

Frequently Asked Questions (FAQ) about FBNR

A small innovative nuclear reactor

Here are brief answers to some of the frequently asked questions about FBNR. More questions are welcomed [send to: Farhang@Sefidvash.net] in order to make the FBNR project as comprehensive as possible thus demonstrating its merits.

1. What is FBNR and its purpose?

Fixed Bed Nuclear Reactor (FBNR) is a small innovative nuclear reactor to generate electricity, produce desalinated water, supply steam for industrial applications, and in its simplest form can produce hot water for district heating utilizing nuclear energy.

[\[http://www.sefidvash.net/fbnr/htms/description_of_the_fbnr_reactor_detailed.htm\]](http://www.sefidvash.net/fbnr/htms/description_of_the_fbnr_reactor_detailed.htm)

[\[http://www.sefidvash.net/fbnr/pdfs/FBNRLetter03.pdf\]](http://www.sefidvash.net/fbnr/pdfs/FBNRLetter03.pdf)

2. Why nuclear energy?

Nuclear energy is an abundant form of energy and does not produce the green house gases that cause global warming.

[\[http://www.sefidvash.net/fbnr/htms/energy_and_water_problem_electricity.htm\]](http://www.sefidvash.net/fbnr/htms/energy_and_water_problem_electricity.htm)

3. How the nuclear energy of the future is different than today?

- a. The International Atomic Energy Agency (IAEA) through its INPRO program has established new safety philosophy and criteria for the future innovative nuclear reactors that will meet the demand of general public in all respects such as safety and environment.
- b. It is establishing a new paradigm in relation to nuclear energy.
- c. The FBNR meets the requirements of the IAEA's INPRO standards as a future reactor; namely, Safety, Economy, Non-proliferation, Nuclear waste, Environmental impact., Proliferation Resistance, and Infrastructure.

[\[http://www.sefidvash.net/fbnr/htms/evaluation_of_fbnr.htm\]](http://www.sefidvash.net/fbnr/htms/evaluation_of_fbnr.htm)

4. What guarantees that nuclear energy is a good business?

The IAEA being an agent of the United Nations has put goals for itself to

1. “Help to ensure that nuclear energy is available to contribute in fulfilling energy needs in the 21st century in a sustainable manner”; and
2. “to bring together both technology holders and technology users to consider jointly the international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles.”(IAEA-TECDOC-1362).

Therefore, any feasible and good project that helps to achieve these objectives will have the support of the highest world authority such as the IAEA.

[\[http://www.sefidvash.net/fbnr/pdfs/IAEA-TECDOC-1362.pdf\]](http://www.sefidvash.net/fbnr/pdfs/IAEA-TECDOC-1362.pdf)

5. How does the FBNR work?

- a. The water pump drives the small uranium fuel balls from the fuel chamber up into the reactor core (see the figure). In the core the process of nuclear fission occurs and heat is produced. The heated water coolant goes up into the steam generator and produces hot steam and thereafter returns to the pump. The steam is fed to a turbine-generator system that generates electricity.
- b. A part of this steam can be used simultaneously for industrial applications and water desalination.
- c. A simple version of the reactor can be designed for the purpose of heating water for district heating.
- d. To shut down the reactor, simply the pump is turned off and the fuel elements will fall out of the reactor core and return to the fuel chamber by the force of gravity. The fuel elements in the fuel chamber are in a highly subcritical condition and are passively cooled by natural convection.

[\[http://www.sefidvash.net/fbnr/swfs/fbnr_presentation.swf\]](http://www.sefidvash.net/fbnr/swfs/fbnr_presentation.swf)

[\[http://www.sefidvash.net/fbnr/htms/how_the_reactors_work.htm\]](http://www.sefidvash.net/fbnr/htms/how_the_reactors_work.htm)

6. What is the size of FBNR?

The FBNR is about 2m in diameter and 6m high and produces 70 MWe (megawatts) electricity. In a double purpose plant, at the expense of every MWe of electricity, 1000 cubic meter per day of desalinated water can be produced.

[\[http://www.sefidvash.net/fbnr/htms/technical_info.htm\]](http://www.sefidvash.net/fbnr/htms/technical_info.htm)

7. What is the fuel for FBNR?

- a. The normal fuel used is 5% enriched uranium in the form of CERMET fuel (PNNL -16245).
- b. FBNR can use plutonium from weapons that will be available through disarmament.
- c. FBNR can also use thorium fuel cycle using uranium-233.

8. What are the characteristics of FBNR?

- a. FBNR is a small, simple in design, inherently safe and passively cooled nuclear reactor with reduced adverse environmental impact.
- b. The FBNR is shop fabricated, thus it guarantees the high quality fabrication and economic mass production process.
- c. FBNR uses a proven technology namely that of the conventional pressurized water reactors (PWR).
- d. FBNR is small in nature. The optimum size is about 70 MWe. The higher power can be achieved at the cost of a lower thermodynamic efficiency.
- e. The obvious simplicity of the design and the lack of necessity for complicated control system, make the reactor highly economic.
- f. The steam generator is housed within the pressure vessel having an integrated system, thus avoiding the problems associated with a possible steam generator leakage.
- g. Easy dismantling and transportability.
- h. The reactor can be operated with a reduced number of operators or even be remotely operated without any operator on site.

[\[http://www.sefidvash.net/fbnr/htms/characteristics_of_fbnr.htm\]](http://www.sefidvash.net/fbnr/htms/characteristics_of_fbnr.htm)

9. How is the safety system of FBNR?

Any conceivable accident results in the cutting off the power to the pump, That causes the fuel elements to fall out of the core by the force of gravity. The normal state of control system is “switch off”. The pump is “on” only when all the operating conditions are simultaneously met.

[\[http://www.sefidvash.net/fbnr/fbnr2.htm\]](http://www.sefidvash.net/fbnr/fbnr2.htm)

10. What does make the FBNR a totally safe nuclear reactor? How does it resist against “Terrorist Action”, “Explosion”, “Earthquake”, “Flooding”, “Fire”, “Tornado”, and “Bombing”?

Any adverse event disturbs the signals from the multiple detectors that goes into the control system. Any abnormal signal outside the range of operation from any of the detectors will signal an accident. In such a case the power is automatically cut off the pump and the fuel elements will fall out of the reactor core by the force of gravity and become stored safely in the passively cooled fuel chamber.

11. Why it is said that FBNR is simple in design?

- a. Due to its inherent safety and passive cooling characteristics, the FBNR does not have the complicated and expensive control and emergency core cooling systems existing in the conventional reactors.
- b. It does not need sophisticated containment building.
- c. It does not need fuel storage on site.
- d. There is no fuel assembly.
- e. There is no large expensive pressure vessel.

[\[http://www.sefidvash.net/fbnr/htms/description_of_the_fbnr_reactor_detailed.htm\]](http://www.sefidvash.net/fbnr/htms/description_of_the_fbnr_reactor_detailed.htm)

12. What new technologies need to be developed for FBNR reactor?

- a. FBNR utilizes the existing well proven Pressurized Water Reactor (PWR) technology.
- b. There are various firms that can furnish components of the reactor.
- c. The fabrication of the reactor essentially involves assembling the components fabricated elsewhere around the world.

13. What are the advantages of small nuclear reactor?

- a. Adequate for countries with small electric grids.
- b. Economy of power transmission to long distances.
- c. Low capital investment. .
- d. Good choice for countries with insufficient nuclear infrastructure and limited human resources.
- e. It provides an attractive domain for fuel leasing and facilitates the option of factory fuelled reactor for those who prefer to be just the end users of nuclear power.
- f. It provides means for learning knowledge and technology from a small prototype plant.

[\[http://www.sefidvash.net/fbnr/htms/small_nuclear_reactors.htm\]](http://www.sefidvash.net/fbnr/htms/small_nuclear_reactors.htm)

14. How that FBNR is considered to be a fool proof non-proliferating nuclear reactor?

- a. The non-proliferation characteristics of the FBNR are based on both the extrinsic concept of sealing and the intrinsic concept of isotope denaturing.
- b. Its small spherical fuel elements are confined in a fuel chamber that can be sealed by the authorities for inspection at any time.
- c. Only the fuel chamber is needed to be transported from the fuel factory to the site and back.
- d. There is no possibility of neutron irradiation to any external fertile material.
- e. Isotopic denaturing of the fuel cycle either in the U-233/Th or Pu-239/U cycle increases the proliferation resistance substantially.
- f. Both concepts of “sealing” and “isotope denaturing” contribute to the fool proof non-proliferation characteristics of FBNR.

[\[http://www.sefidvash.net/fbnr/pdfs/Kernteknik_11C.pdf\]](http://www.sefidvash.net/fbnr/pdfs/Kernteknik_11C.pdf)

[\[http://www.sefidvash.net/fbnr/htms/non_proliferation_aspect_of_fbnr.htm\]](http://www.sefidvash.net/fbnr/htms/non_proliferation_aspect_of_fbnr.htm)

[\[http://www.sefidvash.net/fbnr/pdfs/FBNRLetterNo.11.pdf\]](http://www.sefidvash.net/fbnr/pdfs/FBNRLetterNo.11.pdf)

15. How that is the spent fuel of FBNR is not considered as nuclear waste but has commercial value?

- a. The spent fuel from FBNR is in a form and size (15 mm dia. spheres) that can directly be used as a source of radiation for irradiation purposes in agriculture, industry, and medicine.
- b. Therefore, the spent fuel from FBNR may not be considered as waste as it can perform useful functions.
- c. Should reprocessing not be allowed, the spent fuel elements can easily be vitrified in the fuel chamber and the whole chamber be deposited directly in a waste repository.
- d. These factors result in reduced adverse environmental impact.

16. How is the environmental impact of FBNR?

FBNR can be built in urban area as it is inherently safe and has a reduced environmental impact. Its underground containment building hides its industrial image and makes the nuclear power plant with FBNR an agreeable place to visit and can become a pleasant park or a garden for the city.

http://www.sefidvash.net/fbnr/htms/characteristics_of_fbnr.htm

17. How a small developing country can benefit from development of FBNR?

- a. The electricity and desalinated water are the urgent necessities of humanity in general and any country in particular.
- b. The energy market is a large one. Any fraction of this market that FBNR can conquer will be sufficiently great.
- c. The country can become the administrative and financial centre of the institution that will be the supplier of FBNR. The smallness of the country permits creation of an adequate and transparent institution.
- d. The engagement of a country in the development of FBNR will help advancement of science and technology in that country.

18. How a small country with no nuclear technology and modest capital can contribute to the development of the FBNR?

- a. It can accept to be the first country where the FBNR can be constructed. The bureaucracy and complicated licensing procedures in industrialized countries make deployment of FBNR too slow in these countries.
- b. The country can accept the standards set by the IAEA with minimum additional requirements. The industrial countries have developed many new exigencies that complicate the deployment of nuclear reactors.

19. How can a lay person judge that FBNR is a technically sound project?

- a. The principles of FBNR concept are simple and easily can be understood by lay persons.
- b. Moreover, one can be assured of its merits since the FBNR is one of the four water cooled nuclear reactor concepts that has been accepted and is supported by the IAEA, the highest world authority in nuclear field, in its program of Small Reactors Without On-site Refuelling (SRWOR).
- c. FBNR is being evaluated by the IAEA by the INPRO Methodology.

20. What is the size of the nuclear reactor market?

On the basis of present 2 TWe electricity generation world wide where 350 GWe of which is nuclear, and considering a modest increase of 4% per year with the cheap plants

costing about \$1000 per KWe , the potential electrical energy market is about \$800 billions per year. Any fraction of this market conquered by the FBNR is more than good enough .

21. How is the economic aspect of FBNR?

- a. Innovation creates a new paradigm.
- b. FBNR utilizes the "Economy of Numbers" instead of "Economy of Scale".
- c. The FBNR components are shop fabricated with much higher quality than is possible to be done on the site. The mass production process will make them more economic.

22. The development of FBNR is not too expensive for a developing country to afford?

The main investment comes from the international investors who recognize the profitability of investing in the innovative nuclear reactors. The host country principally will provide the financial, administrative and legal means for its deployment.

23. How the FBNR can be financed through leverage factor?

- a. If at least 3 European countries take part in the project, the European Community will contribute with 50% of the cost.
- b. Some governments such as Italy contribute with 60% of the cost of energy projects that are considered to be "clean".
- c. Some governments give free money to help technology development in their countries.
- d. Therefore, under such an ideal condition, if 20 countries participate, one can create a leverage factor of 100 that is \$1 investment by the investor generated \$100 for the project !

[\[http://www.sefidvash.net/fbnr/htms/investment_wonec.htm\]](http://www.sefidvash.net/fbnr/htms/investment_wonec.htm)

[\[http://www.sefidvash.net/fbnr/pdfs/FBNRLetter04.pdf\]](http://www.sefidvash.net/fbnr/pdfs/FBNRLetter04.pdf)

24. How much time is needed for its development?

Less than 5 years should there be no bureaucratic and financial delays.

25. What are needed for the construction of a prototype?

About \$5-10 millions are needed to develop, design and construct the prototype of the FBNR to demonstrate its feasibility.

26. Which countries are involved in this project?

- a. Under the coordination of the IAEA, the countries of Brazil, Japan, Morocco, Russia and USA are cooperating in the research and development of the common problems associated with the reactors FBNR, PFPWR, BWR-PB, and AFPR.
- b. Specifically, Vietnam and Turkey are contributing to the FBNR project.

27. What is needed to start the project?

- a. Create a structure for WONEC to be transparent and that assures the investments of the participants.
- b. Prepare a “Business Plan” to be submitted to the potential investors.
- c. Invite private and government investors, research centers, and industry to participate in WONEC.
- d. Make a plan of outsourcing the activities of the project .

28. What are some of the functions of WONEC?

- a. Research and development of the FBNR.
- b. Obtain venture capital.
- c. Construction of prototype of the reactor.
- d. Fabrication of the reactor.
- e. Management of the fuel cycle.

[\[http://www.sefidvash.net/fbnr/htms/investment_wonec.htm\]](http://www.sefidvash.net/fbnr/htms/investment_wonec.htm)

[\[http://www.sefidvash.net/fbnr/pdfs/FBNRLetter04.pdf\]](http://www.sefidvash.net/fbnr/pdfs/FBNRLetter04.pdf)

29. Should the buyer of the reactor be concerned about possible opposition and accusation?

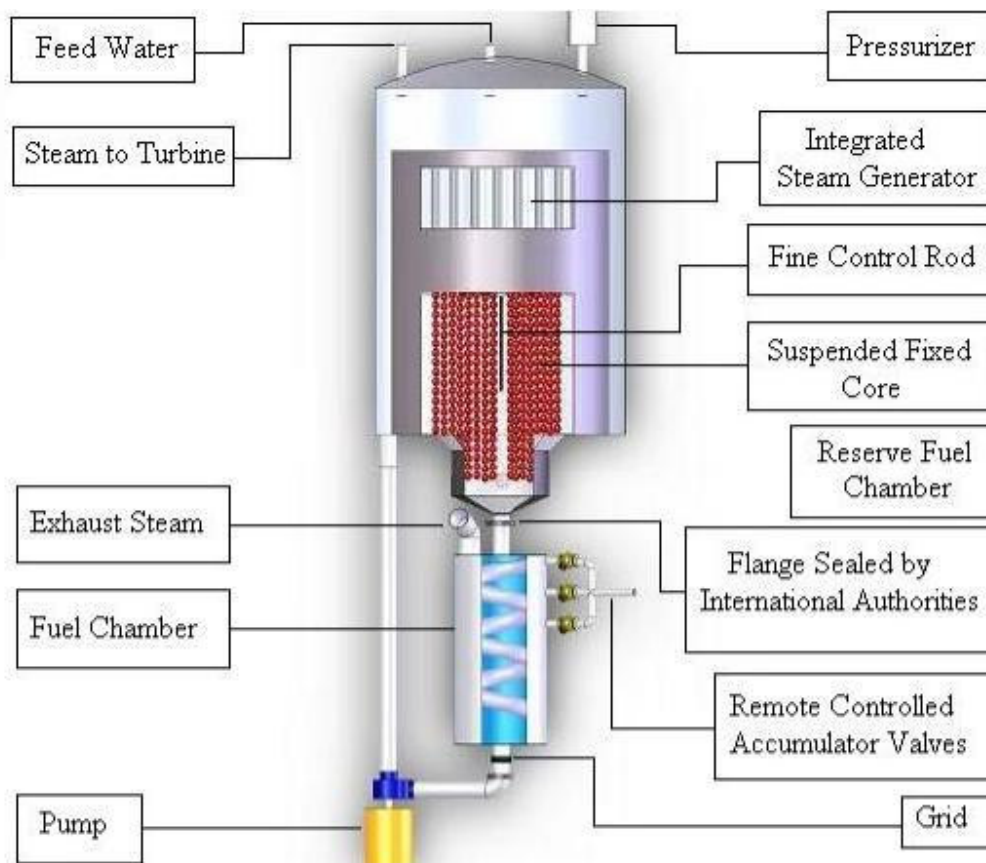
WONEC operates fully under the auspices of the IAEA; therefore, there is no possibility of violating the international laws by any participating country .

30. How the FBNR is given the title of “People’s reactor” and “Peace Reactor”?

- a. The title of “People’s Reactor” was suggested as it is at disposition of all who are interested in the project. The stakeholders are humanity in general without any restrictions. This is possible as it is a fool proof non-proliferating nuclear reactor.
- b. The title “Peace Reactor” was suggested as it can serve as an instrument of peace by "bringing together" the adverse countries around a common project in the interest of establishing harmony and peace. It is remembered that China and USA broke the ice and created peaceful relationship through ping pong games. How more noble will be should some of the Middle Eastern countries come together to develop the FBNR project producing technology, electricity, desalinated water, and above all peace.

[\[http://www.sefidvash.net/fbnr/htms/FBNR_Esp.html\]](http://www.sefidvash.net/fbnr/htms/FBNR_Esp.html)

[\[http://www.espectador.com/principal/documentos/reactor_del_pueblo.pdf\]](http://www.espectador.com/principal/documentos/reactor_del_pueblo.pdf)



Schematic Design of FBNR

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