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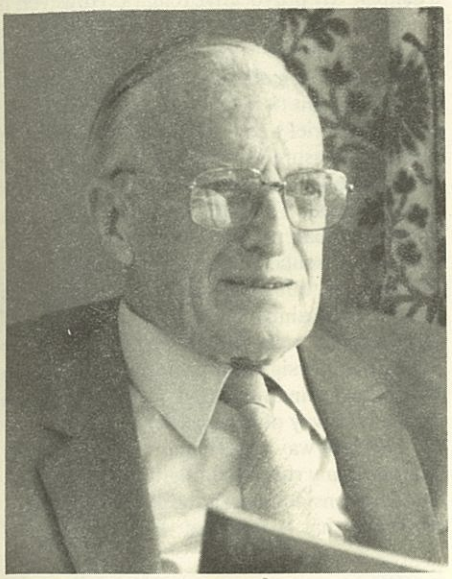

G. C. Laurence

Dr. George C. Laurence – Reflections

"Let the applicant prove the safety of his proposal, rather than regulate the details of design or equipment for him in advance" – G. C. Laurence, founder of the Canadian nuclear regulatory system.

An Appreciation by F.C. Boyd

With the death of Dr. George C. Laurence, November 6, Canada lost not only one of its eminent nuclear pioneers but also a scientist who exemplified the best qualities of a professional and a true gentleman.

Although Laurence was known best for his work on reactor safety and as the first full-time president of the AECB (1961-70), his contribution went far beyond this. As a brilliant young physicist he won the rare opportunity to study and work at the Cavendish Laboratory in the U.K., made famous by its renowned head, Dr. Ernest Rutherford. Later, back with NRC in Ottawa, shortly after the discovery of fission he managed to scrounge enough uranium oxide and graphite to build a sub-critical facility. Foiled by lack of funds he was unable to obtain uranium or graphite of adequate purity, or to carry on his experiments. However, when the Montreal Laboratory project was created in 1942 by Canada and the U.K., Laurence was named the senior Canadian. There he lived through the intrigues and personal squabble of the disparate international team which nevertheless developed, independently of the US program, the basis for heavy water moderated reactors. Laurence helped choose the site for the Chalk River Nuclear Laboratory in 1944 and was one of the first to move to Deep River where he lived until his death.

As head of reactor research and development at CRNL he oversaw the building of ZEEP, the first reactor outside of the USA, NRX, which became the best research reactor in the world, and later NRU, which pioneered on-power refuelling. His review of the NRX accident of December 1952 triggered the deep interest in reactor safety which he maintained for the rest of his life.

Laurence was one of the first to propose risk goals. More importantly he went on to propose practical ways these goals could be achieved and demonstrated. His concepts still form the essence of the Canadian approach to reactor safety today, including such aspects as: safety systems separate from operating systems (and from each other); simple and testable safety systems; numerical goals for the quality of operating systems and the (un)availability of safety systems; specified dose limits for various hypothetical accident scenarios. Perhaps because his ideas were expressed in the Canadian context they were only partially recognized internationally even though they preceded other concepts which were widely acclaimed. Ironically, many of his ideas began to be adopted by other countries long after he retired.

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Editorial

Why Regulate?

Why is nuclear technology regulated?

At first glance, the question seems naive, even obtuse. On further consideration, however, it is an interesting and appropriate one. It is particularly appropriate when suggestions begin to appear, as they are now appearing, on ways in which regulation can be made more effective. This issue and the reflections on it arise out of one of the prominent exercises underway in the Canadian nuclear arena at the present moment: the Ontario Nuclear Safety Review.

By direct statement, or by implication or inference, nuclear regulation often (but not always) comes down to statements about safety. 'Regulation is necessary to ensure safety,' or some equivalent formulation, is the meaning that perhaps most often comes through. It isn't being obscurantist or evasive to respond with the questions: Does regulation really ensure safety? In what way does it ensure safety?

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George Laurence

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When the then-miniscule AECB faced the challenge of regulating the McMaster research reactor and the Nuclear Power Demonstrator (NPD) it turned to Laurence to head the Reactor Safety Advisory Committee which it formed in 1956. In that capacity and subsequently as president of the AECB from 1961 to 1970 he had a profound influence on the concepts, principles and practices of reactor safety in the country. He retired in 1970 when he reached the then mandatory retirement age of 65.

My direct contacts with Laurence began in 1957 when I was arguing the safety of NPD. They became much closer when I joined the AECB in late 1958 specifically to work with Laurence and the RSAC, and continued very close until his retirement. He was a remarkable person to work with. His chairmanship of the RSAC was an example. Despite being, acknowledgedly, the most informed person on the committee he never dominated it but, rather, ensured that all members expressed their views and never concluded a question until a consensus had been reached. Meetings with applicants were often animated. However, he ensured that the discussion was always kept on a professional plane with the result that even after a heated argument members of both sides would often get together for a drink or dinner.

For me, Laurence was much more than a "boss;" he was a mentor, adviser and, in a special way, a friend. He allowed me, and the others he recruited, to be true associates and he displayed a personal concern for all with whom he worked, while often expressing disdain for the bureaucracy of Ottawa.

Although he claimed not to be religious, his manner and life reflected all that most consider noble and good, which, with his scientific excellence, combined to make him a very special person.

Fred Boyd

An Appreciation by W. G. Morison

On November 6, 1987, Dr. George Craig Laurence, who has been involved in nuclear energy development in Canada from the very beginning, died at the age of 82.

Most of us remember Dr. Laurence as President of the Atomic Energy Control Board in the period between 1961 and 1970, when he originated and implemented unique Canadian regulatory systems to ensure that nuclear power could be developed safely in Canada. Many of his safety principles and regulatory guidelines form the basis of current Canadian nuclear regulations. He presided over the licencing of Canada's first nuclear power stations with insight and great integrity, frequently providing critical review and comment as he peered over his spectacles from the AECB President's chair. His judgements and decisions were always carefully considered, based on the wisdom of years of study and experience in nuclear safety.

A Canadian by birth in Charlottetown, P.E.I., George Laurence was educated in Dalhousie and Cambridge Universities and joined the staff of the National Research Council in 1930, where he worked on radiation dosage in the treatment of cancer and in promoting safety from radiation exposure. In 1939-40 Dr. Laurence constructed, virtually alone and mostly on his own time, a carbon-uranium subcritical assembly at NRC, using ten tonnes of calcined petroleum coke and 450 kilograms of black uranium oxide in little paper bags dispersed throughout the coke. While the impurities in the coke, uranium oxide and paper bags prevented this assembly from reaching a critical state, early information on neutron capture and neutron release by fission were determined from his sub-critical assembly. But for these tiny amounts of impurities, George Laurence's experimental assembly may have preceded the first demonstration of large amounts of nuclear energy in a similar atomic pile built with more pure materials in 1942 in Chicago by Fermi and his associates.

Dr. Laurence was an early member of the Joint British-Canadian Team set up in a laboratory at the University of Montreal in 1942 for nuclear research leading to the construction of a reactor for the production of plutonium. Dr. Laurence recruited Canadian staff for this project and headed up the Technical Physics division. The work of Dr. Laurence and his talented associates in the Joint British-Canadian Team led to the construction and first criticality of the Zero Energy Experimental Pile (ZEEP) at Chalk River in 1945, the first such critical assembly outside of the United States, and to the very beginnings of the nuclear program in Canada.

He served in the Canadian delegation to the UN Atomic Energy Commission in 1946 and later became head of the Reactor Research and Development Division of the Atomic Energy of Canada Limited at Chalk River where he played an important role in the study and development work on the CANDU system, until he was appointed President of the Atomic Energy Control Board in 1961.

Dr. Laurence was recognized by his peers by being awarded the Canadian Physicists Medal for Achievement in Physics, the W.B. Lewis Canadian Nuclear Association medal, and a number of honorary degrees.

Dr. Laurence has contributed much to Canadian knowledge in his chosen field and provided important leadership in ensuring that nuclear power in Canada is safe. At times of doubt and question about the safety of nuclear power, George Laurence gave us wisdom and counsel and lasting strength.

W.G. Morison

Editorial

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Due to its prominence in the public and the professional discussions on nuclear safety, regulation was expected to loom large in the ONSR's work and it has done so. The ONSR itself has commissioned experts to look into the regulation question, and a number of individuals and organizations have submitted briefs on the topic. Surprisingly, or perhaps not so surprisingly, the question "why regulate?" has not been explicitly confronted in any of those written presentations.

The submissions to the Commissioner seem to raise as many questions as they try to answer. In one brief, commissioned by the ONSR, the author compared aspects of the way in which nuclear regulation is carried out in the USA and Canada. In effect, he was saying 'Here is a description of the ways in which our two countries go about regulating nuclear technology. The reasons for doing things this way are intuitively obvious.' This is a deliberately provocative remark. However, it is not an unfair one in the absence of explicit statements on the purpose of regulation, and on why a given method for achieving this purpose is thought to be appropriate. The author of another brief went so far as to state that the ultimate measure of the goodness of a system of regulation was in the degree of accountability it engendered. This was consistent with that author's apparent interest in increasing the amount of public participation in the regulatory process, but it fell short of explaining his fervour in pushing for a greater number of more explicit rules on the details of nuclear power plant design and operation. One has to know the destination before formulating rules on the best way of getting there.

The 'best way of getting there' applies only second to any rules that might be formulated. The first consideration is the overall process or approach that is followed. Is one system of

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La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. La cotisation annuelle est de $40.00, $20.00 pour les retraités, et $5.00 pour les étudiants.

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regulation better than another? What are the advantages of any competing systems? Does one system have significant advantages over another in the situation in which one finds oneself? Are lessons transferable from one system to another and if so how? What is a valid and fair formula for comparing two systems of regulation? Some of these questions have been touched upon in the submissions to the ONSR. Others have not and significant questions appear not to have been raised at all.

As an example, in submissions to the ONSR, statements have been made that in Canada the responsibility for safety lies with the licensee. Where does this leave the AECB? What is its role when this lion's share has been claimed? Is the AECB really there only to ensure that the licensees are held accountable? If, in the process of carrying out their jobs, the AECB staff apply pressure to the licensees to do things in a slightly different way, are they not usurping some of the licensee's responsibility, or at least limiting the licensee's scope of action for discharging this responsibility?

The vague and incomplete manner in which the vital area of regulation was treated in the submissions to the ONSR is of concern. Given this vague and confused treatment, the various appeals for changes to the AECB and to the way it operates, changes which are (presumably) intended to result in 'improvements' to the regulatory process, are of even greater concern. It is to be hoped that the report of the ONSR will present a thorough and penetrating review of this fundamentally important topic. Only then, when an unequivocal statement has been made on where we are going and what the obstacles are in our path, can we turn to the question of how best to get there.

A Laurel Branch

Imagine a team of master carpenters, journeymen plumbers, bricklayers, electricians, public health officials, etc., descending on your house to give it the critical once-over. Not only would they peer at your wiring, fusebox, ground wires, examine and test all your appliances, smoke detector system, burglar alarm, pesticide cupboard and medicine cabinet, crawl under sinks, poke at brickwork, check locks; they would also question you, ask to see your household accounts, records of repairs, and a host of other things. Oh, one other thing: your house is about half a mile long and filled with several billion dollars worth of very complicated devices.

The custodians of just such a house in Pickering were recently subjected to just such a searching examination. The examiners came from the most advanced countries in the world and among them had many decades of detailed experience in handling similar expensive devices. They knew what to look for.

Of course they found things that were not right. In fact they made quite a few suggestions for better housekeeping and for making minor repairs. They also said, after a few weeks of looking, that they didn't find anything seriously wrong and in fact that this particular house was one of the best on the block.

Following the issuance of the OSART report on the Pickering stations, well-deserved compliments are due to those who were responsible for bringing home such a good report card. It's nice to know that the big house on the corner is well cared-for.

Heat, Heat, Glorious Heat

About four months ago, as of the time of writing, a new reactor came into the world. On the afternoon of July 15, the SLOWPOKE Demonstration Reactor began operating at WNRE.

Media coverage was restrained. And rightly so.

What possible interest could there be in a reactor that needs a minimum of licensing, only produces warm water and seems to be able to keep itself under control no matter what is done to it? What self-respecting reporter would trek all the way to Winnipeg in order to look at – what? A lid covering a hole in the ground?

The SDR is a two megawatt (th) pool reactor whose compact core is cooled by natural convection and is contained in a stainless steel lined concrete tank sunk into the ground. The tank is about 10 metres deep and about 4.5 metres in diameter. The water in the tank is the primary coolant and circulates naturally through the core and the primary heat exchangers. The secondary coolant is pumped through the primary exchangers which are immersed in the pool, and through secondary exchangers located outside the pool. Water for space heating passes through the secondary exchangers as a tertiary fluid. The WNRE prototype is expected to demonstrate both walk-away safety and unattended operation; the cost of energy (capital, fuel, operating and maintenance costs) is expected to be about two cents per kWh (th) for a 40% capacity factor over a 30 year life.

Anybody still awake will know instinctively that such a creation is a boring ugly brute and no competition for a sexy stock market run amok. It may look much more attractive down the road when we rediscover that oil is a finite resource.

Perspective

Creation Science – Whose Problem?

Elected a Fellow of the Royal Society in 1986, Michael Ruse is Professor of Philosophy at the University of Guelph. His interests are in the field of philosophy of science. His numerous books include "The Darwinian Revolution – Science Red in Tooth and Claw" and "Taking Darwin Seriously – A Naturalistic Approach to Philosophy."

I imagine there are few of us today who have not heard of so-called "Creation Science," the body of beliefs that claims evolution is untrue and that humans were created about six thousand years ago by some miraculous force beyond our ken. For several years now I have myself been much involved in the fight against this doctrine, most notably as a witness for the American Civil Liberties Union in 1981 in the state of Arkansas, when it opposed (successfully) a bill mandating the teaching of Creationism alongside evolutionism in the public and high schools of that state.

This last summer, there were two items of news about Creation Science that caught my attention especially. The first was very good news. After Arkansas, the State of Louisiana decided that it would like a Creationist law of its own, and duly passed one. Equally, duly, the A.C.L.U. swung into action, asking that the Louisiana law be overturned on the same grounds as that earlier Arkansas law. Finally, the case reached the U.S. Supreme Court, which (in June) ruled 7-2 that the Louisiana law was indeed unconstitutional. And, as far as compulsory Creation Science in the U.S. is concerned, that is that. The majority opinion – involving conservative judges who usually vote for executions, guns, and prayer – was simply decisive. The reign of Creation Science is over.

But not in Canada. For now I come to my second item of news. The Ministry of Education in Ontario – note, not British Columbia or Alberta or Newfoundland, or one of the other philistine provinces over which we Ontario sophisticates like to crow – has decreed in its wisdom that the children of Ontario may learn of the size of the sun but not of its age. Scared of – or perhaps not scared of but happily acquiescing in the lunatic ideas of – the Creationists, the civil servants who decide on the science content of Ontario school courses have insisted that rock-solid (happy metaphor!) items of science must be excluded from the curriculum. Instead, our children must be fed some pallid pap that will not offend those Biblical literalists who persist in the belief that the author of Genesis was a qualified geophysicist.

I could say lots of things about the Ontario Ministry's decision, starting with my burning shame at living in a province with such craven hired functionaries. (I will not say "professionals," since that hints at some expertise). However, I will content myself with three comments.

First, Creation Science so-called is not genuine science at all. Its basic tenets are that the earth is six thousand years old, that all organisms were created miraculously in a very short time at the beginning with humans being the last creation, and that some time after the Creation a world-wide flood wiped out everything except those lucky organisms which managed to float it out. This is obviously the early chapters of the Old Testament by another name, and it was "invented" as science by a Seventh Day Adventist at the end of the last century. It has been taken up in our time by religious fundamentalists, purely as a ploy to get around the U.S. Constitution's separation of Church and State. The above-mentioned rejections of Creation Science laws by U.S. Courts, up to and including the Supreme Court, simply reflects the fact that a rose by any

other name would smell as sweet – or that Creation Science has the stench of simplistic religion about it, by whatever name you may call it.

You think I exaggerate or am bigoted? Then you tell me why Creation Scientists never refer to most of the facts for evolution – like systematics or embryology or biogeographical distribution? Why do they not tell us why the Galapagos Archipelago has slightly different but similar finches from island to island? And how do they explain this fact, if not through evolution? Rather, they talk always and only of the fossil record – when they are not misrepresenting the Second Law of Thermodynamics. They ignore entirely the distinction between the fact of evolution and the particular paths of evolution ("phylogenies"), failing to note that our frequent ignorance about the latter says nothing about our confidence in the former.

My second point is that although Creation Science is really religion, it is not very good religion. Do not be foxed by the claims that if you are against Creationism you cannot be a Believer. This is just not true. No less a conservative but orthodox Christian than the present pope has said that the Bible does not tell us where we have come from but rather where we are going to. Creation Science represents a particularly crude form of extreme American Protestantism. It is not the standard-bearer for all Christianity, or Judaism, or any of the other major religions of the world.

Nor is this an issue of censorship. I would defend to the end the right of Creationists to believe in any daft ideas that they wish. I would defend also their right to teach their ideas to their children, and even – although I do not much like it – to set up schools where their ridiculous ideas are standard fare. Democracy means letting people do what they want, not what you think they should want. What I object to is children being taught nineteenth-century Biblical literalism in state-supported schools. Democracy also means not letting a minority shove their beliefs down the craws of the majority. Or of the majority's children.

Third and finally – and this is the real reason why an essay such as this is appearing in a physics magazine – I warn that you should not sit back complacently, thinking that Creation Science is just a problem for the biologists. (And we all know that that is a second-rate science, anyway!) The Ontario Ministry has already put the lie to this illusion. The Creation Scientists are after all science where it conflicts with their barmy beliefs. Along with evolutionary biology goes geophysics (age of the earth), astronomy (age of the sun), hydrodynamics (Can you prove that there was a universal flood using current theory?), and just about the whole of thermodynamics. I have spoken above of the Creationists' seizing of the Second Law. They twist it all ways to their perverted ends, as they prove – more strictly, "prove" – that physics shows definitively that entropic principles could never have allowed a gradual process of transmutation.

After Hitler, everyone in Germany sat around wondering how it had happened. As he lay in jail before his execution, Dietrich Bonhoffer had already put his finger on the question and its answer. Everyone had said: "It's not my problem." Finally, as Bonhoffer pointed out, it was everybody's problem. There was no one left to stand up for decency and truth. Unfortunately, this is not a problem confined to the era of the Second World War. It is a crisis we face all of the time, no more so than today, with its hate and bigotry and ignorance.

Therefore, at least, with respect to Creation Science, let no one write our epitaph: "It's not our problem." It is.

Michael Ruse

Further Reading

The best book on Creation Science is by Philip Kitcher, "Abusing Science" (MIT Press, 1983). A good collection, with lots of information about the Arkansas trial (together with the judge's ruling) is edited by Ashley Montagu, "Science and Creationism" (Oxford University Press, 1984).

Special Report – The Ontario Nuclear Safety Review (ONSR)

In response to a recommendation of the Select Committee on Energy, the Ministry of Energy of Ontario established an independent nuclear safety review headed by Dr. F. Kenneth Hare of the University of Toronto as Commissioner.

The review has largely completed the task of information gathering. A workshop on 'CANDU Reactor Safety' sponsored by the ONSR took place in Toronto on September 24-26. The major AECL and Ontario Hydro briefs were received on August 1. The workshop succeeded in bringing together the major participants in the nuclear power debate (the industry, the regulator, the opposition) for an informed, open discussion and in providing an opportunity for some public involvement in the work of ONSR. Most of the briefs, received in advance of the workshop, were distributed to workshop participants for study before the meeting. The deadline for submission of briefs by intervenors and consultants (with some exceptions) was September 1. This allowed an opportunity for all participants to examine and study other briefs, including the information provided by AECL and Ontario Hydro. At the workshop, each participant who had submitted a brief was allowed to make a short oral presentation which was then followed by discussion. The workshop was also used as the occasion for the public release of the IAEA Operational Safety Review Team (OSART) report on Pickering.

The discussion at the workshop, despite its quality, was inconclusive. It still remains for the Commissioner, with the assistance of his staff, advisory panel and consultants, to continue to study and to reflect upon the views presented. Ontario Hydro has undertaken, and submitted to the Commissioner, a major critique of almost all the briefs, and AECL has prepared a supplementary brief on the role of the nuclear power plant designer. In the remainder of this article we provide an overview of the submissions.

Overview of Submissions to the ONSR

Part of the primary input to the ONSR is the approximately 60 submissions which it has received from individuals, groups, consultants, municipalities, academics and government bodies. The submissions cover many of the technical aspects of nuclear reactor safety in the present context of that term in Ontario, and some of the submissions go well beyond what even a generous interpretation of the term might allow. The cross section of views presented in these submissions is revealing. In what follows we attempt to give a brief glimpse of the material presented.

These comments only reflect our own reading of the material. Although we have tried to summarize fairly, we may not have done justice to some of the briefs in the eyes of their authors. A number of the briefs included practically all the main themes listed below. We have attempted to extract what we felt were the essential points. Clearly, some of the authors might contest that the themes we assigned to them were what they intended to be their main theme. In such a venture, horse races are practically inevitable.

It also seemed of interest to give some idea of the relative concentration of the briefs on certain subject areas. This categorization is of necessity rather arbitrary; the subjects dealt with in the briefs cover a wide range and just do not fit neatly into any such convenient grouping of topics. For instance, it is very difficult to separate some aspects of decision making from public participation, at least the way the issues are presented in some of the briefs. Similarly, health effects and social and environmental aspects cover a rather large common gray area. This breakdown is only intended to give an indication of what is in the briefs and should not be interpreted as implying any order of relative importance or significance. Such a judgement, presumably, is a job for the ONSR, and easily outdistances our temerity.

Coming as they do from a very wide range of sources, with vastly divergent interests, outlooks, and technical backing, the briefs are very varied in nature. There were good submissions by lay authors and poor ones by academics and specialists, as well as vice versa. For example, the submission by the United Church (for fuller references to the briefs, in the order in which they are mentioned in the text, see the listing at the end of this article) was embarassingly bad, and the brief submitted by Hutchinson and Chouinard of the Institute for Environmental Studies was of exceptionally low quality. On the other hand, the Queen's University Women's Centre submission and the review by Diamond were at the high end of the quality scale. For the present audience, and considering the terms of reference of the ONSR, "mastery of the technical aspects of nuclear safety" is probably one of the most interesting and useful criteria against which to evaluate the briefs. Even this may not be an entirely adequate yardstick.

From the scientific and engineering aspects of nuclear safety, a number of the briefs are of good standard providing interesting views and

insights. Some fall rather below the level that one might expect from their authors, while a few are appallingly bad by almost any standard. One or two briefs are interesting because of what they don't say, or because of the way in which they say what they do say. An enormous volume of commentary on the details of the briefs could be made; the comments on the briefs submitted by Ontario Hydro, for example, reflect only a fraction of these possible comments.

The following general themes appear to surface most noticeably in the briefs.

- Safety Philosophy, Regulation and Decision-Making
- Design and Safety Analysis
- Emergency Planning
- Operational Aspects
- Health Effects
- Probability, Risk and Risk Perception
- Severe Accidents
- Environmental Effects
- Public Participation
- Social and Political Aspects

From our classification of the briefs, the areas of apparent interest were concentrated in the first four topics. As might be perhaps expected, regulatory aspects arose frequently in the briefs, but by way of stressing just how broad these topic areas are, a closer look at the briefs grouped under the first heading is instructive.

Safety Philosophy and Regulation

The treatments here extended from the very broad to the quite specific. The brief by Oxman et al. proposed an all-encompassing framework which could be used to incorporate, in a rational and systematic way, both nuclear safety decisions in particular and energy policy decisions in general. Unfortunately, the distinction between the two was not always made clear in the brief. A brief of a general nature was also presented by John Ahearne, a former Chairman of the U.S. Nuclear Regulatory Commission, in which he discussed the differences between the regulatory approaches in Canada and the U.S. Despite his credentials, Ahearne's brief was disappointing and unsatisfactory; his comparisons between Canada and the United States provided few insights with respect to regulatory approach and its influence on nuclear safety and the brief ended on a note of vague anxiety that was less than helpful.

At a somewhat more restricted but still general level, the Canadian Environmental Law Association led one to believe that they would discuss the relation between regulation and nuclear safety, but then set to work on their other agenda which was apparently to argue for more public participation in all aspects of nuclear regulation (without indicating how or why this might have any positive effect on nuclear safety).

A more consistent and useful brief is that of Adams and Jerrett which documents the recent performance of the AECB. Of the remaining submissions that dealt with the theme of regulation in one way or another, two from Energy Probe considered the need for more stress on regulations that would take into account the hazards of older reactors, and a discussion of the nuclear liability act; a submission by the Nuclear Awareness Project presented a discussion of the present treatment of Significant Event Reports and the role that the AECB and other agencies should take in this area, concluding somehow that most of Ontario's nuclear stations should be shut down immediately; and a rather thoughtful brief by a private individual, Peter Brogden, calling for a rethink on how public input should be dealt with when making nuclear decisions.

Severe Accidents and Health Effects

Among the other topics listed above, severe accidents and health effects appeared in a number of heavyweight briefs. Several commissioned studies were performed in the area of severe accidents (particularly those by Lonergan on the potential effects of a severe accident at the Pickering station, and by Thompson on the adequacy of our understanding of severe accidents "beyond the design basis" in CANDU reactors). Both these briefs ran into deservedly strong criticism from Ontario Hydro. Health effects stands out as a topic area principally because of the submission of the IICPH (Rosalie Bertell), which received a great deal of severe comment and criticism from both AECL and Ontario Hydro.

Risk and Perceptions

Where it appeared as a major theme, probability, risk and risk perception was perhaps the most poorly handled subject. It was quite evident from a number of the briefs that on the topic of risk, its calculation, its perception and what should be done about it, there is a great deal of confusion and misunderstanding. The outstanding examples of this appear in the briefs by Schrecker and by the Canadian Environmental Law Association. In both these briefs, the authors reject the generally used definition of risk but then go on to discuss "risk" in the absence of any explicit alternative definition, as though the term has some other more basic meaning that everyone knows by instinct. In both these briefs, the authors come close to arguing implicitly that the important risk to bring under control is the perceived risk. A similar but not so blatant confusion pervades the discussion of risk in a number of other submissions as well.

A general observation is that those areas away from the scientific and technical aspects (e.g. probability, risk and risk perception; public participation; social and political aspects) were almost uniformly badly or inadequately treated. This was rather surprising in a way because these are perhaps the areas which one would expect non-technical people to come to terms with in their own way most clearly and most readily. Not only was the expression not clear, but in some instances wishful thinking replaced evidence and some authors appeared to reserve the right to ignore the facts, if necessary, and to be wrong. It is surely unfair to criticize people overly strongly for not getting correct those facts that they do not deal with every day and are perhaps not accustomed to dealing with. At the same time, it must be recognized that enthusiasm, good intentions and an insistence on the 'right to be wrong' are dangerous and inadequate substitutes for mastery of the facts. But it was disappointing to see that in some cases, at least, clarity of thought was spread so thin that it was below the li..it of detection. Two stupefying examples here were in the briefs by Burtsch and Tomalty and by Schrecker. In both cases, the authors made the simplifying step of assuming the answer they were trying to demonstrate and, not too surprisingly, in both cases they reached their objective. In all three of the general headings listed above, one could cite numerous other examples of fuzzy thinking, poor or non-existent definitions and contradictory statements.

However, one should come away from all this with a rather more upbeat impression. A good deal of work obviously went into most of the submissions and this effort is apparent when one reads them.

Other Work

The Commissioner has now visited all the major Ontario Hydro nuclear facilities, including the system control centre and the research laboratories. On September 17 he made his second visit to the Pickering NGS, at which time he dressed in plastics and entered the restricted area of one of the reactors to examine some of the recent retrofitting. The full Advisory Panel to the Review visited Darlington construction site in July, and in addition to the tours have been given a number of detailed technical presentations by Ontario Hydro. The ONSR also initiated an important piece of investigation in July when it requested Ontario Hydro to undertake a severe accident analysis (which assumes a loss of shutdown following a large LOCA) for Pickering NGS A. Results of the Ontario Hydro and Argonne National Laboratory (ANL) study were made available to the ONSR on October 15.

Dr. Hare and the staff scientist to ONSR have also visited a number of nuclear research facilities and organizations in Sweden (SKI, SSI, ASEA-ATOM), Germany, the Netherlands, Austria (IAEA, IIASA), the UK (CEGB, NII, BNFL) and the US.

The report being prepared by the ONSR will be reviewed by external reviewers for the Royal Society of Canada, prior to its submission to the Ministry of Energy. The reviewers are Sir Frank Layfield, Dr. Harry Duckworth, and Dr. Larry Korchinski. The ONSR report will be delivered to the Ministry of Energy on February 29, 1988.

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Keith Weaver

Jatin Nathwani

What the Liberal Majority Government Means for Ontario's Nuclear Program

If one were to judge solely by what they said in opposition, one would have to say that, with the Liberals now firmly in control at Queen's Park, the outlook for Ontario's nuclear program seems very bleak indeed.

Any competent review of press clippings shows that the Liberals, in opposition, made no bones about their view that Ontario had too much nuclear energy; that we were putting all our eggs in one basket; that we needed diversity; that we should be conserving energy; that we should be buying more hydro-electric power from Quebec and Manitoba, and developing more of our own.

So now here they are, in control. Backed by nearly three-quarters of the 130 seats in the Ontario Legislature. Nothing to stop them from doing whatever they wish, except possibly money and the electorate's sense of propriety.

What happens next?

The best way to get a handle on that, in the view of this writer, is to imagine yourself Premier of Ontario.

You've just won an impressive endorsement from the people. There are certain things you must do, but you have a certain amount of flexibility in how you do them. You're carrying some emotional baggage from opposition days that will colour your thinking, but within certain limits you are free to carry out an energy policy of your own making.

In the rest of this article, we will look at your imperatives, your options, the questions you would ask about nuclear, your personal feelings about it, and how you might want to accommodate it.

The Imperatives

Your main imperatives are twofold:

- Ensure that the demand for and supply of electricity remain more or less in balance; and
- Ensure that what you do in power is not too far removed from what you said in opposition; at least, not without good reason, or you'll lose credibility.

Secondarily, you would want to keep peace among your supporters, particularly between urban-based environmentalists and small-town Ontario, where concern for the environment is necessarily balanced against concern for jobs in local economies.

Thirdly, since you are also human, you might feel a personal imperative to do things differently than they were done during four decades of Conservative rule.

Finally, you would want your energy policy to enhance, or at least fit in with, whatever other changes you were contemplating in Ontario's political and economic fabric.

The Options

You've been at the Ontario Legislature for 12 years, and have a pretty good acquaintance with Ontario Hydro, mostly as critic. You know by now that your options boil down to some combination of conservation – energy efficiency, if you like – and new plant.

You know that the nuclear industry is eager to get on with another station, but you're damned if you're going to just carry on what the Conservatives left you. You haven't forgotten your commitment as opposition leader to conservation, cogeneration, diversification and hydroelectric energy.

As you think about this, your environmentally-sensitive self starts to come to grips with your business self. They're at odds, but can co-exist, perhaps agreeing on some compromises:

- Acid gas controls, if cost-effective in the long run and provided you can get the environmental assessment approvals;
- Conservation, if it means making the most of what we have, without depriving people of their democratic right to use as much electricity as they can afford, and provided it doesn't make Ontario industry less competitive or push Ontario farmers into bankruptcy;
- Hydraulic co-ventures with Quebec and Manitoba provided they don't make ghost towns of the communities which would normally produce the concrete, steel and hardware that goes into made-in-Ontario generating stations.

Nuclear Questions

What about nuclear? Well, as Premier, and knowing what concerns people most about it, you might want answers to a few questions:

- Waste disposal. If the feds are thinking of getting out of their commitment to AECL, does that mean they'll renege on their commitment to handle long-term waste disposal? What's it going to cost me to handle this problem and when do I have to start looking for a site?
- Transportation of nuclear waste. How am I going to get the waste to the site? If by rail, do I need to use abandoned lines so as to avoid big population centres? If by road, do I have to spend hundreds of millions on highways?
- Public relations. Do I have to embark on a long-term PR campaign to persuade the communities involved that transportation and disposal can be managed safely?
- Safety. How much money will Hydro have to commit to ensuring that citizens living close to a new plant feel secure in its shadow? Will Hydro have to build yet another shutdown system to satisfy Metro, and more importantly Metro's major daily newspapers, that I am committed to nuclear safety?
- Emergency preparedness. Can we now handle a major problem at a nuclear station? Can we inform and move people in a densely populated area quickly and safely? Should I require that Hydro spend even more money in this area?
- Credibility. Politically, this is the most crucial question I face: can I tell Hydro to go ahead with another nuke and keep my credibility?

The answers to such questions should emerge from whatever review process your government decides to impose on Hydro's Demand/Supply Options Study,. and only then will you be in a position to decide whether nuclear is one of your supply options.

Nuclear Reactions

You may already have concluded that there is nothing sacred about nuclear energy – what's sacred is the balance, and its cost, which should be reasonably low.

Nor is there anything sacred about the next new generating station, whether it's fired by nuclear, coal, oil or something else.

People in the power production business see nuclear's obvious advantages as a means of generating electricity, and take pride in designing, operating and defending it.

As Premier, you have seen enough on plant tours, and heard enough at briefings, to give nuclear credit. But it's a grudging credit, with reservations.

Useful? Certainly.

Economic? Prove it to me.

Clean? Maybe compared to coal, but it still has an impact on the environment, and my kids will have to live with the waste, not to mention the monthly payments.

Sacred? Sorry, I don't buy it.

First Things First

As Premier, you have long since concluded that anything as cheap as electricity is certainly being wasted, and as a businessman, you would find that abhorrent.

You would first want to mount a highly visible campaign to eliminate this waste, to show the electorate that you meant what you said about promoting conservation.

If you could get them, you'd also want to be able to point to a new hydroelectric project or two. Falling water may not be sacred, either, but as an energy source it's a lot more sacred than nuclear. Despite the relative cost and the paucity of new sites, the conservative streak in the public mind still puts hydroelectric energy on the same sort of emotional pedestal as railways, and it would stand the Liberals in good stead to kneel at that altar.

Having launched some conservation and some hydroelectric, and having let Ontario Hydro cool its heels for a while, you might then want to come to grips with a challenge you knew all along you'd eventually have to face: the fact that someday, Ontario will need the capacity to generate more electricity.

You would also know that sooner or later, you'd better do something to keep people employed in the nuclear industry, or you might end up importing a PWR next time you needed

more generation.

Your experts would tell you (one hopes) that for all the doomsaying on the cost of nuclear, Darlington will come in at around seven cents a kilowatt-hour, when American PWRs are coming in at twelve or more. Why complicate your nuclear program with a second technology, when your own, a homebrew, has demonstrated superiority?

Eventually, too, you might need a make-work project. The workforce at Darlington has already peaked, and the housing boom will not last forever. What's going to happen to all those construction workers after 1992?

Opportunity

Sooner or later, you might also ask yourself the big question: 'How can I turn this problem into an opportunity?'

Once you've asked that, it may prove hard to go back. You already know that work at Bruce is approaching the end, and that Darlington won't be far behind. You'd know that by adding a unit or two at one or the other you would maintain those construction jobs, at least for a while.

It might eventually dawn on you – if you didn't know it all along – that a generating station somewhere in the north or the Ottawa Valley would do wonders for the economies in those regions. Could you perhaps launch small ones in both? Such thoughts would have to occur to you.

You'd know that such a move would cause a lot of trouble within the party, and in parts of the electorate as well. The baby-boomers may be worried more these days about raising children and meeting mortgage payments, but they won't abandon easily the 'small is beautiful' prejudices of their youth, and you'd have to persuade them it was a sound idea.

Getting Consent

By now, you may be more than a little enamoured yourself, and wondering just how you would sell the idea. Chances are, because you're a smart politician, and committed to democratic ideals too, you'd decide to ask the electorate for help.

You might start with a select committee of the Legislature, and you might want it to tour the province, getting people's views on their electrical system and how to keep demand and supply in balance. Or, you might want to appoint an academic – an independent expert with lots of credibility – to hear Hydro, and hear the people, and come up with some possible alternatives for meeting future energy needs.

Then, wherever the facts lead you, you haven't imposed a decision – be it a generating station, a massive conservation campaign or both – arbitrarily on your constituents: you've simply looked at the facts and acted on them.

The outlook for the nuclear program under a Liberal majority? Probably as good as it would be under the Conservatives. But things will certainly take longer to materialize, and will likely do so on a somewhat smaller scale than the megaprojects of the past 20 years.

John C. Nuffield

FYI

UK Report on Cancer Near Nuclear Installations (Nature)

The UK Office of Population Censuses and Surveys (OPCS) has recently published a report "Cancer Incidence and Mortality in the Vicinity of Nuclear Installations England and Wales, 1959-80." The report's principal conclusions are that there has been no general increase in cancer mortality near nuclear installations in England and Wales during the period 1959-80.

The OPCS report provides a mass of information that is so large that it should be possible to detect quite small changes in disease levels with considerable confidence. The data on cancer mortality are less subject to selective bias than the registration data on which incidence rates are based, and they provide the firmest grounds on which evidence of any effect can be obtained.

These data show conclusively that there has been no general increase in cancer mortality in the vicinity of nuclear installations in a 22-year period beginning several years after the opening of the installations that have released the largest amounts of radionuclides to the environment. On the contrary, the mortality from cancer has tended to be lower in the local authority areas (LAAs) in the vicinity of nuclear installations than in control LAAs selected for their presumed comparability with the former. This is unlikely to be due to a protective effect of ionizing radiation and suggests that, despite the efforts that were made to choose comparable control areas, there were non-installation differences between the populations relevant to the risk of dying from one or other type of cancer.

Detailed examination of the few types of cancer that were relatively more common in the installation areas suggests that several of the differences were most likely to be due to chance, diagnostic artefacts or social factors rather than to any hazard specifically related to the installations.

Uranium Notes (R.T. Whillans)

Early in October, Canada and the United States entered into a Free Trade Agreement (FTA) that could have a significant impact on Canada's uranium industry. Based on the preliminary transcript of the elements of the FTA, Canada agreed to "eliminate its requirement that uranium exports be upgraded to the maximum extent possible in Canada prior to export," while the U.S. agreed to "eliminate the legislative restriction on enrichment of Canadian uranium."

The FTA "binds the Parties not to adopt policies requiring minimum levels of equity holdings by their nationals in domestic firms controlled by investors of the other Party, or requiring forced divestiture." It was also agreed "that all existing laws, regulations, and published policies and practices not in conformity with any of the obligations described [in the investment section] shall be grandfathered."

On October 23, Cigar Lake Mining Corporation (CLMC) announced that it had received final approval from Saskatchewan Environment and Public Safety to proceed with its $40 million test mining project at Cigar Lake in northeastern Saskatchewan, and had also completed negotiations for its surface lease and human resources agreements. The 490m-deep shaft will be collared in 1987, and sunk in 1988/89; 5,000 tonnes of ore will then be mined and stockpiled in a 6-month test.

Late in 1986, CLMC had submitted its proposal for the underground program, designed to study the feasibility of various mining methods, and began an environmental impact study in support of the project; it received an Underground Exploration Permit from the Atomic Energy Control Board in mid 1987.

Canadian Government States Its Official Position on Food Irradition (M. Marcotte)

On September 11th in Parliament, Jake Epp, Minister of Health and Welfare Canada and Harvie Andre, Minister of Consumer and Corporate Affairs Canada released the Canadian government's official response to an earlier Parliamentary Committee Report on Food Irradiation. The very positive, firmly worded and comprehensive report re-affirmed the safety of irradiated foods and authoritatively answered many concerns raised by consumer groups. The Canadian regulatory system will now be in step with Canada's leadership role in this technology. This official position complemented the April report by the Science Council of Canada, the premier advisory body on matters of science policy. That report also affirmed the safety of irradiated foods but went further to suggest a broadening of the utilization of our technological abilities.

The government indicated its intention to regulate food irradiation as a process instead of a food additive, although product by product clearances will still be required. The new clearance process will accept international evidence of toxicological safety, removing the mandatory requirement for toxicology data that was a major stumbling block in the past. Evidence of commercial efficacy, nutritional value, radiation effects on packaging materials and details of chemical, physical or microbiological changes will be required as conditions of clearance.

The government accepted the need for labelling of irradiated foods but did not fully indicate their proposed regulations on labelling. They noted it was important to consider Codex recommendations and the U.S. labelling position to preclude the creation of non-tariff trade barriers. Consumer and Corporate Affairs Canada has indicated their intention to publish labelling regulations by the end of 1987. The currently ambiguous labelling regulations have caused confusion and concern in the food industry; new regulations, especially if they closely follow those in the United States,

will be welcomed.

Scientific advisors with the departments of Health and Welfare, Agriculture and Energy, Mines and Resources thoroughly answered the concerns raised by consumer and activist groups in the hearings conducted by the Parliamentary Committee. This approach may ease the concerns of some individuals. Established activist groups have not, however, indicated they trust the government's response on such issues as the study by the Indian National Institute of Nutrition.

This past summer, many companies, organizations and individuals, including the Canadian Nuclear Society and its members, gave a clear message to the ministers involved in regulating food irradiation. That the government chose to base this policy decision on the scientific evidence and not on emotionalism is a tribute to the government, the departmental scientific advisors, the science community and the food industry.

The Testimony of Experts (Staff)

"The theory of the adversary system is that if you set two liars to exposing each other, eventually the truth will come out."

This quote from Shaw is used in an article by Michael Saks in *Technology Review*, August/September, to illustrate that there are problems with the way the judicial system handles expert testimony. Among the problems discussed are the almost total dependency of the courts on the views and opinions of scientists and engineers in instances where important evidence is of a technical nature, the difficulty for the courts in deciding what constitutes relevant technical evidence and the influence of lawyers on scientists, in sometimes drawing them out onto a limb and encouraging them to stretch their interpretation of the facts to their limits or beyond. Scientists and engineers are therefore somewhat vulnerable, since they may be induced by lawyers or the justice system to take a position and act as an advocate rather than as an expert. This is not reassuring when one considers that "the law's reliance on experts to decide what is generally accepted is a remarkable show of deference to scientific and technical people. In virtually all other situations the courts reserve such judgements for themselves."

Some advice is suggested for experts who find themselves having to give testimony.

"Experts should learn the basic rules of evidence and procedure and their professional organizations' canons of ethics. They should know the rules of the game into which they usually wander naively, not be introduced to them by a lawyer who has no incentive to educate and every incentive to control.

"Experts should obtain as many details as possible about a case and their role in it. They should find out the scientific issues. They should learn to stand up to lawyers who try to lure them further than they should go. And they should learn to give accurate, two-sided presentations in court, recognizing that they are witnesses, not advocates.

"Experts will develop such awareness only if they want to take greater control of their role as witnesses."

AECL to Evaluate Reactors for Canadian Nuclear Submarines (AECL)

Canada's Department of National Defence has asked Atomic Energy of Canada Ltd. to contribute to the initial evaluation of potential vendors of the nuclear power source to be used in the Canadian nuclear submarine program. In response, AECL Corporate Office has established a Marine Propulsion Unit in Ottawa. AECL has responded positively to the DND invitation because, as leader of the Canadian nuclear industry, the corporation considers assisting in this new program an obligation.

A task force of senior AECL Research and CANDU Operations staff has been acting in an advisory capacity during the early stages of the initiative. Over the next few months this advisory role on the nuclear propulsion system may be expanded as the program requirements become clearer. Staff at the Research Company as well as at CANDU Ops will then be called on to contribute their expertise.

The Canadian government, in announcing its decision to use nuclear propulsion for Canada's new generation of submarines has made it clear that the decision does not in any way imply acquisition of nuclear weapons or the creation of a capability to construct them. It is no more and no less than substitution of a nuclear-fuelled engine for a diesel-fuelled engine. The role of the new submarines will be the same as that of conventional subs – honouring NATO commitments and performing a monitoring function in the Arctic to protect Canada's sovereignty and security.

Canadian Uranium Exports and Safeguards Defended (EMR Canada)

OTTAWA — In October, Marcel Masse, Minister of Energy, Mines and Resources, responded to claims by Greenpeace Canada that this country's uranium is "bought, sold, shipped, received and processed in total secrecy," and that there is no means of "conducting an independent analysis" of the government's statement that Canadian uranium is not used in nuclear weapons.

"Canada exports almost $1 billion worth of uranium a year for use in civil nuclear power reactors," said Masse. "We sell uranium only to countries that make a commitment to the international community that they will not develop any nuclear explosive device with our uranium, and that they will accept inspection by the International Atomic Energy Agency (IAEA) of all their nuclear facilities.

"Where the country is a recognized nuclear weapons state," Masse added, "it must provide Canada with assurance that material, equipment and technology supplied by Canada will not be used for explosive purposes."

Canada's major customers are the United States, Japan, and several western European countries.

Masse pointed out that for most of the world's nuclear power reactors, uranium must be enriched before the fabrication of fuel rods. The energy minister said that it is impossible to trace precisely each and every molecule of Canadian uranium through the complex enrichment process, especially since uranium from a number of different countries is often enriched at the same time. When the uranium leaves an enrichment plant, identity is assigned to that product, both enriched and depleted uranium, on the basis of the origins of the uranium that went into the plant.

"This is an example of the internationally accepted principle of fungibility," said Masse. "It is on the basis of this principle that the Government of Canada satisfies itself that Canadian uranium exported, for example, to France, the United Kingdom or the United States, is not used for nuclear explosive devices."

Masse added that Canada is a strong supporter of the safeguards operations of the IAEA. In 1978, he said, Canada established the Canadian Safeguards Research and Development Program to assist the international agency.

The IAEA's objective is to detect diversion of significant quantities of nuclear material from peaceful activities to the manufacture of nuclear explosive devices. To accomplish this, the agency examines records provided by countries, collects information by means of various kinds of inspections, and monitors the flow of nuclear material in nuclear facilities. Monitoring equipment includes cameras, closed-circuit TV, and security seals.

"In addition to our support of the inspection activities of the IAEA," said Masse, "we require that all customer countries reach a bilateral agreement with Canada covering retransfer to third parties and the use of highly enriched uranium and plutonium derived from Canadian material.

"The Canadian safeguards regime," Masse concluded, "is acknowledged internationally to be one of the most stringent in the world."

Exports of Uranium of Canadian Origin

Country of final destination	Tonnes of contained uranium[1] 1982	1983	1984	1985	1986
Belgium	85		121	157	63
Finland	96	179	137	64	116
France		435	525	661	1 399
Italy	143		50	53	301
Japan	718	663	2 436	1 799	816
Netherlands					42
South Korea	74	94	30	194	403
Spain	110				150
Sweden	889	613	254	514	449
Turkey					2
United Kingdom	379	675	692	691	700
United States	4 852[2]	860	2 397	3892	4 001
West Germany	471	490	295	269	654
Total	7 817	4 009	6 937	8 294	9 096

[1] Some of this uranium was first exported to intermediate countries, namely France, USA, and USSR, for enrichment and then forwarded to the country of final destination.

[2] The bulk of this material is uranium exchanged by Eldorado Resources Limited in the purchase of the Rabbit Lake operation.

Source: Atomic Energy Control Board

TECHNICAL SUPPLEMENT

CNS Bulletin November/December 1987 Canadian Nuclear Society

Expert Systems

Peter Staadecker

The author has built, maintained and promoted Expert Systems for a large manufacturer of chemicals and related products.

Abstract - Expert Systems are computer programs that provide expert advice.

Significant practical applications appeared in the 70's. Applications have spread rapidly since then. Expert Systems are expected to permeate industry, public service and government just as traditional computing and, more recently, microcomputing have done. The nuclear industry is lagging behind other industries in the use and development of Expert Systems.

This article describes Expert Systems' characteristics, limitations and opportunities for their use.

Introduction

A senior consultant and professor of radiology at a London hospital was interviewed for a 1985 BBC 'Open University' production. He was asked about the ability of one of the hospital's computer system to diagnose brain damage or brain disease.

His response is recorded on video and is as chilling to listen to now as it was then.

He says, "the system is better than I am."

The system under discussion is an example of a computer program called an 'Expert System'.

Expert Systems and Early Examples

Expert Systems are a subset of 'Artificial Intelligence' computer programs. Artificial Intelligence programs seek to emulate intelligent behaviours like pattern recognition, vision, speech recognition, purposeful movement, symbol manipulation, etc.

Expert Systems, the subset, are computer programs that give advice that might otherwise be sought from human experts.

This is a departure from the traditional use of computers for calculation, filing, process control, administration, communications and labeling junk mail.

Significant practical Expert Systems were developed in the 70's and early 80's and included systems that diagnose bacterial infections (MYCIN, Stanford University), systems that configure new computer installations (XCON, DEC and Carnegie-Mellon), and systems that suggest where ore deposits may be found (PROSPECTOR, SRI).

The Spread of Expert Systems

Table 1 is an extract from the H.W. Wilson Company's 1986 Applied Science and Technology Index, an index of articles of the preceding year from selected journals and magazines. The extract is one page of four dealing with Expert Systems. It shows how by 1986 Expert Systems had spread to endevours as diverse as moulding plastics, laying out printed-circuit boards, assessing toxic waste sites etc.

By contrast the 1980 index carried just seven references for the entire field of artificial intelligence.

While many of the titles deal with systems under development a few titles indicate systems in use and achieving results -

'Expert System boosts output'

'Expert System cuts chip design time by up to 50%'

'Expert System cuts harvest problems'

'Expert System lays out printed-circuit boards, and whittles time to 25%'

It should be mentioned that successful Expert Systems are often regarded as industrial secrets by their owners and not written up in journals. The author can vouch for this, being involved with one such system.

The mix of the academic, the hype and the practical in the titles is reminiscent of the early uses of microcomputers. The spread of Expert Systems can be expected to continue just as computing, and later microcomputing, did.

Some economic sectors, notably the chemical industry, medicine, agronomy and finance, already have large numbers of Expert Systems in regular use and on sale. This author's literature searches indicate that in the nuclear industry though, Expert Systems are still in their infancy. Very few examples were found of Expert Systems in regular use in the nuclear industry.

Characteristics of Expert Systems

- Users typically conduct dialogues with Expert Systems through a computer keyboard and screen. An Expert System giving advice on what hybrid of soybean a farmer should plant might query the farmer on what soil and climatic conditions he is subject to.

- The course of the consultation is often not predetermined but will vary according to the user's responses. For instance if the farmer described dry, cool growing conditions the soybean Expert System would not ask questions about the prevalence of Phytophthera Root Rot in the surrounding area. This is not a threat under the growing conditions described.

- Like the better human experts, better Expert Systems can explain why they are asking for certain information. E.g. if the farmer asked why the soybean Expert System wanted to know whether his crop was for export the system might tell him that the export market requires beans with a yellow hilum.

- In addition to dealing with rules (if export then yellow hilum) and facts (cool, dry) Expert Systems must often deal with uncertainties. In medical consultations the results of preliminary lab tests might not be conclusive for instance, or the patient's clinical history might be unknown.

  The Expert System's answers are then often also given as a range of likelihoods. The system diagnosing brain damage, e.g., will present its diagnoses in order of most likely to least likely.

- Like the better human experts, the better Expert Systems can explain the reasoning behind their conclusions.

TABLE 1. Sample of expert systems literature titles.

Expert system lays out printed-circuit boards, and whittles time to 25%. B. Milne. diag *Electron Des* 33:161 O 3 '85

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Expert systems research focuses on combat emergency procedures. K. J. Stein. *Aviat Week Space Technol* 123:89+ O 28 '85

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Expert systems: the cutting edge of artificial intelligence. N. S. Rajaram. diag *Rob Eng* 8:16-20 My '86

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Expert systems using shells. P. Kelly. *Data Process* 28:139-40 Ap '86

Finding rules in data. B. Thompson and W. Thompson. diags *Byte* 11:149-52+ N '86

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As a consequence many Expert Systems are used as assistants to trainees or to the experts themselves. E.g. a trainee agronomist might use the soybean system to check his reasoning, as might an agronomist wanting to have his conclusions confirmed.

- Expert Systems have a very narrow area of knowledge - their 'domain' of expertise in the jargon of the day - and lack broad based knowledge and common sense. A system that advises a farmer which hybrid of soybean to plant, say, will likely not offer judgement on whether the farmer should be growing grapes instead.

  This requires users of Expert Systems to have some expertise and a fair dose of common sense themselves. The system will advise, but the user will make the final decision and bear the consequences.

- Very few of today's Expert Systems have graphic display capabilities or access to other databases or instrumentation. This limits most Expert Systems to receiving the kind of information and

  giving the kind of advice that one might get through a telephone consultation with a human expert.

  E.g. if you need the expert to point to a component, or draw a picture, or take a blood sample (things a human expert couldn't do on the phone) than the Expert System will have to rely on a human to do these tasks.

  This is a significant limitation on Expert Systems capabilities and is another reason that they often appear as assistants to an expert, rather than being the expert.

Figures 1, 2 and 3 illustrate the above points with a dialogue from the Mycin Expert System that diagnoses bacterial infections and advises on antibiotic treatments according to a patient's medical history. The figures are reproductions from 'Expert Systems Research', an article by R.O. Duda and E.H. Shortliffe published in Science, April 1983, Volume 220.

Worthwhile Applications for Expert Systems

Expert Systems costs can reach hundreds of dollars per rule and sometimes millions of dollars per system. Clearly, applications need to be carefully selected to offer a net benefit.

Fruitfull areas are those where:

- where the experts are in short supply:-

  Agronomists have been often cloned in Expert Systems because during certain key farming seasons every farmer wants to consult one and there aren't enough to go around.

  Some organizations now consider the benefits of cloning key personnel before they retire.

- where fast response is essential:-

  Medical emergencies are one case. Another is when operators of complex equipment like oil rigs or nuclear power stations have to decide quickly what fault has triggered an alarm and what action to take before a crisis is reached.

  One fault in a complex installation can trigger thousands of other alarms within minutes leaving operators too bewildered to respond correctly. Expert Systems are being built for oil rig operators caught in just such crises.

- where large sums of money can be saved or lost:-

  Oil companies build Expert Systems because, e.g., the cost of flying a drilling engineer from the States to trouble-shoot a well in Borneo, say, is high, and the production losses while waiting for him are even higher.

  Another area where the payback of improving efficiency by mere fractions of a percent are enormous is banking and finance. This is a high growth area, but is also one of the most secretive.

- where an Expert System would provide a more effective reference work than a book, checklist, technical manual or case histories:-

  Consulting a live expert is usually quicker than consulting a reference book or manual. Likewise consulting an Expert System is often quicker than reading through chapter after chapter of a manual.

  Medicine once again, equipment fault diagnosis and trouble-shooting, which all traditionally rely on reference works or shop manuals, are now popular application for Expert Systems.

  Buyers of equipment are sometimes given Expert Systems with new equipment or as part of ongoing service. Suppliers increasingly maintain Expert Systems to assist their own technicians. Companies as different as British Telecom and GE are examples of those having built Expert Systems for fault diagnosis.

  Some futurists predict that administrations, bureaucracies and civil services will be dramatically changed by Expert Systems. They point out that not only are many of the decisions that judges, bank managers and bureaucrats take repetitive and based on rules and manuals of procedures, but, that an Expert System would also bring uniformity to sentencing, granting of loans, approval of building permits etc.

Domains of expertise that are rapidly changing are unsuitable unless the program has the capacity to learn about change. Keeping an artificial expert abreast of its field can be very labour intensive and expensive.

The Components of a Typical Expert System

Traditional computer systems include computer programs that operate (calculate, print, etc) on databases. Programs that can be easily adapted to different custom applications are called packages.

Figure 1: The Consultation

```
Please enter information about the patient.

      Name      Age          Sex          Race
1) ** Pt219     42  YEARS    FEMALE       CAUCASIAN

2) Are there any positive cultures obtained from Pt219?
** NO

3) Are there any pending cultures of Pt219?
** YES

      site      date         stain        method of
                collected    examined?    collection
                                          [urine,sputum only]
4) ** CSF       3-Jun-75     YES          N/A

      stain of smear    morph
      [type NONE if no organism was seen on the smear]
5) ** NONE

                                .
                                .
                          (more questions)
                                .
                                .
13) Has Pt219 recently had symptoms of persistent headache or other
 abnormal neurolgic symptoms (dizziness, lethargy, etc.)?
** YES

14) Has Pt219 recently had objective evidence of abnormal neurologic
signs (nuchal rigidity, coma, seizures, etc.) documented by
physician observation or examination?
** YES
```

Popular designs for Expert Systems include computer programs that specialize in logical and sometimes statistical operations and operate on files of facts, rules and sometimes uncertainties. These computer programs are commonly referred to as inference engines and the files of facts, rules and probabilities are referred to as rule-bases or knowledge-bases. Inference engines that can be readily adapted to different custom applications they are called 'shells'.

As with many abstractions the component boundaries are less clear in reality. E.g. rule-bases are not always separate from the inference engine, etc. Nevertheless the abstraction is a popular and useful one. It is shown in figure 4.

The basis for dealing with uncertainty is sometimes an empirical weighting of facts and rules to reach a conclusion, sometimes a Bayesian statistical approach, and sometimes so-called 'Fuzzy Mathematics'.

Seven Guidelines for Successful Expert Systems

- An area of expertise worth cloning must be chosen. Having the imagination to spot a worthwhile application is the number one bottleneck to developing good Expert Systems (see the preceding section of 'Worthwhile Applications').

- There should be an expert. This is the 'Catch 22' of Expert Systems. If the expert has enough time to build Expert Systems then his expertise probably isn't in great demand or of great value. If the expert has no time for Expert Systems then his expertise may be well worth cloning.

- The user community for the system must be chosen. Representatives who will try out the system as it develops and critique it are needed.

- A 'knowledge engineer' is often needed. This is an analyst who knows enough (or will learn enough) about the domain of expertise and about Expert Systems to be able to draw out the expert's knowledge and express it in a form suitable for coding as an Expert System.

  Drawing knowledge out of the expert is often a slow process. Experts are sometimes no longer conscious of their own reasoning steps.

- A computer language or package (an Expert System 'shell' in the jargon) that is appropriate to the desired consultation is needed. There is no perfect solution and comprises will be inevitable.

- Appropriate computing hardware is needed. A major choice is microcomputer versus mainframe computer.

Figure 2: The Recommendation

My therapy recommendations will be designed to treat for organisms that either are very likely or, although less likely, would have a significant effect on therapy selection if they were present. It is important to cover for the following probable infection(s) and associated organism(s):

```
INFECTION-1 IS MENINGITIS

   + <ITEM-1> MYCOBACTERIUM-TB [from clinical evidence only]
   +     ...  COCCIDIOIDES     [from clinical evidence only]
   +     ...  CRYPTOCOCCUS     [from clinical evidence only]

43) Does PT219 have a clinically significant allergic reaction to any
antimicrobial agent?
** NO
                [Considering ETHAMBUTAL-AND-INH-AND-RIFAMPIN
                 for use against INFECTION-1...]
44) Is Pt219 pregnant or breast feeding?
** NO
45) Do you have reason to suspect that Pt219 may have impaired renal
function?
** NO
46) Pt219's weight in kilograms (or <number> POUNDS):
** 51.3

[REC-1] My preferrred therapy recommendation is as follows:
        Give the following in combination:
        1) ETHAMBUTAL
        Dose: 1.28 g (13.0 100 mg-tablets) q24h PO for 60 days
              [calculated on basis of 25 mg/kg]
              then 770 mg (7.5 100mg-tablets) q24h PO
              [calculated on basis of 15 mg/kg]
           [The dose should be modified in renal failure.
           I can adjust the dose only if a creatinine clearance
           or a serum creatinine is obtained.]
        Comments: Periodic vision screening tests are recommended
                  for optic neuritis.

        2) INH
        Dose: 513 mg (5.0 100mg-tablets) q24h PO
              [calculated on basis of 10 mg/kg]

        3) RIFAMPIN
        Dose: 600 mg PO q24h
        Comments: Administer dose on an empty stomach

Although I suspect that fungus may be a possible pathogen, in the
absence of definitive evidence. I will not recommend antifungal therapy
at this time. Please obtain samples for fungal, TB, and  viral cultures,
cytology, VDRL (blood and CSF), coccidioides complement-fixation (blood
and CSF), cryptococcal antigen (blood and CSF), viral titers (blood and
CSF) . An infectious disease consult may be advisable.
```

- Attempts should NOT be made to draw up complete systems specifications. Building rough prototypes and showing them to the experts and users is preferable. This usually helps them make explicit their reasoning and needs.

Limits To Expert Systems

A variety of limitations have been mentioned in passing. Before summarizing them it is worth noting that computer systems in general share these limitations. The limitations have not stopped computer systems entering general use and are unlikely to stop Expert Systems entering general use.

Limitations include:

- Expert Systems are likely to cause social change and to encounter social resistance. Whereas general computer systems affected clerical tasks most, Expert Systems are likely to affect people with expertise - professionals, administrators, bureaucrats, technicians, craftspeople etc.

- Lack of powerful Expert Systems hardware and software will likely long be a limitation.

- Means for Expert Systems to gather information are usually limited to custom data bases and a

Figure 3: Question and Answer.

```
34) Is the meningitis a hospital-acquired infection?
** NO
35) Is Pt219's clinical history consistent with EPIGLOTTITIS?
** NO
36) IS Pt219's clinical history consistent with OTITIS_MEDIA?
** NO
37) Has the patient ever been to an area that is endimic for
coccidiomycoses?
** UNKNOWN
38) Is Pt219 a burn patient?
** WHY

[i.e. WHY is it important to determine whether PATIENT-219 has been
seriously burned?]

[4.0] This will aid in determining the organisms (other than those
seen on cultures or smears) which might be causin the infection.
  It has already been established that
     [4.1] the infection which requires therapy is meningitis, and
     [4.2] organisms were not seen on the stain of the pending csf
culture (CULTURE-1), and
     [4.3] the type of the infection may be bacterial
  Therefore, if
     [4.4] Pt-219 has been seriously burned
  then
     there is suggestive evidence that Pseudomonas-aeruginosa is one
of the organisms (other than those seen on cultures or smears)
which might be causing the infection
  Author: Yu
  [RULE578]

   [BACK TO QUESTION 38...]
   ** HOW 4.3

[i.e. HOW was it established that the type of the infection may be
bacterial?]

The following rules concluded about: the likelihood that the type of
infection may be bacterial
```

.
.
.
.

- Expert Systems usually have no robotic abilities. Thus a system might diagnose brain damage but could not be a surgeon.

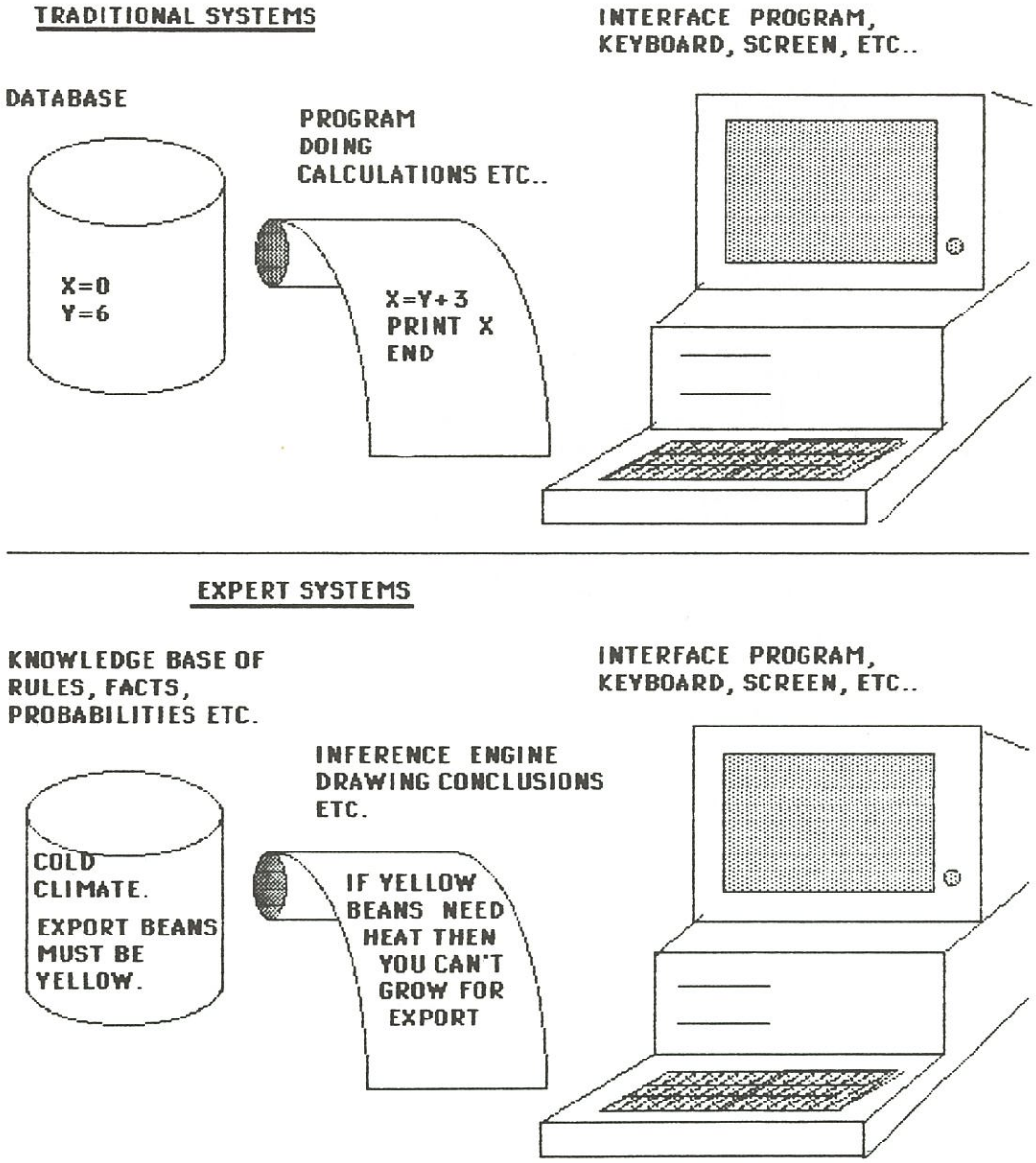
- Expert Systems have narrow fields of expertise, no common sense, and so far very few have the capacity to learn. Again this requires them to have expert human supervision.

- Transferring expertise from human experts is slow.

Conclusions

Expert Systems are expected to continue their spread through industry, civil service and government. They are expected to chiefly affect the work of craftspeople, technicians, professionals and administrators. Limiting factors to their spread are likely to be the slowness of extracting and transferring human expertise, the lack of powerfull hardware, the lack of powerfull software and the limited means for Expert Systems to gather information (keyboard or database access) and learn. Literature searches indicate that the nuclear industry is not yet a large user or developer of Expert Systems.

FIGURE 4



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A. Letendre, 'Expert Systems, Report No. 1/85', Office of Industrial Innovation, Department of Regional Expansion, Government of Canada, October 1985.

Recommended Reading/Viewing

For an overview:

'Expert Systems in British Industry' (Video), 1985, The Open University, Centre for Continuing Education, Milton Keynes, U.K.

For 'Hands-On' enthusiasts:

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Nuclear Utilities Take Step Towards World Federation

(Nuclear Europe)

First steps toward a worldwide federation of nuclear utilities were taken by 127 representatives from 31 countries at a meeting in Paris on October 5 to 6, 1987. The meeting was jointly sponsored by the US Institute of Nuclear Power Operations (INPO) and the International Union of Producers and Distributors of Electric Energy (UNIPEDE), hosted by Electricité de France (EDF) and chaired by Lord Marshall, chairman of England's Central Electricity Generating Board.

Lord Marshall announced that a resolution had been adopted setting the goals: to harmonize the existing systems for the exchange of information on operational experience, in nuclear power plants, to encourage the comparison and stimulate emulation between the utilities operating nuclear power plants. The information exchange fosters excellence in plant operation and maximization of safety.

There already exist networks between utilities in order to enhance this exchange. The Paris meeting was the opportunity to establish a close collaboration between them.

The resolution establishes the principles. In the coming 12 months, an organization should be built up, with a small headquarters in London or Vienna. The backbone are four existing regional centres in Atlanta (INPO), Paris (UNIPEDE), Tokyo and Moscow (Institute for Atomic Energy Research in the newly established Ministry of Nuclear Power). These centres collect information from utilities, assess their significance and analyse possible consequences. This work is being done independently of the regulatory bodies. According to the resolution, the activity of the new organization should enable the regional networks to exchange the information worldwide, including the Soviet Union, the other CMEA countries, and the Developing World. The new network which is the first step towards a truly worldwide federation of nuclear power plant operating utilities, will complement the activities by international bodies like the International Atomic Energy Agency (IAEA) and the OECD Nuclear Energy Agency, who were also represented at the meeting.

Solar Research Gets Left in the Shade

(New Scientist)

One of the great energy ironies of our time has come home to roost in the vast but little known central African state of Niger. Having depended on exports of uranium for the world's nuclear industry for the past 20 years, Niger's economy has hit rock bottom now that the demand for uranium has fallen off.

Buildings in the capital, Niamey, are left unfinished, roads are becoming little more than Tarmac links between the potholes, and reforestation projects wither as fast as the trees themselves in this furnace of a country. But the ironic twist to the tale is to be found near Niger's university where, until a few years ago, the National Solar Energy Centre flourished.

Some of the profits from the sale of the uranium to power nuclear reactors were ploughed back to fund Niger's researches into technologies for tapping solar energy. But not any longer. Funds for research into solar energy have dwindled in parallel with the fall in the price of uranium on the world market and solar projects in Niger have suffered accordingly.

A huge solar thermal pump which once generated 4 kilowatts of power to irrigate crops in a remote corner of the country lies abandoned in a corner of one of the centre's sheds. Researchers had taken it back to the centre to repair leaks in the system and to add more solar collectors to increase the pumping power to 10 kilowatts. But then the slump began to bite and there seems to be little chance that the pump will ever see sunshine again.

A factory for solar water-heaters on the premises does little but shelter the workforce from the very resource they are trying to tap. According to the director of the centre, a Nigerien called Albert Wright (his mother came from Niamey, the capital city of Niger, while his father was from Birmingham, England), the factory could, if it had the orders, make five solar water-heaters a day. With the economy in its present state, they are lucky if they get the chance to make 10 heaters a year. At about ($300 Cdn) for a heater, there aren't many Nigeriens who can can afford the luxury of solar-heated water, or, for that matter, heated water from any source.

Wright is not amused by the irony. "I started this research in 1965 to try to adapt technologies that originated in your world and make them more suitable and affordable in mine. The whole essence of the work was to try to find ways of reducing Niger's dependence on imported fuels and on firewood, which is largely responsible for the horrific rate of deforestation and desertification here. Now, again, your world is proving the downfall of mine."

Another of the centre's developments which has become quite popular is a large scale solar drier in which farmers dry their crops. But the success of the drier has been directly offset by the dismal failure of the solar ovens developed by Wright in an effort to stop people burning firewood and destroying what's left of the forest.

"They say that Niger has lost half of its forest since 1970 and I believe wood stoves are largely responsible. If people would only use the one resource that Niger possesses in abundance – solar energy – to cook their food, our forest replanting programs might get somewhere. At present, we're at the stage of taking one step forward in lead sandals and fifty steps backwards in cushion-soled walking boots."

Apparently it's not really the technology that's at fault, although the solar stoves won't heat up properly if they're not pointed directly towards the Sun. The problem has to do with people's reluctance to change their habits. Most rural families traditionally eat in the evenings, whereas the solar ovens and stoves work best, for obvious reasons, at midday. The result is that the solar stoves have worked well in trials but have failed heroically under real conditions.

The same could be said of Niger's forest replanting programs. The country's authorities have concentrated to a large extent on planting large areas with quick-growing eucalyptus for cropping for firewood. They have also irrigated some of the plantations to make the trees grow as quickly as possible. Not only does the growing of eucalyptus damage already fragile soils by returning few of the nutrients it takes out, but the cost of irrigation puts the final product out of reach for the average Nigerien. As a result, anarchic tree felling and gathering of firewood continues in direct contradiction to the aim of the projects.

The trouble is that, once started, such extravagant projects cannot be altered without the government forking out yet more money. In the present economic circumstances, that seems unlikely.

Letters to the Editor

Dear Sir,

Your editorial on "public education" (September/October 1987 *CNS Bulletin*) was not only thoughtful but thought provoking.

You point to the old corporate illusion that if you present the right information in the right way the public will decide in your favour. This myopic approach, despite being long discredited, still prevails in industrial and business circles. It is perhaps time that we in the nuclear industry looked more closely at the analogy between communication and our prime product, electricity. Like electricity, communication requires generators. It needs supporting media and conditions to let it move freely. The delivery system requires high standards of care and precision. And it provides light as well as heat to the recipient.

Unfortunately, information is frequently regarded as the superconductivity route to persuasion. Information on its own does not persuade,

It can do so only if the source has credibility – the right combination of expertise and trustworthiness. Even then, the desired persuasion may not be induced. Sound arguments, convincingly and frankly presented, are also required. Preparing and disseminating them takes time and effort and commitment. The communications spectrum ranges from clearly articulated objectives, through the delivery process, to an evaluation of how effectively the objectives have been met.

In the communications process anything that mutes the message, compromises accuracy, parrots the patter of the snake-oil salesman or conforms to the lowest common denominator is unacceptable. Scientists and engineers should not condone slickness and gimmicks masquerading as "public education." Nor should professional communicators. To its credit, the nuclear industry has resisted the instant press release mentality that often parades as a pretense for public relations. What it must also do is apply the same standards of professionalism and dedication to all facets of communication that are taken for granted in the development of the technology. Your editorial put that paradox into perspective. To follow ominous present trends of diluting messages, packaging them in a glossy wrapper, and transmitting them on a gossamer network will not do justice to the nuclear industry nor to the very many people who want to know more about it.

John Macpherson

Dear Sir,

Your editorial "A Dangerous Thing" was a timely warning flag. If the Canadian nuclear industry (in which the majority of us have direct involvement) is to embark upon a program of "public education" it is probably quite important to define at the outset what is meant by "education" in this context, and what the program aims to achieve.

The Oxford definitions of "education" centre around concepts of nurture, "bringing up" and "cultivation" of the intellectual and moral powers. Two related Latin roots are identified – "educare" (to rear) and "educere" (to lead forth). In the sixteenth century, "educate" and "education" included the rearing of infants, instruction, the formation of habits, manners and attitudes and training a person in the development of intellectual and moral powers. By the nineteenth century the word tended to be more often used with a modifier, as in "a classical education," or, when used alone was used in the sense of "culture or development of powers, formation of character *as contrasted with the imparting of mere knowledge or skill*" (my emphases).

It is possible that in the last quarter of the twentieth century – in North America at least – "education" has come too often to refer to a program of training to fit a person for a particular career rather than the "leading forth" of the intellect. Indeed some universities are beginning to make a virtue of this in their attempts to attract students by offering courses which will provide them with the skills and knowledge needed to become manager's assistant to the Assistant Manager. But in spite of this it's probably true to say that most people regard "education" as something more than the acquisition of sufficient intellectual and procedural skills to guarantee survival in the workplace. One can note the recent (undoubtedly Oxonian) compiler of a university calendar who noted of one faculty member that he received his degree from Cambridge and of another that she was *educated* at Oxford.

How does all this relate to a "public education program?" We might first ask ourselves in what sense the nuclear industry intends to "educate" the public. In the "nurturing" sense? In the "instructional" sense? To "lead forth" the intellect?

I've asked a number of people in the business this question and received the following (not, I believe, atypical) responses: educate the general public about the benefits of nuclear energy; show people the important part nuclear energy plays in the economy; demonstrate to the public that nuclear energy is an essential part of a balanced energy program; make the public better informed about the nuclear issues such as public safety, nuclear waste, etc.; make people realize that we need nuclear energy.

As you stated in your Editorial, this certainly seems to be information – coupled with advocacy – walking abroad in the borrowed gown of "education." Whether the information is complete or accurate is another, quite important question.

But what is the ultimate objective of this program? Surely that is implicit in the comments quoted above – to persuade people that nuclear power is necessary, desirable and worthy of public support. It is not unreasonable to suggest that most of us believe this, and believe that we can support that contention. And it is a short step from this to the idea that if we provide people the information (data) upon which we have based our conclusions, then, as "reasonable" people, they will agree with us. But it is this short step which can be so treacherous since all too often, embedded in our more general statements about the desirability of nuclear power are a whole range of assumptions and values which we ourselves are quite unqualified to evaluate.

If the scientists and engineers from the nuclear energy endeavour are to participate in a "public information program" then it is important that they not abuse the undoubted confidence that the general public has in their ability and integrity. Information must be information, not advocacy advertising in a lab coat.

D. Mosey

CNS President Joins Sherritt Gordon

Dr. Irwin Itzkovitch, CNS President 1987-88, has moved from Eldorado Resources Ltd. to become Manager, Business Development, External Technology with Sherritt Gordon Mines Ltd. in Fort Saskatchewan, Alberta. His new address is: Fort Saskatchewan, Alberta T8L 2P2, (403) 998-6911.

PRV

Is That a Fact?

Recent numbers of the *Ethics and Energy Newsletter* have carried interesting items on the "fact versus value" theme. Two articles of a theoretical nature have appeared recently discussing the difficulties posed by the fact-value question and the implications that these difficulties raise for decisions on energy supply choices. Both articles were vigorously rebutted by Archie Robertson.

The two articles in question are almost textbook examples of how not to put one's case clearly. Like French chivalry at Agincourt or Crecy, these theoreticians charge onto the field bristling with nasty-looking jargon and protected by a thick chain-mail of knotted and contorted prose. Both articles are virtually incomprehensible in any practical sense. They outline the fact-value conflict in remote and uniquely unhelpful terms. Apparently strong and common sense approaches, such as those of Robertson and Bernard Cohen, are dismissed as being "positivist"; the word is thrown out with distaste as though it describes something revolting on the sidewalk that needs a wide berth. The tone used in the articles is one of generality but filled with dire warnings that these philosophic waters are full of treacherous reefs. Before the charts can be deciphered and the course set, many navels will have to be peered at intently.

The rebuttals are as swift and effective as were the archers at Agincourt. Where the articles are content to issue only vague and querulous Delphic warnings, Robertson properly taxes them with obscurity; where they indicate those areas in which gaping theoretical pitfalls abound, he challenges them to point out the resulting errors in his or Cohen's arguments; where the philosophers attempt to leap from their generalities to condemnation of specific conclusions, all they manage to do is fall on Robertson's claymore. Under the circumstances, one can hardly blame him for chopping up these offerings and leaving them for the sparrows.

The whole exchange is an odd confrontation between aspects of the sciences and the humanities, and one in which the latter have acquitted themselves rather poorly. This is a pity because they have an interesting and important case to make.

In the early eighteenth century, Berkeley concluded that the material world can not be shown to exist, that the only reality is the human mind. Following him, Hume's writings cast discredit on the reality of the mind in turn. Faced with what appears to be such intellectual anarchy, it may be understandable that engineers' and scientists' faith in philosophy as a practical tool could be shaken. In consequence, they are likely to be unmoved by general pronouncements that the philosophical underpinnings of certain decisions on energy options are faulty and that the decisions themselves are questionable as a result. However, positive and

useful clarification would be welcome and should be given a fair hearing; the truly noble search for first causes and the need to harmonize our approach to real world problems with this search should be pointed out in as straightforward terms as possible. What an interesting discussion might have resulted if only the academics had touched down and come to practical grips with the case instead of trying to push it through on obscure theoretical grounds alone. Suppose they had picked out "benefit," for example, as it is used in cost-benefit-risk analyses, and concentrated their attention on that.

They might have begun by noting that "benefit" is apparently a readily defineable term: the filling of an economic need might be one definition of a "benefit." Of course, this is only a valid definition if what one really wants to do is "fill economic needs." To many, the term "benefit" probably implies something more, such as the creation of some common "good." Defining whatever one understands to be "good" then becomes the problem and whether something is good or bad is evidently a philosophical question. Cast in these terms, it can be shown that those things which might at first seem to be "facts" sometimes contain significant "value" components. (At least part of the problem here may be the use of the rather limp term "value"; this grey and unsatisfactory word basically admits any old "preference" into the game, and allows one to avoid the difficult and rather uncompromising choices that are enforced by the less fashionable words "good" and "bad."

As an illustration, suppose that the "good" that one is actually attempting to deliver is increased human welfare (another definition required). Then, to choose arbitrary examples, one might be able to argue that a unit of electricity used to illuminate the marquee of a smutty movie house does not produce as much benefit as a unit of electricity used to power electric tooth brushes and that this in turn is less beneficial than a unit of electricity which powers the equipment in a hospital operating room. Rethinking things according to some such scheme might indeed add a different perspective and point to different decisions. If the case had been put in these terms, it would have been clearer that instead of being a peripheral and largely irrelevant intellectual exercise, philosophical questions can indeed be framed succinctly and are at the very heart of the matter. As such, they need and deserve wide discussion. Generally, the best treatment they can expect is vapid political lip service, sickening motherhood blatherings, distant theoretical pontificating and soulless economic processing. The fact-value theme is not only much wider than indicated here; indeed, the example quoted may be far from the best one available and could well be deficient in other ways. Clearly, the problem needs the attention of trained professional philosophers.

With such an interesting and important topic at their elbow, and with such a strong apparent need for their guidance, one would expect to find ethicists and philosophers right in the thick of it with their sleeves rolled up. Why aren't they?

Keith Weaver

C N S Branch Programs

New Brunswick Branch

On June 15th, 1987, a new executive for the branch was elected. Dr. C. Keith Scott was elected Chairman of the branch; Mr. Harry Storey will serve as Vice-Chairman and he will be responsible for membership coordination. Dr. René Girard will act as Secretary-Treasurer. Mr. Paul D. Thompson and Mr. Ken Biron have been elected councillors and they will be technical program coordinator and liaison program coordinator, respectively. The executive would like to take this opportunity to thank Dr. Dan Meneley and Mr. J.F. Lafortune for all their efforts in creating the New Brunswick Branch. Many thanks go also to Mr. Evan Young who chaired the nominating committee with the help of Mr. Ken F. Sollows. D.J. Wilson is the new contributing editor for the *CNS Bulletin* and will co-ordinate input to the *Bulletin* for the New Brunswick Branch.

Section du Nouveau-Brunswick

Une nouvelle direction a été éluée à la tête de la section le 15 juin dernier. Dr. C. Keith Scott a été élué Président de la Section, M. Harry Storey occupera les fonctions de Vice-Président et il sera responsable du recrutement de nouveaux membres. Dr. René Girard sera le Secrétaire-Trésorier de la Section. M. Paul D. Thompson et M. Ken Biron ont été choisis comme conseillers et ils seront respectivement coordonnateur du programme technique et agent de liaison de la Section. La nouvelle direction de la Section s'en voudrait de passer sous silence les efforts du Dr. Dan Meneley et de M. Jean-François Lafortune qui ont menés à la mise sur pied de la Section. Jusqu'à juin dernier la direction a été assurée par J.-F. Lafortune. Il faut souligner l'implication de M. Evan Young comme directeur du comité d'investitures. Cette élection n'aurait pas en lieu sans l'aide de M. Ken F. Sollows, ses efforts sont grandement appréciées.

Ottawa Branch News

Seminar Series for 1987/88

The following program has been lined up for the coming season:

Sept. 17	Canada's Energy Options
Oct. 15	AECL Spin-off business
Nov. 19	National Fusion Program
Jan. 14	Flow Induced Vibrations
Feb. 11	CNA Public Information Program
Mar. 10	Licensing Small Reactors
Apr. 14	Star Wars
May 12	Food Irradiation Debate

(to be followed by a social function)

The branch extends its welcome to any visitors who may wish to participate in this year's activities.

Canada's Energy Options

The Ottawa Branch 1987/88 Seminar Series began on September 17 with a presentation by Doug Patriquin of the Department of Energy, Mines and Resources on the "EMR Energy Options Process."

The energy options process was initiated by Minister Masse in April 1987 with objectives of obtaining public views and gaining new insights on principles and directions for Canada's energy future.

Four study sessions are to be held this fall on different aspects of policy:

- Technologies
- Environmental issues
- Trade, security and investment issues
- Energy pricing and fiscal matters

A final conference will be held in Montreal, and will consist of a plenary session plus a series of showcase sessions for each segment of the energy industry.

The interplay of views and experience of people with different philosophical orientations are expected to yield a clear picture of Canada's energy situation and options.

Mr. Patriquin's presentation, which took the form of a round table discussion, was well received and sparked an extensive question and answer period.

Terry Jamieson

Toronto Branch Opens New Season with SLOWPOKE Presentation

One of the biggest R & D areas in the nuclear industry today is in the application of small reactors to meet district heating and electrical supply requirements. Dr. Gerry F. Lynch, General Manager of the Local Energy Systems Business Unit at AECL-CRNL opened the Toronto Branch's 1987-88 presentation series with a discussion of AECL's small reactor design – the 10 MW modular SLOWPOKE. The meeting took place at the University of Toronto on September 29, 1987.

The commercial SLOWPOKE design is the culmination of an evolutionary development program which began in 1971 with a series of research reactors and progressed to a 2 MW Demonstration Unit at WNRE in Manitoba (first critical, July 1987).

Representing a complete departure from the high pressure operating environment of the CANDU reactor, the SLOWPOKE energy system has been tailored to its primary purpose of providing "warm water" (85° C) for heating applications. The core rests at the bottom of a light water pool, 12 metres deep and 6 metres in diameter. Natural convection obviates the need for heat transport pumps. Intrinsic safety features will permit unattended operation and allow the units to be placed in populated areas. Commercial units will be fuelled with 2.3% enriched uranium fuel.

Dr. Lynch explained that with the virtues of low capital and operating costs, the SLOWPOKE

is competitive with a fossil-fuel-fired system under a wide range of scenarios. The excellent economic characteristics and relatively standard equipment requirements make the system particularly attractive in the international marketplace. The system allows for progressive increases in localization of components and construction, thereby limiting the requirements for foreign exchange.

Dr. Lynch described AECL's strategy for commercial application. The program hinges on committing a field prototype in Canada. This would allow the marketplace to gain confidence in the concept. As the program develops, Dr. Lynch expects unit financing to progress from a utility-owned, joint-venture, or leasing arrangement, to eventual full unit sales. Institutional buildings are the primary targets for initial marketing.

The discussion period that followed Dr. Lynch's presentation brought up such questions as excess core reactivity, capacity factor, enriched fuel supply, and site security.

Dr. Lynch has chosen McKenzie High School in Deep River as the recipient of a CNS Toronto Branch Scientific Excellence Award. A certificate and $50 cheque will be issued on the Branch's behalf to a deserving graduate student at the school's next commencement exercises. The recipient will be nominated by the school's principal.

John Marczak
Eva Marczak

Regulation and Radiation

"Regulated and non-regulated radiation exposures – a comparison" was the subject of a seminar given by Dr. A.M. Sourkes, of the Manitoba Cancer Treatment and Research Foundation, at the University of Toronto on October 19, 1987. The seminar was jointly sponsored by the CNS and the Centre for Nuclear Engineering at the University of Toronto.

Dr. Sourkes provided a quantitative comparison of various radiation exposures to which people are typically subjected in everyday life, in medical diagnostic procedures, etc. He also discussed the exposures of radiation workers, such as those in the fields of radiology, radiography, or the nuclear industry (mining and reactor operation). He also touched upon radiological accidents, such as the recent cesium exposure in Brazil.

One of Dr. Sourkes' conclusions is the reaffirmation that from the radiation-worker data presented, it is possible to see that the individual risk is really quite acceptable (typically less than 10^{-6} per year), and that the nuclear industry is a safe industry.

Another conclusion is that although current radiation protection practices are in general sufficient for normal-use situations, additional attention and vigilance needs to be paid to device design and to planning non-routine events or practices, in order to avoid potential serious radiation accidents.

The seminar was well received and prompted many questions from the interested audience.

Ben Rouben

Book Reviews

The Whale and the Reactor: A Search for Limits in an Age of High Technology, Langdon Winner, University of Chicago Press, Chicago, 1986, ISBN 0 226 90210 2.

Langdon Winner is no lover of nuclear technology. This is clear in the final chapter of his book in which he discusses the Diablo Canyon nuclear station. He states that the plant is "out of place, out of proportion, out of reason"; it stands as a "permanent insult to its natural and cultural surroundings"; Diablo Canyon is a "ghastly new neighbor" with "inherent destructiveness" and is a disaster in every sense short of a meltdown. Fortunately, none of this has the slightest bearing on whether one should read his book.

The Whale and the Reactor is a study of technology. The book comprises ten chapters, each of them in the form of an essay, and they are grouped under three main headings: the philosophy of technology, reform and revolution, and excess and limit. Although the last mentioned of these is actually the 'punch line' of the work (as might be divined from the subtitle), a number of themes are developed in the book. Each of these themes, indeed the entire book, unfolds with a clarity, a combination of intellectual vigour and common sense and a degree of sober and measured urgency that is truly exemplary.

Philosophy of Technology

The first of the main themes is the failure of political philosophy and the philosophy of technology to come to grips with the nature and significance of technology as an aid to human activity. "At this late date in our industrial/technological civilization the most accurate observation to be made about the philosophy of technology is that there really isn't one." Engineers come in for a fair measure of flak in this regard; they "appear unaware of any philosophical questions their work might entail." To them, the products of their work are just tools or objects or aids, to be picked up, used, and then put down again. They have no effect beyond that for which they were designed. "If Socrates' suggestion that the 'unexamined life is not worth living' still holds, it is news to most engineers."

All this might be dismissed by some as just more idle philosophers' navel gazing, except that such a view would eventually lead to grave problems. The reason for this is that technology is not just an aid to human activity but is also a set of "powerful forces acting to reshape that activity and its meaning." The introduction of robots to a workplace not only increases productivity but also redefines the very notion of "work"; advances in medical technology and treatment can transform the way people think about health, sickness and medical care; technologies, therefore, are not merely external artefacts, but become intimately involved in peoples' social and moral life. The general failure to recognize this fact leads to our being in a state of "technological somnambulism"; we go where the technology we develop pushes us and are philosophically (and thus politically) ill-equipped to do anything about it.

Technology and Politics

The second of his main themes brings politics to centre stage. Aspects of technology have become inseparable from politics; "In our time *techne* has at last become *politeia* – our instruments are institutions in the making." Technologies have become so pervasive, so vital that in some cases their political attributes are beginning to overshadow their characteristics as tools. The "energy crisis" is used as an illustration of this: technologies associated with oil, nuclear power, and, in the future, solar power, can have overriding political implications. Although solar energy is often cited as a way around this question, Winner presents plausible arguments as to why this will probably not be the way things unfold. In his view, a likely scenario for extensive solar energy use could be through distributed solar collectors or photovoltaic cells at the household or neighbourhood level, but that these devices would likely be manufactured by General Electric, marketed through Sears and installed by local plumbers and electricians. In this case one has done little to avoid the demon "centralization" and its accompanying structural and political problems.

Alternative Technologies: A Better Mousetrap?

At this point, we have covered the first three chapters; the following three chapters indicate the (imperfect) understanding of the problems of technology which was reached in the recent past and the ways that were used to try to overcome those problems. In general, these solutions took the form of "reform and revolution." One such method was to build a better mousetrap. That mousetrap was "appropriate," "intermediate" or "alternative" technologies. As a description, sympathetic yet with rough honesty, I have never found anything to match Winner's account of the origins, the rise and the fall of the appropriate technology movement. From distant early likenesses, such as the works of Robert Owen, William Morris and the British Guild Socialists, Winner traces the development of radical views of technology, and how it should be used, through the early Vietnam war protests and the 1960s campus violence to its days of ideological senescence at the time of Earth Day and The Whole Earth Catalog. The roles of authors such as E.F. Schumacher, Lewis Mumford, Herbert Marcuse, Theodore Roszak, Jacques Ellul, Amory Lovins and Ivan Illich are noted.

A great deal of idealism was brought to bear. There was also, however, an enormous load of ignorance, naivete and nonsense that eventually bore fruit. Visionary projects which would ensure social change were mounted. "As successful grass-roots efforts spread, those involved in similar projects were expected to stay in touch with each other and begin

forming little communities, slowly reshaping society through a growing aggregation of small-scale social and technical transformations. Radical social change would catch on like disposable diapers, Cuisinarts, or some other popular consumer item." This millstone of untempered idealism, a gross underestimation of the facts of organized social and political power and, most important, the lack of any serious attention to the history of modern technology sealed the doom of the appropriate technology movement.

Decentralization and Myths

One of the notions that often appeared in conjunction with ideas of appropriate technology is "decentralization." The existence of centres of political control, of energy and particularly electricity production, and of industrial and manufacturing power were viewed with a jaundiced eye and their "decentralization" was touted as a desirable objective.

"Unfortunately," declares Winner, "the word 'decentralization' is something of a linguistic train wreck." It is "one of the foggiest, most often abused concepts in political language. For those who think it is a cure for the ills of modern society, a crucial first step is to clarify what the idea means." The chapter on decentralization is a consummate demonstration of the dangers awaiting those who fail to define their terms. Decentralization is shown to be vague to the point of uselessness, or worse. The definitional problems are legion. What's more, this application is only one in a long series of repeat performances. In the 1920s, paradoxically, electricity was seen by some as the saviour that would liberate people from their "servitude to steam," the centralizing evil of the time. This was nothing new. "Dreams of instant liberation from centralized social control have accompanied virtually every important new technological system introduced during the past century and a half." Furthermore, the dream is alive and well and still with us today.

A contemporary dream-world situation in which decentralization gallops to the rescue yet again is illustrated in the sixth chapter, entitled "Mythinformation." This chapter is about "the computer revolution" and represents a case study in which many of the phenomena discussed up to this point in the book are identified. It is also a devastating critique of the vacuous nonsense, the mindless hype and the preposterous claims that have been and are being put forward as the birthright of personal computers. All this is nothing new, as Winner points out, and the same flights of utopian fancy have preceded the factory system, railways, the telephone, electricity, automobiles, aeroplanes, radio, television and nuclear power. Anyone familiar with the early history of nuclear power's promotion will recognize, without edification, the same wild and unthinking exaggerations that are now being repeated with computers.

Excess and Limit

Up to this point, Winner has been preparing the ground from which, in the final four chapters, he will deliver his main messages. In these chapters, grouped under the general sectional heading "Excess and Limit," he discusses nature, what it is and what we can infer or learn from it (The State of Nature Revisited), his views on hazard and risk ("On Not Hitting The Tar-Baby"), the problems we create for ourselves by hiding behind washed-out non-words ("Brandy, Cigars and Human Values") and a final chapter which is a personal statement and a description of the points of departure for the book ("The Whale and the Reactor").

In these chapters, in which Winner begins to unveil his own views, there are things that everyone could find to disagree with. "The State of Nature Revisited" examines different views of nature: as a stock of economic goods, as an endangered ecosystem, as a source of intrinsic good, as a social category. The main points of these outlooks are noted and their implications discussed. The purpose is to provide a philosophical inquiry on nature: what is it and how should we view it and treat it?

"Brandy, Cigars and Human Values" is yet another attack on vague definitions, but is chiefly an appeal to humanism: don't cover up the things that really matter with a bland paste called "human values" and then delude yourself that you can discuss the whole thing objectively and completely unemotionally while still getting right down to the heart of the matter. Indeed, Winner feels that the ability to get down to the heart of the matter seems to be slipping away from us. A frequent cop-out here is to dismiss the whole business as being in the realm of the "soft" sciences, not susceptible to structured thinking. Winner assures us, however, that the questions here are every bit "as 'hard' and as challenging as any that science could hope to tackle. They are, furthermore, eminently practical, involving the combined practice of ethics, politics and technology."

The final chapter, "The Whale and the Reactor," is too much a personal statement to summarize or encapsulate fairly.

"On Not Hitting The Tar-Baby" is a chapter that one could criticize technically on the validity of its main points. The thesis here, very briefly, is as follows. While those things that could cause harm were viewed as "hazards," we were generally in good shape. A measure of public consensus was still possible while the term "hazard" was used, since it implied only something negative, to be neutralized or avoided. The moment we started talking in terms of "risks," however, all that changed. Risk, in Winner's view, automatically incorporates not only the possibility of loss but also inevitably the prospect of gain. Furthermore, he states, the term's association with visions of the riverboat gambler and the fast and loose dealings of the commercial world, inevitably cause the public to link "risk" with something undertaken voluntarily, perhaps with overtones of a sort of daredevil mentality. For these reasons, Winner believes, it is not now and never will be possible to "sell" the notion of risk to the public. They won't buy because they haven't been given the choice to purchase in the first place; anything called a "risk" represents a choice that has already been made without their agreement and is being foisted off on them. They aren't happy about being pushed.

His advice, therefore, is "don't hit the tar-baby"; stay away from the notion of risk altogether because it can't be made to work. Stick to hazard; if something is a hazard, accept it as such and either avoid it or find a way of dealing with it. The shortcomings of such a view are evident. This chapter should not simply be written off, however. There is much to be gained from Winner's discussion of risk and its perception by the public.

In this book, and others like it, one detects the beginnings of a re-unification of sorts, a willingness to look beyond the traditional limits of science and technology to find other fragments of the answer. Whether such a re-unification is taking place or not, one gets a feeling of things coming together from reading *The Whale and the Reactor.* The expression is clear and powerful, the writing is elegant, the fusion of information from disparate fields is exquisite and masterly. Winner's liking or dislike of nuclear power is unimportant; his criticisms are of a quality that transcends any such trivial considerations. Would that we always faced critics of this calibre.

The Whale and the Reactor is a superb book. I can recommend it without reservation.

Keith Weaver

Recently Published

Principles of Nuclear Science and Engineering by A.A. Harms, Professor of Physics and Engineering Physics, McMaster University, Hamilton, Ontario, Canada.

John Wiley & Sons, New York, NY (1987), $43.00, p. 192.

In this book, the theme of matter-energy transformations is developed as a systematic extension of the basic sciences normally covered in lower division courses at universities. Conceptual constructs of physical systems are formulated and suitable mathematical formulations applied in order to provide an integrated description of nuclear physics, radiation environments, radioisotopes and applications, principles of fission reactors, emerging fusion energy systems, and related topics. Graphical depictions, tabular information, and illustrative case-problem analyses are used throughout and a fold-out chart of the nuclides is included as a back-cover insert. It is intended as a text book for university students in year II/III.

CNS Publishes Engineering Centennial, Annual Conference Proceedings

The Canadian Nuclear Society has published the proceedings of the sessions on nuclear power and fusion which were held at the 1987 Canadian Engineering Centennial, May 18-22, 1987 in Montréal. The theme of the conference was "Canadian Engineering: The next hundred years."

The volume contains 30 papers on many aspects of nuclear power in Canada, in honour of the CANDU reactor having been selected one of the top ten Canadian engineering achievements.

Presentations included: the history of the

CANDU reactor, specific engineering developments supporting the reactor, the management of domestic and foreign nuclear projects, regulation, nuclear safety, nuclear waste disposal, small reactor development in Canada, and Canadian fusion projects including fusion fuel and the Varennes Tokamak.

The volume is available for $35.00. Also recently published are the proceedings of the CNS 8th Annual Conference, held June 1987 in Saint John, New Brunswick, with over 60 papers in 12 sessions. This volume is available for $60.00 to CNS members, $75.00 to non-members.

Conference Reports

Artificial Intelligence and Other Innovative Computer Applications in the Nuclear Industry

This ANS topical meeting, co-sponsored by the Human Factors Division and the Remote Systems Technology Division, Idaho Section (ANS) and by the European Nuclear Society, took place August 31 through September 2 in Snowbird, Utah.

Approximately 250 international participants attended a total of 15 sessions on topics ranging from "Alarm and Signal Validation" to "Plant Operations and Support."

Canadian participants included representatives from AECL, NBEPC, Ontario Hydro and ECS-Power Systems. Also, J. Anderson of AECL represented Canada in the opening international plenary session by presenting a paper entitled "Development in the Application of Knowledge Base Systems in the Canadian Nuclear Industry."

There is currently much international activity in the introduction of Artificial Intelligence (AI) techniques in the nuclear industry. Particularly impressive are the national efforts of France, Japan and the United States, although North American efforts are in general lagging behind European efforts due to the lack of new plant ordering.

The recent progress made in AI applications is very encouraging. Whereas only two or three years ago virtually all projects were only in the development stages, this year marked the introduction to service of several AI tools. However, certain areas of development remain to be investigated, including verification and validation issues, consistency checking and cost/benefit analyses.

A one-day tutorial workshop on AI preceded the conference, and was attended by about sixty participants. The tutorial focussed on applications of AI, and sought to bridge the gap between theoretical and practical issues.

The conference also included a utility panel discussion on AI issues from the user's point of view, a product hall featuring several commercial exhibitors and an interactive demonstration session where many of the projects discussed in the 15 sessions could be viewed 'in action.'

Proceedings for the topical meeting will be available in about six months.

Terry Jamieson

Conferences & Meetings

Annual Reliability and Maintainability Symposium

Sponsored by IEEE and others, to be held **January 26-28, 1988** in Los Angeles, California. For information contact: **V.R. Monshaw, RCA, AstroElectronics, P.O. Box 800, MS 55, Princeton, N.J. 08540.**

Seminar on Food Irradiation for Developing Countries in Africa

Sponsored by the UN FAO and IAEA, to be held **February 15-19, 1988 in Dakar, Senegal. For information contact: Conference Service Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.**

International Conference on Man-Machine Interface in the Nuclear Industry

Sponsored by IAEA, OECD NEA and CEC, to be held **February 15-19, 1988** in Tokyo, Japan. For information contact: **Conference Service Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.**

International Symposium on Severe Accidents in Nuclear Power Plants

Sponsored by IAEA and OECD NEA, to be held **March 21-25, 1988** in Sorrento, Italy. For information contact: **Conference Service Section, IAEA, P.O. Box 100, A-1400, Vienna, Austria.**

Safety of Next Generation Power Reactors

Sponsored by ANS; cosponsored by U.S. DOE, CNS et al., to be held **May 1-5, 1988** in Seattle, Washington. For information contact: **Alan E. Waltar, Westinghouse Hanford Co., P.O. Box 1970, Richland, Wash. 99352,** (509) 376-5250.

Third Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications

Sponsored by CNS, cosponsored by American Nuclear Society, to be held **May 1-6, 1988** in Toronto, Ontario. For information contact: **C.D. Burnham, CFFTP, 2700 Lakeshore Rd. W., Mississauga, Ontario, L5J 1K3,** (416) 823-6364.

Interested in Contributing to the *CNS Bulletin*?

To submit original articles, letters, FYI items, reviews, calls for papers, etc., contact one of the following:

- J. Nathwani, Editor, *CNS Bulletin,* c/o Ontario Hydro, 700 University Avenue, Toronto, Ontario, M5G 1X6.
- The *CNS Bulletin,* c/o the CNS office.
- Your branch or division representative.

CNS Bulletin Issue:	Editorial Deadline:
January/February	January 1
March/April	March 1
May/June	May 1
July/August	July 1
September/October	September 1
November/December	November 1

Intéressés à contribuer au *Bulletin SNC*?

Pour soumettre des articles originaux, des lettres, des nouvelles, des revues, des appels aux communications, etc., veuillez bien entrer en contact avec l'une des personnes suivantes:

- J. Nathwani, Rédacteur, *Bulletin SNC,* a/s Ontario Hydro, 700 University Avenue, Toronto, Ontario, M5G 1X6.
- Le *Bulletin SNC,* a/s Bureau de la SNC.
- Le représentant de votre section locale.

Numéro du *Bulletin SNC*	Date limite pour l'éditorial:
janvier/février	le 1 janvier
mars/avril	le 1 mars
mai/juin	le 1 mai
juillet/août	le 1 juillet
septembre/octobre	le 1 septembre
novembre/décembre	le 1 novembre

4th Workshop on Analytical Chemistry Related to Canada's Nuclear Industry

Sponsored by AECL, Ontario Hydro and others, to be held **May 15-18, 1988** in Kimberly, Ontario. For information contact: **K.R. Betty, Eldorado Resources Ltd., 255 Albert St., Suite 400, Ottawa, Ontario, K1P 6A9,** (613) 238-5222.

Nuclear Technology for the Future: CNS 9th Annual Conference – Call for Papers

The Ninth Annual Conference of the Canadian Nuclear Society will be held in Winnipeg, Manitoba, Canada, in parallel with the Canadian Nuclear Association's 28th Annual International Conference, **June 12-15, 1988.** The

CNS Conference provides a forum for presentation of contributed and invited papers, subject to peer review by a panel of CNS members and acceptance by the Program Committee.

Papers are invited on all subjects relating to applications of nuclear technology. In keeping with the theme of the conference, particular emphasis will be placed on the future developments of all aspects of nuclear technology. Thus, submissions in the following areas are particularly encouraged:

- Small reactor development: this includes heating reactors, compact electricity producers, and research reactors under development.
- Radiation applications: this includes prospects for food irradiation and industrial radiation processing applications, as well as accelerator development.
- Medical applications of radiation and isotopes: this includes applications, isotope production and hardware developments, and transportation of radioactive isotopes.
- Reactor decommissioning: this includes past experience and plans for decommissioning recently retired reactors.
- Waste management: this includes both the management of used fuel wastes, low-level wastes, and mine and mill tailings.
- Reactor safety: this includes not only progress in reactor safety research but also developments in improving the safety design of future reactors.
- CANDU performance and improvements: this includes design and operational changes that have been conceived to improve the capacity factor and reliability of reactors; topics such as plant aging, life extension, computer-aided design and operation, and expert systems are included.
- Fuel channel performance, research and development: this includes work of materials properties, development of improved fuel channel concepts, and operational experience in pressure tube performance.

Persons wishing to present a paper are requested to submit a summary to the Conference Chairman for review, postmarked no later than **January 19, 1988.** Summaries should include an introductory statement indicating the purpose of the work and a closing statement summarizing the significant conclusions. All summaries will be reviewed by the Technical Review Committee and the principal author will be notified of the status of the summary on or about **February 26, 1988.**

For further information:

H. Tamm,
1988 CNS Annual Conference,
c/o Whiteshell Nuclear Research Establishment,
Pinawa, Manitoba,
R0E 1L0;
telephone: (204) 753-2311 (ext. 2335).

14th International Symposium on Effects of Radiation on Materials

Sponsored by ASTM, to be held **June 27-29, 1988** in Andover, Massachusetts. For information contact: **ASTM, 1916 Race St., Philadelphia, PA 19103,** (215) 299-5400.

Spectrum '88: International Topical Meeting on Nuclear and Hazardous Waste Management

Sponsored by ANS, cosponsored by U.S. Department of Energy, Canadian Nuclear Society and others, to be held in Pasco, Washington **September 11-15, 1988.** The major topics to be addressed include: international overviews; high-level waste management; low-level waste management; environmental issues; hazardous waste management; decontamination and decommissioning; media relations; construction and maintenance; federal/state agency interaction; regulatory training; and cement-based form technology. Deadline for 500-word abstracts: **February 1, 1988.** Notification of author acceptance: **March 31, 1988.** Deadline for final camera-ready mats: **June 1, 1988.** Submit original and three copies (all in English) to **D.D. Wodrich, Technical Program Chairman, Spectrum '88 Technical Program, P.O. Box 159, Richland, Wash. 99352-0159.** For further information, contact **Eva Rosinger, Whiteshell Nuclear Research Establishment, Pinawa, Manitoba,** (204) 753-2311.

International Symposium on Uranium and Electricity – The Complete Nuclear Fuel Cycle

Sponsored by CNS, cosponsored by Canadian Nuclear Association, Australian Nuclear Association and others, to be held **September 18-21, 1988** in Saskatoon, Saskatchewan. For information contact CNS office, (416) 977-7620.

International Conference on Thermal Reactor Safety

Sponsored by SFEN, cosponsored by CNS et al., to be held **October 2-7, 1988** in Avignon, France. For information contact: **F. Cogne, Société Française d'Énergie Nucléaire (SFEN), 48, rue de la Procession, F-75724 Paris, CEDEX 15, France.**

STAO '88 Conference – Science: Expanding Horizons

Sponsored by the Science Teachers' Association of Ontario, to be held **November 3-5, 1988** in Toronto. For information contact: **Pam Heron Consultants, Jefferson Building, 11570 Yonge St., R.R. 1, Richmond Hill, Ontario, L4C 4X7.**

3rd International Topical Meeting on Nuclear Power Plant Thermal Hydraulics and Operations

Sponsored by CNS, Korean Nuclear Society et al., to be held **Nov. 14-17, 1988** in Seoul, South Korea. For information contact: **Ken Talbot, Pickering NGS, Box 160, Pickering, Ontario, L1V 2R5,** (416) 839-1151.

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The Unfashionable Side

Licence, Luxury and Licentiousness

I remember the day very clearly when the idea first came to me – or rather was brought to my attention. It was in the course of my lecture on the application of the finite element technique to the structural analysis of *King Lear,* or it may have been the lecture on the development of the mythic element in CANDU safety documentation. Be that as it may, my discourse was abruptly checked by one McPhee – a precocious student who combined a somewhat perverted predilection for obscure Chaucerian references with a laudable (if over ambitious) desire to get to know (in the Biblical sense) as many female undergraduates as possible. "Would you not agree, Professor Worthing," said the Home Counties caledonian, "that the question of Shakespeare's 'missing years' can best be explained by his involvement in reactor licensing questions?" He paused expectantly while I thoughtfully tossed a piece of chalk at the EXIT sign in a manner calculated to indicate scholarly interest combined with academic scepticism. "That is a very interesting point, Mr. McPhee," I admitted, "pray continue." McPhee produced a rather battered Arden *Lear* and thumbed through the pages dislodging as he did so two dead cockroaches, a cloud of unidentifiable debris and what appeared to be the remains of a gingernut biscuit. "Here it is!" he boomed triumphantly, "Three, five, line 15, Edmund to Cornwall, 'If the matter in this paper be certain, then you have mighty business in hand.' Doesn't this represent the discussion of an operating utility just after receipt of a 'show cause' letter from the Control Board?"

I paused for a moment (indicating judicious consideration of even the most absurd proposition). "That is indeed, Mr. McPhee, a possible, not to say plausible, interpretation of the line. But have you considered Edmund's character?" I could see by the look of stricken realization spreading over the haggis-fancier's features that he had not. "Recollect," I continued, "that Edmund is a man of instant action. He is also demonstrably highly intelligent, witty and entertaining and ruthless in action. By these qualities he is the complete antithesis of the typical nuclear facility licensee." With no great pleasure I watched McPhee sag back into his habitual intellectual langour. I lobbed another piece of chalk in the general direction of the portrait of Vice Chancellor Sprogget which desecrated the opposite wall of the lecture room. As the calcinaceous missile entered the terminal phase of its flight I was suddenly struck by the realization that McPhee was right – but the evidence was not in *King Lear* but *Macbeth*!

"McPhee!" I shouted, disturbing two sleeping bats and a cloud of dust from the light fixture, "I believe you have something. Abandon your current thesis topic this instant and substitute 'Safety and Licensing in Shakespearean Tragedy'! We have here a paper that will knock their socks off at the CNS. It will dominate *Shakespearean Quarterly* for the next three years. It's the biggest thing in Shakespearean scholarship since Wilson Knight. It's the biggest thing in licensing since the Big Z got photographed with the female contortionist and the two coconuts." A babble of questions seethed up from the class, but I had no time for further discussion. After erasing the more libellous of my notes from the blackboard with the corner of my gown, I made a dash for the door. I needed to get Bauer in on this one.

A mere five minutes was all it took to drive to my rooms, grab the Arden Macbeth, the Furness Variorum text, the Spevack concordance and a handful of floppy disks, then zoom over to Aphasia U's accelerator laboratory where I knew Bauer to be working that morning. Leaving the Bentley somewhat inexplicably entwined with the faculty bicycle rack, I strode into the building and found Bauer seated before a rather large and complex control panel. "Bauer!" I cried, tossing the weighty volumes onto the desk in front of him, "come with me at once – the game's afoot!" My attention was temporarily distracted by a prodigious pyrotechnical display from the far end of the room, but luckily this obviously marked the end of the day's work for the scientist chappies since the knocking-off siren started up. A flicker (or perhaps a spasm) passed over Bauer's classical features (I could sympathize with him since I often suffer these migraine twinges myself), but he merely remarked that his practice was not particularly absorbing at that moment, and got up to follow me as I pushed through the crowd of departing physics types in their natty plastic suits.

For some odd reason Bauer declined my offer of a lift, choosing to follow me in his own vehicle. This was just as well, since on the way I was able to sweep the detestable Armitage Loathing (Underwater Ornithology) off his velocipede, thus averting an ugly confrontation.

Bauer's elegant penthouse was in its usual state of compulsive tidiness, but I did not allow this to divert me from my course. Thrusting the Arden into Bauer's hands I busied myself with his brandy bottle, ice cubes and gasogene, explaining the while the broad outlines of my proposed plan of investigation.

"But Worthing," he protested mildly, "what evidence can you possibly have unearthed in the last ten minutes during which time you have not only destroyed (or seriously damaged) several expensive pieces of university equipment and violated about a dozen traffic regulations, but also seriously reduced my brandy inventory?" (Bauer always talks in this manner before he's finished his second drink. I think it's the effect of spending too much time in the company of protons or something).

I decided to come straight to the point. "Act I, scene i, line 11"* I said laconically. Bauer turned to the relevant page: "'Fair is foul and foul is fair / Hover through the fog and filthy air.' " he read. "Well, what's that got to do with safety and licensing?" "Elementary, my dear Bauer," I responded, "it's a description of the assumed meteorological conditions during a radioactive release." Bauer's eyebrows moved from the Angle of Polite Scepticism to the Frown of Interested Concentration as I continued "and you will notice the linguistic inversion Shakespeare uses (quite typically) to draw attention to the atmospheric one." The level of brandy in Bauer's glass dropped suddenly, then he looked up. "I do believe you're on to something" he said, "for example I see reference to triplicated systems here in I, iii, 35 ('Thrice to mine, and thrice to thine')."

"– Exactly, Bauer, and if you go on to IV, i, line 1 onwards you'll see that treated in more detail, including two out of three and three out of four voting." As Bauer turned to the reference and nodded agreement, I decided to play the ace: "Now Bauer, listen to this: IV, i, 92-95: Macbeth has been told that he shall not be vanquished until 'Great Birnham wood to high Dunsinane Hill / Shall come against him', and Macbeth responds 'That will never be'." Bauer drew a sharp breath – "You mean . . . ? " he started.

"I mean the non-design basis accident has just been identified, Bauer old chap!" I cried with understandable triumph, "And," I added, "if you now turn to V, vi, 34, you'll see the part that begins 'methought the wood began to move' indicates both operator misinterpretation and, subsequently, failure to identify a common-mode failure – in this case Malcolm's army."

Bauer needed no further convincing. We worked far into the night, and, as the empty brandy bottles piled up (or were lobbed carelessly through the window), we nailed down the case still further . . .

- On shut-down system performance (I, vii, 1): "If it were done, when 'tis done, then 'twere well / It were done quickly"
- On site approval (I, vi, 1): "This castle hath a pleasant seat; the air / Nimbly and sweetly recommends itself"
- On consequence assessment (I, iii, 137): "Present fears / Are less than horrible imaginings"
- On the relationship with consultants (III, iv, 16): "We will proceed no further in this business" and (III, iv, 47): "Which of you have done this?" and (III, iv, 91): Avaunt and quit my sight / Hence horrible shadow!"

Bauer was particularly chuffed when he identified treatment of the problem of two-phase flow following a single failure during a seismic event in I, iii, 79: "The earth hath bubbles as the water has."

The rest, of course is not silence, but history. McPhee, I'm glad to say, received a well-earned First and left to pursue post-graduate studies at MIT on the environmental assessment and site selection criteria in Shakespearean comedy. He will return to Aphasia next Autumn to take up a cross-appointment in my Department and Bauer's. Through a plethora of contracts George has managed to add significantly to his collection of Nineteenth Century erotica – and indeed I have benefitted to the extent that I shall be able to afford the initial development costs of my steam driven Difference Engine.

Naturally, our departments flourish. Three courses on Seventeenth Century Drama are now required to accommodate the numerous applicants from Engineering and Physics who, as a side benefit, are showing signs of being able to construct short, but coherent, English sentences. And George Bauer has his work cut out ushering numerous Honours English students through the convolutions of such things as CRAC-II and RODFLOW – in the course of which they seem to gain sufficient familiarity with such arcanae as the Second Law of Thermodynamics to reassure the shade of C.P. Snow.

However this is only the beginning. Just the other day I received a telephone call from the Big Z: "I say Worthing, do you remember what Webster has to say about probability in *The Duchess of Malfi?*" . . .

Ernest Worthing

* For the convenience of the reader, all references are to the Arden *Macbeth.*

Correction

Concerning the FYI news item titled "ONSR Completes Receiving Submissions" which appeared in the *CNS Bulletin* of September/October 1987, the Ontario Ministry of Energy did not give a formal submission to the Ontario Nuclear Safety Review, but has provided it with background information on an ongoing basis.