

ject in the Netherlands. In the present situation where these technologies did not mature due to other technological hurdles, the PHWR, the heavy water reactor system is much better suited to thorium fuel than the Light Water Reactor with its poor neutron economy and without any capability for on-load fuel reshuffling.

The concept of a PHWR started with natural uranium, gradually leading to a self-sustaining ^{233}U + thorium cycle by passing through a plutonium–thorium intermediate stage is nothing new. Our studies have shown that such a self-sustaining fuel cycle started with no external supply of fissile material will increase the PHWR-based nuclear capacity by about 50% compared to what can be achieved with the same quantity of natural uranium used in the once-through mode. What is more important to recognize is that the energy that one can extract by going into Th– ^{233}U mode in PHWR is many times larger than without it. One should not confuse the question of growth with energy potential. For growth we need to breed fissile material fast. For realizing the energy

potential of nuclear resources, we need to develop thorium utilization capability. We need to do both. When talking about thorium we are concerned with the latter.

4. It is clear that early generation fast reactors should use ^{239}Pu – ^{238}U fuel system to enable faster growth of fissile material. That does not preclude beginning with thorium utilization which is equally well done in thermal reactors with perhaps much lower cost.
5. With the hypothetical situation of unlimited availability of fissile material, the question of whether one should opt for reprocessing the discharged fuel or go for a high burnup once-through cycle depends on many considerations. However, as far as comparison between PHWR and LWR is concerned, what can be said with absolutely no uncertainty is that a thorium fuel cycle is far more beneficial in a PHWR than in a LWR for the simple reason that all the neutrons that are absorbed by hydrogen and by the various reactivity regulating materials in a Light Water Reactor with its shut down refuelling will be profitably absorbed by ^{232}Th to produce ^{233}U in a

PHWR where the deuterium that is present, instead of its lighter isotope hydrogen, does not absorb neutrons. Besides, in a PHWR with its on-load fuelling there is hardly any excess reactivity that is nullified by neutron absorbing poisons.

Further, from a long term perspective, the recycle option which we are adopting is environmentally far more benign as compared to the option of permanent disposal of fuel.

Thus, in summary, we have to reiterate that thorium has a very important role to play in the Indian nuclear power programme, and as far as its use in thermal reactors is concerned, there is no doubt that thorium is better used in heavy water reactors than in the light water reactors. Even if the high pressure coolant heavy water is replaced by light water due to other considerations, heavy water is certainly the better moderator that can give higher mileage out of thorium – not light water.

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SRO spy scandal – An unending witchhunt

s individuals associated with the country's space programme over the last twenty years and more, we are deeply concerned about what has happened and continuing to happen to one of our fellow scientists S. Nambinarayanan. We are choosing this route to express our concern because of our inability to intervene meaningfully in the complicated chessboard of moves and counter-moves that seem to make inevitable the continued persecution and traumatization of a valued colleague.

Many of us have known 'Nambi' for over twenty years. He was the leader of the team of engineers sent to France for acquisition of liquid rocket technology. He led with great ability, ISRO teams entrusted with the responsibility of delivering the second and fourth stages of the

PSLV project. He was also for a while the leader of the cryogenic engine project. Like all of us, 'Nambi' may have his share of virtues and faults, but we have always appreciated his deep commitment to technology development in the interests of ISRO and the nation. The arrest and interrogation of Nambi in the so-called ISRO espionage case and the attendant newspaper publicity have done immense damage to his morale and even more damage to his innocent family.

The CBI investigation completely absolving S. Nambinarayanan of any wrong doing and the verdict of the Chief Judicial Magistrate, Ernakulam discharging all the accused in the ISRO 'espionage case' are now on record. However the clearance recently accorded by the Kerala High Court to

further investigate the case will drag Nambinarayanan and his family through another period of misery. From the record and the evidence behind the 'espionage case', there appears to be no basis for the continued harassment of a person whose innocence has been proven. The reasons for our statement are summarized below.

The major allegation against Nambinarayanan was that drawings and documents relating to the Viking engine and cryogenic technology were handed over to foreign/enemy countries in exchange for large amounts of money in US dollars, and that these took place at three different locations (Madras, Bangalore, Trivandrum) in January, June and September 1994 on specified dates and times.

The detailed investigation by the CBI established:

- that the alleged meetings between the various accused never took place, and the various accused were present elsewhere on the specified dates and times;
- that no documents were handed over;
- that no documents were seized from anyone;
- that an independent ISRO investigation also revealed that in the case of both the cryogenic and the Viking engines, no original drawings or documents of any significance were lost or were missing;
- that no documents of any kind or computer compatible tapes of any kind were shipped out of Trivandrum;
- that no money transactions took place.

The CBI investigations also reveal:

- that Nambinarayanan never met Ramon Srivastava, S. K. Sharma or the two Maldivian women;
- that accusations against Nambinarayanan regarding financial gains from espionage are baseless and as a matter of fact, his life style is very close to that of a poor person;
- that a lie detector (polygraph) test administered to Nambinarayanan by the CBI validates that he was speaking the truth.

There is therefore no evidence to prove that espionage ever took place or that documents or money exchanged hands or that the accused including S. Nambinarayanan benefited financially from these dealings. *In view of the evidence on record, oral as well as documentary, it seems clear that the allegations of espionage have been found to be false, and that the espionage story, both in its genesis and subsequent development had no basis in reality.*

As people who have been associated with technology development in India, we have not been able to understand the logic of what is supposed to have happened in the 'espionage case'. Clearly the acquisition of technology by any foreign power is quite a complex process. Experience indicates that even when drawings are acquired under open

technology transfer agreements, their transformation into working hardware takes time, expertise and large financial outlays. The Maldivian women involved, their mode of entry into India or their activities, seem to be inconsistent with the aim of acquiring sensitive technology by any interested foreign power. ISRO does not classify working level documents as secret, top secret or confidential. An internal investigation carried out by ISRO has shown that there are no original drawings related to the Viking or cryogenic engines missing. In fact, in this case, even fabrication drawings, which ISRO routinely passes on to industry, are not missing.

In order to make out an offense under Section 3 of the Official Secrets Act of 1923, there must be sufficient evidence on record to show that any person acts in a manner prejudicial to the safety or interest of the state. Subsection 1 of Section 3 goes on to elaborate what these 'acts' are. We presume that the alleged offense involves:

- approaching, inspecting, passing by or being in the vicinity of a prohibited place;
- making sketches, plans, models or notes which might help the enemy directly or indirectly;
- obtaining, collecting, recording, publishing or communicating to any other person any secret code, password, sketch, plan, model, article, note or other documents or information that is of direct or indirect use to the enemy or which relates to the matter the disclosure of which is likely to affect the sovereignty and integrity of India, the security of the state or friendly relations with foreign countries.

The conclusions of the CBI investigation mentioned above have shown no evidence of any such acts. Indeed searches made by both the Kerala Police and the CBI have revealed no incriminating material or receipt of money from or by Nambinarayanan.

It is clear, that in this case, in view of the facts and circumstances and the legal position, no offence has been committed under the Official Secrets Act by Nambinarayanan.

Like many large organizations, the space organization tends to suffer from

petty jealousies and professional rivalries that get translated into personal animosities. These 'internal' problems have so far not spilled over into national scandals involving personal lives and reputations. The 'espionage case' reveals that the country's space programme, or for that matter other strategic programmes, may no longer be immune to outside interference. These dangerous trends, if allowed to continue, can demotivate and demoralize the many hardworking and dedicated professionals who have made Indian achievements in these areas possible, usually for paltry compensations. Such actions are likely to derail these programmes and adversely affect the national interest more severely than any foreign hand.

The espionage case has now been going on for more than two years. The personal life of an important contributor to the space effort like Nambinarayanan has been given a rude jolt if not ruined. His family has been victimized and socially ostracized. Clearly he has suffered greatly and it is time that this 'charade' is brought to an end so that a hapless victim of the so-called espionage scandal can get on with what is left of his life and career. We trust and hope that good sense will prevail and that further harassment of a valued scientist will cease.

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