RECOMMENDATIONS FOR ARPA-E ACTIVITY ON ADVANCED RENEWABLE TRANSPORTATION FUELS

Personal, unofficial opinions only; Dr. Paul J. Werbos (http://www.werbos.com/CV_2009.pdf)

PRIMARY RECOMMENDATIONS

The two most important missions to ARPA-E from Congress are to seek breakthroughs which could eliminate our dependence on oil imports as soon as possible, and to seek breakthroughs which allow deep reduction in the emissions of greenhouse gasses. In allocating funds and defining programs, it is crucial to base all decisions on these larger goals.

New technologies to produce liquid or gaseous fuels for transportation are one of the two or three most important activities ARPA-E can support, to make these things happen. With oil dependence (the more time-sensitive issue, agreed to by a larger percentage of Congress), our nearest-term hope of eliminating oil dependency is through a **combination** of light plug-in hybrid cars with fuel flexibility, plus a large increase in the production of alternate liquid fuels. (See http://www.ieeeusa.org/policy/positions/PHEV0607.pdf, www.werbos.com/E/500mpg.df and http://www.werbos.com/E/China_IV_Break_Oil.pdf.) According to the EPA analysis of the Waxman climate and energy act of 2009, the biggest remaining source of CO2 emissions by 2050 if the Act passes will be in transportation; thus transportation is the area where new technology breakthroughs have the greatest chance to improve things beyond the limited (44%) reduction in CO2 now projected.

In order to provide maximum benefit to the nation, this topic should be broadened to include **any** new transformational breakthroughs which can bring us to that large increase in alternate liquid fuels; in particular, technologies which offer serious hope of big improvements in the cost or sustainability or total supply of such alternate fuels should get priority. Since the supply of liquid fuels is more of a problem for the next few decades than the supply of gaseous fuel, liquids should have priority in this research.

As one part of this effort -- because there are many unmet opportunities for breakthroughs in these areas, I would recommend that ARPA-E negotiate a memorandum of understanding (MOU) with the National Science Foundation (NSF), structured like the one which led to the earlier joint program with NASA, http://www.nsf.gov/pubs/2002/nsf02098/nsf02098.pdf. In this case, ARPA-E should commit at least $20 million per year to an open solicitation to all US universities, small businesses and other eligible parties. While the NSF machinery for processing proposals and awards and setting up review should be used, a joint working group of ARPAE and NSF program Directors should manage the effort, and the ARPA-E program officers should have direct selection authority through the NSF machinery in allocating the ARPA-E funds. DOD may also be interested in joining and kicking in. This kind of system gives the advantage of more access to a wider pool of ideas, and a faster and easier machinery for getting money out the door.

One major part of this effort should continue the one-time activity funded by NSF this year on Hydrocarbons from biomass ("HyBi"), http://www.nsf.gov/pubs/2008/nsf08599/nsf08599.pdf. The 60 high-quality preproposals for $2 million each demonstrate a great diversity of opportunities here, most of which NSF will be unable to fund; in any case, a continuing effort is needed. However, the scope needs to be broadened to pay equal attention to all liquid fuels compatible with emerging fuel-flexible cars; more precisely, an efficient national effort should include two prongs – efforts to deploy and improve the well-established, low-cost technology for fuel flexibility, and efforts to exploit that by producing whatever fuels can give us the most miles at lowest cost. (The former is more a job for Congress, but ARPA-E could have some role in making improvements and creating more understanding.) University and small business research should be especially efficient in cases like this, where a wide variety of species, natural and artificial, need to be explored, and where help from world-class genetic engineering and bioengineering is needed.

Strictly speaking, the larger goals of this topic should even allow work on things like the new Schobert process for getting 4 barrels of oil per ton of coal; however, the needs in that area are more for demonstration projects, outside the scope of ARPA-E. **However** – grants on the order of $2 million to folks like Periana of the University of California (former Exxon), to develop new catalytic technology to make methanol much more efficiently from remote natural gas, really ought to be included; at a minimum, success in this area would prevent the huge waste of precious liquid fuel which will occur if new remote gas plants are built using the less efficient technology available today. It would substantially improve the supply of methanol fuel available for fuel-flexible cars, to help bridge our national security over the next few difficult decades. And, sadly, it represents an unmet opportunity (or did, last I checked).

In addition to fuel from biomass, an equal high priority should go to any kind of "fuel from flue gas," by any technology whatsoever. To evaluate the potential of competing technologies, it would help to have a distinct group which focuses on getting whatever we can from flue gas as the source of carbon, regardless of whether the technology uses sunlight, electricity, heat or even beamed power as a primary energy source. Because it will take many decades to shut down all of our coal-fired power plants (let alone cement and steel, etc.), because geological sequestration presents a number of difficulties, and because a barrel of fuel made from flue gas displaces a barrel of fossil oil, the technology of "fuel from flue" could play a crucial role in letting us reduce CO2 emissions more deeply in the next few decades. The emerging industry is already achieving impressive successes, but a more complete exploration of the "design space" still offers hope of breakthroughs.

Another key unmet, emerging opportunity for breakthrough research here would be the use of new truly intelligent control technologies, to improve the performance and stability of bioreactors, and to reduce the time and cost needed to get working, efficient reactors to implement a multitude of new technologies and feedstocks. There have been many breakthroughs in the field of computational intelligence and adaptive dynamic programming in recent years. (e.g. See http://www.ieee-cis.org/technical/isatc/alternative/ and http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T08-4VY78NG-3&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=6e73e1f9d7ffb43f8e4aa7f111aac716) A new thrust in this area could allow the creation of new crossdisciplinary teams competent in this area, beyond the limited number now out there, and the expansion of these new teams by including experts in bioreactors and chemical process technologies in general. About ten years ago there were important emerging efforts in that direction in chemical engineering (see http://www.werbos.com/HIC_Chapter10.pdf); however, the key teams in the US shifted their attention to areas like automotive, aerospace, robotic and electric power control, leaving the chemical process part of the field to a few teams in other nations (mainly China and Latin America, so far as I know). I recently heard a major manufacturer predict that Gevo's breakthrough technology for making biofuels will take many more years than expected to scale up "because specialists in these areas tend to underestimate the challenges of large-scale chemical process control."

ADDITIONAL INFORMATION

In another context, some of us have been discussing an unofficial draft idea on these lines, as part of a larger effort to break our dependence on oil imports as soon as possible:

The Secretary of Energy, the Director of ARPA-E and the Director of NSF are directed to sign a Memorandum of Understanding (MOU) by the end of 2010, which provides for a series of continuing joint programs to be funded out of the ARPA-E budget, with an option to receive and use additional funds from other sources if available and to include other interested government agencies. All such programs shall be managed within the NSF electronic proposal submission and review process, and shall be open to all universities, small businesses and nonprofit corporations in the United States, as provided for in the NSF Grant Proposal Guide with no additional eligibility rules. Notwithstanding this provision, the MOU should allow the use of mechanisms such as exclusion of proposals for which the preproposal did not pass merit review. While funds shall be transferred to NSF, actual selection authority shall go to teams of technical experts at ARPA-E and NSF, under terms to be specified in the MOU. Each joint program shall be widely announced through the NSF system, and shall be open to new competitive proposals at least once per year. There shall also be some provision for small seedling grants. Reasonable strategic thinking about future technology costs must be discussed in all proposals and review. No awards shall be for more than $2 million total.

(a) Joint Programs

While ARPA-E and NSF (and their other partners, if applicable) may agree to other joint programs under this MOU, there shall be at least three new continuing programs which receive at least $20 million per year in 2009 dollars from the ARPA-E budget:

(1) Breakthrough battery research – …

(2) . **Breakthrough research in powerplants for cars** – ….

(3) . **Breakthrough in renewable fuels** – Reviewers will be asked to look for breakthroughs in biofuel technology or in the use of other renewable energy sources to produce liquid or gaseous fuels from sources of CO2, which have the greatest potential to reduce the delay before that time when all of our transportation fuel demands could be met without the use of fossil oil, imported or otherwise. Panelists and selection

committee members shall be directed to choose those proposals which are best, in toto, based on this criterion and this criterion only, when allocating the base $20 million from ARPA-E. This program shall continue at least until ARPA-E and NSF agree that research is so mature, across all parts of this rich field, that there is little hope of further significant breakthroughs relevant to national energy security and to global climate change. Reviewers will be asked to think ahead to the time when the vehicle flexibility goals of section 4 have been accomplished, and to think about the opportunity to minimize both the cost and environmental footprint of new fuel production possibilities.

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I wish you all the best of luck in this truly urgent, unique and essential effort.