Proposal for participation at BRICS NU

ENERGY

Banaras Hindu University

Banaras Hindu University

Established	1916
Centenary Year	2016
Institutes	5
Science, Medicine, Agr. Sciences	
Management, Environment	
Departments and Centres	160

There are three aspects of the energy studies being carried out at BHU, viz.

- **Non Conventional Energy: (1) Research Activities in Physics on Energy Production, Storage and Applications, (2) Hydrogen Energy Group, (3) Energy Centre, BHU and (4) Geothermal Energy Resources and**
- **Conventional Energy: (1) To develop coal as a clean fuel**
- **Energy Security: Tackling vulnerabilities of energy supplies among countries**

- **NON CONVENTIONAL ENERGY**
- **Physics Department:**

  Energy Production, Storage and Applications
- **About 24 faculty and their research students involved in research activities addressing various aspects of Solar Cell Energy and Hydrogen Energy.**
- **Hydrogen Energy discussed separately**
- **Researchers are also focusing on the plasmonic solar cell, microbial fuel solar cell; quantum dot sensitized photo voltaic solar cells for renewable energy, thin film solar cells, etc.**

- **Developing and making novel photonic crystals which provide platform for the enhancement of the efficiency of LEDs.**
- **Development of ionic-liquid-polymers electrolytes used to fabricate rechargeable batteries that act as efficient energy storage systems. Development of polymer batteries useful in running the electric vehicles.**
- **Development of luminescent solar collectors, useful in the application of silicon solar cells. The latter are useful in the generation of green and renewable energy.**

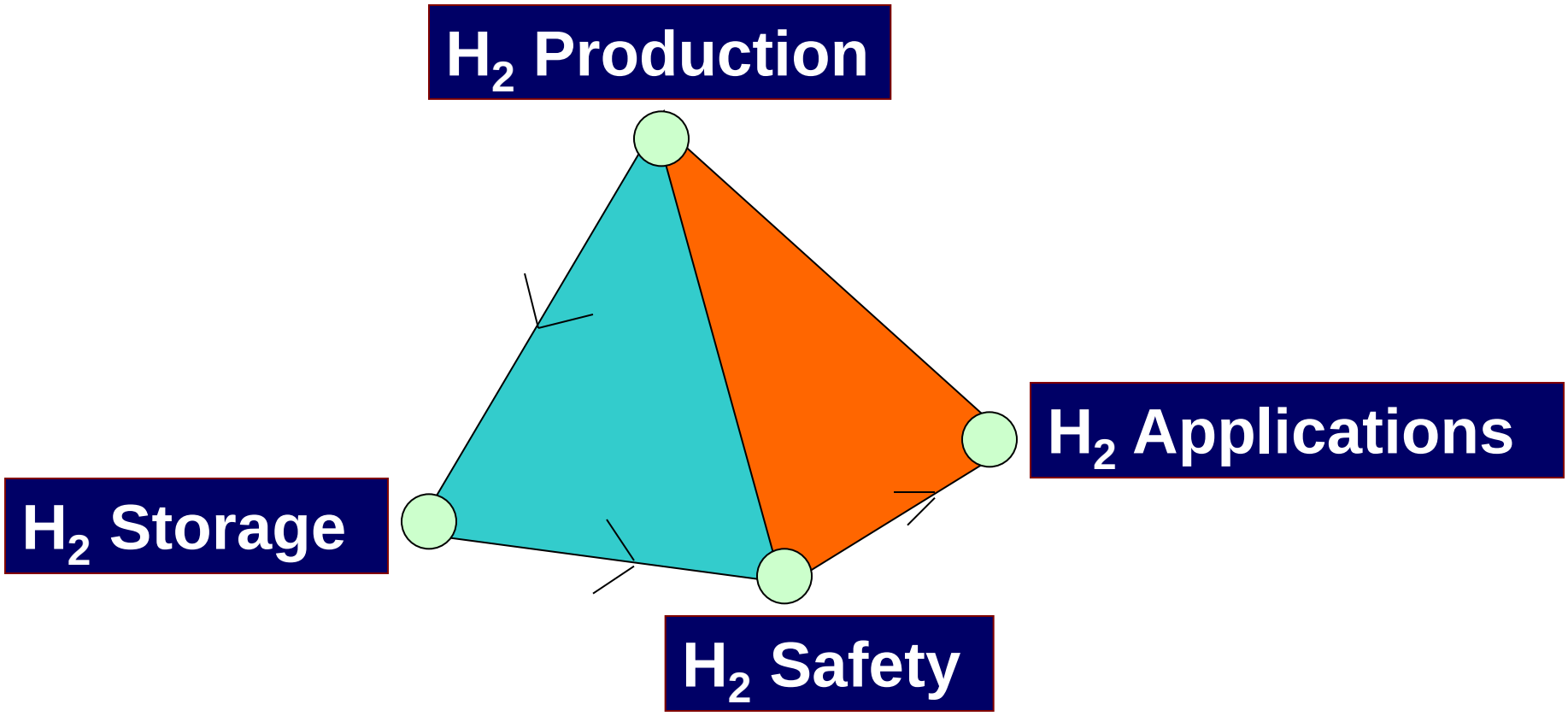
Hydrogen Energy Group (HEG)

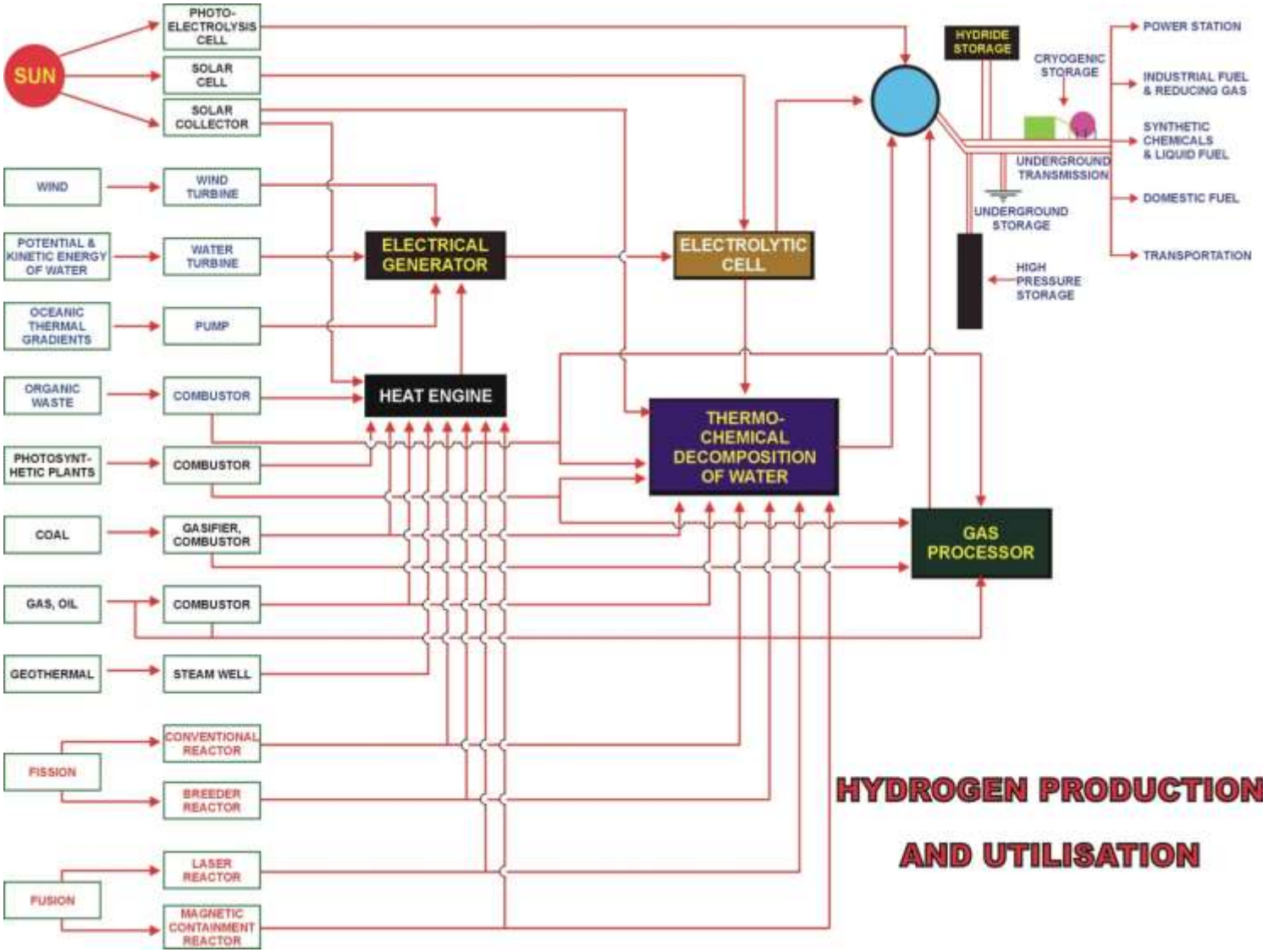
Prof O.N. Srivastava and Group

- **Researches have established that H_2 is the best fuel to combat climate change effects. Clean and inexhaustible**
- **Research Capability: 50 papers in last 5 years in international Journals. 3 R&D projects and International Collaboration Project: Obama Singh Project (C/o Prof Karl Johnson, University of Pittsburgh, USA)**
- **Hydrogen Energy: For successful deployment of hydrogen to replace petroleum and coal the crucial aspects to be taken care of are: (a) production (b) storage (c) applications.**
- **Hydrogen Production: Although 50 MT of Hydrogen is produced annually, mostly from fossil fuels viz. steam reforming of naptha. This will not solve the global warming/ climate change crisis.**

- **Best way to produce: through use of solar energy via the photovoltaic driven electrolysis, photo electrochemical electrolysis, and photo-catalytic electrolysis. Also there are several bio routes through which hydrogen can be produced.**
- **Cost of hydrogen: from fossil sources is ~Rs. 300/kg; from solar energy ~Rs. 700/- kg. The efficiencies of solar driven process of hydrogen production processes have to be increased, for making them competitive with fossil fuels.**
- **Hydrogen Storage: Hydrogen has to be stored in solid state as hydrides**
- **Applications of Hydrogen: We have developed hydrogen fuelled two wheelers, three wheelers and small car (Tata Nano car). Hydrogen stored in hydrides has been used for the purpose.**

(this also includes safety aspect, HPG storage is risky, hydride storage is safest and most efficient). Followed by (3) Applications e.g. as a fuel in vehicular transport, room warming & home cooking and several other uses .

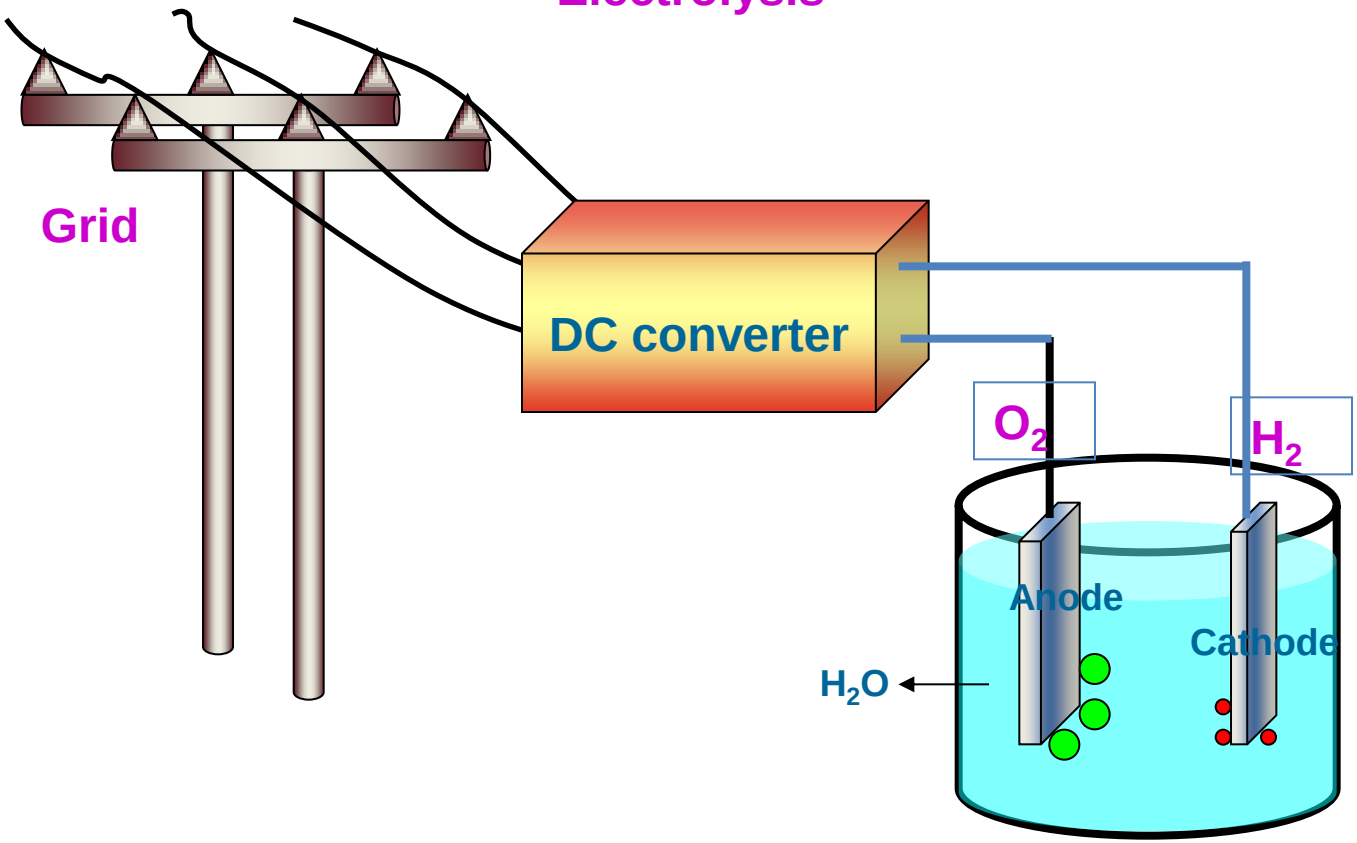




Various routes of Hydrogen Productions. **In the present project photo-voltaic driven electrolysis and photo electrochemical electrolysis will be utilized to produced Solar Hydrogen.**

Storage

Electrolysis

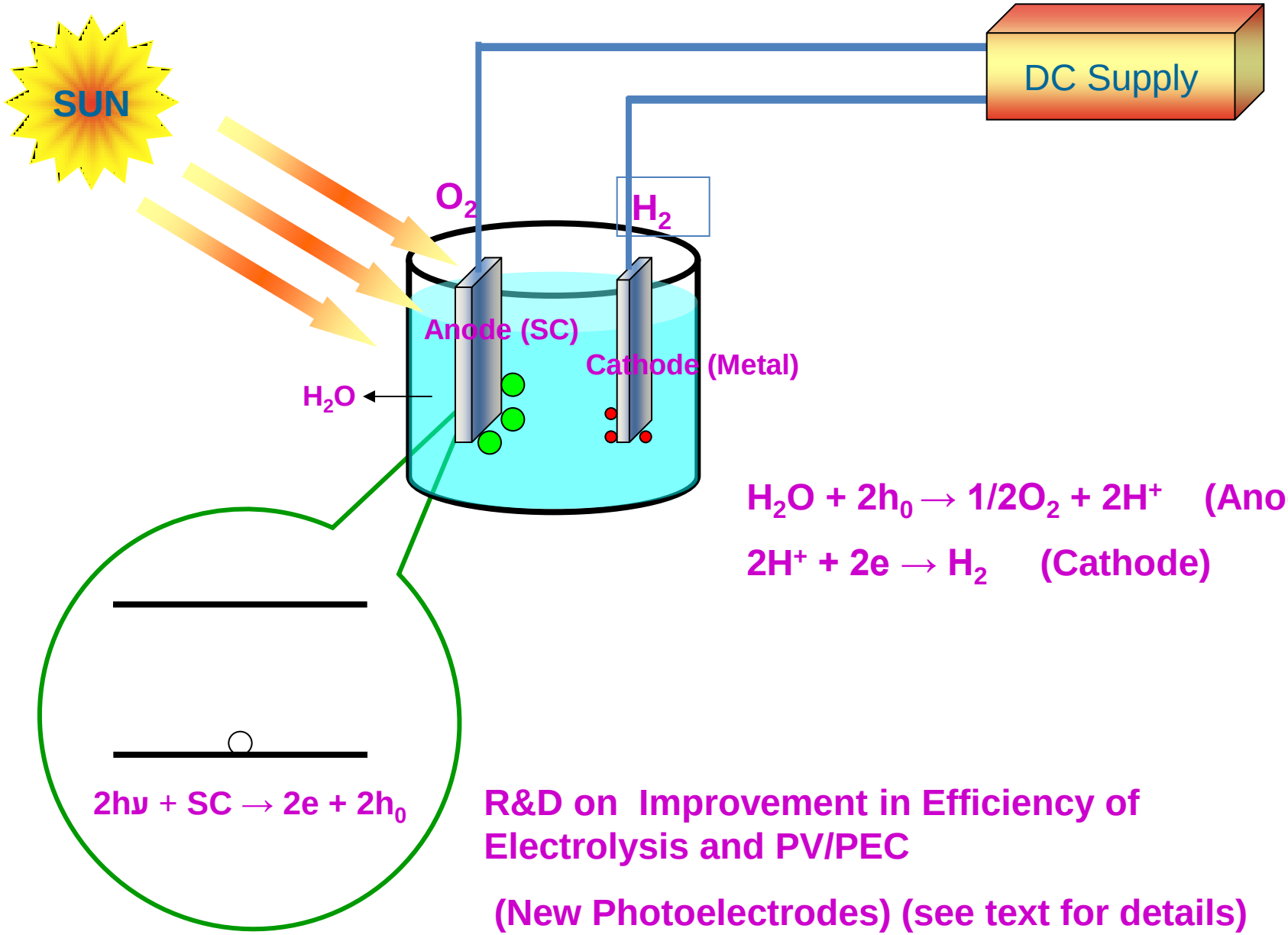


(η ~ 60%)

R&D on New Electrodes

Electrolysis using gird electrolysis. This is not viable if the grid carries electricity produced from burning of coal.

Photoelectrolytic Electrolysis (two in one process)



$H_2O + 2h_0 \rightarrow 1/2O_2 + 2H^+$ (Anode)

$2H^+ + 2e \rightarrow H_2$ (Cathode)

R&D on Improvement in Efficiency of Electrolysis and PV/PEC

(New Photoelectrodes) (see text for details)


03/09/2004

Solar Hydrogen Produced by PV driven electrolysis at HEC Physics department BHU (see text for details)

Hydrogen produced by PV driven electrolysis stored in hydride tank

Intermetallic Hydrides Vs Complex Hydride ($NaAlH_4$)

Reaction Path:

$NaAlH_4 \leftrightarrow 1/3Na_3AlH_6 + 2/3Al + H_2$ (3.7 wt.%) R(1)

$1/3Na_3AlH_6 \leftrightarrow NaH + 1/3Al + 1/2H_2$ (1.8 wt.%) R(2)

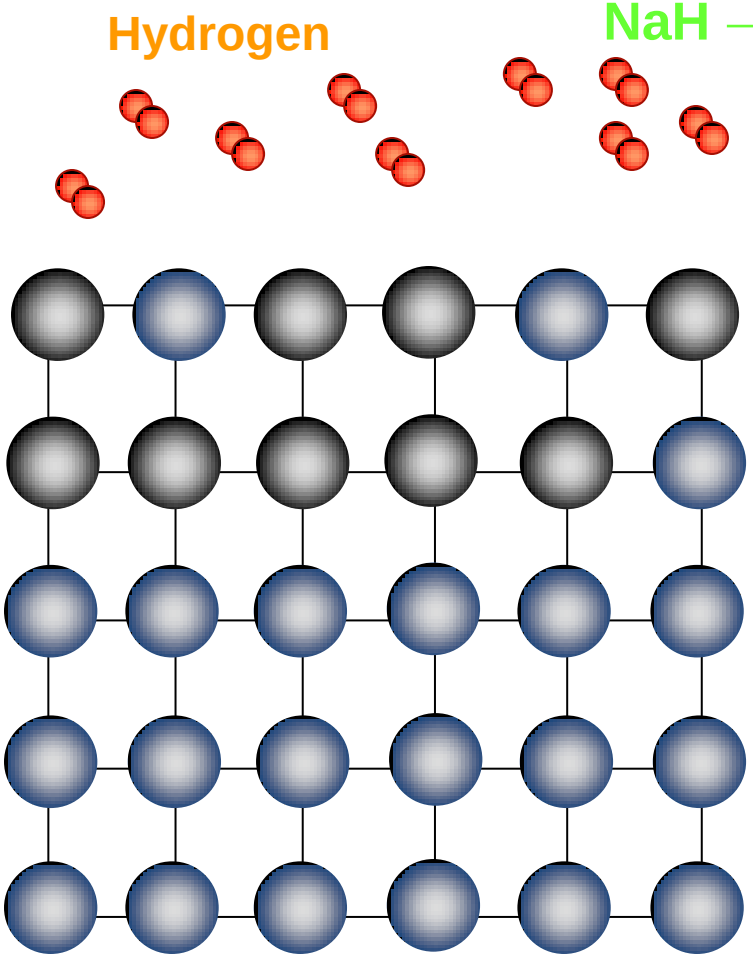
$NaH \rightarrow Na + 1/2H_2$ (1.8 wt.%) R(3)

Reaction Enthalpy:

($\Delta H = 38$ kJ/molH_2) R(1) -- (180°C)

($\Delta H = 45$ kJ/molH_2) R(2) -- (260°C)

($\Delta H = 56$ kJ/molH_2) R(3) -- (>400°C)

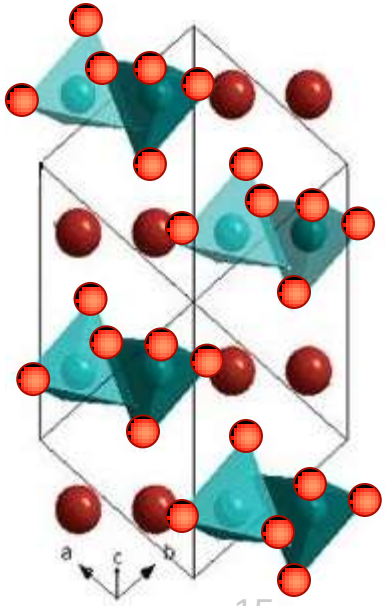


Intermetallic Hydride

Tetragonal: $I4_1/a$

a = 4.9802, c = 11.1482

In the present project emphasis will be paid on complex / built in hydrides e.g. $NaAlH_4$ and MgH_2, . These are light materials and have higher storage capacity (see text for details).



$NaAlH_4$

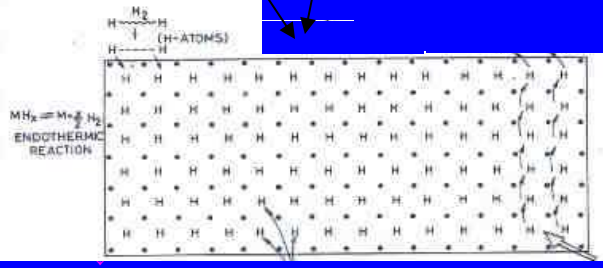
Elucidation of Hydride Storage Mode for Two Wheeler Vehicular Applications

Approximate range 60 to 80 Km in one charge

Produced from water

IC

$2H_2 + O_2 \rightarrow 2H_2O$ (water)
↑ ↑ Engine
Hydride Atmosph.



Cold Spot during Vehicle Running
Locked in Lattice
(Heat) from Vehicle Engine

Fig. 1: Hydrogen / Hydride Fueled 2-wheeler developed at BHU. Notice the schematic diagram which shows how hydrogen is liberated from hydride heat exchanger tank and fed to the IC engine. The scheme through which hydrogen is converted to steam (water) on combustion in the engine has been indicated. It can also be noted that hydride tank has been mounted by the side of the vehicle (RHS fig.) more recently it has been mounted below the seat (LHS fig.).

Process of Development of Five Hydrogen Fueled Two Wheeler Road Transport

Hydrogen Energy Centre Physics Dept., BHU


H2
H2
H2
H2

Energy Centre BHU
Initiative on
Grid-Connected solar power

- **Promote Solar Energy Integration in the Campus for Feeding Local Loads**
- **Joint Collaboration in Solar Energy for Smart Village Electrification**
- **Academic Research & Development in Association with Solar Industry towards Commercialization of new products/ devices**
- **Joint Collaboration in Training & Development on Solar as a part of Skilling India Programme**

BHU South Campus Solar PV Generation

- **Solar Power Injection of 50 MW in Grid Connected Mode – To Gain the Operational Experience of Different Technologies**
- **Clean Energy towards "Net Zero Electricity Consuming Campus"**
- **Training & Development of Rural Manpower on Solar Energy for Job Creation / Deployment**
- **Entrepreneurship Program for Students – Job Seekers to Job Creators**
- **Comparative Assessment of Performance of Different Technologies and Sharing of Best Practices through International Collaboration**

Grid-connected Rooftop solar on BHU Buildings

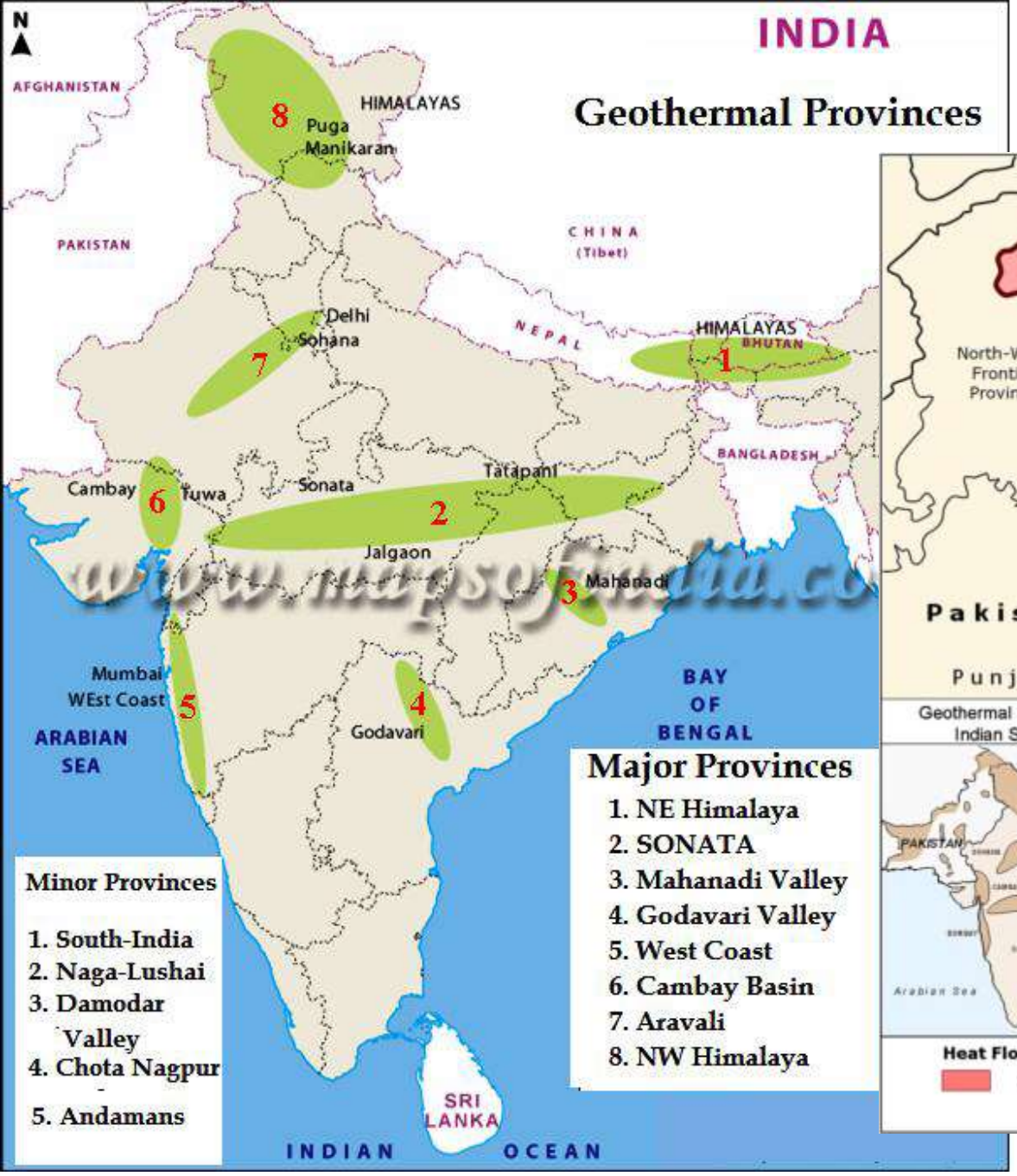
- Clean Power for “Net Zero Campus”
- Creating Awareness among Students/Faculty
- Earning Carbon Credit
- Demonstration of Benefits of Solar Power
- Net Metering Architecture for Reduced Power Bills

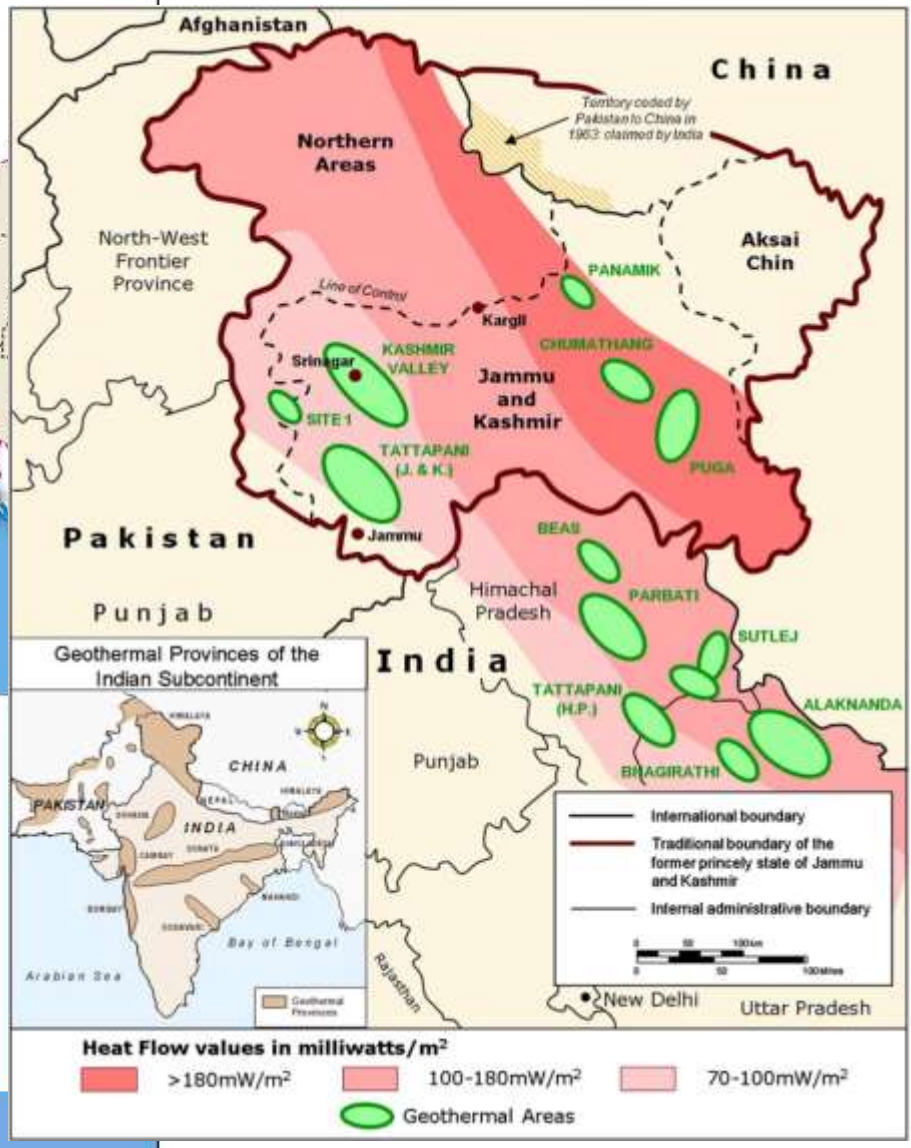
HYBRID generation (Solar & Waste Energy) in Grid Connected Mode

- **Demonstration Effect – Green and Clean Campus**
- **New Storage Technology for Renewables**
- **New Technologies for Forecasting and Scheduling of Renewable Energy towards Grid Integration**
- **Economic Benefits through Reduced Tariff**

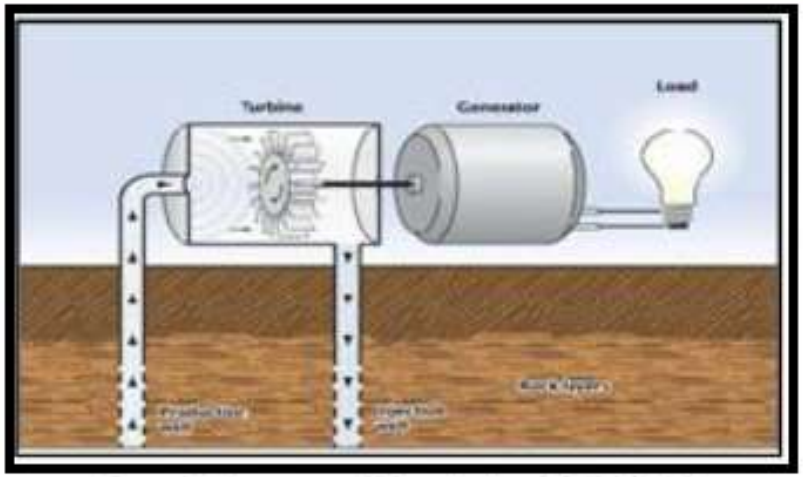
Geothermal Energy Resources
Department of Geology

- **~100 geothermal systems; >350 hot springs in the Indian geothermal provinces.**
- **Geothermal energy sources with net potential of 40x 10^{18} cal, an equivalent of 27.6 billion barrels of petroleum or 5, 730 million tons of coal energy capacity of 10,600MW (Gupta, 1995).**
- **This is 5 times the power being produced from non-conventional energy resources such as wind, solar energy and biomass.**
- **Even at efficiencies as low as 0.25%, Rs. 60 billion could be saved over 30 years with added advantage of clean energy.**

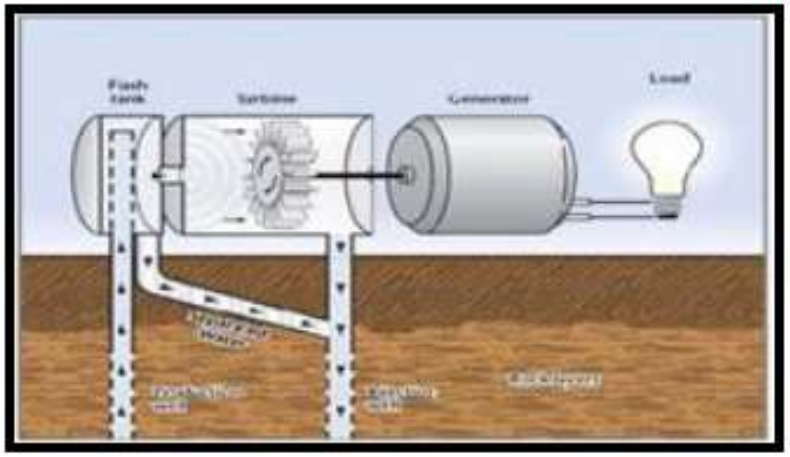




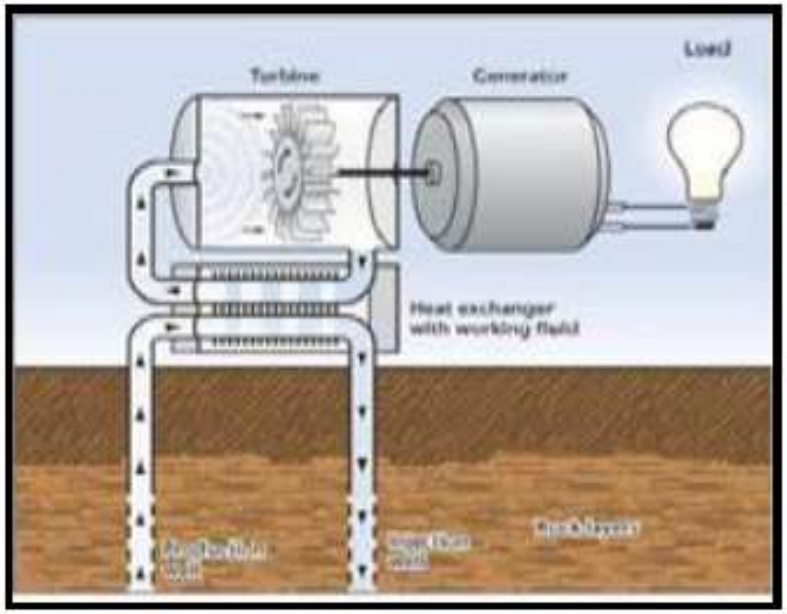
Geothermal Power Generation Technologies



Dry Steam Plant (> 270 ^{0}C)



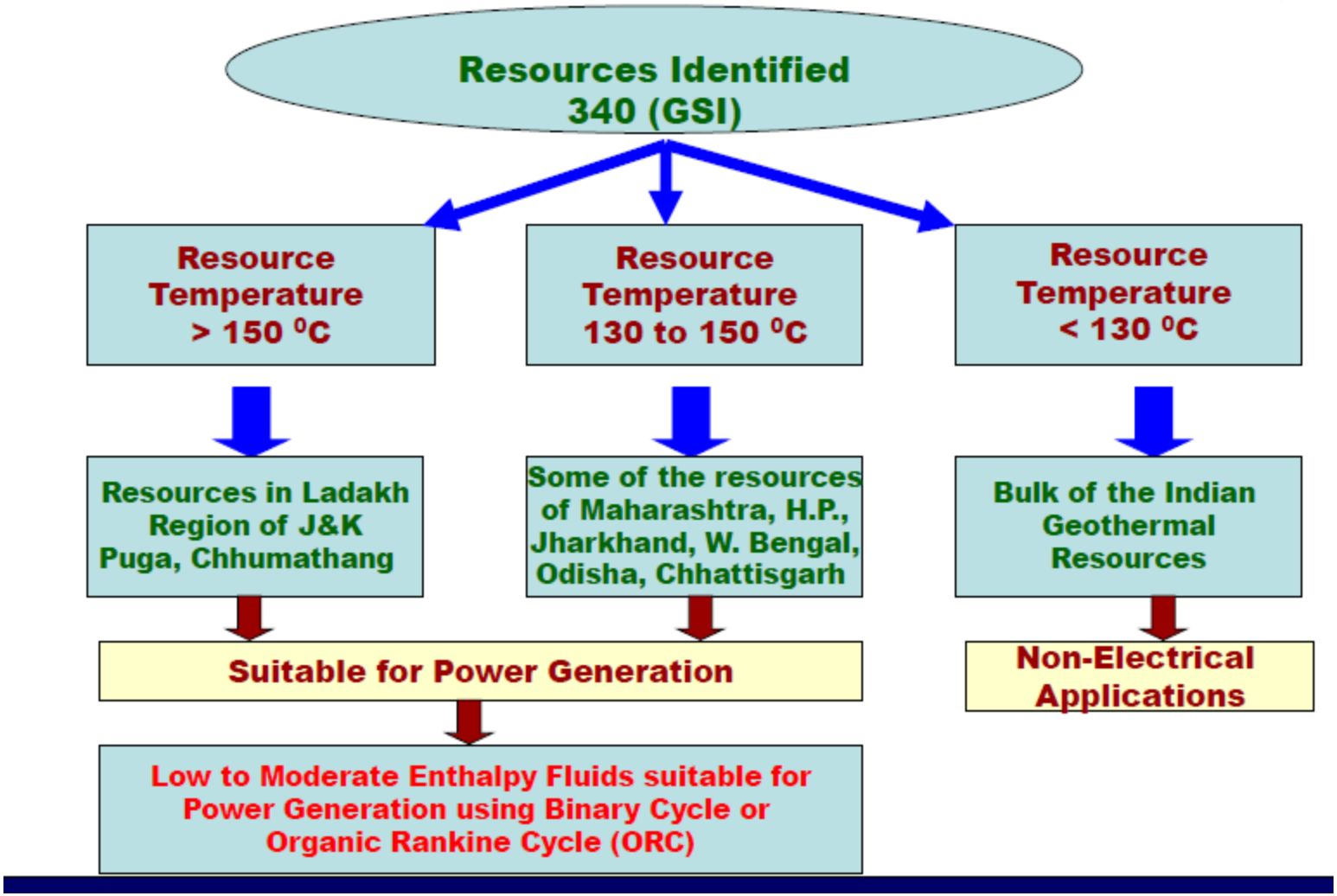
Flash Plant (> 180 to 270 ^{0}C)



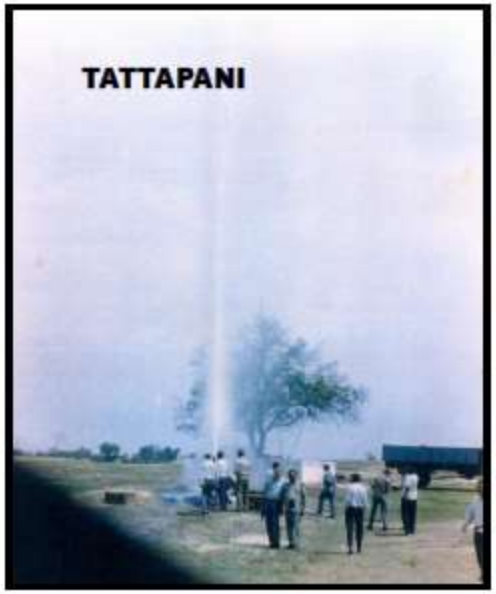
Binary Cycle or Organic Rankine Cycle

- **At temperature of 120 to 180 ^{0}C**
- **Even systems at 67 to 76 ^{0}C also harnessed using this technology**
- **Normally a downstream of Flash Plants**
- **Low B. P. Organic Fluids are used**
- **More Relevant for Indian Systems**

Types of Indian Geothermal Resources



Three Systems Discharging at B. P. or Higher



Puga, Chhumathang and Tattapani have been considered promising as:

1. **In these areas only hot springs are at surface boiling temperature or higher**
2. **Surface manifestations are very impressive, some at boiling point**
3. **These are the only areas where steam forms a fraction of the borehole discharge**

Glimpses of Geothermal Activity at Puga






Geothermal Potential of India

- Official Figure of GSI and MNRE is 10, 600 MW which is in circulation since 1982.
- This figure pertains to 113 systems identified in 1982.
- It seems the Figure may be $MW_{Thermal}$ inadvertently mentioned as $MW_{Electrical}$
- It might have been due to some calculation error too.
- The realistic potential may be about 1000 MW.
- About 30% of this may be achievable by 2020 in 11 states
- The remaining may be taken as virtual power used for heating or may be harnessed when Technology has advanced.

Realistic Geothermal Power Generation Potential achievable by 2020

State	Possible Power Potential (MW)
Andhra	25
Arunachal	10
Chhattisgarh	15
Gujarat	50
Himachal	15
J & K	100
Jharkhand	10
Maharashtra	25
Odisha	10
Uttarakhand	50
West Bengal	10
TOTAL	About 300

- **Geothermal power projects yet to see the daylight.**
- **Due to technical and logistic problems plaguing other non-conventional energy sources, present industry mood is upbeat and Independent Power Producers (IPPs) are showing keen interest in developing geothermal based power projects.**
- **With existing open economic policies of the government and the large incentive given to non-conventional energy sectors, the future of geothermal energy sector in India seems bright.**
- **The non-conventional geothermal energy from the hot springs has remained sadly neglected, largely due to easy access to 192 billion tons of recoverable coal reserves.**

Opportunities for development of geothermal resources

- **Of late, IPPs involved in NCE sources showing keen interest in geothermal energy resources, particularly due to awareness brought by the GSI and others.**
- **Advantages of one time investment, low maintenance costs, low area requirements, coupled with government incentives to the non-conventional energy are attracting many IPPs, including those involved in solar energy. The IPPs are keenly exploring financial possibilities for geothermal projects**
- **Ever aggravating environmental problems with coal based projects and unsolved logistic and technical problems of other NCE projects is likely to leave little choice for the country in future but to depend on clean, rural based cheap energy sources.**

- **It could be imprudent to ignore our 10,600MW geothermal power potential. All the medium enthalpy resources can be developed to support binary power projects.**
- **We propose to undertake integrated geological investigations to identify various viable geothermal energy resources, viz. hydrothermal, geopressurised brines, hot dry rocks and Magma**
- **We have active researchers competent in different specializations necessary to handle geothermal energy project and have published large number of national and international research papers in structure, tectonics, petrology and geochemistry that are required for handling focused geothermal energy projects in the Indian geological set up.**

CONVENTIONAL ENERGY GROUP

To develop coal as a clean fuel

The Problems

- **Coal: major source of energy; largely used in Thermal Power Plants (~66% of the electricity generation in India).**
- **Indian coals: Two distinct stratigraphic levels**
- **The Tertiary coal and lignite deposits (1%) are enriched in sulfur while the Gondwana coals (99%) contain medium to very high ash content and are enriched in a number of trace metals/elements**
- **Large quantity of potentially hazardous trace elements get mobilized into environment. There is growing realization of the impact of trace elements on the environment. The trace metals such as Cd, Cr, Co, Cu, Ni, Pb, Hg and Zn show variable concentrations in coals and are considered toxic to the biological system.**

Gaps in knowledge

- **Study of coal is mainly the area of Geologist; however, bacterial technique can be adopted in the best way by microbiologist. Desired results cannot be obtained if there is gap of knowledge with coal and microbiology.**
- **To overcome this problem the proposed project would be undertaken as an interdisciplinary work under the investigation of a team comprising of geologists and microbiologists.**

Methodology

- Quantitative and qualitative analysis of maceral and mineral matter of coal samples.
- Proximate Analysis of coal samples to know the constituents like Moisture, Ash, Volatile Matter and Fixed Carbon.
- Ultimate analysis to know the elemental concentration of C, H, N, S in coal samples.
- Digestion of coal samples with standard methods and analysis of heavy trace metals/mineral matters with the help of AAS/ ICP-MS/ XRF.
- Isolation of bacteria from coal samples by standard methods.
- Immobilization of different isolates of bacteria and of its consortia.
- Treatment of coal with different bacterial isolates.
- Estimation of sulfur, heavy metals and mineral matters in bacterial treated coal samples.

- **Aspects in which Collaboration is solicited**
- **Technology involved in enhancing the efficiency of bacteria for the removal of sulfur and major/minor/trace elements.**
- **Proposed Probable Universities:**
  - **Sichuan University (China)**
  - **Hunan University (China)**
  - **Huazhong University of Science and Technology (China)**
  - **National Research Tomsk State University (Russia)**
  - **Federal University of Santa Catarina – UFSC (Brazil)**
  - **National Institute of Research of Amazonia - INPA (Brazil)**
  - **Fluminense Federal University - UFF (Brazil)**

- **Deliverables: After completion of the Project the Report and the Technology developed may be transferred to the funding agency and at the same time the patent, if any, may also be obtained.**

- **The objective of the present proposal would be to develop a suitable ‘Clean Coal Technology’ to obtain ‘Clean Fuel’ from coal.**
- **The research group at B.H.U. has already made several experiments on coals drawn from Gondwana and Tertiary basins.**
- **Large number of publications in the leading international journals.**
- **Experiments include petrological and geochemical characterization of coals and lignites on basinal scale and their treatment with bacterial consortia and/or chemicals to leach out potential hazardous components.**

Energy Security

- **Energy Security may be referred to as an association between national security and the availability of natural resources for energy consumption.**
- **Access to cheap energy has become essential to the functioning of modern economies. However, the uneven distribution of energy supplies among countries has led to significant vulnerabilities.**
- **The IEA defines energy security as "*the uninterrupted availability of energy sources at an affordable price*".**
- **Energy security has many dimensions: long-term energy security and short-term energy security.**

- **While the former deals with timely investments to supply energy in line with economic developments and sustainable environmental needs, latter focuses on the ability of the energy system to react promptly to sudden changes within the supply-demand balance.**
- **The economic future of BRICS and it's prospects to emerge as potential Superpowers largely depends on their Energy resources and it's judicial usage.**
- **While the Big five have pledged to join hands for mutual cooperation on issues pertaining to depleting Energy resources and find ways to counter, and ensure Energy security, India being the weakest link in the Chain, cannot afford to be a drag.**

- **Here, the Role of UNESCO Chair and Peace Centre becomes all the more crucial in this threshold hour.**
- **Concentrated research to find possible ways to conserve Indian Energy Resources, ensure it's optimal usage and also educate people to justifiably utilize the available Energy resources is the need of the hour.**
- **As the University celebrates centenary year of it's foundation, it is only pertinent to explore vast terrains, open new vistas and intensify our research on burning issues like Energy Security.**

- **BHU is keen on developing short term joint training, masters and Ph.D. programmes and joint research projects in the areas outlined above.**
- **BHU also eagerly looks forward to being an active participant in the mobility of students, the university faculty and staff of the BRICS NU participants.**
- **BHU has an evolved system for facilitating exchange programmes through its 4 International Hostels and an "International Centre" catering to over 600 international students of about 65 countries. At present BHU has about 45 international MoUs, Many of which are quite active.**

Thanks for Your Time