The development of hydrogen projects included by Germany and Italy in their National Recovery and Resilience Plans: An Institutional Perspective[1]

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Abstract: Since Italy and Germany have found themselves in need of accelerating their low-carbon transition due to both countries' strong exposure to foreign energy suppliers, green hydrogen (produced from renewable energy sources) has come into play as a potential game-changer for the decarbonisation of their respective energy systems. Given the precedence accorded to the «green transition» in the National Recovery and Resilience Plans approved in 2021, both countries in their NRRPs have designed interventions to bolster the development of renewable hydrogen, mainly in the industrial and transport sectors. In analyzing the implementation status along with the «milestones» and «targets» set by the German and Italian national plans, it is important to address both the institutional aspects and the socio-economic constraints that these two EU Member States have been facing in realizing planned investments. The latter, indeed, cannot rely on conventional governance with short-term goals, but must involve a real transition management, in order to overcome already established practices, that keep institutions and other relevant actors entangled in path-dependent choices. This concept is intertwined with policy legacies that - especially when dealing with energy and environmental policies - have kept countries locked in fossil fuel-based energy systems. Considering that projects included in the NRRPs are also the result of negotiations with the European Commission, it is essential to evaluate inter-institutional coordination between the supranational and the national levels, as well as subsequent steps taken by Italy and Germany to develop a hydrogen roadmap for their economies.

1. Introduction

The thrust of this essay is to address the extent to which the adoption and implementation of the National Recovery and Resilience Plans (NRRPs) has been impacting the development of hydrogen (H_2) for the energy transition in Italy and Germany. Since the switchover towards a low-carbon economy can be considered a form of socio-technical transition (Andrews-Speed, 2016), the latter involves profound changes in the institutions that govern society. The pace and nature of these changes do not only depend on the objectives set, but they are also determined by «policy legacies», that actively generate institutional routines and procedures that force decision-making in particular directions, by eliminating or distorting the range of policy options available (Pierson, 2000). In order to grasp the importance of hydrogen for decarbonizing the European Union's (EU) economy and establish whether or not the German and Italian NRRPs represent a one-time window of opportunity for bolstering the energy transition, it is essential to explain the choice of such a policy scenario, considering both the supranational and the national policy-making levels.

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First, it should be pointed out that hydrogen does not constitute an entirely new and groundbreaking factor, as it has been used in several industrial sectors, mainly to produce chemical products, such as plastics and fertilizers. Around 96% of its production is through natural gas[2], resulting in significant amounts of CO_2 emissions[3]. It is this latter element that has moved substantial attention towards green hydrogen[4], since it is relatively easy to produce, and its life-cycle (well-to-gate) greenhouse gas emissions are almost equal to zero. The objective of drastically reducing the production costs of green hydrogen, thereby making it competitive with grey H_2, lies at the core of the «EU Hydrogen Strategy». This was launched by the European Commission in July 2020, with the aim of establishing «a liquid and well-functioning hydrogen market». «Renewable hydrogen is the most compatible option with the EU's climate neutrality and its zero pollution goal in the long term and the most coherent with an integrated energy system» (European Commission, 2020). Being intrinsically sustainable, green H_2 can be used as a secure energy carrier and can provide local energy storage in a decentralized way, thus improving resilience from imports.

As a result, it is evident that such a comprehensive strategy implies inter-institutional coordination between the EU and its Member States, and especially within each single member country. For this reason, this paper focuses its analysis on two different national contexts (Italy and Germany), that have found themselves in need of accelerating their low-carbon transition due to both countries' strong exposure to foreign energy suppliers. While Germany's production ambitions foresee 10 Gigawatts (GW) of green hydrogen by 2030, Italy's target totals 5 GW of both blue[5] and green H_2 (Rademacher, 2022). The nature and impact of these goals will be evaluated alongside the above mentioned EU's strategy, which includes *inter alia* three different and progressive stages: the first to be completed by 2024, then between 2024 and 2030 and finally between 2030 and 2050.

Given that the transition to a new socio-technical regime will take several decades, governments need to develop a long-term vision for an imagined future 25 years or more ahead. This can act as a guide for formulating policy options and setting interim objectives (Andrews-Speed, 2016). After presenting the essential lines of action foreseen by the two countries' NRRPs, this essay will attempt to provide an institutionalist perspective of the H_2 and low-carbon transition, by building on the assumption that institutions (both at the supranational and national level) can provide incentives and rules that fulfill a vital role in lowering

[2] This is the prevailing, existing hydrogen production method, whereby so-called 'grey' H_2 is produced by stripping it from methane using steam methane reformation (SMR), involving high greenhouse gas (GHG) emission levels (IEA, 2019).

[3] See: https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en

[4] The 'colour' depends on how H_2 is produced, and whether residual emissions are captured (Rademacher, 2022): green hydrogen can be understood as that produced through water electrolysis using electricity from renewable sources, and its GHG emissions are close to zero (IEA, 2019).

[5] Blue H_2 is a sub-category of fossil-based (grey) hydrogen, but unlike the latter, it uses Carbon Capture and Storage (CCS) to capture up to 90% of emissions generated during its production (IEA, 2019).

transaction costs and creating order (Andrews-Speed, 2016). Since such an approach can be traced back to rational-choice institutionalism, the final part of this essay will assess the connection between the NRRPs and the green transition agendas that Germany and Italy have been pursuing.

2. Hydrogen investments in the German RRP

The first pillar of Chapter 1 (Climate policy and energy transition) of the German RRP underlines the paramount role of hydrogen for the country's low-carbon transition. Together with climate-friendly mobility (pillar 2) and climate-friendly construction and renovation (pillar 3), H_2 development through the GRRP is not only meant to achieve the energy and climate objectives in the long term, but it is also aimed at pursuing and supporting the goals of the National Hydrogen Strategy (NHS), which was adopted by the Federal Government on June 10, 2020 within the framework of the «Security of the energy supply» dimension of the National Energy and Climate Plan (NECP)[6]. The NHS includes both investments and a significant reform approach. As stated, several important components of the NHS are to be implemented through the GRRP, which is designed to be a strategic document focusing on more general and «lighthouse guiding» objectives over specific quantifiable targets (Kiefer, 2021). With almost €3.2 billion, the first pillar of the German RRP indeed allocates €700 million to pursue the energy supply objective of the NHS, encompassing the scaling up of renewable electricity availability for electrolysis, and realizing R&D in hydrogen to transform Germany into a lead market for H_2 technologies.

A linkage to the NHS can be also found in the second pillar of the GRRP (€6.6 billion). Focusing in this case on mobility, €230 million are earmarked for funding fuel cell applications in transport, accelerating market ramp-up for battery and hydrogen vehicles, establishing development and innovation programs to boost demand, and promoting the purchase of alternative vehicles in bus, rail and heavy commercial sectors (Kiefer, 2021). Another €75 million are allocated in pillar 2 to investment in the form of R&D for electric and hydrogen-based mobility and the related filling and charging infrastructure. As of early 2023, Germany counts around 95 H_2 refueling stations in operation - more than any other EU country - and another eight of them are currently in their execution and trial phases[7]. It is essential to underline that the structuring of the GRRP's decarbonization pillar has been influenced by the adoption - back in June 2020 - of the *Zukunftspaket* stimulus package. It included €7 billion for green hydrogen technology development under the above mentioned NHS, and around €2 billion to boost international partnerships in the hydrogen market[8]. Almost €500 million under

[6] Germany was one of the first countries worldwide to adopt a hydrogen strategy, even publishing it before the European Union.

[7] Italy has just one H_2 refuelling station currently in operation, located in Bolzano. See: https://h2.live/en/

[8] For the *Zukunftspaket* see: https://www.bmbf.de/bmbf/shareddocs/kurzmeldungen/de/zukunftspaket-fuer-das-innovationsland-deutschland.html

the GRRP are instead devoted to the energy infrastructure in pillar 1 under the «Funding program for decarbonization in industry».

Notwithstanding the institutional effort in bolstering Germany's H_2 value chain, the basic principles of market economy suggest that there cannot be a substantial increase in hydrogen supply without a decisive surge in demand. Current figures report that H_2 demand in Germany is around 57 terawatt hours (TWh) per year - used mainly for the chemical and petrochemical industry - which is a relatively low figure compared to the country's total power consumption: 504 TWh/year. The need for H_2 is nonetheless expected to rise in the coming years, until reaching 90-110 TWh in 2030 (Hydrogen-Central, 2022).

For this reason the German RRP also focuses on pursuing both European and global «hydrogen leadership» (Kiefer, 2021). To this end, a critical role is played by H_2 projects within the framework of the «Important Projects of Common European Interest» (IPCEI). These initiatives span the entire low-carbon hydrogen value chain (production, storage, transmission, distribution and industrial applications), and they must involve at least four EU member states (Rademacher, 2022). The core aspect of IPCEI is constituted by the possibility of granting state aid to these projects, being subject only to a simplified notification process to the European Commission. The GRRP has foreseen around €1.5 billion for the creation of a «core» of the future EU hydrogen network through the IPCEI projects. Back in July 2022, the EU Commission announced the approval of the first 41 «IPCEI Hydrogen» projects, including four interventions from Germany, which have been made eligible to receive state funding: 1) the «BoschPowerUnits» project of Bosch, researching stationary fuel cell systems based on solid oxide, 2) the «Sunfire1500» of Sunfire GmbH for producing alkaline and high-temperature electrolysers (the devices used to produce green H_2 from water), 3) the «Pegasus» project of Daimler Truck AG, aiming to use fuel cell-based tractor/trailer combination drivetrains to decarbonize cross-border freight transport by road, and 4) the «NextGen HD Stack» project of EKPO Fuel Cell Technologies, to develop the fuel cells[9]. Aside from the purely technical aspects of the latter subject, the IPCEI can be regarded as a valuable example of the role that institutions - and in this case the European Commission - play in lowering transaction costs by simplifying administrative and technical procedures to kick-start and implement projects aimed at realizing the low-carbon transition.

Before shifting the focus to the Italian scenario and its NRRP, it is important to highlight the role played by sub-national actors and institutions in pursuing the objectives set out in the German RRP with respect to hydrogen development. Given that the majority of the GRRP's measures are implemented and coordinated at the Federal level, there is no regular two-way interaction with the *Länder* (federated states) other than

[9] For the details of each project see: https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/07/20220715-european-commission-approves-41-large-scale-hydrogen-projects.html

consultation. But because *Länder* and *Kommunen* (municipalities) are essential players for directing investors and overcoming investment bottlenecks, several regional governments have drawn up hydrogen roadmap strategies. Furthermore, the northern coastal states of Bremen, Hamburg, Mecklenburg-Vorpommern, Niedersachsen and Schleswig-Holstein have created the «HY-5» green hydrogen alliance aiming to «make Northern Germany the strongest future region for green hydrogen in the heart of Europe and to develop and complete the value chain for green hydrogen»[10].

3. Hydrogen investments in the Italian RRP

Around €23.7 billion have been allocated to the second «component» of Mission 2 (Green revolution and ecological transition) of the Italian Recovery Plan, including €3.7 billion for investments in H_2 technology[11]. Component 2, labelled «Renewable energy, hydrogen, grid and sustainable mobility», foresees reforms and investments aimed at enhancing renewables penetration via decentralized and utility-scale solutions, and strengthening the grid to accommodate and synchronize the new renewable sources and decarbonize end uses. By examining the NRRP document, a focus on medium-to-large scale investments in the industrial sector can be observed. Within Component 2.3 (totaling €3.19 billion), €500 million (Investment 3.1) are allocated for the production of hydrogen in disused industrial areas and for establishing the so called «Hydrogen Valleys» (to be discussed in a separate paragraph due to their specificities), which are envisaged to produce 1-5 megawatts (MW) of H_2 per site. Hard-to-abate sectors (such as steel, glass, ceramics, paper etc.) constitute the primary destination for boosting hydrogen use, according to investment 3.2 (€2 billion) of the Italian plan, which foresees the achievement of significant «milestones» by June 2023, including the signing of agreements with project owners selected to promote the transition from methane to green hydrogen in industry[12].

Some important reforms concerning hydrogen legislation are also to be enacted by June 2023. The interventions, and specifically Reform 3.1 as reported in the NRRP, aim at further simplifying administrative procedures and reducing regulatory obstacles to H_2 nationwide dissemination. As to the reform's status in early 2023, simplifications for the construction and operation of electrolysers up to 10 MW of capacity have been introduced[13], as well as an action plan to initiate tests (in cooperation with the Italian gas transmission system operator SNAM) for amending the rules concerning hydrogen transport in the gas grid. More significantly, the

[10] See: https://www.hy-5.org/en/about-us/

[11] The green transition component of the Italian NRRP can be viewed here: https://www.italiadomani.gov.it/content/sogei-ng/it/it/il-piano/missioni-pnrr/rivoluzione-verde-transizione-ecologica.html

[12] Investment 3.2 regarding hard-to-abate sectors is a keystone for boosting hydrogen use in the Italian industrial system, and the target set by component 2 of Mission 2 of the *PNRR* foresees the introduction of H_2 into the industrial process of at least one industrial plant by 2026 to decarbonize the sector. For more see: https://www.italiadomani.gov.it/content/sogei-ng/it/it/Interventi/milestone-e-target.html

[13] Legislative decree n. 199/2021 «Attuazione della direttiva (UE) 2018/2001 del Parlamento europeo e del Consiglio, dell'11 dicembre 2018, sulla promozione dell'uso dell'energia da fonti rinnovabili. (21G00214)»

envisaged reforms include a system of certification of origin for renewable-based H_2, in order to give consumers reliable price signals. A further reform (Reform 3.2) concentrates instead on promoting the competitiveness of hydrogen, by providing fiscal incentives to support green H_2 production for the transport sector, thus implementing the EU's Renewable Energy Directive II (RED II)[14], whose revision was proposed by the Commission in July 2021[15].

In addition to such «top-down» measures, specific projects have been conceived in order to establish a new hydrogen market from the bottom up, involving economic and institutional actors at a sub-national level. The above-mentioned «Hydrogen Valleys» - i.e. regionally integrated hydrogen ecosystems - have been identified as stepping stones towards the hydrogen economy by making use of clean hydrogen to decarbonize hard-to-abate sectors (Weichenhain *et al.*, 2022). According to the Clean Hydrogen Partnership 2021 report[16], there are three main «archetypes» of H_2 valley: 1) local, small-scale and mobility-focused (green) hydrogen production projects serving mobility applications, usually involving dozens of local stakeholders and being led by public-private partnerships or regional public authorities; 2) locally integrated, medium-scale producers and consumers of hydrogen with a focus on industrial feedstock and 3) large-scale hydrogen production and international export focus. The Italian RRP envisages the creation of such hydrogen districts, in which this molecule can be both produced and used locally[17]. A governmental public notice addressed to the Italian Regions was published at the beginning of 2022[18] in order to invite the local authorities to submit an expression of interest to select proposals aimed at implementing this NRRP investment, realizing H_2 production facilities in disused industrial areas. After all Regions had expressed their interest to participate, a decree (published on 23rd December 2022)[19] was adopted to implement the previous ministerial decree of October 2022[20], to define the outline of the calls selecting project proposals for the fulfillment of investment 3.1 (H_2 valleys). This has been only a preparatory step towards the achievement of both a «milestone» in the first quarter of 2023, entailing the award of all public contracts for hydrogen production projects in disused industrial areas, and a key «target» in the second quarter of 2026, envisaging the completion of at least 10 hydrogen production projects.

[14] Directive 2018/2001/EU

[15] COM/2021/557 final

[16] Weichenhain, U., Kaufmann, M., Benz, A., and Gomez, G. M. (2021). Hydrogen valleys: Insights into the emerging hydrogen economies around the world. *Publications Office of the European Union.*

[17] Retrieved from: https://www.mase.gov.it/bandi/investimento-3-1-produzione-di-idrogeno-aree-industriali-dismesse-hydrogen-valleys

[18] *ibidem*

[19] Official Journal of the Italian Republic: https://www.gazzettaufficiale.it/eli/id/2023/01/02/22A07397/sg

[20] Official Journal of the Italian Republic: https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2022-12-02&atto.codiceRedazionale=22A06807&elenco30giorni=true

Another major target to be accomplished by 2026 is the construction of an industrial plant to produce 1-GW-capacity electrolysers, known as «Gigafactory» (MASE, 2022). A brief focus on this element establishes a further frame of reference for comparing Italy and Germany by looking at the IPCEI funding for hydrogen projects in the NRRPs. The «Gigafactory» has been declared eligible by the Commission for receiving funding under the «IPCEI H_2 Technology» project[21]. This includes six major Italian companies (Ansaldo, Fincantieri, Iveco Italia, Alstom Ferroviaria, Enel and De Nora in partnership with SNAM) and two research organisations (ENEA and Fondazione Bruno Kessler). From a total of around €1 billion destined to Italy for this first IPCEI hydrogen project (the second project approved by the Commission being the IPCEI «Hy2Use», does not include Germany[22]), the latest news reported that SNAM and De Nora will receive around €63 million for the «Gigafactory», which will be built near Milan (Hydronews, 2023a)[23].

Besides lowering political and economic transaction costs (as argued in Germany's section), IPCEI projects can be viewed as a particular form of «policy diffusion» mechanism. It allows innovations to spread from one government to another (Shipan and Volden 2008), particularly if one considers the intended outcome of the IPCEI projects both in Italy and Germany, which is the scaling-up of the hydrogen market through the production of electrolysers (the output) on a large scale. Within the four mechanisms of policy diffusion conceptualized by Shipan and Volden (2008) (learning from earlier adopters, economic competition, imitation and coercion), the approach adopted by the European Commission in approving and authorizing state aid for IPCEI projects can be seen as a «positive sanction» given to different EU Member States. In addition, the competition in the field of new low-carbon and hydrogen technologies emerging in Europe creates positive spillovers across national boundaries, thereby leading policy-makers of EU countries to consider the economic effects of making (or giving up) specific choices.

4. The institutional framework of the energy transition considering Italy's and Germany's NRRPs

The analysis carried out in the previous paragraphs would be incomplete without addressing the institutional aspects of the agents called upon to manage the hydrogen component of the NRRPs and their interactions with economic and social actors. Notwithstanding its federal structure, Germany's RRP is ultimately managed by the Federal Ministry of Finance, which is also the point of contact for EU institutions (DARP, 2021). By contrast, hydrogen investments of the Italian RRP have entailed close coordination among three key ministries: Environment and Energy Security (formerly «Ecological Transition Ministry»), Infrastructures and Transport, and the Economic Development Ministry (now referred to as «Ministry of Enterprises and Made in Italy»).

[21] Ministry of Enterprises and Made in Italy: https://www.mise.gov.it/it/incentivi/ipcei-idrogeno-1-h2-technology

[22] International Energy Agency: https://www.iea.org/policies/16988-approval-of-the-ipcei-project-hy2use

[23] On February 6, 2023, De Nora announced - together with SNAM - the joint purchase of a disused industrial area west of Milan to realize the «Italian Gigafactory» project (Hydronews, 2023b)

Hence, it can be argued for both cases that although energy systems consist of multiple and interconnected regulatory levels (Jehling et al., 2019), the national scale is the most relevant, since energy transitions can be linked clearly to a country's economy, regulations and infrastructure (Cherp et al., 2018).

A deeper look at the management of the H_2 NRRP investments in Italy provides a further analytical tool, which has been applied to a considerable amount of cases, in particular energy, environmental or social policy disputes, namely the advocacy coalition framework (Cerna, 2013). As stated by Geels (2011), the relevant components in the socio-technical regime are corporations, sectors, policymakers, consumers, technology, and culture, thus implying a high degree of potential conflicts in the objectives and also technical uncertainties. A recent case in point concerns the reaction of the Italian Hydrogen Association (H2IT) to the declarations of the Infrastructures and Transport minister on the potential revision of the hydrogen projects included in the Italian RRP (H2IT, 2023). The minister has indeed expressed the will to cancel the investments (around €300 million) foreseen for the realization of hydrogen filling stations on rail and road (Talignani, 2023), thus prompting the reaction of H2IT, which represents more than 100 large, medium and small enterprises, research centers and universities. The Italian association stressed the strategic importance of the hydrogen sector for private investments in companies, and especially for ensuring a leading position of Italy in the energy transition. Therefore, the existence of different perceptions of the problem at the various levels greatly depends on the interests of the different actors but also on their belief system (Sabatier, 1988).

A wide range of institutions play a role in determining the pace and direction of the low-carbon transition (Andrews-Speed, 2016), which may be held back if the combination of rules, paradigms, interests and infrastructures in a country support the existing regime, thus leading to path dependent policies (Geels, 2004). For the purpose of this paper, path-dependency may be regarded as the situation in which a country like Italy has been locked-in to fossil fuel-based energy systems (Unruh, 2000) for a long time, and the institutions' role in policy and investments tends to hinder rather than to encourage the transition to a low-carbon economy. Hence, this creates an «institutional lock-in» (Unruh, 2002), whereby the industry's priorities partly diverge from the government's investments policy which, in this Italian case, includes nearly €3.7 billion allocated by the NRRP to hydrogen development. It is important to recall that the projects included in the NRRP are also the result of negotiations with the European Commission, that has acted as a non-ideological and technologically neutral player in this respect.

5. Policy learning: the German and Italian National Hydrogen Strategies

Drawing from the analysis of the institutional dynamics concerning the management of the two NRRPs, one final aspect should be considered when dealing with hydrogen, namely the «National Hydrogen Strategy»

(NHS). This represents an important term of reference in assessing the development of H_2 investments on a national and comprehensive level. So far, however, considering Italy and Germany, only the latter adopted its NHS (in June 2020), linking it to its Recovery Plan. The Italian government, instead, has so far issued only the «Preliminary Guidelines on the National Strategy for the Development and Use of Hydrogen» (MISE, 2020), even though the detailed national strategy was to be published in 2021, which is still under development. Indeed, after having praised the hydrogen investments foreseen by the NRRP, the president of the Italian federation of energy business associations (Confindustria Energia) recently pointed to the lack of a «smart and inclusive» national H_2 strategy, which would help to support the initial higher cost of producing hydrogen (Hydronews, 2023c).

Together with that of France, Spain and the UK, the German NHS provides for a model from which to take a cue, even though when it comes to highly technical aspects such as energy systems, the physical and structural features of a country cannot be ignored. Nonetheless, in terms of the NHS's governance, which in most cases is the decisive factor in ensuring a smooth implementation of programs, Italy could adapt the German model to its institutional organization. Three bodies can be identified as the key actors in implementing the German NHS: the State Secretaries' Committee on Hydrogen, composed of relevant ministries, the National Hydrogen Council, consisting of 25 high-ranking experts in the fields of economy, science and civil society with an advisory capacity, and the Green Hydrogen Innovation Officer, from the Federal Ministry of Education and Research, with the task of supporting the other two bodies (Federal Ministry for Economic Affairs and Energy, 2020). Still, the final design of the Italian Hydrogen Strategy will depend on such technicalities, given also the recent above mentioned statements of some first-rank national politicians and decision-makers. Therefore, a «policy learning process» (Cerna, 2013) might not occur immediately, because it entails also a change in the system of beliefs (in this case concerning energy and hydrogen) of the governing coalition (Cerna, 2013).

6. Conclusion

In order to assess the magnitude that hydrogen investments in the German and Italian NRRPs have had on the energy transition in these two countries, this essay has attempted to combine a more technical - yet necessary - overview of the different projects with an array of consolidated theoretical concepts, related to institutional change. In particular, given the need to set medium-to-long term objectives so as to establish a full-fledged hydrogen market in Europe, all the investments foreseen by the NRRPs cannot rely on conventional governance with short-term goals, but must involve real transition management. The latter entails more or less radical changes in how the government (both at a national and local level) works, having to deal with forces that pull the decision-making process in opposite directions, due to already established practices.

The examination of the main economic and institutional actors involved in managing the hydrogen component of the NRRPs has demonstrated the complex interconnection between regulatory levels, due to the development of both «top-down» and «bottom up» projects (such as the Hydrogen Valleys in Italy), in which private actors act largely autonomously. This in turn implies the existence of potentially conflicting goals and technical uncertainties in implementing the projects and in achieving the pre-established «targets» by 2026. The possible hesitation or delays in realizing H_2 investments foreseen by the NRRPs can be thus linked to the persistence of path-dependent policies (particularly in Italy) that are due to the characteristics of the present energy system, which hydrogen should help to overcome. When considering the involvement of multi-level institutional actors in delivering the NRRPs, this essay has also stressed the importance of the IPCEI for hydrogen, which has been regarded both as a tool for lowering transaction costs (by the European Commission) and as a «policy diffusion» mechanism (between EU countries).

As a result of path-dependency and policy legacies that force decision-making in particular directions, the phenomenon that has been defined as «institutional lock-in» has assumed different speeds in Italy and Germany. This conclusion can be demonstrated by two elements: the share (not the absolute value) of NRRP resources and complementary funding that has been allocated to hydrogen and green energy development, and the formulation of a clearly defined strategy for expanding the hydrogen economy. Indeed, with a simple proportion, it can be seen that Italy allocated around 1.57% of its total NRRP resources to hydrogen, whereas Germany, despite having a much smaller amount of RRF resources, allocated roughly 11% of them to developing H_2 (only about €500 million less than Italy). However, the final and most important element to underline is the existence of a well-defined National Hydrogen Strategy in Germany, that has not only been introduced before its Italian counterpart (which has yet to be defined and adopted), but has also been linked to the German RRP so as to provide further funding and investment to pursue global hydrogen leadership.

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