U.S. NUCLEAR REGULATORY COMMISSION
NOTICE OF GRANT/ASSISTANCE AWARD

1. GRANT/AGREEMENT NO.	2. MODIFICATION NO.	3. PERIOD OF PERFORMANCE	4. AUTHORITY
NRC-HQ-11-G-38-0076	M002	FROM: 8/22/2011 TO: 8/31/2013	Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended

5. TYPE OF AWARD	6. ORGANIZATION TYPE	7. RECIPIENT NAME, ADDRESS, and EMAIL ADDRESS
[X] GRANT [ ] COOPERATIVE AGREEMENT	Public Institution of Higher ED DUNS: 064234610 NAICS: 611310	University of Texas at Arlington 701 S. Nedderman Dr., Box 19145 Arlington, Texas 76019-0145

8. PROJECT TITLE:

"Development and Deployment of Web Based Interactive Thermal-Hydraulics Educational Modules for the Modules of Nuclear *Engineering Minor Program*"

9. PROJECT WILL BE CONDUCTED	10. TECHNICAL REPORTS ARE REQUIRED	11. PRINCIPAL INVESTIGATOR(S) NAME, ADDRESS and EMAIL ADDRESS
PER GOVERNMENT'S/RECIPIENT'S PROPOSAL(S) DATED See Program Description AND APPENDIX A-PROJECT GRANT PROVISIONS	[X] PROGRESS AND FINAL [ ] FINAL ONLY [ ] OTHER (Conference Proceedings)	University of Texas at Arlington Attn: Dr. Ratan Kumar 701 S. Nedderman Dr., Box 19145 Arlington, Texas 76019-0145 Email: rattan.kumar@uta.edu

12. NRC PROGRAM OFFICE (NAME and ADDRESS)	13. ACCOUNTING and APPROPRIATION DATA	14. METHOD OF PAYMENT
NRC Attn: Tanya Parwani-Jaimes Office of Human Resources MS: GW5A06 (301) 492-2308 11545 Rockville Pike Rockville, Maryland 20852 Email: Tanya.Parwani-Jaimes@NRC.GOV	APPN. NO: 31X0200 B&R NO: 2011-84-51-K-134 JOB CODE: T8453 BOC NO: 4110 OFFICE ID NO: RFPA: NRC-HQ-11-G-38-0076	[ ] ADVANCE BY TREASURY CHECK [ ] REIMBURSEMENT BY TREASURY CHECK [ ] LETTER OF CREDIT [X] OTHER (SPECIFY) Electronic ASAP.gov (See Remarks in Item #20 "Payment Information")

15. NRC OBLIGATION FUNDS		16. TOTAL FUNDING AGREEMENT	
THIS ACTION	$0.00	NRC	$191,150.00
PREVIOUS OBLIGATION	$191,150.00	RECIPIENT	$ 67,588.00
TOTAL	$191,150.00	TOTAL	$258,738.00

This action provides funds for Fiscal Year in the amount of $0 See Page Two

17. NRC ISSUING OFFICE (NAME, ADDRESS and EMAIL ADDRESS)

U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: Shashi Malhotra Email: Shashi.Malhotra@NRC.GOV
Mail Stop: TWB-01-B10M
Rockville MD 20852

18.	19. NRC CONTRACTING OFFICER
Signature Not Required	Sheila Bumpass (Signature) 9/8/2011 (Date) NAME (TYPED) Sheila Bumpass TITLE Contracting Officer TELEPHONE NO. 301-492-3484

20. PAYMENT INFORMATION

Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110).

21. Attached is a copy of the "NRC General Provisions for Grants and Cooperative Agreements Awarded to Non-Government Recipients.
Acceptance of these terms and conditions is acknowledged when Federal funds are used on this project.

22. ORDER OF PRECEDENCE
In the event of a conflict between the recipient's proposal and this award, the terms of the Award shall prevail.

23. By this award, the Recipient certifies that payment of any audit-related debt will not reduce the level of performance of any Federal Program.

TEMPLATE - ADM001 SUNSI REVIEW COMPLETE ADM002

The purpose of this modification is to delete Attachment B in its entirety and add the following program description to reflect the change in equipment requirements and the re-budgeting of the Principal Investigator's time, at no additional cost to the Government:

The attached program description "Attachment B – Program Description" is hereby incorporated as part of this grant award and supersedes the previous "Program Description" in its entirety.

All other terms and conditions remain the unchanged.

Introduction

The College of Engineering at the University of Texas at Arlington (UT Arlington) is submitting this proposal in response to the educational funding opportunity from the U.S. Nuclear Regulatory Commission for FY 2011. The proposal describes plans to enhance the Nuclear Reactor Thermal Hydraulics (NE 4303) course, which is one of the core course offerings in the nuclear engineering (NE) minor program at UT Arlington. The enhancement will be done by developing and deploying interactive web-based simulations. Some of the salient features of this project are:

- NE 4303 addresses the Nuclear Engineering area with Thermal-hydraulics emphasis.
- NE 4303 is a permanent course that is required for all NE minor at UT Arlington.
- NE 4303 is an undergraduate course
- Initially, we anticipate 20-25 students/year at UT Arlington to be directly impacted by this project. However, through our collaboration with Univ. of Texas at Austin (UT Austin) this project will benefit 75-80 students at UT Austin and the Big-12 Nuclear Consortium.
- The project is focused on developing an integrated set of web-based simulation tools that will supplement in-class lecture materials for the NE 4303 course.

The UT Arlington College of Engineering began the offering of a minor in NE in Fall 2009. The NE minor is available to UT Arlington's students pursuing a major in either engineering or physics. This offering was strongly influenced by the following facts:

- UT Arlington is in close proximity to the Comanche Peak Nuclear Power Plant and the Region IV Office of the US Nuclear Regulatory Commission. In addition there are a number of companies in the area which provide services and consultation to these entities.
- Luminant Power and South Texas Project have indicated their intent to build more new nuclear power plants in the state.
- The national and regional need for engineers with training in NE is currently not being met by any university in the Dallas / Ft. Worth Metroplex.
- Several faculty members hold PhD degrees in nuclear and related engineering fields.
- Several members of the College's Advisory Board are involved in power generation industry, and have voiced unequivocal support for this program.
- The NE minor program has its own Advisory Committee which includes representatives from NRC and UT Austin, as well as several other industrial experts from the nuclear field.
- The faculty and administration of the College have been very supportive, providing both moral and financial support to initiate the minor.
- Amongst the UT Arlington students, there has been a very strong interest for the Nuclear Engineering program.

A student earns the NE minor by taking three (3) core courses (Introduction to Nuclear Engineering, Nuclear Reactor Theory/Analysis and Nuclear Reactor Thermal Hydraulics) and three (3) elective courses, chosen from a set of 8 currently available courses related to NE. The initial offerings of the three core courses were in Fall 2009, Spring 2010, and Summer 2010. As these courses are being planned and taught, it has become evident that enhancements are needed to make each as effective as possible.

The project goal is to augment the Reactor Thermal Hydraulics course by developing and incorporating web-based simulations. Such simulation tools will allow for better student

comprehension of a mathematically intensive subject matter through animations and virtual-labs. Similar activities have proven to be extremely successful in other engineering areas, but are seldom found in the Nuclear Engineering and especially in the thermal-hydraulics course. Lessons and instructional modules created will be published and shared with the nuclear community. Additionally, this will help in the future expansion of the NE undergraduate minor to a graduate certificate program in NE for working professional engineers, continuing education short courses in specific topics for nuclear personnel, and seminars / demonstrations suitable for the general public in north Texas

Item 1: Potential for Supporting or Advancing the Nuclear Safety, Nuclear Security, or Nuclear Environmental Protection Education Infrastructure

1.1 Institutional long-range goals

UT Arlington is a comprehensive research, teaching and public service institution whose mission is the advancement of knowledge and the pursuit of excellence. It is striving to attain national research university status. As such, the offering of additional engineering curriculum options such as NE is completely in line with the university's mission (see attached letter from the Provost). Since its initiation one year ago, the UT Arlington NE minor has begun contributing to the nation's NE education infrastructure. Indications are that interest will continue to be at a high level among our students in this minor. This interest is gauged by student survey, class enrollment, attendance in seminars and workshops. UT Arlington feels strongly committed to the program based on this student interest, the renewed interest in nuclear-energy in US and several other countries, and the proximity of the university to nuclear-related organizations. In fact the next goal being contemplated at the College of Engineering is the addition of a graduate certificate in Nuclear Engineering, as

1.2 Identification of the problems or opportunities to be addressed

The nuclear renaissance that is currently being experienced offers academic institutions a chance to stay current by presenting innovative teaching styles and materials. The world-wide-web presents an opportunity to bring new teaching techniques into the classroom. The objective of this project is to develop web-based interactive learning modules for the *Nuclear Reactor Thermal Hydraulics* course. These modules will complement and enhance the traditional lecture format used in-class through visually active learning methods.

Nuclear Reactor Thermal Hydraulics is a computationally intensive course and is an excellent candidate that can make use of simulations for student comprehension of concepts associated with complex flow physics. Web-based simulation will allow students to learn and appreciate the coupled and abstract thermal and fluid equations in a flexible and visual manner. The premise for our proposed activity is centered on the following facts:

- Traditional instructions in thermal sciences make use of end-of-chapter problems that typically has a single correct answer. Quite often it does not allow the student to get a good feel and appreciation of the governing equations. Computer simulation allows the "experimentation" and visualization as a means of reinforcing and extending what they are exposed to in lecture and in the textbook presentation.
- Web-based interactive teaching and learning activity has been shown to be very successful in enhancing the student's learning experience. However such materials are far and few in the Nuclear Engineering area.

- The NE minor program at UT Arlington has an interdisciplinary student population. As such certain fundamental topics in thermal sciences have already been taught to some students, but less thoroughly and possibly less recently to others. Web-based interactive training materials for such topics can be assigned as self learning and will allow the proper time management for the remaining critical nuclear topics.
- Current nuclear thermal-hydraulics simulation tools like RETRAN, RELAP, TRAC and GOTHIC etc. model the entire nuclear system and require a steep learning curve. They are more suited for graduate research and project. In order to educate and illustrate concepts typically presented in text-books, the use of sophisticated software becomes cumbersome.
- Web-based simulation modules do exist in the thermal sciences area, but they are mostly confined to non-nuclear usage. Nuclear engineering applications necessitate the usage of empirical and specialized equations that are not present in traditional thermal sciences textbooks and consequently are not addressed in existing web simulations.

1.3 Project Justification

A clear understanding of the fundamental topics in the nuclear reactor thermal-hydraulics is not only essential to the safe design of the next generation of nuclear reactor but the modification and operation of existing ones as well. The project is aimed at enhancing the manner in which the teachers disseminate information and the students learn nuclear thermal-hydraulics course material, by making use of computer simulations. These simulations when available on the web, will allow for the flexibility in student learning and discovering issues not obvious during classroom lectures and problem solving. This project will help to improve the educational infrastructure, teaching competencies and skills of students studying nuclear engineering. Each of these items is discussed below:

1.3.1 Improvement in Educational Infrastructure:

The traditional lecture-based/weekly problem set paradigm has the advantage of leveraging the numerous end-of-chapter homework problems and, more importantly, the exhaustive answer books provided to the instructor along with the major textbooks in the field. This is the current state for several engineering courses. However in many instances, for developing physical insight and for ready application in design, the end-of-chapter homework problems with a single correct answer seem to be just not appropriate. The creation of this web-based module will train the students to observe, hypothesize, test, verify, design and synthesize – skills that are essential for a well-educated engineer.

A paradigm shift has taken place in engineering education by using technology as an integral part of instruction[1]. Due to the dwindling student population and grants in Nuclear Engineering education for the past several years, a majority of the nuclear engineering departments did not have the resources to adapt to and implement such changes and continued in the "business as usual" mode. Through this NRC grant, such educational improvements can now be achieved to make the nuclear education technologically current.

1.3.2 Improvement in Teaching Competencies:

Instructors who teach courses that are best learned through design based problems, such as reactor thermal-hydraulics, can get a big help from computer simulations. It allows them to show the students the trend of important parameters whose values are calculated through complex mathematical steps. Such trends, which are important to the understanding of the physical phenomenon, cannot be discovered by solving an involved mathematical problem that culminates into a unique answer.

Due to the limited classroom time, an instructor is often not able to cover all the relevant materials and student questions. To make up for this paucity, optional reading assignments or bonus home-work problems are added on. Not all students are motivated to again go through another set of textual material, especially when the requirement is optional. But several instructors can vouch for the fact that these optional materials are equally important and help them along in their future class lectures. Computer simulations are an attractive option to lure the students to such studies.

Computer based learning also addresses various issues related to students' learning styles. It has been found that women students respond better to the use of visualization in heat transfer instruction[2]. Also some students do not react well to passive participation as provided during chalk-and-talk lecture[3]. At the same time, it is well known that not all students are comfortable in asking questions in-class and these unanswered queries can be detrimental to their education. Web-based simulations and teaching, for the thermal-hydraulics course, can play a pivotal role in addressing several of these issues. As a result, we strongly believe that such simulations should help in the teaching competency of instructors from both the academia as well as from the industry.

1.3.3 Skills Serving Students in the Target Disciplines

By using the web-based tools, students will recognize and appreciate that they are being introduced to the kinds of computational, simulation and visualization procedures that they will routinely use in their working careers – even though many will never work directly in nuclear heat transfer again. These skills have become a necessity in our high tech, global economy. With nearly all of the existing modules representing simulations of real nuclear thermal-hydraulics issues, it should be possible to "discover" several items discussed in the corresponding section of a typical textbook.

1.4 Innovation and effectiveness in advancing the educational infrastructure

As indicated ahead, the proposed project addresses improvement to our existing course in Nuclear Reactor Thermal Hydraulics by the addition of web-based simulation modules. This will facilitate an interactive approach in teaching an undergraduate nuclear thermal-hydraulics course. To our knowledge, such resources are currently very few and scattered and address different topics at random and do not coherently address NE undergraduate education. The advantages in the creation and addition of these modules include:

- Providing the student a mechanism for carrying out "what if" queries which bring to life concepts often hidden in mathematical equations.
- Allowing the student more control over his/her learning time by making these modules accessible through the web.
- Encouraging students to learn in a way that has been shown to be more engaging than learning from textbooks and lectures alone.
- The on-line simulations would serve as virtual laboratories and help in pedagogy like active learning; provide relevance, meaning and context for the material; and inquiry-based learning including experimentation and discovery.
- Nuclear thermal-hydraulics is typically taught to graduate / senior undergraduate nuclear or mechanical engineering students. These supplementary materials will be designed to allow students from multidisciplinary programs as well as students from both university and industry to advance their knowledge of key nuclear engineering subject matter.

. Item 2: Proposed Approach and Collaborative Linkages

2.1 Overview

To assure undergraduate students' broad understanding and competence in the vital area of reactor thermal-hydraulics and to achieve a high educational standard in the same subject matter, various interactive software modules will be developed in a web-based environment. The web interfaces created for the course will provide the student an opportunity to study some abstract concepts involved in nuclear reactor heat generation and its transport for power generation. The main aim is to supplement the traditional in-class presentation that predominantly involves discussions of equations with derivations and analytical examples.

NE 4303 Course outline:

The Reactor Thermal Hydraulics course is a core course that is taught to the undergraduate NE minor students at UT Arlington.

Description of Course Content: This course will introduce the students to the processes of energy (heat) generation in nuclear reactor, the transport of that energy by the reactor coolant to the power cycle, and the limitations imposed by the transport mechanism on the design of nuclear reactor cores. Fundamental calculations associated with these processes will explained, examples set and results discussed. An effort will be made to familiarize the students with a thermal hydraulic software code. Also invited speaker(s) from industry and tours will complement the lectures with real life experiences.

Student Learning Outcomes: The student will learn about:

- Fundamentals of fluid flow and heat transfer in a power plant
- Heat generation by nuclear fission in the reactor core
- Heat transfer by conduction in reactor elements
- Heat removal by convection
- Heat transfer with change in phase
- Reactor thermal-hydraulic performance
- Thermal design of the reactor core
- Safety Analysis

Required Textbooks and Other Course Materials:

- Nuclear Heat Transport: M.M.El-Wakil; ANS publication (main textbook)
- Nuclear Systems: Todreas and Kazimi; Taylor and Francis (reference book)
- Handouts provided by instructor

This course is traditionally taught at several universities as a graduate / senior level course for nuclear or mechanical engineering students. Keeping our interdisciplinary student demography in mind, we feel it is necessary to supplement the theory behind these topics with experiments, simulation and analysis. These activities would allow the students to focus on the design aspects of the course and not spend too much time on the pedagogical aspect, as endured by typical mechanical engineering students. Also, this type of interactive activity has been shown to be very successful in enhancing the student's learning experience. Modeling, simulation and visualization have evolved from a practice of researchers to a routine activity of just about any engineer in an industrial setting. To address this change in industry practice, we strongly believe that computer and laboratory based simulation should be an integral part of this course. Unfortunately current nuclear-related simulation packages like RETRAN, GOTHIC, etc. require a steep learning curve and are more suited for graduate research. In order to comprehend the rudimentary fundamentals of thermal sciences, pertinent to a nuclear power plant, these tools become excessive. This project intends to build rich web-based educational modules, which will

help students to rapidly perform "what-if" analyses, and get a hands-on experience with "virtual laboratories" etc. for a better comprehension of fundamental concepts.

During the selection of topics for simulations, an effort has been made to follow the relevant sections of a standard text book (such as M.M. El-Wakil that is used by us) as well as the topics required by NRC for reactor and senior reactor personnel of the nuclear power plant. The Knowledge and Abilities catalog of NRC for Nuclear Power Plant operators (NUREG-1122) identifies essential pedagogical needs in thermal-hydraulics for the safe operation of nuclear power plants.

We plan on covering several salient topics by maintaining a balance between the undergraduate academic needs and some of the industrial needs. The simulations will be housed under four major headings and each of which will in turn host several relevant subsections. The different headings and sub-headings are being shown below:

Heat Generation	Heat Transfer	Hydrodynamics	Safety/Misc. Issues
Introduction	Introduction	Introduction	Introduction
By U-235 fission	From Fuel Element	Pressure drop 1-phase	Critical Heat Flux
In Fuel pellet	From Fuel Rod	Pressure drop 2-phase	Hot Channel Factor
In Fuel Rod	1-phase fluid	Pump Behavior	Thermal Limits
Total in Core	2-phase fluid	Critical Flow 1-phase	Shutdown Heat
Reactor Structure	From Shielding	Critical Flow 2-phase	Flow induced vibration

2.1.1 Description of the Simulations:

To illustrate the functionality of the simulations, we have created *'a very brief demonstration'* for a single item (heat generation during fission of a single U-235 nucleus). This can be viewed at http://www.uta.edu/art/uploads/nuclear. Heat generation by fission is one of the very first topics that is typically discussed in the traditional thermal-hydraulics lecture. Some of the concepts that the students learn are:

- The source of energy during fission
- How this released energy is distributed amongst different fission products
- The stochastic process associated with fission which results in the release of different products and energies.

This concept of energy released during fission of a single nucleus is then expanded into energy released from fuel pellets, to the fuel rod to the fuel bundles and finally to the energy from the reactor core. Each of these topics will be covered by their respective simulations.

Figures 1a and 1b, show screenshots from the fission simulation. *It should be noted that it is the only simulation that has been partly developed to show the proof of concept. It can be found under "Heat Generation ----- By U-235 Fission" menu.* Different runs will show how fission gives rise to different fission products and released energy. Each of the simulations that will be created will have 3 sections: Introduction, Simulator and Additional information. The *"Introduction"* section will briefly describe the topic under investigation and how the simulation tool needs to be used. The *"Simulator"* section will contain the interactive tools to visualize the topic under consideration. The *"Additional information"* section will have images, plots, calculators to glean a little bit more information about the subject matter.

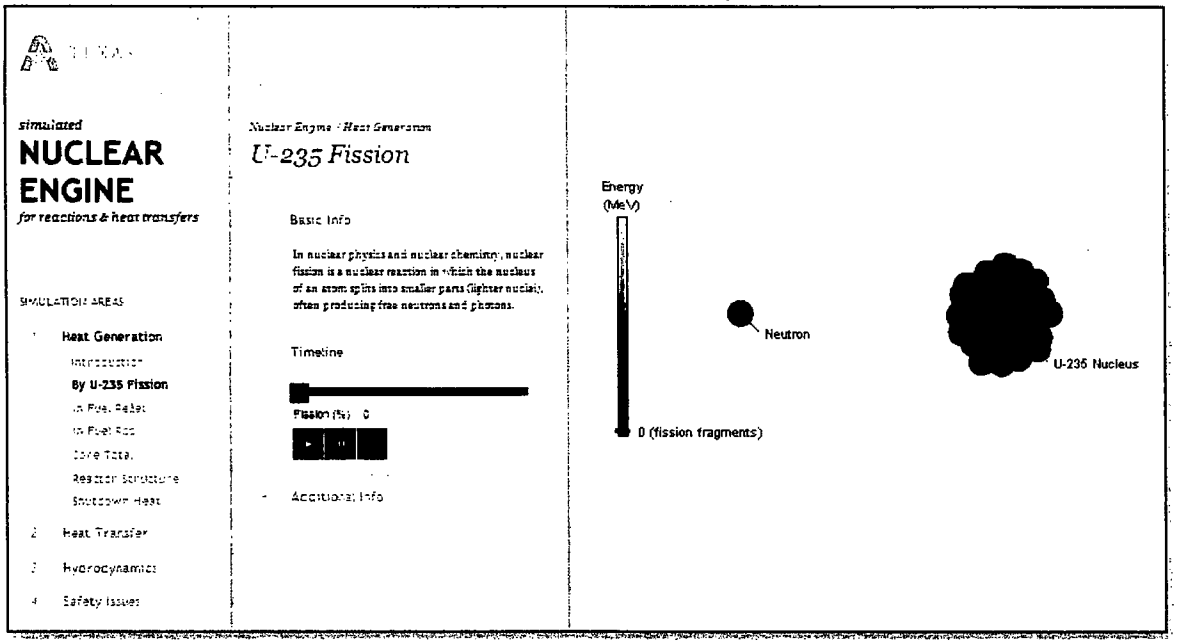

Figure 1a: Simulation of Nuclear Fission

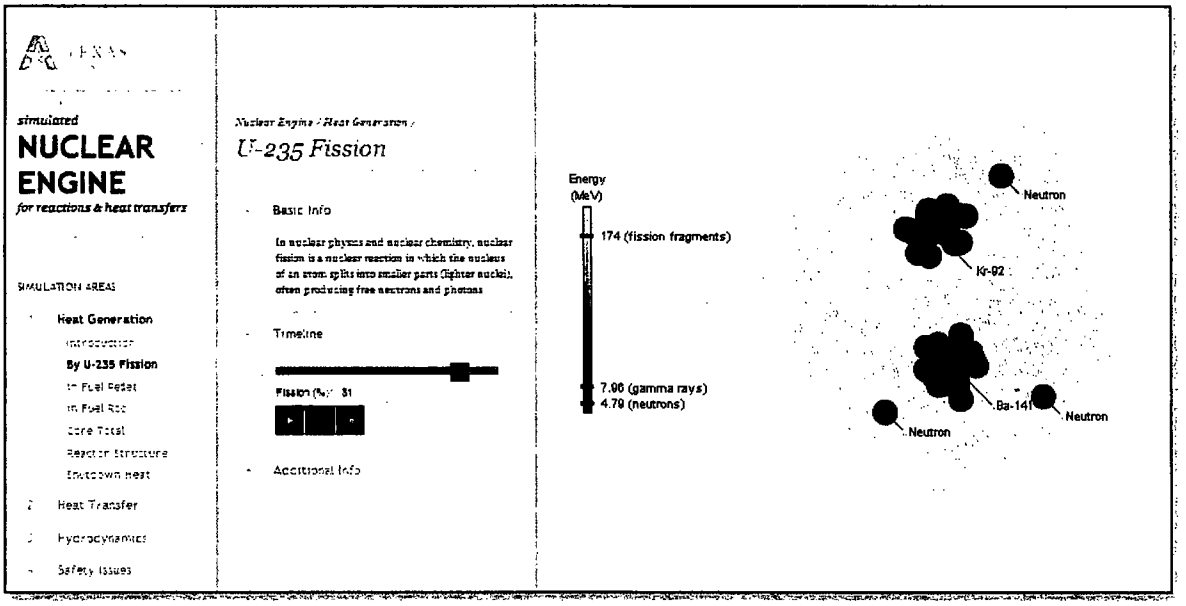

Figure 1 b: Energy released during U-235 fission

To illustrate this thought, a brief explanation for each section is mentioned below:

- The "*Introduction*" section will describe the fission process, and highlight the significance of the energy released when compared to other sources of energy used for power generation.
- On running the *"Simulator"* tool one will notice that for the same neutron and nucleus interaction, different fission fragments, different number of neutrons and corresponding energies are released. Although we teach this in class, this simulation serves the purpose of actively observing the randomness of the fission process. While we do not delve into the nuclear-physics portion of fission in this class, we do want the students to

grasp and appreciate the significant values of energies that are generated. The "*Additional Info*" section will contain information about the fission yield through an interactive graph. It will also contain a calculator for computing binding energy values.

A similar structure will be followed for each of the simulations that will be created for this project.

2.2 Timeline

The project timeline is best shown by means of a table

	Fall 2011	Spring 2012	Summer 2012	Fall 2012	Spring 2013	Summer 2013
NE 4303 Reactor Thermal-Hydraulics			Course Offered			Course Offered
	Web Module Design Start Heat generation module programming	Web programming *(Complete Heat generation module)*	Web programming *(Start Heat Transfer module)*	Web programming *(Complete Heat Transfer module and begin Hydrodynamics module)*	Web programming *(Complete Hydrodynamics module and begin Safety module)*	Web programming *(Complete Safety / Misc. issues module)*
	Collaborative efforts with UT Austin	Beta test some modules for class-room implementation	Training for Thermal-hydraulic code (RETRAN or GOTHIC)	Collaborative efforts with UT Austin	Plans to incorporate Thermal-hydraulic code (RETRAN or GOTHIC)	Implementation of Web simulations Implementation of RETRAN or GOTHIC
		Collaborative efforts with UT Austin and Westinghouse	Compilation of student evaluation and feedback from students	Present working results at ANS conference	Write conference paper	Evaluation from other NE programs Start writing a Journal and conference paper on this experience

Table 1 Project Timeline

2.3 Evaluation

The evaluation of this project will primarily be performed through answers to a questionnaire that will be provided to UT Arlington students, the collaborating members and to other Nuclear Engineering programs. The questionnaire will focus on the following areas:

- A general information section to seek the institution's name and user status (student/ faculty, male/female, department, etc.)
- Course title, course level (graduate/undergraduate), and class size.
- Educational value and pedagogy (rated with 5 being best and 1as poor) that will consist of criteria such as relevance to course, technical soundness, ability to help in student learning, ability to engage the user and the ability to supplement and enhance classroom learning.

- Ease of use (rated with 5 being best and 1as poor) that will judge the navigation system, graphic and color usage, ability to follow on-screen instructions, organization of the materials
- Overall ratings as a relevant educational tool, ease of use, motivation for the student to learn, encouraging of collaborative learning,

The questionnaire will be provided to the UT Arlington students, at the completion of the course, but will be provided to the other Nuclear Engineering program once the project has been completed. Results from this questionnaire will be compiled and used for project refinement and future development. Also results from this questionnaire and the relevant efforts taken in this regard will be reported in technical/educational publications.

2.4 Collaborative Linkages

During the short time since its inception, the minor program in Nuclear Engineering at UT Arlington has developed a number of relationships that have a direct benefit to the program and to our students:

- Students in the NE 3301 course (Introduction to Nuclear Engineering) have had an opportunity to visit the nuclear engineering laboratory facilities and the TRIGA nuclear reactor at UT Austin and at Texas A&M.
- As a part of NE 4302 Reactor Analysis course, necessary arrangements are being made for our students to take part on one or two on-line experiments related to nuclear reactor analysis on the TRIGA nuclear reactor at UT Austin.
- As part of the NE 4303 Reactor Thermal Hydraulics course, arrangements have been made with Westinghouse Electric Company and Luminant power to offer a seminar that provides an industrial overview of this subject matter. Also University of Pittsburgh has tentatively agreed to collaborate in sharing some industry-oriented thermal-hydraulics material that was prepared with DOE and Westinghouse funding.
- Several professionals/educators from NRC, universities (both national and international) and industry have been invited to given a seminar on nuclear engineering issues.

An external advisory committee has been established for the minor in NE. Its objective is to help us tailor the program to nuclear industry needs and practices. The NE Advisory Committee has met twice a year since summer 2009. Members include:

- Dr. Gerald Schlapper, Inspector, U.S.NRC Region IV Office (serving without conflict of interest)
- Prof. Sheldon Landsberger, Coordinator of Nuclear and Radiation Engineering Program at the University of Texas at Austin
- Mr. Mike Blevins, Chief Operating Officer, Luminant (now retired,formerly Chief Nuclear Officer, Luminant Energy, and Director of Comanche Peak Generating Station)
- Mr. Chris Davenport, Partner, DP Engineering Ltd.
- Mr. Joseph Tapia, Licensing Manager, Mitsubishi Nuclear Energy Systems, Inc.

However just for this project, we have set up strategic relationships both within and outside UT Arlington. The goal is to seek expert advice for both technical aspects and for web page design.

Collaboration within UTA:

We are collaborating with our College of Fine Arts to get their expertise in the visual lay-out and design for the simulations. Such cross-disciplinary collaboration has been successfully employed at other engineering institutions (Product Design and Development course taught collectively by MIT's engineering program, Univ. of Pennsylvania's business school and Rhode Island School of Design). Additionally, the two key members of the NE minor program Dr. Lynn Peterson (Senior Associate Dean) and Dr. Rasool Kenarangui (Dept. Of Electrical Engineering) will serve as Senior Personnel. Dr. Peterson is also a Professor in Computer Science and Engineering and has excellent knowledge of programming and engineering education. Dr. Kenarangui, as the instructor for two of the Nuclear Engineering minor course, will provide his guidance in the integration of this project into the overall NE minor framework at UTA.

External Collaboration:

Prof. Sheldon Landsberger from UT Austin and Dr. Hugo da-Silva from Westinghouse Electric company will be our two main external collaborators (letter of collaboration/support is enclosed). Mr. Chuck Kesinger, from the Commanche Peak Nuclear power plant of Luminant Power has also agreed to support this project in the form of collaboration and guidance (letter enclosed).

Dr. Landsberger has been very active in the area of Nuclear Engineering education and research and has made significant contributions in this field (see attached resume). He also has pioneering experience in executing web-based courses for distance learning in the nuclear sciences area. He will collaborate to overview the design of the project and will also provide necessary help to create the on-line experiments. Dr Hugo da-Silva has spent a prolific professional career in the area of nuclear reactor thermal-hydraulics and has had numerous publications (internal and external) in this area. His has been recognized as a Engineering Fellow by the Westinghouse Electric company for his contribution in nuclear engineering. He has graciously accepted to offer his input and feedback to this project.

Item 3: Institutional Capability and Capability Building

3.1 Institutions commitment to the project

UT Arlington's commitment to this project is directly linked to its support of the NE minor program at UT Arlington. Senior administrators at UT Arlington are extremely supportive of the Nuclear Engineering minor program and any elements that may enhance the course offerings. This support is present at all significant levels viz: the Provost office, the Dean of the College of Engineering and the Department Chairpersons of Mechanical & Aerospace Engineering and the Visual Arts (support letters from the Provost and the Dean are attached).

The Dean of the College of Engineering enthusiastically supported the initiation of the NE minor program, and continues to do so. In fact, the Dean provided start-up funding for the program which made possible the initial purchase of laboratory equipment. This funding was crucial to the success of the very first course that was offered (NE 3301: Introduction to Nuclear Engineering). The Dean continues his support in the form of funding for trips to ANS meetings and NRC and DOE workshops for the NE faculty members. These trips are relevant for disseminating the outcomes of this proposed project and to gain feedback to refine and further enhance the web-based modules. The Departments of Electrical Engineering and Mechanical & Aerospace Engineering have provided faculty time to teach and develop the NE courses since Fall '09. It should be noted that NE courses are offered every semester and the NE faculty members are relieved from teaching one departmental course during this time.

3.2 Adequacy of resources (admin, facilities, equipment, material

The College of Engineering at the UT Arlington is a premier college of engineering in the Dallas / Ft. Worth Metroplex with 3988 of the university's 32,000 students, over 2400 of whom are undergraduates. The college offers eight (8) ABET-accredited bachelor's degrees: aerospace, civil, computer, electrical, industrial, mechanical, and software engineering as well as computer science.

The institution possesses the necessary faculty, students, industrial partners, and computing resources to successfully implement the web-based module development in this proposal. Resources such as facilities, equipment and material are not a capital intensive requirement for this project and the institution either already has them or is fully capable of absorbing them with no external funding. What the program lacks is the funding to support the development of this project, and which is being requested here. The key resources crucial to the success of this project are technical and programming expertise and relevant collaborations. The university has several internationally recognized scholars in the area of thermal sciences as well as in computer simulation. The institution's strategic relationships with several key nuclear players, such as the Nuclear Regulatory Commission Region IV, Westinghouse, Comanche Peak Nuclear power plant and UT Austin, to name a few, allows this project to get relevant input during the development and execution of this project.

3.3 Academic enhancement potential

The NE minors goal at UT Arlington is to further develop / enhance the core courses of the NE minor program which was initiated using resources of the College of Engineering. Additionally, this will lay the groundwork for the future expansion of the NE undergraduate minor to a graduate certificate program in NE for working professional engineers, continuing education short courses in specific topics for nuclear personnel, and seminars / demonstrations suitable for the general public in north Texas.

The expected output of the proposed project will be the enhancement of the NE 4303 course through the development of web-based modules. It will result in newly-graduated engineers better equipped to contribute to the field in a safe manner. Lessons and instructional modules created will be published and shared with the nuclear community. The major outcome will be strengthening the NE program at UT Arlington by expanding its teaching and research capability, contributing to the regional and national needs for a nuclear workforce able to respond to 21st century challenges.

3.4 Plans to continue or expand the project beyond the NRC support period.

The initial grant from NRC will be exceptionally timely when the program is aiming to move to the next stage. If this project is successful, it will serve as a model for the development of future web-based simulations for several key subjects of Nuclear Engineering. Such a comprehensive on-line tool is currently lacking for this vital energy industry. This would benefit not only the educational institutions but the workforce in the industry too. Once we get a template in place for module development, we will continue to use UT Arlington students doing projects to develop materials for additional topics. Also we may seek future grants both from governmental as well as private industries to keep on enhancing the project as needed.

Item 4: Key Personnel

Principal Investigator:

Dr. Ratan Kumar, faculty member teaching one of the required NE courses, holds an MS and PhD in Nuclear Engineering from the University of Florida and a BS in Mechanical Engineering from Jadavpur University (see attached CV). He was employed as a mechanical engineer and as a nuclear consultant for 6 years. He has 10 years experience in teaching mechanical engineering and mechanical engineering technology, with four of those years at UT Arlington. His position as senior lecturer in Mechanical & Aerospace Engineering is as a full-time faculty member and undergraduate advisor.
Dr. Kumar will be the project lead and has taught the thermal-hydraulics course in various forms at the university and industry and has several publications (including best-paper) both in the thermal sciences and nuclear engineering area. He is actively involved in computer-based engineering education and created software for web-based education that was a finalist in the International Web-based education conference. He will be involved in the overall design and execution, providing technical content for the various topics, integrating the underlying equations and data with the web-modules and in the interaction with collaborators.

Collaborative Personnel

Dr. Sheldon Landsberger, Professor and Coordinator of Nuclear and Radiation Engineering Program received his PhD in Chemical Engineering from University of Toronto. He has over 25 years teaching and research experience in the area of Nuclear Engineering. During this time he has published over 150 refereed publications with several of them in the area of nuclear engineering and in web-based education.
Dr. Landsberger will play a major role in the collaborative effort between UT Arlington and UT Austin. He will provide his expertise in the initial design stage, help in some of the on-line simulations and also in allowing our students to use some of the simulations developed by UT Austin for the Big-12 consortium. He will also be responsible for knowledge dissemination through joint publications.

Senior Personnel

Dr. Lynn Peterson, Sr. Associate Dean of Engineering, serves to coordinate the NE minor program. She has expertise in monitoring and evaluating academic programs, having served as Associate Dean for Academic Affairs of the College of Engineering for 13 years. Dr. Peterson will provide necessary help with issues related to programming and how the project addresses issues linked with engineering education. She will also play a major role in the evaluation of project results and in the dissemination of the results. As Professor in Computer Science and Engineering, she has experience in development of computer-based instructional systems as well as engineering education.

Dr. Rasool Kenarangui, faculty member teaching two of the required NE courses, holds an MS and PhD in NE from Iowa State University and a BS in Electrical Engineering from the same institution (see attached CV). He has over 20 years experience in teaching in electrical engineering, with 14 of those years at UT Arlington. His position as senior lecturer in electrical engineering is as a full-time faculty member, with prior service as a research faculty member in

the Energy Systems Research Center at UT Arlington. He will oversee the integration of this project into our NE minor program.

It should also be noted that the NE Advisory Committee will provide experience and knowledge of the current needs that will be relevant to this project. In this regard Mr. Chuck Kessinger from Luminant Power has also agreed to collaborate in providing us with information and feedback appropriate to the Reactor and Senior Reactor training at a Nuclear Power plant. Students who would like to pursue a career at a Nuclear Power plant will definitely benefit from this collaborative effort.

Item 5: Budget and Cost-Effectiveness

5.1 Budget and Cost Effectiveness for Project Implementation:

The budget below addresses costs for enhancing the reactor thermal-hydraulics core course in the NE minor program in terms of resources needed to develop web-based simulation to supplement classroom lectures. A request is also being made to purchase computer hardware equipment and specialized software to efficiently develop and deploy the web-based modules. Through these educational modules, an excellent enhancement to the existing course in thermal-hydraulics will be achieved.

5.1.1 Personnel Budget & Justification	*Year 1*	*Year 2*
• PI salary (Yr1: 3 m ; Yr2: 2 mo)	$27,501	$18,884
• Graduate Assistant1 (12 months)	$15,000	$15,450
• Graduate Assistant2 (3 months)	$ 3,750	$ 3,863
• Collaborative personnel	$ 4,500	$ 4,500

Fringe benefits will be 30% for PI and Co-PI and 10% for Graduate Assistant

Resources for the development of web-based simulation are heavily dependent on the development time and very little on any hardware or software resources. A single good programmer with skills in developing interactive web pages will be a minimum requirement to execute this project. The graduate assistant's (programmers) salary is @$1200/month and a 20 hour/week workload is expected. The PI has extensive web programming experience and will also contribute into the programming needs along with other functions as outlined in the *Key Personnel* section. The time requested for PI for budgeting purpose is not adequate to execute this project. As a result the MAE department has committed to a cost-sharing (in kind). The collaborative personnel (Dr. Sheldon Landsberger) will be providing at least 1.5 hour/week on this project. The amount requested for him is marginal considering he will also be travelling within his allocated budget.

5.1.2 Equipment Budget & Justification	*Year 1*	*Year 2*
• Hardware and Visualization software	$10,000	---

For the success of this project, and its ongoing development, we will require dedicated computer for development and for testing. This hardware cost will be shared between the NRC grant and the College of Engineering at the University of Texas at Arlington. To this extent, we

will need dedicated development computers (for Microsoft operating system and for Apple operating system). We will also need tablet PC and other devices to view the web modules on different platform and at different resolutions and a dedicated server. We are requesting a portion of the total hardware/software cost from NRC for this project. We also plan to purchase some high end visualization software, such as ILog from IBM, and Silverlight product from ComponentArt for a rich web visualization experience (around $10,000 total).

5.1.3 Travel Budget & Justification:	*Year 1*	*Year 2*
• For RELAP / GOTHIC training	$ 5,000	---
• For paper presentation	----	$ 5,000

We are requesting for travel budget to offset the cost associated with software training and for conference paper presentation. It should be noted that College of Engineering has supported the travel cost as and when needed. The software training for RELAP / GOTHIC will include registration, airfare, lodging, meals and other expenses for at least 6 days for 2 faculty member. The cost for paper presentation is for 2 persons and includes registration, airfare, lodging, meals and other expenses for 3 days. Some of the pertinent conferences for this presentation would be the ANS or ASEE conference.

5.2 Cost-Sharing:

The College of Engineering at UT Arlington is committed to be a player in the current energy challenges through interest in sustainable energy sources particularly nuclear energy. There is a strong commitment and endorsement by the university and college to the NE program, as is partly displayed through its cost sharing

Cost already borne to date:

- $50,000 provided by the College of Engineering up to this point to develop a radiation detection laboratory
- Travel support to the two NE faculty to ANS meetings and NRC Workshop
- Faculty time to develop courses in the NE minor, the program and the lab up to this point.
- Use of LabView software, relevant instrumentation and 5 desktop computers

Cost-Sharing for this project

- $15,000 for purchase of hardware/software, travel and misc. costs.
- For Dr. Kumar, 15% time over the 2 years of this proposed grant ($32,659 - in kind)
- For Dr. Peterson, 5% time over the 2 years for program support ($19,929 - in kind)

Item 6: Program's Sustainability

All the support, indicated ahead, suggests that the commitment of UT Arlington to the NE minor program is not dependent on the NRC support and it is reasonable to assume that the commitment will extend beyond the requested 2 year support period. Also, as a public institution that receives state funding based on a formula involving student credit hours, state support to the university for these courses will be a function of the enrollment in them. In other words, while the interest in the courses continues and grows, university and college support of the course

offering is almost assured. Student enrollment in the Nuclear Engineering minor program has been very solid and we strongly believe that all relevant support will continue. It should be noted that the programs sustainability was scrutinized when DOE awarded us with a $295K grant to develop the Nuclear Radiation laboratory.

The student interest level has been strong right from the program's inception and grows unabated. This interest level can be gauged by an impressive student survey (when the program was planned), a healthy enrollment in the very first class that was offered (40 students), and a large turnout at seminars when attendance is voluntary. Even local high-school students have shown up in healthy numbers for the workshops that were conducted for them. All these point to the fact that from the student's perspective, the NE minor program will continue to be an attractive option.

Sustainability of the proposed project will be further ensured by commitment not only at the College level but also at the departmental level. The department of Mechanical & Aerospace Engineering is considering giving a course release to the PI (Ratan Kumar) even if the requested funding does not come through. All the involved departments (Mechanical and Aerospace, Computer Science, and Electrical Engineering) are prepared for cost-sharing to accommodate the faculty's time to make this project a success.

References:

1. Wulf, W. A., and Fisher, G. M. C., "A Makeover for Engineering Education," *Issues in Science and Technology*, Vol. XVIII, No. 3, pp. 35-39, Spring 2002.
2. Farrell, E. F., "Engineering a Warmer Welcome for Female Students," *The Chronicle of Higher Education,* February 22, 2002.
3. Ribando, R.J., Scott, T.C., Richards, L.G., O'Leary, G.W., "Using Software with Visualization to Teach Heat Transfer Concepts," *Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition*, Montreal, CA, June 2002.