



# Preserving CANDU Technical Knowledge – The CANTEACH Project

by

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## Introduction

Almost 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.

The pioneers of CANDU development have finished their work. Most of the second generation also has moved on. 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 a "CANDU Textbook" is needed. 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. Too 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.

The CANTEACH project has the objectives of (1) capturing the existing legacy non-proprietary documents and images and making them available to all, and (2) distilling the essence of these documents so that the key concepts and the relations between these concepts can be elucidated. As the project proceeds, documentation gaps will, no doubt, become evident, prompting a third



objective of preparing new documentation. The first objective is as pedestrian as it is necessary. Gathering up the existing documents in an open forum is valid in its own right but it is also necessary for the subsequent tasks of distillation and writing of new documents. The generation of definitive CANDU documents in the public domain will facilitate their subsequent reuse in new documentation preparation throughout the industry. CANTEACH is meant to be a resource for CANDU content. As such, it is a perfect complement to education and training delivery via UNENE, at the utilities, at consulting companies, and at the colleges and universities.

This paper outlines the project, its present status, and its future plans.

### History of CANTEACH

The project concept was first developed in China in 1998, in response to the needs of operating staff, engineers, and professors involved in the Qinshan III project. Very little technical information was available in China at that time. Given the ongoing construction schedule, it was obvious that a large education and training program was necessary. AECL staff in Shanghai undertook part of this task, as indicated in Figure 1. The emphasis of this early work is seen at the bottom of that Figure, along with the large number of other education and training programs that contributed to the whole. Success of the whole is indicated by the reliable operation of Unit 1 of Qinshan Phase III (Qinshan 4) and the imminent startup of the second unit. The education project was a very small part of the whole, but contributed significantly to the overall technology transfer goal.

The CANTEACH project was expanded in 2000 and then restructured to make it more appropriate for application in Canada. Administration of the project was transferred to the CANDU Owners Group in 2002 following the signing of the project agreement by its present partners.

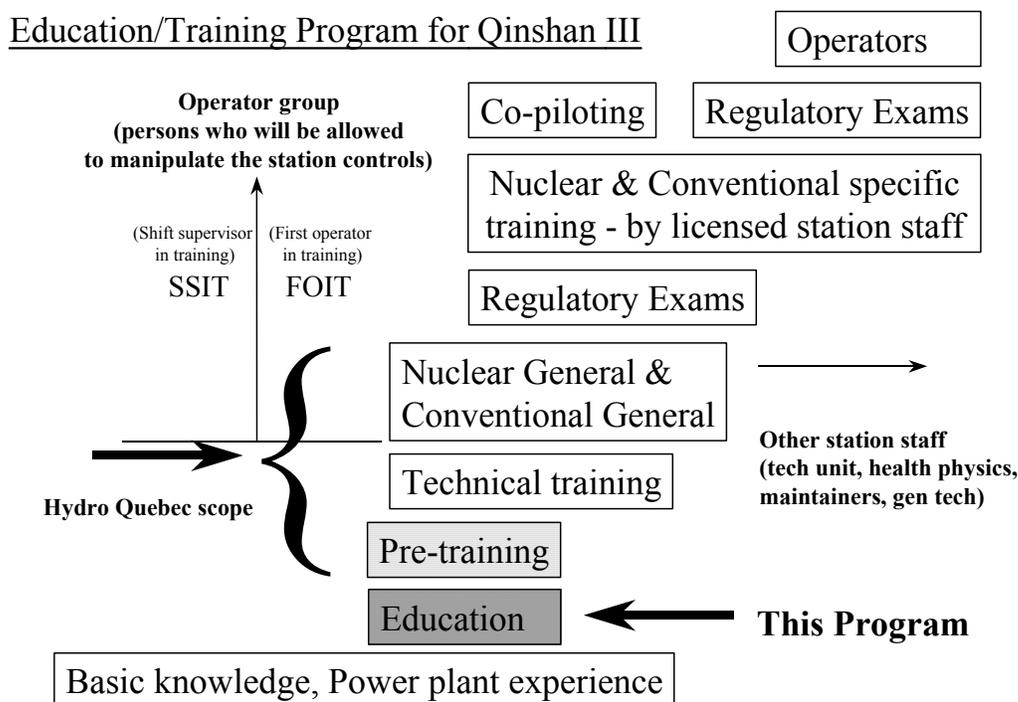


Figure 1 -- Original Role and Place of the Project



### Project Concept

Discussion with individuals and senior managers in Canada in early 2000 led to reformulation of the operating concept of the project. This new concept recognizes that all professionals working in our industry are extremely busy. Furthermore, funding available for this sort of work is very tight. Finally, the number of people both willing and able to write high-quality educational material is quite small.

The driving force for success of this project is the advantage of cooperation. An owner of various packages of information can reduce documentation cost by submitting packages to CANTEACH. A reasonable expectation is that other members of the Project Agreement also will send in their own packages. In this way we avoid the determination of ‘exact exchange value’ for any given piece of information. Everyone gains by the process, and the body of available information on CANDU increases. The cooperative history of the organizations within the CANDU venture makes this possible.

An essential feature of this document exchange is that it is voluntary. No member organization is forced to contribute. In this way we avoid trying to do the impossible: that is, to force any member to release confidential or commercially proprietary information. A direct result of this choice of policy is that the information provided to the project tends to be somewhat archival; most documents are those that have been used for some time within the organization and have, as a result, been cross checked for accurate content. This is perhaps the most important characteristic when establishing a set of records useful for education. A second policy that emerges from this choice is that the project is mainly self-funded by the members themselves. Only a very small project staff is required for collecting, organizing, and filing the material. Individuals who wish to undertake larger tasks such as writing of a hard cover textbook may ask for partial funding by the project.

### Partners

Fourteen organizations involved in the CANDU industry signed a “good will” cooperative agreement in July of 2001. This agreement was re-signed by all partners in April 2002, to recognize several personnel changes that took place in the interim period. Table I lists the signatories of the CANTEACH Agreement.



**TABLE 1 – Partners in the CANTEACH Project**

<b>Partner Organization</b>	<b>Signatory</b>
Atomic Energy of Canada Ltd.	Dr. David Torgerson (Dr. Paul Fehrenbach)
Bruce Power Incorporated	Mr. Duncan Hawthorne
Canadian Nuclear Safety Commission	Mr. Denys Vermette (Mrs. Cheryl Nelson)
Canadian Nuclear Society	Dr. David Jackson (Mr. Ian Wilson)
CANDU Owners Group	Mr. John Sommerville (Mr. Brian MacTavish)
Ecole Polytechnique	Dr. Rejean Plamondon
Hydro Quebec	Mr. Mario Desilets
McMaster University	Dr. M.A. Elbestawi
NB Power	Mr. Frank McCallum
Ontario Power Generation	Dr. Mohan Mathur (Dr. Emad Elsayad)
Royal Military College of Canada	Dr. Ron Weir
University of New Brunswick	Dr. John Christian
University of Ontario Institute of Technology	Dr. George Bereznai
University of Toronto	Dr. A.N. Venetsanopoulos

The main elements of the project agreement are summarized as follows:

1. The CANTEACH Partners agree to develop a comprehensive set of education and training documents prepared according to the highest academic standards to describe the various aspects of CANDU power plant technology. These documents will be subjected to planning and review by the Academic Director and the Project Director, and then will be recommended to the Board of Directors for incorporation into the set of deliverables of the project.
2. The CANTEACH Partners will participate in this in a collegial and cooperative atmosphere.
3. The products of this undertaking will comprise both print and electronic materials suitable for education and training in the range from high school graduate level to the university post-graduate level.
4. All CANTEACH Partners will share in the rights to copy the material contained in the deliverables of the project, provided such copying is for their use in the conduct of their business.

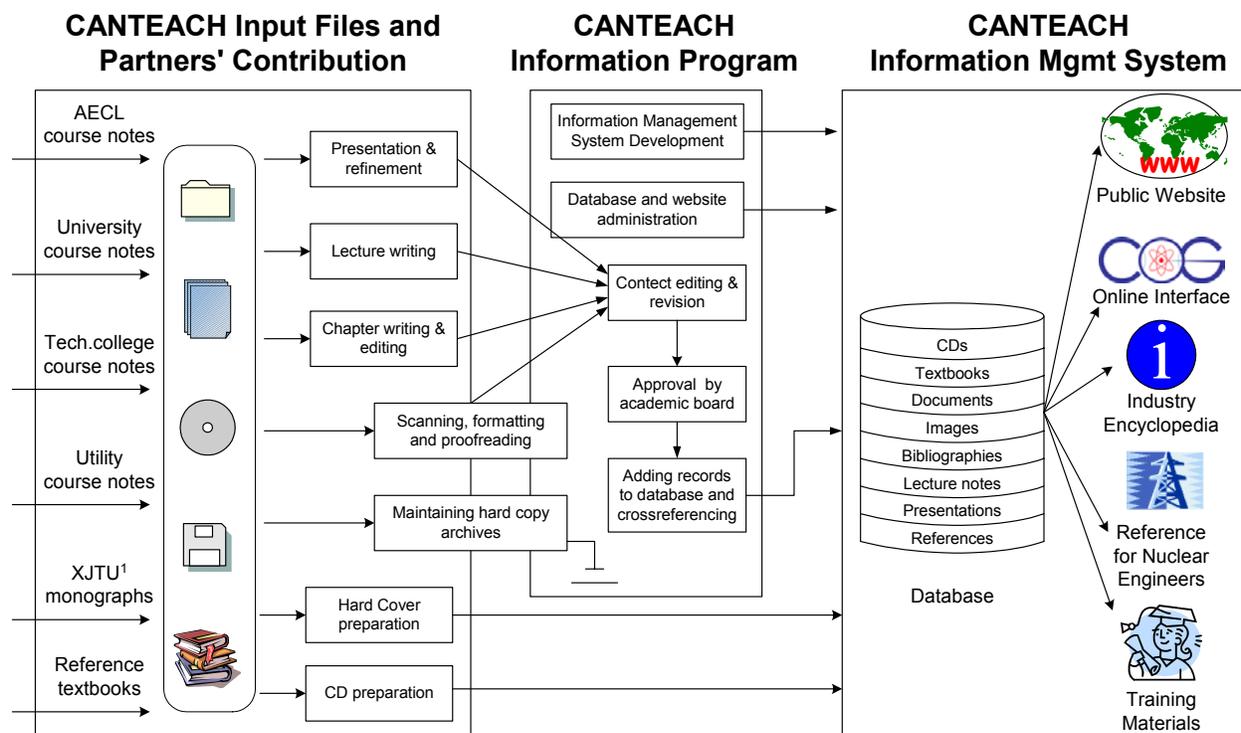
The signatories agreed to a general statement on the subject of copyright, whereby the administrator of the project (currently the CANDU Owners Group) reserves all rights on behalf of the holders of copyright holders who donate materials to the project files.



## Project Model

Figure 2 illustrates the information flow and products of the project. Donors (organizations and individuals) send contributions to CANTEACH staff. 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.



<sup>1</sup> A group of technical monographs being prepared by academic staff of Xi'an Jiaotong University in China with the support of AECL.

**Figure 2. Information Flow and Content**

## Website Structure and Content

Figure 3, 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>. Following are some hints to assist you. If it is your first visit to the site, have a look at “Welcome to CANTEACH”.

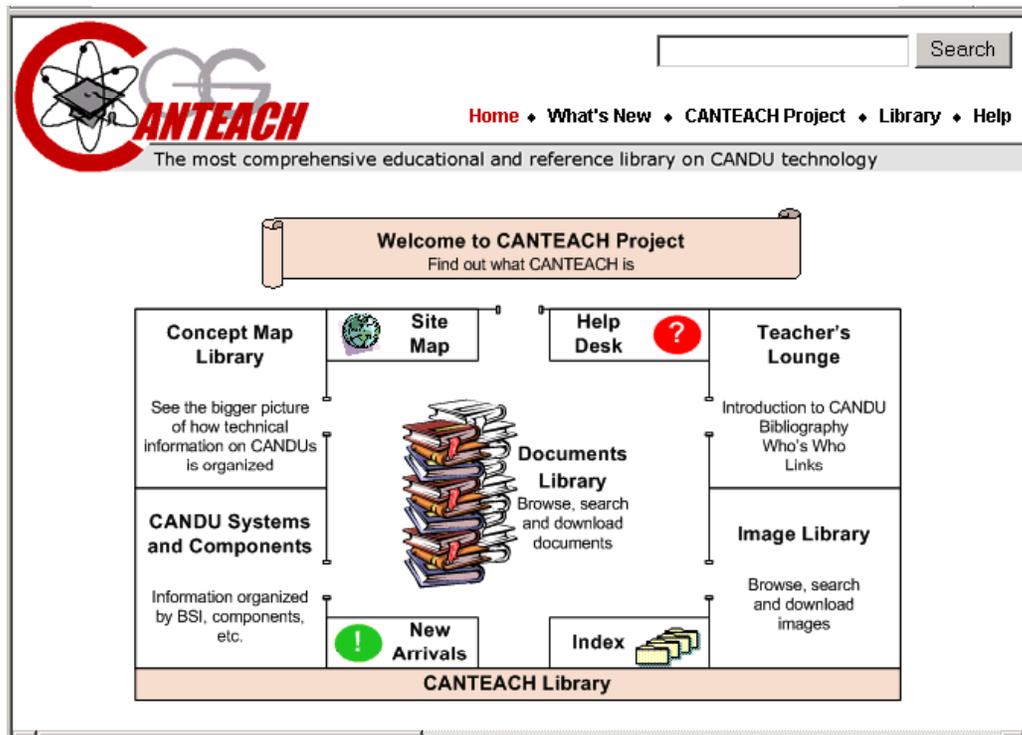


Figure 3 – Reference Library Home Page

If you are a high-school teacher, go to the home page and then click “Teacher’s Lounge”. You will find some general articles about CANDU along with a rich collection of links to other sites containing a variety of information about nuclear energy. 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. 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.

If you are a technical staff trainer, you may be looking for any level of data 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 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 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. 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 on 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.

### Completed Activities:

Some of the major items gathered and posted to date include:

- Extensive training material from the CNSC
- The 1972 Symposium series from AECL
- Presentations and reports from AECL
- CANDU Origins and Evolution documents by emeritus retirees
- Heavy Water Reactors: Status and Projected Development Technical Report by the IAEA
- Links to the full content for many of the McMaster nuclear courses
- List of all nuclear engineering courses in Canada, with links where applicable
- A small image library that we will be expanding.



Supporting all this is, of course, the design and construction of the information system itself. Authoring tools have been researched and the schema has been formulated and implemented.

### Current Activities

#### The database

The CANDU material currently on the web site is static. The library page contains a simple listing of the documents sorted by institution. The user, however, may wish to re-sort or filter the documents by author, date, keyword, system, etc. To add this capability, a database is being constructed and coupled with a web-driven database engine to allow the user to sift and sort the document library. The following figures illustrate some of the dimensions that we are building into the database.

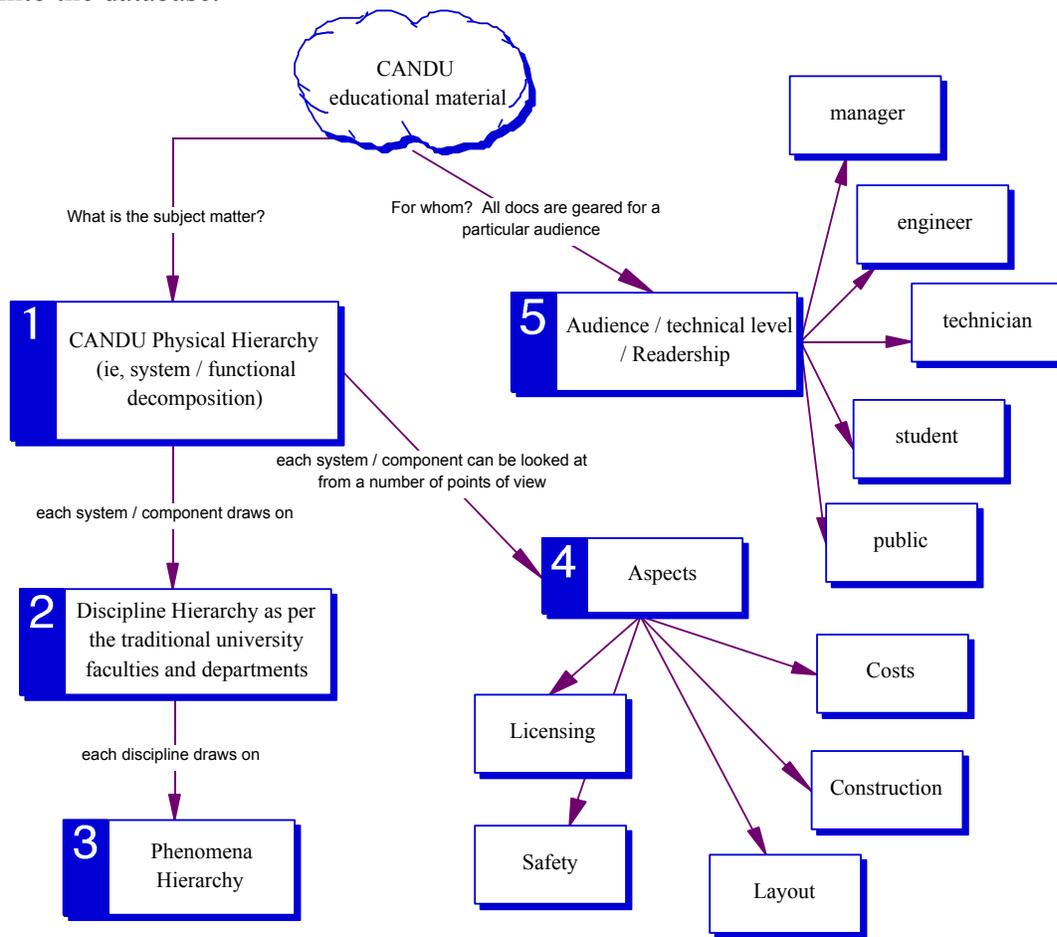


Figure 4 Keyword Dimensions for the CANTEACH Database

This hierarchy of keywords specific to CANDUs in several dimensions would be of great value to the CANDU community in general, quite apart from its use in CANTEACH. Discussions are underway with COG to coordinate CANTEACH keywords with COG's Information Management System.



## **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.

## **Formatting complex documents**

Since the CANTEACH library documents come from various sources and has to cater to different audiences, the issue of document format had to be resolved to provide consistency and modularity. 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.

## Future Developments

In the near future, look for the database system to be enabled on the website. This will permit sifting and sorting of the document listings, a welcome and necessary addition as the library grows.

Recently, Ontario Power Generation has agreed to the release of the older versions of the fundamentals training courses that are ubiquitous in the Canadian nuclear industry. We are in the process of scanning these documents for posting to the web site. This is an important contribution both because these legacy courses have been the backbone of utility training for so many years that they need to be preserved for historical reasons and also because their presence on the web site signals an important and welcome contribution from the utilities. We will be posting Burnham’s fabulous Radiation Protection book in the near future and we have an Instrumentation and Control course waiting to be edited for the web. The 36 courses given at Chulalongkorn University, Thailand a few years ago will also be posted one by one as permission rights are granted and as time permits.

In time, derivative documents are planned to provide a distillation of the key concepts and relations in CANDU design and operation. It is planned to produce small, focused document sections rather than monolithic ‘books’ so that reusability and re-purposing is enhanced.



## 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 partnership agreement between the key stakeholders is in place, the initial web delivery platform is in place and 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.

## Acknowledgements

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

## References

1. The CANTEACH web site can be found at <http://canteach.candu.org>.