REACTOR DEL PUEBLO

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Fixed Bed Nuclear Reactor Concept

FBNR

UM NOVO CONCEITO DO REATOR NUCLEAR

www.rcgg.ufrgs.br/fbnr.htm

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Um novo paradigma

- Uma nova era da energia nuclear está surgindo com:
- Reatores nucleares inovadores sob uma nova filosofia de segurança e novos requisitos.
  - Programa de INPRO da AIEA

Uma nova era de energia nuclear

A Agência Internacional de Energia Atômica (AIEA) está comprometida a:

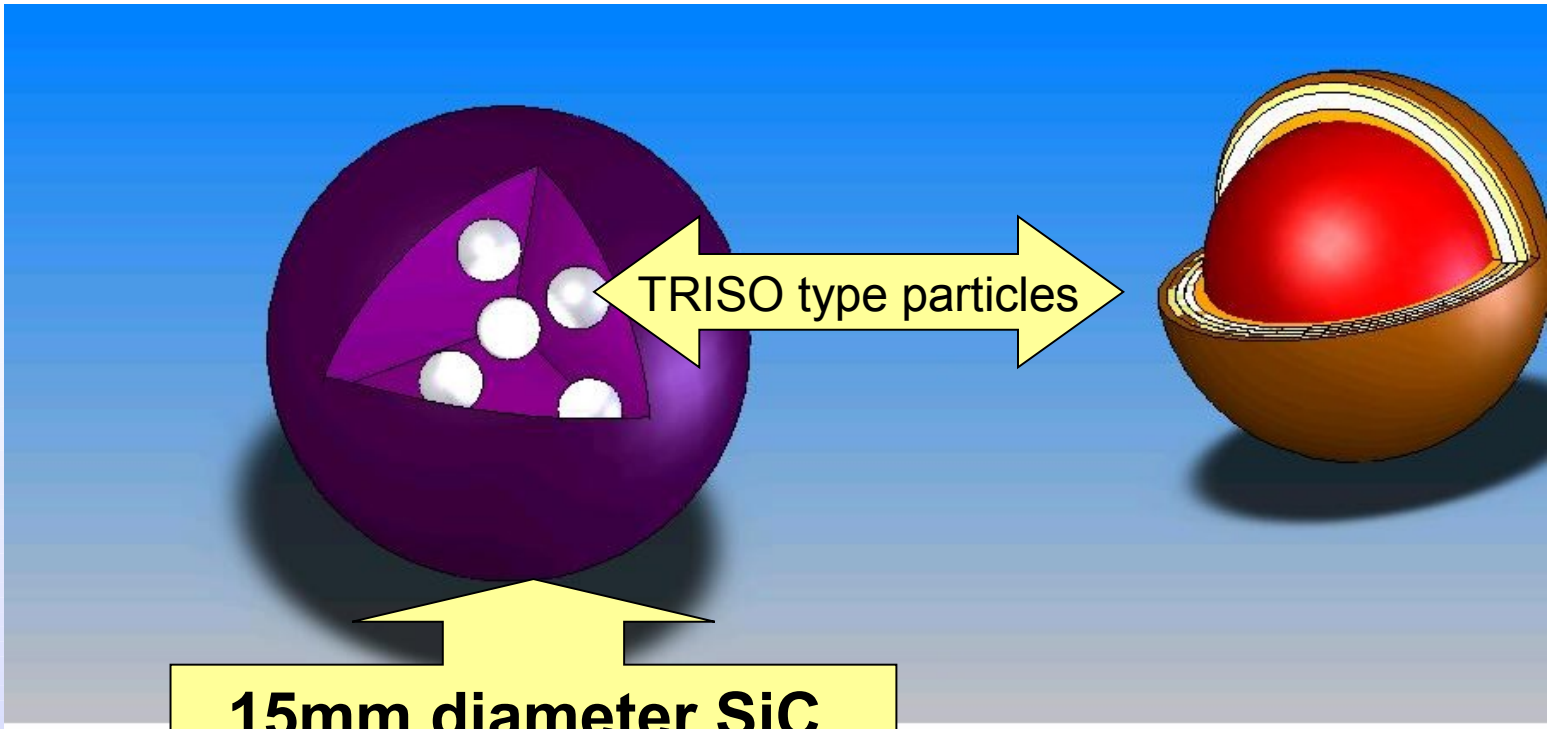
- "**Assegurar que a energia nuclear estará disponível** para suprir as necessidades de energia do século 21 em maneira sustentável.
- Também, **unir os possuidores e utilizadores de tecnologia para que em conjunto tomem ações em nível nacional e internacional para criar os *reatores nucleares inovadores*** e ciclo de combustível desejado." - IAEA-TECDOC-1362.

Gen IV e INPRO

Algumas normas exigidas para os reatores nucleares inovadores:

- Segurança inerente
- Resfriamento passivo
- Economia
- Impacto ao meio ambiente
- Resistência a proliferação nuclear
- Sustentabilidade

FBNR Fuel Element



Algumas características do FBNR

- O FBNR está baseado na tecnologia do PWR já existente no país.
- O FBNR é simples em projeto.
- O FBNR é pequeno porte.
- O FBNR é modular. Qualquer tamanho do reator pode ser construído a partir do modulo básico.
- O FBNR tem segurança inerente.
- O FBNR tem resfriamento passivo.
- O circuito primário do FBNR é um sistema integrado.
- O núcleo do FBNR é suspenso por fluxo da água. A parada do fluxo da água faz com que os elementos de combustível saiam do reator por força da gravidade e serem armazenados na câmara de combustível cuja está resfriada pela convecção natural.
- O FBNR na sua versão avançada pode usar vapor super critico ou gás Helio como refrigerante e utilizar tório ou MOX como combustível. Também pode utilizar o conceito do reator nuclear a leito fluidizado.

Filosofia do projeto

- FBNR – Um projeto da tecnologia do reator nuclear aberto ao todos e para todos.

- “Lembra a humanidade e esquece o resto”

Albert Einstein

Participantes no projeto de FBNR

- **Participantes indiretos (combustível e cálculos de Benchmark):**
  - **EUA : Battelle, Pacific Northwest National Laboratory(PNNL)**
  - **Japao: Hokaida University**
  - **Russia: RRC KI (Kurchatov Institute) & VNIIAM**

- **Participantes diretos:**
  - **Brasil***: Centro Tecnológico do Exército*
  - **Suiça**: *Professor Walter Seifritz*
  - **Turquia***: Gazi University*
  - **Uruguai***: Universidade Católica*
  - **Vietnã***: INST-VAEC (Vietnam Atomic Energy Commission)*

Benefícios para o país

- Desenvolver tecnologia de ponta
- Gerar emprego de ponta
- Exportação dos reatores pequenos da mesma forma como é feito com aviões pequenos (Embraer).
- Tecnologia de ponta que influencia outras industrias, usando o conceito de qualidade total.
- Prestigio cientifico e tecnológico.
- Energia limpa e barata é o negocio do futuro, energia sem produção do CO2 e outros gases que produzem efeito estufa.

Inherent Safety & Passive Cooling

- The reactor core is suspended by the flow of water coolant. The stop in flow causes the fuel elements to leave the reactor core by the force of gravity and enter the fuel chamber.
- The fuel chamber is a highly subcritical assembly cooled by natural convection.
- Detection of any signal due to any type of accident cuts the power from coolant pump.

IAEA Research Coordination Meeting (RCM) on Small Reactors without On-site Refuelling - 2005

Passive safety of FBNR and its characteristics as a small reactor without on-site refuelling

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Fixed Bed Nuclear Reactor

FBNR

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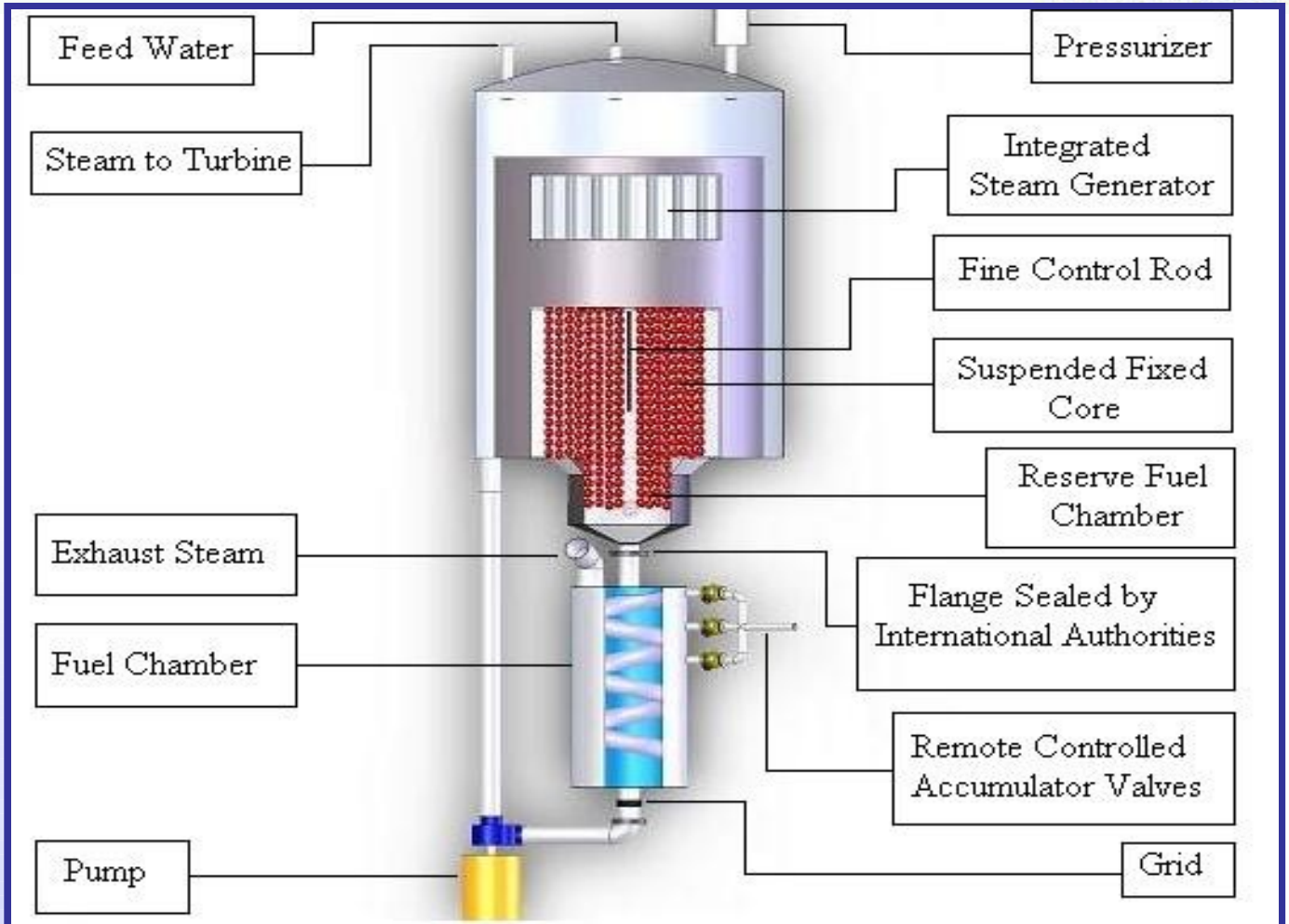
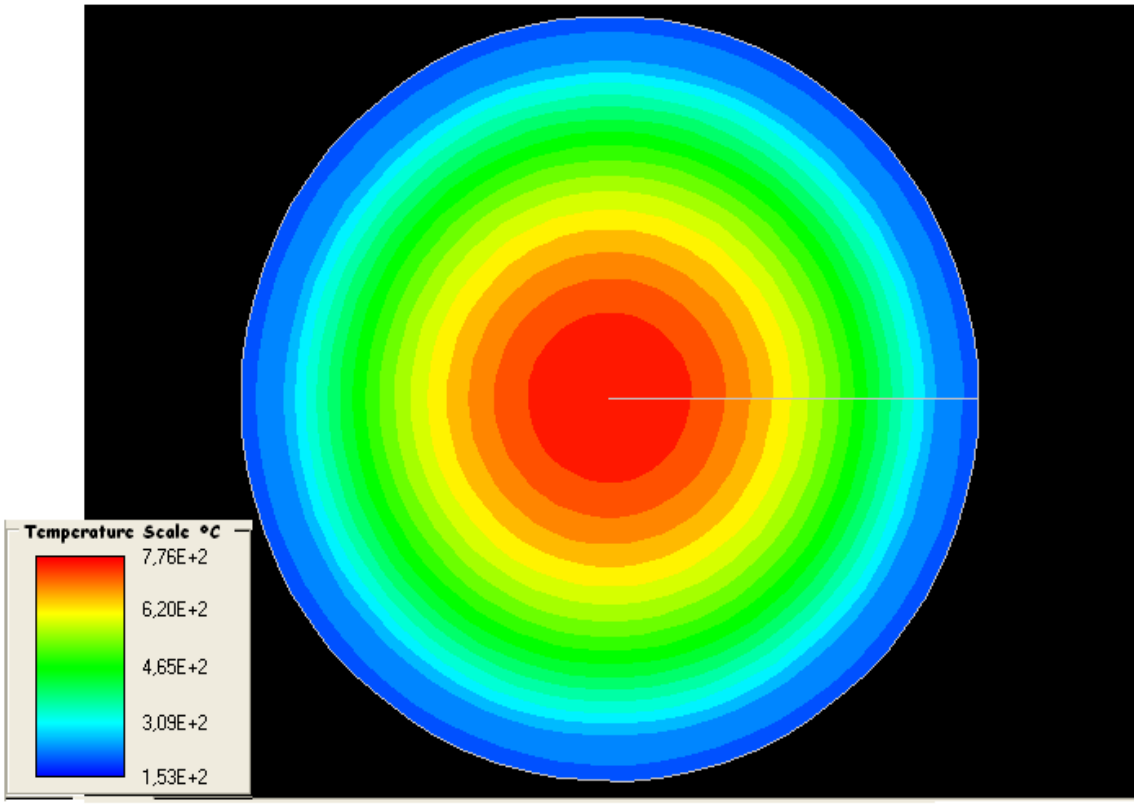


Schematic Design of FBNR

Temperature distribution in the 25 cm diameter Fuel Chamber tube after a LOCA



α_{fb} = 454 W/m²K

Tinf = 100°C

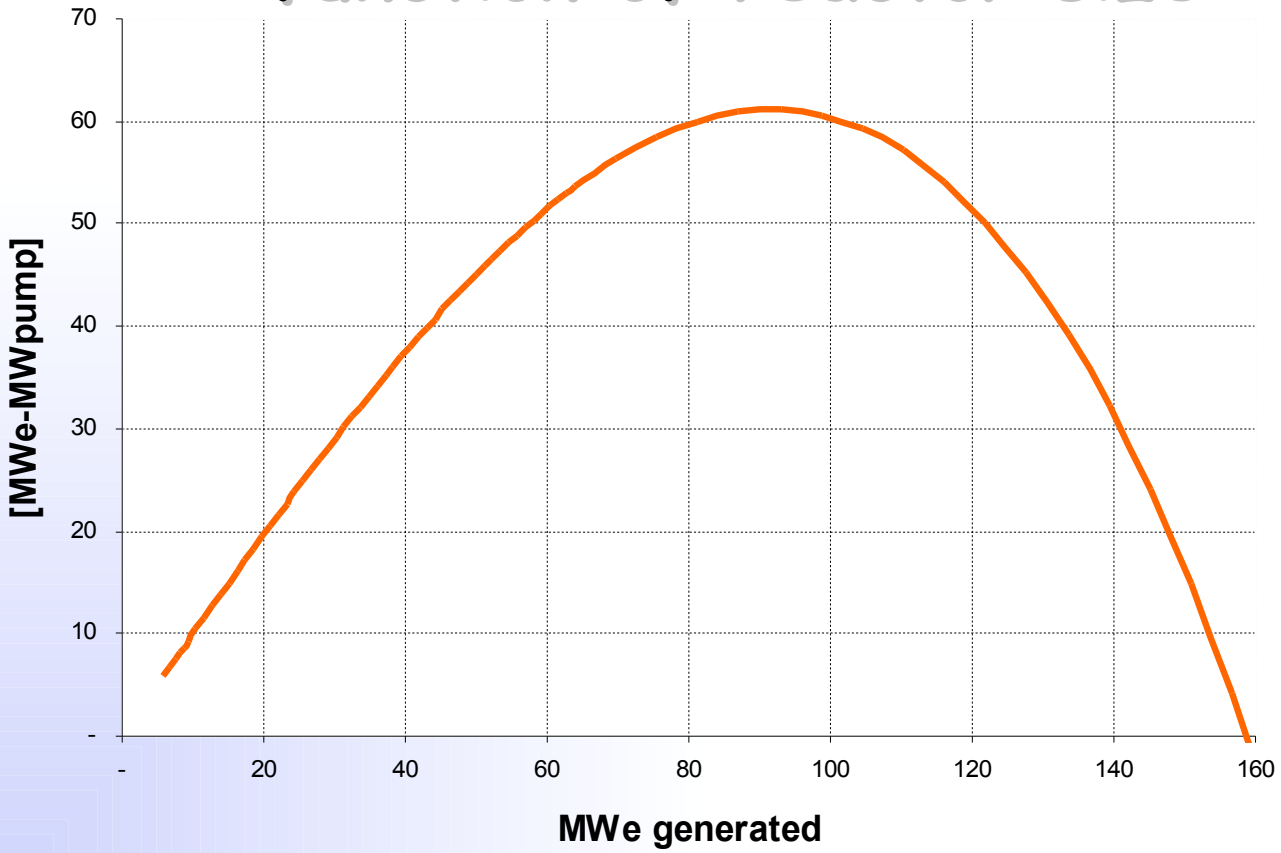
Tw = 300°C

Kf = 30.6 W/mK

Kst = 63.9 W/mK

q”’= 0.8 MW/m³

Net electric power generation as a function of reactor size



Small in size

- FBNR is small in nature.
- The optimum size is about **40 MWe**.
- The larger size up to 60 MWe can be achieved at the cost of a lower thermodynamic efficiency.

Modular

- The modular aspect of the reactor leads to the **mass production** processes resulting in better economy and higher quality products.

No need for on-site refuelling

- The reactor's fuel chamber is fuelled in the factory.
- The fuel chamber is **sealed** by the international safeguard authorities.
- The FBNR can have a very long fuel cycle time depending on the projected **size of reserve fuel chamber.**
- The core life is decided according to the user's need.

Proven Technology

- FBNR makes an extensive use of a proven technology namely that of conventional pressurized water reactors (PWR).
- Its fuel is made of TRISO type fuel particles used in HTGR reactors.

Diversity of applications

- The FBNR is a land-based nuclear power plant for urban or remote localities
- The FBNR is designed to produce electricity alone or to operate as a cogeneration plant producing simultaneously:
  - electricity
  - desalinated water
  - steam for industrial purposes
  - heat for district heating.

Refuelling in the factory

- No refueling on the site is necessary because the fuel elements are always in the **sealed** fuel chamber and transported to and from the factory for refueling under surveyed condition.
- Refuelling is done by the **replacement** of fuel chamber.

Long fuel cycle time

- The length of the fuel cycle chosen depends on the economic analysis of the fuel inventory for particular situation of the reactor and its application.
- The FBNR fuel elements have high burn up capacity.
- The size of reserve fuel chamber can be adapted to the need.
- The replacement of fuel chamber is done at any desired time interval and could be set at every 10 years or for the reactor lifetime.

High fabrication quality & economy

- The FBNR is shop fabricated, thus
- it guarantees the high quality fabrication and economic production process.

Easy dismantling and transportability

- The reactor is less than 2 m in diameter and 6 m high
- Its fuel chamber is less than 2 m in diameter and 1 m high, thus
- The dismantling and transportation to and from the site is very easy and convenient.
- The reactor and its fuel chamber can be disposed off separately and in one piece.

Reduced number of operators

- The reactor can be operated with a reduced number of operators or even be remotely operated without any operator on site.
- This is possible due to the fact that the reactor operates only when all the operating parameters are within the designed ranges.
- In any other situations, the control system do not activate the pump to operate, thus the fuel elements will fall out of the core by the force of gravity and remain in the fuel chamber under a subcritical and passively cooled

Simple infrastructure

- The infrastructure needs for the plant using FBNR is a minimum.
- The important processes are performed in the shop that can be in the **regional centers** serving many reactors.

The reactor that all can become stakeholders

- The technology should become available to all the nations of the world under the supervision and control of the international authorities.

Resistance to unforeseen accident scenarios.

- 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 operating conditions are simultaneously met.

Low capital investment

- The simplicity of design,
- short construction period, and
- an option of incremental capacity increase through modular approach, result in a
- much smaller capital investment.