Shoreham Long Island Nuclear Power Plant - Construction 1973-1984 at a cost of $6 Billion - Never Fully Operational - Decommissioned 1989

Nuclear Energy and Society:
Boom, Bust and Potential for A Sustainable Energy Future

Syllabus HST 411 A

College of Arts and Letters
Stevens Institute of Technology
Spring 2022

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Thursday 3:15PM - 5:45PM - M324
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Course Description - Nuclear Power - Boom, Bust and Potential for a Sustainable Future

The course will focus on the origins, development and future potential of nuclear power arising from scientific discoveries of the 1930's and technological development of the 1940's. Begun as a source of plutonium for nuclear weapons production, nuclear fission emerged in the 1950's as a source of power, first for submarines, and then for civilian use. As with most technologies, the pathway that it followed was not inevitable, but involved power struggles among individuals, national laboratories and industrial organizations. The history of nuclear power was intertwined with national nuclear weapons policy and today is at the heart of controversies regarding the role that it might play in the amelioration of global warming.

While the evolution of nuclear energy, from 1938 to the present, has been the result of scientific discoveries and technological innovations that have played out on the international stage, these developments have been crucially dependent upon key individuals, major industrial organizations and leading government agencies, most notably the three branches of the military. The impact of regulatory constraints, both national and international, have determined much of this history. These interrelationships of science, technology and society have nurtured a rich history and set the stage for an uncertain future, but one which potentially holds great promise.

Most nuclear reactors operating today have design and fabrication characteristics that date from the 1960's. In recent years new approaches have been proposed that hold great promise, but their realization, if achievable, will require significant investment, careful analysis and planning initiatives at the level of countries and international consortia. The challenges that society faces in this regard are particularly dramatic since the potential to utilize innovations including Gen IV reactor technology, molten salt designs and thorium fuels could greatly ameliorate the steadily accelerating threats of global warming. The course will engage students in the consideration of these socio-technical issues.

Student Projects: The course will emphasize student in-depth exploration of questions such as the role of the quest for weapons grade plutonium on the nature of the U.S. civilian power industry; the impact of nuclear accidents on public energy policy in selected countries; the contrast between the development of nuclear energy in France with that in other countries; the history of alternative designs such as molten salt Thorium reactors and sodium cooled breeder reactors as the basis for nuclear energy in the United States and their current role in the energy plans of China, Russia and India. As new opportunities emerge for safe sources of environmentally friendly nuclear power, public fear and skepticism presents a formidable barrier to implementing innovative designs. Students will engage in pursuit of issues such as these through individual research oriented term papers.

CAL Objectives:

1. Students will demonstrate an awareness of ethical responsibility and the societal impact of their future profession.
2. Students will demonstrate a fuller understanding of the traditional humanities and social sciences through an understanding of their relation to the study of science and technology.
3. Students will demonstrate an awareness of cultures and societies other than their own.
4. Students will demonstrate writing and public speaking skills.
5. Students will demonstrate a love of learning in the liberal arts for its own sake.
6. Students will demonstrate leadership and team skills.

STS Program Outcomes:

1. *Philosophical Foundation*. The student will understand the underlying theories and methods used in Science and Technology Studies and be able to apply them to individual and team research.
2. *Historical Foundation*. The student will understand the evolution of Science and Technology Studies as an academic field, and be able to discern different schools of interpretation within STS.
3. *Research*. The student will be able to design and conduct research and to ask and answer appropriate and original research questions.
4. *Tools*. The student will be proficient in the application of STS tools, methods, and concepts toward the resolution of practical problems.
5. *Professionalism.* The student will achieve a high degree of knowledge, accountability, and ability to transfer classroom experiences to professional practice.
6. *Leadership*. The student will be able to develop plans for research projects and policy actions on a professional level.
7. *Teamwork*. The student will be able to contribute to research activity as a working team member, and facilitate cooperation among the members of the team resulting in a successful project.
8. *Communication*. The student will enhance their written and oral presentation skills using a variety of means to convey significant ideas and proposals.
9. *Ethics*. The student will understand and abide by professional standards of ethics appropriate for STS research.
10. *Social Issues*. The student will place into modern social context information derived from research such that the relationship between theory and practice are manifest.
11. *Lifelong Learning*. The student will be treated as a professional with a lifelong investment in one's field of study, and a professional goal of continuing self-assessment and self-improvement.

HST 411 A **Nuclear Energy and Society - Boom, Bust and Potential for a Sustainable Future**

Course Outcomes:

1. Students will attain competency in a variety of nuanced issues relating to the past, present, and future of nuclear reactor technology. (2,4)
2. Students will use group reading and discussion to pool their time and teach one another about a variety of readings. (7)
3. Students will participate in in-class activities (analysis, debates, reviews) that will demonstrate significant engagement with course themes and reading materials as well as analytical methods and historical interpretation. (1,2,3,6,8,10)
4. Students will work on a major research project for the course over the semester. (3, 5,8, 9, 11)

Required Books

Title: Seeing the Light: The Case for Nuclear Power in the 21st Century
Authors: Scott L. Montgomery and Thomas Graham Jr.
ISBN: 978-1-108-40667-3 Paperback
Publisher: Cambridge University Press
First published 2017

Other readings will be provided as handouts and as documents that are available on the Internet.

Course Structure and Requirements

There will be reading assignments every week. Students will be required to submit a short "reading response" prior to attending the class in which that reading will be discussed. The "reading response" will typically be a review, summary or topic analysis based on the reading. The length of the written piece will be in the range of 400 to 500 words.

In some cases, students will be asked to give a short presentation based on the week's reading assignment. Preparation of a few powerpoint slides may help facilitate these presentations. On occasion group presentations will be requested.

Various formats will be used to discuss the new material contained in the readings. These might be lectures, discussions, debates, etc. It is expected that all students will engage in active participation in class discussions.

Note that use of smart phones, text messaging, and multi-tasking are not allowed when class is in session unless a specific use of a digital device is incorporated into a class activity.

There will be no tests or examinations. Grades will be based on the written “reading responses,” (45%); class participation and presentations (20%) and the Term Project (35%)

Current Events

The topics dealt with in this course are constantly evolving on multiple fronts: science, technology, public policy, national strategies, financial investments, etc. Students are expected to regularly scan news media for reports that are relevant to topics that we are addressing in our studies. At the start of every class period current events topics will be discussed. Students are expected to contribute topics for discussion and to actively engage in these discussions. Each week, two students will be asked to make a short presentation about a recent news story. Current Events discussions are an important part of class participation.

Term Projects

An important part of the learning experience in this course will be the production of an analysis paper about 6,000 words in length plus appropriate footnotes and a detailed bibliography. This paper will be completed jointly by two students. The paper will deal with the past history and current policies for energy production in a country, region or state with special emphasis on nuclear energy. During the final three weeks of the course, students will make 15 minute oral presentations, based on their topic, using powerpoint slides. The final paper will be due at the midpoint of the Spring final exam period.

The topics for these presentations will the past history and current status of nuclear energy policy in the following countries and states:

1. Russia
2. China
3. France
4. India
5. Japan
6. U.K.
7. Central Europe
8. South Korea
9. Africa
10. United States (national policies)
11. California
12. New York and New Jersey

Course Policies

Attendance is mandatory. If a student is unable to attend a class, the instructor must be notified and appropriate justification provided. Make-up work will be assigned. Failure to satisfactorily complete the make-up assignment will result in a 0.07% reduction in the final grade for the course based on missing 1 out of 14 class sessions.

As is customary a 10-15 minute break will be taken midway during the class period.

Canvas will be used actively to communicate with the class and for the submission of assignments and for some class discussions. Students should check Canvas regularly for notices and interactions.

Students are expected to submit all written material in grammatically correct form. Writing standards appropriate for college students with high professional aspirations are expected. Submissions that do not meet these standards will be returned for revision and resubmission.

Writing and Communications Center

The College of Arts and Letters maintains a Writing and Communications Center in Morton 210. The office hours are Monday-Friday, 11AM - 5PM. Please utilize these services, as appropriate, to review or improve your writing, presentation and communications skills.
https://www.stevens.edu/academics/undergraduate-studies/writing-communications-center

Stevens Honor Code

Stevens has a proud history of maintaining an outstanding honor code and associated board and system for its implementation. The principles and practices of the Honor Code will be implemented at all times in this course. Please review the follow pages from the student handbook:

https://web.stevens.edu/honor/howitworks.shtml

Students should be aware that plagiarism is a serious offense. The submission of material that is plagiarized will result in a failing grade in this course.

All written work submitted for this course must be pledged.

Students with Disabilities

Students who require special accommodations due to disabilities, or need special arrangements in the event that the building needs to be evacuated, please inform the office of Student

Counseling and Psychological Services.
https://www.stevens.edu/directory/counseling-and-psychological-services

They will assist you in completing arrangements to meet your needs. Please discuss actions taken with the instructor

Course Outline and Readings

The following schedule of class topics, readings and assignments is subject to change based upon the flow of activity in class, student interests and external events that may refocus our attention.

Class 1 - January 20 Introduction to the course and background on the nucleus and fission. Concept of the Atom, Model of Bohr Atom, Mystery of neutrons, Periodic Table, Bombardment of Uranium, Lisa Meitner and Otto Hahn discovery of Fission.

Assignment 1 - Read "The Manhattan Project - Making of the Atomic Bomb"
https://www.osti.gov/opennet/manhattan-project-history/publications/DE99001330.pdf
Write about 400-500 words on how the success of the Manhattan Project was enabled by the industrial resources (experience, capacity and diversity) of the United States.

Class 2 - January 27 - Discussion - Establishment and Scope of the Manhattan Project - first reactor in Chicago and then reactor development at Hanford - radiation - Klaus Fuchs and other spies -

Assignment 2 - Read pages Montgomery-Graham pages 8-31 and pages 64-94.
Also read: Nuclear Power Reactors - Web Site of World Nuclear Association
http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/nuclear-power-reactors.aspx
Read first 5 ½ pages up to "Main Types of Reactors, Pressurised water reactor (PHWR)."

Write 400-500 words on the development of nuclear power, as presented in these readings. Comment on questions that these readings might raise in your mind regarding the safety, efficiency and/or the economic viability of this component of the energy sector.

Class 3 - February 3 - Discussion - Energy production and comparative costs for nuclear power. Post World War II developments - nuclear submarines and beginning of nuclear power for civilian use. Atoms for Peace - Eisenhower Atoms for Peace speech - History of early nuclear power development in U.S. and early developments U.K. and in other countries

Assignment 3

Read Montgomery-Graham pages 95-118
Also read https://en.wikipedia.org/wiki/Hyman_G._Rickover and
https://en.wikipedia.org/wiki/Alvin_M._Weinberg

Note how Rickover's advocacy for pressurized water reactors overcame alternative approaches, most significantly, those of Alvin Weinberg for molten salt reactors.

Write 400 to 500 words about the world wide development of nuclear reactors during The 1960's thru 1980's that was dominated by water cooled reactors.

You might wish to make reference in your essay to this compilation of the world's nuclear reactors:
https://en.wikipedia.org/wiki/List_of_commercial_nuclear_reactors

Class 4 - February 10 - Discussion - Fissile materials - Rickover and nuclear navy vs Weinberg and research at Oak Ridge National Laboratory. - Thorium Reactor development in 1960's. History of the nuclear arms race and the need for plutonium - Radiation and issues regarding nuclear waste management. The development and utilization of nuclear power in the leading nuclear power countries of the world.

Assignment 4 - Read Wikipedia - Three Mile Island
https://en.wikipedia.org/wiki/Three_Mile_Island_accident

Read The Report of the President's Commission on the Accident at Three Mile Island. Pages 1-79

http://tmi.dickinson.edu/wp-content/uploads/2017/09/188.pdf

Optional: Read pages 80-141 on the details of the accident

Writing assignment - Summarize in 400-500 words various factors that precipitated the accident in each of the following categories: Government Policies and Operations, Power Plant Management and Operations at Corporate or Bureaucratic Level, , Power Plant Management and Operations at Plant Level and Staff Operations at Control Room Level.

Class 5 - February 17 - Three Mile Island

Discussion of causes and consequences of Three Mile Island Accident.

Viewing of 51 minute documentary from The American Experience - produced by WGBH "Meltdown at Three Mile Island"
https://www.youtube.com/watch?v=0J7kHfBBBmk

Discussion of film and Commission Report

Assignment 5 -

Wikipedia - Chernobyl Disaster - Up to but not including section on Impact
https://en.wikipedia.org/wiki/Chernobyl_disaster

Also, read Montgomery and Graham first part of Chapter 6 about (pages 144- 149)

Read the following document written by Professor Friedman regarding Chernobyl:

Fifteen Dysfunctional Decisions of Chernobyl in PIR Summer/Fall 2017 pages 14-19

http://mailchi.mp/fas/public-interest-report-summer-fall-2017?e=e7b9629c58

Writing Assignment

Submit a 400-500 essay on the relevance of the Chernobyl catastrophe to the planning and operations of other nuclear reactors. Identify lessons learned that are applicable in other contexts and aspects that are unique to Chernobyl.

Class 6 - February 24
Discussion of two papers written by Professor Friedman

1. Introduction on page 16 by Charles Ferguson and article starting on page 17

https://fas.org/wp-content/uploads/2016/12/PIR-2016_v3.1_small.pdf

2. Exchange of Letters with Alexander DeVolpi in PIR Spring 2017 pages 1-3

https://fas.org/pir-issue/spring-2017-volume-69-number-4/

Discussion of LNT; radiation and health impacts.

Review in class of Montgomery-Graham Chapter 5 Radiation: A Guide for the Perplexed Pp. 119- 143 and World Nuclear Society Radiation and Health Effects http://www.world-nuclear.org/information-library/safety-and-security/radiation-and-health/nuclear-radiation-and-health-effects.aspx

Assignment #6

- Read Montgomery and Graham pp. 149-171 about Fukushima;

Read Wikipedia: Fukushima Daiichi Nuclear Disaster https://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster

Read about the trial of TECO executives for management of Fukushima.

https://www.theguardian.com/environment/2017/jun/30/fukushima-nuclear-crisis-tepco-criminal-trial-japan

https://www.nytimes.com/2019/09/19/business/japan-tepco-fukushima-nuclear-acquitted.html

Submit 400-500 word analysis of how you evaluate the culpability of the TECO executives and state how you would judge them if you were a trial judge in their case.

Class 7 - March 3

FrontLine Inside Japan's Nuclear Meltdown

https://www.pbs.org/wgbh/frontline/film/japans-nuclear-meltdown/

Presentation by instructor on use of Muon Tomography to study aftermath of Fukushima meltdown Discussion of readings and other material relating to Fukuahima including Montgomery and Graham Chapter 7 Godzilla's Children: Origins and Meaning of Nuclear Anxiety pages 174- 208

Assignment 7 -

Read materials TBD regarding Solar, Wind and Batteries

Class 8 - March 10

Discussion Solar Wind and Batteries

Assignment 8

Read:

Fast Sodium Nuclear Reactors

https://en.wikipedia.org/wiki/Sodium-cooled_fast_reactor

And

Integral Fast Reactor

https://en.wikipedia.org/wiki/Integral_fast_reactor

and

Breeders in Russia and China

https://www.powermag.com/rapid-advancements-for-fast-reactors/

The next two links relate to the TerraPower Natrium reactor which is a sodium cooled reactor in which fast neutrons produce fissile Plutonium 239 from U238. The Plutonium 239 immediately participates in a chain reaction producing heat and more neutrons.

https://www.wsj.com/video/bill-gates-sees-future-in-nuclear-energy/2263B1FF-E7DC-481B-A8FC-894375A3F4A1.html

(Links to an external site.)

https://www.terrapower.com/

Prepare a 500 word analysis of the pro's and con's of Fast Sodium Reactors

Class 9 - March 24
Discussion of Fast Sodium Reactors

Video of Integral Fast Reactor

https://www.youtube.com/watch?v=Sp1Xja6HlIU

Video of Bill Gates - Terrapower Reactor

https://www.wsj.com/video/bill-gates-sees-future-in-nuclear-energy/2263B1FF-E7DC-481B-A8FC-894375A3F4A1.html

Discussion of Terrapower and Fast Sodium Reactors in Russia and China

Assignment 9 Readings on Molten Salt Reactors

These two links relate to molten salt reactors and the Kairos technology that uses uranium fuel embedded in ceramic pebbles. The heat is produced by fission of U235 that is initiated by slow neutrons.

https://www.youtube.com/watch?v=aqPLU8ge-0w

(Links to an external site.)

Kairos uses Triso fuel - please read about Triso here:
https://www.energy.gov/ne/articles/triso-particles-most-robust-nuclear-fuel-earth

https://kairospower.com/

Write 500 words on the pro's and con's of molten salt reactor

Class 10 - March 31

Discussion of Molten Salt Reactors and

Assignment 10 Reading on High Temp Gas Reactors

Note that most public discussions about energy use focus on electricity production. However, electricity accounts for only 27% of energy use. Manufacturing, including metals processing, along with production of cement and plastics account for 31% of energy use, while Agriculture applications use 19% of energy and transportation uses 16%. Another 7% is devoted to heating and cooling applications. These sectors account for 100% of energy use.

In order to meet some of the requirements of these applications, nuclear energy reactors with high temperature output are needed. We have discussed various reactor designs in this course thus far, including water cooled reactors, molten salt fluoride reactors, liquid sodium reactors, and liquid salt reactors using uranium fuel. Of the reactors that we have not yet reviewed that are important candidates for development, are gas cooled reactors.

Please read the about Gas Cooled Reactors and Very High Temperature Gas Cooled reactors in this reference on Generation IV reactor technology:

https://www.gen-4.org/gif/jcms/c_59461/generation-iv-systems\

Also, read about the recent success of China to achieve criticality for its HTR_PM reactor

https://www.world-nuclear-news.org/Articles/Chinas-HTR-PM-reactor-achieves-first-criticality

After posting this assignment, news emerged about a large investment by the U.S. government in X-Energy's HTGR.

Please review:
https://www.yahoo.com/now/congress-appropriates-1-1b-dollars-170000514.html and the X-Energy website http://x-energy.com

Prepare a 500 word summary of the history and the present prospects for use of Very High Temperature Gas Cooled Reactors. Comment on how this technology could help meet energy needs other than electricity generation.

Class 11 April 7 - Discussion of High Temp Gas Reactors

Including non electrical energy needs and prospects for a hydrogen economy

Assignment 11 Reading on Thorium Reactors

These first two links relate to FLIBE which is developing a Liquid Fluoride Thorium Reactor that employs slow neutrons to produce fissile U233 when absorbed by Thorium 232

https://www.ted.com/talks/kirk_sorensen_thorium_an_alternative_nuclear_fuel

https://flibe-energy.com/

China Thorium Reactor references:

https://www.abc.net.au/news/2021-08-28/china-thorium-molten-salt-nuclear-reactor-energy/100351932

https://www.nature.com/articles/d41586-021-02459-w

Prepare a 400-500 word essay on the pro's and con's of Thorium reactors

Class 12 - April 14 - Discussion of Thorium Reactor and 2 - 30 minute Term Paper Reports on California and New York.

The New York report should include commentary about the history of the Ravenswood and Shoreham plants that were proposed but never built as well as the Indian Point plants that were closed.

Ravenswood reference:

https://cityroom.blogs.nytimes.com/2011/04/13/when-con-ed-wanted-a-nuclear-plant-in-the-heart-of-nyc/ (Links to an external site.)Links to an external site. (Links to an external site.)Links to an external site.

Shoreham reference:

https://en.wikipedia.org/wiki/Shoreham_Nuclear_Power_Plant (Links to an external site.)Links to an external site.

Indian Point closing reference:

https://www.nytimes.com/2021/04/12/nyregion/indian-point-power-plant-closing.html

Class 13 - April 21 Term Paper Report 5 - 30 minute reports

Canada
India
South Korea
Central Europe
Africa

Class 14 - April 28 - Term Paper Reports 5 - 30 minute reports

Russia
China
U.S.
France
U.K.