2008

The Future of Nuclear Power in India

Neil Crawford
Worcester Polytechnic Institute

Gary Katzoff

Talha Riaz

Victoria Stutz

THE FUTURE OF NUCLEAR POWER IN INDIA

Neil Crawford, Gary Katzoff, Talha Riaz, Victoria Stutz
Advisor: Professor David Spanagel
Contact: Victoria Stutz vstutz@wpi.edu

Abstract

Developing countries face obstacles to meeting their growing energy needs without extensively contributing to global warming. A potential solution to this challenge involves the use of nuclear energy. In this project, we examine India as a case study because it has the fastest growing energy needs in the world. What hurdles must India overcome in order to successfully invest in an aggressive nuclear development program? Despite significant diplomatic and geopolitical concerns, nuclear power must contribute to India's energy solution because of its high energy yield and low carbon emissions.

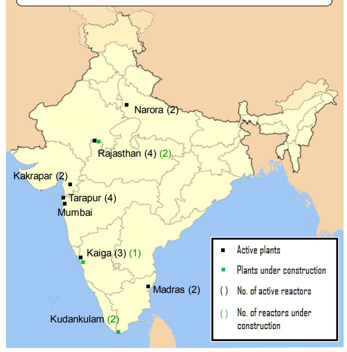
Project Goals/Objectives

- Examine India's current growing energy needs, their dependency on fossil fuels, and their history concerning nuclear power that would affect a national investment in nuclear power
- Use India's situation as a template for other developing nations to look at as an example for embracing nuclear energy
- To determine whether or not India has the technological and economic capabilities to follow through with their plans for major nuclear energy development
- Analyze the political ramifications of India becoming a nuclear power

Key Points

- India's economy and energy needs are growing at an impressive rate, much larger than other nations in the world, including other developing nations.
- Currently, India is getting a substantial majority of its energy from burning fossil fuels, making a contribution to global warming that will only increase as its economy grows.
- India has expressed an interest in alternative energy sources, principally nuclear power.
- India has a large percentage of the world's thorium deposits within its borders that can be used as nuclear fuel.
- India's reluctance to fully cooperate internationally, by refusing to sign the Nuclear Non-Proliferation Treaty, is partially inhibiting its progress in the nuclear realm.

Nuclear Power Plants in India

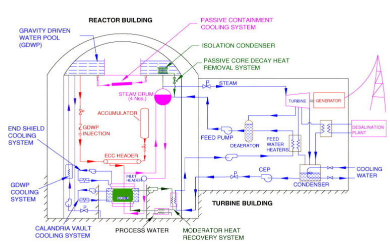


Economics of Nuclear Energy

- Because of effective designs of power plants, cost of electricity generated by nuclear energy is competitive.
- Cost of nuclear fuel is low because of use of domestic thorium.
- Nuclear power is very economical if plants are built away from coal reserves i.e. in north-western, western and southern India.

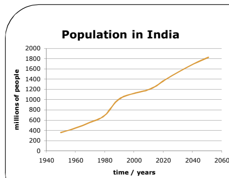
Safety Features of the Indian Thorium Advanced Heavy Water Reactor Design

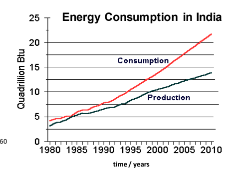
The Indian thorium fueled Advanced Heavy Water Reactor has been designed with safety as a top priority. It has several innovative and passive safety features that would effectively shut down the reactor in the event of any foreseeable accident. Along with the conventional active shutdown capabilities such as scramming or flooding the reactor with coolant, the reactor also has several passive shutdown systems that will automatically activate in the event of a hot shutdown, prolonged shutdown, or loss of coolant accident. During normal operation, coolant is circulated by natural convection instead of pumps, so a loss of power will not cause a loss of coolant. If a loss of coolant accident did happen, the rising temperature would cause the automatic release of a reactor poison into the system, that would kill the reaction. If this system were to fail, and the temperature continued to rise, the large gravity driven water pool at the top of the reactor building would automatically start flooding the bottom the reactor cavity, effectively submersing the whole reactor core. If the reaction rate continues to increase, there is enough coolant to keep there is enough coolant to keep the reaction in check for 72 hours, more than enough time for the operator to step in and manually shut down the reactor.



Three Stage Nuclear Fuel Cycle

Because of India's lack of uranium recourses, every effort has been made to draw as much power as possible out of the uranium they do have. Using a combination of their Advanced Heavy Water Reactor and Fast Breeder Reactors, the Indian program is able to reprocess this fuel. After the uranium is run through the AHWR once, it is sent to a fast breeder reactor and used to produce energy once again. The plutonium which is extracted from the fast breeders is then used in the AHWR with 'thorium' as the main fuel. At the end of the third reaction, the nuclear waste is much less in volume and in a far less hazardous form.





Recent Political Issues

- Pakistan is demanding a U.S. nuclear deal because it believes that it is unfair that India has one and it does not. The United States and other members of the Nuclear Suppliers Group will not be dealing with Pakistan in the near future since its top nuclear scientist has recently given nuclear secrets to Iran, North Korea, and Libya. While it is true that both Pakistan and India tested nuclear weapons in 1998, India has not undergone nuclear proliferation.
- Within the Nuclear Suppliers Group, China was the greatest opponent to the Indian deal. China did not want a U.S. friendly nuclear power in Asia. It took a persuasive letter from President Bush to the President of China to have China's Nuclear Suppliers Group diplomats approve the India waiver.

Conclusions/Recommendations

- India should choose nuclear power as a solution to its growing energy needs for four reasons:
  - Nuclear power has a high energy yield
  - Nuclear power has low carbon emission
  - India has extensive thorium reserves that can be used as nuclear fuel
  - Economically it is favorable to build nuclear plants in western parts of the country
- If India would like to successfully grow its nuclear program, India must first acknowledge that the first step is to cooperate internationally and sign the Nuclear Non-Proliferation Treaty.
  - This would allow a discourse of information to be relayed between India and countries that have well-established nuclear power programs.
- We can look to India as a example for other developing countries because India's potential international cooperation will result in both a successful energy program and a solution to reducing carbon emissions.
- India's example will illustrate how cooperation between nations will be necessary to address global warming.

Indian Nuclear History

- 1947: India becomes Independent
- 1948: Atomic Energy Commission established
- 1956: Negotiates with US and Canada for nuclear reactor
- 1962: War with China.
  1963: Two research reactors and four nuclear plants in operation
- 1964: China detonates nuclear bomb
- 1965: War with Pakistan over Kashmir
- 1968: India refuses to sign Nuclear Non-Proliferation Treaty
- 1974: India performs 15kt "Peaceful Nuclear Explosion". US & Canada suspend their nuclear cooperation with India.
  Nuclear Supplier's Group formed
- 1998: India detonates both fission and fusion devices
- 1999: Indian population exceeds 1 billion.
  Kargil War with Pakistan. Pakistan threatens to use nuclear weapons
- 2006: President Bush declares India a Nuclear Power
- 2008: NSG approves trade with India
  US-India Nuclear deal signed