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It's Critical to Prioritize Commercial and Market Readiness for H2Hubs

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Effectively managing the Energy Department's hydrogen hubs program in the face of formidable challenges will be vital for the success of developing hydrogen-based economic ecosystems.

KEY TAKEAWAYS

- The Department of Energy's (DOE's) $8 billion hydrogen hubs (H2Hubs) program must prioritize commercial viability, as key technologies haven't been tested at scale and the target markets don't yet exist.
- DOE must prioritize the economic sustainability of the H2Hubs by relentlessly driving down the cost of low-carbon hydrogen to parity with hydrogen produced by fossil fuels. Unless this target is met, other program goals won't be achieved.
- The hubs program is designed to pave the way for future ecosystems, so DOE must ensure that critical data on cost, performance, production volumes, and other parameters are widely shared.
- Getting the H2Hubs program right is important to show the impact of demonstration programs more broadly. If it helps support market transitions for new technologies or new applications, there will be many more demonstrations in other sectors as well.
- DOE is using the Cooperative Agreement legal framework for the H2Hubs, which gives the agency increased influence over day-to-day decisions. However, DOE should focus primarily on its oversight role rather than intervening in daily program management.
- While DOE has sought expert advice on many projects, the need here is deeper, broader, and longer term.
- Outside expertise will be needed to understand the market sustainability of proposed projects, ensure that broad strategic decisions are aligned with DOE goals, and review projects against agreed milestones.

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EXECUTIVE SUMMARY

The $8 billion hydrogen hubs program (H2Hubs) being deployed by the Department of Energy (DOE) is the most extensive demonstration program undertaken in energy in the United States. Designed to support the creation of sustainable hydrogen-based regional ecosystems, it faces formidable challenges, and DOE will need to adjust standard management practices to meet them.

Most importantly, the program targets important markets that don't yet exist, in many cases using technologies that have not been tested, missing critical components of the energy transportation infrastructure and facing competition from established and plentiful sources of cheap hydrogen (that emit substantial amounts of greenhouse gases (GHG)). The H2Hubs will likely be at a substantial cost disadvantage, which is why DOE will help fund the cost of building hydrogen production facilities (by reducing capital expenditures for operators) and may also provide operating support once they are made. The Inflation Reduction Act also provides substantial subsidies for clean hydrogen, while the 45Q program offers additional support for carbon capture projects.

These challenges are formidable, and DOE needs to do better completing major projects on time and on budget. So getting management objectives, structures, and resources right is critically important. To help overcome these challenges, we offer some suggestions to DOE that would assist in successfully implementing H2Hubs. These include:

- **Mission.** DOE must prioritize the economic sustainability of the H2Hubs. Without that, the hubs will fail, and any other objectives will fail with them. In addition, hubs must be judged on their capacity to eliminate GHGs, which is why DOE is funding them.
- **Oversight vs. day-to-day management.** DOE is using the Cooperative Agreement (CA) legal framework, which offers DOE more influence over detailed decisions. Overall, DOE should focus on its oversight role rather that intervening in matters in which it may have limited technical expertise and its activities could compromise oversight.
- **Outside expertise.** H2Hubs are a stretch for DOE, demanding expertise across the entire supply chain, including markets. DOE should recruit, pay, and use experts in a number of ways, particularly in the form of an External Expert Board.
- **Post-award negotiations.** DOE should recognize that it holds a very strong position when negotiating with the hubs after selection. Companies wishing to build hubs have nowhere else to go for the funding that is absolutely critical to their projects.
- **Transparency and accountability.** The hubs are designed to become demonstrations for how hydrogen ecosystems can be built and operated. They must therefore share all key data to encourage others to follow and learn from them. This will not happen unless DOE takes a strong pro-transparency position, insisting that hubs fully share their data, and providing detailed data for experts as well as annual reports for stakeholders.
- **Go/No-Go decisions.** The Funding Opportunity Announcement places substantial emphasis on Go/No-Go decisions at the end of each phase. This is misplaced: Important decisions will need to be made at different points (which DOE acknowledges)—but these huge decisions will be rare and will in aggregate be less important than DOE's ongoing ability to influence hub actions.
- **Additional funding/incentives.** DOE plans to set aside significant funding, beyond initial awards. It should use some of this funding to create a funding pool to incentivize acceleration and scope expansion. In the process, doing so would add important leverage to its relations with the hubs.
- **Milestones and metrics.** The Office of Clean Energy Demonstrations (OCED) must first prioritize commercial viability and then GHG reduction. However, other objectives must not be abandoned. The transparency recommended above should apply to all metrics, not just those that are top priority. Hubs can be pressured to meet all their obligations by capturing all objectives in a standard scorecard that is published regularly by OCED.

IMPORTANCE OF EFFECTIVE MANAGEMENT FOR H2HUBS

The Bipartisan Infrastructure Law (BIL) that established OCED provided $8 billion for hydrogen hubs to spur the creation of sustainable regional ecosystems powered by hydrogen. These H2Hubs could significantly impact the emission of GHGs, especially in hard-to-decarbonize sectors such as steel and heavy transportation. The challenge is significant: Technology continues to evolve, new markets are exciting but untested, and there are substantial and multiple challenges in building an entire ecosystem, including upstream linkages to feedstocks, production and storage facilities, transportation infrastructure, and downstream utilization. This means DOE will be making very substantial investments in technologies that have not been

proven at scale, in the expectation that they will help catalyze regional hydrogen-centered economies.

But the H2Hubs are important for another reason as well. They are a demonstration program designed to demonstrate that hydrogen-based ecosystems are ripe for commercial adoption by proving them at scale. The innovation literature has long underscored the difficult boundary technologies must cross between precommercial operations (prototyping, pilot stages, etc.) and commercial activities, especially where the scale is very large and projects are highly capital intensive.

H2Hubs are therefore also examples of the potential impact of demonstration programs more broadly. Can they help important technologies make the jump to commercial viability?

Effective management of the H2Hubs program is therefore doubly significant: A successful program would directly accelerate decarbonization; and success would further show that demonstration programs can work. This has implications far beyond the H2Hubs, beyond DOE, and even beyond the federal government. If the precommercial/market boundary can be crossed with the help of such programs, we can expect to see many more, in other sectors as well.

KEY CHALLENGES

The core challenge faced by hubs funded under H2Hubs is to demonstrate sustainability and commercial success. Without that, the hubs will fail. Funding for the H2Hubs is substantial, but it is not endless, and the selected hubs will eventually have to become commercially viable. Existing sources of hydrogen are already in use across the United States for a variety of purposes, derived from coal and natural gas. So eventually each of the hubs will be measured against the goal of reaching price-performance-parity (P3) in those existing markets.[1] Unless these technologies and business models reach P3, they will require ongoing subsidies or regulatory help to compete effectively with the existing hydrogen high-GHG production technologies.[2] While this may be necessary in the short term to get clean hydrogen to the scale needed, the eventual objective must be P3.

Each of the following challenges for DOE have the potential to derail the H2Hubs program.

Mission

For entirely understandable reasons, the H2Hubs Funding Opportunity Announcement (FOA) is filled to the brim with objectives, all of them worthy. They include the economic imperatives of developing an economically successful ecosystem and making significant progress on DOE's Hydrogen Shot economic objectives; the climate objectives of developing a clean hydrogen infrastructure; social justice imperatives including enhanced community engagement and commitments to share the benefits of the program with communities that have historically been poorly served by energy projects; environmental objectives that include siting and toxic emissions; and good jobs at good pay (ideally with unions attached).[3] In the FOA, these are characterized by more than 40 potential hub metrics, some (or many) of which will conflict at various times.[4]

Prioritizing therefore becomes critical—and failure to do so risks delays or stasis.

The harsh reality is unless each hub emerges as commercially viable and hence sustainable, it will fail, and as a consequence, all other objectives will also fail. So commercial sustainability must be the first priority for each hub. In our view, P3 must be achieved with existing sources of hydrogen (i.e., the hubs must match the price of prevailing hydrogen sources available in the market, at the same purity level, and with the same delivery capacity).

Of course, the hubs may not meet that challenge immediately: That's why the H2Hubs program offers ongoing support beyond initial capital investments. It's also why the Inflation Reduction Act provides generous tax credits for hubs that effectively reduce GHG emissions. But eventually (e.g., after 45Q tax credits for carbon capture run out after 12 years of plant operation), each hub must reach P3, or it will fail.

Beyond P3, the H2Hubs program exists to address climate change. The federal government is making investments only because hydrogen shows promise as a tool for mitigating GHG emissions, especially in some difficult-to-electrify sectors. So the next mission objective beyond economic viability is to demonstrate that the hubs are both reducing GHG emissions and supporting the pathway toward meeting the specific emissions components of the Hydrogen Shot objectives.[5] Once again, all other objectives are subsidiary because, if the hubs are not meeting GHG objectives, the federal government has no reason to keep funding them.

Determining priorities does not mean other objectives are unimportant or can be ignored. Prioritizing does not sideline social justice, environmental, or workforce objectives. Given the often poor history of the energy sector across these dimensions, these additional objectives must be underscored. They should be included in the agreements governing operations for each hub, fully reflected in the agreed metrics and milestones for the project, and fully reported (see accountability and transparency section). But as a matter of logic, these are subsidiary objectives: Hubs can succeed commercially and reduce emissions substantially without meeting any social justice, environmental, or labor objectives. The inverse is, however, not true: Hubs that don't meet commercial objectives will fail, and hubs that miss emissions objectives may well find that DOE will pull the plug.

So DOE must focus. It will be a hard road to commercial viability for all these hubs, and those based on carbon capture technologies may also need help to meet emissions objectives. DOE needs to face those facts and prioritize accordingly.

Program Management Concerns

Beginning in 1999, the National Academies issued what can only be described as a highly critical series of reports on DOE project management. It noted that large DOE projects systematically perform worse than similar projects in both the private sector and other federal agencies and listed 16 areas in which DOE fell "far short of best practices:"

> Documentation shows that DOE's construction and environmental remediation projects take much longer and cost about 50 percent more than comparable projects by other federal agencies or projects in the private sector. Moreover, DOE projects commonly overrun their budgets and schedules, leading to pressures for cutbacks that have resulted in facilities that do not function as intended, projects that are abandoned before they are completed, or facilities that have been so long delayed that, upon completion, they no longer serve any purpose.[6]

These problems have in the past plagued demonstration programs in particular. For example, the FutureGen carbon sequestration project in Mattoon, Illinois, in December 2007 failed in February 2007 and again after a significant restructuring in 2010 with an expenditure of about $200 million. Less recently, the failure of the Clinch River breeder reactor project shows the folly of ignoring market considerations and of overly optimistic construction and cost projections.[7]

Current evidence suggests that those concerns are still salient: In its most recent project management dashboard from October 22, 2022, the top 3 projects listed (by size), and 6 of the top 10, were in breach of baseline cost, schedule, and scope (see figure 1).[8] That is not encouraging, and suggests that effective oversight (and strong technical support) will be significant for the H2Hubs, given that the proposed hubs are larger than all but three of the projects listed.

Table 1: DOE dashboard of active projects, October 2022 (top 10 by budget)[9]

Project Name	Original Budget (Millions)	Project Budget (Millions)	Monthly Overall Assessment
Waste Treatment and Immobilization Plant (WTP)	$5,781	$16,813	Red
UPF Main Process Building Subproject	$4,732	$4,732	Red
UPF Salvage and Accountability Building Subprojects	$1,180	$1,180	Red
ECSE Laboratory and Support Infrastructure	$560	$560	Green
Los Alamos Plutonium Pit Production Project (LAP4)	$529	$529	Green
Saltstone Disposal Unit #10, 11, 12	$496	$496	Green
SPR-LE2-Big Hill	$457	$457	Red
On-Site Waste Disposal Facility—Infrastructure Construction	$373	$373	Green
SPR-LE2-Bayou Choctaw	$355	$355	Red
SPR-LES-Bryan Mound	$315	$315	Red

The H2Hubs program is much more complex, and each hub will (aside from a handful of exceptions) be much larger than the projects listed in the dashboard. The management challenges are therefore much more powerful and complicated.

The remainder of this paper offers selected ways OCED could manage the H2Hubs program to mitigate the multiple risks it faces and build the successful program we all need.

Oversight vs. Day-to-Day Management

DOE plans to adopt the CA framework for working with the hubs. CAs are similar to the better-known Cooperative Research and Development Agreements (CRADAs) used mainly to facilitate cooperation between federal labs and outside entities. CAs differ in offering DOE more day-to-day engagement with the projects, though those details must be worked out in each case.[10]

The CA adds engagement, but in doing so it creates contradictions, or at least tensions, for DOE. CAs anticipate "substantial involvement" for DOE in each funded hub (see box). What exactly this means will be defined through negotiations between DOE and the hubs after selections are made. Critically, it seems to imply at least some DOE engagement in hub decision-making, certainly for major decisions but possibly on a more day-to-day level as well.

Yet, increased input undermines DOE's primary role as a source of effective oversight. OCED will evaluate progress against agreed upon milestones, and it holds the key that unlocks further funding within the phases of funded projects and especially at the end of each phase, when OCED expects to make a Go/No-Go decision. Precisely to the extent OCED becomes involved in detailed hub decision-making, its impartial oversight role is jeopardized: The more involved OCED becomes, the less independent its perspective is likely to be.

About Cooperative Agreements

According to DOE:

An executive agency shall use a cooperative agreement as the legal instrument reflecting a relationship between the United States Government and a State, a local government, or other recipient when—(1) the principal purpose of the relationship is to transfer a thing of value to the State, local government, or other recipient to carry out a public purpose of support or stimulation authorized by a law of the United States instead of acquiring (by purchase, lease, or barter) property or services for the direct benefit or use of the United States Government; and (2) substantial involvement is expected between the executive agency and the State, local government, or other recipient when carrying out the activity contemplated in the agreement.[11]

This contradiction may be inevitable. It is hard to imagine that OCED could provide effective oversight without a detailed understanding of how a project operates, all significant decisions, personal moves, organizational structure, etc.

However, in general, a more arm's-length interpretation of the CA relationship will benefit both parties. DOE will undoubtedly find it hard to acquire the detailed management capabilities that would make it a useful day-to-day partner, and that would in any case tend to detract from its necessary oversight function.

Hence, in structuring the CA, DOE needs to avoid four key traps:

- **It cannot afford to become a roadblock against agile decision-making and the inevitable course corrections.** Detailed involvement in day-to-day decision-making is not likely to be a successful tactic.

- **It should not be so close to the decision-making process that objective oversight becomes difficult or impossible.** DOE also may might need to develop internal processes to strengthen its oversight.
- **It must avoid the worst of all worlds: being implicated in decisions but without any real capacity to affect them.** Given that DOE will wish to see a continuing flow of funding to the hubs, it has relatively little native leverage over decisions once contracts are in place, unless the CA contracts hardwire power over specific kinds of decisions.
- **It must focus significant resources and attention on oversight.** This should include resources from the H2Hubs program, OCED, and the outside experts discussed ahead. In addition, effective oversight will require that OCED commit fully to program transparency: Outside oversight will be absolutely critical, and it can be effective only if access to relevant data is freely provided.

To resolve these challenges, OCED will need both internal and external oversight capabilities. DOE itself must be the first source of oversight, and it should ensure that input into the process is included from a range of DOE components outside the direct chain of command for the hubs. Beyond that, OCED should lean heavily on the external expertise recommended ahead (see Outside Expertise). That can be considered an extension of the kind of independent outside reviews often used at DOE; for example, the DOE Hydrogen and Fuel Cells Technology Office has commissioned several outside reviews.[12]

Outside Expertise

For very practical reasons, OCED should be seeking significant outside expertise. In its October 21, 2021, letter to Secretary Granholm, the Information Technology and Innovation Foundation (ITIF) and other non-governmental organizations (NGOs) strongly recommended that OCED lean on outside expertise in managing the hubs.[13] However, the letter did not address the details of how exactly this outside expertise would work.

National Academies External Review Recommendations

Per the Nuclear Regulatory Commission:

The National Academies reports had specific recommendations for external review of large projects (>$750m). It recommended that for early phases DOE should use an independent project review (IPR) using Federal staff from other agencies unless the project was found to be sufficiently complex that an external independent review (EIR) was warranted during these stages); and that both IPR and EIR review should be used during CD-3 and CD-4.[14]

It appears likely that OCED will put together a Merit Review Board before reviewing the full hub applications starting in April 2023. Membership may come from other federal agencies or from experts outside the federal government (or a mix). However, this review function is only one place where external input would be valuable, and in our view, it is not the most important.

An External Expert Board (EEB) should support four core functions:

1. **Selection.** An EEB is, as OCED has already apparently concluded, needed to provide expert input into the selection process, focused in particular on the commercial prospects for each proposal as well as some aspects of the technologies being proposed, along with

the proposed ecosystem itself (including infrastructure, upstream linkages, storage, and end users).

2. **Expertise during negotiations.** If used correctly, EEB input could help OCED negotiate with hubs and in the process enhance hub proposals. Projects can be tweaked and improved considerably during this period, and OCED would be wise to take full advantage of the EEB's expertise.

3. **Ongoing support for hubs.** Like the H2Hubs program more broadly, each hub will be built largely from scratch, and while some will come with significant expertise in developing and managing such big and complex projects, others may need more support. Access to industry expertise via the EEB could be highly beneficial for the hubs, and OCED should ensure that this expertise is available to them.

4. **Oversight and review.** The H2Hubs program should be highly transparent. Part of that transparency will derive from strong public reporting features, and the EEB could participate here to ensure that hubs reporting is effective and complete. For example, the EEB could be tasked with addressing hub annual reports (see reporting section below). The EEB could also provide its own formal or informal oversight of the hubs by highlighting concerns and offering recommendations and solutions.

These functional requirements suggest the EEB that should remain in place throughout each hub's development, and each would therefore be tasked with a substantial amount of work. That implies EEB members should be paid for their work (this is too much effort for OCED to seek pro bono participants). The EEB will also need its own staffing: not necessarily substantial FTEs, but enough that the EEB can operate as a functioning entity and members can receive enough support to be effective.

Given this deeper and longer role, OCED must ensure that conflict of interest rules are both clearly specified and seen to be applied. This is a challenge, as it is difficult to find experts that don't have some stake in industry outcomes, even among academics. And the use of industry experts often faces challenges— the National Institutes of Health (NIH), for example, uses peer review to manage grant applications, has a separate institute entirely devoted to managing this process, and still runs into controversies.[15] OCED should therefore be prepared to implement best conflict-of-interest practices and also to assume that these will still lead to some difficult moments.

This central and persistent role for the EEB implies that the specific makeup of the EEB will be important. Here, OCED should ensure that it casts a wide net, drawing perhaps on other examples from within DOE: The Electric Vehicles Working Group (EVWG), which is being set up under the Bilateral Infrastructure Law, has slots designated for each key stakeholder group in the electric vehicles sector (e.g., energy providers, automotive dealers, electric vehicle battery manufacturers).[16] In a similar vein, OCED must ensure that the H2Hubs EEB fully reflects all the stakeholders in the emerging hydrogen economy.

OCED should also publish the names of EEB members. The overarching purpose of the EEB is only in part to provide technical assistance to OCED; it is also to provide evidence that OCED is—as an institution—listening to an appropriate range of voices outside the tight circle of the hubs and its own staff. The hubs will need to hear those voices, and different communities will

need to believe they are being heard. Simply listing the EEB by sector (e.g., six academics, five industry experts) is not sufficient, as it is the presence of specific experts that provides a voice for specific perspectives.[17] Again, the example from EVWG is useful; staff have indicated that once the membership is determined, the names of members will be published.[18] Membership in similar panels at other agencies is also published: For example, Defense Science Advisory Board reports include the names of participants, and the names of all participants in NIH proposal study review sections are public information.[19] A secret membership is also one in which potential conflicts of interest cannot be fully surfaced and addressed, as they should be.

One final point on outside expertise: In smaller countries, advisory boards often include foreign experts. In part this reflects the limits of available expertise, but it is also seen as a useful bulwark against cronyism: Finding someone as far from the outside as possible while adding expertise might be helpful here.

Post-Award Negotiations

OCED anticipates an extensive negotiation with hubs after selection and prior to signing contracts. During this period, it will negotiate exact proposal details, project milestones, management structures, the role of OCED in hub operations, reporting, the extent of OCED oversight, etc.

In normal circumstances, large private companies have considerable leverage when negotiating with the federal government. They often have other options available should the terms and conditions of a contract become too onerous. They may even move proposed operations out of the United States altogether.

But that is not the case here. The H2hubs are expensive and high-risk projects in which the federal government proposes to invest large sums, perhaps more than $1 billion in a single project. OCED funding is absolutely central to the viability of these projects, and as a result, OCED has extremely strong leverage.

These negotiations will be far too complex to discuss here except in general terms, but we offer some broad principles OCED might wish to take on board.

1. **OCED has all the leverage.** It is critically important that OCED understand—and act on—our assessment that it holds all the cards until the moment the contract is signed. At that point, the balance of leverage begins to shift quickly. And once the project is into Phase 2, momentum has irretrievably shifted to the private sector partners.
2. **In three key areas, the interests of DOE and its private sector partners diverge, sometimes becoming diametrically opposed.** In each case, it is important that OCED understand these different perspectives and objectives, and take appropriate action to ensure that its own objectives are fully addressed.
    a. **GHG reduction.** Commercial partners will undertake these projects only if they offer the prospect of commercial returns. That return may in part be based on GHG reduction (e.g., through the creation of new markets for clean hydrogen), but it is also possible that GHG reduction will be seen by partners fundamentally as a cost of doing business. That is emphatically not the case for DOE: GHG reduction is the overriding mission of the H2Hubs program.

b. **Community benefit/community engagement (CB/CE).** For the same reasons, CB/CE is centrally important to DOE, but not to the private sector partners. From their perspective, the project could proceed without any CB/CE at all.

c. **Reporting.** Commercial partners will seek maximum confidentiality, both to protect against possible competitors and—as others have observed—because, over time, U.S. private companies have increasingly sought to widen the scope of Confidential Business Information when dealing with the federal government. More generally, DOE has very different objectives: the widest possible diffusion of all knowledge emerging from each hub. The FOA asserts that lessons from the H2Hubs program should be gathered and spread as widely as possible.

3. **OCED must fully exploit its leverage.** OCED has enormous leverage advantages during negotiations, and it should exploit those advantages fully to ensure that where its interests and those of its partners diverge, its own interests are fully protected and indeed prioritized. Much of this leverage will vanish once contracts are signed. There are worrying signs that this is not the view at OCED.[20]

4. **Use the EEB.** We have noted that OCED staff will be stretched and will likely have shallow pools of key expertise available. OCED should use the EEB as an expert resource during negotiations, and should at a minimum ensure the EEB reviews all draft contracts and provides feedback to OCED staff.

5. **OCED should have a backup plan.** It may be that negotiations with one or more hubs will fail. What they propose may, for example, be outside the scope of the program, or too expensive, or simply too implausible to meet mission objectives. OCED should prepare for this by retaining alternative proposals from other hubs that are not initially approved by the selection process. The existence of these alternatives will in itself strengthen OCED's negotiating position; conversely, OCED has few cards to play without viable alternatives.

Go/No-Go Decisions

The FOA lays out a process wherein there are phases, milestones, and specific points at which Go/No-Go decisions will be made, although it notes that such decisions can also be made at other points. This reflects concerns about previous DOE projects that were not cut short, despite good reasons to do so—although it is also fair to note that No-Go decisions have been made on big demonstration projects in the past (e.g., FutureGen).[21]

This crisp framework looks good in theory. We all want a world in which bad projects are ended so that good money is not thrown after bad, where failing projects can be stopped and funding reallocated in more promising directions. Phasing a big project also makes sense, and making decisions based on milestones also seems appropriate. But the devil is in the details, and in this case, the details are not only unlikely to work, but adopting this heavily phase-focused model may make the H2Hubs program less effective overall.

According to the FOA, milestones will mark transitions between four distinct phases:

1. **A preliminary planning phase**, during which OCED is requiring the development of a number of detailed plans (e.g., site plans, operational plans). Hubs are expected to complete the planning phase in 12–18 months and be provided up to $10 million by

OCED to do so. This is the point at which a No-Go decision would be of maximum value to DOE, allowing it to switch funding to more promising projects at the least expended cost. However, Phase 1 also has the least defined set of milestones, which will not, for example, require signed contracts from potential customers or suppliers. So while a No-go decision is possible, it is unlikely that selected projects will fall at this hurdle.

2. **The final planning phase**, which should end with projects ready to break ground. All the detailed planning, offtake agreements, community engagement etc., will have been completed and projects are ready to go. This is the first Go/No-Go decision point according to the OCED project matrix. The end of Phase 2 does mark a major set of milestones. And there could be cases in which failure to acquire a key project component (e.g., the relevant permits) might lead OCED to pull the plug. That seems possible but somewhat unlikely; there is always time to change plans, after all. And while expenditures ramp up sharply during Phase 2, projects will still not have begun the most expensive part of the projects: construction.

3. **The Go/No-Go decision phase** is expected to end with the system in full operation. As Phase 3 proceeds, the balance of OCED funding will flow into the project. Thus, sunk costs will become more and more important. There are really two cases in which No-Go decisions may come into play: The project may get stuck somewhere in Phase 3, suffering ongoing delays that raise risks and may eventually lead private sector partners to pull out. More generally, there may be disruption within the hub—partner plans may change. Or the hub may clearly fail to meet some of the key criteria: It may be on a path that will never be commercially viable; its GHG emissions reduction may fail to meet requirements. It's in these cases that OCED will need to make extremely difficult decisions. Once again, we recommend that it lean heavily on the outside expertise previously described.

4. **Full commercial operations** without ongoing OCED funding.

The FOA emphasizes milestones and gateways between phases. However, all phases are not equal. Funding is heavily concentrated in Phase 3. Further, the most-challenging decisions will be made within Phase 3, rather than at its end.

More generally though, these are huge projects that are highly visible and have immense political and corporate prestige invested in them—and DOE of course will not be at all eager for any of them to fail. There are too few of them to simply take a portfolio approach and hope they succeed overall. OCED is also using the CA model, which gives OCED much closer connections to project operations, so it is more closely implicated in any failures.

In short, while a No-Go decision at some point in the pathway to commercialization is possible, it will be a very difficult decision to make. Of course, if economic factors turn decisively against a project—for example, the price of natural gas continues to climb to levels that make it uneconomic for a feedstock—a project will collapse. But that would happen primarily because private sector partners recognize economic realities. It is hard to imagine a hub project in which private sector partners are willing to proceed and have the money available to fund it further but OCED says no.

In parallel, it is difficult to imagine that OCED will pull the plug if a project's economics remain favorable but other requirements are not met. Will OCED really drop a project because community engagement is insufficient, or Justice40 goals are missed? It seems unlikely, and would have dire consequences for OCED's reputation as a potential partner on commercial green energy projects.

Given this reality, the emphasis placed on Go/No-Go decisions in the FOA is misplaced. Instead, OCED should be looking in two alternative directions.

First, it should seek to build additional leverage short of the nuclear No-Go decision, but also bearing in mind the limits of day-to-day management involvement discussed in the Oversight section. Incentives are discussed in the next section on Additional Funding.

Second, it is OCED's job to make the hubs successful. OCED can help facilitate the sharing of technical, financial, and market resources across the hubs and from DOE's own internal resources, including OCED, the Hydrogen Office, and the National Labs. This will require new thinking at OCED, and a willingness to go both outside the agency and inside the various relevant offices that can provide technical support. This technical support function could be very valuable.

Additional Funding as Incentive for Acceleration or Expanded Scope

The proposed hubs are massive and complex and will take a considerable time to roll out. During that period, facts on the ground will undoubtedly change, and it seems that OCED will hold back perhaps $1 billion out of the total $8 billion authorized. That certainly makes sense.

That held-back funding creates a new opportunity for OCED. Beyond shoring up areas of projects that need extra help, OCED can fund the hubs to accelerate deployment or expand the scope of their projects. The winning hubs have already passed through the competition required by federal acquisition rules, so providing an additional opportunity should be relatively straightforward.

Additional funding could be made available during Phase 2 and especially in Phase 3, when plans are well advanced but new opportunities may also have emerged. Additional funding could take several forms, including entirely discretionary funds, a mini-competition, or OCED setting specific and ambitious goals hubs could seek to achieve. Funding would still require a continued 50 percent match.

These additional funds would play another important role. As noted, once contracts are signed, OCED's leverage over projects declines sharply. And because No-Go decisions will be rare, that nuclear option may carry little weight. So OCED's leverage options become limited: Slowing the project in some way or holding back some part of the committed funds are not really viable options. A more positive set of incentives could increase OCED's capacity to shape hub activities, at least at the margin.

Matching Funds

ITIF has welcomed DOE's decision to allow in-kind contributions toward its 50 percent funding match. Forcing the use of cash would mean that hubs contributed far more than 50 percent of the total cost of a hub, because their own costs (in terms of manpower as well as other assets) would not be counted toward the match.[22]

DOE accepts in-kind contributions that are:

- verifiable from the contractor's books and records;
- necessary for the effective and efficient accomplishment of the project;
- types of charges that would otherwise be allowable under applicable federal cost;
- principles appropriate to the contractor's organization;
- not charged to the federal government under any contract, agreement, or grant, unless specifically authorized by legislation; and
- not included as contributions for any other federal program.[23]

DOE has considerable experience with in-kind contributions, as they are often an integral part of the CRADAs that have been used extensively by National Labs to partner with the private sector—as of FY 2019, DOE had more than 1,000 active CRADAs.[24]

Despite that, the in-kind contributions projected within the H2Hubs program raise some concerns, if only because the amounts involved are so large, and because partners may be able to load their own commercialization activities into the in-kind share. OCED should therefore develop a framework specifically for demonstration projects that indicates the in-kind contributions that will be accepted. In doing so, DOE will need to address a philosophical question: The hubs are designed to reach sustainability at the end of DOE funding, and as they move toward that point, should DOE be allowing standard commercial activities—including sales and marketing—to be counted as in-kind contributions?

Accountability and Transparency

The H2Hubs program primarily aims to build a series of hydrogen hubs that can become the core of regional hydrogen-based economies. But it is also a demonstration program designed to encourage the further adoption of hydrogen.

The success of any demonstration program depends on the effective sharing of critical project information. Transparency allows the dissemination of lessons learned as well as technical information so that follow-on projects are market ready. But that is possible only if critical data about cost, performance, and other key parameters are made widely available.

The H2Hubs program's long-term success will depend on continuing bipartisan support and buy-in from a wide range of stakeholders across the country. A steady and comprehensive flow of information will help sustain confidence in the program, especially under the strain of one or more projects appearing less successful than anticipated, which is inevitable. The recent request from Republican members of Congress for more information is just a marker for more queries and demands—a necessary and legitimate part of congressional oversight.

In short, there are both technical and practical reasons for the H2Hubs program to be highly transparent. The FOA confirmed this principle when it noted, "Phase 4 will also include substantial financial, socio-economic, environmental, and operational data collection and reporting to DOE." Further, "DOE will require unfettered access to project performance and financial data necessary to track progress against a project baseline (or similar). As these

projects are new commercial deployments, to the greatest extent possible, project progress and information will be shared with interested stakeholders."[25]

Reasons for Concern: Contradictions Within the FOA

Despite the undeniable logic of transparency, there are reasons for concern. The H2Hubs program is designed to result in commercially sustainable enterprises. The detailed operations and outputs of such private sector enterprises are typically regarded as business secrets, and hence are confidential. The FOA accepts this logic:

> For this FOA, selectees and recipients may request an extended period of protection (more than five years and not to exceed thirty years) if reasonably required for commercialization for specific categories of data first produced under the resulting awards in accordance with 15 U.S.C. § 3710a(c)(7)(B)(ii) and the Energy Policy Acts of 1992 and 2005. Further direction will be provided during the negotiation process upon request.

This contradicts the previously cited paragraphs: It asserts that the hubs are primarily commercial, not precommercial. And it is based on an expansive reading of the underlying statutory authorities. The Infrastructure Investment and Jobs Act section referenced in the paragraph above invites extended protection for private sector information.[26] But this is available only on a specific basis: According to DOE's guidance document, DOE must determine, in accordance with 15 U.S.C. § 3710a(c)(7)(B)(ii), that the nature of such information, "could reasonably require an extended period of that protection to reach commercialization."[27] As these hubs are all expected to reach commercial production within eight years, there is simply no basis under the guidance for extending protection for up to 30 years.

In fact, the paragraph cited above from the FOA seems to suggest that hub technical and cost data should be protected throughout the period in which the relevant technology or operations are in use. The FOA states that DOE will not assert any special rights over data or information, and that the public at large—or even other stakeholders—should have no rights to that information, despite the enormous investment from U.S. taxpayers.

The FOA seeks to reconcile this tension between transparency and confidentiality by stating:

> To the extent practicable while protecting sensitive and proprietary information, DOE will synthesize, anonymize, or otherwise incorporate site and operations data for the H2Hubs into quantitative and qualitative analyses that can be promulgated to external stakeholders for the purpose of informing future private sector investment decisions.

We do not believe this approach will prove workable. There will be only a handful of hubs, using a limited range of feedstocks and supplying a relatively small number of markets initially. Each will be unique, and it will therefore not be practicable to "synthesize" or "anonymize" site and operational data.

Given the need for rapid acceleration of low-carbon markets and technologies, any extended period of secrecy is unacceptable and counterproductive to DOE's mission. For the reasons articulated, we believe that, in the public interest, DOE should err on the side of greater transparency.

What Should Be Published?

From the perspectives of policy and oversight, what matters is the alignment between project objectives and project outcomes. Accordingly, three sets of information really matter:

1. **The terms of the final agreement and project milestones.** Understanding the agreement and the milestones is the only way for stakeholders and the general public to comprehend exactly what the project aims to achieve, and the markers against which OCED and the awardee have agreed to measure progress at selected points in what is likely to be a lengthy project timeline. OCED should therefore publish the final agreements, particularly the project milestones.
2. **Milestone-related data and information.** Assuming that the milestones are published, H2Hubs must be required to publish the data and information that would allow progress against those milestones to be assessed. It will not be sufficient for the hub to simply assert that specific milestones have been reached successfully, or for OCED to validate this claim. Stakeholders and the public should have full data on which to base their own assessment of milestone-based progress.
3. **Additional technical data.** Beyond formal milestones, there may be important technical data that would help other existing or subsequent hydrogen hubs. While we agree that the companies investing in the hubs deserve to keep some information confidential (especially process information), confidentiality should not extend to outcomes, which should include both performance (including technical results) and costs.

OCED should therefore take advantage of its leverage during negotiations—which exists only until the moment contracts are signed—and seek maximum transparency, particularly for outcomes data. It should balance company demands for confidentiality against the public interest in disclosure. We expect OCED to accept that there are limits to transparency and publication for each hub, but despite that, OCED's default position should be "publish everything," not "publish nothing."

Reporting

The FOA contains almost nothing about reporting on H2Hubs, even though the reporting function is critical to the overall success of the program.

There are two broad audiences for information from H2Hubs. One audience is closely interested stakeholders: other existing hubs, potential participants in possible follow-on hubs, other companies in the energy business (or potential end-use sectors), academics, and researchers. The second audience is communities that are less focused on details but still have a significant interest in the success or failure of the hubs: politicians and their staffs, staff of DOE and other agencies, NGOs, state partners, regional communities that are already affected by existing hubs, and those that may become hub host sites in the future. These two clusters have different information needs: The closely interested will seek information that is as detailed and technical as possible, while less tightly focused communities will seek more predigested reporting.

OCED should therefore take a twin-track approach to dissemination. For closely interested stakeholders, it should make available relevant technical and outcomes data as soon as possible. Raw data should be provided unfiltered, wherever possible; where there are genuine

confidentiality issues, OCED should ensure that the required filters are as narrow and temporary as possible. EEB expertise may help to resolve conflicts here.

Direct access to this data reduces informational friction to a minimum and ensures that those with the greatest need for detailed data and information can access it as soon as possible. This data should be made widely available: on the OCED website, on hubs' individual websites (mandated as such in negotiations), and possibly published via a cross-hub data platform such as that proposed in the recent FOA for Long Duration Energy Storage.

However, raw data is not always easy to understand or contextualize. We therefore also recommend that OCED require each hub to publish an annual report on its activities and DOE itself publish an annual report on the progress of the H2Hubs program. The latter can also act as a report to Congress (that will most likely be required in any event).

It is hard to overstate the importance of transparency and accountability for the H2Hubs program. It should help the United States make progress toward its climate goals, and may become a model for future demonstration programs. Realizing these opportunities depends to a considerable extent on effective reporting as a core feature of the program.

Recommendations

To deal with these formidable management challenges, we offer the following core recommendations for the H2Hubs program:

- **Mission.** OCED must recognize a hierarchy of objectives for the H2Hubs program: Commercial viability comes first (by reaching P3), emissions reduction comes next, and other objectives—though important and worth defending—come after commercial success and emissions reduction. This has implications for the selection process and for ongoing operational decision-making.
- **Outside expertise.** OECD needs to attract a high-quality EEB, pay them, and use them wisely. Their expertise should be used in several distinct ways on the H2Hubs program, and the EEB should be regarded as a source of information, expertise, and resources that can be brought into the work of individual hubs as well as the overall program. The EEB should remain in place for the life of the H2Hubs program.
  - It may be that the best institutional structure for the EEB is as a committee under the federal Advisory Committee Act (FACA). This would enhance transparency but would limit the use of the EEB to work on difficult sensitive problems that DOE will need to address. An alternative model would locate the EEB within the Foundation for Energy Security and Innovation (FESI).
  - DOE should also work to create a mechanism through which the National Labs can help solve technical problems for the hubs. The Labs have cutting-edge technical and modeling capabilities and could be a very important source of support. DOE would need to create a cross-Lab working group and would have to resource that group directly.
- **Additional funding.** The FOA emphasizes the importance of Go/No-Go decisions at various points in a project's timeline. However, such decisions will necessarily be rare at best. OCED must find other positive and negative incentives to influence behavior. In

particular, OCED should set aside a significant amount of program funds as additional acceleration or scope expansion funding. This would of course let hubs take advantage of new opportunities, particularly to exploit new technologies, and would provide OCED with important leverage in discussions with the hubs.

- **Management vs oversight.** The CA model carries some broad risks: First, that OCED will dig in too deeply, risking the imposition of bureaucratic roadblocks; second, that day-to-day involvement risks undermine OCED's oversight function; and third, there is no reason to believe that OCED staff would be better at management tasks than their private sector counterparts at the hubs. So overall, OCED would be best served by negotiating tight timelines along with clear commitments and milestones, and by strengthening its oversight capability rather than seeking detailed involvement in day-to-day management.
- **Governance.** The FOA implies that there will be a single entity that's accountable to DOE at each of the hubs. However, there is already evidence that at least some of the hubs will be more like loose agglomerations of related interests, with little central management capacity, and in particular, little capacity to enforce decisions. DOE needs projects with effective governance, so it should ensure that governance is a central issue in negotiations before selection decisions are made.
- **Accountability and oversight.** DOE has at times struggled to manage very large construction projects, which are analogous to hub development (hubs will involve more than just construction, but the latter will account for a significant share of the costs and much of the early effort). To address management concerns, OCED should develop clear lines of accountability and effective internal review, while enhancing the oversight function. DOE should ensure that OCED develops internal accountability and oversight functions independent of the team managing a particular hub. It should also ensure that expert insight is used to provide additional detailed oversight.
- **Transparency.** Beyond the internal accountability previously described, OCED must also ensure that all stakeholders have an opportunity to exert oversight and accountability by ensuring that each hub's activities—and the H2Hubs program—are fully transparent. This means negotiating hard with hubs to ensure that key elements of the program are not shrouded in operational secrecy. Minimum requirements should include the following:
  - OCED must publish milestones.
  - OCED must require that the hubs publish a continuous stream of project data.
  - OCED must ensure that annual reports on each hub and on the H2Hubs program are published (and are sufficiently comprehensive).
- **Effectiveness, milestones, and metrics.** Milestones can be used to develop appropriate metrics to demonstrate progress toward program objectives. As noted, OCED should prioritize first commercial viability and then GHG reduction. However, other objectives must not be abandoned. The transparency recommended should apply to all metrics, not just those that are top priority. Indeed, one way to help hubs meet all their obligations is to regularly focus on the metrics that reflect them. All objectives should be captured in a standard scorecard that is published regularly by OCED.

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ENDNOTES

1. Hydrogen has traditionally been produced using natural gas or coal as feedstocks (gray hydrogen), which produces substantial amounts of GHGs. The same H_2 production processes with additional technologies to capture the CO_2 released ("carbon capture, utilization, and storage"—CCUS) is known as blue hydrogen. Green hydrogen uses electrolysis powered by renewable energy and generates zero GHG emissions. Pink hydrogen is similar but uses electricity from nuclear power.
2. We plan to address the importance of P3 in a subsequent paper.
3. "Hydrogen Shot," U.S. Department of Energy, accessed March 17, 20223, https://www.energy.gov/eere/fuelcells/hydrogen-shot.
4. "Regional Clean Hydrogen Hubs," DOE, accessed March 17, 2023, https://www.energy.gov/oced/regional-clean-hydrogen-hubs.
5. "Hydrogen Shot," U.S. Department of Energy, accessed March 17, 20223, https://www.energy.gov/eere/fuelcells/hydrogen-shot.
6. National Academies of Sciences, Engineering, and Medicine, *Improving Project Management in the Department of Energy* (Washington, D.C., 1999: The National Academies Press), https://doi.org/10.17226/9627.
7. GAO Analysis of The Department of Energy's Clinch River Breeder Reactor Cost Estimate, December 10 1982, GAO/RCED, 83–74.
8. DOE, Project Dashboard—October 2022, https://www.energy.gov/sites/default/files/2022-11/October%202022%20Project%20Dashboard.pdf.
9. The full list is available at "Project Dashboard – October 2022" energy.gov, https://www.energy.gov/sites/default/files/2022-11/October%202022%20Project%20Dashboard.pdf.
10. Technically, a CA is a legal instrument reflecting a relationship between a federal agency and a non-federal recipient, made in accordance with the Federal Grant and Cooperative Agreement Act of 1977 (31 U.S.C. 6301-6308).

11. U.S. Department of Energy, Office of Science, "Grants/Contracts Differences," webpage accessed April 12, 2023, https://science.osti.gov/grants/About/Grants-Contracts-Differences.
12. "Independent Peer Reviews," DOE, accessed March 17, 2023, https://www.hydrogen.energy.gov/peer_reviews.html.
13. David Hart et al. "First of Its Kind: Making DOE's New Office of Clean Energy Demonstrations a Success" (ITIF, April 2022), https://itif.org/publications/2022/04/18/first-of-its-kind-making-doe-office-of-clean-energy-demonstrations-a-success/.
14. National Academies of Sciences, Engineering, and Medicine. , 1999. Improving Project Management in the Department of Energy. (Washington, D.C., 1999: The National Academies Press.), https://doi.org/10.17226/9627.
15. The NIH Center for Scientific Review.
16. "Federal Advisory Committee (FAC) Membership Balance Plan," U.S. DOE, June 2022, https://driveelectric.gov/files/ev-working-group-membership-plan.pdf.
17. For example, there are 19 separate categories for the 19 non-federal members of the Electric Vehicle Working Group, as published in the Federal Register, https://www.govinfo.gov/content/pkg/FR-2022-06-14/pdf/2022-12755.pdf.
18. DOE staff—private communication.
19. See, for example, "GEMS: gaming, exercising, modeling, & simulation," Department of Defense: Defense Science Board, January 2021, https://dsb.cto.mil/reports/2020s/GEMS%20Executive%20Summary%20FINAL.pdf; See for example the membership of the Arthritis, Connective Tissue, and Skin Study Section, NIH, https://public.era.nih.gov/pubroster/roster.era?CID=102353.
20. Ed Rightor and Robin Gaster, "Joint Letter to DOE Regarding Transparent Implementation of the H2Hubs Program" (ITIF, January 26, 2023), https://itif.org/publications/2023/01/26/joint-letter-to-doe-regarding-transparent-implementation-of-the-h2hubs-program/.
21. Gregory H. Friedman, "Special Report: The Department of Energy's Loan Guarantee to Solyndra, Inc." DOE, August 24, 2015, https://www.energy.gov/ig/downloads/special-report-11-0078-i.
22. DOE defines in-kind contributions as "Noncash contributions provided by the Participant or contractor. In-kind contributions must include collaboration in the research and development efforts of the CRADA and may also include personnel, services, facilities, equipment, intellectual property and other resources. Work may be performed at either party's facilities and include services that are directly beneficial, specifically identifiable, and necessary for performance of the project. In-kind contributions generally do not include work performed prior to execution of the CRADA." DOE O 483.1B Chg 2 (LtdChg), DOE Cooperative Research and Development Agreements, https://www.directives.doe.gov/directives-documents/400-series/0483.1-BOrder-b-chg2-ltdchg.
23. "Acquisition Guide Cost Participation," U.S. DOE, June 2004, https://www.energy.gov/sites/prod/files/17.2_Cost_Participation_0.pdf.
24. National Institute of Standards and Technology, *Federal Laboratory Technology Transfer Fiscal Year 2019*, August 2022, https://www.nist.gov/system/files/documents/2022/09/29/FY2019%20Federal%20Technology%20Transfer%20Report.pdf.
25. DE-FOA-0002779: Bipartisan Infrastructure Law: Additional Clean Hydrogen Programs (Section 40314): Regional Clean Hydrogen Hubs Funding Opportunity Announcement, https://oced-exchange.energy.gov/Default.aspx#FoaId4dbbd966-7524-4830-b883-450933661811.
26. It does not appear that guidance differs for CRADAs and Cooperative Agreements.

27. "Interim General Guidance Regarding up to Thirty-Year Protected Crada Information," DOE, July 20, 2022, https://www.directives.doe.gov/related-items/interim-general-guidance-regarding-up-to-thirty-year-protected-crada-information. The statutory basis for this PCI protection rests on a section (b)4 in title 552, which simply states that FOIA applications do not apply to "(4) trade secrets and commercial or financial information obtained from a person and privileged or confidential." There is no further definition of these trade secrets either in title 552 or in 3710a.