A Vital and Safe Energy Source - Nuclear Fission

Dr. Allan M Salzberg for Congress, Republican from District 1

If President Obama does not authorize a policy which views Nuclear Energy as perhaps the only Energy Source that can solve our coming Energy Crisis, we can be due a future shock far worse than the present financial crisis. Our economy and our civilization are based on a supply of energy that is reasonably abundant and not excessively priced.; without energy our civilization cannot exist. The only way to address this economic reality is through the use of Nuclear power, in particular, Fourth Generation Nuclear Reactors. Renewable energy (Wind, Solar, Hydroelectric), while useful, can produce only a small fraction -- perhaps up to 20%-25% -- of our Electric power. In addition, large Wind and Solar Plants are often are not near where they are needed. Consequently, the cost-efficiency loss and environmental impact of high voltage transmission must be factored in as well as the cost of needed back-up power plants and means to store energy. Today, and for the foreseeable future, the only sure technology that can avoid this looming disaster, are Gen 3 or 3+ reactors followed by Fast Neutron reactors (Gen 4 Reactors). In view of this, it would be imprudent to put all of our eggs into a "renewable" basket ".

We need an intensive R&D effort analogous to The Manhattan Project or Apollo so that by 2020, we need to phase out the construction of 3rd generation plants and move to 4th Generation Fast Neutron Reactors, as they are the only approach that in the time allowed, that shall provide the requisite energy, removes both the threats of proliferation and nuclear wastes. These concerns have also been raised by Joe Shuster in his book **Beyond Fossil fools; his web site is** http://www.beyondfossilfools.com/, and Dr. Hayden in **"The Solar Fraud**" clearly shows the problems if we decided to rely primarily on Wind and Solar. The following analysis is for the USA.

Solar and Wind and bio-fuels cannot produce enough energy to power our country economically for many years, if ever. These factors are generally ignored when enthusiasts talk about their costs. Advanced Nuclear Energy could well have a lower ecological impact than vast arrays of windmills and solar collectors. It takes about 4700 Large Wind Generators to produce the power of 1 Nuclear Plant and the wind turbines will use up to 10 times the materials such as steel and concrete than a Nuclear Plant. Both wind and solar power requires both a back up plant and means to store energy for when the sun doesn't shine or the wind does not blow. This changes the costs for these energy sources. Maintenance costs for the wind turbines due to the environment they are placed could be considerable, and wind turbines cannot extract more than 59% of the wind's energy [1]. Solar could be very useful on hot summer days when demand soars; local solar power could well alleviate expensive to generate peak electric power. Furthermore centralized power plants need far less capacity than would individual generation capacity.

There are those who claim that we should get renewable energy from tapping ocean currents such as the Gulf Stream. Not only do we not have a complete understanding of the ocean currents, but it is at least possible that this could turn off the Gulf Stream which would be catastrophic and plunge Europe into an ice box.[2] This energy clearly

[1] Betz's Limit
[2] Private communication, David Salzberg PhD SAIC

while renewable could be far riskier than Advanced Nuclear Power.

The plan to impose a Carbon Tax (Carbon Credit), close Yucca Mountain, not expand domestic oil supplies, and not recycle spent nuclear fuel is already causing power companies to make decisions that, if extended, could lead to a future where energy is at a premium, While Wind, Solar, and Hydropower will be of great help, producing 33% of our electricity, they will not be nearly enough.

The imposition of any Energy Tax will render our industry non-competitive, cripple the economy, and could lead to trade wars (Secretary Chu's ideas of what to do to countries that do not follow our lead by choice or ability may lead to trade wars). However, in the absence of proven Carbon Sequestration, no new coal plants should built, and extant ones should be gradually phased out. Both coal and oil will always be valued as feedstocks for our chemical industry. In the advent that a Carbon Tax (in any of its incantations), I suggest the following amendment. "**If a company invests in Nuclear Energy, it should receive a dollar for dollar credit against any tax. Nuclear Energy does reduce our Carbon Footprint."** There are special small countries that might obtain over 59% of their electricity Wind. The too need standby power (and/or costly Energy storage. This is in large subsidized for Wind coupled with very high taxes for conventional power. While this can induce the necessary investment, it does have negative effects on other parts of Denmark. You cannot obtain something from nothing; installing the sophisticated sea-based huge 2 Watt Generators is expensive. In the North Sea maintenance is difficult, and the turbines are difficult to service. There have been fatalities. They are in areas where Ice buildup is significant, and lightning is a problem

Unless other countries do the same to reduce Green House Gasses, these costs could injure our ability to remain competitive, and industries could move to countries without these taxes, leading both to more job loss, and greater world-wide emissions of Greenhouse Gasses; a lose-lose scenario. Furthermore, there is a group that actively believes that we must eschew our present energy intensive civilization and/or believes in decentralized energy production. They oppose and any means that redresses the energy problems especially if they solutions are large scaled systems.

President Obama stated that he is not opposed to Nuclear Power provided that it is shown to be safe, and the waste problem manageable. The safety issue I believe has been solved. There were no radiation deaths or severe radiation exposures in civilian US Nuclear Plants for over 5 decades. I was a Flight Surgeon aboard the Enterprise (CV-65), and it has had no nuclear injuries in 49 years, and it has 8 reactors. Chernobyl was aberrancy as it had no containment dome, and they turned off safety programs. At Three Mile Island, there were no injuries.

The new Generation 3 reactors are even safer and cannot melt down. They are not dependent on complex active machinery to quench the reactor in an emergency; rather they are designed so that that passive methods would control severe problems. Pressure Domes have been found to be able to withstand the impact of a fully loaded 757 (including fuel). A detailed computer simulation showed that, there would be some damage some damage, but the dome would not be breached. At 3 Mile Island there was minimal damage to the containment vessel. In actual tests, this was confirmed.

This leaves only the waste problem. It has already been shown that the Administration will virtually end funding for Yucca Mountain. They also appear not to want to pursue reprocessing. Then they will say "the nuclear waste problem is insolvable". Waste is far more of a political problem than a technical one. Reprocessing[3] spent nuclear fuel can markedly reduce the waste problem. Further out by 2020, the introduction of 4'Th generation fast neutron reactors will further reduce the problems with waste. In fact, the spent fuel of earlier generation reactors can be used to fuel the 4'Th generation reactors that also eliminate long lived actinides[4] found in the spent fuel. Only short lived fission products result, and they only need to be stored for 300-500 years at which time they are gone. There is enough waste than can fuel these Advanced Reactors, that we might not need to mine uranium for these reactors for over a century.

It was Carter who in 1977 unilaterally stopped both our reprocessing efforts and the Fast Neutron Breeder Reactor. Later 1n 1994, Clinton closed a program for Fast Neutron Reactors, a decision that was wrong technically and actually cost the taxpayers more to close than to complete. The 2006 Democratic Congress would not fund fast neutron reactor research asked by the Bush White House. There was then a mistaken belief that these new reactors could increase the possibility of diversion. In reality, the reverse is true. Current reactors do produce Plutonium; 4th Generation reactors can be designed not only to not produce Plutonium, but also uses present wastes that contain Plutonium as fuel. By contrast, France obtains 80% of its inexpensive electricity from Nuclear Reactors, and has safely reprocessed spent fuel for over two decades. The effect was to self eliminate our technological advantages. Today we are also-rans and must scramble.

Reprocessing the fuel reduces its volume that needs storage by over 90%. Furthermore, most of the waste after reprocessing using the URE[5]X process that will have much shorter half lives than the present mix. Thus, Yucca Mountain can hold many more years of waste than it presently can, and the radioactivity of this waste would be virtually gone in under 500 years. If it becomes necessary, long lived actinide waste can be now be separated and destroyed in Accelerators or in reactors, or later used by Fast Neutron Reactors.

Presently, the waste needs to be isolated for up to 100,000 years as it contains Pu 239 which is highly toxic and is fissionable. It has a half-life of about 28,000 years. This magnifies the problems of safe storage. Also in the future this plutonium might be mined as a source of fissile material. The previous paragraph shows a highly desirable option. Reprocessing (at least isolating the fission fragments) will greatly increase the amount of useful uranium and other fuel elements that no longer would be thrown away. Advanced systems can use over 99% of the potential energy in the fuel. Today's reactors, with a one pass fuel cycle (no reprocessing) extract less than 0.7% of the potential energy. This efficiency will be needed in the future as the supply of affordable Uranium will run out by the late 21st century if we do not go to Fast Neutron Reactors. Also there are limits to the number of cycles of reprocessing as with each cycle in a conventional

[3] While PUREX reprocessing leads to a buildup of Plutonium, the far better UREX Process does not

[4] Elements whose atomic number exceeds 88, are actinides. These wastes need containment for millennia The element with the highest naturally atomic is uranium whose atomic number is 92

[5] The UREX process does not produce a product that can be used for bombs; Furthermore reprocessing can be co-located with reactors. In fact this plus 4th Gen Reactors actually burns the actinide wastes , and in particular induces Plutonium to fission

reactor produces more isotopes of Pu 240, 241 which eventually poisons the fuel. This limit is avoided in Fast Fission Reactors as they burn all the fuel so that all Plutonium isotopes are burned.

This leads to a rational dual staged program. Initially, Stage 3 (or 3+) higher temperature standardized reactors are used. This cuts costs and legal challenges[6] as the plants would be almost identical. The fuel is reprocessed into two fractions. One is a combination of actinides[7], Uranium + Plutonium; while the second is comprised of fission products. Some of the plutonium produced in the reactor, fissions to provide energy.

The reprocessed fuel is then used to produce energy[8]. Reprocessing does increase costs; however, the costs will be mitigated in the future as fuel will be more available. In any case, the reprocessing costs should be less than other proposed ideas, and nuclear power should remain less costly than natural gas. Also, there would be no CO2 released, and its costs will not be subject to the vagaries of the cost of natural gas.

Once efficient 4th Generation Fast Neutron Reactors become available, they can be deployed. Since some designs of these reactors can produce more fissile fuel than it consumes, we could have an industry that could provide power for millennia[9]. Even if a breeder reactor design is not initially used, these reactors could produce the needed power for many centuries giving us time to evolve to better energy sources such possible as Nuclear Fusion. Fast Neutron Fission Energy is possible as long as there is Uranium 238 or Thorium on Earth which can be burned in these advanced reactors; this gives us billions of years of fuel which compares to the time when an enlarging sun with engulf the Earth.

Our present generations of reactors do not cause U238 to fission, and U235 is only 0.7% of all the uranium on Earth. The fast neutron reactors can cause U238 to fission, and they can actually use stored uranium and actinide wastes for fuel, further mitigating the problem. The only wastes that these advanced reactors produce are small amount of fission fragments that will decay in less than 500 years.

Given the state of the art, markedly increasing the amount of energy produced by Nuclear Fission is today the only reliable way to achieve the requisite carbon dioxide reductions while attaining energy security and maintaining our economy. This is especially true as projections indicate a 20% increase in energy use by 2020. Furthermore, the money (originally stated as $600 Billion- is now stated by the White House to be a staggering $2 Trillion) generated by the proposed Carbon Tax (Carbon Credits) will unfortunately not be used for energy development; rather, it would be used for more income redistribution.

---

[6] There has to be a limit on frivolous law suites. Standardized reactor design should limit this attempt to prevent Nuclear Technology. Because of the high capital costs, these nuisance suited drive up the cost. Perhaps it should be required that:
A: Once a suit is adjudicated for 1 of many identical reactors, it should preclude identical suits on the same or approximately the same site.
B: Winner wins, loser pays the winner's costs

[7] Any element whose atomic number is greater than 89 is an actinide.

[8] France has safely used reprocessed fuel for decades

[9] Actually eons

The relatively short half life of the fission fragments that makes up the reprocessed nuclear waste opens up a plethora of storage options. This is due to it only has to be isolated for a few hundred years. Encased waste could even be stored on dry, isolated land. Deep ocean burial of the encased 'short lived waste' becomes safe and feasible. Examples of this are ocean trenches and subduction zone as they would be isolated for thousands of years, much longer than the time it takes the waste to decay.

These 4'TH generation plants operate at a sufficiently high temperature allowing them to thermochemicaly liberate hydrogen from water at an efficiency approaching 75%, a far more efficient process than electrolysis. This would be economical, and the resultant hydrogen could power planes, trains and automobiles further reducing CO2 Emissions. The high operating temperature increases the efficiency of electricity production by at least 25%, as compared to our present reactors. These features increase the amount of energy that reactor produces, resulting in significant economic savings. More importantly, by 2030-2040 the availability of conventional energy, other than coal, will decrease; there will be the twin specters of water and food shortages that can bring down our civilization. Fast Neutron Reactors represent the only probable means of avoiding a world where energy is scarce[10]. The specter of extremely limited energy is a far worse threat than global warming. It could actually when coupled with fresh water and food shortages bring our technological civilization to an abrupt end[11]. However, both can be controlled with the wide spread use of Nuclear Power; both conventional reactors, and later 4th Generation Fast Neutron Reactors. Using the correct reprocessing techniques (UREX not PUREX) and the right cycle, the danger of fissile wastes becomes infinitesimal. These advanced reactors are far more secure than present reactors as they do not need to make Plutonium 239. In fact the actinides will be consumed in the reactor.

When I finished graduate school in 1963, Fusion was 30 years out; today it is still 30 years out. However by 2060 commercial fusion might reality. If so then it could supply the grid. They will be probably be extremely expensive to build; in this case Fast Neutron Reactors would play a part. Theoretically the most economical use of early fusion could

[10] One future possibility is geo-synchronous solar power stations; these are virtually always in a more intense sun. However, at present they are nor practical due to costs. Launch costs would have to drop by at least a factor of 5 to be economically viable. Plasma, electric or nuclear propulsion, with high ISP would then be able to move the station to geosynchronous orbit so that for every 4 Kg in low orbit, 3 Kg would lifted to geosynchronous orbit. If a conventional propulsion system such as hydrogen/ oxygen were used, only 1 Kg would be delivered to high orbit. I can conceive of a future scenario where energy beamed from a working POWER SAT could provide the requisite energy to boost a low orbit station to high orbit. This bootstrap approach could markedly reduce overall costs to obtain synchronous orbit. Also the amount of pollution due to the vast number of launches must be reduced say by using H2/O2 rather than it be aided by solid fuel boosters that give off hydrochloric acid, aluminum oxide, CO2 plus other products. This is needed as the mass of the POWER SAT is extremely high. It is a far less probable solution than Fast Breeder Reactors, and its timeline is further out. To make it competitive, launch to low orbit has to markedly reduce its cost. Funding for inexpensive methods for lifting large objects to near earth orbit must have significant R&D on a fast track. One possibility might be to have the first stage be a ram jet that could fly to at least Mach 5 at 90,000 feet. If we can develop SCRAM JETS, the launch vehicle could attain velocities of MACH 10, and would be more efficient and possibly less costly. Once this is reached, the rocket booster is launched. The aircraft then returns to base. Care also is needed to ensure that a POWER-SAT IS not weaponized.

[11] This energy can even eliminate salts and toxic materials from irrigation water. This will preserve and renew the irrigated lands which otherwise will eventually go fallow because of salt buildup.

be to produce Pu 239 by neutron capture for use in a Fast Fission Reactor. This could be done with Fusion-Fission Hybrids. If a more desirable technology becomes available, we can switch to it. 4th generation reactors can keep us in clean energy till that time arises, if ever.

Construction costs must be kept under control. One suggested method is design standardization that allows plants to be economically replicated. This could also reduce endless litigation which pushes up costs. The government needs to help financially to guarantee construction loans as they do now, as financing can be difficult do to the perceived uncertainties. About 20 years ago, Bonneville cancelled several reactors and somehow were allowed to not pay their bondholders.

Closing Yucca Mountain, long a goal of Senator Harry Reid, coupled with backing away from reprocessing, is a political statement, not based on science or technology. Unless reprocessing or in 4'Th generation fast neutron reactors are employed, and alternate storage sites are defined, these actions will over time cripple our economy and reduce our standard of living. It will also make us less competitive as a country.

We must begin to immediately deploy Generation 3 (and 3+) reactors[12] while initiating an intense R&D program designed to accelerate the production of safe, economical Generation 4 nuclear power stations; so their deployment can begin deployment by 2020. The 3RD Generation Reactors are needed now to mitigate possible man induced Global Warming and to ensure 30 years from now, we will still have sufficient energy. They are needed for the transition time before enough Generation 4 reactors can be built. The wastes they produce (outside 5% fission fragments which are gone in 300-500 years) will be used for fuel as soon as the Fast Neutron Reactors come on line. Remember, energy is the key to solving many other coming problems such as fresh water availability and food whose lack can disrupt our civilization. Construction of a Nuclear Power Plant will employ about 1500 workers, while somewhere between 500-1000 workers would be needed to run it. Doing the right technical thing saves and creates jobs.

These policies could provide true energy independence in the years 2030-2040, and markedly reduce or perhaps eliminate our balance of payments problem that economically is equivalent to paying a tax to foreign governments. It will also help stabilize the world as we will no longer be competing for a piece of a dwindling conventional energy supply. Unless we attain energy independence, we could well be drawn into military conflict as nations compete for the dwindling energy supply that is absolutely essential. If we follow the path outlined above, we could be energy independent by 2035-2045.

The cumulative cost for Nuclear to supply about 70% of our electricity by 2040 would approximate $0.7 Trillion. This is less than bailouts or the stimulus bill. Also we no longer would have to import Petroleum or Natural Gas whose savings would rapidly pay for the deployment of the Nuclear Plants. The respective costs if we used entirely Wind or entirely Solar would approximate $2.1 Billion and $7,0 Trillion. If we added transportation to the energy requirements the Nuclear option costs would increase to $2.9 Trillion

[12] Even the founder of Greenpeace now believes in the need for Nuclear Energy

which still is in the range of possible. If we tried to accomplish this with Wind or Solar, the respective costs would be a staggering $8,.7 Trillion and $29 Trillion, staggering amounts Going further so that all energy including the heating of houses, and industrial use the respective cost estimates, in trillions of dollars would be 2.9, 8.7 and 29.. Clearly Generation 4 (Fast Neutron Reactors) is the most efficacious route to Energy Independence. .Even the highest, and most ambitious undertaking is doable over our 30 year time line, and could be recovered in less than a decade of importing Petroleum. We would be energy independent for almost the life of the planet. In addition there would be no generation of CO2.

There should be global cooperation to protect nations and to minimize diversion. This plan GNEP (Global Nuclear Energy Partnership) was suggested by President George Bush, and it limits where the needed reprocessing can take place. These countries would then supply the needed reprocessed fuel to the country that sent the fuel for reprocessing. This could help the world to be free from both wars over limited energy supplies. To accomplish this goal, we must begin now!

This, in part, was published in the Idaho Statesman as an OP_ED piece.
Allan M. Salzberg MD, PhD
President, Calcudos.com Inc.
10671 Sandpiper Street
Boise ID 83709-1249
5/8//2009
208-321-1860
208-867-9814 (cell)
Calcudos@hotmail.com
There are two other items that needs to be at least noted when discussing energy. First, no matter what some zealots say, oil will be a significant source of both energy and as a petrochemical feedstock for decades. In addition, we have a severe and persistent trade deficit that only saps our economic strength. Increased dependency on foreign oil not only is a large contributor to this deficit, but it puts us at strategic risk. If we were cut off from foreign oil, our strategic reserve would have less than 2 months supply with present consumption. We must reverse the present policy, and “Drill Now, Pay Less”, not to necessarily make us energy independent but to both redress our strategic vulnerability and to reduce our balance of payments deficit. Our present drilling technology allows a minimum footprint as horizontal drilling is possible. Today natural oil seepage, not drilling, is the main source of petroleum ocean pollution. To buy the requisite time, we should also utilize our vast resources of shale oil.

Secondly, if the government, by means of a severe “Cap and Trade” or “Carbon Taxes” rapidly obsoletes coal plants, they would lose their economic value. This could bankrupt power companies creating an even greater economic debacle than our present one. We must be aware of all unsuspected dangers that such plans could engender.

Latest polls indicate that a majority of Americans favor both nuclear power and expanding our domestic oil supply. It is imperative that we seriously conserve energy by Increasing gas mileage, plug-in-hybrids, all electric cars, insulation and modernizing the grid, etc. These are essential components of policies that move us toward energy independence and energy availability. However with 240 million cars on the road whose lifetime is 14 years, these efficient cars will take between 7-10 years to have a serious

impact. Appliances are similar. We can and should to improve houses efficiency; however, there also are limits on what is practical. In areas where the peak energy use is during the hot summer hays, individual solar photovoltaics could have a significant effect on expensive peak power demands. Conservation stretches out the timeline, but is not enough to solve the energy problem. We will need inexpensive, inexhaustible energy that minimizes greenhouse gasses and other pollutants. We must start now!

APPENDIX A- COMMENTS FROM THE LITERATURE

Nuclear power would help the world and in particular the USA to meet the Commitments made at Kyoto. Nuclear power would also be a simple way of avoiding the health effects of air pollution. But for neither do we need the breeder reactor immediately. We may need reprocessing and the breeder reactor for other environmentalist reason: the perceived objections to disposal of high level nuclear waste. I believe that these objections are technically unsound, but they are psychologically real and it is unlikely that they will disappear in the short term. The problem of nuclear waste might be changed if the volume were changed and if its long lifetime was reduced by transmutation. This could be plutonium recycle, burning in a **fast neutron reactor** (but not breeding until it were necessary), or accelerator transmutation. It is these environmentalist issues that may eventually demand the breeder reactor, assuming that the cost, safety and proliferation issues can be solved.

Breeders for the Longer Term

For a time horizon greater than 50 to 100 years a breeder reactor is probably essential. After this time there may well be a large population increase, and if fuel use per capita in developing countries approaches that of developed ones, a huge appetite for electricity. Since more of the energy in the fuel can be used it would be economic to use fuels with costs much more than US $200 per tonne. All in all, a factor of 1000 increase in effective fuel supply seems not unreasonable. It would be impudent to project the existence of the human race beyond the 100 000 years implied by these factors.

The cost estimates for a liquid metal breeder reactor are certainly smaller than the cost estimates for a fusion reactor, and are (and may remain) smaller than for renewables. A breeder programme deserves by this reckoning at least as much funding as the fusion reactor which is still far in the future. But it may be desirable (although not necessary) in the intermediate term also. It is now 50 years since the start of the nuclear age and it can be said that we are only just beginning to understand how to make a viable LWR

Changing Need for a Breeder Reactor- 10 Uranium Institute Annual Symposium 1999
Wilson. A breeder reactor development programme (including real operating demonstration plants) may give enough experience to overcome some of the cost (and weapons proliferation) problems and enable us to have the safety and environmental advantages of a metal fuel reactor and a coolant that soaks up stray fission products.
Conclusion
Allowing for a price increase of 0.5 US cents per kWh to enable us to use more expensive uranium ore, it appears we could have a future for nuclear power at several times the present level for 50 years without a breeder

reactor, and possibly for many, many more. Any large scale breeder programme must be justified on a longer time scale or on definite cost or environmental advantages. It would be wise to redirect any research programme to these ends. After perhaps half a century it would be wise to be ready to use breeder and other alternate fuel cycles.

Another Comment:
At least 8,000 times more Uranium can be usefully mined using current reactors (10,000 years). Entire crust is minable with Advanced reactors (Hundreds of millions of years)
A fourth generation reactor would:
 help the world and in particular the USA to meet the commitments made at Kyoto.
 Nuclear power would also be a simple way of avoiding the health effects of:
 air pollution
But for neither do we need the breeder reactor.
 But we may need reprocessing and the breeder reactor for another
 environmentalist reason: the perceived objections to disposal of high level[13] nuclear waste. I believe that these objections are technically unsound, but they are psychologically real and it is unlikely that they will disappear
 If successful will provide energy indefinitely
RENEWABLE LIMITATIONS
 However it's not clear that these[14] can meet all our energy needs.
 Hydro is basically exhausted in Australia and faces environmental concern elsewhere
 Biomass cannot supply both food and fuel in many parts of the world. (Current energy use is 10% of total global photosynthesis)
 Wind is not suitable for large scale base-load generation. (Plus is more expensive.)
 Solar-electric is also not suitable for Base-Load generation. (Plus is also more expensive.)
 Limited availability for Geothermal

FRANCE'S PLANS
2. *Innovations for LWRs Fuel, Systems*
1. Development of Fast Reactors[15] for sustainable nuclear with a closed fuel cycle along 2 tracks:
 Sodium Fast Reactor (SFR
 Gas Fast Reactor (GFR)
 New processes for spent fuel treatment

[13] A 4th generation fast neutron reactor plus reprocessing to isolate the short lived fission products would suffice
[14] Renewable energy sources (this was taken from an Australian research report)
[15] These are 4th Generation Reactors. This can be modified into a fast neutron breeder. These reactors greatly increase the availability of fuel. Doomsday critics who say these is not enough Uranium (or Thorium) are incorrect once we field these advanced fast neutron reactors