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Marta Gandiglio * and Paolo Marocco

Department of Energy, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129 Turin, Italy; paolo.marocco@polito.it
* Correspondence: marta.gandiglio@polito.it

Abstract: The global momentum towards hydrogen has led to various initiatives aimed at harnessing hydrogen's potential. In particular, low-carbon hydrogen is recognized for its crucial role in reducing greenhouse gas emissions across hard-to-abate sectors such as steel, cement and heavy-duty transport. This study focuses on the presentation of all hydrogen-related financing initiatives in Italy, providing a comprehensive overview of the various activities and their geographical locations. The examined funding comes from the National Recovery and Resilience Plan (PNRR), from projects directly funded through the Important Projects of Common European Interest (IPCEI) and from several initiatives supported by private companies or other funding sources (hydrogen valleys). Specific calls for proposals within the PNRR initiative outline the allocation of funds, focusing on hydrogen production in brownfield areas (52 expected hydrogen production plants by 2026), hydrogen use in hard-to-abate sectors and the establishment of hydrogen refuelling stations for both road (48 refuelling stations by 2026) and railway transport (10 hydrogen-based railway lines). A detailed description of the funded initiatives (150 in total) is presented, encompassing their geographical location, typology and size (when available), as well as the funding they have received. This overview sheds light on regions prioritising decarbonisation efforts in heavy-duty transport, especially along cross-border commercial routes, as evident in northern Italy. Conversely, some regions concentrate more on local transport, typically buses, or on the industrial sector, primarily steel and chemical industries. Additionally, the study presents initiatives aimed at strengthening the national manufacturing capacity for hydrogen-related technologies, alongside new regulatory and incentive schemes for hydrogen. The ultimate goal of this analysis is to foster connections among existing and planned projects, stimulate new initiatives along the entire hydrogen value chain, raise an awareness of hydrogen among stakeholders and promote cooperation and international competitiveness.

Keywords: hydrogen; funding; decarbonisation; Italy; electrolyser; hydrogen refuelling station

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1. Introduction

Hydrogen is currently experiencing significant momentum, underscored by its recognition at COP28 in Paris in December 2023. For the first time, low-carbon hydrogen was acknowledged as a pivotal avenue to achieve GHG emissions reduction [1]. Hydrogen can in fact play a key role in the decarbonisation of hard-to-abate sectors such as steel, cement and chemical processes [2,3], as well as in heavy-duty transport (maritime, aviation and trucks) [4,5]. Additionally, hydrogen can serve as a long-term energy storage solution in scenarios with a high share of renewable energy sources (RES) [6,7].

1.1. European Initiatives

With the publication of the REPowerEU plan in 2022, the European Commission implemented the EU hydrogen strategy to further increase ambitions for renewable hydrogen as an important energy carrier to diminish dependence on fossil fuel imports [8]. In 2023, the definition of low-carbon hydrogen was also formalised. Specifically, to guarantee

production from renewable energy sources, low-carbon hydrogen must achieve at least 70% greenhouse gas emissions saving [9]. The Hydrogen Bank was also created: a financing instrument to accelerate the establishment of a full hydrogen value chain in Europe [10].

1.2. National Initiatives across Europe

In alignment with the EU's efforts, dedicated funding initiatives for hydrogen have been implemented across Europe in the last 3–4 years, driven by national hydrogen strategies developed in multiple countries [11]. These strategies typically establish goals for installed electrolyser capacity and/or hydrogen utilisation in final end-uses, targeting achievements by 2030 [12,13]. Some countries are aiming for an installed electrolyser capacity in the MW range by 2030. For example, Belgium's federal hydrogen strategy aims to install 150 MW of electrolyser capacity by 2026, while Croatia and Estonia target capacities of 70 MW and 150 MW, respectively, by 2030. More ambitious targets are evident in other countries, such as Denmark's strategy for power-to-X, which aims to achieve 4.7 GW of electrolyser capacity installed by 2030. France and Germany also plan to achieve high capacities, totalling 6.5 and 5 GW, respectively, by 2030. Similar targets for 2030 have been set by the Netherlands (6–8 GW), Spain (4 GW) and Sweden (3 GW). Italy, with a 5 GW target for 2030, can be classified among the high-ambition countries in Europe.

These initiatives are designed to support the large-scale production of hydrogen-related technologies, encompassing electrolysers, storage solutions and various end-use appliances such as fuel cells, engines, burners and vehicles. The primary objective is to lower final hydrogen production cost, enhancing its competitiveness compared to the fossil-based alternatives. According to the 2023 Clean Hydrogen Monitor [14], the number of power-to-hydrogen (PtH) projects planned to be operational by 2030 increased from 628 in 2022 to 813 in 2023 across all stages of development, from concepts to projects under construction.

1.3. Italian Initiatives

The Italian Ministry of Economic Development published, in 2020, the "National Hydrogen Strategy-Preliminary Guidelines" document [15] which, along with the Integrated National Plan for Energy and Climate (PNIEC, released in 2023) [16], constitutes the primary reference for Italy's long-term hydrogen strategy. As of now, no official hydrogen strategy has been formally published. The preliminary guidelines outlined in the national hydrogen strategy [15] establish the vision and targets for hydrogen penetration toward a decarbonised and sustainable economy. By 2030, the ambition is to achieve a 2% hydrogen penetration in final energy demand. This demand is expected to include heavy-duty road transport, industrial applications (chemical industry and refineries), and blending into the gas network. Meeting this demand will require an installed electrolyser capacity of 5 GW, corresponding to approximatively 0.7 Mt/y of hydrogen production. A second target is set for 2050, aiming for up to 20% hydrogen penetration across various sectors including also maritime and aviation transport, the steel industry, long-term energy storage and building applications. According to the 2023 Integrated National Plan for Energy and Climate [16], Italy's demand for low-carbon hydrogen, which stood at 0% (expressed with respect to the total hydrogen demand) in 2021, is projected to reach 42% in the policy scenario. The latter accounts for all of the available policies as of June 2023, i.e., mainly the PNRR funding initiatives explored in this work. The 42% target aligns with the objectives set at the EU level by the FitFor55 and REPowerEU plans. In 2030, the estimated hydrogen demand is 0.251 Mt, comprising 0.115 Mt for industry and 0.136 Mt for transport (of which 0.010 Mt is for aviation and maritime sectors).

1.4. Aim of the Study

Within this context, the current study aims to delineate the hydrogen funding initiatives and anticipated projects in Italy. Although a considerable number of funding initiatives have been introduced both at the regional and national level during 2022 and

2023, a comprehensive overview of these initiatives is presently lacking. Thus, the present work seeks to provide clarity on the location and nature of the numerous planned hydrogen projects, spanning from hydrogen production sites, hydrogen refuelling stations (for road and railway transport), as well as hydrogen valleys and hubs. This overall picture, based on more than 150 funded initiatives, is intended to assist industries, authorities and decision makers in strengthening existing and expected hydrogen projects, while also fostering the development of new ones. The ultimate goal is to promote cooperation on hydrogen projects and strengthen international competitiveness.

The hydrogen-related initiatives in Italy can be categorised into three main areas: firstly, the national and regional calls for projects issued as part of the National Recovery and Resilience Plan (PNRR); secondly, projects directly funded through the IPCEI (Important Projects of Common European Interest); and finally, a variety of other initiatives that may receive funding from private companies, the Clean Hydrogen Partnership or other funding sources. These three initiatives are discussed in Sections 2–4, respectively.

2. National Funding Scheme (PNRR)

The National Recovery and Resilience Plan (PNRR) is the large group of funding received by Italy from Europe through the Next Generation EU programme. The PNRR programme has a duration of 6 years, from 2021 to 2026 and a total funding of EUR 222.1 billion [17]. One of the six missions of the programme (mission two, about EUR 68.6 billion) is dedicated to the energy transition and to fighting climate change. Within this mission, different objectives are set, one of which is to "*Promote the production, distribution and end-uses of hydrogen*" (mission 2, objective 2, topic 3, also referred to as M2C2M3) [18]. This funding is in line with the European hydrogen strategy, which foresees a strong growth of green hydrogen in the energy mix. The aim is to support a progressive decarbonisation of those sectors in which alternative solutions are less competitive or even absent. The European hydrogen strategy envisages an increase in hydrogen contribution in the energy mix of up to approximately 14% by 2050, with a European target of around 40 GW of installed capacity for electrolysers dedicated to green hydrogen production.

Italy, in line with the European hydrogen strategy, intends to promote the production and use of hydrogen, in particular through the PNRR funding scheme. In this context, the development of flagship projects for the use of hydrogen in industrial hard-to-abate sectors is expected. The funding also intends to encourage the creation of hydrogen supply chains (referred to as "*hydrogen valleys*" in the funding scheme), particularly leveraging areas with abandoned industrial sites (brownfield sites). The use of hydrogen in heavy transport and on non-electrifiable railway routes will be pursued through the installation of hydrogen refuelling stations (HRSs) along the main commercial routes. Finally, the funding scheme aims to support research and development while establishing the necessary regulatory framework to facilitate the use, transport and distribution of hydrogen.

The total funding devoted to hydrogen development has been divided into specific calls for proposals as outlined in Table 1. Additionally, a graphical representation is provided in Figure 1.

The largest and widest number of initiatives is contained within Topic 3 of the funding scheme, aimed to promote the production, distribution and use of hydrogen. Furthermore, a dedicated funding scheme (Topic 5.2) has also been devoted to the creation of an industrial value chain, with the goal of building one or more electrolyser production plants. Finally, hydrogen is also mentioned in Topic 4 (aimed to develop more sustainable local transport), which is anyway mostly focused on the electrification of road transport employing batteries [19].

As shown in Table 1, some calls have already been assigned in 2022 and 2023, while others are still waiting for results to be published. The deadline for all initiatives involved in the PNRR is the same: the construction and start-up for all plants should be finalised by June 2026. The following sections will analyse in detail the funding typology and the planned installations.

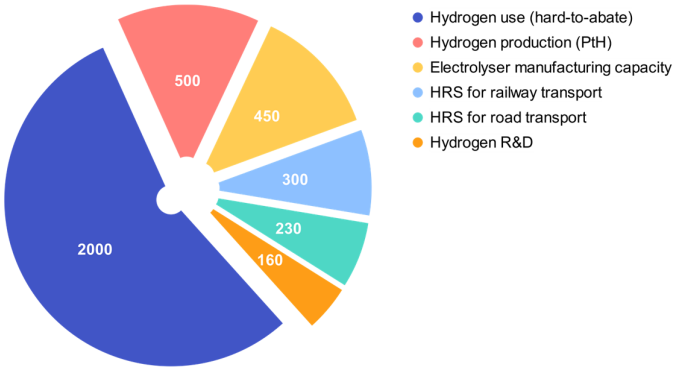

Figure 1. Hydrogen-related PNRR funding initiatives by topic. The numbers are expressed in million euros (M EUR).

Table 1. PNRR funding initiatives devoted to hydrogen [18]. The term n.a. (not available) refers to the topics for which results on the funded initiatives are not yet available as of April 2024.

Topic	Funding [M EUR]	Call	Grant
3. Promote the production, distribution and use of hydrogen			
3.1 Hydrogen production in brownfield areas [20]	500	January–February 2023	April–September 2023
3.2 Hydrogen use in hard-to-abate sectors [21]	2000	March–June 2023	n.a.
3.3 Hydrogen refuelling stations for road transport	230	November 2022	March 2023
3.4 Hydrogen refuelling stations for railway transport	300	July–November 2022	April 2023
3.5 Research and development	160	March 2022	June 2022
5. Support to industrial value chain			
5.2 Support to the installation of electrolysers and fuel cells	450	April 2022	April 2022

2.1. Hydrogen Production in Brownfield Areas (Power-to-Hydrogen Projects)

This investment (Topic 3.1, Table 1) aims to support the production and local utilisation of green hydrogen in industry (especially in small- and medium-sized enterprises), as well as in local transportation, thereby promoting the establishment of new hydrogen valleys. The measure seeks to reconvert brownfield industrial areas into innovative hubs where hydrogen is generated from local renewable resources. Grid electricity can also be employed for the production of green hydrogen. The total funding (EUR 500 M) is allocated across two lines of activities: EUR 450 M was distributed among the regions for implementing the projects, while EUR 50 M was designated for flagship projects [20]. The objective is to finalise at least 10 projects for hydrogen production in brownfield areas, with a total installed capacity (electrolyser size) ranging from 10 to 50 MW. The call for proposals was initiated in December 2022 in all Italian regions, and the results regarding funded projects and their respective locations were published between the spring and summer of 2023 (depending on the region).

By analysing the results of the call for proposal, it is possible to identify the locations of the hydrogen hubs (here referred to as PtH projects) and the type of installation, where such information is available. Figure 2 illustrates the distribution of the funding across the different Italian regions (indicated by the colormap) and highlights the locations of the funded projects (depicted as white dots). The complete list of these projects, including details on hydrogen end-uses and plant sizes, can be found in the Supplementary Materials. For the sake of clarity, a map of Italy with the names of the regions is provided in the Appendix A. Most of the funds were allocated to southern Italy (EUR 40 M to Sicilia, Puglia and Campania) followed by the northern regions (EUR 33.5 M to Lombardia). The average funding per region amounts to EUR 22.5 M, with a range spanning from EUR 14 to 40 M. In some regions—such as Emilia Romagna, Friuli Venezia-Giulia, Umbria and Veneto—only

one large project was financed. In other regions, four to five projects were funded, with each project receiving a smaller funding allocation. The extent of project funding can vary based on the project evaluation, with only some projects receiving complete funding coverage (100%).

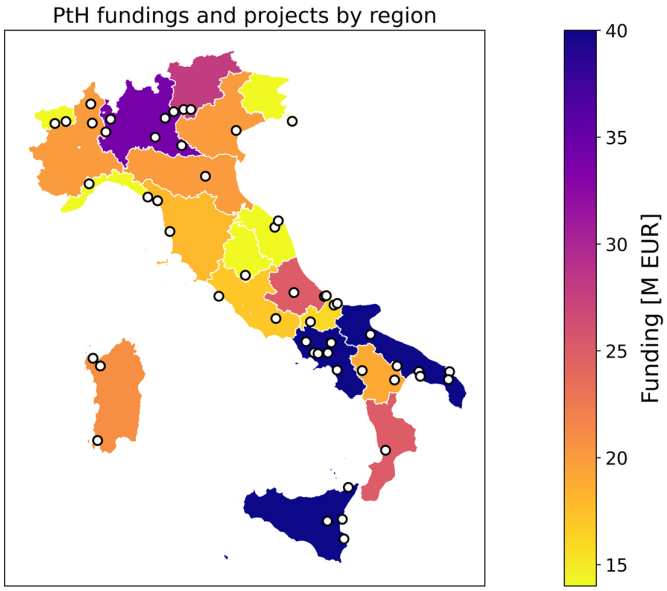

Figure 2. Hydrogen production in brownfield areas: funding available per region and locations of the PtH plants (white dots). Additional details are available in the Supplementary Materials (Table S1).

The funding will enable the installation of 52 hydrogen production plants across Italy. As depicted in the Supplementary Materials (Table S1), 21 plants will produce low-carbon hydrogen for industrial purposes, with a focus on hard-to-abate industries (such as refineries, steel, glass, paper and chemicals). Moreover, 10 projects involve transport applications as an end-use, either solely or in combination with industrial applications. Additionally, there are 21 plants for which no information can be found so far.

2.2. Hydrogen Use in Hard-to-Abate Sectors

This investment (Topic 3.2, Table 1) aims to promote research, development and innovation in the field of industrial processes. The goal is to foster the use of hydrogen in industrial applications that, as an example, currently rely on methane as a source of thermal energy (such as cement, paper mills, ceramics, glass industries, etc.). The production of low-carbon hydrogen from renewable energy sources in accordance with Directive (EU) 2018/2001 or grid electricity is also supported within this funding. The selected projects are expected to design an industrial prototype that uses hydrogen and subsequently proceed to the construction and testing of that prototype [21]. The funding was issued (with a call for proposals) between March and June 2023, but the results are not yet available in April 2024. The call for proposals had a minimum funding request of EUR 0.5 M per project and an overall budget availability of EUR 1000 M (50% of the total funding available within this topic). Ninety percent of this funding is devoted to projects capable of replacing more than 90% of fossil fuels compared to the reference configuration. The remaining available funding should be devoted to the decarbonisation of a large steel production plant in the South of Italy through the direct reduction of iron (DRI) [22].

2.3. Hydrogen Refuelling Stations for Road Transport

The call for proposals for road hydrogen refuelling stations (Topic 3.3, Table 1) aims to install at least 40 HRSs by 2026 (EUR 230 M) along the road network [23]. About EUR 103.5 M for HRSs (36 projects) was allocated in the first call for projects in March 2023. The second call for projects was published in July 2023 and funded the other 12 HRSs. The

48 HRSs, shown in Figure 3, will be strategically positioned, especially for heavy-duty transport, with the goal of decarbonising connections to northern countries (such as the Brennero connection towards Munich, Germany), as well as western–eastern corridors and trans-European routes. This is visible also from the fact that 77% of the EUR 103.5 M is invested in northern countries. The detailed list of HRSs per region is available in the Supplementary Materials (Table S2). Currently, in Italy, only two other HRSs are available and in operation, located in Bolzano and Mestre.

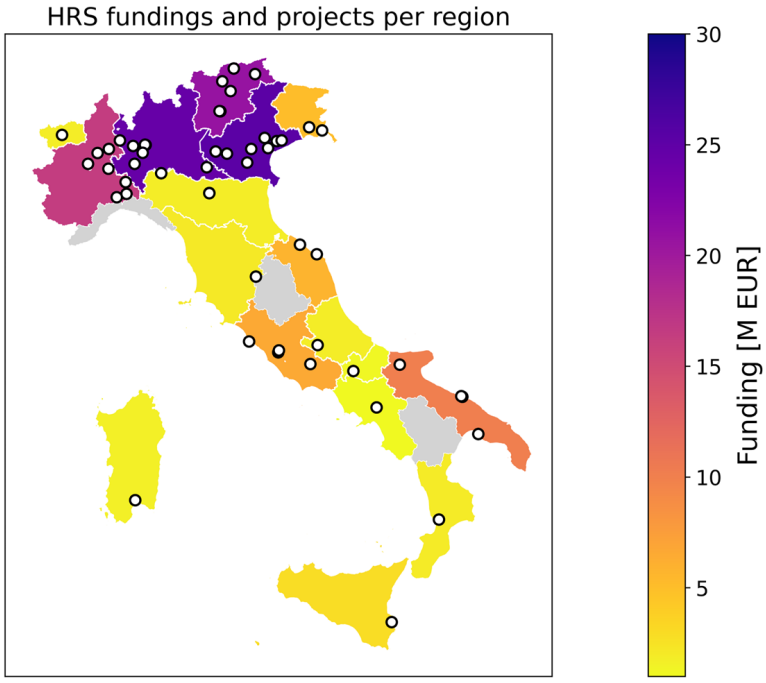

Figure 3. Hydrogen refuelling stations for road transport: funding available per region and locations of the HRSs (white dots). Grey colour refers to regions that have not received any funds. Additional details are available in the Supplementary Materials (Table S2).

2.4. Hydrogen Refuelling Stations for Railway Transport

The EUR 300 M dedicated to railway transportation (Topic 3.4, Table 1) is designated to convert regional or local services currently operated using diesel trains (non-electrified lines) or other fossil fuels. Decree 144/2023 distributed all of the available resources allocated for this area (EUR 300 M). In particular, EUR 276 M has been allocated for the construction of renewable hydrogen production, storage and refuelling stations and EUR 24 M for the purchase of hydrogen-powered trains. Only six regions were involved in this funding (Lombardia, Puglia, Campania, Calabria, Sardegna and Sicilia), covering a total number of 10 railway lines (one per region except for Sardegna and Puglia, with three lines each) [24]. Details on the funded railway lines and the funding quota are available in the Supplementary Materials (Table S3).

Finally, a summary of all of the PNRR funded initiatives (Topic 3.1, Topic 3.3 and Topic 3.4) is depicted in Figure 4, where hydrogen production plants (PtH, 52 plants, Table S1), hydrogen refuelling stations for road transport (HRS, 48 stations, Table S2) and railway lines (10 lines, Table S3) are represented. It can be noted that some initiatives include both hydrogen production and hydrogen refuelling stations at the same location, as indicated by the overlapping circular and triangular markers in certain regions.

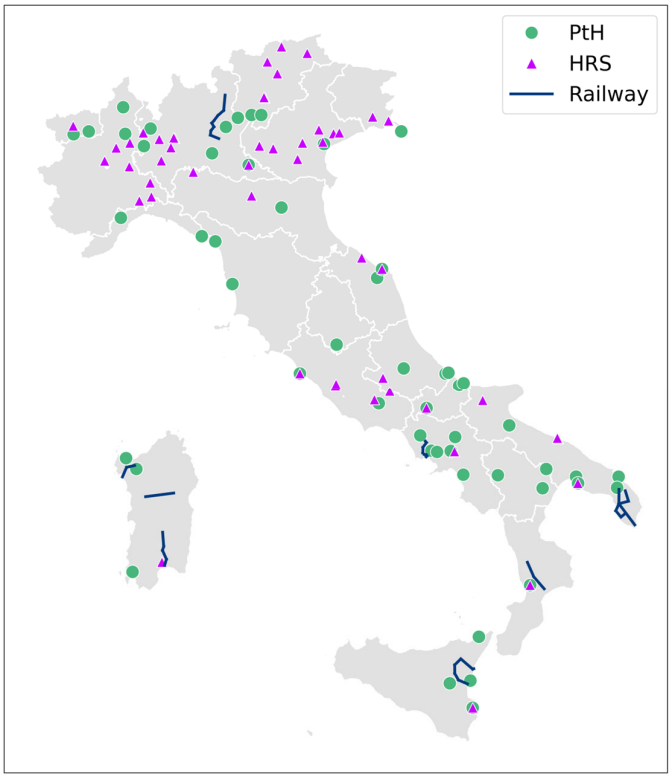

Figure 4. Location of all of the PNRR-funded initiatives, including hydrogen production plants (green dots), HRSs for road transport (purple triangles) and railway lines (blue lines). The location of the projects is based on the information provided in the funding authorization (official ministerial decree) and was updated with data on the actual plant, when available. Additional details are available in the Supplementary Materials (Tables S1–S3).

2.5. Hydrogen Research and Development

Topic 3.5 (Table 1) is devoted to research projects and was assigned during 2022 with two calls for fundamental and industrial research, respectively [25]. The detailed list of funded research projects is available in the Supplementary Materials (Table S4). Seven fundamental research projects were financed, coordinated by universities, for a total funding of about EUR 20 M, focused on materials for catalyst, solid storage and hydrogen production. Another EUR 30 M was given to 15 projects on industrial research (typically coordinated by companies). Even in this case, the spectrum of topics covers hydrogen production (50% of the project, focused typically on the manufacturing/development of innovative large-size electrolysers), transport, storage and end-uses (propulsion systems, power generation and e-fuels production).

2.6. Hydrogen Industrial Value Chain

A dedicated funding scheme (Topic 5.2, Table 1) has also been devoted to the creation of an industrial value chain, with the goal of building one or more electrolyser manufacturing plants and reaching a manufacturing capacity of 1 GW/year. The "H_2 Technology" initiative, which includes two projects by Ansaldo Energia S.p.A and De Nora Italy Hydrogen Technologies S.r.l., received formal authorization on July 2022 and will allow Italy to reach (and even exceed) the target production capacity of 1 GW/year by 2026 [26]. This funding is part of the IPCEI initiative, which will be discussed in Section 3.

2.7. Regulatory Incentives for Low-Carbon Hydrogen

Beside these funding schemes, within Topic 3 (see Table 1) other specific goals [27,28] were set concerning updates in the regulation scheme to promote the competitiveness of hydrogen. Regulatory policies, coupled with demand creation initiatives, indeed play

a pivotal role in facilitating the widespread adoption of low-carbon hydrogen across both existing and emerging applications. The measures implemented in Italy include the following:

- The revision of the existing regulation on hydrogen injection into the natural gas grid, with a new limit of maximum 2%vol. (Ministerial Decree No. 139, June 2022).
- Administrative simplification measures for the construction of small-scale (<10 MW) hydrogen production facilities, with authorization procedures managed by a single entity (Legislative Decree No. 199, November 2021).
- The inclusion of hydrogen production plants in grid-balancing services, through a directive by the Italian Energy Regulator (ARERA).
- The establishment of a system of guarantees of origin for renewable hydrogen, aimed at providing price signals to consumers, issued by the Italian Energy Regulator (ARERA) and the Energy Services Manager (GSE). This activity is not yet finalised.
- Facilitating the construction of hydrogen refuelling stations at strategic locations such as highway service areas, logistics warehouses and ports. This effort involves the identification of selected refuelling areas along the local refuelling network to create hydrogen corridors spanning across Italy.
- Reduction in the grid electricity price to produce low-carbon hydrogen. To this aim, a decree-law was published in 2022 [29]. This decree foresees an exemption from the payment of the variable quota of the general costs ("oneri generali") for the use of renewable electricity in electrolysis plants for the production of green hydrogen (defined as "green" when the lifecycle GHG emissions are lower than 3 t_{CO2eq}/t_{H2}). This benefit can be cumulated with other benefits of any nature. Furthermore, green hydrogen is not subjected to excise duty ("accise"), if not directly used in thermal engines as a fuel.

3. IPCEI Funding Scheme

In addition to the initiatives funded by the PNRR, other funding schemes, directly available through the European Union, have been initiated. Among these is the IPCEI (Important Projects of Common European Interest) initiative, which includes a specific section dedicated to hydrogen (IPCEI Hydrogen) [30]. The IPCEI Hydrogen targets the innovation, demonstration and deployment of hydrogen technologies. It comprises four clusters of projects covering the entire value chain: production, import, transportation and end use.

The focus of IPCEI Hy2Tech (EUR 5.2 billion, 35 projects, 13 member states involved) is centred on developing innovative technologies for producing renewable and low-carbon hydrogen using mainly electrolysis. Within this framework, four topics can be identified. The following list provides details on the Italian companies involved:

- Hydrogen generation technology: Ansaldo, De Nora and Enel;
- Fuel cells technology: Ansaldo, De Nora and Fincantieri;
- Storage, transportation and distribution technology: Enel;
- End-user technology: Alstom (railway sector), Fincantieri (maritime and shipping industry) and Iveco (heavy-duty trucks).

IPCEI Hy2Use will cover a large part of the hydrogen value chain and is divided into two technology fields: infrastructure and hydrogen technologies for industry. The companies involved within this cluster include Nextchem (green chemistry), RINA-CSM (materials development), SardHy Green Hydrogen (potentially associated with the decarbonisation of a refinery in Sardinia) and South Italy Green Hydrogen (likely involved in the decarbonisation of some refineries in Sicily).

The other two projects within the IPCEI hydrogen are Hy2Infra and Hy2Move. Hy2Infra, which was notified in February 2024 (EUR 6.9 billion, 33 projects, seven member states involved), includes (with details on the Italian partners involved) the following:

- Electrolysers: Energie Salentine, SAIPEM;

- Pipelines: SNAM;
- Storage;
- Liquid organic hydrogen carriers (LOHC);
- Handling terminals.

No information is available on the projects included in Hy2Move. A summary of the IPCEI initiatives, with details of the topics in which Italy is involved, can be found in Figure 5.

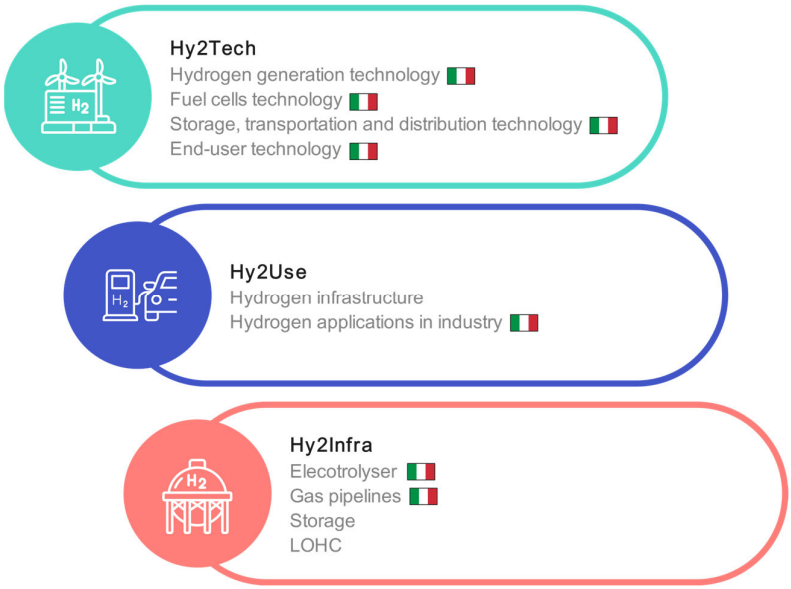

Figure 5. IPCEI initiatives. The Hy2Move initiative is not included since no information is available on the projects funded within this topic. The Italian flags indicate IPCEI topics in which Italian companies and projects have received funding.

4. Other Initiatives

This final section offers insights into additional existing hydrogen-related initiatives at the Italian level, as shown in Figure 6 (more details are provided in the Supplementary Materials, Table S5). The list below aims to encompass significant and advanced initiatives concerning hydrogen in Italy, often co-funded with the PNRR and IPCEI schemes discussed earlier.

- **TH2ICINO valley**: Based around Malpensa International Airport, this initiative aims to establish a hydrogen-ready airport, equipped with ground equipment and aircrafts. The project will feature a 5 MW PEM electrolyser capable of producing 500 t/year of hydrogen [31].
- **H2Iseo valley**: Targeting the decarbonisation of the Brescia-Iseo-Edolo railway line in northern Lombardia, this valley incorporates fourteen trains, forty buses, two HRSs for the railway and 5 HRSs along the main highways in the region [32]. The project is co-funded by the PNRR initiative.
- **South-Tyrol Hydrogen Valley**: Focused on automotive applications, this valley in the province of Bolzano hosts the two already existing HRSs in Italy and aims to decarbonise the Brenner corridor, a critical transit route connecting Central Europe with Italy [33].
- **North-Adriatic Hydrogen Valley**: Serving as a cross-border connection between Italy and other Central European countries like Slovenia, Croatia and Italy, this valley aims to demonstrate the integration of hydrogen production, distribution and consumption across borders. End-uses include hard-to-abate industries and the transport sector [34].
- **HyPER valley**: This initiative concentrates on industrial decarbonisation, particularly in the steel and chemical sectors.

- **LIFE3H hydrogen valleys**: This project demonstrates three hydrogen valleys in central Italy exploiting the local manufacturing industry for hydrogen buses, which will be fuelled by excess hydrogen from local industrial production, including caustic soda and steel plants [35].
- **Puglia green hydrogen valley**: This project aims to install three hydrogen production plants with a combined capacity of 160 MW, powered by PV plants. It is part of the IPCEI H2Infra initiative [36].
- **Agnes initiative**: Focused on energy production from offshore renewable sources in the Adriatic Sea, this initiative also includes hydrogen as a vector to decarbonise industries and transport in the surrounding area [37].
- **ENEA "demo" valley**: Located at the national research centre ENEA, this project aims to create an infrastructural hub for testing and demonstrating hydrogen technologies across the entire value chain.

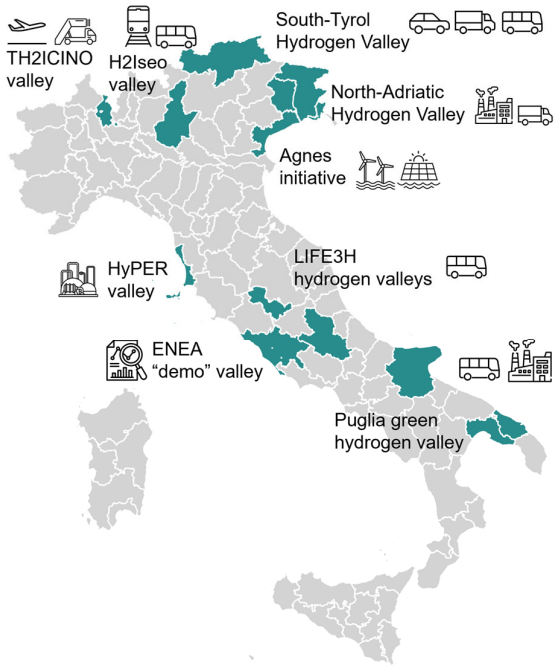

Figure 6. Other hydrogen hubs and valleys. In the map, the green provinces are those where the hydrogen initiatives will be implemented. Data on each initiative are provided in the Supplementary Materials (Table S5).

5. Conclusions

The aim of this work is to provide the reader with a thorough overview of current and planned hydrogen projects in Italy. By collecting data on approximately 150 funded initiatives, it presents a snapshot of the expected hydrogen value chain in Italy.

Italy's commitment to hydrogen as a key instrument for decarbonising both the industrial and transportation sector is evident through the allocation of funds and incentives. The PNRR funding scheme, with its specific calls and objectives, aims to propel Italy towards hydrogen adoption in sectors where electrification is not technically or economically feasible. Funding has been directed towards several key areas:

- Hydrogen production in brownfield areas, with 52 PtH plants financed.
- The establishment of hydrogen refuelling stations and transport applications: 48 HRSs for road transport and 10 hydrogen-based railway lines.
- The implementation of hydrogen in hard-to-abate sectors (with results pending).
- The enhancement of the Italian electrolyser manufacturing capacity.

All of these initiatives should be completed and in operation by mid-2026.

The IPCEI initiative expands the scope of innovation by adding extra funding and supporting other initiatives along the value chain. Italian companies play a crucial role in the IPCEI clusters for what concerns technology manufacturing, transport and end-uses.

Furthermore, other EU- or private-funded initiatives highlight the diversity of approaches and applications across different regions and sectors within Italy. These include hydrogen-ready airports, the decarbonisation of railway lines, many industrial decarbonisation projects and hydrogen-based transport (buses, trucks), showcasing Italy's commitment to a wide-ranging and sustainable hydrogen ecosystem.

By mapping these initiatives on hydrogen production and uses, the analysis highlights the diverse approaches to hydrogen adoption throughout Italy. Some regions prioritise cross-border commercial routes, while others focus on local transport or industrial decarbonisation.

Despite the large number of initiatives and funding connected with the hydrogen value chain, risks remain. The primary risk associated with funded initiatives in the hydrogen sector is the uncertainty surrounding projected hydrogen demand. Industrial projects, where low-carbon hydrogen substitutes fossil hydrogen or other fuels like natural gas, benefit from predictable hydrogen demand. On the other hand, applications such as hydrogen refuelling stations for road transport or public buses face a more unpredictable demand, resulting in a riskier and less robust business plan. Regulatory frameworks play a crucial role in mitigating risks and enhancing hydrogen profitability. Measures such as guarantees of origin and reduction in the electricity price for PtH plants are expected to foster and strengthen the economic viability of hydrogen projects.

This overview on hydrogen-related initiatives could be of significant interest to industries, authorities and decision-makers involved in the development and implementation of hydrogen-related projects. Moreover, the data provided can be instrumental in country-scale assessments where reliable information on current and planned hydrogen production and demand is essential. The ultimate goal is to promote cooperation on hydrogen and strengthen international competitiveness.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/en17112614/s1. Table S1: PtH projects list (Topic 3.1: Hydrogen production in brownfield areas), Table S2: HRS projects list [23,38,39] (Topic 3.3: Hydrogen refuelling stations for road transport), Table S3: Railway project list (Topic 3.4: Hydrogen refuelling stations for railway transport) [40–45], Table S4: Research funded project (Topic 3.5: Research and development) [25], Table S5: Other hydrogen initiatives in Italy [31–37].

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Nomenclature

AEM	Anion-exchange membrane
CHP	Combined heat and power
DRI	Direct reduction of iron
EL	Electrolyser
EU	European Union
GHG	Greenhouse gas
HRS	Hydrogen refuelling stations

IPCEI	Important projects of common European interest
LOHC	Liquid organic hydrogen carriers
M EUR	Million euro
PEM	Proton-exchange membrane
PNRR	National recovery and resilience plan
PtH	Power to hydrogen
PV	Photovoltaic
RES	Renewable energy source
R&D	Research and development

Appendix A

Figure A1. Italian regions names and locations [46].

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