H2CE

D.2.1.1

Report on the testing of a digital GIS database: methodology, prototype and evaluation results

Unioncamere Veneto

Styria

Version 1

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Index

1. H2CE Project

H2CE addresses the challenge of integrating hydrogen solutions and renewable energies into the regional energy transition. Today, existing information and support focuses on the needs and perspectives of project owners and of the industry, treating public authorities as (passive) framework condition instead of understanding their expertise and authority as a further means to pro-actively support change.

H2CE aims at empowering public authorities and administration in Central Europe (CE) to integrate hydrogen proactively and sustainably into regional planning and development. This will lead to an acceleration of hydrogen infrastructure ramp-up and a more efficient use of available funds. The main results of the project will be mechanisms to empower regional decision makers to support a hydrogen-based energy transition, the initiation of a cross-regional & transnational network of H2-ready regions, and the implementation of a digital collaboration platform.

In this scope, the WP2 aims at Increasing the understanding of challenges, potentials and solutions for the cross-regional and cross-sectoral transition of regional energy systems among energy utilities, public authorities, planning departments and regional SMEs in all H2CE partner regions.

In the specific, the deliverable 2.1.1 presents the results of testing a GIS-based decision-support tool developed for the Veneto and Styria regions as part of the H2CE project.

This tool provides a data-driven approach to hydrogen infrastructure planning, offering decision-makers a strategic platform to evaluate hydrogen production, demand, and distribution at different territorial scales.

2. GIS Decision makers' supporting tools

Hydrogen and the Role of GIS Systems in Supporting Public Policies

Hydrogen (H_2) is emerging as one of the key solutions for the energy transition and the decarbonization of production and mobility systems. Its potential in sustainability is widely recognized, particularly for its role in reducing CO_2 emissions and diversifying energy sources. However, the development of a hydrogen supply chain requires an integrated approach that considers multiple territorial, infrastructural, and economic factors.

The European Union has placed hydrogen at the center of its energy strategies through programmatic documents such as the EU Hydrogen Strategy (2020) and Fit for 55 (2021), which promote the integration of green hydrogen into the energy mix and establish ambitious decarbonization goals. The regulation on the hydrogen and decarbonized gas market, part of the European legislative package, aims to ensure efficient infrastructure and a competitive market for hydrogen, fostering the development of energy corridors and the conversion of existing infrastructures.

In this context, Geographic Information Systems (GIS) represent an essential tool for supporting public decision-makers in planning and managing hydrogen-related policies. The complexity of the infrastructure required for hydrogen production, storage, distribution, and use necessitates advanced spatial analysis, enabling the identification of the most suitable areas for implementing new technologies, assessing environmental impacts, and facilitating integration with existing energy networks.

The adoption of GIS systems allows for:

- Mapping the territorial potential for green hydrogen production, by integrating data related to renewable sources, water availability, and infrastructural capacity.
- Analyzing the hydrogen transport and distribution network, identifying strategic areas for new plants and critical points that require investment.
- Evaluating development scenarios, using predictive models to simulate the evolution of the hydrogen market based on adopted public policies.
- Integrating information with other strategic sectors, such as sustainable mobility, industry, urban planning, and environmental management, facilitating informed decisions based on territorial evidence.

The application of GIS in territorial planning for hydrogen supply chain development is fundamental for optimizing infrastructure and ensuring sustainable integration with urban and rural areas. The use of GIS enables:

- Identifying the most suitable areas for production and storage plants, through the analysis of territorial criteria such as the availability of renewable energy (solar, wind, hydroelectric), distances from water resources required for electrolysis, and compliance with environmental regulations.

- Planning logistics and the distribution network, optimizing hydrogen transport via pipelines, road, or rail transport, minimizing costs and emissions while ensuring system safety.
- Integrating hydrogen production with existing infrastructures, such as high-energy-intensive industrial hubs and production districts, promoting the creation of territorial clusters that reduce energy losses and maximize efficiency.
- Supporting the conversion of decommissioned industrial areas into new hubs for hydrogen production, promoting urban regeneration and the sustainable repurposing of obsolete infrastructures.
- Mapping hydrogen consumption zones, including industrial sectors, public and private transport, electricity generation, and urban heating, to facilitate planning for a balanced demand and supply.
- Assessing environmental and social impacts, using spatial analysis to examine the potential effects of hydrogen infrastructures on natural ecosystems, biodiversity, air quality, and social acceptability by local communities.
- Supporting the planning of energy smart grids, through the use of GIS to manage flows of renewable energy and hydrogen, ensuring balanced and sustainable distribution.

GIS and H2 development: a Data-Driven approach

The use of GIS tools to support hydrogen policies enables more effective governance, ensuring greater coherence between economic development strategies, environmental protection, and territorial needs.

Some specific applications of GIS in the hydrogen sector include:

- Suitability analysis for new hydrogen production plants.
- Environmental and social risk assessment.
- Monitoring and management of hydrogen transport infrastructures.
- Integration with climate and environmental models.
- Use of satellite data to monitor infrastructures and environmental impact.
- Predictive modeling to estimate the evolution of hydrogen demand and supply over time.

The construction of a digital infrastructure based on geospatial data is an essential element for facilitating the transition toward a more resilient and sustainable energy system. GIS technologies provide strategic support to public decision-makers, enabling efficient planning for the growth of the hydrogen supply chain, reducing investment risks, and promoting widespread adoption of this key resource for climate neutrality.

Given these premises, the objective of the H2CE project is to test these potentials within a pilot project for the regions of Veneto and Styria, exploring the application of GIS-based planning methodologies to support hydrogen infrastructure development in these territories.

3. GIS-based tool developed in Veneto Region

Challenges in Developing Hydrogen in the Veneto Region

The Veneto region faces several challenges in developing a sustainable hydrogen economy. These challenges include:

- Infrastructure Adaptation: the region lacks a fully developed hydrogen infrastructure, requiring investments in production plants, transport networks, and storage facilities.
- Integration with Renewable Energy Sources: while Veneto has a growing capacity for renewable energy, ensuring a stable supply of green hydrogen requires improved integration with solar and wind power generation.
- Industrial Transition: Veneto is home to several energy-intensive industries that could benefit from hydrogen but need support for technology adaptation and conversion processes.
- Mobility Sector Implementation: developing hydrogen-powered public and private transport remains a challenge, with the need for refueling stations and regulatory frameworks to promote hydrogen mobility.
- Environmental and Social Considerations: Hydrogen infrastructure development must align with territorial planning to minimize environmental impacts and address concerns from local communities.
- Cross-Border Collaboration: as part of a broader European framework, Veneto must collaborate with neighboring regions and countries to ensure interoperability and connectivity of the hydrogen network.

Addressing these challenges requires a coordinated approach involving public authorities, private stakeholders, and research institutions. GIS tools can play a crucial role in mapping the current landscape, identifying optimal locations for infrastructure, and supporting decision-making for hydrogen deployment in Veneto.

General description of Veneto Region pilot tool

The primary objective of this initiative is to support public decision-makers in planning and monitoring investments in the production, distribution, and consumption of hydrogen as an energy source. By providing an evidence-based approach, this tool enhances the strategic capabilities of the Veneto Region in fostering a sustainable hydrogen economy.

The increasing relevance of hydrogen as a clean energy vector requires decision-makers to be equipped with precise and comprehensive data to develop policies that align with both regional needs and broader European objectives for decarbonization. Ensuring that investments in hydrogen infrastructure are well-planned and efficiently allocated is crucial for achieving long-term sustainability.

To achieve this goal, it is essential to understand the potential demand for hydrogen across various sectors, including:

- Industry, where hydrogen can replace fossil fuels in energy-intensive processes.
- Mobility, where hydrogen-powered vehicles and public transport systems can contribute to reducing emissions.
- Residential energy use, where hydrogen can be integrated into heating and energy storage solutions.

This knowledge allows for informed decision-making, ensuring that hydrogen production and distribution infrastructure align with actual consumption patterns. Without a clear understanding of demand, investments risk being misallocated, leading to inefficiencies and wasted resources.

The ability to spatially analyses energy consumption data enables policymakers to predict future trends and strategically position hydrogen infrastructure where it is most needed.

A key component of this initiative is the development of a GIS-based digital mapping tool that visualizes the potential hydrogen demand across the Veneto Region.

This tool enables policymakers to make data-driven decisions by providing an accurate, up-to-date representation of hydrogen consumption needs at different territorial levels. By integrating multiple data sources, including industrial energy consumption, mobility patterns, and population distribution, this tool creates a dynamic platform for scenario analysis and strategic planning.

The capability to assess different development scenarios allows for flexibility in policy formulation and helps identify the most effective pathways for transitioning to a hydrogen-based energy system.

The added value of this initiative lies in its ability to integrate the vast amount of data managed by the Chamber of Commerce System with the energy planning strategies of the Veneto Region. This ensures that decision-making processes benefit from reliable and structured datasets, avoiding fragmented and inconsistent approaches to hydrogen development. By leveraging this synergy, regional authorities can implement policies that are:

- Grounded in economic and territorial realities, ensuring investments align with regional needs.
- Technically sound and economically viable, optimizing financial resources and maximizing return on investment.
- Integrated across multiple sectors, allowing for a coordinated approach between industry, transport, and energy systems.

The expected outcomes include:

- The creation of a user-friendly tool that enables the Veneto Region to map potential hydrogen demand and use this information for strategic decision-making.
- A spatial representation of economic trends, derived from the Chamber of Commerce System's surveys, offering a valuable resource for understanding how hydrogen fits into broader economic transitions.

- Enhanced coordination between different stakeholders involved in hydrogen planning, including policymakers, researchers, and industry representatives, fostering a collaborative approach to energy transition.

Data collection for current energy consumption is a fundamental aspect of this initiative. The tool relies on data collected by UnionCamere's Research Center, which incorporates hydrogen-specific questions into its ongoing surveys of manufacturing enterprises. These surveys target companies with more than 10 employees, ensuring a representative dataset that reflects broader industry trends. In addition to industrial energy consumption data, the tool integrates information on:

- Population trends and regional mobility patterns, sourced from ISTAT and the Veneto Region's statistical office.
- Existing energy consumption patterns, covering diverse economic sectors and their current reliance on various energy sources.

To accurately estimate hydrogen demand, specific conversion coefficients are applied to each type of collected data. These coefficients translate energy consumption metrics into tons of hydrogen equivalent, providing a spatial representation of demand across the region. This methodological approach ensures that:

- Data is not only collected but also transformed into actionable insights that directly inform policy decisions.
- Decision-makers can identify priority areas for investment and development, optimizing resource allocation.
- The impact of hydrogen infrastructure is assessed in spatial terms, aligning policy actions with real-world needs.

The GIS-based decision support tool is built upon business registry data, which includes company addresses, is geolocated and represented at the municipal level, ensuring precise spatial visualization of industrial energy consumption. Using GIS-based feature joining techniques, energy consumption data is integrated with geospatial layers, enabling comprehensive analysis and visualization. Additionally, population and consumption data are mapped at the municipal level, providing further context for understanding hydrogen demand.

The tool is designed to be accessible via a web-based platform, ensuring ease of use for policymakers and stakeholders. A key feature of the system is the ability to conduct customized spatial queries, allowing users to dynamically visualize key information. These queries provide valuable insights into:

- Hydrogen consumption patterns and areas with the highest potential demand.
- Investment opportunities based on spatial proximity to industrial and mobility hubs.
- Regional energy dynamics, ensuring policies align with ongoing sustainability efforts.

This initiative marks a significant advancement in the integration of hydrogen into the Veneto Region's energy strategy. By combining GIS technology, economic data, and spatial analytics, the tool provides decision-makers with a robust foundation for policy interventions and strategic investments in the hydrogen sector.

The ability to visualize hydrogen demand and infrastructure needs in a geospatial format enhances the effectiveness of policy measures and ensures that investments are directed toward areas with the highest impact.

Addressing these challenges requires a coordinated approach involving public authorities, private stakeholders, and research institutions. GIS tools can play a crucial role in mapping the current landscape, identifying optimal locations for infrastructure, and supporting decision-making for hydrogen deployment in Veneto.

Atlas: A GIS Software for Spatial Analysis and Planning

Atlas is a GIS platform developed by Atlas AS, a company based in Oslo, Norway. The software allows users to visualize, map, and analyze geographic data within a browser-based interface. Its goal is to provide tools for processing and representing spatial data, enabling users to conduct territorial analyses and support decision-making based on geographic evidence.

One of the key strengths of Atlas is its ability to facilitate spatial analysis without requiring complex installations or technical expertise. By being entirely web-based, it ensures that users can access and interact with spatial data in real-time, making it a versatile tool for various applications. The software is designed to provide an intuitive experience, allowing users to create, edit, and analyze maps with ease, making it accessible to both experts and non-specialists.

Atlas integrates a range of functionalities that facilitate the management and analysis of georeferenced information. Among its key features are:

- Browser-based access, eliminating the need for installation and allowing use from any internet-connected device, thereby ensuring flexibility for users working across different locations.
- Spatial analysis tools, enabling operations such as overlaying information layers, proximity searches, and transportation network analysis. These tools help users to understand spatial relationships and make informed decisions regarding infrastructure, land use, and environmental planning.
- Customizable visualization, with options to apply filters, classify data, and represent information using various cartographic styles. The ability to tailor visualizations makes it easier to highlight key insights from datasets.
- Real-time collaboration, allowing multiple users to work on the same data, add annotations, and share updates immediately. This feature enhances coordination among teams, particularly for large-scale projects requiring input from multiple stakeholders.
- Integration of data from various sources, including demographic, infrastructural, and economic data, to create detailed thematic maps. This makes Atlas a powerful tool for aggregating and analyzing multiple layers of information to gain a comprehensive understanding of spatial patterns.

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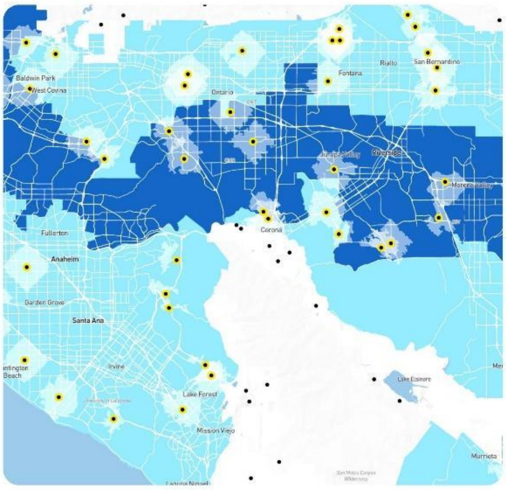
Visualize data with Atlas

Layer styling is essential for making your maps lively and informative. It turns your data into something that's both beautiful and understandable.

Customize colors, symbols, and labels to highlight key patterns and trends. Create dynamic, interactive maps that bring your data to life, making complex information easy to understand and share.

Connected to your data. Delightful to share.



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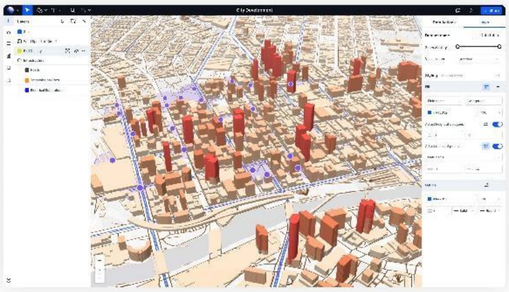
GIS in the browser

Atlas is a browser-based GIS platform that empowers organizations to visualize, map, and analyze their data with ease. No complex software needed – just open your browser and start working.

No installations required



Visualize & style

Transform your spatial data into insightful visualizations with our powerful styling tools.

Dynamic dashboards

Design interactive dashboards with dynamic charts and widgets to visualize your spatial data in real-time.

Spatial analysis

Unlock deeper insights with our advanced spatial analysis tools.

2

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50+ spatial analysis tools

A powerful suite of spatial analysis tools that anyone can use. No prior GIS knowledge required.

Conduct proximity searches, overlay analysis, and data aggregation to reveal hidden patterns and relationships.

Boundary, Buffer, Clip, Difference

Intersect, Subtract, Union, Nearest

Core, Advanced, Domain-specific

It's as easy as using a calculator

GIS analysis used to be for experts only. With Atlas, anyone can perform advanced analyses without prior knowledge.

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Build interactive dashboards

Visualize millions of data points with ease. Create and share interactive dashboards that take your data storytelling to the next level.

Our widgets are designed to be easy to use and highly customizable.

Summarize & compare

Compare the distribution of data across a set of categories. It is particularly useful for comparing the size of a category to the total.

Dynamic filtering

Filter based on viewport bounds, numerical ranges, or any other data in your dataset.

Identify patterns

The Time Series widget allows you to visualize data over time and identify trends and patterns.

5

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Collaborate & share

Facilitate real-time collaboration by sharing your maps and analyses with team members and stakeholders.

Use comments and annotations to discuss insights directly on the map, ensuring everyone is aligned and informed. Keep everyone on the same page with synchronized updates and notifications.

Emily Thompson

3 min ago

Notice the shift in land cover from urban sprawl to lush greenery, indicating a positive environmental change

Reply

Live cursors

Public links

Embeds

Real-time collaboration

Collaborate in real-time in the same project. Say goodbye to sending local files back-and-forth.

Noelle

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Designed to be easily updated

Web maps are live assets designed to be edited, and any changes will be automatically updated synced across all members.

No more endless file versions

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These features make Atlas a valuable tool for various applications, including urban planning, infrastructure management, environmental modeling, and mobility analysis. The ability to process territorial information in real-time and share it among different stakeholders makes it a useful support tool for those who need to make decisions based on spatial data. Additionally, the software's ability to generate high-quality visualizations and reports allows decision-makers to communicate findings more effectively and develop strategies based on solid data-driven insights.

In the context of the pilot project for hydrogen development in the Veneto Region, the project aims to create a GIS-based decision support system that enables the visualization and analysis of potential hydrogen demand, providing useful insights for planning infrastructure and investments in the energy sector.

The use of Atlas in the pilot project addresses several specific needs:

- Spatial representation of hydrogen demand: the software allows mapping of potential hydrogen demand on a territorial scale, using data related to population distribution, industrial activities, and mobility flows. Understanding where hydrogen will be needed most helps in prioritizing infrastructure investments and aligning them with economic and demographic trends.
- Analysis of existing infrastructure: the ability to integrate data on transportation networks and energy facilities helps identify the most suitable areas for locating new hydrogen-related infrastructure. This includes evaluating proximity to renewable energy sources, existing energy grids, and major industrial hubs that could benefit from hydrogen adoption.
- Support for the evaluation of development scenarios: through spatial analysis tools, it is possible to model different demand growth scenarios and simulate the effects of various investment strategies. Decision-makers can assess multiple pathways for hydrogen deployment and select the most viable options based on economic, technical, and environmental considerations.
- Consultation tool for institutions and stakeholders: the platform enables data sharing among public and private entities involved in the project, facilitating coordination and the formulation of shared strategies. Since hydrogen development requires the collaboration of multiple stakeholders, including energy providers, industry leaders, and policymakers, Atlas ensures that all parties have access to the same information and can contribute to a cohesive strategy.
- Accessibility and ease of use: as a browser-based software, Atlas does not require complex configurations and can be easily adopted by public administrations and energy sector operators. This simplifies data access and ensures that decision-makers can integrate GIS-based insights into their planning processes without requiring extensive technical expertise.

The use of Atlas in this context allows for the integration of economic, demographic, and infrastructural data into a single platform, enhancing analytical capacity and optimizing investment planning.

Furthermore, Atlas helps in identifying potential barriers to hydrogen deployment, such as land-use restrictions, regulatory constraints, and environmental considerations. By visualizing these factors within an integrated spatial framework, policymakers can proactively address challenges and create more resilient and adaptable hydrogen development plans.

Through this approach, the Veneto Region gains access to a tool that facilitates the monitoring of energy policies, supporting a more structured decision-making process based on in-depth territorial analysis. By leveraging GIS technology, the region can enhance its capacity to plan and implement hydrogen-related projects efficiently, ensuring that investments align with broader sustainability objectives and contribute to the region's long-term energy resilience.

Tool Design phase

To address these needs, UnionCamere Veneto has structured its work methodology around a multi-phase approach that integrates stakeholder engagement, data collection, spatial analysis, and decision support. The first phase of the project has involved an extensive consultation process, where key industry representatives, policymakers, research institutions, and local authorities have been involved in defining the objectives and scope of the hydrogen strategy. These discussions have enabled the identification of the most relevant parameters to be included in the pilot project, ensuring alignment with the broader energy transition goals of the Veneto Region.

Following this initial phase, UnionCamere Veneto has focused on data acquisition and structuring, leveraging its Research Center's expertise in gathering statistical and economic information. The core of this effort has been the integration of hydrogen-related questions into surveys targeting manufacturing enterprises, thereby obtaining detailed insights into the current energy consumption and potential interest in hydrogen adoption. This data collection strategy has been complemented by the incorporation of external sources, including ISTAT data on population and mobility trends and the Veneto Region's official energy consumption statistics, ensuring a comprehensive dataset that reflects real-world conditions.

Once data has been gathered, UnionCamere Veneto has applied advanced geospatial analysis to map energy consumption and hydrogen demand across the region. This step has involved:

- Geolocating industrial sites and transport hubs to visualize where hydrogen infrastructure could be most effectively deployed.
- Applying conversion factors to estimate hydrogen demand based on existing energy consumption patterns.
- Overlaying multiple data layers to create a spatially explicit model of the hydrogen economy.

«fresh» data collection	State of the art on the territory	Dashboard for policy choices	Policy impact on the territory

The GIS-based tool developed within the project enables policymakers to interact with a dynamic mapping system, conducting queries, evaluating different scenarios, and assessing the impact of potential hydrogen investments. UnionCamere Veneto collaborates with the Veneto Region's Energy Department to ensure that the insights generated by this tool are effectively integrated into policy frameworks and regional planning instruments. This collaboration guarantees that hydrogen-related initiatives are not only technically feasible but also economically and socially viable.

The final phase of the methodology focuses on decision support and policy recommendations that will be indeed included in the Deliverable 2.1.3.

Data sources and data sets

Topic	Sector	Data type	Source	Provider
Industry	Manufacturing companies	Energy consumption of manufacturing companies (38.794)	Annual Survey of Unioncamere del Veneto (v) on the manufacturing companies based in Veneto (38.794), registered in the Business Register of the Chambers of Commerce and active on the 28th February 2018, belonging to section C of the ATECO-Istat classification of economic activities and with a size greater than or equal to 10 employees	Unioncamere del Veneto
Residential	Residents	Number of residents per Municipality > Consumption per Municipality (estimation)	ISTAT, 2024	ISTAT, 2024
Agriculture		Fuel consumption at the municipality level (estimation)	Agricolture Fuel Voucher (Veneto Region)	Veneto Region (online data
Transport	Road	Car registrations (per Municipality)	Annual registrations / immatricolazioni	ACI

		Heavy Truck > Fuel consumption (estimation)	Traffic flows	
	Rail	Number of circulating trains per type Fuel consumption (estimation)	Regional Rail Plan Trenitalia/RFI	Trenitalia
	Maritime	Overall fuel consumption for navigation of the North Adriatic Sea Port Authority (2 ports: Venice + Chioggia)	North Adriatic Sea Port Authority, Regional Transport Plan	North Adriatic Sea Port Authority (ongoing)

Table: Input data sources

The primary source: Veneto Congiuntura datasets

The development of the GIS platform for the Veneto Region's hydrogen planning is grounded in a robust and comprehensive data collection framework. A key foundation of this initiative is the data provided by Unioncamere Veneto, which serves as the primary source for understanding energy consumption trends and industrial dynamics across the region.

The Annual Survey of Unioncamere del Veneto, along with the quarterly business cycle survey on the manufacturing sector, provides a detailed and statistically validated dataset that offers a clear representation of economic activity, industrial energy consumption, and sectoral trends.

This dataset represents the true added value in the data collection process, as it ensures that hydrogen-related planning is based on real-world economic conditions rather than estimations. The integration of spatial economic data into the GIS platform allows policymakers to accurately map hydrogen demand and align infrastructure development with industrial and territorial needs.

This approach enhances decision-making by ensuring that hydrogen investments are strategically positioned where demand is highest and where the transition to hydrogen-based energy systems can be most effectively supported.

Unioncamere Veneto, in collaboration with regional Chambers of Commerce, conducts indeed a quarterly business cycle survey on the manufacturing sector. The main goal is to monitor the economic performance of manufacturing companies in the region by analyzing trends in:

- Production output
- Total and foreign revenue
- Domestic and international orders

The survey provides sectoral, territorial, and temporal insights, with comparisons to both the previous quarter and the same quarter of the previous year. The results are representative at the regional level for 13 manufacturing sectors, three size classes, and seven provinces in Veneto.

Target Population

The reference population consists of 38,794 manufacturing companies registered in the Veneto Chambers of Commerce business registry as of February 28, 2018. It includes only companies with at least 10 employees, classified under ATECO-Istat 2007 (Section C - Manufacturing Activities).

Sampling Plan

The survey adopts a one-stage stratified sampling design based on sector, company size, and province. The Neyman optimal allocation method is used to minimize variance in production trend estimates. The plan is adjusted to ensure homogeneous representativity across all strata, using weighting coefficients to align sample data with the total business population.

The effective weights are calculated based on:

- The ratio of the total population in each stratum to the number of surveyed firms.
- Adjustments for revenue data, considering external production and the share of foreign orders.

Data collection is managed by the Unioncamere Veneto Research Center, which administers a structured questionnaire through a mixed-mode methodology, including:

- CAWI (Computer-Assisted Web Interviewing)
- CATI (Computer-Assisted Telephone Interviewing)
- Fax-based responses

The survey is conducted using the IDSURVEY platform, which provides businesses with secure online access to complete the questionnaire.

Data Quality Control

The quality assurance process includes:

- Verification of business lists, ensuring correct contact details (phone, fax, email).

- Coding of telephone survey responses to standardize data entry.
- Use of replacement lists to maintain sample representativity.
- Validation of survey responses to detect and correct anomalies, inconsistencies, or missing values.
- Additionally, data entry software includes real-time logic checks to prevent non-sampling errors at the point of data collection.
- Processing of Workforce and Revenue Data
- Post-survey data corrections are applied to company workforce and revenue figures to adjust for missing or incorrect values.
- Revenue per employee is validated against external databases to ensure consistency.
- Companies with outlier revenue-to-employee ratios are adjusted using the sectoral median value.
- Outlier Detection and Treatment
- Outliers in revenue per employee are detected using rank distribution analysis, eliminating extreme values outside the top and bottom 5%.

Additional outlier checks are conducted for key variables, including revenue, orders, and production trends, with extreme deviations flagged and adjusted accordingly.

GIS data representation

Methodology

The following section describes the methodology used to develop the GIS platform for the Veneto Region, detailing how data was processed, integrated into the Atlas software, and structured for visualization and analysis by end users.

This platform represents a crucial tool for policymakers, allowing them to assess energy consumption trends at a highly granular level and make informed decisions about infrastructure investments, energy policy, and sustainability initiatives.

The GIS platform was specifically designed and customized to meet the needs of the Veneto Region using Atlas software, which was previously described in this document. The tool was tailored to the regional context, ensuring that it aligns with local energy policies and supports decision-making processes effectively.

The decision to adopt a spatial analysis approach was driven by the need to create a data-driven, evidence-based foundation for policy interventions, where geospatial intelligence plays a key role in understanding energy distribution patterns.

Data Processing and Standardization

The data collected covers multiple energy consumption sectors, including industrial, commercial, residential, and transport energy use. It has been structured and organized in a way that ensures homogeneity and comparability across different datasets. This harmonization process allows for direct comparisons and enables analytical operations to be performed efficiently, providing a comprehensive and integrated view of energy consumption across the region.

To ensure consistency in measurement, all energy data from various sources have been converted into TOE (Tons of Oil Equivalent) per year.

This standardization process enables a unified framework for energy analysis, facilitating comparisons between different sources such as electricity, natural gas, biomass, and hydrogen. Using TOE as the reference unit allows policymakers to analyze the impact of energy transition scenarios, including the gradual shift from fossil fuels to renewable sources and hydrogen-based solutions.

Additionally, for a uniform spatial representation, it was decided to use the municipal geographic level as the reference base.

This choice ensures that data can be analyzed at different levels of detail, from the municipal scale to aggregated provincial and regional levels. The cartographic base utilized is the open-source dataset provided by the Veneto Region, ensuring compatibility with other regional datasets and maximizing data accessibility.

The open-data approach guarantees that information can be shared across institutions, fostering a collaborative framework for regional energy planning.

Data Organization and Visualization

Once standardized, the data was organized into structured tables with respective attributes, making it easier to query and analyze. Each dataset includes metadata on its source, methodology, and temporal coverage, ensuring full transparency in the decision-making process.

The GIS platform was designed to be flexible and scalable, allowing for further data integration and future expansions. This means that as new energy consumption trends emerge, such as the increasing use of hydrogen and renewable energy technologies, the system can seamlessly incorporate updated datasets without requiring extensive modifications.

One of the key strengths of the tool is its ease of adaptability, which enables additional energy sectors to be incorporated seamlessly. This feature ensures that the platform remains relevant over time and can be expanded to address new analytical needs and policy challenges.

By maintaining a modular structure, the tool can support the integration of additional layers of information, such as demographic trends, economic indicators, and environmental impact assessments.

The GIS platform allows users to visualize energy consumption across different sectors at the municipal level, providing the highest possible level of detail. This high-resolution representation allows policymakers to pinpoint energy demand hotspots, identify opportunities for efficiency improvements, and plan targeted infrastructure investments.

Furthermore, by integrating historical data series, the platform enables trend analysis, allowing decision-makers to monitor the evolution of energy demand over time and assess the impact of regional energy policies.

Analysis and Data Aggregation Capabilities

The tool is designed to support sectoral and geographic aggregation, enabling users to analyze trends at different scales. Users can:

- Select individual energy sectors for visualization, such as industrial, commercial, residential, or transport energy consumption.
- Combine multiple sectors to view cumulative energy consumption patterns, understanding cross-sectoral interactions and synergies.
- Aggregate data across multiple geographic areas, providing a regional or sub-regional perspective on energy consumption dynamics.
- Compare different time periods to evaluate the impact of policy interventions and technological advancements.

By offering these analytical capabilities, the GIS platform serves as a powerful decision-support tool, providing policymakers with a clear and comprehensive map of energy consumption by sector across the territory.

This enables more effective planning and targeted policy interventions, ensuring that investments are aligned with actual needs and projected demand trends.

Interactivity and Customization Features

The GIS platform is designed to be interactive and user-friendly, allowing users to customize their analyses according to their specific needs. The tool enables:

- Filtering by energy source, so users can focus on specific types of consumption (e.g., electricity, hydrogen, natural gas).
- Custom queries, enabling stakeholders to analyze data based on selected parameters such as energy intensity, per capita consumption, or emissions impact.
- Overlaying of different datasets, allowing for a multidimensional analysis that integrates economic, demographic, and environmental variables.
- Scenario modeling, where policymakers can simulate different energy transition pathways and assess their potential impact.

The flexibility of the system ensures that it can be continuously updated and improved, making it a long-term strategic asset for the Veneto Region's energy planning efforts. Its capability to integrate new datasets and adjust to evolving policy priorities makes it a key resource for addressing future challenges in energy transition and decarbonization.

Screenshots from the GIS Platform

Below are some screenshots directly taken from the tool, illustrating its functionalities and data visualization capabilities. These visual representations provide an intuitive way to explore energy consumption patterns, facilitating engagement with stakeholders and enhancing public transparency on energy policies.

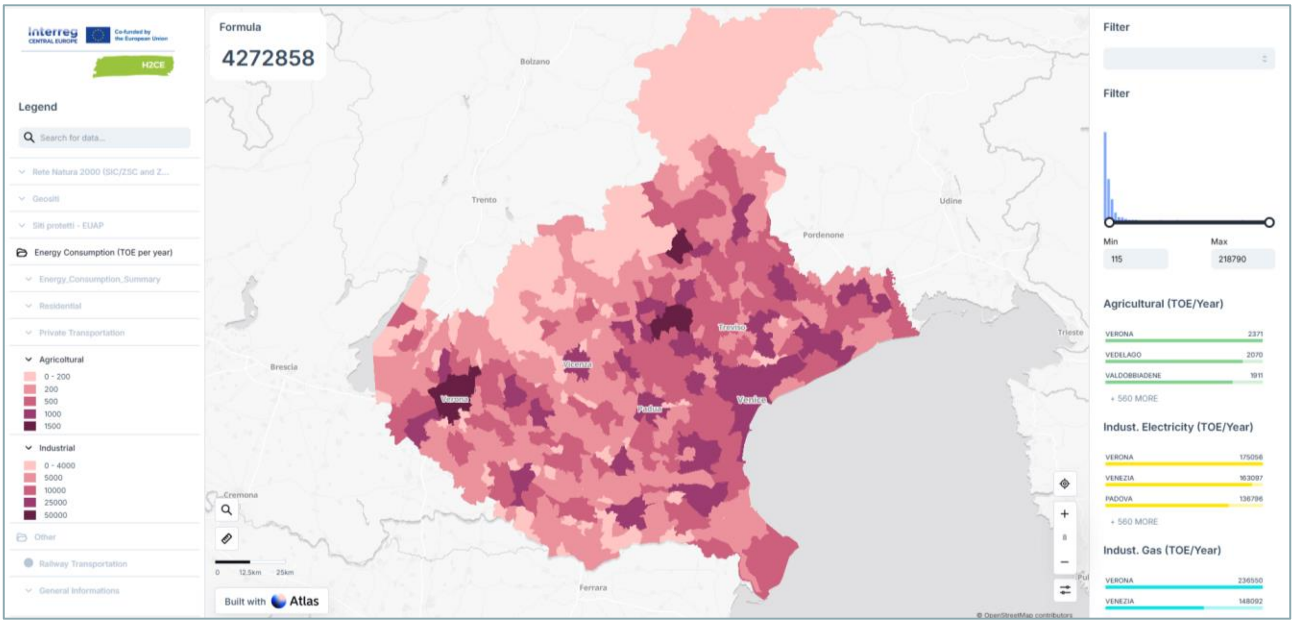

Figure 1:GIS Tool, landing Page

Figure 2:GIS Tool, data queries

Figure 2:GIS Tool, data selector and filter options

Decision Maker Dashboard configuration

The GIS platform developed for the Veneto Region is not only a representation of the current state of energy consumption but also a strategic decision-support tool.

This transformation allows policymakers to simulate different scenarios and assess the impact of hydrogen transition policies in real-time, helping them shape a more sustainable and efficient energy strategy.

The tool enables decision-makers to easily evaluate and plan energy conversion strategies by providing an instantaneous quantitative and geographic representation of energy consumption.

Based on conversion choices toward hydrogen, the platform dynamically updates to reflect the projected changes in energy distribution across different sectors and geographic areas.

This real-time feature enhances its usability for policy and planning purposes, making it an invaluable tool for regional energy transition.

The Dashboard: The Core of the GIS Platform

At the heart of this tool is the dashboard, a control center that allows users to configure strategic decisions regarding which energy consumption sectors to convert to hydrogen.

The dashboard was chosen as the primary interface because energy consumption will not shift from a single energy source to hydrogen but rather evolve into a mixed-energy model combining multiple fuel sources.

This approach is particularly crucial in the current phase of transition, where gradual energy diversification is required before achieving full hydrogen adoption.

The dashboard provides policymakers with the flexibility to adjust transition scenarios, understanding how different levels of hydrogen adoption will interact with other energy sources.

Functionality of the Dashboard

The dashboard allows users to select a conversion percentage for each energy sector—ranging from 0% to 100%—to simulate how that sector would transition to hydrogen usage.

- A custom indicator has been created that enables users to select any fraction between 0% and 100% for each sector, immediately displaying how this change impacts the overall energy mix.
- This functionality ensures that users can test multiple conversion scenarios and adjust strategies dynamically based on policy objectives and technological advancements.
- The dashboard facilitates real-time monitoring of hydrogen integration into the energy grid, helping stakeholders make informed decisions based on accurate projections.

Below is a screenshot of the dashboard, showcasing its interactive elements and simulation capabilities.

Visualizing the Impact of Energy Transition

The GIS platform allows users to select their preferred energy mix and instantly see the effects of these choices on different geographic scales:

- At the regional level, to evaluate how hydrogen adoption impacts the entire energy ecosystem.
- At a sub-regional level, to analyze how different territories are affected.
- At the municipal level, to understand local implications of energy conversion and plan site-specific interventions.

Figure 4:GIS Tool, dashboard slider selector

Display Results

The calculation of the transition from traditional fuels to hydrogen is based on conversion factors derived from sector-specific technical literature. These conversion factors allow the tool to compute, in real-time, how different fuel types interact within the energy mix.

- The tool updates these conversion factors dynamically, integrating them with traditional energy consumption data to provide an up-to-date view of the configured energy mix.
- The conversion factors used in this tool are parameterized, meaning they can be easily modified to reflect changes in industry standards or emerging technological advancements.
- This flexibility was intentionally incorporated, as the hydrogen sector is rapidly evolving, ensuring that the tool remains adaptable and optimizable for future scenarios.

Displaying Results and Impact Assessment

The tool provides a detailed analysis of the impact of different energy transition scenarios:

- The numerical results display the total tons of fossil fuels saved by using the selected energy mix configured in the dashboard.
- The numerical results also show the total tons of CO_2 emissions avoided through the adoption of the configured energy mix.

- These outputs enable policymakers to measure the environmental and economic impact of their strategic choices in real-time.

Below are some screenshots that illustrate how the results are visually represented within the GIS platform.

Visualizing the Impact of Energy Transition

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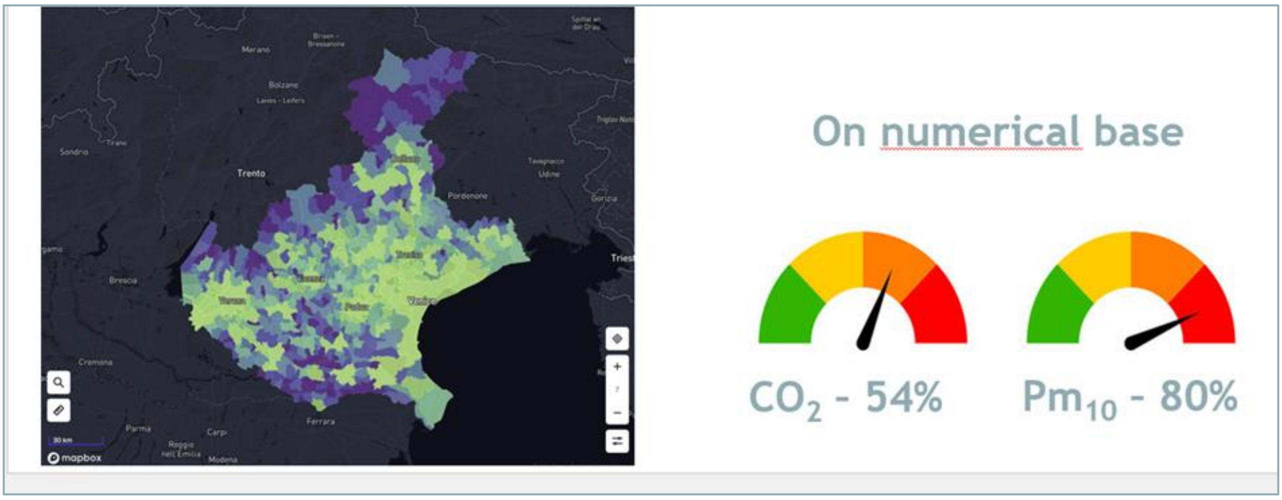

Figure 5: GIS Tool, result editing, geo distribution and quantitative evaluation

Evaluation

The evaluation of the tool is a fundamental step in validating its effectiveness and usability. A comparative analysis of the platform's use has been conducted, involving both technical experts and decision-makers, ensuring that the tool meets both analytical and policy-planning needs.

The feedback received has been overwhelmingly positive, with users appreciating the tool as a highly valuable decision-support system. The evaluation highlights several key benefits of the GIS platform:

- It provides a clear understanding of energy consumption patterns, both in aggregated and disaggregated forms, offering an accurate representation of the current energy landscape.
- It allows real-time visualization of the impacts of transition policies toward hydrogen, offering policymakers immediate insights supported by clear and structured data.

- It is a user-friendly tool, despite its complex computational structure, making it accessible to both technical and non-technical users.

It is a highly flexible tool that can be replicated, improved, and adapted to various energy sectors and territorial contexts, ensuring long-term scalability and usability.

Given these strengths, the evaluation confirms that the GIS platform is an essential tool for regional energy planning. Its strong potential for further developments paves the way for additional refinements and future integrations, making it a cornerstone for advancing the energy transition in the Veneto Region.

4. GIS-based tool developed in Styria

Introduction and objectives of the Planning Tool

The development of a sustainable hydrogen economy is a key component of the energy transition. To enable efficient planning and implementation, a GIS-based planning tool is being developed for Styria. This tool allows for the geographical representation and analysis of hydrogen production, demand, and existing infrastructure.

The goal of the planning tool is to provide a data-driven decision-making foundation for business, public authorities, and other stakeholders. It aims to help identify potential production sites, optimize transport routes, and ensure supply security.

QGIS is used as the GIS tool. QGIS is an open-source geographic information system (GIS) that allows users to analyse, visualize, and edit spatial data. It enables the creation of maps, processing of geodata from various sources, and execution of complex spatial analyses. Additionally, it is used for planning, environmental analysis, and infrastructure projects.

Methodology and Approach

Identification of Stakeholders

The first step in developing a GIS-based planning tool involved identifying and engaging key stakeholders who play a significant role in hydrogen value chain. These include the following sectors:

- **Industry**

  Large-scale consumers such as steel, chemical, and glass manufacturing companies, which require hydrogen as a feedstock or energy source.
- **Energy Providers**

  Renewable energy producers, grid operators, and hydrogen producers that can supply green hydrogen.
- **Mobility Sector**

  Public transportation operators, logistics companies, and vehicle manufacturers interested in hydrogen-based mobility solutions.
- **Public Institutions and Policymakers**

  Government agencies, municipalities, and regulatory bodies responsible for hydrogen infrastructure planning and funding programs.
- **Research Institutions**

  Universities and technology centres contributing expertise in hydrogen production, storage, and distribution.

Companies with the following NACE classification were identified as companies relevant to the development of a hydrogen economy:

- **B05-09** - Mining and quarrying
- **C17, C19-C30** - Manufacturing of goods
- **D35** – Electricity, gas, steam and air conditioning supply
- **F42** – Civil engineering
- **H49** and **H52** – Transportation and storage

In Styria, a total of 3,000 companies fall into this classification. However, 35 companies can be named as the most important Styrian companies in the field of hydrogen economy. For the industrial sector, 22 energy-intensive companies are relevant because they account for 85 % of gas consumption and around 44 % of electricity consumption. These companies are also shown on the map but not in detail so that no conclusions can be drawn about the individual companies. In collaboration with the state of Styria and the Styrian Chamber of Commerce, a questionnaire on the topic of hydrogen was created for these companies. The survey is thematically very broad and attempts to cover all economic areas of a hydrogen economy (industry and commerce, energy supply, mobility, component production, research and development). The result provides real data that reflect the current state of the hydrogen economy in Styria and can serve as a basis for deriving future developments. The survey was sent out to a total of 1,700 companies and first results are expected soon.

In a first step we collected data that we already have in-house about other projects. Next, we requested data from the state of Styria, which is already accessible and retrievable in the GIS maintained by the state of Styria. The energy suppliers themselves are an important source of data. Unfortunately, due to data protection regulations, many data cannot be passed on to third parties. For example, the exact rout of power lines, substations, long-distance gas lines or information on electricity production quantities.

Requirements Specification

To ensure that the planning tool meets practical needs, a comprehensive requirements specification was conducted based on the stakeholder interviews and existing research. The requirements specification serves as the basis for creating the GIS-based map. The map should be structured to contain information about existing and potential hydrogen infrastructure and applications. The potential locations for hydrogen plants should be able to be located sensibly while testing their usefulness with regard to the area of application.

The following questions are addressed in the requirements specification:

- Which parameters are generally essential for an accurate assessment of the H_2 location selection?
- Which spatial, point, line and area units are required for this?
- What data types are the associated data packages divided into (e.g. text, shape, formulas etc.)?
- Which data is already available, and in which form of representation?
- What data is still missing and who/how can it be provided?
- Is there a need for newly generated date (e.g. calculations, optimization, simulation etc.)?
- In what way must the data be prepared for targeted use?
- For uniform and mutually understandable date processing, the required structures are divided into the required column headings application name, object ID, formula, short name/meta information, layer, unit, classification, format, spatial unit etc. presented in tabular form.

To create the mock-up, a data concept was developed that includes the following columns and the following date set (). The content to be entered there is also described as follows. Unless otherwise described, the quantities mentioned in the date sets are described for an entire calendar year.

Table 1: Data concept

Designation	Description
Group	Description of the basic group to which the data record can be assigned (e.g. borders, traffic routes, hydrogen)
Parameter	More specific representation of which parameters the entered data set contains (e.g. national borders, district borders, mobile hydrogen storage)
Module name	Collective terms are defined to cluster data (e.g. basic maps, locations, line infrastructure)
Data source/data holder	Possible data sources for obtaining the data sets (e.g. State of Styria department 17, AGGM, Heat Atlas)
Geometry	Representation of the geometry of the data set and, if no geometry is necessary, description of the other type of data set (e.g. key figure for truck journeys)
Data set description	Description of the data set a closer understanding of what it contains (e.g. national borders for basic geographical orientation)
Attribute	If one or more attributes are assigned to the spatial unit, description of the attribute(s) (e.g. country name, network kilometre, number of bus lines)
Attribute unit	The (quantity) unit assigned to the attribute(s) (e.g. name, km, m^2, Nm^3/a)
Spatial unit (output)	Description of the spatial unit of the data set (e.g. all border lines in Styria, the entire natural gas pipeline network in Styria)
Attribute comment / description	More precise attribute description and information on other aspects such as in the case of intersections of several data (e.g. all border lines of the federal state of Styria as a basis for better orientation, tunnel location, intersection of road networks and bodies of water)
Placeholder for other countries	To consider the transferability of the selected region of Styria in the requirements specification to other partner countries of the H2CE project, especially if these do not play a role in Styria but do in other countries, for example other territorial subdivisions (e.g. “district” in Germany or in other countries oceanic waters are also relevant)

To develop the requirements specification, several interviews were carried out with stakeholders. These interviews provided insights into current needs, challenges and future developments in hydrogen infrastructure. Their input was essential in shaping the functional and technical requirements of the tool. A total of eight stakeholders were interviewed:

Table 2: Stakeholder interviews

Interview partner	Company and Sector
Thomas Starzer	Voestalpine - Production of components made of steel and metal (industry)
Norbert Adler	Chamber of commerce and Kühne+Nagel (logistics company)
Karl-Heinz-Rink	Industrial association - Masterplan Green Energy 2040 (industry)
Philipp Wünscher	Energy Styria (energy provider)
Stefan Fink	E-Netze Styria (operation, maintenance, and expansion of electricity and gas distribution)
Martin Sagmeister	HyCentA (research)
Markus Simbürger	Green Tech Valley (public institution)
Christoph Zirngast	State of Styria (state government - Department 15 Energy, Housing, Technology)

The interviews were structured in such a way that the project was presented first and then the purpose of the GIS-based map we were planning. We asked the interview partner similar questions to be able to compare later, but also specific ones depending on the sector. The interviews took place once and with some interview partner even several times. During the interviews it was also discussed and clarified whether important and essential data for the map could be exchanged. Several appointments were necessary for this specific question.

Data Basis and GIS Integration

For a GIS map to provide meaningful information and insights on hydrogen, it should include at least the following **essential data layers**:

Hydrogen Production

- Locations of existing hydrogen production facilities (electrolysis, steam methane reforming, biomass-based)
- Type of hydrogen production (green, blue, grey hydrogen. Even if only green hydrogen is to be produced in the future, green hydrogen is not currently being produced and used)
- Water resource availability for electrolysis processes
- Land availability and zoning regulations affecting the establishment of production facilities

Hydrogen Demand

- Industrial sites with high H_2 demand (e.g. steel, chemical, and glass industries)
- Energy supply (H_2 for power plants, decentralized fuel cells)
- Future demand projections for different sectors
- Existing and projected mobility hubs that may transition to hydrogen-based transport
- Urban areas where decentralized hydrogen applications (heating, power generation) could play a role

Hydrogen Infrastructure

- Existing hydrogen pipelines and transport routes
- Planned pipelines projects or hydrogen hubs
- Storage facilities (salt caverns, high-pressure tanks, LOHC)
- Integration with existing energy infrastructures (natural gas grid, electricity grid)
- Locations of major energy transmission networks (electricity and natural gas) that could be leveraged for hydrogen transport.

Renewable Energy Sources for green hydrogen

- Locations of wind, solar, and hydropower plants
- Potential areas for renewable energy expansion
- Grid capacity for feeding electricity into electrolysis

Transport and Logistics Network

- Road and rail networks
- Shipping routes for potential H_2 export and/or import.
- Locations of multimodal logistics centres with H_2 applications.

Regulatory and Economic Data

- Regional and national policies affecting hydrogen development.
- Economic incentives, funding programs, and investment opportunities.
- Carbon footprint assessments and environmental impact considerations.
- Funding programs and regulatory requirements.
- Regional development plans for the hydrogen market.
- Tax incentives and subsidies for H2 projects.

Geological and Environmental Factors

- Suitable geological formations for underground H2 storage (e.g. salt caverns).
- Protected areas and environmental restrictions (no hydrogen production in sensitive regions).
- CO2 footprint of different hydrogen production methods.

To summarize this: for basic analysis, the GIS-based tool should at least include **production sites** (existing and potential), **hydrogen demand** (industry, mobility, energy), **infrastructure** (pipelines, storage, refuelling stations), **renewable energy sources** (to assess green H_2 potential) and **transport routes** (for logistics planning).

The integration of this diverse data within a GIS framework allows for spatial analysis, scenario simulations, and strategic planning. By providing interactive maps and data overlays, the tool supports informed decision-making for hydrogen-related projects in Styria.

Results and presentation

The maps in this chapter represent the following points:

- Renewable energy sources
- Current situation of hydrogen
- Planned hydrogen expansion

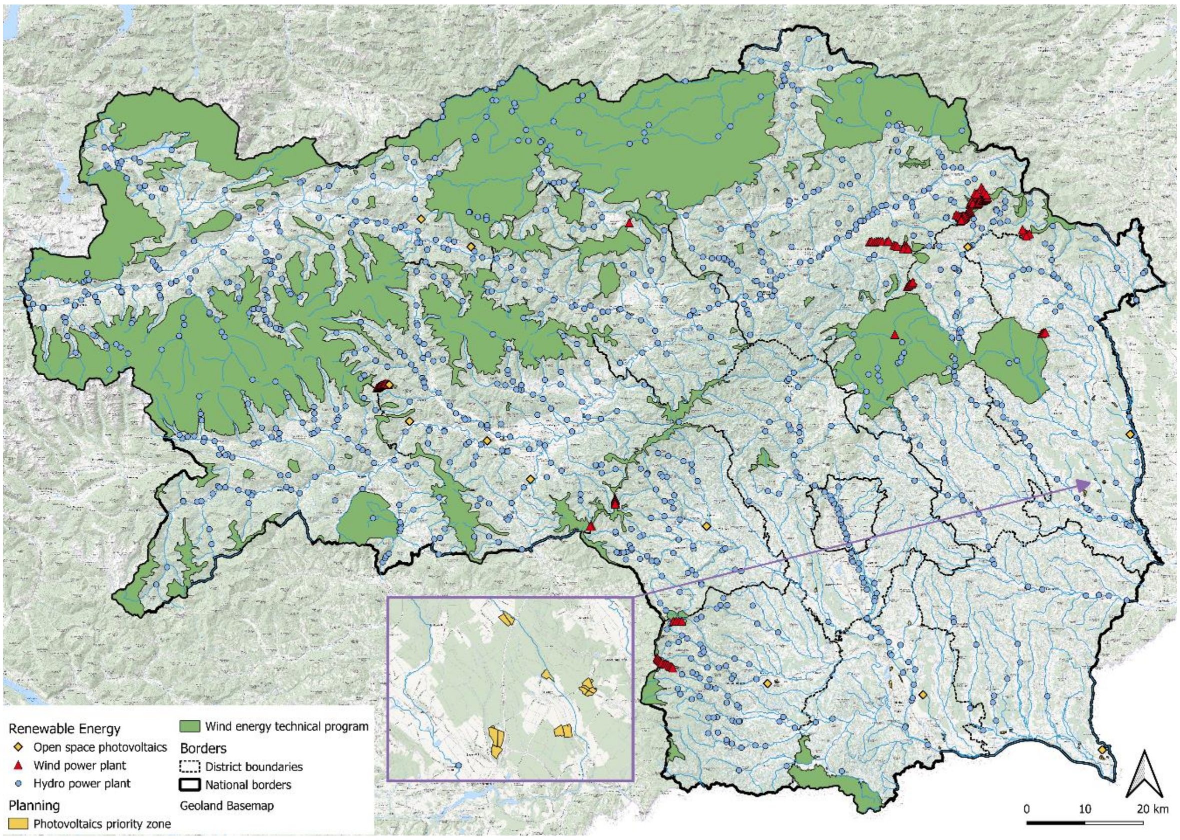

Figure 2: Renewable energy sources

Figure 2 shows the renewable energy sources photovoltaics, wind and hydro power in Styria. On the one hand, we received the data from the state of Styria, and on the other hand, we generated it ourselves (e.g. open space photovoltaics). The wind energy technical program sets guidelines for the spatially compatible expansion of wind energy to increase the share of electricity generation from renewable sources. It serves as an instrument of balance land-use demands in energy supply and economic development with environmental concerns such as natural and landscape protection. By defining priority and suitability zones, it establishes reliable framework conditions for the expansion of wind power in the region. The priority zones for photovoltaic in Styria are designated areas approved by the state government for large-scale solar farms. A total of 36 zones covering about 780 hectares have been identified based on suitability and environmental impact. These zones aim to promote solar energy expansion while ensuring nature and landscape protection.

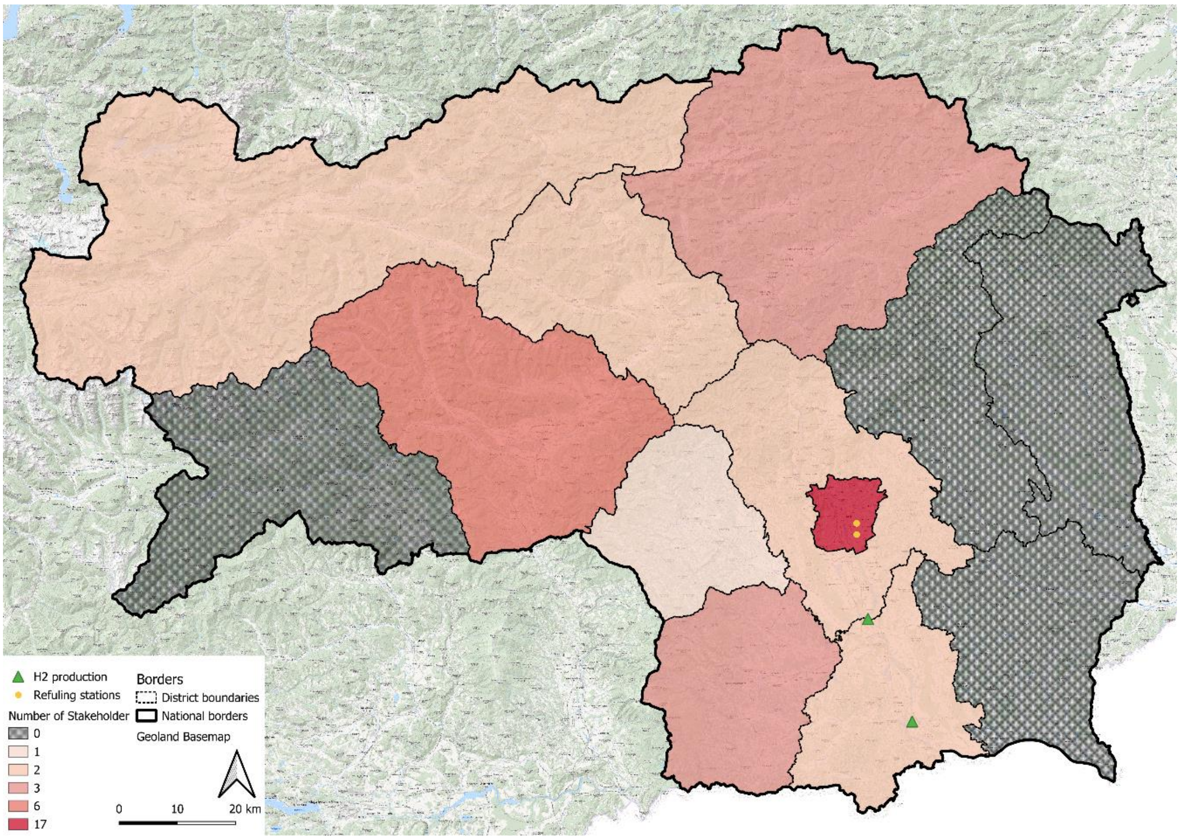

Figure 3: Current situation of hydrogen in Styria

Figure 3 shows the current situation of the hydrogen economy in Styria. Green hydrogen is currently being produced at two locations in Styria. There is a 1 MW electrolyzer in Gabersdorf and a 0.15 MW electrolyzer in Fernitz-Mellach. There are two hydrogen refuelling stations. The first was built by HyCentA and the second by OMW. There is currently not a single hydrogen pipeline in Styria.

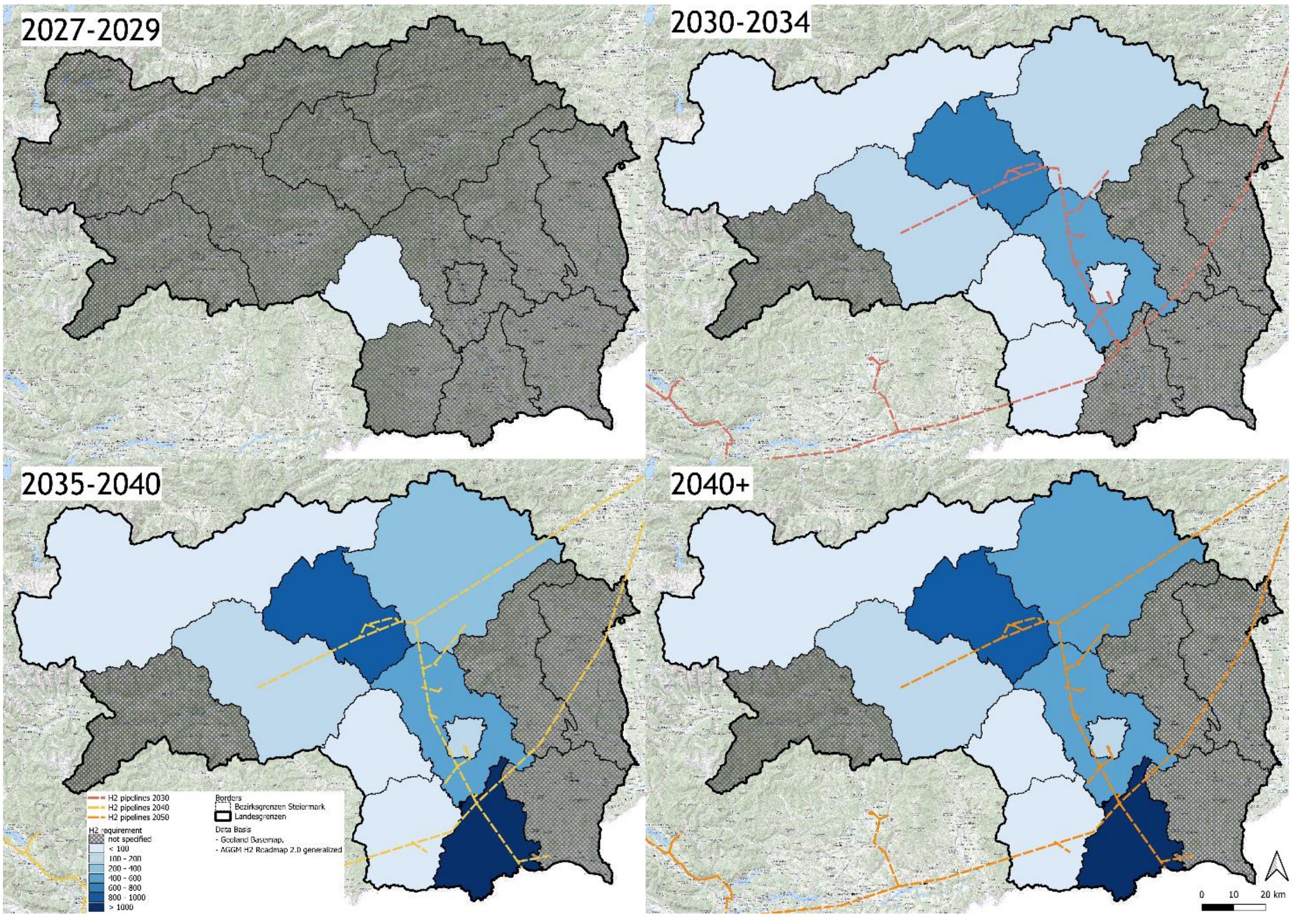

Figure 4: Hydrogen demand and future infrastructure

Figure 4 shows the hydrogen demand in the next few years up to 2040+. Furthermore, the hydrogen pipes can be seen in a generalized form in the figure. In the period between 2023-2029, 70 km of hydrogen pipelines will be newly built, and 82 km will be repurposed in Austria. However, these infrastructure measures do not affect Styria but other federal states. In the period between 2030-2034 will hydrogen pipelines in Styria be repurposed and newly built. In Styria, mainly gas pipelines are being repurposed for hydrogen. Over the next few years, additional lines will be repurposed, and a few new ones will be built. After 2040, a total of 974 km will have been newly built and 1,420 km repurposed. The figures also show that the demand for hydrogen will increase in the individual districts.

For a comprehensive analysis, data with a certain level of granularity is necessary. Certain queries, such as a suitable location for hydrogen production, can only be made if sufficient data is available. In order to enable access to data and information, it is necessary to work together at different levels. For example, energy supplier know how much electricity the photovoltaic system generates, but do not pass on this data. They also know, when and how much excess electricity they have.

5. Conclusions

This report outlines the pilot projects developed by the Veneto Region and the Styria Region to create a GIS-based decision-support tool.

- The preceding sections have provided detailed descriptions of the methodology, structure, and data used in each of these initiatives.
- Throughout the project, the two partners engaged in continuous discussions to align their approaches and adopt a common methodology, which was then adapted to the specific characteristics of each region.
- This shared framework allowed for a broader field of application, with Veneto focusing on GIS representation and the development of a dashboard for policy impact analysis, while Styria concentrated on distribution infrastructure aspects.
- The ability to rely on a common methodology, subsequently implemented in interoperable prototypes enriched with multiple functions, has enhanced the project's outcomes and demonstrated its effectiveness within the H2CE initiative.
- User evaluations confirm that GIS-based decision-support tools are essential for guiding policymakers in shaping energy transition policies toward new fuels, particularly hydrogen.
- The tools developed in both Veneto and Styria are highly flexible, capable of incorporating additional data, and adaptable to various territorial contexts.
- The success of the prototypes strongly suggests the need for broader implementation, leveraging the knowledge gained during the H2CE project.
- These tools, developed as part of the initiative, provide a concrete solution for supporting the transition toward hydrogen use, marking a significant step forward in regional and cross-border energy planning.
- The results demonstrated by the prototypes encourage further scaling of the tools, integrating additional functionalities and expanding their applicability beyond the original pilot regions.
- By building upon the achievements of this project, future developments can optimize decision-making processes and contribute to a more sustainable and efficient energy transition on a larger scale.