# Commentary on Varun Sivaram's Scientific American Article "THE GLOBAL WARMING WILD CARD" by David Earnshaw

The purpose of writing this commentary is to promote the development and deployment of the Liquid Fluoride Thorium Reactor (LFTR, "lifter") as the optimum primary energy platform for India going forward.

India and other countries in the developing world have been able to bypass land-line development by adopting cell phone networks. India has the opportunity to do the same for meeting its major energy needs going forward using a very different type of nuclear power, the LFTR. When developed and deployed these reactors would allow India to eliminate all its fossil-fueled power generation in ways that wind and solar alone cannot. Wind and solar are incurably intermittent, with too low a power density to do the job. Also, they presently need large-scale grid development and backup with natural gas generation.

The LFTR does not use water for core cooling, so it operates at atmospheric pressure. There is no need for a large pressure dome to contain the reactor. This is a huge cost saving both in use of materials and time of construction.

The LFTR is a breeder reactor that, once started with U235 or Pu239, breeds its own U233 fuel from thorium. There is no need for the expensive fuel enrichment or fuel rod fabrication required for conventional reactors. India has thorium reserves for hundreds of years.

The LFTR thorium fuel cycle produces much less and much less radioactive waste than conventional reactors, with radically shorter storage time to neutrality.

The LFTR is inherently safe. The avoidance of core cooling water makes safe shut-down simple, requiring no operator intervention. Had they been LFTRs, the Three Mile Island, Chernobyl, and Fukushima Daiichi reactors would never have made the news.

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The article's introduction is straightforward – no comment or disagreement.

Page 50, paragraph 2:

". . . and a widespread attitude that India, as a developing country, should not have to reduce its carbon emissions and should be able to grow using fossil fuels as other major countries have done."

India can reduce its emissions drastically by adopting the LFTR reactor as its primary power source. LFTRs would replace coal as a fuel: using fossil fuels would be irrelevant.

Page 50, paragraph 3:

"Despite the lofty rhetoric of India's leaders, their vision of a clean energy future is far form assured."

We will use this commentary to explain why the LFTR would go a long way to make this vision a reality.

Page 50, paragraph 4:

“if it adds coal power at the rate needed to keep up with its skyrocketing demand, for example, its greenhouse gas emissions would double by 2040.”

The brightest star in a pantheon of choices is the LFTR, by far. When you examine its multiple advantages, point by point, it overwhelms all other choices.

Page 50, paragraph 5:

“Yet India is in some ways starting with a clean slate.” . . . “ most of India’s infrastructure has not been built yet. The country has a choice to invest in power from wind, solar and natural gas rather than coal.”

Wrong solution! Wind and solar simply cannot do the job. With increasing wind and solar development it will become glaringly obvious that integration into the grid will become impossible without large-scale backup with natural gas. LFTRs can readily accommodate base load *and* peak load 24/7/365. The bad press that nuclear power has received by pursuing conventional reactor technology has poisoned the minds of many people.

Page 50, paragraph 6:

“Primitive and dirty sources dominate India’s energy mix. Two thirds of households continue to rely on cow dung patties, straw, charcoal and firewood for cooking and heating – nearly a quarter of the nation’s electricity, and half of the country’s industries burn coal to generate heat needed for processes such as steelmaking. Oil drives nearly the entire transportation sector.”

Penetration by LFTRs into the cities and the countryside would alleviate much of the dependence on primitive sources with cheap electricity. As electric vehicles are developed, cheap electricity could replace much of petroleum use as well. The LFTR operates at 700°C, and could replace coal and natural gas for most industiral process heat.

Page 50, paragraph 7:

“In addition to climate change, they contribute to urban smog; 10 of the 20 most polluted cities in the world are in India. Coal plants consume large volumes of water.”

LFTRs would solve both problems. They don’t produce CO2 or smog, and they can be run without water for cooling. Air-cooling can be utilized exclusively, at some cost of efficiency.

Page 50, paragraph 8:

“As costs fall, renewable sources of electricity are increasingly cost competitive with coal.”

The cost may be coming down, but that is really a red herring. No matter how cheap, renewables have inherent flaws that make them unacceptable for large-scale generation of either electricity or process heat. There is no way around intermittency except very expensive storage or fossil-fuel backup. Robert Bryce in his book “Power Hungry” states that every megawatt of wind and solar will have to be backed up with a megawatt of gas-powered generation. Their costs could fall to zero and

they still couldn't do the job. LFTRs are as green as you can get. India's thorium reserves would virtually assure LFTR operation for centuries.

LFTRs could be much smaller than conventional reactors and sited much nearer to their markets with much less grid development.

Page 50, paragraph 9:

"The grid does not even reach more than 300 million Indians. Millions more who are within reach lack reliable power because the grid is in shambles, longer–and certainly in no condition to accept an influx of energy from solar or wind technology."

A LFTR energy platform would require far less grid building than wind, solar, gas, or coal. LFTRs emit no GHGs or other pollutants, and much smaller plants could be "snuggled" into areas where no other current generation sources would fit. This much broader distribution would require much less grid building, and the savings over conventional nuclear construction could pay for it.

Page 50, paragraph 10:

"Chronic construction delays also rule out a major role for nuclear reactors"

Dr. Sivaram casually dismisses any role for nuclear by citing construction delays. The vastly superior design of the LFTR solves virtually all of the objections levied against conventional nuclear power.

LFTRs could be licensed by design and assembled in factories. A LFTR could be shipped to its site on a semi-truck and be up and running in a matter of weeks.

Page 51, paragraph 11:

"To meet its 60 percent target, the government's biggest intention by far is to expand solar and wind to 350 gigawatts by 2030. Of this, 250 GW would come from solar, which would exceed 80 percent of all solar capacity currently in existence around the world. Though ambitious, this target is increasingly realistic thanks to the plunging cost of solar power, which in India has dropped by two thirds in the past five years."

There is no mention of the unavoidable costs of gathering this low-power-density resource (wind and solar) or of paying a terrible price for its intermittency, either for storage or fossil-fueled backup. It would take 25,000 4 MW wind turbines to provide 100GW if they could provide power continuously. With a realistic duty cycle of 30% it would require 75,000 turbines and an equal or larger storage or back-up capacity to achieve 100GW.

500, 200MW LFTRs would provide the same amount of power 24/7/365 for both base and peak loads. A LFTR is readily load-following so that demand can easily be matched with supply, continuously. Process heat could be diverted easily to water purification or other tasks during periods of low electricity demand.

Smaller reactors, inherent safety, and small site requirements will make LFTRs much easier to integrate into the areas of need than any other large-scale source.

Page 51, paragraph 12:

“Indians are fond of pointing out that the telecommunications industry was able to “leapfrog’ from very little landline infrastructure to a widespread mobile phone network. By analogy, they argue, India should be able to leapfrog the lack of a fully deployed power grid and adopt local solar power that does not need a national grid.”

The analogy does not hold here because you still need grid based distribution, unlike cell phone networks. Telecommunications are not plagued with low power density and intermittency. My cell phone is much more reliable for communication than my solar array is for consistent power generation.

Page 31, paragraph 13:

“Meanwhile, distributed solar panels and batteries, especially when networked together as a microgrid that can serve a neighborhood, hospital or data center, can make the entire system more resilient.”

Electrons simply hate to be jammed together (stored). The best battery technology we have is still totaly inadequate in storing electrical energy. Despite the great advances in battery technology, it is still way short of being able to store large amounts of electric power. A 3× or 4× improvement sounds great until you realize that if you only have a 0.1% capability, a 4× improvement leaves you with only a 0.4% capability.

Page 51, paragraph 15. Natural gas:

The arguments in this paragraph are cogent and accurate; natural gas is cleaner without solid residue, and it still produces CO2. As mentioned, it would require a large pipeline build-out, and most of the gas supply would have to be imported. India is “awash” in thorium. The microgrids that would compliment LFTRs would be easier, and less expensive.

Page 51, paragraph 16. Natural gas:

The arguments in this paragraph would be more plausible if one just substitutes “LFTR” for “Natural Gas.”

Page 51, paragraph 17. Natural gas:

For now, natural gas. As soon as possible, LFTR.

Pages 51-52 paragraphs 18 – 21. Efficiency:

Efficiency is a “low-hanging fruit” concept, aptly described. We have no argument with emphasis on efficiency. However, you need “megawatts” not “negawatts” to do useful work, and India needs the best possible source, the LFTR.

Page 52, Paragraph 22. Transportation:

“But the country could aggressively invest in charging infrastructure to make electric vehicles more attractive, helping renewable power to reduce vehicle emissions.”

LFTRs will provide the cheapest, safest source of power far into the future. No other source will come close to aiding the electrification of India's transportation sector without emitting greenhouse gases.

Page 52, paragraphs 23 and 24:

"The government is also aggressively deploying solar panels to power 200,000 irrigation pumps by 2019, en route to ultimately converting all 26 million pumps–which run on diesel fuel or the power grid–to solar power."

Solar water pumping makes more sense than most other applications because it bypasses the need to store electrons. The product provides its own storage, so to speak. Still, small LFTRs deployed in a widely distributed system might still be the optimum solution.

There is a side issue here that is very important: What is happening to the aquifers that are being drained by 26,000,000 pumps? Are they being recharged or exhausted? Cheap power from LFTRs would go a long way in purifying and moving water from where it is plentiful but useless (salty) to where clean water is desperately needed.

Page 53, paragraph 25:

"Quintessentially Indian obstacles block easy execution of a clean energy strategy."

Mr. Sivaram's observation here is equally cogent to the general problem of LFTR development.

Page 53, paragraphs 26:

"Already bankrupt utilities cannot afford to upgrade the ailing grid, stuck in a vicious cycle of undercharging customers for electricity, going into debt, and failing to maintain the grid or to combat rampant power theft."

LFTRs will be the cheapest source of power, hands down. Power companies can keep prices low enough and make penalties for theft high enough to reduce theft. LFTR power plants can start small (low initial capital cost), can be built quickly, and added incrementally (ganged) as needed.

Page 53, paragraph 27. Financing, land use, and regulation:

Reasonably managed LFTR projects could be done quickly, on time and within budget. Land use, compared to wind and solar is a non-issue. Long distance power lines will be not be necessary, and microgrids associated with LFTRs, while necessary, will be much easier to plan and manage.

LFTR regulation is an obstacle worldwide. LFTR design is so much different from solid-fuel, water-cooled reactor design that new (much less complicated) regulations will be required. This would be an ideal effort for international cooperation.

Page 53, paragraph 28:

"Another Modi initiative–to repeal wasteful subsidies for consumer fuels–succeeded in raising the prices of gasoline and diesel but has stalled on raising cooking gas and kerosene prices because of political backlash."

The easiest way to eliminate subsidies is to provide an alternative that needs no subsidy. LFTRs would go a long way in providing cheaper fuels. This would also free up government funds to further deploy the more useful power source. LFTRs would provide process heat to refineries and coal-to-chemical plants with no greenhouse gas emissions.

Page 53, paragraph 29:

"Finally, the Modi administration's tax on coal mining companies has raised the ire not only of coal firms but also of their customers, . . ."

Governments face a real headwind when they tax the use of something that does not have a viable alternative. The *real* alternative to coal is LFTRs, not wind and solar.

Page 53, paragraph 30. Policy changes:

We would agree with all, or nearly all of the content of this paragraph if every power source mentioned were changed to LFTR. The benefits of adopting LFTR energy are so profound they are hard to imagine.

Page 53, paragraph 31. Help from abroad:

"Some signs are encouraging: India has partnerships with the U.S. on clean energy research and development, with Germany on financing grid infrastructure and with multilateral development banks on deploying renewable energy."

All these activities are laudable if applied to the right technology. India should work with the U.S. on LFTR development; India should work with Germany on financing microgrids associated with LFTRs; India should work with multilateral development banks on deploying LFTRs.

Page 53, paragraph 32. International cooperation and assistance:

We are in complete agreement with the ideas in this paragraph. Just realize that there will be a vast difference in the outcome depending on the choices made; India needs to choose LFTR.

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