

Title

## **Towards Just Hydrogen Transitions? A Critical Energy Justice Appraisal of Italy's National Hydrogen Strategy**

Purpose of the study

Hydrogen now sits at the centre of Europe's decarbonisation agenda, framed simultaneously as a remedy for hard to abate sectors, an engine of industrial renewal and a geopolitical hedge. Italy's Strategia Nazionale H2 (SNI, Rome, 26 November 2024) follows this approach by projecting an expansion of hydrogen use from today's 1.5 Mtep, used almost exclusively in industry, to 1.7 Mtep in 2030, and to a wide 2050 range between 6 and 12 Mtep driven by industry and especially transport. The SNI explicitly contrasts alternative long run supply configurations that differ in their reliance on imports, comparing a 2050 "domestic production prevalence" case (70% domestic, 30% import) with an "import prevalence" case (20% domestic, 80% import). These cases are not a purely technical detail: they imply sharply different requirements for electrolyzers, renewables build out and investment volumes, and therefore potentially very different regional development footprints.

Yet, as is common in techno economic roadmaps, the strategy is much less explicit on how costs, benefits and decision making power will be distributed across territories and social groups, and on which safeguards should ensure social legitimacy in places that will host new infrastructure. Building on the energy justice literature (Jenkins et al., 2016; Heffron and McCauley, 2017) and on the philosophical critique of equality by Pellegrini Masini, Pirni and Maran (2020), this paper offers a justice oriented assessment of Italy's hydrogen transition. It asks whose decarbonisation is prioritised, who pays, who decides, and whose identities and vulnerabilities are recognised. It also speaks to a core regional studies concern: whether the emerging "hydrogen geography" reinforces Italy's longstanding territorial dualisms, including the North South divide and the gap between dynamic industrial corridors and peripheral inner areas, or whether hydrogen policy can be designed to support more balanced and inclusive regional development.

Methods and methodologies

The analysis employs the canonical energy justice triad of distributional, procedural and recognitional justice, enriched by the distinction between equality as capabilities and equality as power. This implies examining not only where material benefits and burdens land, but also whether governance arrangements enable different actors and territories to shape outcomes, contest decisions and claim redress.

Empirically, the study combines a systematic qualitative content analysis of the SNI with a focused reading of key implementing instruments that shape the early territorialisation of hydrogen in Italy through the PNRR, particularly Mission 2, Component 2, Investments 3.1 (hydrogen production in industrial brownfield areas, often framed as hydrogen valleys) and 3.2 (hydrogen use in hard to abate sectors). The core legal architecture for these investments is provided by the Ministero della Transizione Ecologica decree of 21 October 2022 (published in Gazzetta Ufficiale on 2 December 2022), which defines eligibility conditions, governance roles and implementation arrangements for both investments. In addition, subsequent acts allocate and operationalise resources for flagship projects connected to Investment 3.1, including the 18 November 2024 decree assigning resources for "progetti bandiera" linked to the brownfield hydrogen investment.

The policy analysis is paired with a spatially explicit regional assessment that relates hydrogen deployment logics to pre existing territorial divides and socio economic vulnerability patterns. This component draws on official statistics on energy poverty and deprivation risk, together with indicators of regional economic structure and industrial specialisation. The objective is not to predict exact project locations ex ante, but to identify where the SNI's own infrastructure and demand logic makes

territorial concentration more likely, and which regions and social groups may be most exposed to transition costs or most likely to be excluded from benefits. In line with regional studies approaches to energy vulnerability, the analysis treats the energy transition as a socio spatial process where infrastructure corridors, industrial clusters, port gateways and administrative capacities shape who wins and who loses over time.

#### Observed results

Three findings stand out.

First, distributionally, the SNI's demand narrative remains overwhelmingly oriented toward industrial and transport decarbonisation. The strategy states that Italy consumes 1.5 Mtep of hydrogen today and that it is used almost exclusively, around 99%, in industry, primarily refining and chemicals (ammonia and fertilisers). By 2030 the demand is projected to reach 1.7 Mtep, with roughly half expected to be met by green hydrogen (0.72 Mtep), while blue hydrogen is described as negligible in that time frame. By 2050, the SNI links the 6 to 12 Mtep consumption range to greater diffusion of hydrogen technologies in industry and especially in transport. This framing implies that the most immediate decarbonisation and competitiveness benefits accrue to large industrial and logistics systems rather than to households, raising an equity question that is central for regional studies: how transition gains diffuse beyond incumbent clusters, and whether the social contract of decarbonisation holds when household facing benefits are indirect while public support may be direct and concentrated.

The strategy's own supply "limit cases" further sharpen the distributive issue by making the territorial implications of policy choices visible. Under the domestic production prevalence case, the SNI estimates that supplying a 6 to 12 Mtep demand range implies 15 to 30 GW of electrolyzers (assuming a 40% load factor) and 45 to 90 GW of renewables to power them, with corresponding investment ranges of 8 to 16 billion euros for electrolyzers and 35 to 70 billion euros for renewables. Under the import prevalence case, the implied domestic electrolysis scale is much smaller, 4 to 9 GW of electrolyzers and 13 to 26 GW of renewables, with lower investment ranges. In other words, the choice between "make" and "buy" is also a choice about where land use pressures, permitting conflicts, grid reinforcements, supply chain jobs and public support streams will concentrate. In a country with deep regional asymmetries, this becomes a distributional justice question in territorial form. It also points to a political economy tension: import reliance may reduce domestic siting conflicts but can externalise socio environmental pressures to exporting regions, including North African contexts, while domestic production can raise local opposition unless benefits are credibly shared and governance is trusted.

A closely related distributional finding concerns gateways and corridors. The SNI assigns a strategic role to ports as entry points for hydrogen and derivatives, and explicitly positions the SouthH2 Corridor as a backbone that could make Italy a European hydrogen hub while connecting production centres and consumption poles at both national and European scales. This suggests that specific port regions and industrial corridors may gain disproportionate strategic relevance, with potential clustering of investment and political attention. In regional terms, the risk is a hydrogen transition that amplifies already strong regions and corridors, while lagging regions and inner areas remain peripheral unless deliberate equity triggers are built into implementation.

Second, procedurally, the SNI describes a stakeholder engagement timeline and anticipates an implementation and monitoring phase beginning in 2025. However, it provides limited detail on enforceable participation, transparency and accountability safeguards. This matters because the key implementing instruments for hydrogen valleys and hard to abate deployment rely on multi level governance arrangements and competitive selection mechanisms. The 21 October 2022 PNRR

implementing decree establishes the legal and administrative architecture for Investments 3.1 and 3.2, including roles for central ministries and territorial actors and the logic of support allocation. Subsequent acts earmark and operationalise resources for flagship hydrogen projects, including the 18 November 2024 decree on “progetti bandiera”, a move that signals a governance model where distributional outcomes depend strongly on administrative capacity, project development competence and the ability of regions and local systems to co finance, co plan and coordinate. From an energy justice lens, procedural equity is not only about formal consultation, but also about whether less resourced territories have the capacity to compete on equal footing, access information, shape project design, and negotiate compensations and co benefits.

Third, recognitionally, the SNI confirms a strategic preference for renewable hydrogen but explicitly retains technological openness. It states that the strategy aims to develop green hydrogen while also leveraging the potential of blue hydrogen with CCS and, prospectively, hydrogen obtained from nuclear sources, partly in the name of minimising costs and supporting market development. The strategy also notes that import from North African countries may contribute significantly to future cost reductions for hydrogen supply. However, vulnerable groups are not foregrounded. The narrative of cost reduction and early phase support does not explicitly connect hydrogen policy to energy poverty mitigation, nor does it specify how household facing distributional impacts will be monitored or addressed, even though literature on energy poverty and vulnerability shows that transition costs can become regressive when financed through non progressive mechanisms. This recognitional gap is particularly relevant given that, in the SNI, households are not the primary end users of hydrogen, yet households may still bear indirect costs through energy system charges, public budgets and local externalities in hosting territories.

#### Proposed innovations

The paper proposes four justice oriented innovations aimed at strengthening both social legitimacy and territorial inclusiveness, framed as design principles that can be embedded into implementing instruments rather than treated as optional add ons.

The first innovation concerns progressive cost recovery. Because early hydrogen markets require support schemes to close the cost gap between low carbon and fossil alternatives, the way public value is created and recycled matters for equity. The paper advances mechanisms that recycle a share of hydrogen policy value creation into targeted relief for vulnerable consumers and into building retrofit programmes, so that a transition whose direct benefits accrue to industry and heavy transport does not generate socially regressive spillovers. In practice, this implies designing support financing and certification related revenues so that they can fund social compensation and demand side vulnerability reduction, rather than relying predominantly on flat charges that disproportionately burden low income households.

The second innovation is a set of regional equity triggers for hydrogen valleys and related supply chain support. The core idea is to require that a minimum share of hydrogen valley and supply chain funding flows to lagging regions and inner areas, paired with measures that enable local SMEs and training ecosystems to participate in hydrogen value chains. This is not argued as an efficiency trade off, but as a legitimacy and resilience strategy: broader territorial diffusion can reduce political backlash, strengthen domestic supply chains and enlarge the constituency for decarbonisation. The innovation also addresses the procedural reality that competitive selection mechanisms tend to favour regions with higher administrative capacity unless corrective measures are put in place.

The third innovation targets procedural guarantees and accountability. The paper argues for transparent publication of tender documentation, clearer participation standards for affected territories, and an independent grievance and accountability function to arbitrate disputes and track

distributional outcomes across regions and groups. The goal is to ensure that procedural justice is not left to informal practices that vary by region, but is institutionalised in a way that supports consistent standards, especially where port gateways, storage sites and major corridors create localised risk perceptions and potential conflict.

The fourth innovation concerns explicit recognition clauses in public support schemes. The paper recommends requiring equity impact assessment and measurable social conditionalities as part of eligibility and contracting for subsidised projects, with particular attention to energy poor households, vulnerable workers in transition sectors, and territorially marginalised communities. Recognition is treated as a policy design requirement: if vulnerable groups are not named, measured and protected, they are unlikely to benefit from the transition and may bear disproportionate costs, undermining the just transition ethos.

#### Overall contribution

By embedding these measures in Italian hydrogen governance, policymakers could shift from a technocratic decarbonisation pathway toward a model that foregrounds social inclusion and balanced territorial development. Conceptually, the paper demonstrates how energy justice provides a disciplined lens for turning an apparently sectoral technology strategy into a set of testable claims about equality and power. Methodologically, it shows the value of combining policy text analysis with regional vulnerability evidence to audit justice dimensions of low carbon strategies that are often treated as purely industrial policy. Practically, it offers a roadmap for aligning hydrogen deployment with regional cohesion objectives and with distributional fairness, thereby reducing the risk that Europe's race to scale hydrogen reproduces existing territorial inequalities in new form.

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