

HLW & FD EIS PROJECT - (AR)PF
Control # DC-01

Rev1 EIS Review

Comments on "Draft INEEL HLW EIS, Idaho High-Level Waste & Facilities Disposition"

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Thanks for asking for my opinions of your "Draft INEEL HLW EIS". It's nice to see that the effort I've put into my hobby (HLW management) during the past few years qualifies me to be one of the Site's "key stakeholders". Since the National Academy of Science's Board on Radioactive Waste Management seems to feel the same way (they've sent me a personal copy of their review of the Site's HLW program), I've decided to put my thoughts about both of these reports together into one note.

Here it is:

First of all, I feel that these documents have dealt INEEL's credibility as the "lead laboratory" another big blow. I also feel that its future viability as an applied engineering facility has been seriously threatened.

Since the NAS's report is more prestigious and apt to have greater impact on INEEL, I'll start off with it.

1-2
X(3)

I sympathize with the Panel's frustration with the management "symptoms" that make doing nothing seem more sensible than trying to implement any of the EIS alternatives consistent with today's HLW management paradigm. (These symptoms are identified in another recent NAS Report, "Barriers to Science", 1996.) However, while I agree with the Panel's reservations about the "separations" approach championed by INEEL's decision-makers, I don't agree with its conclusion that it would be best to abrogate the two key HLW-related provisions of the "Batt agreement", i.e., to not render existing calcines "road ready" by 2035 AD and to not calcine the remaining liquid waste by 2012 AD.

Since DOE could honor its promises if it were simply willing to eschew some of its "symptoms", a more constructive conclusion would have been to suggest that it do so and identify specific changes that need to be made.

I also disagree with two of the Panel's rationalizations for its conclusions: 1) it is not necessary to delay decision-making until we know more than we do already about the chemical composition of INTEC wastes: we know everything that's genuinely relevant to implementing any of several reasonable rock-making processes and "characterization" via the science of analytical chemistry cannot prove that there isn't a molecule of "listed" waste somewhere in the tanks/binsets (only God can know such things) - "characterization" done for its own sake is simply another of DOE's fabulously expensive delaying tactics, and 2) it is not necessary to know every conceivable detail about the waste's ultimate resting place (repository) to get on with our job of converting it into road-ready waste forms - we can and should make materials suitable for disposal in any of several already sufficiently-characterized & technically competent potential candidate repository sites, the same assumption made by the people who designed the "historic waste" solidification system for BNFL's Sellafield facility (UK) and who decided to encapsulate everything with concrete.

¹ For example, a recent estimate of what the US taxpayer is now paying to "characterize" each of the barrels of RWMC waste being prepared for shipment from INEEL to WIPP is \$60,000 (roughly the cost of a four-year degree at a good college). The nominal purpose of this activity is to "assign codes" to the waste - the numbers do not influence how the barrel is shipped or what will be done with it at the repository.

EXHIBIT #6
HLW&FD Draft EIS
Idaho Falls, ID
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1-40
iii.D.1(4) [What we genuinely don't know enough about yet are specific details of how to go about applying alternative treatment/solidification technologies to INEEL's wastes.] The reason for this is that DOE-ID's M&O contractor refused to spend any of its "programmatic" money on actual R&D - virtually all the money spent on alternatives to its pet separation/vitrification scheme went to produce "group think" exercises similar to the Draft HLW EIS.]

1-41
X(3)

1-3
V(6)

[There is an important factual error in the NAS report (it isn't the Panel's fault - it was pulled verbatim out of an INEEL technical publication.) Figure 11.1 (p 99) suggests that ICPP/INTEC calcines are about ten times more radioactive than they really are (i.e., that they possess a total radioactivity of about 60,000 curies/m³). In this case, the number is important because it suggests that it would take more than one hundred years for those calcines to decay down to a level now considered to be "low". The fact is that typical ICPP/INTEC calcines generate only about 40 watts worth of radioactive heat/m³ (due primarily to ⁹⁰Sr & ¹³⁷Cs) which corresponds to a radioactivity of ~7,000 Ci/m³ - which, in turn, means that they're about at "Class C" LLW limits now & definitely will be below them (fission-product-wise at least,) by the time that we've promised to have 'em ready to be shipped offsite.]

1-4
V(4)

[Of course, in a rational world it really wouldn't make much difference exactly how "hot" these wastes are because any facility used to treat/dispose of them would certainly be "remoted" anyway - where it makes a difference is when decision-makers decide what they are going to do based solely upon arbitrary (and therefore subject to change) criteria such as the radwaste classification numbers listed in Table II of 10 CFR 61. The US Nuclear Establishment's infatuation with legalistic hair-splitting rather than common-sense implementation of the intent of laws/regulations (another of its "symptoms") is evidenced by INEEL's insistence that SBW is fundamentally different than the reprocessing waste that's already been calcined. If/when we ever screw up enough courage/resolve to calcine SBW, we'll discover that the resulting product is just as nasty as the other calcines (it'll have a higher percentage of plutonium, less of fission products, more mercury, less cadmium, etc., etc.). There is no good reason to treat them differently just because somebody decided to label one of them "high" and the other "incidental". Logically, they should be turned into one type of waste form and disposed of in one type of repository.]

The NAS apparently wasn't told that there's enough room in the binsets (set #7) to accept any calcine made from SBW without having to mix it with existing calcines and thereby render it "high". That's important because one of its rationalizations for recommending that DOE-ID break its promise to calcine SBW (which wouldn't be good for the Site's credibility) is that so-causing it to become "high" would make it more difficult to deal with. It wouldn't, making any kind of durable "rock" out of SBW (concrete, HIPed glass-ceramic, or glass) would be facilitated by first burning out the volatile stuff.]

1-5
iii.C(2)

[As far as how to go about calcining this waste is concerned, the reason we haven't been able to succeed at it is that the Site's decision-makers deliberately decided to not use the only really efficient approach available to do it; i.e., add some sugar just before squirting the stuff into the calciner. It's an well-established and safe way to calcine SBW (the rest of the world (e.g. BNFL at Sellafield) routinely does it that way & we successfully tested the concept here at NRTS/INEL/INEEL thirty-five years ago and again - 3-4 years ago). If you refuse to calcine that way (today's excuse is "safety") then you either have to dilute SBW with massive amounts of easily-denitrated stuff such as aluminum nitrate - which makes calcination extremely slow, unnecessarily "NOx-ous", and creates a lot more calcine than actually we need to - or run the calciner at a temperature that generates so much "fines" that the offgas system becomes plugged up with dust (the reason why the last "high temperature" calcination campaign had to be shut down).] The fact that the Site's decision-makers have also steadfastly refused to do things like recover/recycle Mercury (electroplate it from the calciner's offgas scrub solution) and NO_x from NWCF offgas has made calcination a lot less attractive (& that mission less viable) than it ought to be. Some sorts of modifications to NWCF would indeed cost a lot of money but these two would be pretty cheap.]

1-6
iii.C(2)

[There are two reasons why sugar calcination would greatly reduce the amount of NO_x that's emitted by NWCF. First, much less aluminum nitrate would have to be added to the waste (we'd need an Al:Na ratio of ~1:1 instead of the ~3:1 required by the "basis approach" - each mole of Al so-added adds another three moles of nitrate). Second, sugar calcination reduces most of the nitrate in the calciner's feed to

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elemental nitrogen instead of to NO_x. Since NO_x is probably the most toxic gas emitted by NWCF (& certainly the most visible one), don't you think that an "EIS" ought to mention that there's a cheap fix available for it? [Cheap? @ 20 cents/pound, enough table-quality sugar to sugar-calciate all SBW would cost about \$0.5 million - "running" NWCF costs ~\$50 million/year & sugar-calciation of SBW would cut the required operational time by at least a factor of two.]

1-8
III.D.4(4) [Why doesn't this EIS mention that STUDSVIK offered to sell INEEL a brand new, MACT-compatible calcination system (including a new building to put it in) for considerably less than what it's now spending every year to "run" NWCF?]

1-9
III.D.4(7) [Since the NAS Panel apparently agrees that homogenizing these wastes would be a good thing to do, why isn't the waste coprocessing option that I suggested six years ago (i.e., slurry SBW with existing calcines, add some sugar and then feed both phases into NWCF) and which was then subsequently deemed feasible by a Fluor Daniel report (1986) mentioned in the EIS? The University of North Dakota's fluidized bed combustion research facility ("EERC") offered to do a pilot plant scale demonstration of that process for ~\$20,000. This offer was ignored.]

1-10
VII.D(6) [DOE promised to calcine all of INEEL's reprocessing waste (BATT agreement) going that would make conversion of that waste into good-quality waste forms much easier and it can be done both on time (by 2012 AD) for a reasonable number of dollars - why does this EIS devote so little attention to evaluating ways to actually accomplish it?]

1-43
III.C(1) [Incidentally, I've just heard through the company grapevine that most of BBW's radwaste experts have been cloistered up in town for the last 3-4 weeks trying to decide upon a way of dealing with SBW consistent with all of today's customs/policies/assumptions - apparently someone's pushing for a decision on a "preferred alternative".]

1-11
III.F.3(1) [I've also heard that the SBW treatment alternative viewed with the most favor invokes running it through Columns/contactors to separate it into streams called "non-contact handled TRU" and "Class C" LLW, grouting both of 'em, and then shipping both off to be buried in differently-labeled holes at WIPP. Apparently, somebody's decided that there's only so much "room" for one of these waste categories at WIPP (I forget which one) so it would, therefore, make good sense for us to spend a few tens (hundreds?) of million taxdollars separating the stuff before we ship it all off to the same place. (This kind of gov't spending/planning gives me a warm feeling when I send off my check to the IRS every year.)]

1-12
III.D.4(7) [Again, according to the grapevine, none of the NAS report's suggested SBW treatment options are being considered. Why not?]

Here are some questions about how the processing alternatives are represented in the EIS Summary.

1-13
III.C(4) [First, most of your process options invoke the grouting of one or more waste liquid streams - most of which would be strongly acidic. None of the figures you've shown depict that those streams will be calcined/incinerated prior to being solidified. Why not? Doing so simultaneously reduces the mass/volume of grout you'll have to make, destroys troublesome stuff like "listed" organics, and makes a much more durable concrete product.]

1-14
III.D.2.4(1) [Second, your Hot Isostatic Pressed (HIP) Waste option (Fig. S-9) invokes the HIPing of ion exchange resin. You can't put gas-forming materials into HIP cans. The figure needs to indicate some sort of heat-pretreatment step.]

1-15
III.D.3(4) [Third, your "Planning Basis" (Fig. S-7) and "Minimum INEEL Processing alternatives (S-12) suggest that Cs-loaded ion exchange resin will be "separated" along with the calcines. Would a process designed to dissolve/extract calcines work with ion exchange resins? Wouldn't it be better to burn the resins and treat the ash? If that's to be done, your figures should depict the necessary incinerator. Ditto that for all of the "separation" alternatives.]

Next, let's discuss the management scenarios that I've had some hand in bringing to the Public's attention - all those that would convert stuff now considered to be "high" into concrete.

1-16
III.D.2.b(4) [First, I'm disappointed that the folks you've hired to produce this Draft EIS managed to conclude that the "direct cement" option - turning a pile of sand-like calcine into cans full of "rock" by mixing it with cementing agents & water, injecting that grout into steel canisters, and then curing them in a pressure cooker (which step might not even be necessary - only some hands-on research can really tell) - would be as "dangerous" as your last M&O Contractor's pet separations-based "Planning Approach" - which of course, invokes far more unit operations, more time, more people, (a lot) more toxic chemicals, much higher (>2000 F) processing temperatures, multiple waste forms, an extra incinerator, transport to multiple repositories, etc., etc.] However, in view of the degree of "command influence" that goes into the production of official DOE-EM technical reports (often reflected by deliberate omission of uncomfortable facts), I'm not really surprised at this conclusion.

1-17
III.D.2.b(1) [Here's why a properly implemented "direct cement" alternative would have low environmental impact. First of all, I've always advocated that "direct cement" be implemented in such a way that all of ICPP/INTEC's waste is converted to the same type of waste form and goes to the same repository. [That's not the way the EIS interprets it - it proposes making a large separate LLW waste stream that's very apt to end being left in Idaho - an unnecessary assumption that makes this option much less attractive to stakeholders.] A one-process/one-waste form/one-repository scenario would be much simpler than any of the other alternatives which would actually keep the promises that have been made to stakeholders. Simplicity means less equipment, fewer personnel, less chemicals, less paperwork, less confusion, fewer lawyers, etc., etc. - all characteristics that tend to make doing things less "impactful" to both the environment and the taxpayer's pocketbook.]

1-19
III.D.3 [Our mission is simply to make ICPP/INTEC reprocessing waste "road ready" for transport to an offsite repository that the Federal Government (DOE?) has promised to provide and then clean up the place, period. It's not to "make work" for thousands of DOE/Contractor/subcontractor personnel or to try to justify dumb decisions that have already been made elsewhere with respect to implementing/siting repositories, categorizing radwastes, and/or making them ready for transport. My assumptions are that, 1) there's plenty of suitable "Federal Land" available (notably at the NTS) for a practical sort of repository for defense-type reprocessing waste (meaning one that doesn't assign today's phony premium to "volume reduction" - apparently our HLW experts are still being told that the incremental cost of 1 m³ worth of YM is - a half-million dollars) 2) the politicians who can decide to implement such a repository will eventually do so when convinced that it's simultaneously possible, politically defensible and affordable, 3) cement-solidified calcine would meet the "letter of the law" (10CFR-60 & 40CFR-191) as a HLW disposal form, and 4) that until a suitable repository actually materializes, we should simply emulate the UK's approach to "historic" reprocessing waste management.]

1-20
III.F.2(6) [1-23 III.E(2)]

1-21
III.D.2.b(1)

[If reasonable attention is paid to minimizing the solids content of the liquids generated in cleaning up the place (termed NGLW in this EIS), the amount of radioactive "ash" that would be produced by drying/calciating those liquids will be small with respect to that represented by today's calcines and SBW. Consequently, I propose(d) that they be processed/diposed-of in exactly the same manner - no additional equipment, repositories, assumptions, or paperwork required.]

[Its decision to confound disposal of its own waste with that produced by the commercial nuclear power industry constitutes another reason why the US Federal Government has failed to honor its promises to Idaho (the first official promise to prepare our waste for disposal said it'd be done by 1980). Due to DOD insistence that DOE's civilian waste management responsibilities not interfere with its own interests at NTS, the Federal government chose to "withdraw" another ~600 km² of land from Nevada for today's official HLW repository modeling exercise (YM). This plus the assumption that all commercially-produced HLW is to be sent there engenders enough litigation to indefinitely block implementation of that repository - which means that linking these problems causes total paralysis. The most reasonable place for the Federal Government to site a repository dedicated to cold-war defense-type waste is at its cold-war defense-type test range, the Nevada Test Site (NTS). The NTS makes good sense because, a) it's already "federal land" (no new "withdrawal" required) b) it receives less precipitation than do other DOE sites, c) it possesses the USA's deepest water table, d) it has already been the object of more than thirty years worth of immediately relevant hydrogeological research, e) it's already been irredeemably "crapped up" by ~950 nuclear "events", and, finally, f) a little-publicized real example of a practical (cheap) repository for this sort of waste has already been implemented and (then) exhaustively tested (the "GCD" in area 5). However, it is not necessary to wait for a repository siting decision to begin rendering INEEL waste road-ready (the UK did it) - regardless of exactly where that waste might eventually end up, it is reasonable to assume that HC-type concrete would be at least as durable as glass due to the fact that its mineralogical similarity to natural soil minerals provides less thermodynamic driving force for alteration.]

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1-24
III.D.2.b(1) Concrete-making is intrinsically safer than either glass-making or HIPing (it's done "wet" - generates less dust - and requires much lower temperatures) and is much easier/cheaper to do on an appropriate (large scale). The specific improvements that I and my colleagues have recommended over regular "grouts" (the use of "hydroceramic" rather than regular grout formulations and the calcination (incineration) of everything that would be rendered more suitable for cementitious solidification that way) are to ensure the production of top-quality products - materials distinctly more durable than those which BNFL has recently made out of the UK's "historic waste" and probably also superior to typical radwaste-type glasses. The "Lead lab" should make the DOE Complex's best waste forms.

1-25
III.D.2.b(1) Hydroceramics make especially good sense at INEEL for the following reasons:
1-26
III.D.2.b(1) 1) INEEL has not yet officially committed to any particular way of dealing with its HLW.
1-27
III.D.2.b(1) 2) Because INEEL calcines do not contain excessive concentrations of soluble salts, it would be possible to satisfy the "sodalite formulation" rule-of-thumb with high (>25%) waste loadings.
1-28
III.D.2.b(1) 3) Since two of the three elements making up HC binder phases (Na & Al) are high-percentage constituents of INEEL calcines, there is no need to separate them (or anything else) prior to solidification. This means that everything would be prepared for offsite disposal - the wish of INEEL's local stakeholders. (A primary goal of the "volume reduction" activities practiced at WVDP and SRS is to transfer those elements to "low level" fractions that aren't vitrified.)
1-29
III.D.2.b(1) 4) Simple changes to the existing calcination facility would permit it to efficiently calcine the remaining liquid reprocessing waste - either by itself or (preferably) after it's been slurry-mixed with existing calcines. The latter scenario would consolidate all INEEL reprocessing wastes into a homogeneous feedstream suitable for HC solidification.
1-30
III.D.2.b(1) 5) It would also provide a good way to deal with other INEEL radwastes. For example, INEEL must find some way to dispose of ~1000 metric tons of radioactive NaOH generated by reacting metallic sodium reactor coolant with water. Since this just happens to be the same amount of "activator" that would be required to turn ICPP/INTEC's calcines into HC concrete, coprocessing these wastes would solve two problems. If the changes to the existing calcination facility I've alluded to were to be implemented, virtually any sort of liquid or particulate waste (e.g., contaminated soils) could be readily converted to HCs.
1-31
III.D.2.b(1) 6) It is probable that a formal proposal to properly implement an HC-type solidification process would satisfy INEEL's stakeholders.
1-31
III.D.2.b(1) 7) Finally, if a future generation deems it to be both politically expedient and affordable, HC concrete monoliths could be hot-isostatically-pressed into "vitrified" monoliths without removing them from their original canisters. (This means that today's decision-makers would not have to make an irrevocable commitment to not "vitrifying" this waste.)

Since this EIS is just a "draft", let me suggest some changes for your final version.

1-32
VII.D(2) First, make it very clear up front just exactly what it is you're trying to accomplish. If it's already been decided that it's OK to not honor commitments made in the "Batt Agreement", say so. (For instance, some of the scenarios in this Draft that propose that SBW will be calcined, assume a completion time of 2014 AD, not 2012 AD - does this two-year "slip" reflect a change in policy?)

1-33
IX.A(3) Second, when you present/discuss treatment scenarios that don't seem to make much sense⁴, be sure that you explain the assumptions/conditions that would make them plausible.

⁴for instance, the "Minimum INEEL Processing Alternative" (the "driver" for which is the cost of building a DOE-type vitrification plant here at INEEL) suggests that we are to bundle up our calcines into some sort of transportable (you can't ship powders) temporary waste form (RTV-type rubber cement is being proposed for this purpose) & then ship it all off to Hanford where they will somehow undo our temporary solidification process, separate the stuff into various fractions, vitrify(?) all of them, and then ship it all back here for a few(?) decades worth of "interim" storage. This is too clever to make much sense to the casual reader unless additional background is provided.

1-34
III.D.1(6) Third, you might want to consider integrating some of this Site's other waste treatment/disposal problems into your final version (e.g. using ANLW's caustic as the activator for "hydroceramics" made out of INTEC calcines.) Doing so would prevent a lot of unnecessary duplication, cause a higher percentage of INEEL's radwaste to be prepared for offsite disposal (which would delight local stakeholders), and save taxpayers a lot of money. (The "stove piping" of EM projects to match existing organizational structures/definitions is another of the "symptoms" identified in "Barriers to Science".)

1-35
III.D.4(6) Fourth, when you present/discuss treatment scenarios that have not received programmatic research support, e.g., "Direct Cement/Hydroceramics", make it clear to the reader that that's indeed been the case & also that information about them can be obtained from sources other than therefore non-existent official government reports. (For example, I've co-authored/published a dozen research papers that anyone interested in why "direct cement" makes sense might want to see - the "Draft EIS" doesn't acknowledge that this sort of technical literature even exists.)

1-36
III.D.4(6) Fifth, to ensure that your EIS-preparation subcontractors do a better job of representing alternatives like "Direct Cement" in the final version, insist that they actually contact the persons responsible for developing/championing them - the "draft" doesn't accurately represent what my colleagues & I have done or would recommend.

1-37
III.F.2(1) Sixth & finally, please don't characterize DOE's decision to tell its employees & contractors to assume that all waste forms made from it's reprocessing waste will have 0.5 MTHU/m³ as being merely "controversial" (p. S-21). A policy that is inconsistent with both the intent and letter of the law (see 40 CFR 191) and is largely responsible for DOE's inability to deal efficiently with its own "high level" waste requires a more forceful adjective.

1-38
IX.A(2) Do not change your Publisher. The quality of the photography, printing, general layout, etc. of this EIS is the best I've ever seen in a large government-sponsored document.

1-39
III.D.2.b(1) If you would like to read some technical stuff that's not in a DOE-sponsored report, I've written up another research paper (at this point, it is also just a "draft") discussing why "Direct Cement" makes especially good sense for INEEL. It goes into a good bit of detail about vitrification's drawbacks (one of which is that its prohibitive cost encourages folks to do "separations") and compares leach test performance of radwaste type glasses with "hydroceramics. It's an "easy read" because it's written like the stuff you find in trade journals like *Radwaste Magazine*. Its literature references (35 of them) support the "controversial" contentions I've made in this review. Let me know if you would like to see it.

ACIdoc

WHY HYDROCERAMIC SOLIDIFICATION MAKES MORE SENSE THAN VITRIFICATION
INEEL HIGH LEVEL WASTE

Darryl D. Siemer

ABSTRACT

"Hydroceramics" (HC) are alkali aluminosilicate ("geopolymeric") concretes designed to match the leach test performance of radwaste-type glasses. They are made by curing grouts consisting of mixtures of calcined waste, calcined clay, water, and NaOH under hydrothermal conditions. This paper characterizes them and explains why this approach to radwaste treatment would be preferable to vitrification for the Idaho National Engineering and Environmental Laboratory's (INEEL) reprocessing waste.

INTRODUCTION

In 1970, Idaho's political leadership was told that the "high level waste" (HLW) generated by the Federal Government's nuclear fuel reprocessing facility at INEEL (then "NRTS") would be prepared for offsite disposal (i.e., rendered "road ready") by 1980¹. Since then, billions of taxdollars have been spent on HLW management paperwork, no HLW repository has been provided, none of INEEL's reprocessing waste has been rendered road-ready, and today's official deadline for accomplishing it has slipped to 2035 AD². A recent National Research Council (NRC) report identified the management "symptoms" responsible for this situation³. One of these is that DOE habitually blinds itself to any but predetermined "preferred alternatives" when deciding how to go about solving problems. This paper discusses one "preferred alternative", vitrification, and describes why a particular cementitious technology ought to be used instead.

VITRIFICATION'S DRAWBACKS

During the past three years DOE's contractors have managed to operate two full-scale glass melters long enough to establish that the cost of solidifying its HLW that way will be 2-4 \$million per m³ of glass produced⁴. Because DOE must eventually process ~60,000 m³ of high-solids reprocessing waste (primarily the sludges at its Hanford & SRS facilities) and is unlikely to achieve >100% volumetric loading of those materials into glass, these costs suggest that vitrification will prove to be prohibitively expensive. This was predicted by another "controversial" NRC report published over twenty years ago⁵.

Let's review some of the arguments employed by vitrification's champions.

One of these is, "glass is better because a glass melter can achieve greater volumetric waste loading than low temperature solidification technologies". This is both misleading and irrelevant. It's misleading because it presumes that the other technologies *must* be implemented without appropriate waste pretreatment and, also, as I'll demonstrate later, that only a fraction of the waste "counts". Raw reprocessing waste consists primarily of volatile materials such as water, mineral acid, nitrate/nitrite and, in some cases, organic materials which may include "listed" toxins (both real and imaginary), solvents, and chelating agents. Calcination (or "incineration")^{6,7} is a well-developed, technically justifiable, and obvious way to eliminate those components while producing inorganic ash which can be converted to equally low-volume monoliths by other means. While it is true that glass melters may be (and sometimes are) used as "devolatilizers", it is much more efficient to do that operation with equipment optimized for that purpose⁸.

The argument is irrelevant because the notion that the cost of managing this waste will be proportional to the geometric volume of waste forms made from it is invalid. First of all, history suggests that *any* facility run under DOE oversight will cost taxpayers a lot of money whether or not it actually ever produces anything - which, in turn, indicates that today's practice of judging hypothetical waste treatment scenarios based on an assumed proportionality between cost and volume is overly simplistic. [For example, the cost of producing one canister (~1 m³) of any sort of "rock" will be >90% that of making ten canisters (~10 m³)

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of it with the same equipment - most of the total expenditure (research, development, design, licensing, administrative, construction, personnel training, testing, decommissioning, etc., etc.) will be independent of the amount of product made. Producing something adds only an *incremental* cost.] Similarly, the cost of disposing of waste forms produced from DOE HLW will *not* be proportional to their geometric volume. Why? 1) Formal analyses have repeatedly concluded that transport of waste forms to a repository will represent a small fraction of total cost regardless of their volumes⁹. 2) today's official hypothetical HLW repository site, Yucca Mountain (YM), is physically large enough (several cubic miles - several tens of billions of cubic meters) to accommodate any type of material(s) that DOE might choose to make from its reprocessing wastes, 3) YM's capacity is defined in units proportional to the amount of radionuclides to be buried there (the equivalent of that in 70,000 "metric tons of heavy metal"), not that waste's geometric volume¹⁰, and, of course, 4) YM will cost US taxpayers billions of dollars whether or not any real waste is ever buried there. Again, the cost of using the facility for its intended purpose will add only a relatively small *incremental* cost attributable to mass/volume.

Today's tendency to assign undue weight to "volume" is harmful because doing so diverts both attention and resources from rendering waste road-ready to changing its classification via "volume reduction". Existing defense-type HLWs should be rendered road-ready because they are toxic, radioactive, corrosive, situated in places poorly suited to become permanent geological repository sites, and have already been neglected for far too long - not because they are "big" or "high". "Devolatilization" via calcination/incineration and physical compaction of compressible solids are the only volume reduction technologies that make much sense. In practice, most of the separation technologies used/proposed to effect reclassification decrease the physical size of "high activity" fractions that "must be vitrified" for offsite disposal by increasing those of "low level" fractions destined to be left on-site with little or no further treatment. The latter usually contain the bulk of the original waste's infinite half-life toxic components and, due to the process chemicals added to affect the separation(s), is generally larger (often much larger) in terms of total mass, solids content, and volume than the waste was before it was fractionated. Stratagems used/proposed to achieve enough "volume reduction" to make the vitrification of the "high" stuff in DOE's reprocessing waste more affordable range from the relatively straightforward sludge-washing done at WVDP & SRS to the "full separation" scheme championed by INEEL's decision-makers during most of the 1990s. History suggests that the "volume reduction" of existing reprocessing waste is attractive primarily to those who would be employed designing/building/operating the facilities required to do it - and equally unattractive to independent reviewers¹⁰ and folks who live near the site in question but do not derive their incomes from it¹¹.

Another argument proffered for vitrification consists of a strained analogy; i.e., "because France and Great Britain vitrify their high-level reprocessing wastes, it must be 'best' for US HLW too". This is invalid because about the only characteristic that these wastes have in common is their name. European HLW consists of relatively "young", first-cycle, PUREX-type raffinates generated by the nitric acid dissolution of mechanically-declad commercial reactor fuel. Fission products typically comprise 20-60% of the non-volatile matter in them. On the other hand, today's DOE HLW is "old" (typically >30 years out-of-reactor) and consists primarily of non-radioactive materials derived from fuel cladding and involatile process reagents. Consequently, DOE's HLWs are typically 2 orders of magnitude less radioactive and much more heterogeneous than their European namesakes. The "technical" reason why vitrification of US HLW is prohibitively expensive is that a US melter capable of solidifying any given amount of "bad stuff" must be ~100 times larger and able to safely accommodate a much wider range of feedstocks than its European counterpart ("bad stuff" = the sum of RCRA metals + fission products + TRU).

A more fundamental weakness of glasses for this application is that they are "ineluctably metastable"¹¹. Glasses are rare in Nature because they are unstable with respect to crystalline minerals/rocks and therefore inevitably decompose to form them; e.g. the "zeolitized tuff" that makes up much of today's official hypothetical HLW repository site was originally volcanic glass. Radwaste-type glasses (i.e., ones with relatively low percentages of silica and alumina & high percentages of alkalis and boron) are apt to be especially unstable. Furthermore, because both materials tend to enhance the corrosion rate of glasses under certain conditions¹², some of DOE's radwaste management experts are now suggesting that its proposed HLW repository must be implemented without the use of concretes for construction or clays for backfill -