If the Navy Gets Mixed Results: We Fund It.

Lessons From History:

It cost the Reagan administration 372 million dollars – and they never turned it on. It was the MFTF – at that time the most expensive project in Livermore history[6]. It took nine years to build the machine, which was opened on February 21, 1986 [6]. They had a dedication party and then cancelled the project. Today this amounts to three fourths of a billion dollars[7] – why did this happen?


Figure 1: staff standing in front of the MFTF machine (source: Wikipedia Commons). Figure 2: A picture of the huge ying-yang magnets used to “dam up” the ends of the MFTF [1].

It seems the DOE funded the idea without being totally sure it would work. John Clarke remembers his boss – the head of the U.S. fusion energy program – saying: “'they are good people at Livermore, they will figure something out.'"[6] The closing of the project marked a major fall in magnetic mirror machines and the rise of the tokamak as the premier fusion reactor idea. This was not inevitable. Many voices, both inside and outside the science community, kept pressing for an alternative idea – in case the tokamak proved unworkable. “All kinds of ideas were bouncing around: solar, ocean, thermal, wind, synfuels. And we had only one for a fusion reactor, the tokamak. What we wanted was a strong design to be number two” said Stephen Dean former director of magnetic confinement at DOE [6]. This implies that at the outset, the funding managers were not sure the tokamak was the only path to fusion. They authorized 372 million dollars to a promising fusion idea without being certain it would work. Today, we could test the Polywells’ viability with just 1/5th of those funds.

Economists have said that government R&D budgets are very specific, when compared to industry. Specificity can lead to tunnel vision. Hence, do not assume that because one idea has received lots of government funding – that it is necessarily the best idea, or that the government is sure it will work. History has shown that assumption to be false. Indeed Ed Kintner, the head of the U.S. fusion energy program under Reagan called it: “betting on the come”[6]. Government must also prove to the public that: we are concentrating funds on this specific project, because if it works, it will help us all. An R&D program that is specific and must be publically defended may not be very accepting of change. Moreover, do not look to the rest of the world for new ideas. It is easy to justify expensive projects when you just follow the US’s lead. As of January 2011 there were an estimated 177 tokamak experiments either planned, decommissioned or currently operating, worldwide.[8] In such a funding system, one idea can remain stubbornly unchallenged for a long time.

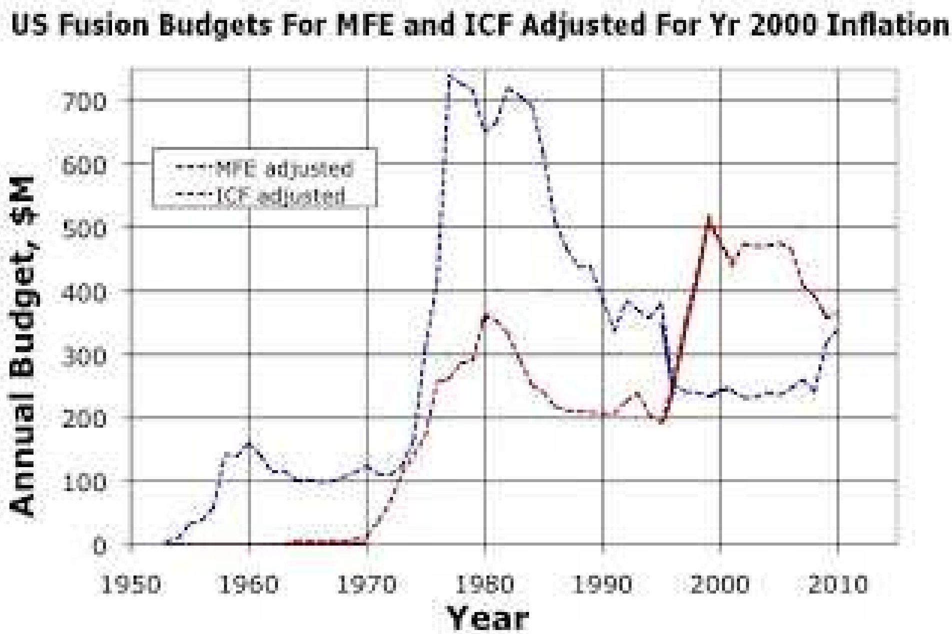

Figure 3: US fusion budgets for magnetic and inertial confinement, adjusted for year 2000 inflation rates.

The Polywell seems to fit with the steady succession of DOE projects. One of the first was the mirror machine. The “mirrors” bounced plasma back and forth in a line. The idea was for plasma to slam into one another in the center, like trains colliding. These machines relied on a very similar idea to the polywell’s: use current inside the plasma to make the confining field. However, plugging the ends was a challenge. The tokamak solved this by looping the ends together into a ring. Still generating the containing field was a problem. The solution was to use the plasma itself to generate part of the field. This was the Spheromak. This was a tighter ring, but still a ring. The collisions that did not fuse, scattered, flinging plasma against the wall. The solution: point everything into the middle. This is the polywell. Pointing everything into the center could offer several big benefits over previous designs. Hence we have steadily moved from lines, to rings, to tighter rings, to spheres. Spheres are the only way the universe has ever produced fusion energy. Dr. Bussard put it best: "Look up, there are billions of fusion reactors, every star is a fusion reactor, and not one of them is toroidal!"

Why this effort can be different - Necessity:

If the MFTF was funded on uncertainty and then cancelled, what makes a polywell effort any different? I would argue a number of things. Today is not the 1980's. Even if a polywell effort is similar to past fusion efforts– the world in which it is conducted is radically different. The earth of 2011 is hotter, more populated, more fragile and more strapped for natural resources then the earth of 1980 [10]. We are projected to pass 7 billion people next year [9] and we are going to need more energy to feed, clothe and house all these people. The national average price for a gallon of gas has risen 90 cents in the past year [11], with little relief in sight. If results are good, funding the Polywell will be easy to justify to the American public. In fact, every nation, organization and group on earth is going to be looking for cheap, plentiful, and clean energy – and if they are not now, they will be soon. It is within this context that we start this polywell effort. As the old saying goes: need is the mother of invention.

Why this effort can be different - Knowledge:

Criticism is key to quality. Indeed, Rider's criticisms may have been the best thing for Polywell research. Thanks to him, we already know many of the Polywells' flaws. If we are smart, we can plan around these issues, save time and money, and increase our chances of success. We will also have the benefit of hindsight. For example, WB-3 had square magnets, something we now recognize as an obvious mistake. We are now on our eighth redesign of the Polywell concept. We have the benefit of over 18 years of research and experience already invested in Polywells to learn from. Even more broadly, we have more than 50 years of fusion's successes and failures to draw on. For example despite the hopes of Livermore scientists, the TMX mirror machine was not a power producing reactor. But it did lead to the particle loss equation. A key equation describing particles lost while electrostatically and magnetically confined [13-15]. That equation, combined with Bussards' ring spacing work and Whiffle ball concept could be powerful, potent design information, knowledge that we did not have before.

Why this effort can be different - Transparency:

A polywell effort will have huge advantages over past fusion programs, mainly from information technology, the internet and the new interconnectedness of the world. Do not underestimate the power of these tools, for transparency, speed and ultimately: success. The MFTF project never had a Facebook group or a blog to connect its followers and build popular support. The researchers could not crowd source technical problems. They could not access as much information, as quickly or as accurately as we can, period. This is an entirely new age – and these tools can speed up a fusion effort in thousands of unforeseen ways.

Why this effort can be different - Competition:

The internet is an information redistribution monster. How will this affect a polywell program? I would argue for the better. The effort would be more transparent. Openness makes it more difficult for one group to hide or manipulate results, to maintain control, or to heedlessly delay research. If this works, ultimately, there is no way the US Navy could hide it. If it works, every nation will be looking for this. If it works, many nations could start their own research programs. Moreover, nations could begin work because the startup costs are much lower than Tokamaks. As of now, Polywells are smaller and cheaper to build then Tokamaks. This is will be especially true if Dr. Bussards' claim that the power output increases as the 5th of the radius is real. It would only take a small Polywell to verify this claim. Cheapness means a Polywell effort would be faster, with innovations and redesigns adopted sooner. Cheapness also means competition. The more competition we have, the better our chance of seeing a commercial power reactor. In conclusion, even if the Navy team gets lukewarm results from this study, a US polywell effort should be started, for the following reasons:

1. The need is very pressing.
2. The capital costs are low.
3. The technology is mature.
4. The potential payoff is huge.
5. The supporting community is large, growing and paying attention.
6. The competition to build is very real.

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