Innovative Energy Climate Action

Part 3: EUROPEAN HYDROGEN VALLEYS

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Discussion paper

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EUROPEAN HYDROGEN VALLEYS

The sustainability paradigm is creating new markets to reach sustainable development levels globally and locally. The sustainable energy carrier, green hydrogen, is one of them and is experiencing a positive momentum.

Its development is occurring in a multi-speed fashion, where some territories are testing technologies and others are in a more advanced stage, beginning a market penetration stage[10]. This is the case of European economies[11] with the model of "Hydrogen Valleys". Such experiences will help "EU's commitment[12] to reach carbon neutrality by 2050 [13]and for the global effort to implement the Paris Agreement while working towards zero pollution" (EC, 2020).

In fact, Weichenhain et al. (2021) affirm that "moving beyond mere piloting and demonstration activities, Hydrogen Valleys are the pioneers of this market and ultimately the stepping stone towards the full rollout of a new hydrogen economy – and the industrialization of the associated technologies simultaneously".

But what is a "Hydrogen Valley"? As usual, a new concept has several ways to be defined, literature is still debating and conceiving its definition. Debating on its definition, is out of the scope of this article.

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10 According to IRENA (2020) there are three policy stages, as follow: 1. Technology Readiness: At this stage, green hydrogen is a niche technology with little use except in demonstration projects; it is mostly produced on-site with limited infrastructure development. The largest barrier to greater use is cost. The main role of policy makers is to encourage and accelerate further deployment of electrolysers.2. Market Penetration: At this stage, some applications are operational and able to prove what green hydrogen can do and at what cost. Scaling up these technologies and developing experience through learning-by-doing reduces costs and helps close the profitability gap. This stage also begins to see benefits from synergies between applications, increasing hydrogen demand and realising economies of scale for production and infrastructure. These synergies can take place in industrial clusters, hydrogen valleys (e.g. cities) or hubs (e.g. ports).3. Market Growth: At this stage, green hydrogen becomes a well-known and widely used energy carrier and is close to reaching its full potential. It has become competitive both on the supply side and in its end uses. Direct incentives are no longer needed for most applications and private capital has replaced public support in driving hydrogen growth. There is full flexibility in converting hydrogen to other energy carriers, making it possible to use the most convenient alternative depending on the specific conditions in each region. The power system has been decarbonised and only green hydrogen is being deployed. Most natural gas infrastructure has been repurposed to transport pure hydrogen. For further information, please read IRENA (2020).

11 It is worth to note, though, that Hydrogen Valley experiences are occurring already in a global scale, in countries such as United States, Japan, China, Australia, Chile, Oman, Thailand, United Kingdom. Please read Weichenhain et al. (2021).

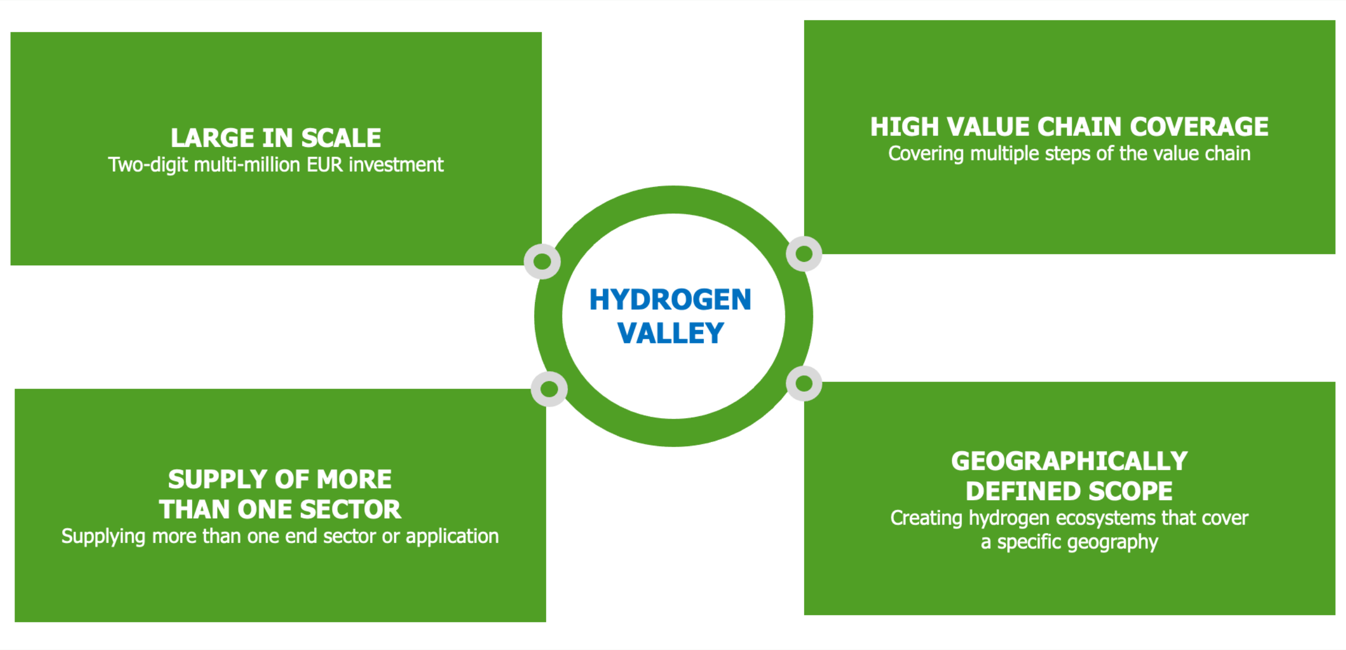
12 Please find more information here: https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en

13 In the first phase, from 2020 up to 2024, the strategic objective is to install at least 6 GW of renewable hydrogen electrolysers in the EU and the production of up to 1 million tonnes of renewable hydrogen, to decarbonise existing hydrogen production… In a second phase, from 2025 to 2030, hydrogen needs to become an intrinsic part of an integrated energy system with a strategic objective to install at least 40 GW of renewable hydrogen electrolysers by 2030 and the production of up to 10 million tonnes of renewable hydrogen in the EU … In a third phase, from 2030 onwards and towards 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale to reach all hard-to-decarbonise sectors where other alternatives might not be feasible or have higher costs (EC, 2020).

On the other way, it is possible to highlight relevant elements that make a Hydrogen Valley, elements that are observed in several ongoing cases. It is worth to note, though, that Hydrogen Valleys model has to be adapted to the territories' characteristics, there is no "one-size-fits all" model.

Given that, according to Weichenhain et al. (2021), there are four key elements that a Hydrogen Valley must possess (Figure 1).

Figure 1 – Hydrogen Valley Concept



Source: Weichenhain et al. (2021), FGV adaptation

The first element is "Large in Scale". Thus, the Hydrogen Valley has to invest in two-digit million EUR investment, in order to go beyond demonstration projects. Furthermore, hydrogen valley investments also include a set of "subprojects", constituting a projects portfolio. The second element is "High Value Chain Coverage". This factor considers that the projects cover the whole range of hydrogen value chain phases – Production, Transformation, Transportation and End Use. The third element is "Geographically Defined Scope". The Hydrogen value chain occurs in a specific and limited geographical area, a territory.

The fourth element is "Supply of more than a Sector". Due to hydrogen multiple-uses characteristic, the hydrogen valley is conceived by identifying several hydrogen end uses, attending territorial demand.

Hence, Hydrogen Valleys are territorial innovation ecosystems that leverage endowments, capabilities, infrastructures, resources, technologies and assets through a set of heterogeneous of stakeholders – public, private, civil society and academy – in order to produce, transform, transport and use green hydrogen, in favor of sustainable development, in line with local and global needs. It is possible to argue that such concept "aims to enable the emergence of locally integrated hydrogen ecosystems for climate change mitigation and regional economic development" (Weichenhain et al. 2021).

A peculiar aspect that has to be highlighted about Hydrogen Valleys, is the one of Smart Specialization approach. In fact, the "European Hydrogen Valleys partnership" (EHV), an initiative launched in 2017, was established under the "Smart Specialization for Industrial Modernization" framework of the European Commission[14]. Moreover, the Smart Specialization Platform[15] considers "Energy" as a key thematic area for Smart Specialization initiatives, where hydrogen is part of that[16].

But what is Smart Specialization? How it fits with Hydrogen Valley Model for Sustainable Development?

The Smart Specialization Platform defines Smart Specialization[17] as a "place-based approach characterized by the identification of strategic areas for intervention based both on the analysis of the strengths and potential of the economy and on an Entrepreneurial Discovery Process (EDP) with wide stakeholder involvement. It is outward-looking and embraces a broad view of innovation including but certainly not limited to technology-driven approaches, supported by effective monitoring mechanisms".

The Smart Specialization approach was also introduced in Europe in the Cohesion Policy 2014-2020 framework and in the European legislation as a "requirement (ex-ante conditionality) for regions and Member States to access funding under Thematic Objective 1 "Strengthening research, technological development and innovation" of the European Regional Development Fund for the period 2014–2020 (European Union, 2013 In. GUZZO and GIANELLE, 2021)".

14 Over recent years, the Hydrogen Valley concept has emerged as a firmly established term in the European funding and collaboration landscape. Building on the FCH JU Regions and Cities Initiative launched in 2017, a „European Hydrogen Valleys partnership" (EHV) was created under the „Smart Specialisation for Industrial Modernisation" framework of the European Commission. The partnership supports the setup of joint hydrogen projects between the 30 participating European regions and increases the visibility for fuel cell and hydrogen applications at European level. In parallel, the FCH JU awarded two European regions dedicated funding of more than EUR 25 million to pursue their tailor-made Hydrogen Valley concepts, besides the FCH JU's extensive regular funding activities of many more Hydrogen Valleys (Weichenhain et al. 2021).

15 The Smart Specialization Platform provides advice to EU countries and regions for the design and implementation of their Smart Specialization Strategy (S3). https://s3platform.jrc.ec.europa.eu/home

16 Please visit the following website: https://s3platform.jrc.ec.europa.eu/s3-thematic-platforms

17 Please visit the following website to deepen the issue: https://s3platform.jrc.ec.europa.eu/what-we-do

Lately, such place-based innovation strategy has re-oriented its trajectory to include recent sustainable development policies' goals of the European Union: "Green Deal" in 2019[18], and after COVID-19 crisis, the green and digital recovery[19]. Thus, smart specialization strategies have to be channeled to Sustainability. Mccann and Soete (2021) depicts such change: "a shift in policy logic from Smart Specialization Strategy (S3) to smart specialization strategies for sustainable and inclusive growth (S4+) would change the logic on which regional development strategies would be based in Europe".

Hence, both from a conceptualization and policy perspectives, these kind of territorial innovation ecosystems – Hydrogen Valleys –, are embedded into a broader and strategic approach that European Union is supporting as a key element for implementing sustainable development and digital transformation goals. Which is, Smart Specialization Strategies for Sustainability (S4).

Given such scenario, **hydrogen valleys experiences of green hydrogen are Smart Specialization Strategies for Sustainability (S4) cases that are contributing to reach climate change objectives and sustainable development goals, through innovation and territorial socioeconomic development.**

In order to deepen such fruitful industrial experience, let's consider three (03) paradigmatic cases – picked-up in the Hydrogen Valley Platform (H2V)[20] – that show green hydrogen valley characteristics (Table 1):

- **HEAVENN**: Located in Netherlands is a large-scale program of projects bringing together core elements: production, distribution, storage and local end-use of hydrogen (H2) into a fully-integrated and functioning "H2 valley" (H2V), that can serve as a blueprint for replication across Europe and beyond[21]. According to Hydrogen Valley Platform data, daily H2 production volume (T/day) is of 7,70. The project investment amount is 88 M€, of which 20 M€ are European Commission subsidies. The project's end uses are mobility, energy and industry feedstock sectors. The project started in 2019 and its finalization is due on 2025;

18 Please visit the following website: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
19 Please visit the following website: https://ec.europa.eu/info/strategy/recovery-plan-europe_en#nextgenerationeu
20 Please visit the following website to get more information about hydrogen valleys cases: https://www.h2v.eu/about-us
21 Please visit the following websites to get more information about this case: https://heavenn.org/about/ https://www.newenergycoalition.org/en/projects/heavenn/

- **NDRL (Norddeutsches Reallabor – Living Lab Northern Germany)**: As mentioned in h2v platform, the Norddeutsche Reallabor is a project that intends to test the overall transformation of the energy system in order to demonstrate a rapid decarbonisation of all energy consumption sectors in Northern Germany. According to Hydrogen Valley Platform data, daily H2 production volume (T/day) is of 10. The project investment amount is 325 M€, constituted by a mix of public national funds and private ones. The project's end uses are mobility and industry feedstock sectors. The project started in 2018 and its finalization is due on 2026;

- **HYDROGEN VALLEY SOUTH TYROL**: The h2v platform affirms that the Hydrogen Valley South Tyrol aims to decarbonize the mobility sector and to connect the region with the main Italian and European economic areas along the Brenner Corridor[22]. According to Hydrogen Valley Platform data, daily H2 production volume (T/day) is of 1. The project investment amount is 55 M€, mixing public European and local funds with private ones. The project end use is the mobility sector. The project started in 2017 and its finalization is due on 2026.

22 *Please visit the following website to get more information about the project: https://www.h2-suedtirol.com/en*

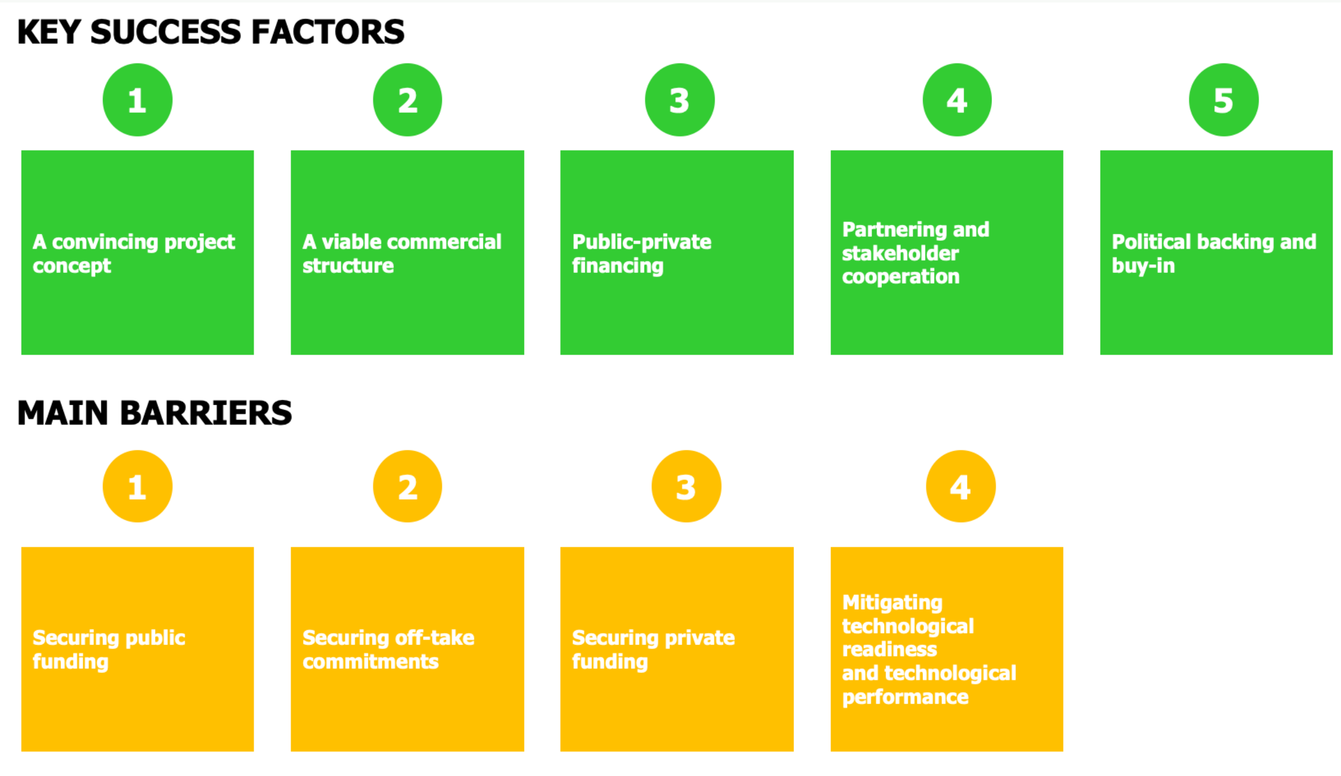
Table 1 – Green Hydrogen Valleys Cases

Project Name	Country	Location	Lead Developer	H2 production (T/day)	Value Chain Coverage	End Uses	Investment volume M€	Funding	Current Status
HEAVENN	Netherlands	Municipality of Groningen	New Energy Coalition	7.70	- H2 Production - H2 Storage - H2 Transport - H2 distribution for mobility	- Mobility - Energy -Industrial Feedstock	88.00	Public and private	Start of Implementation
NDRL (NORDDEUTSCHES REALLABOR - LIVING LAB NORTHERN GERMANY)	Germany	Hamburg	Joint Development (+ 50 stakeholders)	10.00	- H2 Production - H2 Storage - H2 Transport - H2 distribution for mobility	- Mobility -Industrial Feedstock	325.00	Public and private	Concrete project plan agreed by main stakeholders
HYDROGEN VALLEY SOUTH TYROL	Bozen	Italy	IIT - Institut für Innovative Technologien Bozen	1.00	- Primary Energy Sourcing - H2 Production - H2 Storage - H2 Transport - H2 distribution for mobility	- Mobility	55.00	Public and private	Start of Implementation

Source: https://www.h2v.eu/

The analysis of these cases, and in general with the experiences of the Hydrogen Valley Platform, it is possible to identify key success factors and main barriers for hydrogen valleys (Figure 2).

Figure 2 – Key success factors and main barriers



Source: Weichenhain et al. (2021), FGV graphic adaptation

First key success factor pinpoints to the fact that the project concept must be conceived based on territorial needs and demand. In the second key success factor, it is necessary to deepen the project analysis with feasibility and business case studies, evaluation of costs, cash flows, commercial, funding, geography, project timelines, as well as, project scale and technology issues. The following success factor, the third one, deals with public-private financing. It is crucial to search and apply for public funds, especially in the preparation phase. Moreover, the private funding share in hydrogen valleys, has grown over time, showing more attractive and feasible business cases. Another major factor of success is the fourth one, “Partnering and stakeholder cooperation”. In fact, it is of paramount relevance to engage stakeholders, and enable cooperation and governance mechanisms during the entire project. Finally, the fifth key success factor is the political backing and buy-in. Since its early stages, the project should engage policy makers, regulators, agencies and local communities to share project objectives, means, results and benefits.

At the same time, hydrogen valleys present some barriers that have to be overcome to spur hydrogen investments. The first barrier deals with “Securing Public Fundings”. As it is a key factor of success, it also brings some degree of difficulties in order to get it done. In fact, public funding institutions have little knowledge regarding hydrogen valleys, funding procedures are resource intensive, so public funding institutions need to be engaged in the early phase of the project conception to get on board. On the other hand, the second barrier “securing off-take commitments” highlights the issue of securing buyers’ commitments of hydrogen valley products and services. The conception of the project has to take into account dialogues with potential off-takers from different sectors in order to guarantee commercial feasibility. The third barrier “Securing private funding”, is the first one complementary. It pinpoints the need of conceiving a bankable project that is able to attract private equity funds, institutional investors, local private funding among others. Finally, the fourth barrier “Mitigating technological readiness and technological performance” shows the difficulty to ensure flexibility of the project and efficient system integration, as well as, commissioning, operation and maintenance issues.

As it is shown, green hydrogen valley cases are crucial market experiences that will spur global hydrogen market penetration. In fact, already,

> “Hydrogen Valleys represented on the Mission Innovation Hydrogen Valley Platform[23] comprise a total investment volume of more than EUR 30 billion covering more than 20 countries worldwide. Only little more than 10% of Hydrogen Valleys have entered operations so far. In the upcoming five years and beyond, the bulk of the remaining projects will enter the implementation phase and will thus contribute significantly to the further industrialization of the industry (Weichenhain et al. 2021)”.

Hence, the spreading of the Hydrogen valley model is key to keep market momentum and boost further development in a global scale.

Within this scenario, the Latin American experience on hydrogen valley is very little though. Only in Chile and in French Guiana we can find hydrogen valley projects, according to the Hydrogen Valley Platform (H2V)[24]. Thus, it is strategic to spread-out the hydrogen valley model in Latin American countries due to its sustainable development and industrial contribution on a global and territorial levels.

23 *Please visit the platform https://www.h2v.eu/*
24 *This information refers up to November 2021. Eventually, in the future, can appear other projects from Latin America.*

It is worth to note, that both the hydrogen valley model and the smart specialization approach (S4) are comprehensive and flexible perspectives that can be adapted according to territorial demands and characteristics of Latin America.
Furthermore, there is already an established dialogue and cooperation framework between EU and Latin American and Caribbean countries (Barroeta et al 2017), where smart specialization[25] is a key element, as well as, the green and digital transition. So, the green hydrogen valley approach could be a novel domain of joint work between Europe and Brazil.

In particular, in these articles we focus on Brazil, a country with a strong and vibrant energy market, and a high share of renewable technologies. A cooperation between Brazil and Europe on hydrogen valleys in a S4 approach, can be fruitful for both. It is geopolitically strategic and it will bring sustainable and innovative results. The next article will describe Brazil hydrogen market experience.

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