High Efficiency Accelerator Driven Reactor

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Thorium Energy Alliance (TEA) Spring 2010 Conference
Google HQ, Mountain View, CA
March 29-30, 2010

Overview

- Brief History
- Initial Contacts with India – 2005-2006 (thorium)
- BARC – JLab MOA (CW SRF with low RRR ingot Nb-2007)
- HBNI – UVa MOA 2009
- DAE – Virginia Thorium Energy Discussions
- US – India Joint Workshop Committees
- Break Out Session – Energy Amplifier-Accelerator Transmutation of Waste

Brief Early History of ADS

- 1950 – U. E. O. Lawrence, High power accelerators for producing fissile materials
- 1952 – W. B. Lewis, proposed use of thorium with intense neutron generator
- 1992 – V. Bowman, Energy generation with ATW
- 1993 – C. Rubbia, Energy amplifier

Thorium – non proliferation, no melt down, safe and least NRC involvement

Department of Atomic Energy (DAE, Government of India) Institutions

- Tata Institute of Fundamental Research (A deemed University, 1943, Homi Bhabha)
  - TIFR-Hyderabad Center, Andhra Pradesh
- Bhabha Atomic Research Center (Homi Bhabha, AEET 1954, 1957 Nehru, 1967 Indira Gandhi)
  - BARC-Vizag Center, Visakhapatnam, Andhra Pradesh
- Saha Institute of Nuclear Physics
- Nuclear Power Corporation of India (NPCIL)
- Variable Energy Cyclotron Center (VECC)
- Tata Memorial Center
- Indira Gandhi Center for Atomic Research (IGCAR)
- Raja Ramanna Center for Advanced Technology (RRCAT)
- Institute of Mathematical Sciences
- Institute of Physics
- Harish-Chandra Research Institute
- Institute of Plasma Research (IPR – ITER partner Institution)

✓ Except for TIFR and NPCIL – the rest are Constituent Institutes of Homi Bhabha National Institute (HBNI, a Deemed Government of India University)

Green Energy - Thorium

World Thorium Resources

Country	Reserves (tons)
Australia	300,000
India	290,000
Norway	170,000
USA	160,000
Canada	100,000
S. Africa	35,000
Brazil	16,000
Malaysia	4,500
Other Countries	95,000
World total	1,200,000

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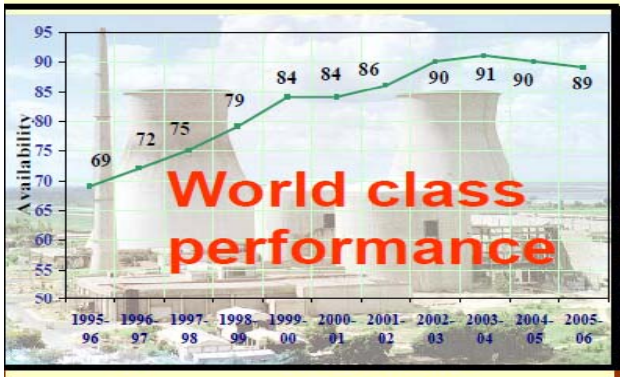
Dr. Banerjee

India‘s Nuclear Energy R&D Programs

Three Stage Nuclear Power Programme- Present Status



Stage – I PHWRs

- 15 - Operating
- 3 - Under construction
- Several others planned
- Scaling to 700 MWe
- Gestation period has been reduced
- POWER POTENTIAL ≅ 10,000 MWe

LWRs

- 2 BWRs Operating
- 2 VVERs under construction

Stage - II
Fast Breeder Reactors

- 40 MWth FBTR - Operating since 1985, Technology Objectives realized.
- 500 MWe PFBR- Under Construction
- POWER POTENTIAL ≅ 530,000 MWe

Stage - III
Thorium Based Reactors

- 30 kWth KAMINI- Operating
- 300 MWe AHWR- Under Development

POWER POTENTIAL IS VERY LARGE

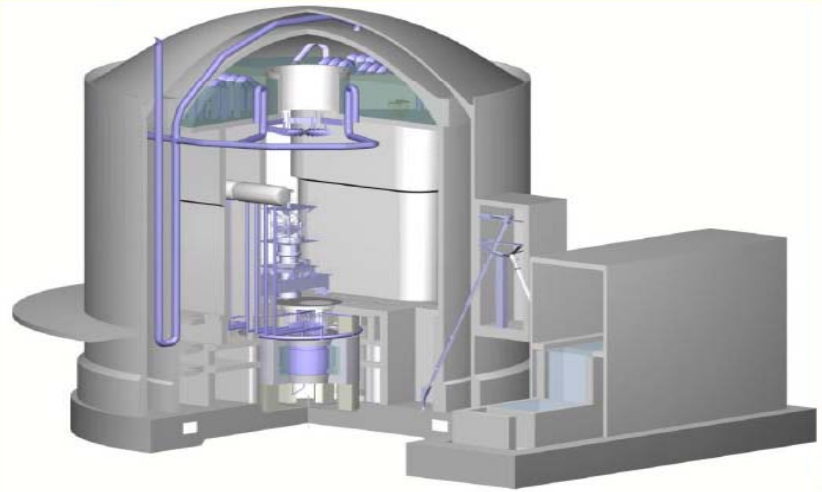
Availability of ADS can enable early introduction of Thorium and enhance capacity growth rate.

India's Advanced Reactor

Advanced Heavy Water Reactor (AHWR)

- Vertical pressure tube.
- Boiling light water cooled.
- Heavy water moderated.
- Fuelled by ^{233}U-Th MOX and Pu-Th MOX.

Technology demonstration for large-scale thorium utilization



Major Design Objectives

- Power output – 300 MWe with 500 m^3/d of desalinated water.
- Core heat removal by natural circulation.
- A large fraction (65%) of power from thorium.
- Extensive deployment of passive safety features – 3 days grace period, and no need for planning off-site emergency measures.
- Design life of 100 years.
- Easily replaceable coolant channels.

- Currently under Pre-Licensing Safety Appraisal by AERB.
- International recognition as an innovative design.

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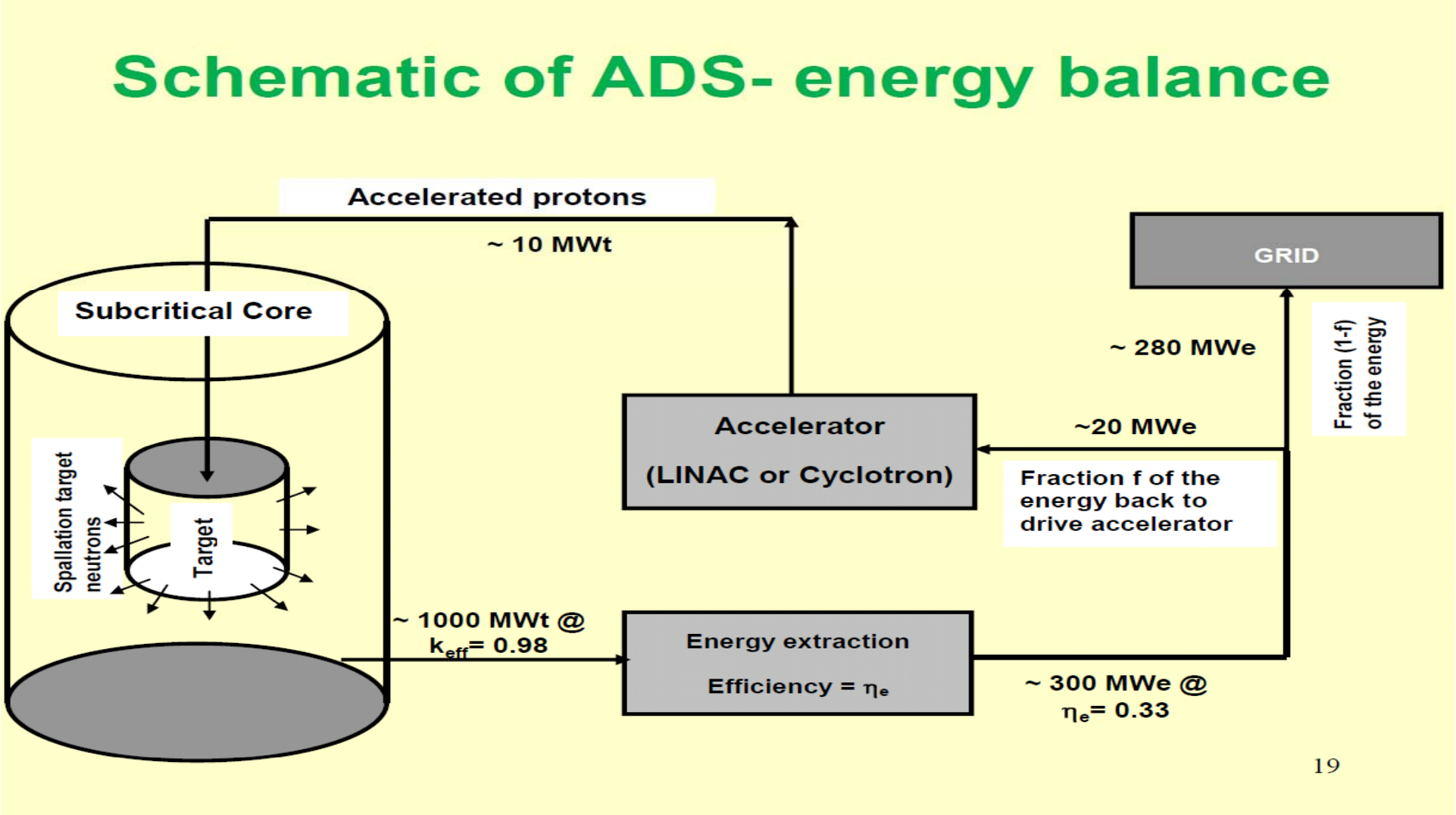
UVa-HBNI Thorium Energy Discussions

US-India Joint Development



Ingot Niobium: Frontier Technology for Nuclear Power

Ganapati Rao Myneni

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&
Department of Physics, University of Virginia

Bhabha Centenary Symposium
TIFR, Mumbai, India
December 3-5, 2009

Initial vision

- **Small Accelerator Driven Sub-critical Thorium System (AD-STS) on the grounds in the old reactor building** for **reactor physics and engineering**, **materials research and training**

- **Full fledged US facility 300 MWe AD-STS (Lake Anna – VA? or IDAHO National Lab?)**

- **Vision: India & US teams jointly work on implementing one each AD-STS in US and India**

US-India Joint Workshop Committees

Program Committee:
Jack Dorning, UVa, Chair
Ganapati Myneni, JLab/UVa, Co-Chair
Ross Anderson, VCU
Roll Johnson, Muon Inc.
Geoff Krafft, JLab
Blaine Norum, UVa
Mark Pierson, VT
Bob Rimmer, JLab
Marcos Stuart, CBMM
Bruce Vogelaar, VT
John Wallace, Casting Analysis Corp. &
Several more from Indian Atomic Energy Labs

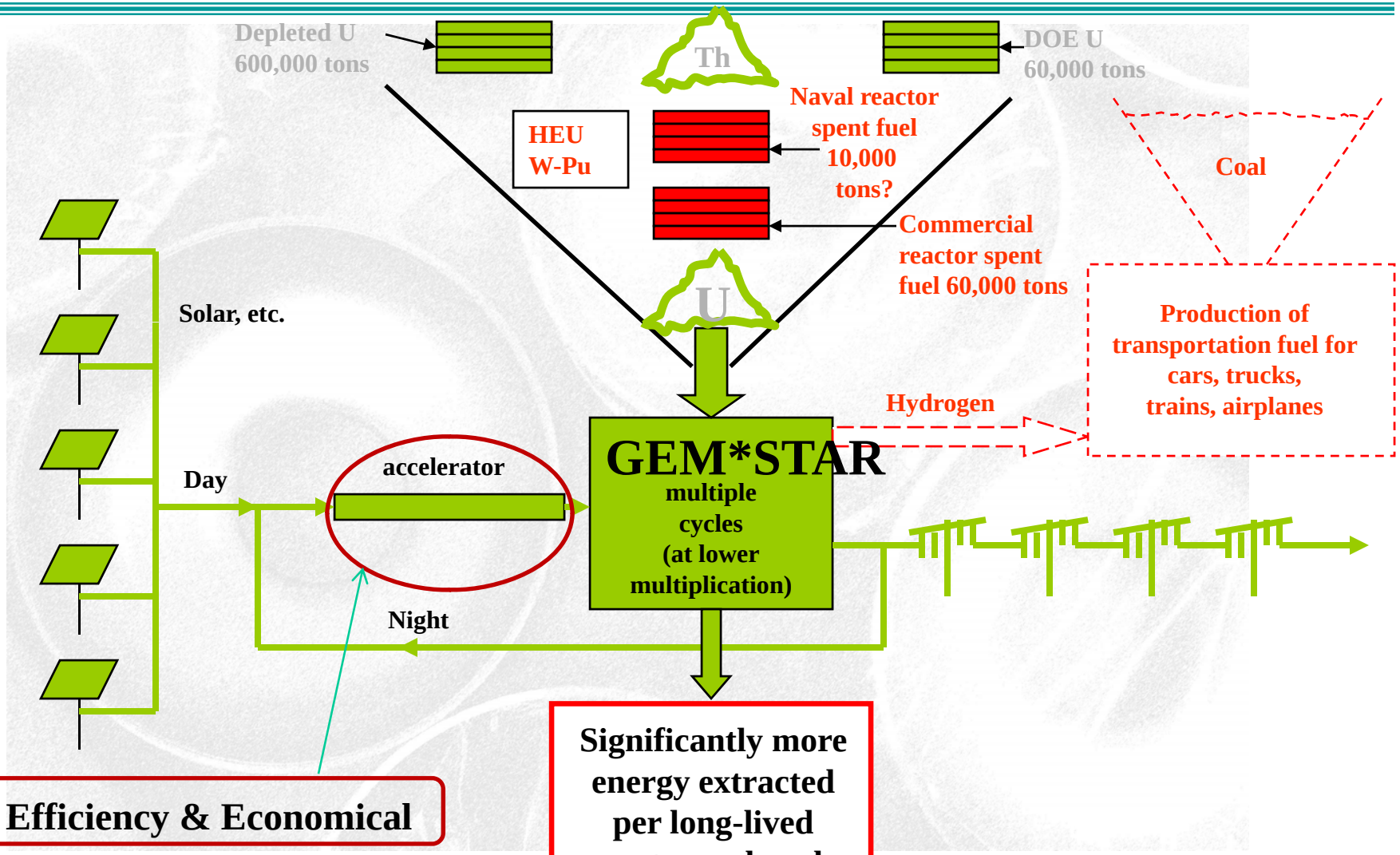
International Advisory Committee:
Srikumar Banerjee, Chairman, AEC-India
Carlo Rubbia, CERN
Jim Aylor, Dean/SEAS, UVa
Charles Bowman, ADNA Corporation
Tadeu Carneiro, CEO/CBMM
Jack Dorning, UVa
Purshottam Das Gupta, Director-RRCAT
Andrew Hutton, AD/Accelerators, JLab
Frank Macrina, VPR-VCU
Baldev Raj, Director- GCAR
Amit Roy, Director-IUAC
Ratan Kumar Sinha, Director- Reactors, BARC
Tom Skalak, VPR-UVa
Bob Walters, VPR-VT

Local Organization Committee:
Blaine Norum, UVa, Chair
Ganapati Myneni, JLab/UVa, Co-Chair
Roderick Hall, VT
Phil Parrish, UVa
Gary Tepper, VCU
Marissa Fazenbaker, (JLab Admin)
Beth Oser, (UVa Physics Admin)
Jeannie Reese (UVa Material Science Admin)

Energy amplifier and nuclear waste transmutation break out session March 29, 2010 9 – 11 am

- A review of Accelerator Driven Systems - Richard Sah, Muons Inc.
- Gem*Star Science - Bruce Vogelaar, Virginia Tech
- Gem*Star Demonstration and Deployment - Charles Bowman, Accelerator Driven neutron Applications Corporation
- High Current Superconducting Linac Accelerator Driven System – Andrew Hutton, Jefferson Lab
- Economic and High Efficiency Ingot Niobium Cavities - Ganapati Myneni, Jefferson Lab/UVa

ADNA Corporation – VT GEM*STAR
Multiple Fuel Options – Extremely Versatile



High Efficiency & Economical

Significantly more energy extracted per long-lived waste produced.