

Revisiting the Energy Quadrilemma: Balancing Revisiting the Energy Quadrilemma:
Institutional Competition, Defence Priorities, and the Political Economy of Energy Transitions

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Introduction:

The global shift towards net-zero greenhouse gas emissions has placed energy transitions at the centre of economic and industrial policy. Electricity systems, responsible for a large share of global emissions, are a primary focus of decarbonisation strategies, with renewable energy technologies—particularly offshore wind—playing a central role. While the environmental rationale for renewables is well established, recent policy discourse increasingly frames the energy transition as an opportunity for economic development, job creation, and industrial renewal. This expansion of objectives moves energy policy beyond the traditional “energy trilemma” of sustainability, security, and affordability, towards an “energy quadrilemma” that explicitly incorporates economic development.

However, the assumption that green investment automatically delivers broad-based economic gains is increasingly contested. The realised economic benefits of renewable energy deployment depend not only on technology choice and investment scale, but also on institutional structures, industrial capacity, and competing policy priorities. This paper argues that the economic pillar of the energy quadrilemma is highly contingent on governance alignment and supply-side conditions—factors that are often overlooked in both academic modelling and policy appraisal.

The paper contributes to the literature by operationalising the energy quadrilemma within an economy-wide modelling framework that explicitly accounts for institutional competition over scarce industrial capacity. Using offshore wind development in Northern Ireland as a case study, it demonstrates how competing government objectives—specifically national defence procurement—can significantly constrain the economic benefits of the green transition at the regional level.

Conceptual framing: from trilemma to quadrilemma

Energy policy has traditionally been analysed through the lens of the energy trilemma, which emphasises trade-offs between security of supply, environmental sustainability, and affordability. While this framework remains useful, it is increasingly incomplete. Governments now explicitly justify renewable energy investments on the basis of their contribution to economic growth, regional development, and industrial strategy. Offshore wind, in particular, is promoted as a source of high-value manufacturing, skilled employment, and export potential.

Yet the economic dimension of the quadrilemma is often treated rhetorically rather than analytically. Many impact assessments focus on gross economic effects and implicitly assume that supply chains can expand elastically to meet new demand. In practice, industrial capacity is limited, geographically concentrated, and subject to competing claims from other policy domains. Where labour, facilities, or capital are scarce, green investment may crowd out other activities—or itself be crowded out by higher-priority objectives.

This paper advances the energy quadrilemma literature by embedding these institutional and supply-side constraints directly into an economy-wide analytical framework, allowing trade-offs between policy objectives to be quantified rather than assumed away.

Why Northern Ireland and offshore wind?

Northern Ireland provides a particularly revealing case study. The region has committed to ambitious climate and energy targets, including the deployment of 1 GW of offshore wind capacity by 2030 as part of its pathway to net zero. Offshore wind is attractive not only because of the region's strong wind resource, but also due to its historical strengths in marine engineering and heavy fabrication. These capabilities position Northern Ireland to capture economic value from offshore wind supply chains, particularly in the fabrication of fixed-bottom foundations.

At the same time, Northern Ireland's institutional context creates potential tensions. Energy and economic development are devolved responsibilities, while defence procurement remains a reserved power of the UK government. In recent years, heightened geopolitical tensions have led to increased defence spending, including the commissioning of three Royal Navy vessels to be built at Harland & Wolff's Belfast shipyard—the same facility identified as central to offshore wind foundation manufacturing.

This overlap creates a clear case of institutional competition: the same workforce, facilities, and industrial capabilities are required to deliver both defence and renewable energy objectives. The Northern Ireland case therefore illustrates a broader issue faced by many small or specialised regional economies, where limited industrial capacity must be allocated across multiple strategic priorities.

Modelling approach

The paper employs a Computable General Equilibrium (CGE) model of the Northern Ireland economy to assess how these competing priorities affect the realised economic impacts of offshore wind investment. The model is not used as a forecasting tool, but as a policy analysis framework designed to reveal opportunity costs, crowding-out effects, and economy-wide interactions that are not captured by partial-equilibrium or input–output approaches.

The CGE model is calibrated to a multi-sector Social Accounting Matrix for Northern Ireland and captures interactions between households, firms, government, and external trade. Crucially, it allows supply-side constraints—such as limited industrial capacity and labour availability—to

influence economic outcomes. All simulations are conducted in deviation-from-baseline form, focusing on structural impacts rather than absolute forecasts.

Two stylised scenarios are simulated over the period 2023–2032, corresponding to the construction phase of a 1 GW offshore wind programme and the expected completion of the defence contracts. The scenarios are designed as analytical boundary cases to isolate the economic significance of institutional alignment.

Scenario design

Scenario 1: Unconstrained (upper-bound) case

The first scenario represents an optimistic case in which Northern Ireland is able to capture the maximum feasible share of offshore wind investment. It assumes that domestic industrial capacity—particularly at Harland & Wolff—is fully available for the fabrication of fixed-bottom offshore wind foundations. Based on existing supply-chain assessments, total local content is estimated at approximately 27% of total project expenditure. This includes foundation manufacturing, onshore construction, electrical works, and professional services.

Scenario 2: Capacity-constrained case

The second scenario introduces a key institutional constraint: Harland & Wolff's fabrication capacity is assumed to be fully occupied by Royal Navy shipbuilding contracts throughout the period. As a result, offshore wind foundations must be imported, reducing the local content share to around 17%. All other aspects of the investment profile remain unchanged, allowing the analysis to isolate the economic impact of losing access to a single, high-value segment of the supply chain.

Results

The modelling results show that offshore wind development generates positive economic impacts in both scenarios, but that the scale of these benefits is highly sensitive to industrial capacity constraints.

In the unconstrained scenario, the 1 GW offshore wind programme generates approximately **£285 million in Gross Value Added (GVA)** and **2,630 person-years of employment** over the period to 2032. Economic activity is concentrated in the late construction phase, with strong impacts in manufacturing, construction, and professional services. These direct effects spill over into the wider economy through indirect and induced channels, supporting additional employment in retail, transport, and other service sectors.

In the capacity-constrained scenario, economic impacts are substantially reduced. GVA falls to approximately **£135 million**, while employment declines to **1,110 person-years**—representing reductions of over 50% relative to the unconstrained case. The largest losses occur in manufacturing and construction, reflecting the absence of domestic foundation fabrication.

While the timing of impacts is similar across scenarios, the magnitude and breadth of spillovers are significantly diminished when local industrial participation is limited.

These results demonstrate that the economic pillar of the energy quadrilemma is not guaranteed by renewable deployment alone. Instead, it is contingent on the alignment of energy policy with industrial and institutional realities.

Policy implications

The findings have several important implications for energy and industrial policy.

First, they challenge overly optimistic narratives around green growth. Gross impact assessments that ignore supply-side constraints may substantially overstate the economic benefits of renewable energy investment, particularly in small or specialised economies.

Second, the results highlight the importance of cross-government coordination. In Northern Ireland, devolved energy ambitions are undermined by reserved defence decisions that divert critical industrial capacity. Similar tensions are likely to arise in other regions where defence, infrastructure, or export manufacturing compete with green supply chains.

Third, the analysis underscores the value of economy-wide modelling frameworks for policy design. By explicitly capturing opportunity costs and institutional competition, CGE models provide insights that are not available from conventional appraisal techniques.

Finally, the paper suggests that realising the economic promise of the green transition requires proactive capacity planning. This may involve sequencing investments, expanding workforce skills, upgrading infrastructure, or developing parallel facilities to avoid zero-sum trade-offs between policy objectives.

Conclusion

This paper reframes the energy quadrilemma as a governance and capacity challenge rather than a purely technological one. Using a CGE model of Northern Ireland, it shows that competing government priorities can materially constrain the economic benefits of renewable energy deployment, even when environmental targets are met. More broadly, it argues that the success of green transitions depends on institutional alignment across policy domains. Without such coordination, the economic promises of the energy transition risk being systematically overstated in both academic research and policy discourse.