



PRESERVATION and DISSEMINATION of CANDU® TECHNICAL KNOWLEDGE (The CANTEACH Project)

by

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Abstract:

There is a critical need for preserving CANDU technical knowledge and for providing a means of disseminating that knowledge to the nuclear community in a convenient and cost effective manner. The CANTEACH project is aimed at fulfilling those needs. This paper describes the project model and the current website content, discusses how you might use the site and, most importantly, the key role that you can play in ensuring that CANTEACH is successful.

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1 Introduction

CANTEACH [1] is a recently devised project with the purpose of preserving technical knowledge of the CANDU® nuclear-electric generating system for use by present and future members of the CANDU community. This paper details the logical structures of the data filing and recovery systems. It also serves as the base for an on-line demonstration that will take place during the paper presentation.

Sixty years have passed since the nuclear energy venture began in Canada. Fifty years have passed since the founding of AECL. Tens of thousands of dedicated people have forged a new and successful primary energy supply. CANDU technology is well into its second century. This specialty within the world's fission technology community is quite unique, first because it was established as a separate effort very early in the history of world fission energy, and second because it grew in an isolated environment, with tight security requirements, in its early years. Commercial security rules later sustained a considerable degree of isolation. As yet, we cannot point to a consistent and complete record of this remarkable achievement. We, as a nuclear enterprise, have not captured the design legacy in a form that is readily accessible to the current and future generation of professionals involved with CANDU reactors, be they students, designers, operations staff, regulators, consultants or clients. This is a serious failure.

Young people entering our field of study must make do with one or two textbooks and a huge collection of diverse technical papers augmented by limited-scope education and training materials. Those employed in the various parts of the nuclear industry rely mostly on a smaller set of CANDU-related documents available within their own organization; documents that sometimes are rather limited in scope. University professors often have even more limited access to in-depth and up to date information. In fact, they often depend on literature published in other countries when preparing lectures, enhanced by guest lecturers from various parts of the industry. Because CANDU was developed mostly inside Canada, few of these text materials contain useful data describing processes important to the CANDU system.

For many years it has been recognized that we need a "CANDU Textbook". However, other work priorities and intense activity within AECL and the utilities have prevented the completion of such a reference volume. There is, in fact, a large volume of existing documents that describe CANDU systems and operations. Much of that documentation is repetitious and contains less depth than is desirable. Very few of the documents detail why CANDU is designed the way it is. How can designs evolve appropriately and how can retrofits and design changes be implemented correctly if the 'whys' are not elucidated? How are the graying experts passing on their knowledge and wisdom? It is this need that the CANTEACH project is striving to fill.

2 Project Model

Figure 1 illustrates the information flow and products of the project. Donors (organizations and individuals) send contributions to CANTEACH staff. Staff then arrange the documents into a consistent format and vet material to ensure a high level of quality. The main activities of staff to date relate to development and refinement of the information management system. Results



may be judged by browsing the website. Several of the data categories are “under construction”; that is, we have not yet had resources available to populate major portions of the site.

At the present time we are heavily occupied with the task of content generation and organization. There has not been much editing done as yet; a major task yet to be undertaken is content editing for quality. In some cases several versions covering the same subject are available; eventually this diversity will be reduced by merging or by rejection of some materials.

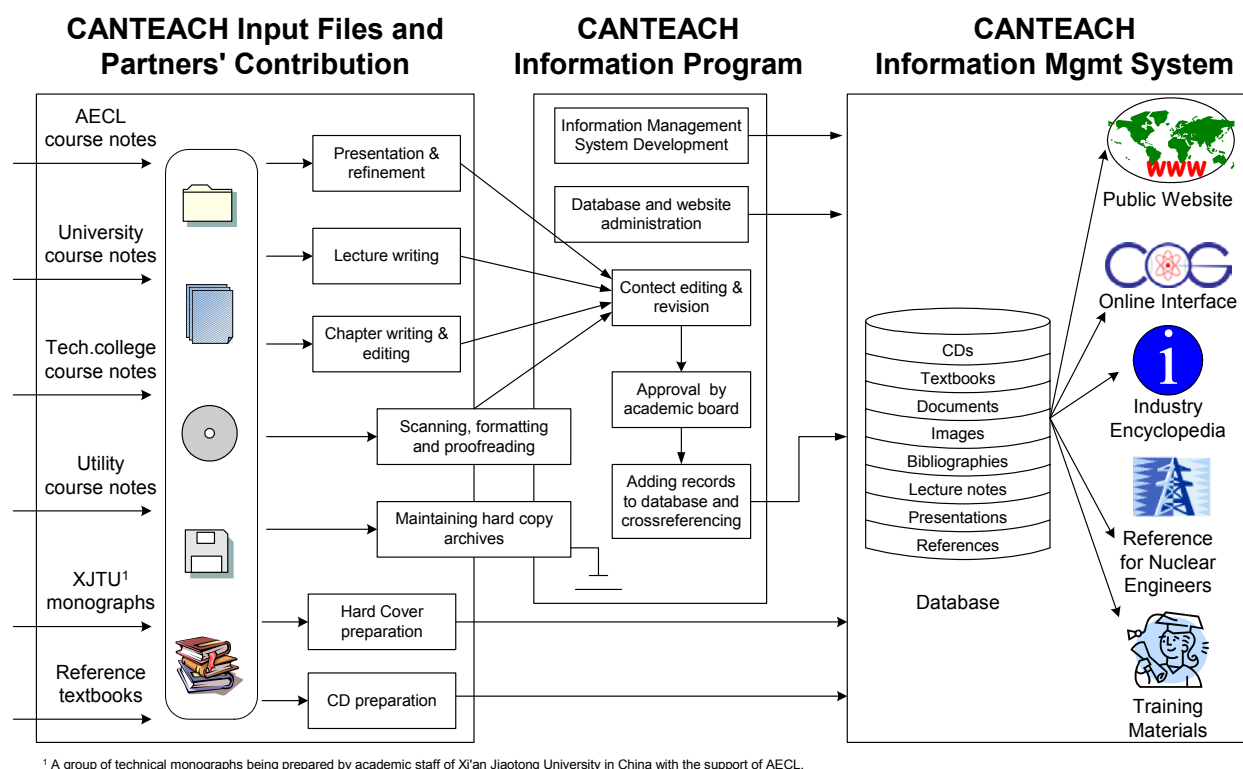


Figure 1. Information Flow and Content

The obvious dissemination media is the world wide web. It provides a convenient and easy access to a virtually unlimited volume of information at negligible distribution cost. Documents on the web are searchable electronically and, if attention is given to the details, is able to reproduce the page layout of the original documents in printed copies. We look at the details of CANTEACH website next.

3 Website Structure and Content

Figure 2, copied from the website home page, serves as an introduction to the features of this site. The contents of the dedicated server containing this information are varied, and they change almost daily as new materials are added. The easiest way to find out what information is available today is to access the website at <http://canteach.candu.org>.

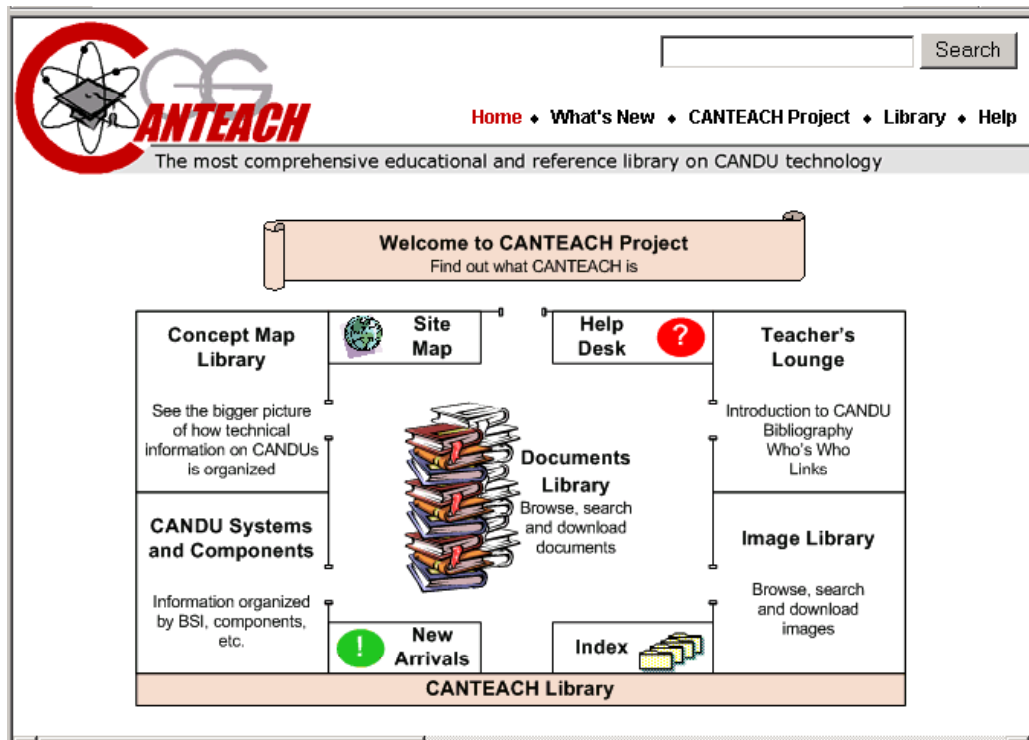


Figure 2 – Reference Library Home Page

3.1 Filing and archiving

Behind the simple and clean CANTEACH user interface to the library lays the non-trivial task of document management. Archives for source files are maintained, documents under review are held in a restricted web area pending acceptance and editing to prepare them for the web. Archiving and record management will remain an important function of the project, and the documents database is developed with that in mind.

3.2 Formatting complex documents: Storage Structures and Main Software Packages

Since the CANTEACH library documents come from various sources and must cater to different audiences, the issue of document format had to be resolved to provide consistency and modularity. It is essential that an effective format be established and maintained for the development and presentation of technical material. All documents are posted in Acrobat pdf format to enable consistent reading and printing without loss of the document format and to enable the use of complex page layouts, something that web browsers cannot currently provide. This is important for legacy documents so that historical accuracy can be maintained. Currently large and complex documents such as courses and books are formatted so that they can easily be



copied to different media as “modules” consisting of several cross-referenced Acrobat documents. There is no need for complex web browser or service files such as tables of contents. The whole module can be copied “as is” to a CD, desktop or company’s Intranet. Archival copies of all documents in their native format are kept and can be made available upon demand for re-purposing.

It is required that there be ease of information exchange and subject matter delivery, efficient and effective preparation of text material for web based delivery, and efficient and effective preparation of mathematical equations and graphics for the web.

It was decided that the ultimate delivery format is to be the Adobe pdf file since it is the de facto standard, is compressed and any application that prints can generate it. A HTML front end (captured to pdf if desired) will be used for hyper linking the various modules. A fully web based approach is not advised because current html language standards do not permit adequate control of page layout nor is it possible to zoom in on items of interest if desired. In contrast, pdf files are faithful representations of the original documents, be they scanned legacy documents or electronically prepared documents. In Acrobat Reader, the pdf file viewer, the user has full control over document viewing, including scale and rotation. There is a good article at <http://www.hypertextnavigation.com/infoaxcs.htm> by Michael Hoffman on the need for an evident document structure (ie a good Table of Contents), whether on the web or on paper. The ability to jump around on the web does not remove the need for the reader to see a structure. In this regard, the CANTEACH pages are designed to be longer individual pages rather than short and excessively hyper-linked screen-sized pages. This promotes clarity of structure and emulates the book-like structure that the reader is familiar with. The book structure (table of contents, chapters and index) is an enduring structure for a very good reason: it works!

Various text preparation software was evaluated and it was found that Microsoft Word was the preferred word processor since it is ubiquitous and since it interfaced better with Adobe Acrobat in the preservation of hyperlinks in the table of contents. Other software is not forbidden, however, since all software does ‘print’ to the pdf format.

For the representation of mathematics, [MathType](http://www.mathtype.com/) (<http://www.mathtype.com/>) was chosen as the standard. MathType is a superset of the new equation editor used in WordPerfect and the equation editor used in Word, the two most popular document formats. MathType installs itself in both these word processors and equations prepared in the subset editors migrate to MathType directly. MathType also exports to a variety of formats for the web and can be used standalone for creating equations for insertion into drawing packages, etc. MathType will be extended to include the emerging web standard for math, MATHML, so the growth path is there and the time and effort involved in creating a library of equations is protected. Other standard formats exist, like Latex, but overall, MathType is the most mainstream, is easy to use, can do all that is needed and fits well with the model for this project: standard office application tools that we are all familiar with, the use of pdf and the use of the web.

Graphics are stored either as raster images (bmp, jpeg, tif, gif, pcx, ...), ie pixel by pixel, or as Scalable Vector Graphics, SVG, (wmf, ai, wpg, ...). Most applications read and write to these formats. Line drawings are best saved and manipulated as vector graphics to reduce file size and permit scaling without losses. Sometimes we only have a raster image and need to turn it into a



vector image. A number of popular graphical programs were tested (Visio, Flash, Corel Draw, Adobe Illustrator, Inspiration, etc). No preferred standard was chosen since the discipline and the context dictate the preferred format.

In summary, all documents are posted in Acrobat pdf format to enable consistent reading and printing without loss of the document format and to enable the use of complex page layouts, something that web browsers cannot currently provide. This is important for legacy documents so that historical accuracy can be maintained. Currently large and complex documents such as courses and books are formatted so that they can easily be copied to different media as “modules” consisting of several cross-referenced Acrobat documents. There is no need of complex web browser or service files such as tables of contents. The whole module can be copied “as is” to a CD, desktop or company’s Intranet. Archival copies of all documents in their native format are kept and can be made available upon demand for re-purposing.

3.3 Tour of the Website

If it is your first visit to the site, have a look at “Welcome to CANTEACH”. Entering a library can be a daunting experience so a quick tour is recommended to get a feel of what type of information is available and roughly where it is stored. Clicking on the central stack of books on the front page of the website takes you to the library stacks, analogous to a physical library. The documents are arranged by institution. Below is a brief outline of the library contents. You can see what is on the site, but you can also see what is not. Can you help?

3.3.1 AECL

- Nuclear Power Symposium Series, circa 1972
 - AECL 17 Lectures on Nuclear Power Symposium
- Presentations
 - Introduction to CANDU 6 - A Six Lecture Course - Overheads and notes for a course presented at Xi'an Jiaotong University, 1998-09-22 to 25 by D.A. Meneley and Y.Q. Ruan
 - CANDU Safety - Shanghai 1999 - 25 presentations - overheads by V. Snell and F.J. Doria
- AECL Topical
 - A Reactor Cannot Explode Like a Nuclear Bomb by Dan Meneley, AECL, November 2000
 - A Human Turning Point - Overheads for a lecture presented at University of Victoria, 2001 March 06 by D.A. Meneley
 - Fuel for the Next Millennia - Overheads for a lecture presented at University of Victoria, 2001 March 06 by D.A. Meneley
 - "CANDU Origins and Evolution", paper in 5 parts, by Gordon L. Brooks and John S. Foster
 - A Short History of the CANDU Nuclear Power System, prepared by Gordon L. Brooks
 - Starting up a CANDU Reactor, Abbreviated Step-by Step Procedure, by Dan Meneley, 2001.07.20
- AECL - Public Relations



- CANDU
- CANDU - How a Reactor
- Why a Chernobyl-type accident cannot happen in CANDU
- AECL Reports
 - Chernobyl – A Canadian Perspective, by V.G. Snell and J.Q. Howieson,
 - AECL-3068 The Performance of Zirconium Alloy Clad UO₂ Fuel for Canadian Pressurized and Boiling Water Power Reactors, by R. D. Page and A. D. Lane
 - AECL-3972 Commissioning and Operating Experience with Canadian Nuclear Electric Stations, by L. W. Woodhead, D. C. Milley, K. E. Elston, E.P. Horton, A. Dahlinger and R.C. Johnston, Paper No. A/Conf. 49/A/148 presented at the Fourth U.N. International Conference on the Peaceful Uses of Atomic Energy, Geneva, 6-16 September, 1971
 - AECL-5609 Canadian Power Reactor Fuel, by R. D. Page

3.3.2 Canadian Nuclear Safety Commission

- CNSC training courses: Fundamentals of Power Reactors
 - Module One - Science & Engineering Fundamentals
 - Module Two - Nuclear Reactor Systems
 - Module Three - Radiation Protection
- CNSC training courses: Science & Reactor Fundamentals
 - Volume One
 - Mechanical Equipment
 - Basic Instrumentation and Control
 - Materials
 - Volume Two
 - Reactor Physics
 - Volume Three
 - Electrical
 - Volume Four
 - Heat & Thermodynamics

3.3.3 International Atomic Energy Agency (IAEA)

- "Heavy Water Reactors: Status and Projected Development", Technical Report Series No. 407, IAEA, Vienna, Austria, 2002. Published on IEAE web site at <http://www-pub.iaea.org/MTC/publications/publications.asp>.

3.3.4 Ontario Power Generation (OPG)

- Papers
 - Testing the Dynamics of Shutdown Systems: Instrumentation in Reactor Trip Measurements by Oszvald Glockler, OPG. *Paper presented at the 8th Symposium on Nuclear Reactor Surveillance and Diagnostics at Göteborg, Sweden, May 27-31, 2002.*
 - Reactor Noise Measurements in the Safety and Regulating Systems of CANDU Stations by Oszvald Glockler, OPG. *Paper presented at the 8th Symposium on*



Nuclear Reactor Surveillance and Diagnostics at Göteborg, Sweden, May 27-31, 2002.

- Presentations
 - Safety Analysis Technology: Evolution, Revolution and the Drive to Re-Establish Margins by John Luxat, OPG. Seminar presentation, Canadian Nuclear Society, Sheridan Park Branch,
- Training Courses
 - OPG has donated all the old operator training courses in the fundamentals area. One course (227 Nuclear Theory) has been posted. Look for others to appear in the coming months.

3.3.5 Chulalongkorn University

- 36 university level courses will eventually be placed on the CANTEACH website, pending authors' approvals.

3.3.6 McMaster University

- McMaster courses
 - Engineering Physics 3D3 (Principles of Nuclear Engineering)
 - Engineering Physics 4D3 (Nuclear Reactor Analysis)
 - Engineering Physics 704 (Nuclear Power Plant Systems and Operation)
 - Engineering Physics 712 (Advanced Nuclear Reactor Analysis) - under construction
 - Engineering Physics 714 (Nuclear Reactor Safety Design)- was EP704
 - Engineering Physics 716 (Nuclear Reactor Process Systems: Thermalhydraulic Design)
 - Science for Nuclear Energy and Radiation - a comprehensive course for Grade School and High School Science Teachers
- Books
 - An Introduction to the CANDU Nuclear Energy Conversion System by A.A. Harms, 1975

3.3.7 University of Toronto

- Presentations
 - The CANDU System: A Canadian Achievement - Overheads for a presentation 2000 November 15 by Adam McLean

3.3.8 Other Canadian Universities

- See <http://nuceng.mcmaster.ca/courses/courseindex.htm> for a listing of all nuclear related courses taught at Canadian universities.

3.3.9 Manufacturers / Service Providers

- What is RTD - an article about Resistance Temperature Detectors, courtesy of RdF Corporation



3.3.10 Image Library

Almost 100 images concerning CANDU systems and components are currently in the image library covering

- 00000-General
- 32000 Moderator
- 33000 Heat Transport System
- 34000 Shutdown Systems
- 37000 Fuel
- Basic topics suitable for the general audience
- Maps

We have a number of additional images that will be posted in due course.

4 Potential Users

4.1 High-school teacher

If you are a high-school teacher, you would be interested in introductory material that can be given to students verbatim or that could be used as content, in part or in its entirety for instructional units. Go to the home page and then click “Teacher’s Lounge”. You will find some general articles about CANDU. Then check the Links page for a rich collection of links to other sites containing a variety of information about nuclear energy. Finally, you might want to contact someone if you can’t find what you are looking for or you might like to make contact with a live person to answer a question or to find potential speakers. Look for the contacts given under the HELP DESK icon, and ask, if you need some specific item and cannot find it – we will try to direct you. This whole project is “under construction”, so that you likely will find many gaps in the files. We are working hard to add materials to all of these records.

As a teacher you appreciate how much time and effort goes into preparing a unit for the classroom. If you have used the content of CANTEACH and other nuclear courses to build a nice unit, why not share it with others? Send it to us for posting with acknowledgement. Other teachers will surely appreciate it.

4.2 Technical staff trainer

If you are a technical staff trainer, you may be looking for any level of information ranging from a single figure to add to a lecture, up to and including a full academic course covering a particular topic, or the ISBN reference to a textbook on materials science. Exchange of courses and detailed course content between Canadian nuclear utilities has taken place informally for many years and has reduced the training development cost of all organizations involved. The CANTEACH project intends to foster even greater cooperation between utilities, with the objectives of improving the quality of technical information available and reducing the overall cost of developing and delivering requisite training courses.

One large section of course material, originally developed by AECL under contract to the CNSC,



recently has been donated to the project. The IAEA has delivered a set of training packages concentrated on illustration of how to operate the plant from the main control panel. Desktop simulators used by IAEA for international training programs also have been donated. It is hoped that these will be made publicly available; versions exist for CANDU, PWR, BWR, and VVER systems. IAEA staff has augmented these programs through development contracts, issued mostly to the original code developers.

If you have prepared or are preparing a course for your company, please send it to us for posting with acknowledgement. There are many gems out there sitting on bookshelves. Dust them off and send them in. We'll ensure we have the rights to post the info and take care of all the tedium. You get to help make CANTEACH an even better and more complete reference library. We are currently looking for copies of the old OPG training courses. We have permission to post them but we do not have the material itself. Check your basement and give us a call.

4.3 Nuclear Industry Professional

If you are a professional working in the nuclear industry you will likely be looking for specific technical information on a system or device related to your professional activities. You might be just starting out and need general fundamentals information to help you put your job into the larger context. Or you might be more seasoned and need to read up on systems that are peripheral to your core area. Or you might need some descriptive words and images for an introductory section of a technical document you are writing.

CANTEACH was developed with you in mind, more so than any other category of user. The website library already has a wealth of fundamentals material and is still expanding. Look at the AECL and CNSC material for some great reading. Come back in the near future for OPG material. Also check out the university based courses. Many provide the full text on the web. You might also be interested in the degree and diploma programs offered by these institutions as part of your professional upgrading. A new and complementary initiative, UNENE, the University Network of Excellence for Nuclear Energy, also offers professional development opportunities. You can find out more at www.unene.com.

And don't forget, as a professional, you have access to CANDU technical material that would be ideal for the CANTEACH site. You might want to consider contributing, even in a small way.

4.4 University professor

If you are a university professor you likely will be looking not only for detailed descriptions of CANDU systems and processes, but for discussion of the underlying logic that led to some of the thousands of choices made in the design and operation of the CANDU nuclear electric generating system. All materials in the system are available for download and copying into your lecture notes or to those of your students. Links may be of particular value to students working on research projects related to the nuclear industry around the world.

If you are a nuclear professor, you already have a large inventory of choice material gathered



over the years. Some of it is hand written notes, some of it is personal reference material left over from a previous life in industry, some of it is neatly typed and honed over the years. But none of it is of any real use to the industry at large if distribution is limited to the handful of students you teach each year. Remember, students remember content only till the exam, at best. How much of the words of wisdom of your own professors do you recall? What a waste of wisdom. So do look through your own library of lecture notes and see what you can send in for posting. We can get it typed and formatted for the web. You get the credit. It might not be appropriate to submit your course in its entirety but, most likely, there are sections that would be wonderful contributions to CANTEACH. Worried that you will be putting yourself out of a job? That is hardly likely; teaching and learning are dynamic activities. Content is static. Like verbs and nouns, the two domains are nothing without the other. To date, contributions from university professors have been limited. It is time to rectify that.

4.5 Senior management

If you are a senior manager you might be trying to judge the value of CANTEACH, and whether or not it should be given continued funding support. The most direct response is to give some idea of the basic costs of developing high quality technical information of this sort. First, the cost of one person-year of a senior technical expert is about \$150,000 per year. Second, the typical ratio of time for development of a single university-level course to the delivery time of that course is between 5:1 and 10:1. If multimedia is involved, the ratio is much higher. One single-term course, then, will cost about \$30,000 to develop. Maintenance and updating of such a course adds at least another \$5,000 per year.

So, if your staff exchanges one course instead of developing a new course in-house, your cash saving will be in the neighborhood of \$20,000. In addition, exchange of such courses adds a bonus in quality improvement – difficult to quantify, but probably important. An added value derives from the fact that the information is public and can be used by all those people working in the CANDU enterprise. This feature results in a further reduction of cost, again difficult to quantify, that arises through more efficient education and training of non-utility staff and instructors.

You may ask: “How long must this project go on?” The CANTEACH project staff estimates that it will take about 10 years to properly document the existing set of education and training information, with an annual project cost in the range of \$250,000 per year. However, recognizing that this field is still developing and new information is becoming available each year, it may be of benefit to the CANDU enterprise to continue the project indefinitely at a modest, ‘maintenance’ level of funding.

The enlightened manager will readily see the enormous potential for cost savings in the training area. But just as huge is the potential for self-directed continuous informal training on the part of the interested employees who get caught up in reading the material on CANTEACH (and they will – we have evidence of that already). Apart from employee empowerment and satisfaction, the knowledge gained could help avert a design or operation error. This is not something that we can easily measure and quantify, but it is a real consideration nonetheless. Do support your



employees in their desire to contribute to CANTEACH and in their desire to learn from the material on it.

Finally, acknowledging that you weren't always a manager and have not forgotten those hard earned lessons, CANTEACH represents a golden opportunity to revive those seminal thoughts and send them in. What a waste if you don't.

5 CANTEACH and You

5.1 How to Contribute to this Project

Hopefully by now you are inspired to contribute to the CANTEACH project. Whether you have an article you wrote yourself, an archival document that you found useful, some good images, or something else of CANDU value, there are some steps that you will need to take:

1. Check to ensure you have permission to release the information. We cannot post any information without permission from the author / copyright holder.
2. Contact CANTEACH staff. Contact information is posted on our webs site at <http://canteach.candu.org/>. Check with us early since we might already have a blanket permission for certain classes of documents or we might be able to suggest people to contact, etc.
3. Send material in the appropriate format. The format of already published documents should not be altered. Thus we will need the original or a good photocopy of the original suitable for scanning. Most common office applications of electronic documents are acceptable. We will retain an electronic copy of the source documents and post a pdf version on the web site.

We have a very modest budget which limits the direct assistance we might be able to offer you in document preparation. Some possibilities include:

1. We can offer technical advice on document preparation.
2. We can offer document scanning services
3. We can assist with copyright discussion.
4. We can advise on document formatting and offer limited assistance. We do the final formatting and pdf production.
5. We can provide team coordination of multi-authored documents (wherein you receive a task assignment, execute it, and return results to CANTEACH).

In return, we recognize that you have limited time and limited means to devote to a project even as worthwhile as CANTEACH. Consider it as part of your professional activities, knowing that it will be personally fulfilling and useful for the profession:

1. As an area expert, you can commit to assisting in submission reviews.
2. As a professional, new or seasoned, you can commit to gathering information in a chosen technical area. Be on the alert for seminal material.
3. As an area manager, you can commit to empowering your staff to contribute to CANTEACH. Consider it part of professional development. Consider it a neutral territory for team building.
4. As an educator, you can contribute segments of your educational material. The possibility of sabbatical support exists. Or you can set student projects that involve



background paper searches for documents that students find particularly beneficial or projects that require the development of technical summaries or knowledge acquisition from the experts.

Don't hesitate to contact us with your ideas and suggestions. Email addresses can be found at <http://canteach.candu.org/>.

5.2 Feedback

Though this project is just now fully underway, kudos have begun to arrive from several areas around the world -- from Argentina, Austria, India, Romania, Spain, and elsewhere in addition to several from Canada. It is gratifying to know that the message is getting through, and that the limited information already in the site is found to be useful.

6 Summary

The CANTEACH project exists to provide access to existing legacy education and training documents and images, to distill the essence of these documents and to prepare new documentation. The task of populating the CANTEACH library with seminal documents is underway. The underlying philosophy of an open and free, cooperative exchange of fundamental CANDU design and operation information has proven to be sound. Do take the time to visit the CANTEACH library. We look forward to hearing your comments and suggestions after you visit the CANTEACH web site.

7 Acknowledgements

The authors wish to thank all those individuals who have kindly donated to CANTEACH and the Partner institutions for their continuing support.

8 References

1. Bill Garland, Yulia Kosarenko, Dan Meneley, "Preserving CANDU Technical Knowledge – The CANTEACH Project", Bulletin Can. Nuc. Soc., to be published in 2003.
2. The CANTEACH web site can be found at <http://canteach.candu.org/>.