INTERVIEW

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An Interview with the Hon. Chris Fall: on Fostering Innovation in Federal Research & Development

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The *MIT Science Policy Review* spoke with the Hon. Chris Fall, who previously served as the Senate-confirmed Director of the United States Department of Energy's (DOE) Office of Science and the Acting Director of DOE's Advanced Research Projects Agency-Energy (ARPA-E). Dr. Fall's career has included time as a university professor, chief scientist of a government agency, and White House policy advisor and spanned topics ranging from neuroscience to clean energy to high-performance computing. In this interview, we discuss government models for funding and performing high-risk, high-reward research, emerging technologies with the potential to change the scientific landscape, and a vision for the future of national laboratories.

***Science Policy Review*: The COVID-19 pandemic has impacted nearly every facet of society over the last year. Do you see COVID-19 having a long-term impact on the Department of Energy and other Federal science agencies?**

Chris Fall: Absolutely. I'd be remiss if I didn't celebrate our career folks at the DOE and contractors at the national laboratories for their wonderful, collaborative response to COVID-19, both in terms of keeping people safe and keeping the science going. Almost every DOE laboratory participated in the science, and they did it brilliantly. The ability of our national laboratory system to respond to a national crisis is a profoundly important resource, and we learned a lot of lessons because we haven't had to respond in such a way in a very long time. We set up something completely novel and cool — the National Virtual Biotechnology Laboratory — in order to organize this work to address COVID-19 across all of the labs.

Post-COVID-19, I don't think that the DOE will be the same. By the time I left, we had been running remotely for almost a year. Folks are staffing the laboratories and user facilities relevant to COVID-19 in a safe, distanced way in person. This was difficult, expensive, and slow. However, the administrative work of the department went on remotely almost without a hitch. Remote work also opens the door to accessing talent from a much greater geographical area.

Figure 1: Dr. Chris Fall speaking at the Endless Frontier Symposium at the National Academy of Sciences in Washington, D.C. (Credit: K. Sayre / Eikon Photography).

In my experience, remote work goes smoothly when you already know your team, but it's much harder to onboard new team members or to start a new organization entirely remotely. This is a challenge, but I don't see us going back entirely to the old system. I don't see the government as being that different from the private sector. Of course, there are exceptions: classified work cannot be done from home, but that is a relatively small piece of what most of the government does.

***SPR*: Not many people realize how much work the Department of Energy does in computing. Can you speak on the use of High Performance Computing (HPC) to tackle COVID-19 challenges?**

CF: One of DOE's responsibilities is to be the executive lead for HPC for the government, and DOE leads the nation and really the world in cutting edge computing. COVID-19 was an emergency involving questions — structural biology, epidemiology, physical models of transmission, for example — that HPC could help to answer. With support from the White House, we realized we could bring government, academia, and the private sector together in a consortium model to share resources and tackle computational problems related to COVID-19 — called the High Performance Computing

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Consortium.

Now, it's kind of humorous that, amidst the pandemic crisis, the first instinct for both the government and the private sector was to start talking about writing and negotiating MOUs (memoranda of understanding) and agreements and involving a lot of lawyers. Out of the gate, DOE Office of Science took a stand that we would participate with our resources only as long as there were no MOUs or lawyers involved. We really needed to move quickly, and so the team invited members to contribute the resources that they could, to participate as they wanted, to go away when they wanted — a real coalition of the willing, so to speak. And we were not going to spend a year simply figuring out how to work together before we got started. Seriously, among the most important contributions from the DOE other than the world's fastest supercomputers and the amazing experts was the insistence that we were not going to get bogged down in process. That worked brilliantly. Hats off to the career staff at DOE who came up with this idea of the HPC consortium, assembled the team, managed the flow of projects and resources, and held this whole thing together during a very serious crisis. They are heroes.

"... the enduring core basic science mission of the Office of Science is very important and it is finely tuned; it's important to not upset this very carefully organized apple cart by moving too quickly or too dramatically."

***SPR*: What are the future directions of scientific research that you are most excited about? What are the areas that aren't getting a lot of attention that you think we should be directing resources towards?**

CF: The Office of Science is very good at understanding what is important now and going forward and at making sure that they are investing appropriately. Now every new administration gets to make changes and address their priorities, but I would caution that the enduring core basic science mission of the Office of Science is very important and it is finely tuned; it's important to not upset this very carefully organized apple cart by moving too quickly or too dramatically.

We are going to continue to see a profound revolution in computing, and we are just starting to look at what comes after the Exascale effort in terms of new architectures. We have ramped up our emphasis on quantum information science dramatically in the past few years. The Office of Science is investing in AI for science which is different from commercial applications of AI. Computing, AI, Quantum Sciences — we've heard about these things and DOE is working on them and Congress is funding them. The new team gets to tune those choices for sure, but I'd be surprised if there were any changes other than towards more resources for all of them, which would be great. One critical area not getting nearly enough support at DOE is engineering biology and biosecurity. Somehow it's gotten lost in the discussions about new funding, Endless Frontiers, etc. despite the critical role that the labs played in COVID-19 and have historically played in support of pharma. Biosecurity work belongs at DOE labs and we need to get busy building that capability before the next pandemic.

As a side note, it's not really basic science, but an almost completely unexploited area for government is AI for operations. Nobody in government is seriously using AI for utilities, human resources, logistics, and that sort of thing the way the Googles and the Amazons of the world leverage it. That is a big opportunity — we could revolutionize the operations of the government with AI for operations and that's not talked about enough. Last cycle, we asked the DOE laboratories to begin to build AI into their operations — to help manage and run these amazing machines for science that they build for example — and they are starting to make some progress so I hope that continues.

"What would national laboratories look like if we started with what could be instead of what we already have?"

One thing that excites me a lot is not necessarily a particular science direction, but rather the idea of rethinking what it means to do public sector science. I'm very interested in rethinking the form and function of our national laboratories. The form they are in now, with all their benefits and all their constraints, is an evolution of the Cold War weapons laboratories. We still are inward-looking with fences and government rules and a very conservative culture. What would national laboratories look like if we started with what could be instead of what we already have? The reason we have user facilities is that they are profoundly complicated and very expensive unique things that a lot of organizations need to be able to use. We need these things, but do they need to sit at a national laboratory? Does a national laboratory have to be a physical place, or could it be a distributed capability, for example? Given the discussions around increasing science funding in the new administration, what's the model for doing all that science? Maybe do we want to talk about that before multiplying the money? There are all kinds of opportunities to do that better, and I'm excited about that.

***SPR*: You were formerly the acting director of ARPA-E, the DOE's agency for high-risk, high-reward research. The Biden Administration recently proposed the creation of an "ARPA-C" to focus on climate change research, which could overlap with ARPA-E's broad mandate to reduce emissions and improve energy efficiency. How would you see ARPA-E effectively collaborating with a hypothetical "ARPA-C"?**

CF: ARPA-E is an amazing place. One important thing to understand about ARPA-E is that not only is it working on important revolutionary technology, but ARPA-E is also an ongoing experiment in reinventing government. It does

things in a fundamentally different way than DOE and most other agencies, including an extra focus on transition and commercialization that sets it apart even from its spiritual parent DARPA. It is meant to experiment with and to disseminate those techniques in innovation across government.

Anyway, the overlap will have to be treated carefully. A little bit of overlap is okay, but having two agencies with the same fundamental mission would be problematic or at least wasteful. The intention is good but it suggests a lack of understanding of what is already available: many government agencies are funding research on climate, advanced energy, earth systems modeling, etc. including ARPA-E, the DOE Office of Science, the DOE Office of Energy Efficiency & Renewable Energy (EERE), NSF, and even the Department of Defense. Every time we have a problem, do we want to stand up an agency or is it better to do the work to adapt the agencies we already have?

Formally, ARPA-E already has the explicit authorization per Congress to work on whatever the Secretary determines is important, so another agency really isn't necessary other than to signal priorities. But overlap is actually not the most serious problem with the proposed entity. I don't know if it's still in play but I have to say that the idea of mixing resources from other agencies to fund a notional ARPA-C scares the heck out of me, and I would urge deep consultation with leaders who actually have run an agency or have been on the receiving end of the authorization and appropriations process. Climate and advanced energy are undoubtedly whole of government problems, but tying bureaucratic knots will only make them harder to solve. So sure, create another ARPA for climate or more simply just create a dedicated separate division of ARPA-E. But just fund it there in the DOE and don't overcomplicate it with born-in rivalries, stovepipes, and cross-threaded incentive structures.

"Every science and technology agency needs to have that group that flies the pirate flag — you need to have the disruptors."

***SPR*: Since its creation in 2009 as part of the American Recovery and Reinvestment Act, annual funding for ARPA-E has more than doubled, but it still represents only a small fraction of the total DOE budget (only 6% the size of the current DOE Office of Science budget). Do you believe the current balance is too little, too much, or just right?**

CF: There is a right size for every agency. My experience at ARPA-E was that it was just about the right size — everyone could work together, meet together, exist on one open plan floor of a building, and know what was going on. That was the right paradigm for ARPA-E. There is a tension between the size of an agency dedicated to disruption and its effectiveness. So maybe slowly increasing the ARPA-E budget could be a good idea, but I wouldn't advocate for doubling its budget overnight and risk messing the place up. A lot of this work does not have to be funded the ARPA way — EERE, Office of Science, and other components of DOE are perfectly capable of funding a lot of this advanced energy work and indeed have more appropriate models for a lot of performers.

***SPR*: Regarding the ARPA-E model, "high-risk, high-reward" investments, did you learn any lessons that were transferable across ARPA-modeled agencies?**

CF: My takeaway from my time at ARPA-E is that it's genius... If you hold to the original premise. Every science and technology agency needs to have that group that flies the pirate flag — you need to have the disruptors — and yes, they need to be separate. The skunk works model is a great model. It's also an awful lot of fun to work there.

"That's the big takeaway for me: don't get locked into any one model and don't forget the mission there: to be bold and to be disruptive."

But you have to keep it fresh. You have to keep turning over the leadership and the staff. It only works well when you have fresh, hungry talent. The secret there is the tour of duty model: staffing people who come in from outside the government like most of the program officers — who know that they cannot stay in government — and are given the resources to do something cool in the time that they have. That is a powerful motivator. Of course, people don't want to leave because it's the best job they may ever have. But things will go sideways when you relax those standards, when people are allowed to stay too long. This is a real risk for ARPA-E right now.

Another great feature of ARPA-E is that unlike almost any other agency, ARPA-E gets a bucket of money and they are given flexibility to go do good things, with almost no line item restrictions from Congress. This is very special in government and is similar to the philosophy for funding DARPA. I suppose that's more of a lesson for Congress — let folks do their jobs without over-prescribing the rules and directions, and then hold them accountable for performance. It works.

The staff at ARPA-E therefore owe it to the country to use that flexibility and to be experimenting with new topics and new models for programs and funding and motivating performers. If you don't keep it fresh, then that's when you get into a trap, when things become stale, and are institutionalized, you lose the special forces feeling, the pirate ship, what have you... good people leave. That's the big takeaway for me: don't get locked into any one model and don't forget the mission there: to be bold and to be disruptive to achieve risky technical and techno-economic objectives.

But what was really impactful from ARPA-E was often not the results of the program (failure is an option at ARPA-E) but instead the process of putting the program together and consulting with the advanced energy community and saying,

"Here is where we are, the art of the possible now, and here is where we think we can get in 10 years if we work really hard." Putting numbers to that vision, not just technical specifications, but also the techno-economic specifications: How do we build this, finance this, make this economically viable? A lot of thought goes into each of those programs and that work becomes a roadmap for the community — independent of the particular ARPA-E program — that is very valuable. Oftentimes, the program vision becomes a reference document for the larger field, for the startup companies, and for the big companies to work on to get to the next level.

***SPR*: Compared to Office of Science funded R&D which is 80% performed by Federal researchers or the national labs, ARPA-E funded research is almost entirely conducted by non-Federal researchers. What lessons did you learn about government working with private sector and academia at ARPA-E? What were characteristics of successful government partners?**

CF: Great ideas come from all sorts of places, and ARPA-E really embraces that. There is not ongoing funding, such as repeated grant renewals, and the sort of long term intertwined relationship you might find with basic science agency performers. Generally, the more successful groups, investigators, and consortia, in terms of attracting ARPA-E funding, are those who actually read, take seriously, and respond to the call for proposals. Interestingly, a robust community has formed around ARPA-E. They help craft the programs through convenings, they participate (with appropriate boundaries regarding conflicts of interest) in reviewing proposals and responding to requests for information. This community comes together for an ARPA-E summit from time to time — that is a huge service to the community and the agency. So I'd say anyone with great and responsive ideas has a great shot at funding. The successful ones stay and participate long term in the community, but they can't make an enduring business out of ARPA-E funding in a way that crowds out new entrants.

"For agencies to have enduring missions, they must have enduring principles and guardrails."

The relatively unique focus of ARPA-E is in the space between the basic or applied science and commercialization. What is unique about ARPA-E is that for a given proposal, there are technical goals and techno-economic (i.e. tech transition) goals. At DARPA, if you don't meet technical goals, you're out. But ARPA-E assesses both sets of these goals. Successful teams know they need to have a commercialization or transition plan, to find partners, hold discussions about financing their project. It's not just about the science and successful performers understand that. Oftentimes it is folks outside of academia — companies, nonprofit research organizations for example — that are especially well suited as performers under the ARPA model because they understand the productivity demands and the urgency.

***SPR*: There is a certain school of thought that advocates for operating ARPA-like agencies on fixed lifecycles (*e.g.* 10 years), shutting them down, and then rebuilding them. Do you think such an idea would be beneficial in preventing issues that develop over time, such as regulation creep or stagnation that stifles the "pirate crew" mentality you mentioned earlier?**

CF: I would definitely want to listen to that argument some more. It is absolutely the case that ARPA-E is a great agency, but it's certainly not the same agency as it was 10 years ago when it was in startup mode. The natural flow of government is that barnacles grow, more processes, etc. ARPA-E should be a "tour of duty" in government for people coming from outside government and it should be a temporary developmental experience for people inside government including the administrative functions like contracting, legal, HR, etc., as well as program and commercialization officers. No one should have a permanent role in ARPA-E. It is not a terrible idea to take this idea to the next logical level and say that the organization itself should have a lifetime, maybe 10 or 20 years. It is the inexorable nature of government to complicate things and bog things down in process. I'm intrigued by the idea of shutting it down and starting over from time to time. That's something that should be discussed to explore the merits.

***SPR*: Longer-term employees and contractors can help hold down institutional knowledge for an organization. Are there other mechanisms to provide that? Or is it a feature to leave that institutional knowledge behind?**

CF: It's a balance. Another great feature of ARPA-E is that you have a phenomenal group of contractors supporting the organization. But there's a tension there — institutional knowledge is a double-edged sword, often otherwise known as process. And an example of that is the DOD acquisitions process which can take decades. ARPA-E was created 10 years ago, and at some point the institutional knowledge also resides in the community of people who have worked with the agency, with staffers on the Hill, advisors at the White House Office of Science and Technology Policy, etc. But it's OK to let some of that go if the alternative is to get stale and not turn people over.

***SPR*: The Office of Science notably funds many large-scale facilities and multinational programs. Having overseen many of these projects, can you share any high-level lessons learned with regards to ensuring project success over the long-term?**

CF: The Department of Energy Office of Science is a complicated and nuanced organization that includes the functions of something like the National Science Foundation for supporting basic research, but also the operation of ten national laboratories, international collaborations like International Thermonuclear Experimental Reactor (ITER), European Organization for Nuclear Research (CERN),

Long-Baseline Neutrino Facility, and Brookhaven's future Electron-Ion Collider. A lot of diplomacy and hard work go into convincing people to participate in these international projects. When it comes to high energy physics, international bodies and countries come together to say, "This is what we've got to do next," and make a roadmap. While these roadmaps aren't determinative for the United States, we carefully consider them when developing our plans. But one of the big lessons in the context of plans and projects that can take a decade or more to realize, is that a new leader needs to take some time to understand the totality of the mission and the interrelated threads of work before making any decisions. The natural timescale of ARPA-E is the notional 4 year tenure of a program manager. The natural timescale of the Office of Science is much longer.

One of the things that I discovered at the Office of Science was that the long-term investment strategy was a little out of balance, in part because of the natural inclination want to do big things. To fix that, I re-established a long-term budget balancing research, operations, and capital projects. We're going to spend 40% of our money across the whole office of science on operation of our user facilities. We're going to spend 40% of our budget on research including money for laboratories and academia. We're going to spend 20% of our money on "other" which includes capital projects such as building new colliders, rebuilding existing synchrotrons, and new facilities. Across the whole Office of Science that 40/40/20 rule is something that everyone can understand, including Congress and the White House. I say re-established because this was an idea that was already in place, but we were not following the guidelines. It's so easy to compromise on these framing principles — to sacrifice the important for the urgent — but you can't do that. For agencies to have enduring missions, they must have enduring principles and guardrails.

***SPR*: What advice would you give to early career scientists interested in science policy?**

CF: Thanks for the question and thanks to *SPR* for what you do to communicate issues in science policy. The opportunity to participate in and understand programs and policy in science and technology is such a gift — or it has been to me — and it is also critical to attract outside perspectives into government. I tell everyone who will listen that it's an awful lot of fun as well. Take some time out of your bench science career to do a tour of duty at a science agency, or maybe even consider a career in government. You will not regret it.

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