technology is to first gain a better insight into differing risk perceptions. This is what we aim to achieve from the Belgian version of the IRSN risk barometer survey.

Q8. *The work that you carry out into ways of continually improving safety standards within the nuclear industry reflects SCK•CEN's mission to protect mankind and the environment. It has led to a number of collaborative projects with international bodies like the IAEA and IRE (the National Institute for Radio-elements). Could you highlight one of these initiatives and explain how it has produced results?*

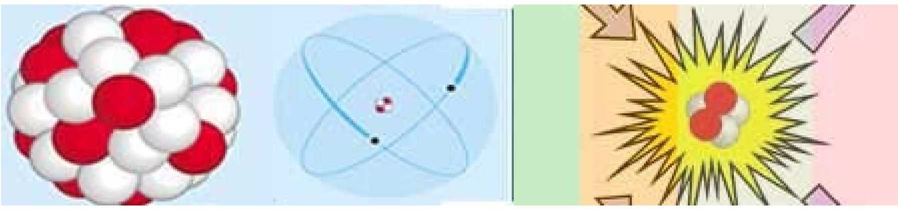
SCK•CEN has been involved in many projects related to standardisation. It actively participates in the development of safety standards for operational NPP's through its involvement with ASTM and USNRC (Belgium follows, to a large extent, the example of US legislation). The reason for this participation is twofold: firstly, it is a statutory obligation and secondly, it also is also a way of establishing the contacts needed to obtain contractual work related to reactor safety assessments. Another example of collaboration with international bodies is the continuous and very active interaction that SCK•CEN has with the IAEA – in particular, participation in many safety related commissions, as well as several CRP (Concerted Research Projects); In addition, we have been asked by the IAEA to perform expert assignments with regards to safety and other issues.

Q9. *Many of SCK•CEN's research programmes are carried out within the framework of the EU's 6th Framework Programme. In your opinion, what new initiatives will emerge from the 7th Framework Programme- or will it be simply a case of* ***status quo****?*

We sense that the EU is putting more and more emphasis on the fact that they consider that plant owners (stakeholders, end-users) are ultimately responsible for the financial input needed to carry out their research programmes. As such, the EU concentrates more on bringing different groups together to bring about a more integrated European research scenario. In reality, we believe that FP7 will largely promote continuity with regards to existing FP6 programmes and ideas. We hope that future research projects will receive adequate funding to create the necessary basis for fully-fledged and effective research projects to emerge.

Thank you Mr. Van Walle (interview conducted by Mark O'Donovan) http://www.euronuclear.org/e-news/e-news-14/cea.htm

MEMBER SOCIETIES



A “humanising” process: Making science stimulating and relevant to young people

By Nathalie Guillaume (CEA)

In France, the number of students studying the sciences decreased by 23% between 1994 and 1999. And that tendency has not been reversed since. This is a worryingly familiar scenario that is repeated in a number of countries across Europe, where the appreciation for science learning – at both the secondary and university level – appears to be in decline. The general lack of interest among many young Europeans for studying sciences or pursuing a scientific career is a major challenge facing the nuclear industry. This disturbing trend will lead to a talent deficit and have a significant impact upon our future capacity to bring innovative solutions to the market place. This, in turn, could have a negative effect upon a European economy that thrives on innovation and new technology.

Many young people have been discouraged from studying the sciences, a situation that is mirrored in most European countries - as the last EU ***Eurobarometer*** survey on sciences confirmed. But why is this so? 67% of students in European schools who responded to the survey said that they thought that science lessons should be made more attractive. Furthermore, sciences are often used as a basis for identifying and selecting the best performing pupils, who then very rarely go on to pursue scientific careers.

The lack of interest in studying for degrees in certain scientific subjects seems to indicate that many young people do not perceive a career in the sciences to be an interesting or lucrative option. And yet, more and more young people - quite reasonably - want to participate in debates on key issues that involve making fundamental scientific and technological choices.

From our industry’s perspective, involving more young people in such a debate and showing them how the sciences are more “human” and relevant to every day life will help to correct the many myths, misunderstandings and misrepresentations that have led to the demonisation of nuclear technologies and will help to inspire more of them to pursue a scientific career path.

A reliable partner for government

Conscious of the challenge facing the nuclear industry, the Communications Division of the CEA has developed tailor-made products and organised a number of activities aimed at raising the interest level and appetite for the sciences among young people. The main goal of these initiatives is to make them more conscious of how vital the sciences and research are to the future of society and the global economy. Our first objective, one which has been achieved, was to establish a basis for co-operation with the French Education Ministry, so that the CEA would be included as a major partner in the government's programme for action. Indeed, we have played a fundamental role in establishing the first specially adapted training and the post-graduate training programme for science teachers offered by one of the most important national teacher training establishments in France – the IUFM (Institute for the Training of Primary and Secondary Schools Teachers).

Another successful initiative has been the "science cafés" that are organised by the CEA in a number of secondary schools across France. The focus of these interactive discussion sessions is not so much what is on the drinks menu, but rather a number of key scientific issues chosen by teachers and pupils, such as radioactivity, the global climate, astrophysics and nuclear medicine. Pupils get to meet young researchers outside of the school context - in a less traditional, extra-curricular setting.

Teachers as opinion-leaders

Today, teachers are more and more seen as opinion-leaders for pupils and families, especially when it comes to providing career guidance and orientation. That is why we at the CEA have recently co-ordinated a project with the French Institution for the Information of Families and Orientation of Pupils (ONISEP). This project, called "Chercheurs Croqués," is aimed at making teachers and pupils meet with researchers and discuss the many aspects involved in pursuing a career in science (in France and Belgium). A DVD and a magazine have been produced and distributed to 12,000 secondary schools in France. The project was financed by the European Union as part of an initiative of the FP6 (6^{th} Framework Programme of the European Commission) called "Researchers in Europe, 2005".

Choose disseminating partners

National and regional actions are also organised by the CEA's Communications Division and by the communications teams at the nine CEA centres across France.

In schools, in laboratories, in bookshops and cafés, the CEA centres - even those working in the military research field - organize meetings, carry out research experiments and organise conferences, both during Science Week and throughout the year. This is a responsibility that all public research institutions are required to fulfil. However, there are 13 millions pupils and nearly one million teachers in France, so we must also rely on partners to help us organise activities and to disseminate information. We are also trying to reach certain regions where the CEA is not yet present, for example in the centre of France in cities like Poitiers and Clermont Ferrand. Some of our partners, like Fondation 93, are actively spreading the message and meeting young people on a regular basis in the eastern suburbs of Paris, many of them areas plagued by major social problems. We also organise experiments and teaching sessions in many secondary schools with experienced researchers.

New tools to "humanize" the sciences

The approach adopted differs according to the age group of the pupil. With the very young, it is a question of "charming" them, i.e. emphasising the appealing and fun aspects involved. With the older pupils, it's more a question of guidance and advice.

The key, whatever the age group, is to work hand-in-hand with the teachers and to make the sciences seem more human and relevant to young people.

Among the projects that we do with the youngest age group one that is particularly original. It involves the creation of a book (fictional) on the subject of the sun or on the global climate by a class of pupils of primary school age, together with the help of a CEA physician.

A fun and educational booklet for children aged between 10 and 14 years has also been published by the ***Playbac*** publishing house. It is all about energy and simple physics. IN addition, a special issue of a very successful daily magazine for youngsters aged between 14 and 18 years, called "***l'Actu***", and another one called "***Imagine ton future***", have also been published by the CEA – this time on the subject of the atom. Reactions to these publications have been very positive and new special issues are in the pipeline.

For teenagers and their teachers, we have printed new pedagogical teaching booklets (120, 000 copies). So far, booklets have already produced dealing with around 15 different subjects. A teaching folder on radioactivity has also been produced with the help of two NGOs devoted to scientific education. They contain, for example, playing cards on the CEA and on radioactivity, and a cartoon on radioactivity. Another folder on the subject of fusion has been produced by the CEA's centre at Cadarache.

On the CEA's website, pupils can now find possible subjects and information to do their homework and new scientific and teaching-based cartoons are available for them. To further "humanize" the sciences, a new website more adapted to young people's needs has been created, broadcasting video clip portraits of young researchers and featuring animated clips and teaching folders. We intend to increase by 20% this year the number of visits to the educational part of our website. Most of these educational tools can be viewed or ordered on the CEA website at: www.cea.fr.

When we look at the results of studies carried out among pupils on the subject of choosing a scientific carrier, the most frequently received answer that sends out a negative message about the sciences (40%) is "I am not good enough in mathematics". Teachers echo this finding and recognize that young people rarely cope with or recover from a failure in maths experienced in their early school career. The second most commonly given answer concerns the ability - or perceived difficulty - of balancing a normal private or family life with a scientific career. The CEA's CEA ***Jeunes*** project aims to prove, with the help of teachers, that it is possible to manage the family and professional life conundrum, and that the life of a researcher is a perfectly normal one.

Although much remains to be done to make studying sciences (at schools and university) and pursuing a career in science appear a more relevant and attractive option to young people, the CEA - like organisations in other countries - is tackling the problem head-on. It is a strategic option for the nuclear industry and the nuclear sciences must take the initiative. The sings are that the tide could be turning at last.

More information can be found at the following web sites:

www.cea.fr/fr/jeunes/
www.cea.fr/fr/jeunes/Animation/anim.htm
www.cea.fr/fr/jeunes/Animation/LesFondamentaux.htm#Autres

http://www.euronuclear.org/e-news/e-news-14/itre.htm

EUROPEAN INSTITUTIONS

European Commission outlines Joint Undertaking proposal on ITER

Then decision on how exactly the EU will support the international ITER fusion project has moved a step forward in August with the publishing of the European Commission's (EC) proposals for the creation of a ***Joint Undertaking for ITER and the Development of Fusion Energy***. Here is the EC's press release detailing the proposals:

The Commission has published proposals for the creation of a Joint Undertaking to provide the European contribution to the ITER international fusion energy project. The European Joint Undertaking for ITER & the Development of Fusion Energy will work with European industry and research organisations to build around half of the high-technology components that make up the ITER fusion project. It will also support other projects to accelerate the development of fusion as a clean and sustainable energy source for the 21st century. The Joint Undertaking will be based in Barcelona and should be up and running by the first half of 2007.

"Building upon the success of the integrated Euratom fusion research programme, the Joint Undertaking will be a dynamic new organisation that will play a leading role in the construction of ITER and enhance Europe's role in the technological development of fusion energy" Commissioner Potocnik said today.

The Joint Undertaking's primary task will be to meet Europe's wide-ranging obligations towards ITER, by working with European industry and research organisations to supply the components for the construction of ITER and will administer the EU's financial contribution to the project, which will mostly come from the Community budget.

The Joint Undertaking will also contribute to the implementation of the "Broader Approach", an agreement between the EU and Japan conceived to work on a number of joint projects to accelerate the development of fusion energy. These projects, including finalising the design for a material testing facility and the upgrade of a fusion experiment, will complement ITER by filling possible knowledge gaps. A proposal on the "Broader Approach" will be made by the Commission later this year.

Looking to the longer term, the Joint Undertaking will progressively implement a programme of activities to prepare for the first demonstration fusion power reactors, building on the experience of ITER.

The Joint Undertaking will have a lean managerial structure, respecting accountability and transparency. Its activities will complement the other parts of the integrated European fusion energy research programme carried out in national fusion laboratories in the EU Member States and other associated European countries - Bulgaria and Romania, plus Switzerland since 1979 - under the Euratom umbrella.

A Governing Board, composed of the members of the Joint Undertaking – Euratom, the EU Member States and other associated countries, will ensure overall supervision of its activities. Day to day management of the organisation will be the responsibility of its Director. The Joint Undertaking will be able to call on the best possible scientific and technical advice through one or more Scientific Programme Boards.

The Joint Undertaking will pool resources at European level. It will receive contributions from Euratom, its members and other sources. The organisation will have its own financial rules adapted to its special tasks, particularly the procurement of high tech components from industry ensuring sound financial management.

The success of the Joint Undertaking will ultimately depend upon the expertise and dedication of its staff. In particular, the organisation will recruit top notch engineers and technicians who will interact with industries, fusion laboratories and other organisations to ensure that Europe delivers upon its international commitments to ITER and beyond.

More information
DG Research website

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http://www.euronuclear.org/e-news/e-news-14/ECs-recommendation.htm

EUROPEAN INSTITUTIONS

FORATOM broadly welcomes EC's recommendation on the efficient use of nuclear decommissioning funds in the EU

FORATOM, the trade association representing the European nuclear industry, broadly welcomes the Recommendation that was adopted yesterday by the European Commission (EC) on the way that Member States should appropriate, manage and use funds destined for the decommissioning of nuclear installations and for the management of spent fuel and radioactive waste. FORATOM fully supports the general principles that underpin the Recommendation, namely that sufficient decommissioning funds should be set aside, that funding arrangements are managed in a transparent way and that any decommissioning activity should be carried out with safety and environmental protection as primary considerations. FORATOM acknowledges the EC's call for harmonisation of rules governing the appropriation and use of decommissioning funds. It particularly welcomes the Recommendation's emphasis on maintaining a flexible approach to harmonisation that recognises how operational, regulatory and legal conditions vary among the Member States.

One of the main principles behind the EC's Recommendation on decommissioning funds is that it would be of clear benefit for nuclear safety if rules for the constitution, management and use of decommissioning funds were harmonised throughout the EU in such a way that ensures sufficient funds will be made available when required.

The nuclear industry recognises the EC's overall objectives of ensuring that adequate funding should be made available across the EU to meet all future financial decommissioning obligations and agrees that it is ultimately the responsibility of the licence holder, under the supervision of the national regulatory body, to ensure that decommissioning is carried out safely and efficiently.

FORATOM's Director General, Santiago San Antonio, gave the following reaction to the main points outlined in the Recommendation: "The safe management of nuclear facilities from start-up to decommissioning remains a priority for the nuclear industry. Decommissioning is already being successfully carried out in several EU countries and financing systems have been put in place. All external costs, including those to cover decommissioning and waste management are included in investment plans for the building of future nuclear units in Europe. This demonstrates how nuclear energy is one of the most competitive ways of generating CO2-free base-load electricity. However, financing models vary from country to country due to basic differences in operational, regulatory and legal requirements. The European nuclear industry does not favour any one model of financing as long as transparency of funding arrangements is maintained. We believe that greater harmonisation can be achieved if a flexible approach that takes into account differing operational, regulatory and legal requirements is adopted."

The issue of decommissioning will continue to grow in importance in the coming years, especially in light of the nuclear revival that is gathering momentum in a number of European countries. With this in mind, the nuclear industry welcomes the Recommendation's emphasis upon the need for continuing consultation and dialogue on decommissioning funds between the EC, Member States and operators.

For more information on the EC Recommendation can be found on the Europa website. Alternatively, you can contact Mark O'Donovan of FORATOM at: Tel.: 0476 98 42 18

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http://www.euronuclear.org/e-news/e-news-14/epr.htm

EUROPEAN INSTITUTIONS

FORATOM welcomes EC approval of EPR investment plan

FORATOM, the trade association representing the interests of the European nuclear power industry, has warmly welcomed the approval given today by the European Commission (EC) to the investment plan for the construction of an EPR (European pressurised water reactor) nuclear power plant at Flamanville, France, that was submitted by Electricité de France (EDF).

The green light given today to the investment plan that underpins the construction of a new-generation EPR power plant at EDF's nuclear facilities in north western France was the culmination of a lengthy approval process. This process involved, in accordance with the terms of the Euratom Treaty, prior notification by the project owners and the subsequent statutory approval of the EC. The construction of the EPR in France could signal the gradual renewal of the French nuclear fleet. It is not, however, a first – a groundbreaking EPR is already under construction at the Olkiluoto plant in Finland, which is run by the Finnish power utility TVO. However, the fact that it will be built in France, which is Europe's premier nuclear country, is highly significant. Furthermore, the technology behind the EPR was co-developed by EDF and AREVA-NP in the 1990s, in partnership with the German engineering company, Siemens. The national nuclear safety authorities in France and Germany were also associated with the development of the EPR project from day one.

The new reactor's design represents the very latest in cutting edge nuclear technology and sets a new benchmark in terms of safety, environmental protection and economic performance. Significantly, the investment plan approved by the EC took into consideration all relevant costs, including those associated with waste management and decommissioning, which shows the economic added value of the project.

Within the context of European energy policy, which was recently articulated through the EC's consultation document ***Energy Policy Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy***, the EC's approval of the investment plan that will fund the construction of the latest EPR shows clearly how nuclear energy is now officially recognised as a key policy driver. A fundamental element of that policy is the promotion of an energy mix that includes nuclear energy and all low-carbon emitting technologies.

Commenting on the EC's rubber stamping of the funding project, Santiago San Antonio, Director General of FORATOM, was quick to add: "We welcome the European Commission's decision to approve the EPR project's investment plan. The decision represents a clear recognition and endorsement of the vital role that nuclear energy has to play in ensuring security of energy supply, combating climate change and providing a safe, efficient and affordable supply of base-load electricity. The construction of the EPRs in France and Finland will enable Europe to maintain its position of leadership in a technological field that is vital to its sustainability goals and future prosperity. Other countries around the world are actively looking to exploit this state-of-the-art technology, which confirms that the global nuclear revival is gathering momentum. Nuclear is not the only solution, but there is no solution without it."

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http://www.euronuclear.org/e-news/e-news-14/hlw.htm

ENS WORLD NEWS

International Nuclear Energy Academy

HLW disposal: Status and Trends

An International Nuclear Energy Academy Statement by

Bertrand Barré

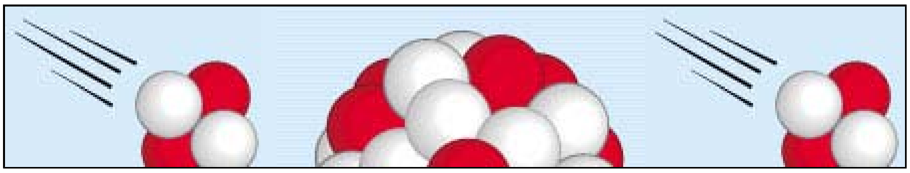
Assisted by Dan Meneley, Dave Rossin and Jorge Spitalnik

Introduction

High Level Waste disposal is viewed by many as Nuclear Power's Achilles Heel, and some people are even convinced it constitutes an insoluble problem. It is certainly a question about which the perception of the specialists, aware of the progress achieved in the last two decades, differs deeply from the perception of the public-at-large and the media. This paper attempts to bridge part of this gap by providing up-to-date information on the status of HLW disposal across the world.

Each country having its own classification of radioactive waste, we shall adopt the simplest. A radioactive substance is a substance which contains radioactive nuclei in amount or concentration high enough to motivate radiation protection measures. A radioactive waste is a radioactive substance resulting from a process of human activity and which has no foreseen use in the present technical and economic context: it must be disposed of without harming people and environment. We shall distinguish only three broad categories: Low level waste LLW, intermediate level waste with long lived isotopes LL-ILW and high level waste HLW.

LLW constitutes the bulk of the radioactive waste in volume and in mass, but it contains only a small fraction of the total waste radioactivity. The origin of LLW is quite diverse: nuclear power, medicine, research, industry, etc. Many countries have licensed operating LLW disposal sites, usually surface storage sites which accept conditioned (immobilized) waste packages with such specifications as to insure that within two or three centuries, given the short radioactive period of most isotopes, the radioactivity of the disposal site will be of the same order of magnitude as the natural background radioactivity.



LL-ILW and HLW originate almost exclusively from nuclear reactors and their fuel cycle facilities, as well as the defense facilities of those countries which developed nuclear weapons. Though quite limited in volume, they constitute the bulk of the waste radioactivity. For those countries with no weapons activities and which do not reprocess their spent fuel, all their HLW and LL-ILW is inside their spent fuel assemblies which constitute for them the ultimate waste. We shall now focus only on those two categories of waste.

Containment, Storage, Disposal, Transmutation

For all the fear it inspires, radiation has two precious characteristics:

1. It is easy to detect at levels far below the detection threshold of any noxious substance (one can detect a single disintegration when one cannot detect a given chemical unless billions of molecules are present);

2. When detected, it is easy to protect oneself from radiation by a combination of three ways: keeping distance, limiting exposure time and providing shielding.

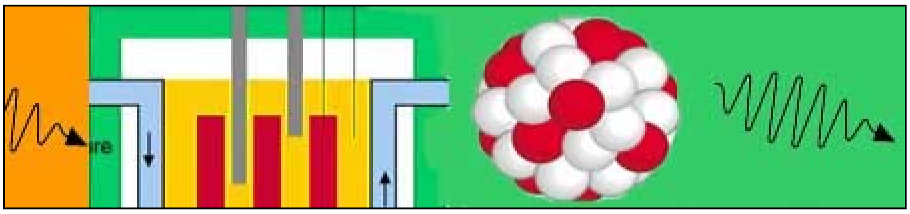
The problem of radioactive waste disposal is therefore only a problem of containment: making sure the radioactive species will stay where they were located, or that the migration time from their original site to the biosphere will be long enough for the radioactivity to have decayed much below present acceptable limits.

The problem is exactly the same for the containment of the radioactive elements within a nuclear reactor, but in the case of HLW the volumic activity is far smaller, while the containment time must be far longer. The solution, therefore, is basically the same: containment by multiple imbedded barriers. The first barrier is the matrix which contains the radioactive elements, then there is the waste packaging, and then additional barriers are added, according to the chosen disposal method.

The basic choice is between long term surface (or subsurface) storage and deep geological disposal. Transmutation of the longest lived elements might in the future be a preliminary to either method.

In surface storage – sometimes called interim storage – the conditioned waste packages are stored in engineered facilities for a given period of time, it being clearly stated that they will be retrieved from the facility at the end of the specified period. The facility may be located at ground level (surface facility) or shallowly buried (subsurface facility) in order to improve its physical protection against external aggression. Both surface and subsurface storage facilities must be kept under full surveillance and monitoring during the specified period, and one must demonstrate that the waste package can actually be retrieved if the decision is made to do so. Interim storage provides a satisfactory medium term solution, but it still leaves to our successors the burden of implementing a permanent disposal solution.

In deep geologic disposal, the stratum itself constitutes the ultimate barrier against the migration of the radioactive elements: once full, the disposal facility will be sealed and one does not intend to retrieve the waste packages. Such was the initial concept, a concept put forward by the US National Academy of Sciences as early as 1957, when asked by the Atomic Energy Commission. More and more, in order to facilitate public acceptance, the concept is being refined into "reversible" geological disposal. In a reversible geological disposal, waste packages are intended to stay, but the possibility to reverse the decision and retrieve them is kept open for a significant period of time, ranging from one to a few centuries. It is meant to be a definitive solution, the best which can be implemented today, but it does not preclude the possibility for our successors of finding an even better solution. For practical reasons, HLW will be held in a surface storage facility for a number of years before being sent to geological disposal. This allows all but the longer half-life radio-nuclides to decay, and thus the heat source itself is substantially cooled down.



During the first few centuries, most of the radioactivity of the waste comes from the fission products; thereafter, the longer lived actinides (uranium, neptunium, plutonium, americium and curium) take over. When the spent fuel is reprocessed, recovered uranium and plutonium remain in the nuclear cycle and only traces of them, together with the fission products and the "minor" actinides are vitrified to constitute HLW packages. The radioactivity of vitrified HLW decays much more rapidly than the radioactivity of the spent fuel. If one pushes the reprocessing one step further to recover the minor actinides ("partitioning"), curium could be conditioned to decay by itself while neptunium and americium could be fissioned in nuclear reactors into "ordinary" fission products ("transmutation"). The radioactivity of the resulting HLW packages would decay even faster, and the necessary containment time within the disposal facility would be reduced. This is called P&T, for partitioning and transmutation.

Implementing P&T would not eliminate the need for ultimate disposal, but it would alleviate some design constraints on the disposal facility. Partitioning has been developed at the laboratory scale, and significant results have recently been obtained. Transmutation has been demonstrated experimentally, but present Light Water Reactors would be poor transmuters. The high neutron fluxes inside the core of a Fast Neutron Reactor would be much more efficient. Furthermore, a metal-fuelled Fast Neutron Reactor with integral reprocessing and fabrication facilities promises both high P&T efficiency and very low levels of trace actinide materials in the waste stream. P&T is therefore a possible useful future sophistication of the basic two methods above described.

International Survey

As shown on the table below, which is not exhaustive, many advances were achieved throughout the world during the last two decades:

USA	LL-ILW	Since 1998, a disposal site is actually operating near Carlsbad (New Mexico): The WIPP, a non-reversible geological disposal in a salt bed, devoted to transuranic Defense waste disposal
	Spent Fuel	A disposal site for spent fuel in volcanic tuff (Yucca Mountain, Nevada) has been selected in 2002, with Congress approval despite State opposition. Licensing is in progress. Preliminary consideration is being given to reprocessing the spent fuel in order to increase the site capacity.
Finland	Spent Fuel	Decision vas taken in 2001 to build a reversible geological disposal in granite near Olkiluoto. The site should open around 2015. An underground laboratory ONKALO is under construction.
Sweden	Spent Fuel	Site selection is almost completed for a reversible geological disposal in granite. Target date for operation is 2015. An underground lab has been operating in Aspö since 1994.
Switzerland	HLW	2 underground labs in granite (Grimsel) and clay (Mont Terri) are in operation. The Swiss law stipulates a geological disposal should open before 2040.
Belgium	HLW	Many experiments have been carried out since 1984 in the Mol underground lab (in clay). Decision for a geological disposal site is expected in 2030.
Japan	HLW	The law voted in 2000 foresees a geological disposal operational by 2040. JAEA has started construction of two underground labs
France	HLW	One underground lab in clay is operating. The law voted in 2006 plans for a reversible geologic disposal in 2015-2020 and calls for interim storage and continued R&D on P&T.
Germany	HLW	Extensive R&D was carried out in the 70s on geological disposal in a salt dome near Gorleben. A 10 year moratorium was decreed in 2000
Spain	Spent Fuel	No search for a disposal site. A centralized storage is foreseen for 2010.
Netherlands	HLW	Long-term storage in the HABOG facility.
Canada	Spent Fuel	Storage was considered in 1998 “technically acceptable, but not socially”. Disposal policy is still under study by the government.
UK	LL-ILW	Disposal policy under consideration

Almost all countries using nuclear power have studied geological disposal, through underground labs or “natural analogues”, and taken part in international round robin computer simulations. Main results show that glass and concrete, the most extensively studied matrices for HLW and LLW containment respectively, are durable. High integrity copper containers have also been developed for the geological disposal of spent fuel. If the proper site and the proper stratum are selected, the geological barrier is very efficient at preventing radioactive nuclides migration.

While no demonstration of the behavior of a geological disposal facility can be fully rigorous and definitive, given the timescales involved, there are now many converging indices that the mechanisms governing the disposal evolution in time are understood and mastered, and that those mechanisms will induce minimal environmental impacts.

Conclusion

We have inherited radioactive waste and we produce it every day. We cannot simply transmit the burden to our grandchildren. On the other hand, we must take into account a certain degree of public mistrust of scientists and engineers when the horizon spoken about exceeds a few centuries.

Contrary to widespread perception, a lot of progress has been accomplished in many countries towards achieving technically and socially acceptable HLW disposal. While there is no perfect consensus, the majority trend is to construct geological disposal sites, with some requirements for temporary reversibility.

Concerns about HLW management should not, therefore, prevent mankind from pursuing the development of nuclear power. Nuclear power and hydropower are today the only significant and reliable sources of baseload electricity which do not originate from fossil fuels and do not emit large amounts of gas that contribute to the greenhouse effect.

This is an Executive Statement of the International Nuclear Energy Academy. It represents the views of the author, but has been endorsed by the Executive Committee of the Academy as a contribution to the responsible development of civil nuclear energy.

http://www.euronuclear.org/e-news/e-news-14/Member-Societies.htm

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