

The Honorable Ken Salazar
United States Senate
702 Hart Senate Office Building
Washington, DC 20510-0607

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Dear Senator Salazar:

Thank you again for your thoughtful and personal reply to a letter I sent you a year and a half ago about the "hydrogen initiative". I have continued to be concerned about our energy future, and have been investigating an alternative approach to nuclear energy which may remove most worries about its use with much less technical difficulty than the long-sought fusion reactor. This is the "energy amplifier" or accelerator driven reactor proposed by the Nobel prize winner Carlo Rubbia and others over ten years ago. Its development continues in several countries, but we hear very little about it in public discussions in this country. I am sending the note below to you and to others in the hope that it may be taken more seriously and given higher priority in research and development. Please forward this to anyone you may think has the time and expertise to look into it carefully, as a possible means to a publicly acceptable source of abundant energy to complement renewable sources.

We have nearly all read the recent United Nations report on global warming. It makes clear that a lot of damage has been done, and that the effects will be severe even if immediate action is taken. The report is a somewhat conservative compromise; the consequences may very well be much worse. Note that it only used studies up to a couple of years ago and recent information suggests catastrophe especially for sea levels. I dread the report promised for April or May which will outline the consequences for humanity.

I have been an enthusiastic backer of renewable energy sources such as solar, wind, and perhaps ethanol (but not from corn!) and biodiesel, and above all conservation. I'm unable to get enthusiastic about coal and CO₂ sequestration, because of other environmental costs. However, there is still a need for "baseline power" and a total use of electric power well beyond the above sources. Lately I've been learning about a promising approach to nuclear power, which I think could be a critical part of curtailing carbon dioxide emissions. (I'm one of the lonely few pro-nuclear environmentalists; only recently have I been getting a lot of company!) See this Cosmos magazine article ¹ from Australia about a thorium-based reactor which requires a 1 GeV proton accelerator to keep it running; a small fraction of the produced energy is needed to run the accelerator but the reactor turns off when the accelerator is turned off. No Chernobyls! It also produces much less radioactive waste, in fact can be used to "burn" waste from uranium reactors. It's quite nuclear proliferation resistant, using thorium it may be impossible to make a bomb (from produced U-233) because of accompanying high radioactivity; furthermore the addition of natural uranium to the thorium could "adulterate" the U233 requiring expensive isotope separation to make a bomb, one might as well start with natural uranium (like Iran). But perhaps most attractive is the use of all the natural thorium, unlike uranium where only a fraction of a percent (the U-235) produces the energy, unless a proliferation-prone "breeder reactor" is used. About 700 kg of thorium can produce the same power as 29,000 kg of natural uranium in a conventional reactor. Thorium is about three times more common than uranium, as plentiful as lead or molybdenum, and with less residual radioactivity when mined. It could provide thousands of years of energy, including the use of electrical power or perhaps direct heat to produce hydrogen vehicle fuel. Upon reviewing several papers and commentaries I find a lot of skepticism but also work progressing in several places, especially Italy (Rubbia's project) and India (with large thorium resources). In the USA it's a seldom mentioned component of the "Advanced Reactor Concepts", directed primarily toward "burning" nuclear waste and some other more fully developed "fail-safe" reactor designs. I can't help but think that this "energy amplifier" or ADS (Accelerator Driven Subcritical Assembly) is much, much more promising than controlled nuclear fusion, which has been "ten years away" since I was a graduate student and on which billions of dollars have been spent. I think that a Manhattan-project effort with parallel

development and some risk-taking could make this practical in just a few years. I'm not sure how to push this; realistically I think it will be developed in India and/or Australia in 10-15 years, but not in the USA although it could be done faster with the resources here if enough were persuaded. The emphasis here seems to be on already existing programs for new reactor development. To my mind, the proliferation resistance and safety aspects of the ADS warrant much more attention here especially because of the public's sometimes irrational fears as well as the very real examples of Chernobyl and Three Mile Island. The critical point in development here is probably public perception: Whether it is understood to be much safer than present nuclear reactors and in particular whether the exceedingly expensive regulatory restrictions might be relaxed.

There is a local aspect which might be of interest to Colorado legislators. There are major deposits of thorium ore in the Powderhorn region between Gunnison and Lake City, where titanium mining has recently been planned, as well as near Canon City and elsewhere. This has been of little interest since the loss of interest in breeder reactors in recent years since the only other use for thorium is for gas mantles and (surprisingly) as a constituent of high strength magnesium alloys. Despite my concerns about tearing up some beautiful nearby wilderness I far prefer this means of meeting the nation's energy needs to the current proliferation in Colorado of often destructive natural gas and coal bed methane drilling!

I hope this letter may get further attention from your office. I would be delighted to provide more information if I can, space and your patience limit what I can write here. I am not an expert in this field, my professional background before retirement was in experimental particle physics (Fermilab, Brookhaven) so I feel confident about the feasibility of a high current 1 GeV linear accelerator at a cost small compared to the whole ADS project. However, Rubbia and others may underestimate the difficulty of an entirely new fast reactor development project, although precedents exist.

Here is a list of a few references which your office might wish to pursue. The first is the well written and enthusiastic Cosmos article. The second is an enthusiastic report from the CERN Courier in 1995 about the Nobel Prize winner Carlo Rubbia's proposal in 1995. It is followed by a reference to a 75 page detailed report by Rubbia and others on the economics of the ADS. The fourth is a "roadmap" for Indian ADS development. Maybe they'll get to it first! I have no doubt there is a wealth of other references on this subject which I haven't seen yet. In particular it isn't clear to me what is the detailed outline of "Advanced Reactor Development" in the most recent United States energy bill.

- 1) <http://www.cosmosmagazine.com/node/348/>
- 2) http://einstein.unh.edu/FWHersman/energy_amplifier.html
- 3) R. Fernandez, P. Mandrillon, C. Rubbia et J. A. Rubbio CERN/LHC/96-01 (EET)
<http://doc.cern.ch/archive/electronic/cern/preprints/lhc/lhc-96-001.pdf>
- 4) http://www.iaea.org/OurWork/ST/NE/NEFW/documents/TMonUseofLEUonADS/PDFPapers/Degweker_Paper.pdf
- 5) A note of thanks to Dr. Ralph E. Clark III for information about the local thorium deposits, and to Dr. Richard Karas for many comments and suggestions

For your convenience, I'm including a printout of the (copyrighted) COSMOS article referred to.

Sincerely,
Dr. Donald McLeod