The Political Economy of Energy Transitions and the Role of Fusion in the Climate Change Debate

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KEYWORDS

fusion energy, political economy, energy transitions, climate policy, stakeholder analysis, public-private partnerships

ABSTRACT

This article examines the political economy of energy transitions with a particular focus on the role of nuclear fusion in the climate change debate. Drawing on an ideas–interests–institutions framework, the analysis investigates how fusion is integrated into national decarbonisation pathways in the United Kingdom and the United States. The study combines a documentary analysis of 28 policy documents with 22 semi-structured interviews, which were coded manually using thematic content analysis. Findings show that although both countries demonstrate strong commitments to decarbonisation, their institutional architectures differ markedly: the United Kingdom relies on State-led coordination whereas the United States emphasises private-sector innovation. These structural variations shape stakeholder power, investment patterns, regulatory clarity, and social acceptance. Fusion's growing presence within policy discourse, especially after COP26, illustrates its symbolic and strategic significance for long-term climate governance. The study concludes that fusion's political prospects depend not only on technological progress but on the alignment of institutional incentives and stakeholder interests, demonstrating the need for a multidisciplinary governance approach to support its potential as a low-carbon energy source.

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I. **Introduction**

The accelerating climate crisis has transformed global energy debates from questions primarily about technological innovation to questions about political will, institutional capacity, and economic justice. Over the last two centuries, industrialisation driven by fossil fuels has emitted more than 2.4 trillion tonnes of carbon emissions which has reshaped the biosphere and the political order that governs it.[1] The accumulation of greenhouse gases such as carbon dioxide, methane, and nitrous oxide have intensified global warming and influenced States to adopt sustainable energy alternatives.[2] Within this context, nuclear fusion has re-emerged as a compelling but complex energy solution. As a process that fuses light atomic nuclei to release vast quantities of clean power, nuclear

[1] Zhong, Qirui, et al. "Global Estimates of Carbon Monoxide Emissions from 1960 to 2013." *Environmental Science & Pollution Research*, vol. 24, 2017, pp. 864-873.

[2] Fouquet, Roger. "Historical Energy Transitions: Speed, Prices and System Transformation." *Energy Research & Social Science*, vol. 22, 2016, pp. 7–12.

fusion promises a virtually limitless, non-polluting energy source.[3] Yet the path from scientific demonstration to commercial deployment is deeply political. National governments, private investors, regulators, and civil society actors all compete to define how fusion will be governed, financed, and integrated into the energy mix. The technology's promise of near-infinite clean energy sits beside questions of ownership, control, and legitimacy, which are issues that have historically shaped energy transitions since the Industrial Revolution.

In this article, the "role of fusion" refers specifically to the political, institutional, and socio-economic mechanisms through which fusion energy is framed, governed, and incorporated into national energy-transition strategies. Rather than treating fusion solely as a technological case study, the study examines how political incentives, institutional path dependencies, and stakeholder coalitions shape its development. In doing so, it extends existing work in the political economy of energy transitions by conceptualising fusion as a political artefact embedded in climate governance, industrial policy, and long-term decarbonisation planning. The analysis is based on an ideas–interests–institutions framework, which provides a structured lens for examining how actors construct meaning around fusion, how competing interests are translated into policy preferences, and how institutional arrangements stabilise or constrain change. Ideas capture normative visions such as sustainability, energy security, or technological leadership; interests refer to the strategic aims of State and non-State stakeholders; and institutions encompass the formal and informal rules that govern decision-making. This framework allows fusion to be situated within broader debates in comparative political economy concerning State capacity, market liberalisation, and the politics of technological transitions.

This article adopts a comparative approach between the United Kingdom and the United States which are two industrial democracies with advanced fusion programmes to understand how divergent policy architectures are working towards fusion commercialisation. The United Kingdom's State-centric model relies on public research infrastructure such as the Spherical Tokamak for Energy Production project, while the United States emphasises private-sector leadership under milestone-based funding schemes.[4] By analysing these contrasting pathways, this study identifies how institutional quality, stakeholder power, and policy design shape the political economy of energy transitions. The significance of this analysis lies in connecting technological prospects to the realities of governance. Energy transitions are never purely technical transformations; they redistribute resources, influence social hierarchies, and redefine State–market relations. Understanding these political and economic dimensions is therefore essential for formulating policies that ensure fusion's potential contributes effectively to global decarbonisation targets. The urgency of this debate has grown since COP26, where renewed commitments to net-zero targets underscored the need for novel clean-energy technologies. Fusion now occupies a symbolic position within climate politics; a technological frontier representing human ingenuity and the obstacles of institutional inertia. Accordingly, this article is guided by three questions:

- How do national institutional frameworks shape the direction of fusion development?
- To what extent do stakeholder interests and governance models influence fusion's integration into broader decarbonisation strategies?

[3] El Bassam, N, "Energy Basics." *Distributed Renewable Energies for Off-Grid Communities: Empowering a Sustainable, Competitive, and Secure Twenty-First Century*, edited by Marcia Schlichting and Daniele Pagani, 2nd edn, Elsevier, 2021.

[4] *Towards Fusion Energy 2023: The Next Stage of the UK's Fusion Energy Strategy.* UK Department for Energy Security and Net Zero, Oct. 2023; *Fusion Energy Strategy 2024.* US Department of Energy, 2024.

- What lessons can comparative political economy offer for aligning innovation with equitable climate governance?

The article is structured as follows. Section II reviews the literature on the political economy of energy transitions and outlines the ideas–interests–institutions framework. Section III presents the research design, including the documentary analysis and semi-structured interviews. Section IV discusses the empirical findings from both data sources, structured around the research questions. Section V concludes by summarising the key contributions, reflecting on the study's limitations, and outlining policy implications for the governance of fusion energy.

II. **Literature Review**

A. *The Political Economy of Energy Transitions*

Notwithstanding that the energy transition is not a singular technological shift but a contest over political priorities, institutional frameworks, and market incentives, recent scholarship argues that policy reforms must balance technical feasibility with political legitimacy and institutional quality. In the low-carbon sector, nuclear fusion represents a distinctive case: an emerging technology with transformative potential but constrained by high capital, regulatory uncertainty, and public unfamiliarity. Using a political-economy approach which traditionally focuses on State–market interactions,[5] the negotiation between State and non-State actors in its adoption is analysed and, as Collinson observes, these negotiations are embedded in power structures that shape economic outcomes over time.[6]

Building on Newell and Paterson's[7] argument that climate governance is embedded within capitalist political structures, fusion development can be understood as part of a broader contest over technological change, power, and institutional adaptation. Energy transitions often replicate existing power hierarchies unless deliberate policy interventions redistribute influence and investment. Studies of electricity-market evolution identify three phases: regional integration, liberalisation, and low-carbon inclusion, all of which reflect different constellations of political and economic interests.[8] Where liberalisation privileges private investment, integration and inclusion rely more on State direction. Fusion's development depends on this balance, and its progress will show how national regimes align or diverge from their governance philosophies.

The literature further emphasises that energy transitions are path-dependent processes which are constructed through institutional legacies and political culture. Countries with coordinated market economies tend to pursue State-led industrial policy, while liberal economies favour competition and decentralisation.[9] The UK and US exemplify this distinction: Britain's emphasis on regulatory stability contrasts with America's entrepreneurial dynamism which provides an ideal case study for assessing how institutional differences affect technological deployment. Despite extensive research on renewable energy deployment and nuclear fission politics, the political economy of fusion remains relatively underexplored. Existing studies tend to prioritise technical feasibility, cost projections, or long-term scenario modelling, with limited studies focusing on how governance structures and stakeholder influence shape fusion's political landscape.

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[5] Butler, Catherine, et al. "Nuclear Power After Japan: The Social Dimensions." *Environment: Science and Policy for Sustainable Development*, vol. 53, no. 6, 2011, pp. 3-14.

[6] Collins, Stephen. *People, Politics and Power: From O'Connell to Ahern*. O'Brien Press, 2007.

[7] Newell, Peter, and Matthew Paterson. *Climate Capitalism: Global Warming and the Transformation of the Global Economy*. Cambridge University Press, 2010.

[8] Grubb, Michael, and David Newbery. "UK Electricity Market Reform and the Energy Transition: Emerging Lessons." MIT Center for Energy and Environmental Policy Research Working Paper No. 2018-004, Feb. 2018.

[9] Bridge, Gavin, and Ludger Gailing. "New Energy Spaces: Towards a Geographical Political Economy of Energy Transition." *Environment and Planning A: Economy and Space*, vol. 52, no. 6, 2020, pp. 1037-1050.

Within the climate change debate, fusion occupies an ambiguous position. On the one hand, it is framed as a potential long-term contributor to decarbonisation and energy security; on the other, its lengthy timelines and capital costs raises questions about its practicality for near-term transition strategies. Fusion is therefore used as a symbol of technological ambition and national leadership, not merely as a prospective technology. Thus, this article addresses a research gap by offering a comparative political-economy analysis of the UK and US fusion sectors, focusing on how ideas, interests, and institutions mediate fusion's role on the climate change debate.

B. *Ideas, Interests, and Institutions*

Following the 'three Is' framework,[10] ideas comprise of normative visions such as sustainability, energy security, or national competitiveness which justify State intervention. These ideas influence energy discourse by shaping the cognitive frames of stakeholders through the interpretation of risk and opportunity. Interests translate these ideas into action, producing coalitions that influence technological change through the strategic aims of stakeholders, and institutions stabilise these relationships through laws, regulations, and organisational routines.[11]

Fusion deployment requires an analysis of how formal structures interact with informal norms and institutional quality mediates between ideas and interests to determine transparency, rule enforcement, and access to decision-making.[12] When institutional coherence is high, fusion policy tends to evolve through structured public–private partnerships. When this coherence is fragmented, progress depends more on entrepreneurial initiative and venture capital.[13] Critical institutionalism however, challenges earlier functionalist views by emphasising historical contingency, social inequality, and the politics of knowledge.[14] Leach and Cleaver support this school, stating that communities and institutions are not neutral collectives but arenas of contestation. These insights underscore that institutions are not static containers but dynamic arenas where ideas and interests continually reconfigure. While institutions often stabilise existing coalitions of interest, they can also exert a transformative force by reshaping incentives, altering access to authority, and reframing what actors perceive as politically or economically viable. In this sense, institutions do not merely reproduce established power relations but can actively redirect them, precipitating change in energy governance trajectories.

C. *Social Acceptability and Public Engagement*

Social acceptability also intersects with political economy through the reinforcement of existing hierarchies of energy access, technological control and the need for an equitable policy design.[15] The history of fission has left ambivalent public attitudes toward nuclear technologies, from which fusion must consciously differentiate itself. Though technological feasibility is important, the societal acceptance of fusion determines its traction within national energy systems. Empirical studies show that continuous stakeholder participation, policy commitment and credible commercialisation are factors that influence social acceptability.[16] Recent research also links public trust to perceptions

[10] Butler et al. (n 5) *supra*.
[11] Sayer, Andrew. *Radical Political Economy: A Critique*. Oxford Blackwell, 1995.
[12] Umut, Uzar. "Political Economy of Renewable Energy: Does Institutional Quality Make a Difference in Renewable Energy Consumption?" *Renewable Energy*, vol. 155, 2020, pp. 591-603.
[13] Anadón, Laura Díaz. "Missions-Oriented RD&D Institutions in Energy Between 2000 and 2010: A Comparative Analysis of China, the United Kingdom, and the United States." *Research Policy*, vol. 41, no. 10, 2012, pp. 1742-1756.
[14] Cleaver, Frances, and Jessica de Koning. "Furthering Critical Institutionalism." *International Journal of the Commons*, vol. 9, no. 1, 2015, pp. 1-18.
[15] Setyowati, A, and J Quist. "Contested Transition? Exploring the Politics and Process of Regional Energy Planning in Indonesia." *Energy Policy*, vol. 165, 2022, 112997.
[16] Grundel, Ida, et al. "Identifying Interests and Values in Forest Areas through Collaborative Processes and Landscape Resource Analysis." *Forest Policy and Economics*, vol. 142, 2022, 102801.

of procedural justice. In situations where the public is excluded from the decision-making process, resistance intensifies.[17] Conversely, transparent communication and visible community benefits can generate legitimacy even for high-technology projects. However, the case studies illustrate divergent engagement strategies. While the United Kingdom embeds engagement through consultations within its government-led initiatives, the United States is inclined towards outreach events such as lobbying. Both the UK's STEP consultations and the US Department of Energy's outreach programmes demonstrate the growing role of dialogue in technology governance.[18] However as Stirling warns, community participation should transition from deficit models of education to genuine co-production of knowledge.[19]

III. **Methodology**

A. *Research Design*

This study adopts a qualitative comparative research design to examine how political and institutional dynamics shape fusion deployment within two national contexts: the United Kingdom and the United States. The article combines policy documentation analyses and semi-structured interviews to generate a multi-layered understanding of the political economy of energy transitions, while the comparative approach allows for the identification of both convergence and divergence models across governance systems.[20] The United Kingdom represents a centralised, State-led model in which government agencies such as the Department for Energy Security and Net Zero and the UK Atomic Energy Authority retain strategic control. In contrast, The United States embodies a decentralised, market-oriented framework which is dominated by the private-sector and supported through government funding.[21] This dual-case design aligns with the logic of comparative political economy, where differences in institutional quality, regulatory culture, and stakeholder participation produce distinct policy outcomes.[22]

A qualitative research design was selected due to the exploratory nature of the study, allowing for detailed analysis of stakeholder interpretations, institutional processes, and policy evolution that cannot be captured through quantitative indicators alone.[23] The use of thematic analysis in analysing the policy documents and semi-structured interviews was also chosen for its flexibility in identifying latent meanings across textual and verbal data.[24] A comparative angle further strengthens the explanatory depth of this article by investigating how national institutional variations benefit from divergent approaches. This approach mirrors the most-similar systems logic, as both the UK and US have strong economic capabilities, democratic governance, and scientific leadership in fusion.

B. *Data Collection*

For this study, I conducted a policy review of 28 fusion policy documents, which is based on substantial and ongoing commitment within the fusion sector and 22 semi-structured interviews which provided a basis for stakeholder ideas and interests in fusion deployment (**Table 1**, below).

1. Policy Documentation Analysis

Documentary analysis was used to examine how fusion is formally positioned within

[17] Bridge & Gailing (n 9) *supra*.
[18] *Technology Report: Safety and Waste Aspects for Fusion Power Plants.* UK Atomic Energy, UKAEA-RE(21)01, no. 1, Sept. 2021; *The Global Fusion Industry in 2022: Fusion Companies Survey.* Fusion Industry Association, 2022.
[19] Stirling, Andrew. "Risk, Precaution and Science: Towards a More Constructive Policy Debate." *EMBO Reports*, vol. 8, no. 4, 2007, pp. 309-315.
[20] Onwuegbuzie, Anthony, and R Burke Johnson. "The Validity Issue in Mixed Research." *Research in the Schools*, vol. 13, no. 1, 2006, pp. 48-63.
[21] US Department of Energy (n 4) *supra*.
[22] Persson, Torsten, and Guido Tabellini. "Political Institutions and Policy Outcomes: What Are the Stylized Facts?" Institute for International Economic Studies Working Paper, Feb. 2001.
[23] Flick, Uwe. *An Introduction to Qualitative Research*. 4th edn, Sage, 2009.
[24] Braun, Virginia, and Victoria Clarke. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology*, vol. 3, no. 2, 2006, pp. 77-101.

national strategies, legislation, and regulatory frameworks, which directly addresses the first research objective on how institutional frameworks shape fusion development. A systematic review of 28 policy documents published between 1965 and 2024 was conducted, and these documents comprised legislations, national strategies, and bilateral agreements. These texts were obtained from official UK and US government databases to analyse the evolution of fusion governance frameworks. Thematic coding identified recurrent patterns relating to stakeholder roles, funding mechanisms, and regulatory principles. Policy documents included the UK Energy Act 1965, Energy White Papers (2003, 2017, 2020), Fusion Strategy 2023, and the US Fusion Energy Act 1974 and Fusion Energy Act 2023.

2. Semi-Structured Interviews

Semi-structured interviews were conducted to capture stakeholder interpretations of political willingness, interests, and institutional constraints, which directly addressed the second and third research objectives which focus on stakeholder power and strategies of influence. 22 in-depth interviews were conducted with policy officials, research directors, private-sector executives, and civil-society representatives. The interviews explored perceptions of fusion's commercial viability, political support, and barriers to integration. Participants were selected through a purposive snowball sampling to ensure representation from both public and private stakeholders. Interview questions were open-ended to allow participants to define salient issues in their own terms, which is consistent with interpretivist research principles.[25] Transcripts were coded manually to identify thematic clusters such as viability and stakeholder significance.

C. *Analytical Framework*

The analytical framework draws on the concept of ideas–interests–institutions which was outlined in the literature review. This framework conceptualises political economy as a relational system where stakeholders pursue interests within institutional constraints and discursive contexts.[26] Coding categories were derived inductively from the data but aligned deductively with this theoretical model. Stakeholders were categorised by power and influence. Power is defined as control over resources and decision-making processes, while influence reflects the ability to shape outcomes indirectly through persuasion or alliance-building.[27] To assess these dimensions, the study modified Clucas's index of legislative influence to examine formal powers (policy authorship, site selection) and informal powers (advisory roles, agenda-setting).[28] Cross-case synthesis was then applied to compare institutional configurations between the United Kingdom and the United States. This method, following Drass and Ragin,[29] is appropriate for multi-country qualitative research where causal mechanisms are configurational rather than linear. The choice of an interpretivist rather than a positivist framework reflects the study's agenda with meaning and agency in policy processes. As Yanow argues, political analysis must capture how actors interpret rules and norms, alongside their reason for compliance, and this perspective was essential for unpacking differences in how UK and US stakeholders frame fusion, and how these framings shape commercialisation.[30]

IV. **Results and Discussion**

These findings are presented in alignment with the three research questions, which focuses on the role of national institutional frameworks, influence of stakeholder

[25] Kvale, Steinar. *Doing Interviews*. 2nd edn, Sage, 2018.
[26] Butler et al. (n 5) *supra*.
[27] Willer, Robb, et al. "Influence over Observers of Structural Power: An Experimental Investigation." *The Sociological Quarterly*, vol. 46, no. 2, 2005, pp. 263-277.
[28] Clucas, Richard. "Legislative Professionalism and the Power of State House Leaders." *State Politics & Policy Quarterly*, vol. 7, no. 1, 2007, pp. 1-19.
[29] Drass, Kriss, and Charles Ragin. "QCA: Qualitative Comparative Analysis." Northwestern University Institute for Policy Research Working Paper, 1992.
[30] Yanow, Dvora. *Conducting Interpretive Policy Analysis*. Sage, 2000.

interests and governance models and the comparative political economy for aligning innovation with equitable climate governance.

A. *Stakeholder Constellations and Power Relations*

The policy documents and interview data identified a diverse ecosystem of stakeholders which shape fusion policy within the United Kingdom and the United States. In both countries, State actors form the core of influence and are supported by non-State actors. The mapping of power relations revealed four recurring coalitions (**Figure 1**, below).

Though non-State actors increasingly shape the agenda through think tanks and industry associations that frame fusion as both climate imperative and economic opportunity, influence flows differ. In the United Kingdom, the Department for Energy Security and Net Zero (DESNZ) and the UK Atomic Energy Authority (UKAEA) are centrally responsible for policy execution. Their collaboration under the Spherical Tokamak for Energy Production (STEP) programme consolidates public oversight and directs funding streams toward research hubs such as Culham Science Centre and private partners such as Tokamak Energy.[31] This arrangement produces a vertically integrated governance model where State agencies are involved in partnerships through contractual frameworks and strategic memoranda. In contrast, the United States exhibits a decentralised, market-driven model. The Department of Energy's Office of Fusion Energy Sciences sets energy priorities, but execution is designated to private firms such as Commonwealth Fusion Systems and Xcimer Energy.[32] For instance, the Department of Energy's Milestone-Based Development Program is based on competitive funding, where grants are disbursed based on demonstrable technical progress. As US6 noted, "government acts less as a regulator and more as a catalyst—our role is to prove commercial pathways rather than design them".

While influence flows in the UK move hierarchically from government departments to delivery agencies, influence flows in the US circulate horizontally through a network of investors, start-up companies, and laboratories. These differing institutional logics shape stakeholder power as UK stakeholders perceive legitimacy through State endorsement while US stakeholders derive influence from market credibility and technological performance. In both contexts, academic institutions serve as epistemic brokers which translate scientific advances into policy discourse.

However, the degree of stakeholder integration also reflects deeper historical legacies in national innovation systems. In the UK, fusion policy evolved within a long tradition of corporatist governance in energy and defence industries.[33] The central government historically retained ownership over major scientific assets such as the Atomic Energy Authority, ensuring close alignment between research priorities and State industrial policy. Even after market liberalisation in the 1980s, this centralised pattern persisted through quasi-autonomous agencies such as the UK Atomic Energy Authority. The UK's model of coordination thus remains hierarchical and strategic, reflecting what Hall and Soskice describe as a coordinated market economy.[34] While the UK approach provides institutional coherence and continuity, it can also produce bureaucratic inertia. Interviewees in the UK highlighted the challenge of reconciling long-term public missions with short-term fiscal constraints. In contrast, the US exhibits traits of a liberal market economy where private

[31] *Our Strategy 2022–2026: Leading the Delivery of Sustainable Fusion Energy and Maximising Scientific and Economic Benefit.* UK Atomic Energy Authority, 2023.
[32] *Department of Energy Announces $46 Million in Awards for Commercial Fusion Development.* US Department of Energy Funding Opportunity Announcement DE-FOA-0002809, 31 May 2023.
[33] Helm, Dieter. *Energy, the State, and the Market: British Energy Policy Since 1979*. Oxford University Press, 2004.
[34] Hall, Peter, and David Soskice, *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage*. Oxford University Press, 2001.

entrepreneurship and venture capital act as primary drivers of innovation. This explains the rapid emergence of fusion start-ups that dominate the American fusion landscape.[35] The US system rewards rapid innovation, but the absence of a unified national roadmap can result in duplication and inconsistent licensing practices. US7 stated, "our advantage is speed, but our weakness is alignment". Though public–private coordination exists, it is grounded on transactional characteristics as the government provides funding with minimal involvement in technological development.

From a political-economy perspective, stakeholder influence in the UK and the US reflect the interplay of formal power and informal influence. The UK's institutionalised partnerships foster predictability but limit diversity of perspectives while the US encourages competition but can amplify inequities in access to decision-making. The overall pattern supports the argument that governance design mediates technological outcomes, and institutions determine not only what policies are possible but who gets to define them.[36]

B. *Themes from the Qualitative Analysis*

1. International Cooperation and Governance

Cross-national collaboration emerged as a recurrent theme. Both countries participate in ITER and maintain bilateral agreements such as the 2023 UK–US Joint Statement on Fusion Energy.[37] Interviewees viewed these alliances as crucial for standardising regulatory frameworks and sharing risk. However, institutional asymmetry complicates cooperation: UK interviewees emphasised compliance with European safety norms, while US counterparts focused on export-control flexibility and intellectual property protection. This divergence reflects broader geopolitical strategies, with Britain positioning itself as a regulatory leader within global climate diplomacy, and the US as a commercial innovator seeking first-mover advantage. Thus, effective international governance will depend on reconciling these regulatory cultures. Scholars such as Stirling & Johnstone argue that energy geopolitics increasingly hinges on technological sovereignty, which is the ability of States to shape global standards through early adoption and rulemaking.[38] In this context, the UK's commitment to transparency and public-sector leadership represents a soft-power strategy for influencing international norms while American private-sector dominance represents a market diffusion strategy.[39] Interviewees from both contexts acknowledged that collaboration is essential but fraught with political tension. UK stakeholders highlighted the importance of continued involvement in multilateral initiatives like EUROfusion despite post-Brexit uncertainty. US stakeholders also expressed concerns that international cooperation could affect domestic innovation, if overly constrained by bureaucratic harmonisation. US8 supported this notion, stating that "global alignment is vital, but we can't wait for consensus to make progress". This evidence suggests that while the UK and the US both value collaboration, they differ in the logic underpinning it, and these variations reflect each country's historical experience with nuclear technology governance and broader climate diplomacy strategies.[40]

2. Regulatory Frameworks and Institutional Capacity

Interviewees consistently described regulation as both enabling and constraining.

[35] *Global Investment in the Private Fusion Sector*. F4E Fusion Observatory, 2nd edn, 2025.

[36] Pierson, Paul. "Increasing Returns, Path Dependence, and the Study of Politics." *American Political Science Review*, vol. 94, no. 2, 2000, pp. 251-267.

[37] *Joint Statement Between the United Kingdom and the United States on a Strategic Partnership to Accelerate Fusion Energy Demonstration and Commercialisation.* UK Department for Energy Security and Net Zero / US Department of Energy, 8 Nov. 2023.

[38] Stirling, Andrew, and Philip Johnstone. "Hidden Military Implications of 'Building Back' with New Nuclear in the UK." *Responsible Science*, no. 3, 2021, pp. 11-14.

[39] Mazzucato, Mariana. *The Entrepreneurial State*. Anthem Press, 2013.

[40] Goldthau, Andreas, and Benjamin Sovacool. "The Uniqueness of the Energy Security, Justice, and Governance Problem." *Energy Policy*, vol. 41, 2012, pp. 232-240.

The UK's Towards Fusion Energy (2021) introduced proportional licensing distinct from fission law,[41] which stakeholders praised for legal clarity. Although not statutory, it functions as formal policy guidance that shapes regulatory expectations for both the Office for Nuclear Regulation and the Environment Agency. As government-issued guidance, it carries persuasive authority and frames how regulators interpret compliance obligations for emerging fusion facilities. This document was developed through extensive consultation between the UK Atomic Energy Authority, the Office for Nuclear Regulation and the Environment Agency to reflect a participatory approach in decision-making. UK5 also noted that "the challenge is to remain flexible enough to support innovation but strict enough to maintain credibility". Comparatively, the US Fusion Energy Act (introduced in 2023 and not yet made law) establishes a dedicated regulatory pathway under the Nuclear Regulatory Commission by clarifying safety requirements, distinguishing fusion from fission in licensing burden, and mandating the development of risk-proportionate standards. It also directs agencies to develop technical guidance notes and consult with industry to ensure regulatory predictability for pilot plants.[42] Nevertheless, interviewees cited residual uncertainty about liability regimes and waste classification. US4 supported this claim, stating that "regulatory clarity is improving, but we're still navigating uncharted territory". In both cases, institutional capacity proved decisive: where bureaucratic expertise was thin, policy innovation lagged. These findings align with Uzar's argument that institutional quality correlates directly with low-carbon investment inflows.[43] From the analysis, the UK's approach exemplifies anticipatory regulation, where rules evolve proactively alongside technology while the American approach exhibits adaptive regulation where rules are adjusted incrementally in response to market developments. Both approaches have merits; anticipatory frameworks build public trust and reduce future uncertainty, while adaptive ones preserve flexibility and innovation. Yet, as Stirling notes, governance must also confront the political dimension of uncertainty. The evolving regulatory landscapes in both nations thus reflect broader struggles to balance technological optimism with accountability.[44]

3. Public–Private Partnerships and Financing Models

Both the UK and the US utilise public–private partnerships which differ in architecture. In the UK, partnerships are formalised through strategic funding calls administered by the Department for Energy Security and Net Zero and the UK Atomic Energy Authority. The British model is known for emphasising risk sharing, where government funds early-stage research while private partners contribute to innovation and project-specific capital. The STEP Programme epitomises this approach as an integrated framework which links national laboratories, industrial suppliers, and universities under a single strategic mission.[45] Interviewees also noted that this structure encourages continuity but sometimes slows decision-making. In the US, venture capital and philanthropic investment dominate early-stage funding, which is complemented by the Department of Energy's matching grants.[46] This model reflects a venture governance, where competition and milestone validation are substituted for State coordination, but increases volatility and dependence on private risk tolerance.

Comparative synthesis indicates that hybrid financing which combines UK-style stability with US-type entrepreneurialism is an effective model for fusion commercialisation and the safeguarding of public accountability.

[41] *Towards Fusion Energy: The UK Government's Fusion Strategy*. UK Department for Business, Energy & Industrial Strategy, Oct. 2021.

[42] Fusion Energy Act, HR 5244. Introduced in the House of Representatives to amend the Atomic Energy Act of 1954 to include fusion energy machines and referred to the House Committee on Energy and Commerce.

[43] Uzar (n 12) *supra*.

[44] Stirling (n 19) *supra*.

[45] UK Atomic Energy Authority (n 31) *supra*.

[46] Casady, Carter, et al. "Public–Private Partnerships for Low-Carbon, Climate-Resilient Infrastructure: Insights from the Literature." *Journal of Cleaner Production*, vol. 470, 2024, 143338.

For instance, UK7 stated that "the challenge is to de-risk private investment without re-nationalising science", while US7 remarked that "federal milestones give us legitimacy; private equity gives us speed". It is evident that both perspectives highlight tensions between public and private interests, and the literature also supports these findings. Mazzucato argues that the State's role as market shaper is critical for de-risking low-carbon technologies while retaining social value.[47] In fusion where high capital and long timelines are associated with its development, private finance remains insufficient and public finance struggles to scale. Successful transitions require polycentric innovation ecosystems, where multiple actors share authority and responsibility and policy frameworks that embody these hybrid arrangements through co-funding, intellectual property agreements, and transparent oversight are more resilient to political change.[48]

4. Energy Security and Social Acceptance

Energy security discourse is grounded in the UK and US policy environments. UK interviewees framed fusion as a sovereign capability which ensures net-zero resilience, whereas US interviewees highlighted global competitiveness and technological leadership. In both countries, the political narratives of autonomy and modernisation are reinforced due to fusion's potential as a sustainable energy source. However, these narratives are filtered through the UK's climate responsibility and American innovation exceptionalism.[49]

Public understanding of fusion remains limited and often conflicted with nuclear fission.[50] Several interviewees in both contexts acknowledged that public perception "lags decades behind the science". The UK has taken deliberate steps to address this gap through outreach programmes by the UK Atomic Energy Authority and consultations at the designated STEP host community, West Burton. These processes include community benefits packages and local skills development initiatives to generate socioeconomic value. Similarly, American communication efforts are industry-led, with private firms investing in branding fusion as clean nuclear through media campaigns and university partnerships.[51] Societal legitimacy thus depends on perceived fairness, transparency, and inclusion. Interdisciplinary scholars of science and technology emphasise that acceptance emerges from the co-production of knowledge.[52] Empirical studies of wind and geothermal projects show that procedural justice, where communities can design and shape governance is strongly linked to acceptance and is applicable to nuclear fusion.[53]

In both countries, interviewees highlighted equity concerns: who benefits from fusion development, and who bears its risks? Civil-society actors cautioned that inconsistent engagement within the fusion sector could result in regional inequalities. Though the UK fosters a higher baseline trust through government stewardship, consultation fatigue can emerge if communities perceive decisions as predetermined. The American approach, which encourages diverse experimentation, has the limitation of uneven participation because of its market-driven engagement. Bridging these gaps requires mechanisms such as citizen panels, deliberative assemblies, or

[47] Mazzucato (n 39) *supra*.
[48] Sovacool, Benjamin, et al. "Energy Transitions from the Cradle to the Grave: A Meta-Theoretical Framework Integrating Responsible Innovation, Social Practices, and Energy Justice." *Energy Research & Social Science*, vol. 75, May 2021, 102027.
[49] Labussière, Olivier, and Alain Nadaï. *Energy Transitions: A Socio-Technical Inquiry*. Palgrave Macmillan, 2018.
[50] Jones, Christopher, et al. "Predicting Attitudes Towards Fusion Energy in Europe: Results of a Cross-National Public Survey in Austria, Finland, Spain and the UK." *Energy Research & Social Science*, vol. 75, 2021, article 102028.
[51] *The Global Fusion Industry in 2023: Fusion Companies Survey*. Fusion Industry Association, 2023.
[52] Jasanoff, Sheila. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton University Press, 2005.
[53] Wolsink, Maarten. "Wind Power Implementation: The Nature of Public Attitudes—Equity and Fairness Instead of 'Backyard Motives'." *Renewable and Sustainable Energy Reviews*, vol. 11, no. 6, 2007, pp. 1188-1207.

statutory advisory boards that embed citizen voice in planning. These mechanisms align fusion governance with the required democratic accountability of low-carbon technologies. As Mercer et al. note, distributive justice is integral to sustainable technology governance.[54] Therefore, governments face a dual mandate: the delivery of clean energy and its contribution to social inclusion.

C. *Cross-Case Comparison*

This subsection presents a comparative synthesis which underscores how institutional variations shape fusion deployment. The findings reinforce the broader theoretical claim that energy transitions are political projects embedded in institutional contexts. They also show that while fusion is technologically universal, its governance is nationally specific. Thus, its political economy exemplifies how climate goals are negotiated through institutional systems. These contrasts further illuminate nuclear fusion's dual identity: as a technological frontier and as an arena of political negotiation.

Across the UK and the US, three patterns emerged to illustrate stakeholder interpretations (**Figure 2**, below). These patterns were generated through a thematic analysis of both policy documents and interview transcripts, which involved an iterative process of manual coding and a cross-case comparison between the UK and US data. The first pattern shows that institutional coherence provides predictable pathways for fusion development, but it also constrains adaptive decision-making when political priorities shift. In contrast, institutionally flexible environments such as the US accelerate experimentation but generate coordination challenges, highlighting a trade-off between stability and innovation. The second pattern illustrates that public–private partnerships operate differently across governance regimes: the UK model embeds partnership within State-led strategy, while the US model relies on competitive market dynamics. These differences shape how risk is distributed, which actors hold agenda-setting power, and how accountability mechanisms are constructed. The final pattern underscores the fragility of societal legitimacy, showing that technical optimism alone is insufficient for public acceptance. Community involvement, procedural fairness, and distributive equity emerged across interviews as core determinants of social license to operate.

V. **Conclusion and Policy Implications**

This comparative investigation of the United Kingdom and the United States demonstrates that the political economy of energy transitions is about governance, ideology and technology. Though it is scientifically promising, fusion energy advances within complex systems of interests, institutions, and discourses that determine its commercialisation. The study shows that fusion is neither a purely technical innovation nor a politically neutral enterprise: but its development reflects underlying social contracts between the State and the market.[55] The UK's model of fusion governance shows the strength of State coordination and long-term strategic planning. Its reliance on government-led frameworks such as STEP programme and the Fusion Strategy 2023 has created institutional coherence and public trust, at the cost of bureaucracy. By embedding fusion within its national decarbonisation and industrial strategy, the UK demonstrates how government-led planning can foster stability and legitimacy. However, the system's highly centralised character also constrains responsiveness to changing scientific or fiscal conditions. Conversely, the US model exemplifies innovation through decentralisation. Competitive funding, venture capital participation, and milestone-based incentives have accelerated technological breakthroughs

[54] Mercer, Jessica, et al. "Ecosystem-Based Adaptation to Climate Change in Caribbean Small Island Developing States: Integrating Local and External Knowledge." *Sustainability*, vol. 4, no. 8, 2012, pp. 1908-1932.

[55] Meadowcroft, James. "What About the Politics? Sustainable Development, Transition Management, and Long-Term Energy Transitions." *Policy Sciences*, vol. 42, no. 4, 2009, pp. 323-340.

but produced uneven regulation and limited civic engagement. While this pluralism encourages experimentation, it affects policy coherence and long-term accountability. These findings affirm the dual nature of liberal regimes: adaptive and entrepreneurial, but fragmented and vulnerable to short political cycles. Both countries reveal that institutional quality and political will are decisive in transforming fusion from experimental research into commercial reality. The analysis yields three core insights. First, fusion development in the UK and US is shaped by distinct national governance logics, with the United Kingdom relying more heavily on State-led frameworks and the United States on private-sector innovation. Secondly, stakeholder interests and the distribution of power across public, private, and civil-society actors significantly influence the degree of political willingness to prioritise fusion within broader decarbonisation strategies. Third, fusion's integration into climate policy remains contingent on regulatory clarity, credible timelines, and the alignment of fusion narratives with existing low-carbon regimes. The study is not without limitations: it focuses on two advanced industrial democracies and captures stakeholder perspectives at a specific moment in time, when fusion policy and technology are rapidly evolving. Future research could extend this analysis to additional countries and explore longitudinal changes in fusion governance. Where political consensus aligns with transparent governance and inclusive stakeholder participation, fusion can emerge as a suitable low-carbon technology.

A. *Policy Implications*

This subsection discusses the three central policy implications that emerged from this study.

1. Institutional Integration

Fusion policy should be integrated into comprehensive national climate and industrial strategies rather than a stand-alone innovation agenda to ensure coherence between research, regulation, and market deployment.

For the UK, this means sustaining cross-ministerial collaboration between the Department for Energy Security and Net Zero, the Treasury, and the Department for Business and Trade to ensure that fusion's industrial potential aligns with regional development. For the US, this implies that a more coordinated national framework that aligns the Department of Energy's programmes with State-level initiatives and private-sector investments. The renewable sector suggests that this policy design enhances investor confidence and accelerates deployment.[56]

This recommendation follows from the finding that institutional coherence significantly shapes fusion's political trajectory in the UK, while institutional fragmentation in the US has hindered regulatory predictability (Sections IV.A and IV.B).

2. Public Trust and Social Legitimacy

The governance of fusion must prioritise social legitimacy as a condition of its development. Public understanding of fusion remains limited and susceptible to association with fission. Transparent communication, inclusive consultation, and equitable benefit-sharing are essential.

In the UK, this could take the form of permanent citizen advisory panels linked to STEP host communities. In the US, this requires stronger environmental-justice protocols and clear community engagement standards in Department of Energy milestone funding initiatives. Social acceptance is not peripheral but central, and political coalitions within the fusion sector remain fragile in its absence.

This emphasis on public trust derives from the observed fragility of societal legitimacy across both cases, where interviewees warned that fusion's public acceptance is contingent upon

[56] Panos, Evangelos, et al. "Deep Decarbonisation Pathways of the Energy System in Times of Unprecedented Uncertainty in the Energy Sector." *Energy Policy*, vol. 180, 2023, 113642.

transparency and meaningful participation (Sections IV.B.4 and IV.C).

3. International Coordination and Standardisation

Global progress in fusion requires harmonised regulation and shared R&D infrastructures. The 2023 UK–US bilateral framework is a significant achievement, but broader multilateral collaboration through the OECD and IAEA platforms is necessary to establish common safety, waste, and licensing standards. As technological maturity increases, coordinated global standards will reduce duplication and improve public confidence. International cooperation also mitigates technological nationalism, ensuring that fusion contributes to collective decarbonisation rather than competitive advantage.

These policy implications highlight a common principle: fusion must be governed as a public good. While market incentives can accelerate innovation, strong public institutions can guarantee that its benefits are distributed equitably and sustainably. The political economy of energy transitions underscores a broader truth of climate governance; the success of technological revolutions is embedded in credible, legitimate, and accountable political orders.

This recommendation reflects findings on cross-national interdependence and interviewee concerns that regulatory divergence may slow commercialisation unless harmonised global standards evolve in parallel (Section IV.B.1).

VI. **Future Research Directions**

This study offers a comparative framework but also recognises its limits. Further research could extend this analysis to include emerging economies such as China, South Korea, and India, where fusion policy operates within different developmental and institutional contexts.[57] Comparative multi-level analyses could also examine how local authorities address national policy goals. Moreover, as fusion powerplants are starting to reach viability, longitudinal research which tracking socio-economic outcomes such as employment, community benefits, and environmental performance is crucial. From a methodological presentative, integrating quantitative indicators such as investment flows and patent data could complement qualitative insights and future interdisciplinary studies could explore how fusion interacts with other low-carbon technologies in energy-system modelling. These extensions would not only refine academic understanding but also support evidence-based policymaking in an era where climate, technology, and geopolitics are increasingly intertwined.

[57] Zheng, Jinxing, et al. "Recent Progress in Chinese Fusion Research Based on Superconducting Tokamak Configuration." *The Innovation*, vol. 3, no. 4, 2022, 100269.

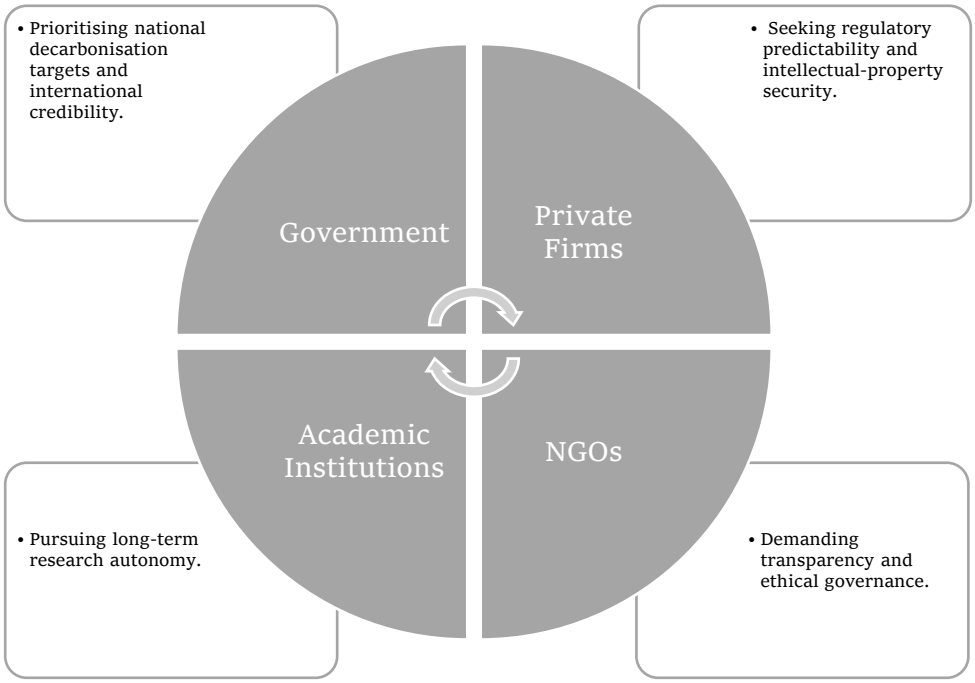


Figure 1: Stakeholder Coalitions.

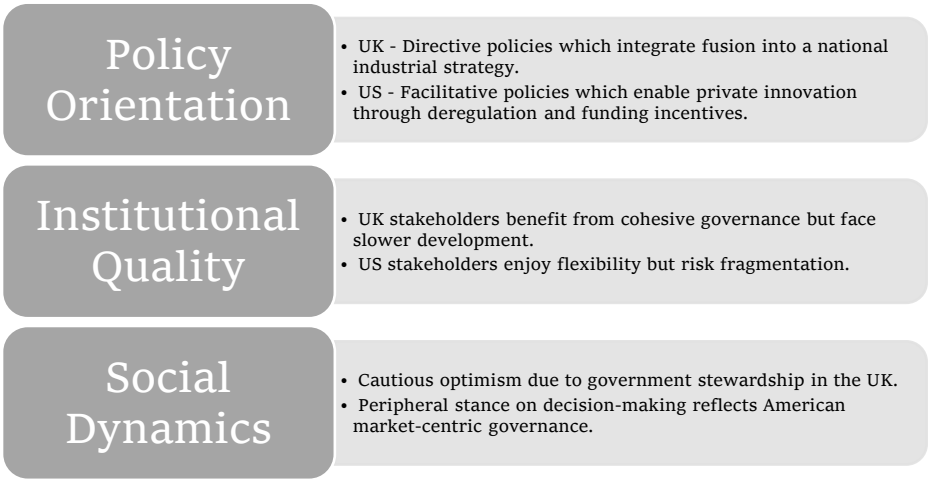


Figure 2: Comparative Stakeholder Synthesis.

Stakeholder	***Organisation***	***Code***
State Actors	*Department for Energy Security and Net Zero*	*UK1*
	Fusion Energy Advisory Committee	*US1*
	Gloucestershire County Council	*UK2*
	North Dakota Energy Office	*US2*
	Office of Fusion Energy Sciences	*US3*
	Stroud District Council	*UK3*
	UK Atomic Energy Authority	*UK4*
	UK Parliament	*UK5*
	US Fusion Outreach Team	*US4*
	US Congress	*US5*
Private Firms	*Commonwealth Fusion Systems*	*US6*
	First Light Fusion	*UK6*
	Tokamak Energy	*UK7*
	Xcimer Energy	*US7*
Academic Institutions	*Dalton Nuclear Institute*	*UK8*
	Fusion Centre for Doctoral Training	*UK9*
	Institute for Fusion Studies	*US8*
	Princeton Plasma Physics Laboratory	*US9*
Non-Governmental Organisations	*British-American Security Information Council*	*UK10*
	Campaign for Nuclear Disarmament	*UK11*
	Clean Air Task Force	*US10*
	Energy for the Common Good	*US11*

Table 1: Interview Participants and Coding Schemes.