



Designing an Intellectual Property and Data Governance Framework for a Superhot Rock Geothermal Testbed

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0. Executive Summary

Superhot rock geothermal (SHR) offers a pathway to globally scalable, zero-carbon, always-available power. Achieving this potential requires credible, field-validated evidence of drilling performance, reservoir creation, and high-temperature tool reliability at conditions that individual companies cannot replicate alone. Early-stage SHR development is capital-intensive, technically complex, and commercially sensitive, which makes well-designed SHR testbeds a critical enabler of progress.

To function effectively, an SHR testbed must offer participants **predictable intellectual property (IP) and data governance rules** that protect the development of proprietary technology while enabling the shared learning required for sector-wide advancement. This need is particularly acute in the SHR context, where technology development is often venture-backed and value resides primarily in proprietary tools, processes, and know-how rather than in commodity assets. To date, the geothermal sector lacks a clear, widely accepted framework addressing these issues. Across discussions with industry leaders, startups, and public-sector stakeholders, uncertainty around IP and data governance consistently emerges as a key barrier to establishing SHR testbeds.

This report responds to that challenge by providing a **practical, modular IP and data governance architecture** designed to operate under two realistic scenarios: (i) a **fully private** or philanthropically funded testbed, and (ii) a **hybrid model** incorporating public support, illustrated through United States (U.S.) Department of Energy (DOE) financial assistance or laboratory collaboration.¹ The U.S. framework is used as a reference case to provide jurisdictional specificity and to demonstrate how public funding can shape IP and data obligations in practice; not because these dynamics are unique to the U.S. The analysis draws on lessons from U.S. subsurface and energy-sector programs (including HFTS, NCCC, FORGE, GAIN, RAPID, and NOWRDC) as well as international geothermal initiatives (including AOSTRA, Iceland, Canada, and New Zealand) (each described in Section 4).

Although the mandatory IP and data requirements discussed arise under U.S. law, **comparable constraints** on IP generation, licensing, and data disclosure commonly **attach to publicly supported R&D in other jurisdictions** (examples include France, the United Kingdom, Denmark, and Japan), albeit under different statutory or policy instruments such as national innovation laws, public-research IP regimes, or government-use safeguards. The relevance of the U.S. case study therefore lies in the **structural levers it reveals**, including scope-based compliance, ring-fencing, and time-bounded confidentiality, rather than in its specific legal form.

¹ This paper is not intended to operate as a substitute for legal representation and does not create an attorney-client relationship. If you have specific questions about intellectual property or data governance legal issues for a geothermal project, you should consult a lawyer. Neither CATF nor any of the authors assumes any liability for the actions taken (or not taken) by any party in reliance on this paper.

Across the examined models, several principles consistently determine whether multi-party field-scale R&D succeeds:

- **Clear contractual protections for Background IP and Proprietary Information** are essential for attracting technology developers and investors, with no implied licenses and limited operational-use rights for the host.
- **Foreground IP should follow creation**, with joint ownership minimized to avoid administrative gridlock.
- **Data governance must be tiered**, clearly separating proprietary data, restricted test data, and publishable results, often supported by configurable embargo periods.
- **Where public funding or laboratory support is involved**, mandatory IP and data rules attach only to the supported scope, not automatically to all activity at the site, making careful ring-fencing critical to preserving commercial participation.
- **Governance must be transparent, predictable, and operationally credible**, with clear operator authority and defined decision-making channels.

The proposed framework combines (i) **clear contractual rules** for Background IP, Proprietary Information, Foreground IP, licensing, publication review, and access rights; (ii) a **multi-tier data architecture** aligned with participant risk tolerance; and (iii) a **public-funding compliance module** illustrated through DOE practice (see Sections 5 and 6). The structure is intentionally modular, allowing it to be adopted in full for a private testbed or selectively integrated into a hybrid model.

Taken together, these elements provide a **workable, commercially credible blueprint** for designing an SHR testbed that can be adapted across jurisdictions while protecting sensitive technologies, enabling structured knowledge release, and accelerating SHR innovation at the scale required for meaningful climate impact.

1. Background and Purpose of the Report

1.1. The Need for a Purpose-Built IP and Data Framework for SHR Testbeds

Superhot rock geothermal energy (SHR) is a **visionary yet largely untapped** energy source with significant potential to meet long-term demands for zero-carbon, always-on power and to expand global pathways for replacing fossil fuels. **Interest in such testbeds is growing internationally**, alongside rising geothermal investment and rapidly increasing patent activity. To accelerate innovation and to eventually drive the commercialization of SHR on a global scale, the Clean Air Task Force (CATF) is advancing domestic and international partnerships to support the exploration of joint testbeds for field-testing and pilot demonstrations.

SHR testbeds involve high up-front cost due to high investment per well, sequential and multi-stage exploration, cross-border collaboration, and tension between preserving commercial interests and enabling shared innovation. These conditions make **clear and predictable IP and data governance essential** to de-risking corporate engagement. Yet no established roadmap currently guides how geothermal testbeds should allocate IP, structure data governance, or balance confidentiality with scientific and public-interest objectives.

This report fills that gap by **outlining the key considerations that should guide the design of an effective IP and data framework and governance considerations for an SHR testbed** and by recommending adaptable provisions suited to different funding scenarios. Although the analysis uses the U.S. context as its primary reference point (reflecting both the availability of useful precedents and the likely location of early SHR pilots), the underlying concepts (such as protections for Background IP, Proprietary Information, and Foreground IP, data-tiering, licensing approaches, and participation structures) are **broadly transferable** across testbed initiatives in a range of jurisdictions.

1.2. Participant Incentives and the Value Proposition of SHR Testbeds

SHR testbeds are intended to attract a diverse set of participants, including technology developers, drilling and service companies, utilities, researchers, and public-sector sponsors. For these actors, participation is driven not only by access to physical infrastructure, but also by the strategic and reputational value that a well-designed testbed can provide. In particular, SHR testbeds can offer **priority access** to shared infrastructure and subsurface conditions that would be prohibitively expensive or risky for individual companies to replicate independently, while enabling testing under real-world conditions.

Well-structured testbeds can also generate **credible, third-party validation** of technology performance through standardized testing protocols, independent measurement, and documentation conducted by trusted hosts or partners. These outputs (test reports, datasets, or performance benchmarks) can be critical inputs for downstream investment decisions, regulatory engagement, and customer adoption, while participation may also confer signaling and credibility benefits through association with reputable institutions, government-backed or

internationally coordinated initiatives, and visibility within a growing ecosystem of geothermal innovators.

These benefits are realized only when access to shared infrastructure is matched with clear governance. Participants must understand how proprietary technologies are protected, what data may be shared and when, and how results can be used. Without that clarity, the same features that make testbeds attractive can also deter participation by creating risks of premature disclosure, loss of competitive advantage, or uncertain commercialization pathways.

1.3. Purpose of this Report

This report is intended to serve as a **practical reference for stakeholders when considering the development of SHR testbeds**, including policymakers, funders, project hosts, nonprofit organizations, established industry participants, and emerging technology developers. It is designed as a roadmap for thinking through IP and data governance choices, rather than as a jurisdiction-specific compliance guide.

While the analysis uses the U.S. and DOE practice as a primary reference point to ground the discussion in a concrete legal and institutional setting (see Section 2.1), the report focuses on structural challenges and design decisions that commonly arise in multi-party, capital-intensive testbed environments and recur across testbed initiatives globally (such as aligning proprietary protection with shared learning, structuring IP allocation among multiple participants, and managing data access where public and private interests intersect). The considerations and design principles identified here are therefore intended to be broadly applicable across diverse regulatory and operational contexts, subject to appropriate local adaptation.

The report does not propose a single universal model. Rather, it is intended to **help readers identify critical questions early in the design process** and to understand how structural decisions affect participation incentives, protection of sensitive information, and pathways to commercialization. It should be read as a **toolkit rather than a prescription** and may be used to inform early-stage feasibility studies, requests for proposals (RFPs), memoranda of understanding (MOUs), or other planning documents, and to support constructive dialogue among public and private stakeholders.

The framework presented here focuses on IP and data-sharing arrangements that can help enable and structure participation in a collaborative test centre by addressing concerns identified through the comparative analysis of IP and data-sharing arrangements applied in previous research and development programs and raised in ongoing stakeholder discussions. It does not purport to provide a comprehensive IP strategy or address every legal and strategic IP consideration that may arise. Broader and more detailed IP considerations will depend on the applicable legal framework, technologies involved, participants, and commercial objectives and should be addressed with appropriate IP expertise.

Land access, value areas, water rights, reservoir ownership, and liability considerations are closely related to the design of an SHR testbed but raise distinct legal and factual issues. These

critical adjacent topics fall outside the scope of this report and would warrant separate, dedicated analysis as part of future SHR testbed development.

1.4. Scope and Methodology

This report focuses on the design of intellectual property and data governance frameworks for SHR testbeds, with particular emphasis on structures relevant to early-stage field testing and pilot demonstrations. The analysis benchmarks a limited set of existing frameworks with high relevance to geothermal and subsurface research, including U.S. DOE-supported programs and selected international analogues, and assesses the suitability and transferability of their IP and data rules for an SHR testbed context.

The report draws on a combination of document review and targeted interviews with subject-matter experts. Because few SHR-specific testbeds currently exist, examples are also drawn from adjacent research and energy contexts and should be read as illustrative rather than exhaustive.

Definitions Used Throughout this Report

- **Background IP** means intellectual property developed or owned by a participant prior to its involvement in the testbed or outside the scope of testbed-funded activities.
- **Proprietary Information** means non-public information that a participant owns, controls, or is entitled to protect, including trade secrets, confidential know-how, proprietary technical information, commercially sensitive business information, and other confidential information. Proprietary Information is protected through contractual confidentiality and use restrictions rather than through intellectual property ownership.
- **Foreground IP** means intellectual property generated through testbed activities.
- **Protected Background Data, Restricted Test Data, and Public Data** are used as defined in Section 5.

1.5. Conceptual Testbed Lifecycle

For clarity, this report uses a simplified, conceptual testbed lifecycle to help readers visualize how SHR testbeds typically evolve over time and how legal and structural considerations may change across phases. This lifecycle is not intended to prescribe a single development path, but to provide a common reference point for discussing access, IP, and data governance issues in a complex, multi-stage testing environment.

Illustratively, an SHR testbed may progress through several phases, including: **(i) site selection and characterization, (ii) drilling and reservoir creation, (iii) downhole tool testing and operational experimentation, and (iv) knowledge release, iteration, and repeat testing.**

Importantly, **IP, data, and access rules often shift across these phases**. Early phases typically involve more sensitive information and higher technical risk, requiring stronger protections and tighter access controls, while later phases often support broader data sharing, publication, and third-party participation. Recognizing these dynamics early helps designers structure participation terms that remain flexible, predictable, and aligned with commercialization and public-interest objectives.

2. Baseline Scenarios: Legal, Funding, and Governance Parameters

2.1. Legal Framework Reference Point and International Applicability

For clarity and analytical consistency, this report uses the U.S. as the primary legal reference point for evaluating IP and data-governance considerations, given the availability of relevant precedents, established funding mechanisms, and operating testbeds. This choice is intended to ground the analysis in a concrete jurisdictional context, not to privilege a U.S.-specific outcome.

The **core principles underlying the framework** (such as the treatment of Background IP and Foreground IP, licensing structures, data tiering, and publication-review mechanisms) **are not unique to U.S. law and reflect common design challenges in multi-party R&D environments**. Separately, when industry projects are supported with public funds or conducted in partnership with public research institutions, mandatory IP and data governance requirements often apply as a matter of law or funding conditions. While these requirements are implemented through different statutory, regulatory, or contractual instruments, comparable constraints commonly attach to publicly supported R&D outside the U.S. as well.²

Accordingly, the **framework presented here is designed to be adaptable to other national systems with appropriate modification**. Where this report refers to DOE requirements, it does so as an illustrative reference for jurisdiction-specific, mandatory IP and data-governance obligations that may similarly apply in other jurisdictions when public funding or public-sector collaboration is involved. Future SHR testbeds established outside the U.S. may require adjustments to reflect local legal requirements, regulatory expectations, and disclosure obligations, but the core architecture (particularly its modularity, scope-based compliance, and time-bounded confidentiality mechanisms) is intended to be internationally relevant and scalable.

² By way of illustration, some jurisdictions outside the U.S. impose similar public-interest constraints on IP ownership, licensing, and data disclosure through a range of legal and policy instruments, including national innovation statutes, public-research IP regimes, and government-use safeguards. Examples include France's *Loi n° 99-587 du 12 juillet 1999 sur l'innovation et la recherche*, university IP ownership frameworks in the United Kingdom, Denmark's Act on Inventions at Public Research Institutions (Act No. 347/1999), and Japan's so-called "Bayh–Dole–style" framework reflected in Article 30 of the Act on Special Measures Concerning Revitalization of Industry and Innovation in Industrial Activities (1999). These regimes differ in scope and implementation and are referenced here to illustrate the existence of comparable structural constraints rather than to provide a comprehensive comparative analysis.

2.2. Cross-Border Participation

Strong international interest in SHR underscores the need for a framework that functions predictably for cross-border participation. Under a U.S.-based testbed model, foreign entities would retain their home-country Background IP, while contractual IP and data obligations would be governed by U.S. law to ensure consistency and enforceability.

More broadly, the framework is intended to support international participation and collaboration. While this report does not attempt to resolve conflict-of-law issues or jurisdiction-specific enforceability issues, its core design principles are intended to operate coherently across participants subject to different national regimes. Future work could expand on conflict-of-law considerations to further support the establishment of international SHR testbeds.

2.3. Governance Models and Infrastructure Ownership

Effective governance is central to the operation of an SHR testbed. A viable structure must clearly allocate infrastructure ownership, access rights, decision-making authority, and cost-sharing responsibilities across all phases of activity – from drilling and reservoir creation to stimulation and tool deployment. Because each phase influences the viability and value of subsequent testing, governance must be predictable, transparent, and aligned with the incentives of participating organizations.

In practice, **governance models fall along a spectrum**, each with distinct implications for ownership distribution, risk allocation, and operational control (see Sections 2.3.1 through 2.3.6 for descriptions of potential models). Although these models can be implemented under U.S. law, they are **not specific to the U.S.**; rather, they reflect widely used structures in multi-party research environments and energy infrastructure projects globally and can be adapted to different legal and regulatory systems with targeted adjustments.

When evaluating governance models in the U.S., it is also critical to account for the **potential role of the DOE**. Where DOE funding or laboratory collaboration is involved, the DOE's structural and contractual oversight influences ownership arrangements, cost share structures, and the definition of operator responsibilities. For example, DOE financial assistance awards **typically require a defined non-federal cost share** (often 20% or more) which directly shapes how private partners participate, how financial responsibility is allocated within the testbed, and who has leverage during execution.³ Certain governance terms may also require DOE approval or alignment with federal program objectives.

Private participation can be **strengthened through incentives** embedded in the governance structure. These may include priority access windows, preferential scheduling, embargo periods on data release, or equity-like recognition for major funders. Other examples include early

³ See 42 U.S.C. § 16352 (general requirements for cost-sharing in DOE "research, development, demonstration, or commercial application program[s] or activit[ies]") or 2 C.F.R. § 200.306 (government-wide cost sharing or matching requirements, adopted by DOE, with modifications, in 2 C.F.R. § 910.120(a)); see also typical DOE Notices of Funding Opportunity requiring 20% non-federal cost share for R&D and demonstration projects.

access to high-quality raw data, coupled with confidence that proprietary interpretation methods can remain internal. Access to other testbed participants, sponsors, or consortium members (through joint governance bodies, technical committees, or sponsor forums) can also provide valuable visibility, networking opportunities, and pathways to future partnerships or funding.

Financing decisions further shape governance design. Across all models, the use of debt financing depends on the presence of a creditworthy entity and a clear, predictable revenue stream from which debt can be serviced. Without these conditions, equity- or grant-based funding is typically required.

Although the described structures differ in ownership distribution and operational control, the modular IP framework proposed later in this report is designed to apply across all of them, ensuring consistency in how IP and data rights are allocated regardless of governance model.

2.3.1. Governance Board Models

Comparable, high-cost, multi-stakeholder R&D environments demonstrate three dominant governance models that could credibly structure an **SHR governance board**: (i) an industry-member technical committee, (ii) an independent expert board, or (iii) a hybrid host-led model with advisory participation.

An **industry-member technical committee** model places decision-making authority in a group of subject-matter experts nominated by participating companies, typically with a defined voting structure and clear pathways for operational input. This approach concentrates expertise among entities with direct commercial stakes and ensures that field-execution decisions (such as testing new tools, expanding diagnostics or modifying the work program) reflect the technical judgment of parties with "skin in the game." *This model was used in the Hydraulic Fracturing Test Sites (HFTS) joint industry project, where GTI Energy convened company-nominated experts and each member company designated a single voting representative, with DOE, the host operator, and GTI also each holding one vote on operational decisions.*

An **independent expert board** model relies on a neutral body composed of individuals with no direct ties to participating companies or project operators. This "arms-length" structure is well suited for initiatives that require long-term strategic coherence, high-risk experimentation, or counter-cyclical investment decisions (i.e., continuing to fund R&D through market downturns or periods of low commodity prices), as independence mitigates conflicts of interest and enhances public and stakeholder trust. It can also help avoid the common dynamic in industry-member committees, where representatives may naturally prioritize technologies aligned with their own portfolios, which can slow consensus on which innovations to advance first. *The Alberta Oil Sands Technology and Research Authority (AOSTRA) adopted this approach by appointing retired industry and academic experts to a fully independent board that guided major decisions, including funding of its underground test facility and the pioneering of early horizontal drilling initiatives.*

A **hybrid host-led** model centers operational authority with the host operator while providing structured pathways for sponsors, government entities, or industry groups to contribute perspectives through advisory councils. This approach preserves operational efficiency and clear lines of responsibility while still integrating industry insight into the technology-development agenda. *The National Carbon Capture Center (NCCC), operated by Southern Company under a DOE cooperative agreement, reflects this model by combining host-led execution with an Industrial Advisory Council that contributes technical feedback alongside DOE.*

2.3.2. Overview of Governance and Ownership Models

This Section compares governance and ownership models most relevant to SHR testbeds, showing how each allocates ownership, decision-making, and financing responsibilities.

	Host-led Model (Host Majority)	Consortium Model (Shared)	Nonprofit (Capped Return) (Neutral Operator)	Special-Purpose Entity (Hybrid)
<i>Infra-structure</i>	Host owns wells + facilities; participants get defined access.	Jointly owned (equal or proportional shares).	Held by a nonprofit entity; participants contribute for access, not ownership	Owned by a new SPV/SPE with flexible equity distribution.
<i>Decision-Making</i>	Centralized with host (participant advisory optional).	Steering committee (of industry member participants).	Board of directors with mission obligations.	Board or managing member structure.
<i>Financing</i>	Host is debt capable. Participants pay testing fees, access charges, or slot-based participation fees (per well, per test window, per campaign). Those fees create predictable cash flows that can support debt service.	Shared across members; may require creditworthy members. Consortium-funding dramatically lowers individual exposure, making participation economically attractive even for large operators.	Based on participation fees or philanthropic support; financial flexibility to service debt is limited.	SPV may take on debt; contributions reflected in equity.

<i>Best Suited For</i>	One operator controls the site, early-stage testbeds where drilling risk dominates and speed matters.	Later-stage or research-intensive testbeds where multiple participants are aligned and contribute complementary technologies.	Public-interest or internationally coordinated testbeds seeking neutrality, where credibility and long-term data stewardship are central to participation.	Complex, multi-party testbeds requiring flexible ownership and finance.
<i>Watch-outs</i>	Risk of perceived host capture of data or learning; participant mistrust if data rules unclear. Works best where the host is a credible operator with strong execution discipline.	Governance gridlock; unclear IP ownership if roles are not well defined.	Limited commercial upside may deter some industry participants.	Requires strong upfront legal structuring and governance discipline.

2.3.3. Host-Led Model (Single Operator with Participation Access Rights)

A **host operator owns and controls the site** and core subsurface and surface infrastructure (e.g., wells, equipment, monitoring systems, shared utilities) and **provides structured access to participants** through standardized participation agreements. This model is suitable for early-stage SHR development when drilling risk, operational complexity, and safety requirements favor centralized control.

Key features include:

- The host retains majority ownership (often >50%) of key infrastructure to ensure operational control. Participants may make financial or in-kind contributions.
- **Decision-making authority** is principally **centralized with the host**, with participants' rights defined contractually through access agreements rather than ownership stakes.
- Participants, sponsors, government entities, or industry groups may **contribute perspectives through advisory councils** consistent with a hybrid host-led governance board (NCCC-style).
- Testbed host may also rely on a **separate organizing or coordinating entity to structure participation**, manage agreements, and facilitate technical alignment across members, even while the host retains ownership and operational control of the site (e.g., HFTS, described in Section 4.1.2).
- Participants receive defined access windows, test campaigns, or fee-for-service arrangements, rather than ownership stakes, unless they negotiate specific buy-in rights.

- **The host is typically the most creditworthy entity** and therefore best positioned to assume debt obligations for drilling or infrastructure development, repaid through management fees, participation fees, access charges or a portion of revenue from cost-sharing arrangements to generate a predictable cash-flow to support debt service.
- Because early-stage geothermal projects involve high execution risk, this model often benefits from a host with **strong operational capacity and a proven ability to coordinate contractors** and service providers, reducing the likelihood of cost overruns and schedule slippage.
- Hosts may also **leverage existing supplier, original equipment manufacturer ("OEM"), and permitting relationships**, which can materially accelerate execution timelines and reduce uncertainty for participants.
- **Infrastructure upgrades** or additional wells may be **co-funded**, with cost-sharing proportional to use or agreed contribution levels.

This model provides clarity and centralized control, which can accelerate execution, especially in early-phase testbeds.

2.3.4. Consortium or Joint-Venture Model

Participants **collectively fund and own** the infrastructure, either equally or proportionally to contributions. A steering committee or technical committee directs operations and manages decisions.

Key features include:

- **Infrastructure is collectively owned**, with ownership shares either being equal or proportionate to financial or in-kind contributions.
- Costs (including drilling, stimulation, and monitoring systems) and associated risks are **allocated in proportion to ownership or financial contribution**, dramatically lowering individual exposure. Financing is driven by risk-sharing, not profit: consortium-funding dramatically lowers individual exposure, making participation economically attractive even for large operators.
- Decision-making processes must be carefully structured to avoid gridlock, often requiring a clearly defined and technically qualified **steering committee** (industry-member committee model).
- Shared governance may slow decision-making, making it essential to define **escalation pathways, quorum rules, and (operator) override authorities** that preserve forward momentum during time-sensitive activities drilling, stimulation and tool deployment.
- An **operating entity** (either a designated partner or a separate SPV) **manages the facility** and may collect membership or management fees.
- **Debt-financing requires the operating entity** (or select members) to have **sufficient creditworthiness**; alternatively, participants may provide guarantees proportionate to ownership stakes.

- A consortium structure requires deliberate **alignment of incentives to prevent conflicting priorities across members** (particularly across scientific, engineering, and commercial teams).

This model distributes risk and infrastructure control more evenly but requires strong coordination mechanisms to prevent deadlock.

2.3.5. Mission-Oriented Nonprofit Model (Capped-Return Structure)

A **neutral nonprofit** (e.g., a 501(c)(3) or special-purpose nonprofit) **owns the infrastructure on behalf of the consortium** and operates the testbed on a mission basis under a capped-return or return-limited structure. Transparency rules, open-governance mechanisms, and mission alignment can attract philanthropic or public-interest capital while still providing structured access and predictable rights.

Key features include:

- Infrastructure is **owned by the nonprofit**, not individual participants.
- Participants contribute funding rounds or resource-sharing but do not obtain conventional commercial profit rights. Participants gain structured **access rights tied to their contribution level**, not ownership stakes.
- Decision-making is carried out by a **board of directors** or governing body, similar to an independent expert board model, which is responsible for ensuring neutrality, mission alignment and adherence to capped-return principles.
- **Revenue (if any) is reinvested into operations or cost recovery** rather than distributed.
- Debt may be taken on by the nonprofit only if supported by predictable revenue streams (e.g., participation fees, philanthropic commitments).
- This structure is particularly compatible with **philanthropic and catalytic funding models** that aim to de-risk early geothermal pilots before commercial investors enter.
- A nonprofit operator can also provide stronger international neutrality, **helping attract foreign participants** who seek transparent governance and reduced commercial entanglements.

This model maximizes mission alignment and international neutrality.

2.3.6. Independent Special-Purpose Entity Model

A new **special-purpose entity (SPE or SPV)** is formed to own and manage testbed infrastructure. This model is highly adaptable and can blend features of the host-led and consortium approaches, including differentiated ownership shares, supervisory rights, and financing structures.

Typical features include:

- Infrastructure **ownership is allocated through equity or membership interests**.

- Flexible ownership structures, allowing a host to retain control while participants hold minority stakes linked to investment level or testing needs.
- Governance exercised through a **board or managing-member structure defined in the SPE's operating agreement** with configurable voting rights, ensuring clear governance with flexible equity distributions (e.g., an independent-board, industry-committee, or hybrid advisory model).
- **Host entity may take on debt** to finance drilling or expansion **where it can rely on predictable revenue streams** from participation fees, access charges, or long-term cost share commitments.
- Infrastructure access rights, management fees, and upgrade responsibilities are typically defined in an operating agreement.
- Because SPEs require disciplined governance and investor confidence, this model benefits from clear contracting, strong project-management practices, and early alignment on commercial pathways.

This approach also aligns well with blended finance structures and multi-party ownership models commonly used in large-scale energy infrastructure projects. It provides clarity of ownership and operational authority while allowing diverse participation structures.

2.4. Funding Models and Their Implications for IP and Data

Funding structures play a defining role in the IP and data governance framework of an SHR testbed. SHR testbeds involve disproportionately high capital needs, subsurface uncertainty, and sensitive early-stage technology development. **DOE financial assistance awards and DOE laboratory collaborations each trigger distinct statutory and contractual IP and data regimes.** Accordingly, the way in which infrastructure and project activities are funded – whether they rely on private (including philanthropic) capital, DOE financial assistance, or DOE laboratory collaboration – materially shapes expectations around confidentiality, disclosure, and ownership of results. Understanding these relationships is essential for designing a governance and contractual structure that is workable for both private and public partners.

To provide clarity, this Section distinguishes between (i) how the testbed itself is funded (infrastructure-level funding) and (ii) how individual testbed participant projects are funded (project-level funding). These two dimensions together determine when DOE requirements apply, and when a purely contractual IP regime is available.

2.4.1. Testbed-Level Funding Models

Testbed infrastructure and core operations may be financed in three primary ways:

- *T1 – Fully Private Testbed:* The testbed is funded exclusively by private or philanthropic capital, with no DOE financial assistance and no DOE laboratory involvement. IP and data rights are governed entirely by contract.
- *T2 – Hybrid Public–Private Testbed:* The testbed receives DOE support through a financial assistance award, cost share arrangement, or collaboration with a DOE national laboratory,

alongside private or philanthropic contributions. DOE IP and data provisions attach to the DOE-funded or collaborative scope and activities and have a downstream effect to participants.

- *T3 – Fully Public / DOE-Led Testbed:* The testbed is funded and operated primarily under DOE programs. DOE IP and data rules apply broadly to activities conducted using DOE-funded infrastructure.

2.4.2. Participant-Level Funding Models

Parallel to the testbed-level, each participant may enter with its own project funding structure:

- *P1 – Privately Funded Participant Project:* The participant relies entirely on internal R&D, philanthropic or corporate investment, or venture capital.
- *P2 – DOE-Supported Participant Project:* The participant receives DOE funding directly (e.g., cooperative agreement), as a subrecipient, or through a DOE laboratory collaboration such as a CRADA. DOE IP and data provisions attach to that participant’s funded or laboratory-supported scope, even if the testbed itself is privately funded (T1).

2.4.3. Interaction of Testbed and Participant Funding Models

These two dimensions combine to create the following practical scenarios. The following table summarizes how they interact and what this means for resulting IP and data expectations. Importantly, as described further in Section 3.1.1, participating in a DOE-supported site does not, by itself, convert all data generated at the site into public data.

<i>Testbed Funding</i>	<i>P1 – Privately Funded Participant Project</i>	<i>P2 – DOE-Supported Participant Project</i>
<i>T 1 – Fully Private Testbed</i>	Purely contractual regime. Participation agreements define Background/Foreground IP, confidentiality, data tiers, and publication controls. No DOE IP or data obligations apply.	Dual framework. Participant’s DOE award or CRADA imposes DOE IP/data terms on <i>that participant’s</i> funded or laboratory-supported scope only; the testbed infrastructure and other privately funded activities remain governed by contract. Testbed agreements must be compatible with, and not frustrate compliance with, the participant’s DOE obligations.
<i>T 2 – Hybrid Public-Private Testbed</i>	DOE rules attach to DOE-funded scope. Activities using DOE-funded infrastructure, DOE lab resources, or counted as cost share will fall under DOE IP/data rules. Other privately funded activities may remain contractual if cleanly ring-fenced (i.e., clearly	Layered DOE regime. Both the testbed’s DOE funding and the participant’s own DOE funding apply. DOE IP/data rules attached to each award govern relevant activities; contractual terms operate

	segregated from DOE-supported activities in scope, personnel, facilities, and data flows).	only within DOE-permitted boundaries. ⁴
<i>T3 – Fully Public Testbed</i>	Effectively DOE-governed. Use of DOE-funded infrastructure generally brings participant activities under DOE IP/data terms. Limited carve-outs may be possible through CRADA-protected data.	Fully within DOE framework. Project and testbed-level DOE requirements align; contractual terms largely refine obligations within DOE’s regulatory structure.

For foreign testbed participants, DOE IP and data requirements apply in the same way as for U.S. entities whenever the testbed receives DOE funding or uses DOE laboratory resources; however, if the testbed is fully privately funded and a foreign participant does not receive DOE funding itself, then no DOE-specific IP or data restrictions apply to that participant’s work.

2.4.4. Practical Takeaways for the IP and Data Framework

The key determinant for whether statutory U.S. federal IP and data requirements apply is whether any activity relies on **DOE financial assistance, DOE-counted cost share, or DOE national laboratory resources**. When these inputs are used, Bayh–Dole or CRADA obligations attach to the relevant scope of work and form a mandatory baseline for invention ownership, disclosure, data-access rights, and publication (see Sections 3.1 and 3.2). These federal requirements do not govern the entire testbed by default; they apply only to the funded or laboratory-supported scope, which must then be integrated into the contractual framework used among private participants.

A purely private IP and data regime is available only where an activity is **entirely privately funded** and remains operationally segregated from DOE-supported components. In shared testbed environments, however, maintaining strict separation is difficult when central functions (such as drilling, diagnostics, monitoring systems, or data platforms) are supported through DOE awards or national laboratory involvement. Consequently, even privately funded participants may come under federal requirements if their activities depend on DOE-supported infrastructure or services.

The most consequential inflection point is whether the **testbed operator or managing entity** receives DOE funding or engages a DOE laboratory. Testbed-level DOE support attaches federal IP, data, and public-access requirements to **any** activity performed using DOE-funded infrastructure or DOE laboratory resources, regardless of individual participants’ funding sources. In practice, a testbed becomes DOE-supported when the entity responsible for managing it (host operator, nonprofit intermediary, consortium lead, or special-purpose vehicle) becomes the recipient or prime recipient under a DOE financial-assistance award. By contrast,

⁴ In addition, because DOE awards typically require a non-federal cost share, developers should ensure they can meet the required non-federal contribution in a layered funding scenario. Participants should verify that any proposed contributions qualify as allowable cost share under DOE rules, and that the same funds or resources are not counted toward cost-share obligations under multiple awards.

in a fully private testbed (T1), DOE obligations apply only to those participants that themselves receive federal support or collaborate with a DOE laboratory.

Among the funding structures described, the **hybrid model (T2)** is the most realistic for SHR testbeds given the capital intensity, subsurface risk, and early-stage uncertainty of SHR development. While a fully private structure (T1) allows the greatest contractual flexibility and strongest preservation of proprietary interests, the practical scale of SHR activities makes some degree of DOE involvement likely. A fully public or DOE-led model (T3) is the least likely and, from an IP and data-governance perspective, functionally similar to T2 because DOE requirements attach whenever federal funding or laboratory participation is used. Accordingly, the recommended IP and data framework in this report focuses on modular approaches that operate effectively in **T1 and T2 environments**, allowing privately funded, DOE-funded, and laboratory-supported activities to coexist within a single testbed while maintaining clear and enforceable boundary lines.

3. Government-Mandated IP and Data Requirements (Illustrated by DOE)

This section describes the IP and data obligations that may attach to activities conducted within an SHR testbed as a result of public funding or other forms of governmental involvement. For purposes of illustration and analytical clarity, it focuses on the U.S. regulatory framework governing federally supported research and demonstration activities. If an SHR testbed were to be located in, or primarily funded from, another jurisdiction, a separate analysis would be required to determine the applicable government-mandated IP and data obligations. Although public funding regimes in other jurisdictions rely on different statutory instruments,⁵ they may raise **analogous structural considerations** around IP allocation and data governance where public support is involved, making the DOE framework a useful reference point even where it is not directly applicable.

Activities conducted in a U.S.-based SHR testbed may trigger federal intellectual property and data obligations under two distinct legal frameworks, **depending on how DOE is involved**.

First, **DOE financial assistance** – including grants, cooperative agreements and cost share arrangements – triggers application of the Bayh–Dole Act⁶ and DOE’s implementing regulations⁷, which govern "subject inventions" and related data arising from work performed under a federal funding agreement (see Section 3.1).

Second, **collaboration with a DOE national laboratory** (including in-kind contributions such as laboratory personnel, facilities, equipment, or technical services), triggers application of the

⁵ Examples include France’s *Loi n° 99-587 du 12 juillet 1999 sur l’innovation et la recherche*, university IP ownership frameworks in the United Kingdom, Denmark’s Act on Inventions at Public Research Institutions (Act No. 347/1999), and Japan’s so-called "Bayh–Dole–style" framework reflected in Article 30 of the Act on Special Measures Concerning Revitalization of Industry and Innovation in Industrial Activities (1999).

⁶ 35 U.S.C. §§ 200–212.

⁷ 2 C.F.R. pt. 910.

Stevenson–Wydler Technology Innovation Act⁸ and requires the relationship to be structured through a Cooperative Research and Development Agreement (CRADA), which governs IP ownership, data protection, and publication for laboratory-supported work (see Section 3.2).

In an SHR testbed context, it's unlikely that activities will proceed entirely without some form of public funding or public research-institution involvement (in the U.S., without DOE financial assistance or DOE national laboratory involvement). Experience from comparable testbeds shows that **both DOE funding and laboratory resources are often used in parallel**, triggering the concurrent application of Bayh–Dole and CRADA regimes to different aspects of the same activity (see Section 3.3). Understanding these baseline requirements is therefore a foundational step in structuring IP and data governance terms that ensure compliance while preserving strategic advantages for testbed participants.

3.1. Bayh–Dole Act and DOE Implementing Regulations (DOE Financial Assistance)

Whenever any portion of SHR testbed activity is **conducted under a federal funding agreement** (including grants, cooperative agreements, R&D contracts, or subawards), any invention conceived or first actually reduced to practice under that funding becomes a "**subject invention**" governed by the Bayh–Dole Act and its implementing regulations.⁹

DOE-funded testbeds often operate through public–private, partnership-based arrangements, where statutory requirements and award-specific IP and data rules together set the boundary between public transparency obligations and commercial confidentiality needs. This section explains how DOE IP and data requirements are typically implemented in testbed documentation (see Section 3.1.1), which requirements apply to DOE-supported SHR testbed activities (see Section 3.1.2), and what those requirements mean in practice for testbed operators and participants (see Section 3.1.4).

3.1.1. How DOE Regulations Attach in a Testbed Setting

Federal regulations require DOE to include the **standard Bayh–Dole patent rights clause** in its funding agreements with universities, nonprofits, and small businesses. DOE implements this obligation through its **Standard Intellectual Property Provisions** for Financial Assistance Awards, which incorporate the Bayh–Dole clause and layer in DOE-specific requirements derived from the Department's separate statutory authorities, including those affecting invention ownership by large for-profit entities (discussed in Section 3.1.2).¹⁰ These Standard IP Provisions **are included as part of DOE financial assistance awards**, typically within or

⁸ 15 U.S.C. § 3710a.

⁹ Bayh–Dole establishes a government-wide framework for allocating rights in inventions arising from federally funded research, while DOE's regulations specify how those rules are applied in DOE financial assistance awards; 35 U.S.C. §§ 200–212; 2 C.F.R. pt. 910.

¹⁰ DOE Standard Intellectual Property Provisions for Financial Assistance Awards; 42 U.S.C. § 5908; 10 C.F.R. pt. 784 (patent-waiver regulations).

attached to, the **cooperative agreement**, which governs rights related to inventions, licensing, data management, and publication.

In a testbed environment, federal IP and data obligations first attach to the **recipient of the award** (i.e., the entity that signs the cooperative agreement with DOE) and then **flow down to sub-awardees** performing DOE-funded work. As demonstrated by GTI at the Hydraulic Fracturing Test Sites and Southern Company at the National Carbon Capture Center (NCCC) (see Section 4.1.2 and 4.1.3), the prime recipient becomes the steward and owner (for data purposes) of DOE-funded "**project data**," while **privately funded**, ring-fenced activities remain governed solely by contract. DOE requirements therefore apply only to: (i) the award recipient, (ii) any sub-recipients performing DOE-funded tasks, and (iii) data generated with DOE funds or eligible cost share. Privately funded work that falls outside the DOE-funded scope remains outside Bayh–Dole even when conducted at the same physical site. Understanding this structure is essential for planning hybrid SHR testbeds in which DOE-funded and privately funded activities may operate in parallel.

In most testbed settings, DOE enters into the cooperative agreement with a **single lead entity** (typically the testbed operator or managing entity), which then governs how federal requirements **flow down** to other participants. Additional companies (participants) engage with the testbed through **subawards, participation agreements, or purely contractual access arrangements**, depending on whether their activities fall inside or outside the DOE-funded scope. Where developers participate under their **own** separate DOE award, Bayh–Dole and DOE data rules apply independently to that company's funded work, operating **in parallel** to the testbed-level framework. This creates a layered compliance environment in which only those activities supported by federal funds are subject to DOE IP and data requirements, while all other participation remains governed by contract.

In practice, DOE's intended IP, data governance, and manufacturing requirements are often signaled first in the applicable **Notice of Funding Opportunity (NOFO)**¹¹ and then implemented through the Standard IP Provisions and the final funding agreement. For testbed operators and participants, this means the FOA is the earliest indication of the IP and data obligations that will apply to funded activities, with those expectations formalized and enforced through the executed award terms.

Based on CATF's experience and stakeholder discussions, DOE is generally **open to structuring IP and data governance terms within the bounds of its statutory authority** (see Sections 4.1.2 and 4.1.3). At the same time, DOE has demonstrated that it will enforce Bayh–Dole requirements where circumstances warrant. Understanding these baseline obligations and engaging transparently with DOE is essential to managing risk and preserving viable commercialization pathways for SHR testbeds.

¹¹ Previously referred to as Funding Opportunity Announcements (FOA).

3.1.2. Applicable DOE Requirements

The following requirements apply to DOE-funded testbed activities.

- Timely Disclosure of Subject Inventions:** Recipients must promptly disclose each subject invention to DOE within **two months** after the inventor discloses the invention in writing to personnel responsible for patent matters.¹² **Failure** to disclose may result in **loss of title**, as DOE may take title to the invention if timely disclosure is not made, even if the contractor later seeks to retain ownership. *Participants must maintain internal processes to identify potentially patentable innovations and ensure timely reporting, typically through DOE's iEdison system. In a testbed environment involving multiple contributors, clear allocation of disclosure responsibility is critical.*
- Election of Title and Ownership of Invention:** Under U.S. federal funding rules, **award recipients** may retain title to subject inventions arising from DOE-funded work, provided they meet the required disclosure, patent filing, and commercialization obligations.¹³ This right applies automatically to universities, nonprofits¹⁴, and small businesses¹⁵.¹⁶ **Large for-profit entities, however, do not automatically receive the right to elect title.**¹⁷ For these participants, title remains with DOE unless the agency grants a patent waiver (either in advance of the work or for a specific invention). Although DOE routinely grants such waivers when private-sector commercialization is expected, certain federal rights remain mandatory even after a waiver.¹⁸ *Large commercial participants should therefore not assume automatic ownership and should confirm early whether a patent waiver applies to their DOE-funded scope.*
- Government-Use License:** Regardless of who owns a subject invention, DOE automatically receives a **nonexclusive, irrevocable, paid-up license** to practice or have practiced the subject invention worldwide on behalf of the U.S.¹⁹ This license is mandatory

¹² 35 U.S.C. § 202(c)(1); 37 C.F.R. § 401.14(c)(1).

¹³ 35 U.S.C. § 202(a); 37 C.F.R. § 401.14(a), (b).

¹⁴ Pursuant to 35 U.S. Code § 201(i), the term “nonprofit organization” means universities and other institutions of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1986 (26 U.S.C. 501(c)) and exempt from taxation under section 501(a) of the Internal Revenue Code (26 U.S.C. 501(a)) or any nonprofit scientific or educational organization qualified under a State nonprofit organization statute.

¹⁵ Pursuant to 35 U.S. Code § 201(h), the term “small business firm” means a small business concern as defined at section 2 of Public Law 85–536 (15 U.S.C. 632) and implementing regulations of the Administrator of the Small Business Administration (SBA). Under SBA rules (13 C.F.R. §§ 121.105, 121.201), a firm is a small business concern if it is organized for profit, has a U.S. place of business, contributes to the U.S. economy, and does not exceed the employee or revenue size standard for its NAICS code (SBA size standards vary by NAICS code and are published at 13 C.F.R. § 121.201 (Table of Small Business Size Standards)).

¹⁶ 37 C.F.R. § 401.14; 10 C.F.R. § 600.325; 35 U.S.C. § 200.

¹⁷ For large for-profit entities, DOE has independent statutory authority to determine invention ownership (42 U.S.C. § 5908; 48 C.F.R. 927.303; 10 C.F.R. pt. 784).

¹⁸ Such as 35 U.S.C. § 202(c)(4) (government-use license); 35 U.S.C. § 203 (march-in rights); 35 U.S.C. § 204 (U.S. manufacturing requirement for exclusive licenses).

¹⁹ 35 U.S.C. § 202(c)(4).

and cannot be waived. *This license does not prevent private commercialization, but it should be considered when assessing exclusivity and downstream licensing strategies.*

- March-In Rights:** DOE retains statutory march-in rights, allowing it, in limited circumstances, to **require a contractor to grant licenses to third parties** – for example, where the contractor fails to achieve practical application of a federally funded invention within a reasonable time, where public health or safety needs are not reasonably satisfied, or where statutory U.S. manufacturing requirements for exclusive licenses are not met.²⁰ March-in rights do not permit the government to take ownership of the invention or to obtain trade secrets or other proprietary know-how; they are limited to compulsory licensing of patent rights on reasonable terms.²¹ While DOE has not exercised march-in rights to date,²² they remain legally enforceable.
- U.S. Manufacturing Requirement for Exclusive Licenses:** Under the Bayh–Dole Act, a contractor may not grant an exclusive right to use or sell a subject invention in the U.S. unless the licensee agrees that any **products embodying the invention**, or produced through its use, will **be manufactured substantially in the U.S.**²³ In recent years, DOE has emphasized this requirement and, in some programs, expanded it through award-specific provisions. *Developers should factor domestic manufacturing obligations into commercialization planning at an early stage, particularly where exclusive licensing is contemplated.*²⁴
- Data Management and Public Access Plan:** Activities performed under DOE financial assistance awards are also subject to **DOE’s Public Access Plan** and the award’s **DOE-approved Data Management and Sharing Plan**,²⁵ which together govern when and how scientific publications and underlying digital research data must be made publicly accessible.
- Protection of Sensitive or Proprietary Data:** The DOE’s public-access obligations are not absolute, however: DOE statutes, regulations, and award terms protect certain categories of information from disclosure, including **Proprietary Information, Confidential Business**

²⁰ 35 U.S.C. § 203; Congressional Research Service. March-in Rights Under the Bayh–Dole Act. R44597. Prepared by John R. Thomas. Aug. 22, 2016.

²¹ Robin Feldman, *Trade Secrets in Biologic Medicine: The Boundary with Patents*, 24 Colum. Sci. & Tech. L. Rev. 1, 47 (2022).

²² In recent years, the government has been pressured to use their march-in rights for COVID-19 vaccines to increase supply, but federal agencies have not taken action even in the dire circumstances of the coronavirus pandemic; Reynolds, 18 Minn. J.L. Sci. & Tech. at 73–74.

²³ 35 U.S.C. § 204.

²⁴ Developers should also be aware that satisfying the domestic manufacturing requirement is not sufficient on its own: if a Prohibited Foreign Entity (PFE) or Foreign Entity of Concern (FEOC) holds IP or licensing rights in the technology, the project may be disqualified from U.S. incentive programs regardless of where manufacturing occurs.

²⁵ DOE Public Access Plan (2014, as updated: <https://www.energy.gov/doe-public-access-plan>, last accessed June 15 2026); 2 C.F.R. pt. 200.

Information (CBI), Protected Data, export-controlled information, and other restricted data.²⁶ In practice, DOE-funded testbed participants may protect sensitive information by properly designating qualifying materials as proprietary or confidential and by relying on approved embargo periods under the project's Data Management and Sharing Plan. Information eligible for protection may include **trade secrets, confidential commercial or financial information, non-public technical know-how, detailed operational data**, and similar materials that would be considered proprietary if generated outside the DOE-funded activity. When correctly identified, marked, and managed in accordance with the funding agreement and DOE policies, such information may be withheld from public release for defined periods – typically up to 12 months for publications and associated datasets under DOE's Public Access Plan, and longer where justified and expressly approved in the project's Data Management and Sharing Plan.²⁷

3.1.3. DOE's Expanding Approach to U.S. Manufacturing Requirements

Since 2021, DOE has moved beyond the statutory baseline of the Bayh–Dole Act in how it structures many of its funding agreements.²⁸ While Bayh–Dole's statutory manufacturing preference applies only to exclusive licenses of subject inventions, DOE's own model clauses in several programs now go further: requiring that products embodying DOE-funded inventions be manufactured substantially in the U.S. unless the recipient obtains an approved waiver or modification.²⁹ Although this enhanced domestic manufacturing requirement is not part of Bayh–Dole's core statutory minimums, it reflects a recent policy trend at DOE designed to tie federal support more explicitly to domestic industrial impact and supply-chain benefits.³⁰

3.1.4. Key Takeaway for an SHR Testbed

For purposes of SHR testbed design, **Bayh–Dole obligations attach at the level of DOE-funded testbed activities**, not automatically to the testbed as a whole. Clear scoping of funded work, early attention to invention disclosure and ownership rules, and careful alignment of data-management plans are essential to ensuring compliance while preserving commercial incentives for participants.

²⁶ U.S. DOE Public Access Plan 'Ensuring Free, Immediate and Equitable Access' to the Results of DOE Scientific Research', June 2023, p. 5.

²⁷ See DOE Public Access Plan; 2 C.F.R. Part 200 (Uniform Guidance); DOE Financial Assistance Data Management and Sharing Plan requirements; applicable award terms.

²⁸ <https://www.gao.gov/assets/gao-24-106504.pdf> (last accessed June 15, 2026).

²⁹ <https://www.energy.gov/gc/us-manufacturing> (last accessed June 15, 2026).

³⁰ See for further context Hogan Lovell's discussion of the DOE protesting a Massachusetts solar company's request for an exemption to U.S. import tariffs by arguing that the company's plan to build a factory in Asia instead of New York appears to violate agreements to manufacture its breakthrough technology in the U.S.: <https://www.hoganlovells.com/en/publications/a-word-to-the-wise-for-advanced-reactors-accepting-doe-money-doe-enforces-its-ip-rights> (last accessed June 15, 2026); <https://subscriber.politicopro.com/article/eenews/1060080571?keyword=Obama+era+solar+success+story> (last accessed June 15, 2026)).

3.2. CRADA Minimum Standards (Collaboration with DOE National Laboratories)

Where an SHR testbed involves collaboration with a DOE national laboratory, the Stevenson–Wylder Technology Innovation Act applies, and the relationship is typically governed through a CRADA. A CRADA is the primary legal instrument through which DOE laboratories are authorized to participate in joint research and development with non-federal partners.

Entering a CRADA includes a **multi-step federal approval process**, involving internal laboratory review and DOE oversight, that takes several months (often six to twelve) to complete. Once in place, the CRADA establishes mandatory minimum standards for IP ownership, data protection, and publication that apply to work performed with, and data generated through, laboratory participation.

In DOE practice, any material **"in-kind" contribution by a DOE laboratory** – such as laboratory personnel time, access to facilities, specialized equipment, testing, modeling, analytical capabilities, or technical services – constitutes federal laboratory participation and CRADA requirements,³¹ even where the non-federal participant is privately funded.

By contrast, **in-kind contributions by private companies** (e.g., provision of rigs, tools, or proprietary equipment) are treated as **cost share under DOE financial assistance rules** (see Section 3.1) rather than as laboratory collaboration, and are instead governed by the applicable funding agreement or participation terms.³² For an SHR testbed, this distinction is critical, as private in-kind support does not by itself trigger CRADA requirements, whereas laboratory involvement does, even in the absence of DOE cash funding.

For an SHR testbed, this means that any test or research activity that relies on DOE laboratory collaboration and resources must be structured to comply with the CRADA requirements described in the following Section 3.2.1.

3.2.1. Minimum CRADA Standards Relevant to an SHR Testbed

While project-specific terms may vary, the following elements are consistently required.³³

- **Background IP Protection:** Each party retains ownership of its pre-existing intellectual property ("Background IP"). A CRADA does not grant default rights or licenses to Background IP, which must be identified in advance and excluded from the scope of jointly performed work. *In practice, this allows SHR developers to contribute proprietary tools, methods, or know-how without risking loss of ownership, provided such assets are clearly documented upfront.*

³¹ 15 U.S.C. § 3710a (Stevenson–Wylder Technology Innovation Act) (authorizing federal laboratories to enter into CRADAs with non-federal parties and to contribute personnel, facilities, equipment, or other resources in collaborative research and development); U.S. DOE, Office of the General Counsel, *Laboratory Partnering: Cooperative Research and Development Agreements (CRADAs)*, describing CRADAs as collaborations in which DOE laboratories provide personnel, services, facilities, or equipment to non-federal partners, <https://www.energy.gov/gc/laboratory-partnering> (last accessed June 15, 2026).

³² See 2 C.F.R. § 200.306 (addressing third-party in-kind contributions as cost sharing).

³³ The standards are prescribed by the Stevenson–Wylder Technology Innovation Act and implemented through DOE Order 483.1 ("DOE O 4831.1"), DOE Manual 483.1-1, and DOE's approved CRADA model agreements.

- **New IP Ownership:** Ownership of inventions arising under a CRADA follows inventorship. Each party owns inventions made solely by its employees, and inventions made jointly by laboratory and non-federal personnel are jointly owned. Non-federal participants may negotiate licenses, including exclusive licenses in defined fields of use, to laboratory-owned inventions, subject to DOE approval. *For testbed participants, this means careful planning around personnel roles and invention management is critical, as joint work with laboratory staff can result in joint ownership or a need to license lab-owned IP for commercialization.*
- **Data Protection & Confidentiality (Up to Five Years):** CRADAs provide specific mechanisms to protect sensitive information from public disclosure. First, "**Proprietary Information**" (confidential business information that a party *brings into* the collaboration or provides during its performance, such as trade secrets, commercial data, technical know-how, or other non-public information) remains the property of the disclosing party and may be protected from public release, provided it is properly identified and handled in accordance with the CRADA. The CRADA does not transfer ownership of Proprietary Information to other parties or to DOE. In addition, certain data or information *generated* over the course of the collaboration may be designated as "**Protected CRADA Information**" where it would qualify as proprietary if created outside the CRADA. When properly designated, this information may be withheld from public release for up to **five years** from the date of creation. *In practice, this allows SHR developers to protect commercially sensitive test results, operational data, and technical insights generated during testbed activities, even where no patentable invention arises, provided confidentiality requirements are followed.*³⁴
- **Government-Use Rights:** Regardless of ownership, DOE retains a nonexclusive, irrevocable, paid-up license to practice, or have practiced, all CRADA subject inventions worldwide on behalf of the U.S. This government-use license is mandatory and non-waivable. *While this does not prevent private commercialization, developers should account for the government's retained rights when assessing exclusivity and downstream licensing strategies.*
- **Publication Review:** CRADAs preserve the ability to publish research results, subject to a review period, typically 30 days. During this period, a party may request removal of proprietary information, Protected CRADA Information, or patentable subject matter to allow for appropriate protection prior to public disclosure. *Developers should factor this review step into project timelines and coordinate closely with laboratory partners to avoid premature disclosure.*

³⁴ 15 U.S.C. § 3710a(c)(7); DOE O 483.1; DOE Manual 483.1-1; DOE Model CRADA.

3.2.2. Key Takeaway for an SHR Testbed

For testbed design, the key takeaway is that DOE laboratory involvement triggers CRADA requirements, such that **any use of DOE laboratory personnel, facilities, or technical capabilities** will subject that portion of a developer's work to CRADA IP, data-protection, and publication rules, **even if the project is otherwise privately funded**.

At the same time, meaningful **flexibility remains**. CRADA requirements attach only to activities involving laboratory participation, not to the testbed as a whole. Privately funded activities that are clearly scoped, documented, and operationally separated from laboratory-supported work may remain governed by contractual terms (insofar as they are not DOE-funded).

3.3. Overlapping Bayh–Dole and CRADA Regimes

In some SHR testbed configurations, different participant activities within the same testbed may trigger **both** Bayh–Dole and CRADA obligations where DOE funding is used and DOE laboratory resources are involved. In such cases, the **two regimes apply in parallel** to different aspects of the work. **Bayh–Dole governs** inventions and data arising from the federally funded portion of the activity, including disclosure, title election, government-use rights, march-in authority, and applicable manufacturing and public-access requirements. By contrast, **the CRADA framework governs** laboratory collaboration, including ownership and licensing of inventions made by laboratory personnel or jointly with non-federal participants, as well as data protection and publication review. DOE-supported programs such as FORGE, HFTS, and NCCC (each described in Section 4) illustrate this layered structure in practice.

Importantly, **the involvement of the same physical well, samples, or datasets does not, by itself, merge these regimes**. They intersect only at defined boundaries, most commonly where (i) outputs from Bayh–Dole-funded work (such as samples or field data) are used as inputs for CRADA-governed laboratory research, or (ii) where a single invention is jointly conceived by company and laboratory personnel. In those situations, ownership follows inventorship under the CRADA framework, while Bayh–Dole obligations continue to apply if DOE funding contributed to the invention's conception or reduction to practice.

4. Comparative Benchmarking Findings

This section synthesizes the principal findings from the benchmarking undertaken for this report. The benchmarking examined geothermal and subsurface programs including Utah FORGE, the Hydraulic Fracturing Test Sites (HFTS), the Iceland Deep Drilling Project (IDDP) and Krafla Magma Testbed (KMT), the New Zealand Supercritical Geothermal Project, and the Alberta Oil Sands Technology and Research Authority (AOSTRA), as well as analogous energy-sector and research programs including the National Carbon Capture Center (NCCC), the Geothermal Technologies Office's Geothermal Accelerating the Development of Innovative Technologies (GAIN) program, the Rapid Advancement in Process Intensification Deployment (RAPID) Manufacturing Institute, the National Offshore Wind Research and Development Consortium

(NOWRDC), and the International Thermonuclear Experimental Reactor (ITER). Detailed profiles of the benchmarked programs are provided in the Appendix.

Rather than describing each program individually, this chapter identifies the recurring IP and data governance approaches observed across the benchmarking and highlights the principal lessons relevant to the design of future SHR testbeds. References to individual programs illustrate how particular design principles have been implemented in practice.

4.1. Protection of Background IP and Proprietary Information

Protection of participants' pre-existing technologies, know-how, software, data, and other proprietary assets emerged as one of the most consistent features across the benchmarked programs. Regardless of whether the initiative operated as a DOE-funded geothermal field laboratory (FORGE), an industry consortium (HFTS), a host-operated demonstration facility (NCCC), an academic research collaboration (RAPID), a national laboratory access program (GAIN), a publicly funded research consortium (NOWRDC), or an international collaboration (ITER), participants consistently retained ownership of their Background IP and protection of Proprietary Information.

Although implemented through different contractual mechanisms (including Inter-Institutional Agreements (FORGE), Technology Collaboration Agreements (NCCC), Data Use Licenses (RAPID), CRADAs (GAIN), consortium participation agreements (HFTS), and formal treaty provisions (ITER)), the underlying principle remained the same: participation did not transfer ownership of pre-existing technologies. Where access to Background IP or Proprietary Information was necessary for project execution, programs generally relied on narrowly defined research or operational licenses rather than transfers of ownership or broad commercialization rights.

The benchmarking therefore demonstrates broad consensus that robust protection of Background IP and Proprietary Information for members participating in or contributing to a testbed is a prerequisite for attracting commercial participation, particularly where technology developers contribute proprietary drilling tools, software, operational methodologies, or other commercially valuable technologies.

4.2. Ownership and Licensing of Foreground IP

Approaches to Foreground IP were similarly consistent across the benchmarked programs. Ownership generally followed established legal principles based on inventorship (or authorship for copyrightable works), while contractual arrangements primarily focused on allocating access and licensing rights rather than altering default ownership rules.

Several benchmarked programs (including HFTS, NCCC, and FORGE) reported relatively limited creation of jointly owned Foreground IP because collaborative activities focused principally on technology validation, operational testing, and data generation rather than joint technology development. HFTS intentionally structured field activities to avoid collaborative tool

development, allowing participating companies to develop proprietary interpretations independently while minimizing joint ownership. NCCC similarly reported that most testing generated operational performance data rather than patentable inventions.

Where collaborative research did generate new inventions, programs generally relied on inventorship-based ownership combined with contractual licensing arrangements. FORGE, GAIN, NOWRDC, and ITER all followed this approach, while RAPID represented a notable exception, reflecting its academic mission by allocating university-generated IP to the University of Texas and providing sponsors only limited opportunities to negotiate commercial licenses.

Overall, the benchmarking suggests that commercially oriented testbeds should preserve predictable ownership rules while minimizing unintended joint ownership through careful project design and clearly defined contractual boundaries.

4.3. Data Governance

Unlike IP ownership, approaches to data governance varied considerably across the benchmarked programs, reflecting differences in governance structures, funding models, commercial sensitivities, and research objectives. Nevertheless, four recurring design principles emerged.

1. **Separation of proprietary information from project-generated data.** All benchmarked programs distinguished, either expressly or in practice, between proprietary participant information and data generated through project activities. Variations of tiered data-governance structures were observed across HFTS, NCCC, GAIN, RAPID, NOWRDC, and FORGE, separating proprietary technologies and know-how from operational and performance data and, where applicable, information intended for broader dissemination. Although terminology differed, this distinction consistently allowed participants to protect commercially valuable technologies while enabling collaborative research and testing.
2. **Time-bounded confidentiality preserves commercial incentives.** Embargo periods emerged as one of the most effective mechanisms for balancing commercial incentives with longer-term knowledge sharing. Most benchmarked programs provided participants with an initial period of exclusive access to project-generated data before broader dissemination. HFTS employed a three-year participant-only embargo, which participants consistently identified as essential to securing industry cost-share participation. GAIN and CRADA-based collaborations protected generated information for up to five years where permitted by law, while RAPID relied on extended confidentiality obligations for industry datasets. NCCC adopted a different but comparable approach, limiting public disclosure to aggregated performance-level information while allowing proprietary and Protected Data to remain confidential. Although the duration and scope of confidentiality differed, each approach provided participants with a meaningful commercial head start before broader release.

3. **Public-funding obligations shape disclosure requirements.** The benchmarked programs demonstrated that public funding primarily influenced the timing and scope of data disclosure rather than the ownership of IP. FORGE reflected a comparatively open-science model with broad dissemination of non-proprietary research outputs. HFTS combined DOE funding with a substantial embargo period before releasing non-proprietary datasets, while NCCC satisfied DOE oversight through aggregated performance reporting that protected commercially sensitive operational information. By contrast, AOSTRA adopted a participant-only data-sharing model, reflecting a different funding structure and policy objective. Together, these examples demonstrate that public funding does not require a single disclosure model but rather permits different approaches depending on the applicable funding instrument and project objectives.
4. **Data governance must be calibrated to the objectives of the testbed. Collectively,** the benchmarked programs demonstrate that there is no universally optimal approach to data governance. While ownership and protection of IP remained comparatively consistent, approaches to governing operational and subsurface data varied according to the objectives of the testbed, the applicable funding arrangements and resulting public-funding obligations, and the commercial sensitivities of participating organizations. These recurring observations provide the foundation for the recommended data-governance architecture presented in Chapter 5.

Collectively, these examples demonstrate that no single data-governance model is universally appropriate. Rather, successful programs calibrated confidentiality, access rights, embargo periods, and publication obligations to the objectives of the testbed, the applicable funding arrangements, and the commercial sensitivities of participating organizations.

4.4. Public-Funding Obligations

The benchmarking further demonstrated that public funding influences data governance and reporting obligations more consistently than underlying ownership principles.

DOE-supported initiatives, including FORGE, HFTS, NCCC, GAIN, and NOWRDC, all incorporated federal requirements relating to reporting, publication, government-use rights, and protection of data generated through publicly funded activities (see Section 3 for a discussion of the requirements arising from DOE funding). However, these obligations generally attached only to the work conducted with public financial assistance and did not alter ownership of participants' pre-existing technologies.

The benchmarked programs also demonstrated considerable flexibility in implementing these obligations. FORGE emphasized broad dissemination of federally funded research outputs, HFTS combined public funding with a substantial participant-only embargo period, and NCCC demonstrated that aggregated reporting can satisfy public oversight while preserving commercially sensitive information. Together, these examples illustrate that public funding does

not require a single approach to IP or data governance but instead establishes a framework within which different contractual solutions can be developed.

5. Recommended Data Governance Architecture

Effective data governance is central to the success of a geothermal testbed. It must give technology developers confidence that their proprietary know-how will remain protected, while ensuring that the results generated through collaborative testing can ultimately be shared in a way that advances scientific understanding and accelerates commercialization beyond any single developer.

There is no single data-governance model suitable for every testbed. The appropriate approach depends on the objectives of the testbed, the funding model, the commercial sensitivities of participants, and the degree of collaboration sought. The benchmarking nevertheless identified several recurring principles that provide a practical foundation for designing data-governance arrangements across different governance structures and legal systems.

Building on those observations, this section presents a practical, tiered data-governance architecture (see Section 5.2). The focus is on how operational and subsurface data should be classified, shared, protected, and ultimately released over the course of a project. IP ownership is treated as a complementary but distinct issue in consideration in Section 6.

The recommended architecture draws on the benchmarking findings presented in Section 4. It begins by distinguishing between different **funding structures**, as these determine the public-funding obligations that may apply to project activities. It then applies a **tiered, activity-based data model** that can operate under fully private, hybrid, or fully public funding configurations. Because geothermal development is capital-intensive, future testbeds are likely to involve different combinations of private, philanthropic, and public funding. The framework is therefore designed as a configurable toolkit that can be calibrated to the applicable funding arrangements, legal framework, and commercial objectives of the testbed.

5.1. Funding Structure and Resulting Data-Sharing Obligations

The primary determinant of data-sharing obligations is **whether** and **how** DOE funding (or DOE laboratory support) enters the testbed structure. DOE rules do not apply universally; they attach **through the award recipient**, meaning the prime recipient of DOE assistance and any sub-awardees who perform federally funded work.

5.1.1. Fully Private or Philanthropic Funding (T1)

If the SHR testbed is funded entirely with private and philanthropic capital and does not use DOE laboratory resources, **all confidentiality and publication rules are contractual**. No statutory public-release requirements apply, unless a participant brings its own DOE award into the facility. In this scenario, the parties can determine the scope and timing of information shared among participants and what, if anything, becomes public. The SHR testbed may adopt

the tiered categories in Section 5.1, but all disclosure is voluntary and can be calibrated to commercial or philanthropic missions.

5.1.2. Hybrid (Publicly Supported) Model (T2)

A **hybrid model (T2)**, the most realistic for SHR given the capital intensity of drilling, assumes that some components of the testbed will receive public support. Where a testbed receives DOE funding for research, federal requirements apply only to the data generated through the federally funded activities (see Section 3.1.2), which may include, for example, drilling, reservoir creation, monitoring systems, or site infrastructure. Additionally, any collaboration with a DOE national laboratory requires a CRADA, which incorporates publication-review rights, government use rights, and up to 5-year protection periods (see Section 3.2.1). These federal obligations attach **only** to the portion of work conducted with federal assistance.

If the **testbed-managing entity** (host operator, nonprofit manager, or consortium lead) receives a DOE financial-assistance award, it becomes the **prime recipient** responsible for generating, managing, and delivering all **project data** produced with DOE funds or eligible cost share, including data generated by sub-recipients.³⁵ Practically, this means the prime recipient must hold stewardship and control over DOE-funded project data, even though other parties may access it under contract. Participants that receive a **sub-award** or otherwise perform work within the DOE-funded scope are themselves subject to DOE IP and data terms for that portion of their activity; participants who provide only **cost share** (e.g., in-kind equipment, personnel time, or cash) do not become federal awardees, but their contributions are still treated as part of the DOE-supported project, and associated data must be reported through the prime recipient. **Privately funded** work that is cleanly ring-fenced in scope, personnel, and data flows can remain governed purely by contract. DOE rules apply only to DOE-funded activities and data streams.

A key nuance for hybrid testbeds is that DOE-funded scope (not the physical location) **determines what becomes project data**. Previous examples show that hybrid models diverge significantly depending on how DOE support is structured. In **HFTS**, nearly all operational activities fell within the DOE-funded project, so raw datasets became project data owned and stewarded by the prime recipient (GTI) and were subject to a multi-year confidentiality period followed by public release. In **NCCC**, by contrast, private developers often paid for access or operated in ring-fenced scopes outside the DOE-funded tasks in Southern Company's cooperative agreement; as a result, much of the test data never became project data at all. DOE received only aggregated performance summaries, while raw developer datasets remained confidential indefinitely. This distinction is critical for SHR: a hybrid model may be structured to

³⁵ See U.S. DOE, Financial Assistance Regulations, 2 C.F.R. § 200.300–§ 200.329 (as supplemented by 2 C.F.R. Part 910). Under these regulations, the prime recipient of a DOE financial-assistance award is responsible for ensuring that all project performance data, technical reports, and research results produced with DOE funds or eligible cost sharing (including data generated by sub-recipients) are collected, managed, and submitted to DOE in accordance with DOE reporting and data-management requirements. See, e.g., 2 C.F.R. § 200.301 (performance measurement requirements), § 200.329 (responsibility for monitoring subrecipients), and § 910.360 (DOE reporting and intellectual property requirements).

resemble either HFTS (embargoed detailed release) or NCCC (aggregated reporting with confidential raw data), depending on how DOE structures the award and what portions of work fall inside or outside federally funded scope.

5.1.3. Fully Publicly Funded (T3)

In a fully publicly funded testbed, DOE expectations generally align with models such as FORGE: CRADA-based confidentiality windows may apply, but the overall posture **favours broad public release** of non-proprietary operational and subsurface results. In SHR contexts, performance and operational data will likely be viewed as competitively sensitive. This underscores the importance of carefully designing confidentiality and data-sharing mechanisms to ensure alignment with both public-interest objectives and private-sector participation considerations.

5.2. Recommended Data Categories for an SHR Testbed

Within this funding-driven structure, the SHR testbed should adopt a three-tier data architecture. These categories define (i) what remains proprietary, (ii) what is shared among participants, and (iii) what ultimately becomes public.

5.2.1. Protected Background Data

Protected Background Data consists of data, models, datasets, and other information that embody, incorporate, reveal, or are derived from a participant's Background IP or Proprietary Information, or that participants otherwise designate as confidential under the participation agreement. In practice, this includes information that a **participant already owns or controls before joining the testbed**, or develops independently outside the scope of testbed activities and any publicly funded work, and that the participant chooses to keep confidential.

This category includes datasets, trade secrets, proprietary designs, materials compositions, manufacturing methods, firmware, internal modeling workflows, commercial or financial information which is privileged or confidential, and any pre-existing datasets or models contributed solely for safety or integration.

Background Protected Data:

- **remains owned** by the contributing party;
- is disclosed, if at all, only under strict confidentiality and only to the site operator or essential technical personnel; and
- is **excluded from any DOE public-access expectations**, unless the participant affirmatively incorporates such data into the scope of federally supported work or fails to maintain its confidentiality (see Sections 3.1.2 and 3.2.1).

This category is central to reassuring geothermal developers that participation does not convert their core technology, trade secrets, or internal workflows into public property.

5.2.2. Restricted Test Data

Restricted Test Data consists of **operational, observational, and performance-related outputs generated during testbed activities** that are necessary for coordination, troubleshooting, sequential and parallel testing, and shared subsurface understanding. Although this data may be commercially sensitive, it is not intended to include Proprietary Information. Where operational data would embody, reveal, or permit reconstruction of Proprietary Information, it should instead be treated as Protected Background Data or otherwise protected under the applicable confidentiality provisions.

Restricted Test Data includes:

- drilling parameters, image logs, fiber-optic and microseismic measurements;
- stimulation diagnostics and reservoir-response information;
- standardized performance metrics;
- success-or-failure outcomes of tools or processes tested *in situ*; and
- factual learnings developed during testing (e.g., how a configuration behaved at temperature or how the reservoir responded to specific operational sequences).

Restricted Test Data reflects **what happened in the subsurface, not how a participant's tool is engineered**. Specifically for SHR, this category can be divided into further sub-categories (raw, derived, performance-level, or divided by topics) to address sensitivities and confidentiality demands of participants.

a) In a Privately Funded SHR Testbed

All sharing obligations are contractual. To ensure the testbed **delivers collective value and accelerates technological advancement** rather than becoming a collection of isolated proprietary experiments, the framework should, at a minimum, require participants to share **performance-level observations** (including reservoir response, stimulation behavior, operational envelopes, and empirical performance outcomes) either immediately or after a short confidentiality or "embargo" period. In practice, privately funded testbeds can further subdivide Restricted Test Data into **sub-tiers** (such as raw field measurements, processed or derived diagnostics, and aggregated performance summaries) each with tailored access and confidentiality periods that reflect operational needs and commercial sensitivities. Information revealing design internals, formulations, manufacturing details, proprietary workflows, or modeling logic should remain protected and should not be shared. This approach preserves competitive advantage while ensuring that membership confers meaningful technical insight.

b) In a Hybrid Funded SHR Testbed

Restricted Test Data generated with DOE-support will generally qualify as "project data" and must ultimately be delivered to DOE. However, DOE practice regarding allowable protection mechanisms for such data varies substantially across hybrid models:

- **NCCC-style:** DOE permitted project data to remain private within the facility, with developers retaining full control over their raw datasets, tool outputs, and operational results. The NCCC operator provided DOE with aggregated or synthesized performance summaries (not raw or disaggregated datasets) and DOE accepted this reporting format, particularly where developers paid to access the facility and their work was operationally ring-fenced from DOE-funded tasks.
- **HFTS-style:** DOE required eventual public release of non-proprietary project data but allowed a multi-year confidentiality ("embargo") period, documented in the Data Management and Sharing Plan (see Section 5.3)

These examples show that the mechanisms available to protect Restricted Test Data in hybrid testbeds depend heavily on DOE cooperation, program-office expectations, and the negotiated terms of the cooperative agreement. Unlike fully private models (where parties have broad contractual flexibility), hybrid structures must accommodate DOE's requirements for transparency, public access, and data stewardship. Accordingly, an SHR testbed may use aggregated reporting or embargoed detailed release depending on:

- the terms of the DOE cooperative agreement,
- the NOFO under which the project is funded, and
- the extent to which private activities are cleanly separated from federally supported work.

5.2.3. Public Data

Public Data includes any outputs ultimately released outside the testbed, either because DOE requires public access, philanthropic objectives encourage transparency, or participants voluntarily agree to publication. These outputs typically include sanitized subsurface datasets, aggregated performance results, benchmark curves, and generalized learnings suitable for public repositories or peer-reviewed publications.

Before release, Public Data must be sanitized to remove proprietary identifiers and protect any Protected Background Data. The transition from Restricted to Public Data occurs only at the end of any embargo period (if used) and is managed by the prime recipient with participant input.

5.3. Conflict Resolution Procedures

To ensure consistent application of these data categories, participation agreements should designate a neutral operator or governance committee to determine data classifications and access rights, with unresolved disagreements escalating through the test center's established governance and contractual dispute-resolution procedures. For example, where participants disagree over the appropriate classification of a dataset, the issue could first be considered by a neutral data-access committee, escalated to the test center's governing board if necessary, and only then referred to the contractual dispute-resolution process.

5.4. Embargo as a Participant Advantage in Hybrid Testbeds

Where public funding obligations require eventual public dissemination of project data, an embargo period offers a lawful and effective mechanism for balancing transparency with commercial protection. If included in the Data Management and Sharing Plan and approved by DOE, an embargo delays public release while granting participants early competitive advantage. The appropriate duration of the embargo should reflect the objectives of the testbed, the applicable public-funding framework, and the commercial needs of participants. Existing programs demonstrate a range of approaches, from relatively short confidentiality periods to multi-year embargoes before public release.

- **Embargo window:** A multi-year period (e.g., one to three years) during which Restricted Test Data is available only to participants and DOE for oversight. Subject to DOE's discretion and consistent with DOE's CRADA and Protected Data authorities, this period could potentially even be extended up to five years. During this period, **access is limited to testbed participants** and DOE for oversight. Participants may use the data internally to refine tools, develop models, or improve operational strategies, and any such interpretive or derivative outputs remain proprietary to the participant. These proprietary interpretations do not become part of the shared dataset and, unless a participant elects otherwise, fall within Protected Background space, whereas the underlying data are preserved for eventual publication. For DOE-funded project data, the prime recipient must preserve, manage, and ultimately deliver the embargoed dataset to DOE after the embargo expires, subject to appropriate sanitization.
- **Participant edge:** The embargo period provides industry participants with a competitive advantage by giving them early, exclusive access to high-resolution subsurface and performance datasets that will not be available to non-participants until after public release. During the embargo, participants receive access to the full set of Restricted Test Data relevant to their participation *via* license from the prime recipient. Early access enables participants to refine tools, models, and strategies before data becomes public. Interpretations and derivative models developed during this period remain proprietary and fall within Protected Background space.
- **Transition to public release:** Transition to public release: After the embargo, the prime recipient curates the dataset, sanitizes proprietary elements, and submits Public Data to DOE or the appropriate authority in accordance with publication and confidentiality requirements.

5.5. Designing for Diverse Market Participants

Data-governance arrangements should be designed with the recognition that participants may enter an SHR testbed from different commercial and technological starting points. Established companies and emerging technology developers may differ in the maturity of their technologies, existing IP portfolios, technical capabilities, financial resources, and commercial leverage. In

international testbeds, these differences may also reflect broader national innovation ecosystems, strategic priorities, and legal or regulatory environments.

These asymmetries should inform the practical design of data-access arrangements, confidentiality obligations, and publication pathways. The objective is to encourage collaboration while ensuring that the data governance framework does not unintentionally create disproportionate competitive advantages or discourage participation by organizations with different commercial positions.

At the same time, the framework should remain sufficiently flexible to accommodate future entrants and emerging technologies rather than reflecting only the needs or market positions of today's participants. Data governance should ultimately be calibrated to the commercial context, participant composition, and objectives of the relevant testbed while supporting broad and commercially credible participation over time.

5.6. Contractual and Procedural Mechanisms for Implementation

Implementation requires a layered contractual approach:

- **Nondisclosure Agreement:** Protects Background IP and confidential information exchanged during scoping.
- **Participation or Membership Agreement:** Defines data categories, internal-sharing rules, review processes, and publication pathways; sets any embargo periods; addresses DOE flow-down requirements where applicable.
- **DOE Flow-Downs (if hybrid):** Incorporates cooperative agreement terms for DOE-funded activities, including data management, publication procedures, and CRADA terms for any laboratory collaboration.

Standardized data-reporting templates should be adopted to ensure comparability and provide transparency regarding what will ultimately be published.³⁶

Governance, IP, and data arrangements should be addressed early, meaning during feasibility studies, requests for proposals, memoranda of understanding, and other planning stages, rather than as a downstream legal exercise. Early engagement with prospective industry participants, technology developers, investors, public funders, and other stakeholders can identify shared priorities, commercial sensitivities, and potential areas of conflict before they become barriers to participation. It also helps organizers understand which protections, incentives, and governance arrangements are needed to attract participation, allowing the framework to be shaped around the practical needs of future participants. While participation agreements should apply

³⁶ While data-governance frameworks for collaborative energy test centers remain program-specific and have not yet been standardized, the underlying challenges are not unique to energy innovation. Other fields, including health care research, financial services, and public digital infrastructure, have addressed analogous questions concerning confidentiality, access controls, and data stewardship. Although data governance in those sectors must also account for personal, regulated, or security-sensitive information, established standards and governance practices developed in those fields can nevertheless provide useful reference points for the development of SHR testbed data governance, complementing the lessons drawn from existing subsurface R&D programs. See, e.g., Digital Governance Standards developed by the Digital Governance Council (Canada) (<https://dgc-cgn.org/digital-standards/?srsltid=AfmBOopVsl1n42Epq-YWZa20GgnSFFXaOsiJrSN0-NCcZWGGI6XsuGUX#standards>, last accessed August 5, 2026).

consistently to all participants, equal contractual rights do not necessarily produce equal practical outcomes. Early engagement therefore allows organizers to account for differences in participants' technical capabilities, commercial objectives, and existing positions when calibrating governance arrangements.

6. Recommended IP Framework

This chapter sets out a modular, funder-agnostic IP framework designed to operate under either a fully private model or a hybrid model incorporating public support (illustrated through DOE financial assistance or laboratory collaboration). The recommendations synthesize the benchmarking undertaken throughout this report and are intended as a configurable toolkit rather than a prescriptive model. Although developed in the context of future SHR testbeds, the recurring design principles identified across geothermal, subsurface, and analogous energy-sector programs are relevant to geothermal testbeds more broadly and may provide useful guidance for energy test centers in other sectors. While informed by geothermal, subsurface, and analogous energy-sector programs internationally, the framework draws particular insight from U.S. DOE-supported initiatives because they provide the broadest range of governance models and the most detailed information on IP and data-governance arrangements.

The framework is designed to (i) protect proprietary technologies, (ii) enable controlled but meaningful knowledge transfer necessary for technological acceleration, and (iii) maintain compliance with public-funding requirements where applicable. Because it is anticipated that most realistic SHR testbed configurations will involve some combination of private and public financial support, the architecture is drafted "hybrid-first," with clear carve-outs showing how each module operates under purely private funding.

The recommendations that follow are calibrated to U.S. default rules, both for initial ownership (inventorship for patentable inventions, authorship for copyrightable works) and for the ability of joint owners to use and license IP independently. Where an SHR testbed is established under another jurisdiction's law, these principles should be applied to that jurisdiction's defaults rather than assumed to produce the U.S. result.

6.1. Core Design Principles

The design of an SHR testbed requires a clear set of core principles to align diverse participants, protect commercial interests, and ensure compatibility with potential federal funding.

- 1. Support modular, multi-stage, multi-actor participation.** The IP framework must allow different companies to enter at different phases (drilling, reservoir creation, tool deployment) through modular participation agreements with clear sequential and access provisions that protect proprietary technology.
- 2. Ensure that infrastructure access complements IP and data protections.** Participation should give companies access to scarce, high-cost infrastructure while preserving control over their Proprietary Information.

3. **Protect Background IP unequivocally.** All pre-existing tools, models, designs, workflows, and trade secrets remain with their owners. Access for integration is provided only through limited operational-use licenses. Strong background protection is essential for attracting tool developers.
4. **Creation governs initial ownership.** Each participant owns the IP it creates. Foreground IP should follow the default ownership rules of the governing jurisdiction, allocated by assignment and participation agreements.
5. **Allocate Foreground IP based on contributions and avoid unintended joint IP.** Geothermal operations create higher likelihood of joint inventions due to integrated tool use under extreme conditions. Joint inventions are jointly owned but not automatically cross-licensed unless expressly agreed. To reduce risk of accidental joint creation and to protect proprietary tool design and workflows, the testbed could restrict collaborative design work.
6. **Provide predictable commercialization pathways.** Where jointly owned or lab-generated IP arises, participants should have defined rights (e.g., internal-use licenses, optional negotiated commercial licenses), with DOE patent waivers and field-restricted rights where applicable.
7. **Separate IP from data governance and manage each with a different focus.** Testbeds will generate large volumes of operational and subsurface data, much of which is commercially sensitive. While IP rights are governed by established legal principles, parties retain considerable flexibility to structure ownership, licensing, and commercialization arrangements by contract. The commercial value of many technologies, however, depends not only on IP rights but also on preserving the confidentiality of proprietary know-how and commercially sensitive information. Consequently, data governance plays a critical role by determining what information participants must disclose, who may access it, and when it may be shared. It should be designed as a distinct but complementary component of the IP framework, using a multi-tier classification (Section 5).
8. **Accommodate hybrid funding models without discouraging private engagement.** The framework must function in both private and DOE-supported settings and maintain strong commercial protections even when federal funding is introduced.
9. **Ring-fence funded scopes.** In hybrid models, DOE IP requirements attach only to DOE-funded work. Contractual terms remain available for ring-fenced, privately funded activities conducted in parallel.
10. **Activate public funding requirements when applicable.** DOE-related IP and data rules apply automatically in case of federal funding / DOE laboratory collaboration.

Together, these principles provide the foundation for a testbed architecture that protects commercial interests while still enabling the structured knowledge-sharing needed to advance SHR technologies.

6.2. Modular IP Components

Each component includes (i) the default recommendation and (ii) how it operates differently in fully private vs. hybrid environments where DOE-funding and private capital is used.

6.2.1. Background IP and Proprietary Information

Participants bring **two categories** of proprietary assets into a testbed: (i) **Background IP**, consisting of intellectual property owned or controlled before participation or developed outside the scope of testbed activities, and (ii) **Proprietary Information**, including trade secrets, confidential know-how, proprietary technical information, confidential commercial information, and other information that participants elect to protect through contractual confidentiality obligations. Both categories should remain protected throughout participation, but through different legal mechanisms. Background IP remains with its owner as a matter of intellectual property ownership, while Proprietary Information remains protected through confidentiality obligations and limited disclosure rights established in the participation agreement.

Recommendation.

- Each participants retains **exclusive ownership of all Background IP**. Participation agreements should also provide **robust protection for Proprietary Information**, limiting disclosure and use to what is strictly necessary for operation of the test center and subject to confidentiality obligations at least equivalent to those applied under a CRADA, or more protective where the test center operates outside a public-funding framework
- Background IP and Proprietary Information must be **described with sufficient specificity** (annex or schedule) to establish the scope of protection.
- **No implied licenses**. Any required access for safe operations is granted under non-disclosure agreements or via limited, non-transferable, royalty-free operational-use license to the host or service companies only.

Hybrid vs. Private Application.

- **Hybrid**: Background IP remains owned by the participant, and Proprietary Information remains protected through contractual confidentiality. Public-funding obligations apply only to the funded scope of work, and sharing Background IP or Proprietary Information with the host for safety or integration does not, by itself, bring those assets within that funded scope or convert them into “project data”.
- **Private**: Same structure, with greater flexibility to determine whether, when, and on what terms Background IP and Proprietary Information are disclosed or licensed.

Rationale.

This mirrors NCCC (strong background protection), RAPID’s DUL structure, HFTS practice as well as DOE requirements where operators kept all proprietary interpretation workflows internal.

6.2.2. Foreground IP Allocation

Recommendation:

- **Default:** each participant owns the IP it creates; joint ownership arises only when contributions are inseparable for purposes of obtaining or maintaining protection. In such cases, the parties enter a separate agreement governing their respective rights.
- **For jointly owned IP:** parties grant each other non-exclusive, royalty-free internal-use licenses and negotiate any commercial licensing where appropriate.

Hybrid vs. Private Application.

- **Hybrid:**
 - Foreground inventions in DOE-funded scope become subject inventions under Bayh–Dole.
 - Nonprofit organizations, small businesses and universities may elect title; large for-profit entities³⁷ require DOE patent waivers.
 - DOE retains a nonexclusive, irrevocable Government-use license and march-in rights regardless of the category of recipient.
- **Private:**
 - Purely contractual: no government-use rights, no march-in, no manufacturing requirements.
 - Full freedom to negotiate exclusive licensing, field restrictions, etc.
 - Alternative: IP generated through joint work is owned by coordinating research host (e.g., consortium) and licensed to all participants, likely to deter participants because they lose ownership of generated IP.

Rationale.

Tool vendors and geothermal developers need assurance they will own improvements to their tools and new technologies; DOE-funded improvements must follow federal rules.

6.2.3. Licensing

Recommendation.

Depending on participant preferences, an SHR testbed could either stipulate that participants do **not** receive rights to other participants' technology, or implement a **two-tiered licensing model**:

1. **Internal Research License:** Participants receive a non-exclusive right to use certain data and results needed to interpret their own data or tests for research purposes only

³⁷ A large for-profit entity is any domestic for-profit organization that does not qualify as a "small business concern" under SBA size standards (13 C.F.R. Part 121). Under SBA size standards (13 C.F.R. § 121.201), a business that exceeds the applicable small-business thresholds is treated as a large business. For industries relevant to geothermal and advanced energy technologies, this generally means companies with more than 1,500 employees (e.g., NAICS 333132, Oil and Gas Field Machinery and Equipment Manufacturing) or more than \$41.5 million in annual receipts (e.g., NAICS 541715, Research and Development in the Physical, Engineering, and Life Sciences).

(scope could be subject to separate participant negotiations). Does not extend to commercial use of another participant's IP.

2. **Commercial Licensing Pathway:** For any **jointly owned inventions** or lab-owned inventions (CRADA), participants receive a **first right to negotiate** exclusive rights within defined fields of use.

Consistent with the jurisdictional note above, the internal-use and first-right-to-negotiate tiers assume the U.S. joint-ownership default and would require adjustment in jurisdictions where co-owners cannot license without mutual consent.

Hybrid vs. Private Application.

- **Hybrid:**
 - Exclusive U.S.-market licenses require U.S. manufacturing commitments.
 - CRADA inventions in collaboration with DOE national laboratories require DOE approval; five-year confidentiality for Protected CRADA Information.
- **Private:** Fully customizable commercial licensing; no U.S. manufacturing requirement; no government-use license.

Rationale.

Reflects NCCC (no automatic cross-licensing), RAPID SRA (first right to negotiate), and GAIN (options to negotiate exclusive licenses).

6.2.4. Publication Review

Recommendation.

- Minimum **90-day review** prior to publication or disclosure.
- Host/operator must remove proprietary info and patentable subject matter before release.
- A **tiered review** aligned with the data architecture:
 - **Raw** data and interpretation models: never publishable.
 - **Performance-level** data (differentiated sub-tiers can be tailored based on participant preferences): publishable after embargo and participant review, including removal of proprietary Background Data.
 - **Non-sensitive operational learnings:** publishable subject to participant and host review.

Hybrid vs. Private Application.

- **Hybrid:** Must comply with DOE Public Access Plan; allowable embargoes depending on negotiations with DOE; Proprietary/Protected Data exceptions apply.
- **Private:** Full contractual freedom; publications entirely optional.

Rationale.

Provides guardrails that balance acceleration of SHR knowledge with commercial protection.

6.2.5. DOE Compliance Module

Recommendation.

Hybrid: Include a short, standardized module that:

- Confirms which activities fall under DOE funding;
- Recites the applicable Bayh–Dole and CRADA provisions;
- Clarifies that DOE rules apply only to funded scope, not the entire testbed;
- Defines ring-fencing (separate teams, separate tasks, separate data environments);
- Requires documentation of which outputs are subject inventions or Protected CRADA Information.

Private: This Module collapses to a short statement confirming no federal obligations.

6.2.6. Infrastructure Access and Operator Rights

An SHR testbed must define clear and predictable rules for how participants access scarce, high-cost infrastructure such as wells, monitoring systems, and surface facilities. The access framework should support safe operations, protect proprietary technology, and allocate finite testing capacity in a transparent and commercially reasonable way. A detailed access-rights structure will need to be developed in a separate workstream, but at a high level, **three viable models** emerge depending on the funding structure and governance priorities:

- **Host-Control Model:** The operator retains full control over borehole access, scheduling, sequencing, and safety oversight. Participants receive time-limited testing windows defined by their participation agreements. This model provides the strongest operational discipline and is well suited to hybrid DOE-supported testbeds where the operator must meet federal reporting, safety, and stewardship obligations.
- **Tiered-Access Model:** Access windows and scheduling priority are allocated based on contribution level, whether financial, in-kind, or strategic. Early or anchor participants may receive earlier, longer, or more flexible testing windows. This model aligns incentives, supports cost-sharing, and mirrors access structures used at large multi-actor industrial testbeds.
- **Equal-Access Model:** All participants receive equivalent access and scheduling priority, regardless of contribution level. This model aligns with public or philanthropic funding arrangements and supports maximum transparency and research value, but requires careful planning to prevent bottlenecks.

Across all models, the operator should receive only the limited rights necessary for safe integration and regulatory compliance, while participants maintain control over proprietary tools and data. The practical implementation of any access structure (including scheduling, safety protocols, and conflict-resolution procedures) will require a separate workstream.

6.3. Overview of Recommendations

<i>Component</i>	<i>Fully Private (T1)</i>	<i>Hybrid (T2)</i>
<i>Background IP and Proprietary Information</i>	Full contractual protection; participants retain full ownership of Background IP and receive robust contractual protection for proprietary information; no disclosure is required except to operator for test site safety.	Same protections; Public funding should not affect ownership of Background IP. Proprietary Information should remain protected through contractual confidentiality and clear ring-fencing of the publicly funded scope.
<i>Foreground IP</i>	Creator-based ownership; no government rights; fully negotiable.	Subject inventions rules apply to DOE-funded scope; patent waivers for large for-profits; march-in; gov-use license.
<i>Licensing</i>	Fully customizable commercial licensing; exclusive rights freely negotiable.	Exclusive licenses require U.S. manufacturing; CRADA inventions created in collaboration with DOE national laboratories require DOE approval.
<i>Data Rights</i>	Multi-tier data regime governed purely by contract.	Same architecture, but DOE-funded data must follow data-management plan and embargo limits as negotiated and approved with DOE.
<i>Publication</i>	Optional; full contractual control; long embargoes possible.	DOE Public Access Plan applies; carve-outs for Proprietary/Protected Data.
<i>Ring-Fencing</i>	Not required but recommended for clarity.	Essential: DOE rules attach only to DOE-funded scope. Ring-fencing determines what stays contractual.

7. Conclusion

The development of SHR testbeds will require balancing two imperatives: **protecting high-value proprietary technologies** and **ensuring sufficient data exchange to accelerate collective learning**. This report demonstrates that these objectives are compatible, provided the testbed adopts clear governance, disciplined IP boundaries, and a structured, multi-tier approach to data sharing.

Across the examined examples, several consistent lessons emerge: (i) strong Background IP protection is indispensable; (ii) Foreground IP rules must be predictable; (iii) data must be tiered and confidential for a defined period; and (iv) federal requirements apply only to federally supported activities. Applying these principles to SHR yields a flexible but coherent IP and data architecture that can function under both fully private and hybrid (in the U.S., DOE-supported) models.

The recommended framework is not a rigid template but a **practical toolkit**. It offers **configurable modules** that operators, funders, and participants can tailor to different

governance structures, funding sources, and phases of development. As early SHR pilots progress toward more complex, higher-temperature experiments, the framework can expand accordingly to support more granular data categories, scaled participation, and increasingly sophisticated licensing, publication, and access rules.

While each country will require its own legal tailoring, the core IP and data-governance principles outlined here are broadly **transferable across jurisdictions**. Grounded in U.S. DOE practice as a reference case, the framework presented here is intended to inform SHR testbed design more broadly by identifying durable structural choices that recur whenever public funding, shared infrastructure, and commercially sensitive innovation intersect. The benchmarked examples reviewed in this report highlight common pressure points and shared considerations that can support cross-border collaboration, which remains essential to accelerating SHR development.

Looking forward, additional workstreams such as land access, reservoir ownership, liability allocation, insurance, and permitting, will need to be developed in parallel, but a clear and credible IP and data architecture is a necessary foundation. It is the mechanism through which developers understand what they gain by participating, how their competitive advantage is protected, and how shared testbed evidence can support commercialization.

By adopting a predictable, modular, and industry-aligned IP and data framework, SHR testbeds can create the trust, structure, and incentives needed to accelerate technological progress. With clarity on these fundamentals, the pathway toward the first generation of SHR testbeds becomes not only technically feasible, but strategically and commercially desired.

8. Appendix – Benchmarking of Existing Frameworks

This Appendix provides detailed profiles of the geothermal, subsurface, and analogous energy-sector programs benchmarked in this report. Together, these profiles identify governance, IP, and data governance practices relevant to design of a future SHR testbed.

Each profile summarizes the project's purpose, governance structure, participants, and relevance to future geothermal testbeds, followed by a structured assessment of its intellectual property (IP) and data-governance arrangements. The assessment considers five criteria: (i) Background IP protection, (ii) ownership of Foreground IP, (iii) licensing and access rights, (iv) data governance, including confidentiality and embargo periods, and (v) public-funding and disclosure obligations. These detailed case studies provide the evidentiary basis for the comparative benchmarking findings presented in Chapter 4 and the recommendations developed in Chapter 6.

8.1. U.S. Geothermal and Subsurface Frameworks

8.1.1. Frontier Observatory for Research in Geothermal Energy (FORGE)

a) Project Summary

The Utah Frontier Observatory for Research in Geothermal Energy (FORGE) is the U.S. DOE's flagship field laboratory for Enhanced Geothermal Systems (EGS). Located near Milford, Utah, the project is funded and overseen by DOE and operated by the University of Utah's Energy & Geoscience Institute (EGI). Its purpose is to provide a controlled, deeply instrumented environment to test technologies for creating and sustaining EGS reservoirs at depth and high temperature. FORGE operates under a staged, multi-phase structure and hosts R&D performers from universities, national labs, and private companies through competitive solicitations. FORGE can be considered as the most advanced EGS-dedicated field lab currently operating in the U.S.

b) IP / Data Structure

FORGE follows a DOE-directed **open-data mandate**: all non-proprietary data generated with federal funding must be uploaded to the Geothermal Data Repository (GDR), the designated DOE open repository for datasets produced under Office of Geothermal (OG)³⁸ funding. Proprietary data may be uploaded only with the owner's permission. FORGE also maintains a private, password-protected internal site for sharing pre-publication and proprietary information among team members.³⁹

³⁸ Previously referred to as Geothermal Technologies Office (GTO).

³⁹ FORGE, Data Dissemination and Intellectual Property Plan, p. 1.

IP management is governed by standard DOE grant and cooperative agreement provisions (see Section 3.1.2), initially described in the Financial Assistance Funding Opportunity Announcement (FOA) for FORGE.⁴⁰

Where multiple organizations collaborate or where pre-existing intellectual property exists, FORGE uses Inter-Institutional Agreements (IIAs) to define pre-existing IP, set out joint ownership of new IP when appropriate, and determine responsibility for filing, and managing jointly owned patents. IIAs also ensure each party receives a non-exclusive royalty-free license to pre-existing IP necessary for research or commercialization of jointly developed inventions. Material Transfer Agreements and Confidential Disclosure Agreements are used for data or sample exchanges. FORGE's IP and data regime reflects DOE's open-science mandate, complemented by university-based mechanisms to manage proprietary contributions and joint IP.⁴¹

c) Relevance for an SHR Testbed

FORGE provides a valuable benchmark for understanding how a **DOE-funded geothermal field lab manages IP, data, and multi-party R&D participation**. Its structure illustrates how open-data requirements can coexist with protection for proprietary contributions through IIAs, CDAs, and carved-out confidentiality provisions.

However, **FORGE differs from an industry-led SHR testbed in two key ways**: (1) its data is intended for broad public dissemination, which may not align with the commercial sensitivities of SHR developers; and (2) its IP arrangements assume academic R&D performers and federally funded research, not private-sector tool developers seeking competitive advantage. Even so, FORGE's structured processes for data uploading, and handling of pre-existing IP offer procedural lessons for designing an SHR testbed's data and IP framework if DOE funding triggers public-release obligations.

8.1.2. Hydraulic Fracturing Test Sites (HFTS)

a) Project Summary

The Hydraulic Fracturing Test Sites ("HFTS") I and II represent one of the most relevant U.S. analogues for a multi-party, DOE-supported subsurface research testbed. Implemented in the Permian Basin of West Texas, these projects combined federal funding with substantial industry cost share to execute controlled drilling, hydraulic stimulation, and intensive diagnostics programs under real operational conditions. GTI Energy ("GTI") served as the project organizer and integrator for both phases, while operating companies with acreage in the basin (Laredo Petroleum for HFTS I and Occidental Petroleum ("Oxy") for HFTS II) executed drilling and stimulation work.

⁴⁰ Financial Assistance Funding Opportunity Announcement of the U.S. DOE for FORGE, FOA Number DE-FOA-0000890.

⁴¹ FORGE, Data Dissemination and Intellectual Property Plan, p. 2 *et seq.*

b) IP / Data Structure

HFTS I and II were primarily structured as **data-generation experiments**, focused on **resolving key questions** about fracture propagation, reservoir behavior, and stimulation effectiveness. The focus of the joint industry partnership was more on collecting, analyzing, and sharing high-quality subsurface data rather than developing shared technologies or jointly owned inventions. As a result, limited patentable IP was created at the test site, and companies maintained their own proprietary interpretation workflows and modeling tools outside the shared project environment. The underlying participation and IP agreements were not available for this analysis.

1. **Background Protection:** All participants retained full ownership of their Background IP, including tools, software, workflows, proprietary modeling methods, and host-operator subsurface datasets. Host-supplied background datasets (e.g., Oxy's 50-well data package) never became public because they were not generated with DOE or cost share dollars. These datasets were made available only to consortium members under confidentiality agreements.
2. **Foreground IP:** Parties affiliated with HFTS noted that HFTS did not produce significant new jointly created IP. Rather, participation agreements intentionally restricted collaborative design work to avoid creating jointly owned IP. Although raw data was shared among all members, companies used the shared raw data to build their own internal models and interpretations, and these remained proprietary. If Foreground IP did arise, ownership followed inventorship, but this was rare; most companies developed proprietary interpretations internally, which remained exclusively theirs.
3. **Project Data Ownership, Access, and Release Structure:** As the prime recipient of the DOE award, GTI owned all "project data" generated with DOE or cost share funds. This included all raw and processed datasets acquired through HFTS activities. GTI served as the neutral steward of this data and licensed it to consortium members under strict confidentiality. Members accessed the full raw datasets through a GTI-managed portal or hard-drive transfer, while DOE had oversight access but no right to publish during the confidentiality period.

Data governance followed a structured, **two-phase** release model:

- **Confidential Embargo Period (3 years):** All project data was accessible only to consortium members for three years. This embargo was identified by participants as essential, as it created meaningful commercial advantage and justified cost share contributions. During this period, companies developed their own proprietary interpretations and internal models based on the raw datasets; these interpretations remained solely owned by the respective participants and didn't enter the shared project-data space.
- **Public Release of Non-Proprietary Data:** After the embargo expired, GTI and DOE published non-proprietary, normalized, and anonymized datasets on NETL's EDX platform.

This structure was repeatedly described by participants as the key reason industry was willing to join a DOE-supported multi-party project.

c) Relevance for an SHR Testbed

HFTS offers several **strong and directly transferable lessons** for structuring a future SHR testbed. First, HFTS demonstrated that multi-company subsurface R&D can function effectively when roles, responsibilities, and data-sharing expectations are clearly defined upfront. HFTS' success depended heavily on early alignment, a well-scoped experimental program, strong operator execution, and the presence of highly capable technical representatives from each participating company. Collaboration worked because clear guardrails allowed and required participants to share data but prohibited co-development of tools or designs in the field, which kept IP boundaries predictable and avoided joint-IP issues entirely.

Because SHR experiments will likely involve complex well designs, high-temperature tool testing, and early-stage technology integration, the **potential for inadvertent joint IP creation is higher than in HFTS**. The geothermal sector also has a different investor base: many geothermal companies are **technology-driven and IP-sensitive**, often backed by venture investors with strong expectations around owning and protecting proprietary processes. These companies may be reluctant to expose operational practices or proprietary workflows to broader observation if they fear they cannot fully monetize their innovations or if the value of participating in the testbed is uncertain. In contrast, the oil and gas companies involved in HFTS did not demonstrate the same level of IP anxiety and were more comfortable sharing raw data under controlled conditions.

This difference means that an SHR testbed will require **more granular data-tiering** and clearer contractual boundaries than HFTS. For example, whereas HFTS used a uniform 2–3 year embargo followed by public release, SHR will likely require a multi-tier regime distinguishing raw data, derived data, processed data, and interpretive models. Similarly, while HFTS produced little Foreground IP, SHR testbed operations may generate proprietary tool-performance data, thermal-mechanical behavior insights, and design learnings that companies will consider commercially material. Ensuring that these boundaries are well-defined will be essential to attracting participation from geothermal developers and technology vendors.

At the same time, HFTS illustrates the **benefits of a strong operator and integrator model**, where the site host retains control over field execution while a neutral convening body (in HFTS, GTI) owns the project data and manages the consortium, agreements, data processes, and DOE obligations. An SHR testbed will similarly require a **technically credible operator**, capable of drilling and operating high-temperature wells, and a **capable coordinator** to manage participants, data flows, confidentiality tiers, and compliance with DOE requirements in case of public funding, whether coordination is provided by a separate entity or the host itself, depending on the governance model selected (*see* Section 2.3).

8.1.3. National Carbon Capture Center (NCCC)

a) Project Summary

The **National Carbon Capture Center (NCCC)** is a DOE-supported, host-operated test facility led by **Southern Company** under a cooperative agreement with DOE, with approximately **80% DOE funding and 20% industry cost share**. Its purpose is to provide **shared infrastructure** that enables technology developers to test, scale, and validate carbon capture and conversion technologies under real-world conditions without having to build bespoke facilities. Participants include DOE-funded developers, privately funded companies, industrial sponsors, and OEMs, all accessing the site through structured agreements with the host.

Participation at NCCC is subject to a DOE **technology screening and approval process**: each proposed project must be reviewed by DOE to confirm alignment with program objectives, safety requirements, and data/IP expectations before site access is granted. This step operates alongside the host's own technical and operational review and functions as a gatekeeper for participation.

b) IP / Data Structure

Access to NCCC infrastructure is governed through **Technology Collaboration Agreements** (TCAs) between Southern Company and each developer, layered beneath the DOE cooperative agreement. These agreements define scope of work, site access, operational responsibilities, and IP/data handling. Industrial sponsors participate through separate contribution agreements that provide visibility and engagement, not IP rights.

- 1. Background Protection:** NCCC places strong emphasis on explicit identification and protection of Background IP at the outset of each collaboration. Developers retain ownership of all pre-existing proprietary technology (e.g., solvent formulations, hardware designs, control algorithms), which is carved out clearly in agreements. In practice, certain background information may still need to be disclosed to the host operator under NDA to enable safe operation and integration, but this does not convert it into publishable or shared data. Clear upfront definition of Background IP was identified as critical to developer comfort and participation.
- 2. Ownership of Foreground IP:** At NCCC, most testing occurs at the scale-up and validation stage, and participants generally do not create new patentable inventions at the test site. As a result, Foreground IP creation is limited, and the primary focus is on performance data rather than invention ownership. Where new IP does arise, ownership follows the governing DOE cooperative agreement and applicable flow-down terms, but in practice this has been less contentious than data rights.
- 3. Licensing & Access Rights:** Developers do not receive licenses to other participants' IP; instead, the value proposition lies in infrastructure access, integration support, and credibility rather than shared technology rights.

4. **Data Rights:** NCCC employs a tiered data-rights model, which was repeatedly emphasized as essential to private participation:
- **Proprietary / Background Data - fully protected.** This includes formulations, hardware designs, control logic, internal analytics, and other protected know-how. It is never published or shared beyond what is required for safe site operation.
 - **Data "first-produced" - inspectable by DOE but not published.** This intermediate category reflects data generated during a test that is technically revealing and could expose proprietary chemistry, reaction pathways, or process behavior that relates too closely to background technology. NCCC emphasized that DOE may inspect this tier to confirm appropriate use of federal funds, but DOE does not publish it.
 - **Unlimited data rights – publishable performance-level data.** This is the performance-level, aggregated data (e.g., capture efficiency, regeneration) that NCCC must report to DOE under its cooperative agreement, and that DOE ultimately does publish after approval.

All developers submit a **final report** subject to DOE review and approval before public release. Embargoes and carve-outs are negotiated upfront. NCCC noted past challenges when developers later sought to withhold data they had initially agreed to disclose, underscoring the need for early, precise definition of data categories. DOE has shown some flexibility where developers **pay to access the facility**, allowing greater confidentiality, but this remains evolving.

Unlike HFTS, NCCC did not operate under a uniform multi-year embargo period before public release. The cooperative agreement required DOE review and eventual publication only of non-proprietary, publishable performance results, while proprietary information, background data, and Protected Data (including CRADA-governed datasets) remained shielded for up to five years or indefinitely where applicable. As a result, the volume of data that ultimately became public was **substantially narrower than in HFTS**, illustrating the flexibility DOE exercises in host-facility models where private developers pay to access infrastructure.

c) Relevance for an SHR Testbed

While NCCC focuses on carbon capture rather than geothermal, it is **relevant to SHR testbeds** because it illustrates a **host-led testbed model** that balances DOE transparency requirements with protection of proprietary technology. Key parallels include high capital intensity, sequential testing by multiple industry developers, reliance on DOE funding and cost share, and the need to attract private participation while operating within federal IP and data constraints.

Transferable lessons for SHR: (i) a host-led model with standardized, repeatable agreements can significantly reduce transaction costs; (ii) tiered data-sharing is critical to attracting industry; (iii) early alignment on IP and data terms prevents later disputes and loss of trust; and (iv)

access to DOE visibility, sponsors, and future funding pathways is a powerful non-financial incentive.

Limits of transferability: (i) Because operations at NCCC are more focused on commercialization and scaling-up production, SHR testbeds are likely to involve more direct invention and IP creation than NCCC, increasing the importance of Foreground IP allocation; and (ii) geothermal drilling and reservoir creation introduce higher irreversibility and operating data sensitivity, making ring-fencing and phased disclosure even more important.

Overall, NCCC provides a useful reference point for balancing DOE requirements with private incentives, but SHR testbeds might need tighter treatment of subsurface data, earlier IP creation, and potentially clearer participant-level optionality to allow participants to tailor their IP exposure, data-sharing commitments, and depth of engagement.

8.2. Analogous (U.S.) Energy Sector Models

Because U.S. geothermal examples are limited, this Section looks to analogous U.S. energy-sector models and distills IP and data features that may inform the design of an SHR testbed.

8.2.1. Rig Automation and Performance Improvement in Drilling (RAPID)

a) Project Summary

The Rig Automation and Performance Improvement in Drilling (RAPID) consortium, based at The University of Texas at Austin (UT), is a long-running drilling automation and performance optimization program that brings together operators, service companies, and equipment providers to support academic research and field-data analysis. Although RAPID conducts validation studies and demonstration activities, it is not a commercial testbed. Its agreements are primarily designed to (i) preserve academic publication rights, (ii) protect Background IP, and (iii) ensure that UT retains ownership of research outputs unless explicitly licensed.

RAPID operates through a consistent contractual architecture: Industrial Affiliates Program (IAP) agreements, Data Use Licenses (DULs), and Sponsored Research Agreements (SRAs) collectively define how background technology, datasets, research outputs, and publications are handled. While these agreements differ in detail, their underlying IP and data governance principles are stable and prove relevant to an SHR testbed.

b) IP / Data Structure

1. **Background Protection:** Across the RAPID agreements, Background IP of both UT and sponsors is expressly retained, with no implied licenses. Companies may disclose certain background information to UT under NDA where needed for integration or safety.
2. **Ownership of New IP (Foreground IP):** RAPID maintains clear and predictable rules for ownership of research-generated IP:
 - **UT generally owns new IP created by UT investigators**, regardless of whether the project is funded through an IAP, DUL-based project, or SRA.

- **No preferential commercial rights** are granted to industry sponsors under IAP or DUL arrangements.
- Under SRAs, sponsors may receive a **first right to negotiate a commercial license** within defined windows, subject to reimbursement of patent costs.
- Joint inventions arise rarely, and when they do, inventorship governs ownership under U.S. law. UT will attempt in good faith to enable sponsor licensing of UT's share, subject to obligations to other collaborators.

This structure limits the predictability of commercialization pathways for companies; a reason it cannot be transplanted wholesale into an SHR testbed.

3. Licensing & Access Rights: RAPID's licensing framework centers on a research-only model:

- Across all models UT Austin retains ownership of university-created IP **and industry participants receive no automatic commercial rights** to university-created IP.
- Affiliates under IAPs receive access to research results on a non-confidential basis but cannot obtain exclusive or preferential licenses.
- **SRAs offer the most commercial flexibility**, providing sponsors a time-limited window to negotiate exclusive or non-exclusive licenses.
- DULs give UT a **narrow, non-commercial license** to use company-provided datasets for internal research, with no right to sublicense or disclose.

4. Data Rights: RAPID uses a layered data structure centered around the DUL:

- Company datasets (e.g., rig-sensor data, MPD signals, drilling reports, BHA details) remain **company-owned**, with UT receiving only limited research-use rights.
- Datasets are stored in secure UT-controlled environments; disclosure to third parties is prohibited without written consent.
- Confidentiality typically lasts **five years** after expiration of the agreement.
- Under SRAs, UT retains publication rights subject to a short sponsor review window (commonly 10 days) to remove confidential information.
- Under IAPs, results are shared with affiliates but cannot be further distributed.

This structure provides strong protection for sensitive operational datasets while still enabling academic research and publication.

c) Relevance for an SHR Testbed

RAPID offers **some useful lessons** for an SHR testbed, such as its clear separation of background IP, predictable treatment of university-owned Foreground IP, and disciplined use of Data Use Licenses (DULs) to manage sensitive industry datasets. However, **RAPID's academic IP and licensing structure is only partially transferable**. Under its frameworks, UT retains ownership of all university-created IP and sponsors receive only a right to negotiate a commercial license. This model does not provide the predictable commercialization pathways that tool vendors or geothermal developers would require when contributing technology or

conducting high-temperature tool testing. An SHR testbed would therefore need clearer ex-ante allocations of Foreground IP, defined rights to use or license results arising from participant contributions, and mechanisms to prevent unintended joint ownership. RAPID's emphasis on academic publication, subject to short sponsor review windows, also differs regimes likely necessary in an SHR environment.

Overall, RAPID's academic ownership model, limited commercial licensing pathways, and publication-first orientation are not directly suitable for SHR.

8.2.2. Gateway for Accelerated Innovation in Nuclear (GAIN)

a) Project Summary

The Gateway for Accelerated Innovation in Nuclear (GAIN) is a DOE Office of Nuclear Energy initiative, launched in 2015, that provides private developers cost shared access to national laboratory facilities, expertise, and data. Operated primarily through Idaho National Laboratory, GAIN is **not a standalone physical testbed** but a coordinated DOE mechanism that gives private companies **access to national lab facilities** and expertise through standardized, non-negotiable agreements, primarily the Nuclear Energy Voucher CRADA. Its value for SHR lies in how it structures IP, data protection, and DOE obligations in a public-private collaboration.⁴²

b) IP / Data Structure

Under the Nuclear Energy (NE) Voucher program, all recipients must execute a non-negotiable CRADA with the host lab (separate forms for small and large businesses,⁴³ which incorporates federal statutory and regulatory obligations. Under the Voucher CRADA:

- **Background IP** is pre-identified, remains owned by the provider, and is ring-fenced from CRADA rights.
- **Subject Inventions** are owned by the generating party (subject to DOE waiver and election requirements), with joint inventions jointly owned, and the Government retaining a royalty-free worldwide license and march-in rights.
- Participants receive a **baseline nonexclusive license** to lab-generated subject inventions and may negotiate exclusivity under U.S. manufacturing and competitiveness conditions.
- **Data** is split into (i) Proprietary Information (pre-existing/confidential; protected for 5 years) and (ii) Protected CRADA Information (generated under the CRADA and protectable for up to 5 years). DOE receives broad internal-use rights, but public release is delayed to protect patentability and confidentiality.

⁴² See <https://www.energy.gov/ne/gateway-accelerated-innovation-nuclear-gain> (last accessed Feb. 6, 2026).

⁴³ See <https://gain.inl.gov/industry-support/gain-ne-vouchers/applying-for-a-voucher/voucher-crada-agreements/> (last accessed Feb. 6, 2026); NE Small Business Voucher CRADA available under: https://gain.inl.gov/content/uploads/4/2022/10/GAIN_SmallBusinessVoucherCRADA_11.1.2018.pdf (last accessed Feb. 6, 2026).

c) Relevance for an SHR Testbed

GAIN provides a useful structural template for how DOE-funded work can (i) preserve participant ownership of Background IP and subject inventions, (ii) define licensing paths to lab-generated IP, (iii) protect proprietary and project-sensitive data for finite periods, and (iv) integrate non-waivable federal rights in a predictable way.

Structural elements of the GAIN model could inform an SHR testbed operating under a mixed public-private funding structure, providing a starting architecture that prioritizes speed, predictability, and reduced transaction friction. While many benchmarked programs rely on standardized agreements, these are often facility-specific or not publicly accessible; GAIN's voucher model is paired with publicly available, pre-negotiated documentation, offering a transparent and straightforward pathway for accessing DOE laboratory capabilities. This structure (focused on facilitating lab collaboration rather than open-ended project funding) illustrates how standardized, visible terms can accelerate project initiation and lower coordination costs once established. These elements would require adaptation for a multi-party, open-access SHR environment, particularly considering subsurface data sensitivities and longer development timelines. In a purely private or philanthropic SHR testbed, GAIN's relevance is more limited, beyond good practice in Background IP identification and time-limited confidentiality.

8.2.3. The ITER Project

a) Project Summary

ITER (originally standing for International Thermonuclear Experimental Reactor) is a treaty-based nuclear research project with one of the most elaborate international IP frameworks in the energy sector. As a treaty-based, multi-sovereign collaboration, its structure is not directly applicable to commercial geothermal testbeds, but it demonstrates how large, international multi-party collaborations manage IP allocation, confidentiality, and publication review. It was formally established by the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project, signed in Paris on 21 November 2006 by Euratom, China, India, Japan, Korea, Russia, and the U.S. (collectively, the "Members") (the "ITER Agreement"). The ITER Organization is an international organization headquartered in France. ITER has a physical site ("the ITER facilities") built and operated jointly, with each Member providing cash and in-kind contributions through national "Domestic Agencies."

b) IP / Data Structure

Key principles include⁴⁴:

⁴⁴ Article 10 of the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project and the Annex on Information and Intellectual Property govern the allocation, dissemination, and licensing of IP.

1. **Background IP:** Each Member retains ownership of Background IP it contributes. Access rights for the ITER Organization and other Members depend on what is necessary for performing work within the scope of the ITER Project. Background IP (except confidential information such as know-how and trade secrets) is licensed to other Members and the ITER Organization on an irrevocable, royalty-free, non-exclusive basis to the extent required for project execution and for the purposes of publicly sponsored fusion research.⁴⁵ ITER receives an irrevocable, royalty-free license to Background IP to use such information for construction, operation, and maintenance, safety or integration of ITER technology.⁴⁶
2. **Foreground (Generated) IP:** Title, interest and rights in Foreground IP created during ITER activities are allocated based on the generating entity. If jointly created IP cannot be separated for the purpose of applying for, obtaining and/or maintaining in force the protection of the relevant IP, Members or the ITER Organization own IP jointly, and regulate on the allocation and the terms of exercising the ownership over such IP by means of a separate co-ownership arrangement.⁴⁷
3. **Licensing:** A generating entity's rights in Foreground IP is subject to broad, non-exclusive, royalty-free licenses to all Members for **fusion-energy research purposes**. Additionally, the generating member must grant all other members a non-exclusive, equal, and non-discriminatory license **for commercial fusion use**, including the right for each Member to sub-license that IP to domestic third parties. These commercial licenses must be offered on terms no less favorable than those granted to the generating Member's own national or foreign commercial partners and may only be revoked in cases of contractual breach. The ITER Organization owns copyrights on scientific publications and may require protection before release.⁴⁸
4. **Protections and Controls:** ITER enforces strict flow-down requirements to ensure that all supplier and R&D contracts incorporate the project's IP, access-right, confidentiality, and publication-control obligations, preventing downstream agreements from eroding ITER's rights or releasing unprotected or sensitive information.⁴⁹
5. **Data governance:** ITER distinguishes "Information" (non-IP data such as drawings, measurements, reports, published data) from "Intellectual Property" (protectable subject matter, including confidential know-how). Members commit to the broad dissemination of generated Information during ITER activities, but scientific results may only be released or published after a "reasonable" period to allow for the obtaining of appropriate protection. Members may reproduce and publicly distribute non-commercial scientific

⁴⁵ Article 4.2 Annex to the ITER Agreement.

⁴⁶ Article 4.2.3 Annex to the ITER Agreement.

⁴⁷ Article 7.4 Annex to the ITER Agreement.

⁴⁸ Article 10(2)–(4)) ITER Agreement.

⁴⁹ Article 2.2 Annex to the ITER Agreement.

information, provided confidentiality is respected and dissemination is equal and non-discriminatory.⁵⁰

6. **Publication Review:** ITER's framework requires pre-dissemination review to protect patentability, remove confidential information, comply with safety/export-control rules, and follow Council-adopted IP procedures. This is implemented through provisions in Annex 2.1, 7.1–7.2, and the confidentiality rules in 4.2.3(b).

c) *Relevance for an SHR Testbed*

ITER can be considered one of the clearest examples of a single, shared physical research site operating under a unified, multi-jurisdictional IP and data framework and is therefore instructive for SHR efforts that contemplate international collaboration. It demonstrates how a centralized test facility can support participation by multiple sovereign and private actors through clearly defined access rights, enforceable IP flow-down provisions, and structured publication and confidentiality controls.

For SHR, ITER illustrates one end of the spectrum for structuring international engagement around a centralized test facility. It reflects a large-scale, long-horizon, intergovernmental model developed through extensive coordination among participating states over a prolonged period. ITER's IP and data governance architecture provides a valuable reference point for coordinated international testbed initiatives, as it identifies which IP and data issues must be specified upfront and in demonstrates how predictable and enforceable rules can support sustained cross-border participation over time.

Because of the extended negotiation and implementation timeline, treaty-based models like ITER can offer strong lessons in governance and predictability but tend to involve significant administrative effort and long lead times compared with host-country-led or contractual arrangements that more quickly enable cross-border participation.

Beyond its formal governance and IP framework, ITER also highlights important operational considerations for internationally coordinated research infrastructure. In practice, the ITER Organization has experienced challenges in data and information management and in providing effective sharing tools for participating member states. A key lesson learned from the ITER project that is directly applicable to an SHR testbed is that, alongside clear intellectual property rights regulation, a robust data-management system should be implemented to enable easy access, use, and transfer of data among partners and their organizations.

At the same time, applying this model to SHR would require adaptation to reflect commercial sensitivities specific to SHR development, particularly around emerging drilling technologies, tools, and subsurface data. This would include a significant narrowing of ITER's broad, non-exclusive licensing regime.

⁵⁰ Article 10(1) ITER Agreement, Articles 1.2, 1.3, and 4.2.3, Annex to the ITER Agreement.

From a legal and institutional perspective, it's also important to note that the U.S. is an active full Member of ITER, with participation authorized by Congress and implemented by the DOE through its Office of Science and the US-ITER Domestic Agency, and federal appropriations supporting U.S. contributions to hardware, research, and collaborative.⁵¹ As a result, ITER's IP and data rules operate by international agreement among sovereign states, rather than through domestic U.S. R&D mechanisms such as Bayh–Dole, CRADAs, or standard DOE financial assistance terms.⁵²

8.2.4. Solar Consortia and DOE SETO Frameworks

Solar R&D consortia supported by the U.S. DOE's Solar Energy Technologies Office (SETO) such as the DOE-funded Durable Module Materials Consortium (DuraMAT)⁵³ and the U.S. Manufacturing of Advanced Perovskites Consortium (US-MAP)⁵⁴ are relevant primarily as illustrations of how standard DOE-funded research programs apply baseline IP and data-governance requirements, rather than as direct analogues for an SHR geothermal testbed.

SETO-supported consortia operate under the same statutory and contractual IP and data provisions that apply across DOE financial-assistance awards (see Section 3.1), as implemented through program-specific Notices of Funding Opportunity. These include upfront identification and protection of Background IP, participant ownership of subject inventions subject to Bayh–Dole, non-waivable federal rights, and structured data governance obligations with defined confidentiality or embargo periods for proprietary information.

Based on a high-level review of available program descriptions, the SETO experience appears relevant primarily in a U.S. context and, even there, useful mainly as confirmation of how DOE's standard IP and data requirements are applied in practice, rather than as a source of additional, testbed-specific design insights beyond those reflected in other DOE-funded subsurface and energy-sector examples discussed above (see Sections 4.2.1, 4.2.2, and 4.2.3). Given the heightened commercial sensitivity of SHR technologies, any application of these frameworks would require material tailoring to preserve participant incentives while remaining compliant with federal requirements.

8.2.5. National Offshore Wind Research and Development Consortium (NOWRDC)

a) Project Summary

The National Offshore Wind Research and Development Consortium (NOWRDC) is a U.S.-based, mission-oriented nonprofit consortium established to coordinate and fund pre-

⁵¹ U.S. participation in ITER is authorized by the Energy Policy Act of 2005 and reiterated in subsequent U.S. energy legislation; U.S. contributions are managed by DOE's Office of Science through the US-ITER Domestic Agency and funded through annual appropriations. See Congressional Research Service, "ITER – An International Nuclear Fusion Research and Development Facility", <https://www.congress.gov/crs-product/R48362> (last accessed June 15, 2026).

⁵² See the ITER Agreement and associated protocols, reflecting treaty-style commitments rather than standard U.S. federally funded research terms (Bayh–Dole, CRADA, etc.).

⁵³ See <https://www.duramat.org> (last accessed June 15, 2026).

⁵⁴ See <https://www.usa-perovskites.org> (last accessed June 15, 2026).

competitive offshore wind research to reduce technical risk, cost, and supply-chain barriers while accelerating commercialization. Funded primarily by the DOE and the New York State Energy Research and Development Authority (NYSERDA), NOWRDC does not operate a centralized test site, but instead functions as a distributed R&D platform, issuing competitive awards for projects that are executed at existing university, national laboratory, and independent testing facilities. It is therefore best understood as a coordination and funding model rather than a site-based testbed, with relevance for SHR primarily in its structured approach to multi-party IP management and publicly funded R&D.

b) IP and Data Approach

NOWRDC's IP Management Plan (the "Plan") provides a DOE-aligned framework under which participants retain ownership of their **Background IP** (after upfront identification), and other participants may only use it for award-funded work, with no implied right to commercialize such Background IP.⁵⁵ Participants retain ownership of any **Foreground IP** or subject inventions developed solely by their employees or agents, consistent with Bayh–Dole and DOE flow-down requirements, while jointly developed IP is held in undivided co-ownership, with joint patent applications required where appropriate.⁵⁶

Participants may grant exclusive or non-exclusive **licenses** to generated "Project IP", but all licenses are subject to federal government rights (see Section 3.1). Participants must also use commercially reasonable efforts to commercialize subject inventions or grant licenses to facilitate deployment, reflecting the consortium's mandate to accelerate technology adoption.

The Plan also includes **protection of designated confidential** ("Protected") **data**, which must be safeguarded, shared only within the project team under appropriate NDAs, and withheld from public dissemination unless redacted. At the same time, non-confidential scientific results generated through award-funded work are expected to be publicly disseminated, and publication may only be delayed to secure patent protection.⁵⁷

c) Relevance for an SHR Testbed

NOWRDC's framework is not directly transferable to an SHR testbed because it does not involve a centralized, shared physical test site or long-term infrastructure ownership. Its relevance instead lies in the underlying governance structure it applies in a mixed public–private, DOE-funded environment, including early identification of Background IP, clear treatment of designated confidential data, and a predictable separation between proprietary information and publicly disseminated research outputs. An SHR testbed would require calibration to reflect the commercial sensitivities of subsurface activities such as downhole tool development, drilling services, and reservoir characterization. In particular, while the NOWRDC model contemplates licensing among participants, an SHR testbed would likely limit cross-

⁵⁵ NOWRDC IP Management Plan, p. 5.

⁵⁶ NOWRDC IP Management Plan, p. 5.

⁵⁷ NOWRDC IP Management Plan, p. 5.

licensing to narrowly defined operational or safety-related rights for the testbed operator to avoid discouraging participation by competing technology developers or service providers.

8.3. International Geothermal and Subsurface Frameworks

Because advanced SHR and deep geothermal activities are occurring outside the U.S., this section reviews international geothermal and subsurface research frameworks to examine how other jurisdictions approach governance, funding, IP ownership, and data governance. These examples also illustrate the limits of direct transferability, as many international models operate under open-science mandates, public resource ownership regimes, or fully government-funded structures that differ from the commercial and IP-sensitive environment anticipated for SHR.

8.3.1. Iceland Deep Drilling Project III (IDDP) and Krafla Magma Testbed (KMT)

a) Project Summary

The **Iceland Deep Drilling Project (IDDP)** is an international consortium pursuing access to supercritical geothermal resources at extreme depths (>4–5 km). Its first well (IDDP I) was drilled in the Krafla geothermal field, and a second well (IDDP II) was drilled in the Reykjanes geothermal system. A third deep drilling effort (IDDP III) is currently being planned in the Hengill area, with drilling expected to begin in 2026.⁵⁸ In addition to IDDP III, a deep injection well and further associated work is being planned for 2027 and 2028 at this test site. Governance and IP arrangements for this work has not yet been published.

The **Krafla Magma Testbed (KMT)** is an international research infrastructure being developed in northeast Iceland to provide unprecedented access to a shallow magma body discovered during the 2009 IDDP-1 drilling project. KMT was first funded in 2021 through support from the International Continental Scientific Drilling Program (ICDP) and the Government of Iceland. In 2024, additional funding was secured from the Government of Iceland, ICDP, Landsvirkjun (the National Power Company of Iceland), Reykjavík Energy, and Iceland Drilling, enabling the next phase of project development. KMT is governed as an Icelandic non-profit foundation, overseen by a Board of Directors and supported by an Executive Office, Science Board, and Technical Consortium. The structure separates institutional oversight, scientific direction, technical delivery, and site/operator responsibilities. Landsvirkjun, as resource owner, will retain legal and operational responsibility for the physical infrastructure, including drilling, operation, and maintenance of the wells.

KMT is planned as a two-well research facility. The KMT-M (Monitoring) well will serve as a long-term magma observatory, providing direct measurements of heat transfer, fluid flow, rock properties, and magma dynamics at the rock–magma interface. The KMT-E (Energy) well will focus on testing technologies for superhot and near-magma geothermal energy production,

⁵⁸ See <https://iddp.is> (last accessed June 15, 2026).

including well construction, materials, instrumentation, reservoir engineering, and flow-testing under extreme temperature conditions.

b) IP and Data Approach (High Level)

No project-specific IP or data governance agreements were available for review; the observations below are therefore indicative rather than definitive and based on publicly available information. Historically, IDDP has followed an open-science consortium model, emphasizing collaborative research, widespread data sharing, and eventual public release of subsurface and scientific results. Data and scientific outputs from IDDP, including drilling logs and operational results, have been made publicly accessible following project completion.⁵⁹ This reflects Iceland's policy preference for transparency in subsurface resource development rather than a structure optimized for protecting proprietary tools or commercial IP.

KMT is designed as both an open-access scientific research infrastructure and a technology testbed for academia and industry. Scientific data, measurements, observations, samples, and research results generated through KMT will, as a general principle, be made openly available to maximize scientific and societal benefit. At the same time, KMT will provide a unique environment for testing and qualifying equipment, materials, sensors, and other technologies intended for extreme geothermal conditions. Intellectual property and confidential information that may be associated with proprietary technologies brought to the project by industrial partners will remain protected under appropriate agreements. Participation in KMT is open to organizations that support its collaborative and open-access mission

Because KMT is still under development, no IP or data policy has been published, and it is unclear whether it will follow the traditional IDDP open-science model, adopt stricter confidentiality tiers, or implement a hybrid structure for international industry participation.

c) Relevance for an SHR Testbed

IDDP demonstrates that deep and supercritical geothermal testbeds can successfully attract international participation and deliver high scientific value under an open consortium model. For a SHR testbed, however, the **IDDP approach is only partially transferable**: while its governance and collaborative structure could offer useful lessons, its relatively permissive data-sharing norms could deter private developers seeking to protect tool-performance data and early-stage commercial IP. An SHR testbed in another jurisdiction may therefore require **stronger data-tiering, confidentiality protections, and clear IP delineation** than is typical in Iceland's open-science tradition. Krafla's forthcoming governance and IP framework may

⁵⁹ IDDP has a long history of publishing scientific results and making project outputs publicly accessible. See e.g., IDDP-2 Public Data, International Continental Scientific Drilling Program (ICDP), <https://www.icdp-online.org/projects/by-continent/europe/iddp-2-iceland/public-data/> (last accessed June 15, 2026); See DEEPEGS (the EU-supported research program associated with IDDP) reports that its scientists published research in journals, conference abstracts, and public reports, all available online, and the International Continental Scientific Drilling Program hosts publicly accessible drilling data and project reports for IDDP-2, see, e.g., <https://iddp.is/2022/07/> (last accessed June 15, 2026).

eventually offer additional lessons, but no conclusions can be drawn until those details become public.

8.3.2. New Zealand Supercritical Project

a) *Project Summary*

New Zealand's supercritical geothermal effort has recently moved from a broad research ambition toward a defined first-of-a-kind exploration well. In September 2025, New Zealand's government announced that land within the Rotokawa Geothermal Reservoir (Taupō Volcanic Zone) was selected as the preferred site for New Zealand's first supercritical geothermal exploration well, with design work underway and drilling expected to begin in 18–24 months following pre-feasibility studies, business-case development, and preferred-site validation.⁶⁰

The project is framed as a partnership among resource guardians, government, and the field operator: a Memorandum of Understanding was signed between Tauhara North No.2 Trust (guardian of the Rotokawa geothermal resources), the Ministry of Business, Innovation and Employment (MBIE), and Mercury NZ (operator of the Rotokawa geothermal power station), with Earth Sciences New Zealand contributing technical and scientific expertise.⁶¹ A multi-disciplinary design team (local and international) is being assembled to lead work across regulatory approvals, design, risk assessment, geoscientific modelling, engineering, procurement, drilling, and asset management.⁶²

The Government has committed up to NZ\$60 million from the Regional Infrastructure Fund to support development of the first well, with plans indicating two additional wells in the future; the initiative also secured an additional NZ\$10.69 million from the Endeavour Fund.⁶³

a) *IP and Data Approach (High Level)*

No project-specific IP or data governance agreements were available for review; the observations below are therefore indicative rather than definitive. At a high level, IP and data governance for the New Zealand supercritical project appears to reflect:

- Crown regulatory authority over geothermal resources, which are subject to statutory control and resource consent regimes rather than general public ownership [*NZ to specify legal context*];
- Treaty obligations and Māori partnership/consent requirements; and
- Public-interest research mandates for government-funded scientific work.

⁶⁰ See <https://www.beehive.govt.nz/release/first-supercritical-geothermal-site-chosen> (last accessed June 15, 2026).

⁶¹ See <https://www.growregions.govt.nz/new-funding/regional-infrastructure-fund/supercritical-geothermal> (last accessed June 15, 2026).

⁶² See <https://www.beehive.govt.nz/release/first-supercritical-geothermal-site-chosen> (last accessed June 15, 2026).

⁶³ See <https://earthsciences.nz/news/earth-sciences-new-zealand-secures-endeavour-fund-support-to-unlock-superhot-geothermal-energy> (last accessed June 15, 2026).

Taken together, this suggests an approach in which publicly funded scientific work anticipates a degree of data sharing consistent with public-interest objectives, while commercial participants retain confidentiality over operational data, methodologies, and proprietary models.

b) Relevance for an SHR Testbed

The New Zealand supercritical project illustrates how resource ownership, land access, and stakeholder consent frameworks can meaningfully shape IP and data outcomes in a geothermal setting. For an SHR testbed, this experience highlights the importance of aligning IP and data governance arrangements with the underlying legal and permitting context. At the same time, the New Zealand approach reflects a distinct governance and funding environment; a SHR testbed in another jurisdiction aimed at supporting private tool and drilling innovation might require a differently calibrated contractual framework to balance public-interest data objectives with the protection of participant-specific operational know-how.

8.3.3. Alberta Oil Sands Technology and Research Authority AOSTRA (Canada)

a) Project Summary

The Alberta Oil Sands Technology and Research Authority (AOSTRA), created in 1974 as a provincial crown corporation, accelerated oil-sands extraction through government-backed R&D, as only 20 percent of Alberta’s vast heavy oil deposits were accessible at the time. Initially funded with CAD 100 mio. (CAD 625 million in today’s dollars) and eventually expanding to a total of \$620 million (\$1.7 billion in today’s dollars),⁶⁴ AOSTRA’s early projects operated under a 50/50 cost share model with industry, supporting university research, operator-led testing on industry leases, and early-stage technology demonstrations. Limited early progress led AOSTRA’s independent board to establish the Underground Test Facility (UTF), a fully government-funded subsurface test site operated independently from industry. UTF became the proving ground for horizontal drilling and steam-assisted processes that enabled commercial steam-assisted gravity drainage (SAGD) production.

A **key difference** for SHR is context: in the 1970s–80s, oil-sands know-how had very low global competitive value, reducing IP defensiveness. With the government bearing all UTF costs, companies could participate at low buy-in while accessing high-quality data. These conditions are unlikely to be replicable in a modern, commercially competitive SHR environment.

b) IP and Data

AOSTRA’s IP model was designed to maximize learning and accelerate sector-wide update, not to protect commercial exclusivity. For most AOSTRA-funded projects – including all 50/50 cost share projects and work conducted at the Underground Test Facility (UTF) – **AOSTRA owned all new data and technology, obtained patents, and served as the exclusive Canadian**

⁶⁴ Emily Smejkal, Peter Massie, and Leighton Gall, AOSTRA: A Model for Funding Geothermal Innovation (Cascade Institute, May 2025), p. 2.

licensor. Companies retained their Background IP but contributed project results into AOSTRA's confidential IP library.

A defining feature of the model was its **portfolio-wide access structure**: any company that entered into any agreement with AOSTRA (whether for a 50/50-funded project or through the UTF buy-in) **automatically received access to all AOSTRA-owned data and IP across all projects**, regardless of which project generated it. This included the full UTF dataset. Industry could also "buy in" retroactively (at roughly CAD 1 million increments) to gain access to the entire AOSTRA data and IP bank.

AOSTRA carved out two exceptions:

- **Investor Assistance Program**, a program designed to help inventors with limited funding develop their ideas, to ultimately obtain patent protection and commercial funding. AOSTRA did not take ownership in technologies or IP developed through this program.
- **Demonstration projects** for existing technologies, where patent ownership remained with the developer and AOSTRA recovered its investment through licensing revenue.

On **data disclosure**, AOSTRA never released its data publicly but made it available to any legitimate industry user through membership, internal reporting, and annual closed technical conferences. This unique non-public model was enabled by AOSTRA's status as a crown corporation operating on government-owned land.

c) Relevance for an SHR Testbed

AOSTRA illustrates how a **publicly owned, arm's-length testbed** can enable high-risk subsurface innovation that the private sector may hesitate to pursue alone. Its independence, governed by a Board of retired industry and academic experts without commercial ties, allowed for bold decisions like fully funding the UTF when SAGD was considered too risky, leading to significant sector breakthroughs. This governance structure (centered on an independent expert board insulated from commercial interests and pressures) may offer useful insights for future government-led initiatives or other configurations where similar arm's-length oversight is desired.

However, AOSTRA's direct applicability to SHR requires consideration: the **IP environment has shifted** since the 1970s, when oil sands operators faced lower IP exposure due to the resource's geographic constraints. Today's geothermal developers are more IP-sensitive, backed by technology-focused investors who prioritize protecting proprietary processes and performance data. Accordingly, AOSTRA's approach, under which it owned all new data, technology, and IP generated by participants, may require modernization to accommodate the commercialization concerns of participants operating in a more competitive, investor-driven environment.

While AOSTRA's IP model may require such updates for SHR transferability, its broader architecture and public-risk appetite remain instructive and valuable. Additionally, its non-public,

participant-only data-sharing model demonstrates how a **privately or philanthropically funded SHR testbed** (where DOE publication requirements would not apply) could use controlled, member-level access to raw data or technical results as a strong participation incentive, while tailoring stricter IP guardrails to ensure that sensitive proprietary data is shared only on a need-to-know basis.

8.3.4. Alberta Drilling Accelerator (Canada)

a) Project Summary

The Alberta Drilling Accelerator ("ADA") is a Government of Alberta–supported initiative to establish Canada’s first open-access, technology-agnostic, industry-led drilling test site, intended to accelerate the development and field validation of advanced drilling techniques in deep, high-temperature, and geologically challenging subsurface conditions.⁶⁵ The accelerator would allow domestic and international companies to test and develop drilling techniques and technologies with potential application across geothermal energy, helium, critical minerals, carbon capture and storage, and other drilling-dependent industries, serving as an incubator for next-generation drilling innovation. While initial announcements indicated a start to drilling by 2026, ADA appears to be subject to ongoing developments and collaboration among stakeholders.⁶⁶

The Government of Alberta has committed up to CAD 50 million from its industry-funded Technology Innovation and Emissions Reduction (TIER) program to support ADA through a public-private partnership model, in partnership with Eavor Technologies, the Canadian Geothermal Energy Association (CanGEA), and the Canadian Association of Energy Contractors (CAOEC). As part of Alberta’s broader innovation strategy, the testbed is being advanced in parallel with Emissions Reduction Alberta’s (ERA) Drilling Technology Challenge, which supports the development of technologies intended for use and validation at the ADA.

b) IP and Data – Relevance for SHR Testbed

While no ADA-specific IP or data framework has yet been published, the project’s reliance on provincial funding mechanisms (including TIER and ERA-administered programs) suggests that ADA will ultimately need to balance public-interest obligations, transparent data governance expectations, and commercial incentives for technology developers, offering a potentially useful point of comparison for understanding how publicly funded Canadian testbeds structure participation and protect innovation while supporting broader policy goals.

⁶⁵ For more information, see <https://www.thinkgeoenergy.com/alberta-canada-invests-on-test-facility-for-advanced-drilling-technologies/> (last accessed June 15, 2026).

⁶⁶ See <https://www.thinkgeoenergy.com/alberta-canada-invests-on-test-facility-for-advanced-drilling-technologies/> (last accessed June 15, 2026); <https://www.alberta.ca/release.cfm?xID=91415E5576CC5-01B0-48D6-B1B8F215591EEC02> (last accessed June 15, 2026).

8.3.5. German Continental Deep Drilling Programme (KTB)

a) Project Summary

Germany's Continental Deep Drilling Programme (*Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland (KTB)*) was a federally funded deep scientific drilling project (€ 270 million) conducted in the late 1980s and 1990s, culminating in boreholes exceeding 9 km depth in Bavaria (Bayern). Led by German research institutions with strong federal support, KTB advanced scientific understanding of deep crustal conditions, drilling technologies, and subsurface behavior under extreme temperature and pressure. The project is widely regarded as technically successful and remains a global reference point for deep drilling, demonstrating Germany's long-standing capability to plan, execute, and govern complex, high-risk subsurface research programs.

b) Relevance for an SHR Testbed

KTB provides an important historical reference point demonstrating that German institutions have successfully participated in and led ambitious deep drilling initiatives under public research frameworks. While its open, science-first IP and data model is not directly transferable to a SHR testbed designed to attract proprietary technology development, the technical expertise, institutional experience, and governance discipline demonstrated through KTB are directly relevant. An SHR testbed can therefore be framed not as a novel or unfamiliar undertaking for German partners, but as an evolution toward a more commercialization-oriented model building on capabilities Germany has already demonstrated at scale.