HySUCCESS

groenvermogen nl | Innovation engine for the green hydrogen economy

An overview of key factors shaping public acceptance of industrial hydrogen developments

Milestone 4.1.1

April 2026

Colophon

This milestone report *An overview of key factors shaping public acceptance of industrial hydrogen developments*[1] has been prepared as part of Task 4, Workstream 4.1 of the Hy-SUCCESS project. The work reported here was carried out by researchers from Leiden University, the University of Groningen, and the University of Amsterdam.

Team

- Dr. Julia M. Burggraaf — Leiden University *(MS4.1.1 Project lead)*
- Dr. Emma ter Mors — Leiden University
- Dr. Lara H. Engelbert — University of Amsterdam
- Dr. Gonzalo F. Palomo Vélez — University of Groningen
- Dr. Lars M. J. van Doorn — Leiden University
- Dr. Marion M. F. Collewet — Leiden University
- Prof. dr. Goda Perlaviciute — University of Groningen
- Dr. Christine Boomsma — University of Amsterdam & National Institute for Public Health and the Environment (RIVM)
- Prof. dr. Frenk van Harreveld — University of Amsterdam
- Prof. dr. Olaf P. van Vliet — Leiden University

How to cite this report

Burggraaf, J. M., ter Mors, E., Engelbert, L.H., Palomo Vélez, G. F., van Doorn, L. M. J., Collewet, M. M. F., Perlaviciute, G., Boomsma, C., van Harreveld, F., & van Vliet, O. P. (2025). *An overview of key factors shaping public acceptance of industrial hydrogen developments*. Hy-SUCCESS, Workstream 4.1, Milestone report 4.1.1.

Acknowledgements

We thank colleagues from Hy-SUCCESS Workstreams 4.2 and 4.3 at Hanze University of Applied Sciences, Utrecht University, University of Twente, Conversion, and Leiden University for sharing their time, expertise, and valuable insights.

Contact

For questions or comments regarding this milestone report, please contact:
Dr. Emma ter Mors
Leiden University
Email: emors@fsw.leidenuniv.nl

[1] In the Hy-SUCCESS programme plan, this report is referred to as “Curated list of key factors behind the acceptability of hydrogen systems (MS4.1.1)”.

Table of contents

1 Executive summary

This report constitutes Milestone 4.1.1 within Workstream 4.1 of Hy-SUCCESS Task 4 on the public acceptance of industrial hydrogen developments. In this report, we adopt a broad understanding of *public acceptance*, encompassing both general evaluations of hydrogen technologies (often referred to as acceptability) and responses to specific, real-world projects at the local level. To ensure a comprehensive review and avoid excluding relevant empirical insights, we include studies addressing both types of public responses under this overarching concept of public acceptance.

This report provides a structured overview of key factors that may shape both general and local public acceptance of industrial hydrogen developments, including production, transport, storage, and related infrastructure. These types of developments are central to the Hy-SUCCESS project and reflect current policy priorities in the Netherlands and Europe, where industrial hydrogen infrastructure is seen as essential for the energy transition.

The report is organised around a four-domain framework based on Boudet (2019) encompassing technology-related, people-related, place-based, and process-related factors. Each domain captures a distinct dimension through which public acceptance is shaped:

- **Technology-related factors**, referring to characteristics of hydrogen developments and their perceived impacts. The perceived impacts include how developments are evaluated in terms of risks, benefits, and broader consequences.
- **People-related factors**, referring to individual and social characteristics. These include levels of knowledge, awareness, and experience, trust in relevant actors, values, emotions, beliefs, perceived social influences, and sociodemographic characteristics.
- **Place-related factors,** referring to the physical and social context of hydrogen developments. This includes how individuals relate to their surroundings and how well hydrogen technologies are seen to fit the local context.
- **Process-related factors**, referring to how decisions about hydrogen developments are made and governed. These include public participation, perceptions of fairness and legitimacy, and compensation.

Within this framework, we (1) identify and describe relevant factors, (2) examine how these factors are reflected in existing empirical literature from Europe on public acceptance of industrial hydrogen developments, and (3) include expert perspectives on prominent factors. The focus on European literature reflects the geographical scope and policy relevance of the Hy-SUCCESS project.

This report can be read as a guide to understanding which types of factors may play a role in shaping public acceptance of industrial hydrogen developments. It is intended to support policymakers, industry stakeholders, and researchers by offering a structured overview of relevant factors and providing an indication of which factors have received more or less attention in empirical literature on industrial hydrogen developments in Europe.

The insights presented here form a foundation for further research and empirical work within Workstream 4.1, which include the examination of the relative importance of factors and their development over time, using methods such as repeated-measures longitudinal surveys and choice-experiments. These insights will also be shared across other workstreams within Hy-SUCCESS and with related GroenvermogenNL work packages, to support alignment between social, technical, legal, and economic analyses of the hydrogen transition. Ultimately, this work contributes to the design of hydrogen systems and decision-making processes that are responsive to societal perspectives.

2 Introduction

Hydrogen is expected to play a key role in Europe's transition towards climate neutrality, particularly in reducing emissions in energy-intensive industries that are difficult to electrify directly (IEA, 2021). This is especially relevant in the Netherlands, where industrial clusters and existing energy infrastructure create both opportunities and challenges for large-scale hydrogen deployment. The development of industrial hydrogen production, transport, usage, storage, and related infrastructure therefore not only represents a major technological shift, but also a broader societal transition.

For this transition to succeed, technical, legal, and economic feasibility alone are not sufficient. Both general and local public acceptance are increasingly recognised as important conditions for the successful and timely implementation of energy infrastructure and industrial developments. Public acceptance may influence project timelines, decision-making processes, and the overall direction of the hydrogen transition.

Research on public acceptance has generated valuable insights across a range of energy technologies (Görsch and colleagues, 2025). However, hydrogen-specific evidence is still limited, particularly with regard to industrial applications and infrastructure across the value chain (Scovell, 2022). As hydrogen developments expand across the Netherlands and Europe, there is a growing need to bring together existing knowledge and provide a clear overview of the factors that may shape public acceptance in this context.

This report is developed as part of Workstream 4.1 of the Hy-SUCCESS project. It provides a structured overview of factors that may shape both general and local public acceptance of industrial hydrogen developments. The analysis is organised around a four-domain framework adapted from Boudet (2019), distinguishing between technology-related, people-related, place-related, and process-related factors.

Within this framework, we (1) identify and describe relevant factors, (2) examine how these factors are reflected in existing empirical literature on public acceptance of industrial hydrogen developments, and (3) include expert perspectives on prominent factors. We adopt a broad understanding of public acceptance, encompassing both general evaluations of hydrogen technologies (often referred to as *acceptability*) and responses to specific, real-world projects at the local level. To ensure a comprehensive review and avoid excluding relevant empirical insights, we include studies addressing both types of public responses under this overarching concept of public acceptance, which we use throughout this report.

In this report, the term 'the public' is used as a general reference. However, it is important to recognise that the public is a heterogenous group, and that perceptions and public acceptance may differ substantially between groups. For example, this may include differences between residents of industrial regions, local communities directly affected by industrial hydrogen developments, and the general population. Recognising this heterogeneity is important for understanding how different factors may operate across contexts and groups.

By focusing specifically on industrial hydrogen developments, this report provides a more targeted perspective than much of the existing literature, which often considers hydrogen applications more broadly. Structured overviews with this specific focus remain scarce, making this a timely contribution to an emerging field.

The insights in this report provide a foundation for further research within Workstream 4.1, including the examination of the relative importance of factors and their development over time, using methods such as repeated-measures longitudinal surveys and choice experiments. The findings will also be shared across other workstreams within Hy-SUCCESS and related GroenvermogenNL work packages, supporting alignment between social, technical, legal, and economic perspectives on the hydrogen transition.

3 Method

We first provide a brief overview of the method, followed by a more detailed explanation of each step. The approach consisted of three main steps:

- Establishing an initial structured overview of factors, followed by refinement of the factors and their descriptions.
- Conducting an empirical literature review, including:
  - Identifying relevant empirical studies.
  - Reviewing each publication for the presence of factors from the framework and recording the results in a dataset.
  - Coding the results as input for the visualisations used in this report, which summarise how often factors have been studied and how they relate to public acceptance.
- Gathering expert perspectives to complement the literature findings.

3.1 Factor overview

The first step was to establish an initial overview of factors, structured around a four-domain framework distinguishing between technology-related, people-related, place-based, and process-related factors. This framework and the initial set of factors were based on Boudet (2019).

Boudet's framework was used as a starting point because it is broad, was developed for new energy technologies, and can be applied to industrial hydrogen systems.

The factors and their descriptions were then refined to better fit the context of industrial hydrogen systems and infrastructure across the value chain. While some factors are based on hydrogen-specific studies, the available evidence is still limited for several areas. To address this, we used expert judgement within the research team and input from Hy-SUCCESS Workstream 4.2 and 4.3 experts.

This means that the framework includes both factors that have already been studied in the hydrogen context and factors that are known to be relevant based on research into other energy technologies.

The refinement process was iterative, combining insights from the literature review and expert input to identify, define, and organise the factors.

3.2 Empirical literature review

The literature was analysed in relation to the factor framework described in Section 3.1.

3.2.1 Literature scope and inclusion criteria

Scientific databases (including Google Scholar and Web of Science) and general web searches (for example Google) were used to identify empirical social science literature on public acceptance of industrial hydrogen developments in Europe. The search covered studies published up to January 2026.

The search strategy was based on core terms related to hydrogen and public acceptance (such as *hydrogen*, *public acceptance*, *social acceptance*, *attitudes*, and *perceptions*), combined with additional targeted searches on specific factors identified during the review (for example, *trust*, *risk perception*, *participation*). The main search query and examples of additional search queries are documented in the dataset and are available upon request.

The analysis focused specifically on the industrial hydrogen value chain, including large-scale production, storage, and transport (such as pipelines, shipping, and associated infrastructure), as well as broader system configurations. These types of developments are central to the Hy-SUCCESS project and reflect current policy priorities in the Netherlands and Europe, where industrial hydrogen systems are seen as essential for the energy transition.

Studies on household applications, end-use consumption, or hydrogen use in the transport sector (such as passenger vehicles) were excluded, unless they were directly linked to industrial hydrogen systems

or infrastructure. These applications were excluded to maintain a clear focus on industrial hydrogen systems, where public acceptance is expected to differ from consumer-oriented applications.

Both peer-reviewed publications and selected grey literature were considered.

Studies were included if they:

- Reported empirical findings (quantitative, qualitative, or mixed methods).
- Measured public acceptance or closely related constructs (such as acceptability, support, opposition, willingness to accept or host, attitudinal measures).
- Included participants from European populations[2].

The empirical literature on public acceptance of industrial hydrogen developments, based on studies conducted in Europe, is still relatively limited in both size and scope. The review should therefore be interpreted as an exploratory overview of an evolving field, rather than as providing definitive conclusions.

In total, 21 empirical publications met the inclusion criteria. All publications are listed in Section 7 (References). Two studies were published in 2014 and 2016, while the remaining publications date from 2019 to 2025, including 12 publications from 2024 and 2025. Of the 21 publications, 19 are peer-reviewed articles and two are reports published by reputable Dutch research or governmental institutes, namely TNO and RIVM.

The sample of publications is summarised below in terms of country, study design, and hydrogen system characteristics.

- **Country** – Most studies were conducted in Germany (N = 11), followed by the Netherlands (N = 5). A smaller number of studies come from other national contexts (N = 4), including Norway, France, Spain, and Albania, or use cross-country samples (N = 1).
- **Study design** – Most studies use quantitative survey methods (N = 17), often with large samples intended to be broadly representative of the population studied. Qualitative approaches (such as interviews, focus groups, participatory workshops and media analyses) are less common (N = 9). Some studies use experimental designs, such as vignette studies or choice-based experiments (N = 3). The way in which both factors and acceptance are measured varies considerably across studies, except for more standard sociodemographic factors such as gender and age. Many studies focus on either general public acceptance (N = 8) or local public acceptance (N = 7), while some include both (N = 6).
- **Hydrogen system characteristics** – The studies differ in the types of hydrogen systems examined. Several focus on production facilities (N = 5), while others (N = 8) address storage and/or transport (mainly pipelines) and hydrogen refuelling stations. One study examines industrial applications such as green methanol and green steel. Several studies take a more integrated, system-wide perspective or incorporate multiple aspect of the value chain (N = 5). A few studies do not specify the value chain (N = 2). Many studies focus on green hydrogen (N = 8), while others (N = 4) include multiple production methods (such as green, blue, and grey hydrogen), and in a larger number of studies the production method is not specified (N = 9).

These categories are not mutually exclusive, meaning that individual studies may be represented in multiple categories (for example, studies may include both quantitative and qualitative data, or examine multiple aspects of the hydrogen system).

Taken together, the literature shows variation in its coverage of countries, methods, and hydrogen system characteristics.

[2] This review has an exploratory character and aims to identify relevant factors rather than provide a complete overview of all available literature. We focus on empirical studies in Europe for two reasons. First, this improves comparability and keeps the review manageable. Second, the findings are directly relevant to hydrogen developments in the Netherlands, which take place within a broader European policy context. At the same time, we recognise that public acceptance is context-dependent and that studies from other regions may provide additional insights.

3.2.2 Extraction of empirical results

For each publication, key information was first extracted, including the study context, research design, how public acceptance was measured, and which factors were examined.

Each publication was then reviewed to identify the presence of factors from the framework described in Section 3.1. The results were recorded in a dataset (Excel format), referred to as the database.

The database includes:

- The reported relationship between each factor and general public acceptance, and between each factor and local public acceptance.[3]
- How each factor was operationalised (measured) in the study.
- How public acceptance was operationalised (measured) in the study.

General public acceptance refers to broader societal support for hydrogen developments. Local public acceptance refers to acceptance of projects in one's own environment, including both real and hypothetical cases.

The database is primarily intended for researchers. It contains additional information on individual studies, such as measurement approaches, sample characteristics, statistical analyses, and (where reported) effect sizes and distinctions between direct and indirect effects. The database is available upon request.

3.2.3 Coding of empirical results

Given the broad and diverse audience of this report, the results from the database are presented in an aggregated and accessible format. The results were coded to provide input for the visualisation presented in this report, which summarise the relationship between the factors and public acceptance.

The visualisations provide an overview of how often factors have been studied and the presence and direction of their relationship with public acceptance, rather than focusing on effect sizes[4] or causal relationships. This reflects the aim of this report to provide an overview of relevant factors and an indication of the available empirical evidence. The implications of this approach, including its limitations regarding the relative importance and interplay of factors, are discussed in Section 6.

To ensure clarity and consistency, the following rules were applied:

- Relationships were coded based on statistical significance ($p < .05$) and direction (positive, negative, no significant relationship, or interaction effects), as reported by the original authors. We did not reanalyse or reinterpret the results.
- Only results that directly relate a factor to public acceptance, and for which the direction of the relationship can be determined, were included.
- When studies reported multiple results (for example across different models, measures, or subgroups), these were included separately rather than aggregated.
- When factors were measured as part of a broader scale and could not be interpreted separately, these results were not included in the visualisations. This helps avoid overinterpretation of composite measures while ensuring that the visualisations reflect clearly attributable relationships.

More detailed information on the coding procedure is available upon request.

[3] This distinction was made because the same factor may relate differently to general and local public acceptance.

[4] Effect size refers to the strength of the relationship between two variables — for instance, how strongly a factor such as trust is related to public acceptance.

3.3 Expert perspectives

In addition to the literature review, several experts provided their perspectives on selected factors and their relationship with public acceptance. These perspectives are based on professional experience and broader knowledge of public acceptance of energy technologies, including insights from contexts beyond industrial hydrogen.

The expert perspectives are intended to complement the literature findings and provide additional context where empirical evidence is limited. They do not constitute empirical evidence and are presented separately in Section 5.

4 Results

This section presents the overview of factors that may shape public acceptance of industrial hydrogen developments, together with the aggregated results of the literature review, presented through visualisations.

Section 4.1 provides an overview of the framework and the factors identified across the four domains: technology-related, people-related, place-based, and process-related factors. Sections 4.2 to 4.5 then present the results for each domain in more detail, combining descriptions of the factors with visualisations summarising how often they have been studied and how they relate to public acceptance.

The visualisations show:

- whether a factor has been studied in relation to general and/or local public acceptance of industrial hydrogen developments.
- whether there is a statistically significant association (positive or negative[5]), no statistically significant association, or an interaction effect[6].
- whether the relationship has been found in one or more studies. Each symbol represents a result from an individual study. Where studies report multiple results for the same factor, these are shown as separate symbols but connected with a line.

See the legend of each visualisation for further details on how to interpret the symbols and relationships shown.

It is important to note that the results reflect associations reported in the literature and do not necessarily imply causal relationships. For example, a positive association between climate change concern and public acceptance indicates that higher climate change concern is linked to higher public acceptance but does not demonstrate that increasing concern will necessarily lead to higher acceptance.

Overall, the visualisations provide a structured overview of how often different factors have been studied and how they relate to public acceptance, rather than an assessment of their relative importance or causal impact.

The visualisations do not indicate which results originate from which individual studies. This information is included in the underlying dataset (Excel format), which is available upon request.

4.1 Overview of framework and factors

The factors are structured according to a four-domain framework based on Boudet (2019). The framework organises factors into four categories: technology-related, people-related, place-based, and process-related factors.

Figure 1 presents the full set of identified factors across these four domains. Together, these factors reflect the range of aspects which are considered relevant for public acceptance of industrial hydrogen systems across the value chain.

Although the factors are presented as part of a structured four-domain framework, it is important to note that these domains and their associated factors are not independent. Public acceptance emerges from the interaction between multiple factors across domains. For example, perceptions of risks and benefits (technology-related) may be shaped by trust (people-related) and influenced by participation processes (process-related). The framework should therefore not be interpreted as a checklist or a set of isolated drivers, but as an interconnected system of influences.

In addition, public acceptance is dynamic and may change over time in response to new information, societal and technological developments, or specific events such as incidents or media coverage. This

[5] A positive association means that higher levels of the factor are associated with higher public acceptance. A negative association means that higher levels of the factor are associated with lower public acceptance. Some factors are not measured on a numeric scale (for example gender), but as categories (for example female, male, other). In those cases, the visualisation indicates which category is associated with higher public acceptance.

[6] An interaction effect means that the relationship between a factor and public acceptance depends on other factors or conditions. This implies that the effect of a factor may differ across contexts or groups.

temporal dimension is not explicitly captured in the static overview of factors but should be considered when interpreting the framework.

Within this framework, four domains of factors are distinguished, each representing a different category of factors shaping public acceptance:

- **Technology-related factors**, referring to characteristics of hydrogen developments and their perceived impacts. The perceived impacts include how developments are evaluated in terms of risks, benefits, and broader consequences.
- **People-related factors**, referring to individual and social characteristics. These include levels of knowledge, awareness, and experience, trust in relevant actors, values, emotions, beliefs, perceived social influences, and sociodemographic characteristics.
- **Place-related factors,** referring to the physical and social context of hydrogen developments. This includes how individuals relate to their surroundings and how well hydrogen technologies are seen to fit the local context.
- **Process-related factors**, referring to how decisions about hydrogen developments are made and governed. These include public participation, perceptions of fairness and legitimacy, and compensation.

The following sections (4.2 - 4.5) present, for each domain, the identified factors with their descriptions, followed by visualisations that indicate how often these factors have been studied and what types of relationships with acceptance have been reported.

Figure 1 *Overview of factors in the four-domain framework*

4.2 Technology-related factors

This section describes the factors in the technology domain (**Box 1**), followed by the visualisation of the literature review results (**Figure 2**).

Box 1 *Factors in the technology domain with their subfactors and descriptions*

Characteristics of hydrogen systems

The characteristics of hydrogen systems describe how they are designed and organised.

Hydrogen colour - the method of hydrogen production is commonly described using colour labels (such as grey, blue, or green). These labels indicate how hydrogen is produced and what the associated environmental impact is. Grey hydrogen is typically produced from fossil fuels and is associated with high CO_2 emissions. Blue hydrogen is also produced from fossil fuels but includes carbon capture and storage to reduce emissions. Green hydrogen is produced using renewable electricity and is generally associated with low emissions. Public evaluations may vary depending on how hydrogen is produced.

Carrier type - medium and way in which hydrogen is stored and transported (such as ammonia, liquid hydrogen, compressed hydrogen), which differ in their physical and chemical properties, infrastructure requirements, and associated risks and benefits. Public acceptance may vary depending on how these differences are perceived.

International orientation of hydrogen systems - geographical sourcing and destination of hydrogen, including whether it is produced domestically or imported, and whether it is intended for domestic use or export. Public acceptance may vary depending on the perceived distribution of benefits, dependencies, and international relationships.

Component of the hydrogen value chain - component of the hydrogen value chain on which evaluations are focused. The value chain includes hydrogen production (such as electrolysis), processing and conversion (such as compression, liquefaction, or conversion to carriers like ammonia), storage (such as tanks or underground facilities), transport and distribution (such as pipelines, ships, or trucks), and end-use applications (such as industry, mobility, heating, or power generation). The different components of the hydrogen value chain differ in their associated risks and benefits. Public acceptance may vary depending on how these differences are perceived.

Perceived negative impacts

The subjective evaluation of undesirable consequences associated with hydrogen developments.

Health and safety risks and hazards - perceived likelihood and severity of adverse consequences, particularly in relation to health and safety, as well as affective concern about these consequences. This also includes perceptions of hazards, referring to the extent to which aspects of hydrogen technologies or infrastructure are seen as sources of potential danger.

Environmental impacts - perceived negative effects on the natural environment, climate, and living environment. This includes impacts on biodiversity, ecosystems, air, water, and soil quality, as well as greenhouse gas emissions and contributions to climate change, and the overall ecological quality of the local living environment.

Economic and financial costs - perceived personal or societal financial costs associated with hydrogen-related developments. This includes reduced property values, increased energy prices, and infrastructure costs.

Labour market impacts - perceived negative consequences for employment, income, and regional economic conditions associated with hydrogen developments. This includes expectations about job losses or the need for job changes across occupations, industries, and skill levels, and the distribution of employment effects across regions.

Spatial and landscape impacts – perceived negative effects on the physical and living environment. This includes visual impacts, noise, land use changes, and perceived disruption of the landscape or living environment.

Energy system and transition risks - perceived risks related to the broader energy system and transition. This includes concerns about becoming dependent on certain technologies or infrastructure (making it difficult to switch to alternatives later), inefficiencies, or delays in achieving decarbonisation goals.

Geopolitical and strategic risks - perceived risks related to the international and strategic context of hydrogen. This includes dependence on imports, geopolitical vulnerabilities, and concerns about energy security.

Perceived positive impacts

The subjective evaluation of beneficial consequences associated with hydrogen developments.

Environmental and climate benefits – perceived positive effects on the natural environment and climate. This includes reductions in greenhouse gas emissions, improvements in air, water, and soil quality, and contributions to climate change mitigation.

Economic and financial benefits – perceived economic advantages associated with hydrogen developments. This includes opportunities for economic growth, cost savings, new investments, and innovation, as well as research and development activities.

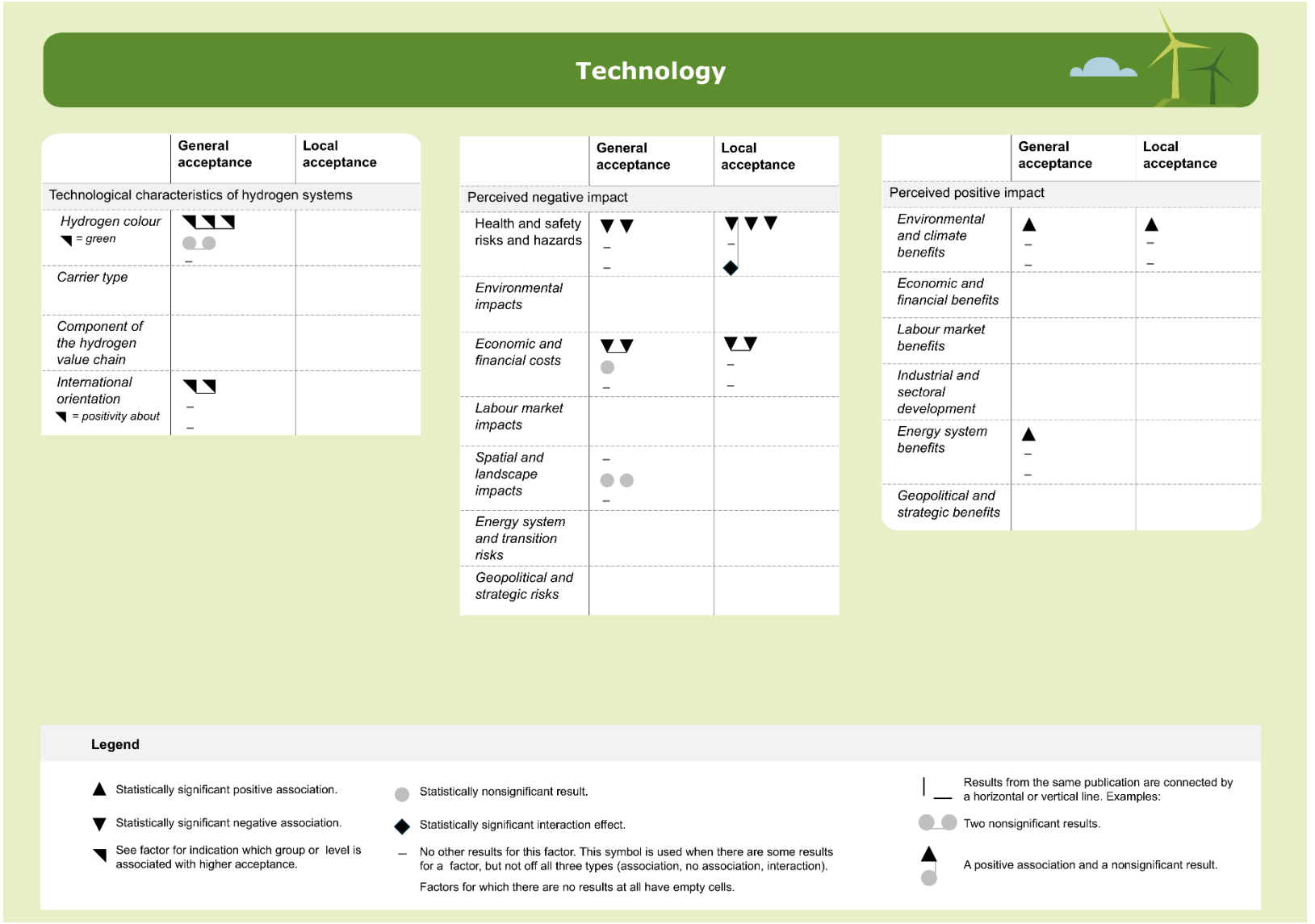
Labour market benefits – perceived positive consequences for employment and income. This includes job creation, new employment opportunities, and positive regional economic development.

Industrial and sectoral development – perceived benefits for specific industries or sectors. This includes the decarbonisation of existing industries, the creation of new industrial activities, and the continued presence or competitiveness of sectors and companies within a country or region.

Energy system benefits – perceived advantages for the broader energy system. This includes increased system flexibility, improved energy security, integration of renewable energy, and contributions to a reliable and resilient energy system.

Geopolitical and strategic benefits – perceived advantages related to the international and strategic position of hydrogen. This includes reduced dependence on energy imports, increased energy autonomy, and strengthened geopolitical positioning.

Figure 2 *Visualisation literature review results technology-related factors*



4.3 People-related factors

This section describes the factors in the people domain (**Box 2**), followed by the visualisation of the literature review results (**Figures 3.1 and 3.2**).

Box 2 *Factors in the people domain with their subfactors and descriptions*

Knowledge, awareness, familiarity

The extent to which individuals know about hydrogen technologies and are aware of their existence. This includes both self-perceived understanding and factual knowledge, as well as whether individuals have heard of and feel familiar with hydrogen developments.

Objective knowledge - individuals' factually correct understanding of hydrogen, including its characteristics, applications, and implications.

Subjective knowledge, awareness and familiarity - individuals' self-assessed level of knowledge about hydrogen, including whether they have heard of hydrogen technologies or developments and how familiar they feel with them.

Experience with hydrogen

The degree to which individuals have direct or indirect experience with hydrogen technologies or related industries, including professional, personal, or local exposure.

Trust

The extent to which individuals believe that actors involved in the hydrogen value chain act competently, honestly, independently, and in the public interest. Trust includes both competence-based trust (confidence in actors' expertise and ability) and integrity-based trust (belief that actors act transparently and in the public interest).

Trust in government and political actors.

Trust in companies involved in hydrogen production or related processes.

Trust in civic organisations (such as non-governmental organisations, citizen initiatives, consumer organisations).

Trust in scientific institutions and researchers, including trust in the credibility, objectivity, and reliability of scientific knowledge.

Perceived control

The extent to which individuals feel they have control over hydrogen developments, their potential impacts, and related decision-making processes. This includes both perceived control over personal exposure and outcomes, and perceived influence over how decisions are made.

Values

General guiding principles in life that transcend specific situations and shape individuals' perceptions, evaluations, and behaviours.

Biospheric values - concern for the environment.

Altruistic values - concern for others and society.

Egoistic values - concern for personal resources and self-interest.

Hedonic values - concern for pleasure and comfort.

Environmental concern

A general orientation towards environmental protection, reflecting the extent to which individuals are aware of environmental problems, care about their consequences, and support actions aimed at preventing or mitigating environmental harm.

Climate change concern

The extent to which individuals are concerned about climate change and perceive it as a serious societal problem.

Climate action effectiveness

The extent to which individuals believe that actions to address climate change are effective in reducing its impacts or contributing to solutions.

Attitudes towards the energy transition

Overall positive or negative evaluations of the broader energy transition and shifts towards low-carbon energy systems.

Affect

Immediate emotional responses and feelings (such as enthusiasm, worry, fear, pride) towards hydrogen technologies or related aspects, which may influence public acceptance independently of cognitive evaluations.

Interpersonal influence

The extent to which individuals are influenced by the views of people in one's direct social environment, such as family, friends, or local communities.

Media and public discourse influence

The extent to which individuals are influenced by media coverage and the public debate about hydrogen.

Coverage and visibility – the extent to which hydrogen is discussed in media and public communication.

Content and framing – how hydrogen is presented in public debate and media, including dominant narratives and associations.

Sociodemographic characteristics

Individual background characteristics that may be associated with differences in public perceptions and acceptance of hydrogen technologies or infrastructure.

Age

Gender

Education (highest attained degree)

Household income

Employment status

Political orientation

Figure 3.1 *Visualisation literature review results people-related factors*

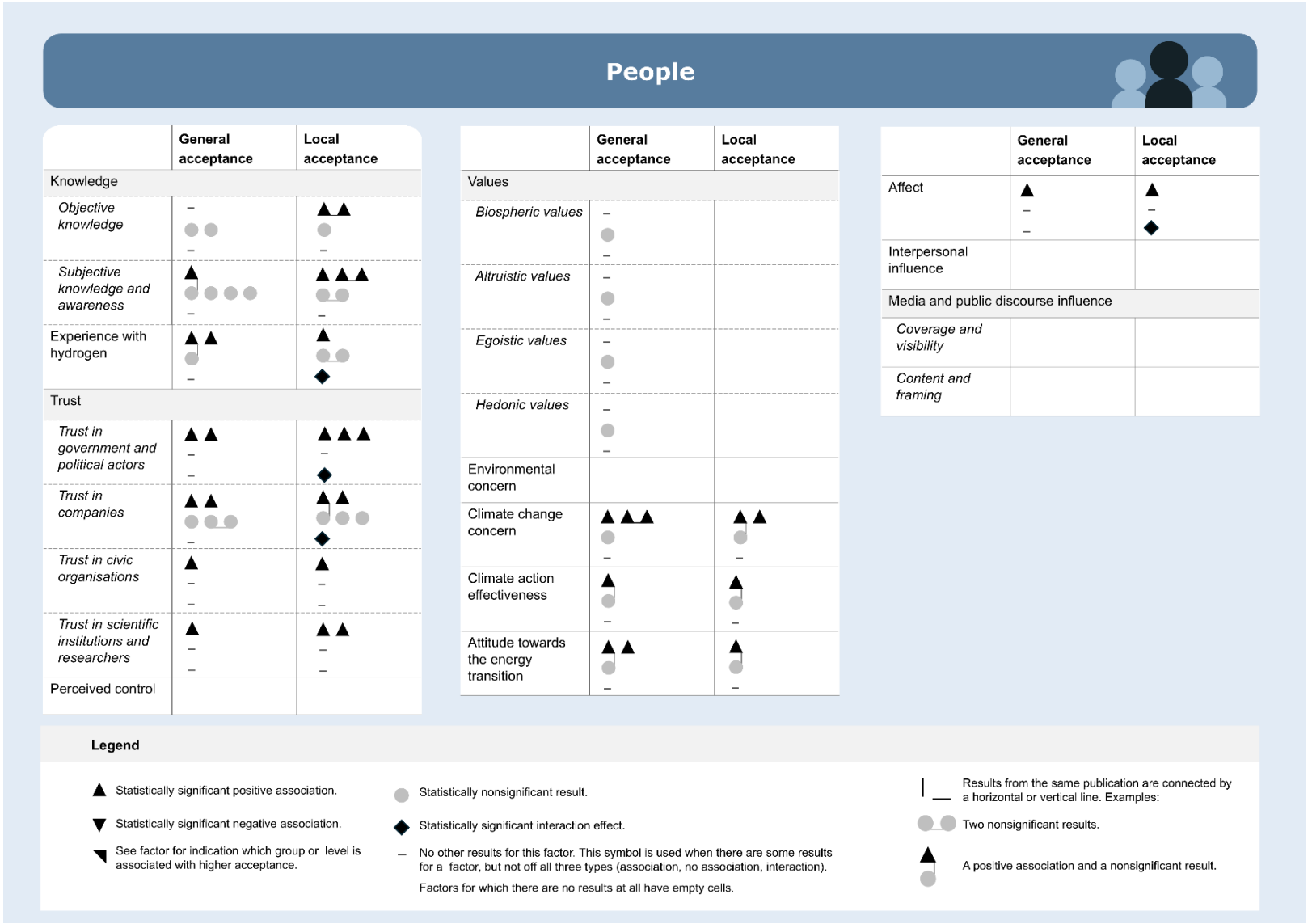
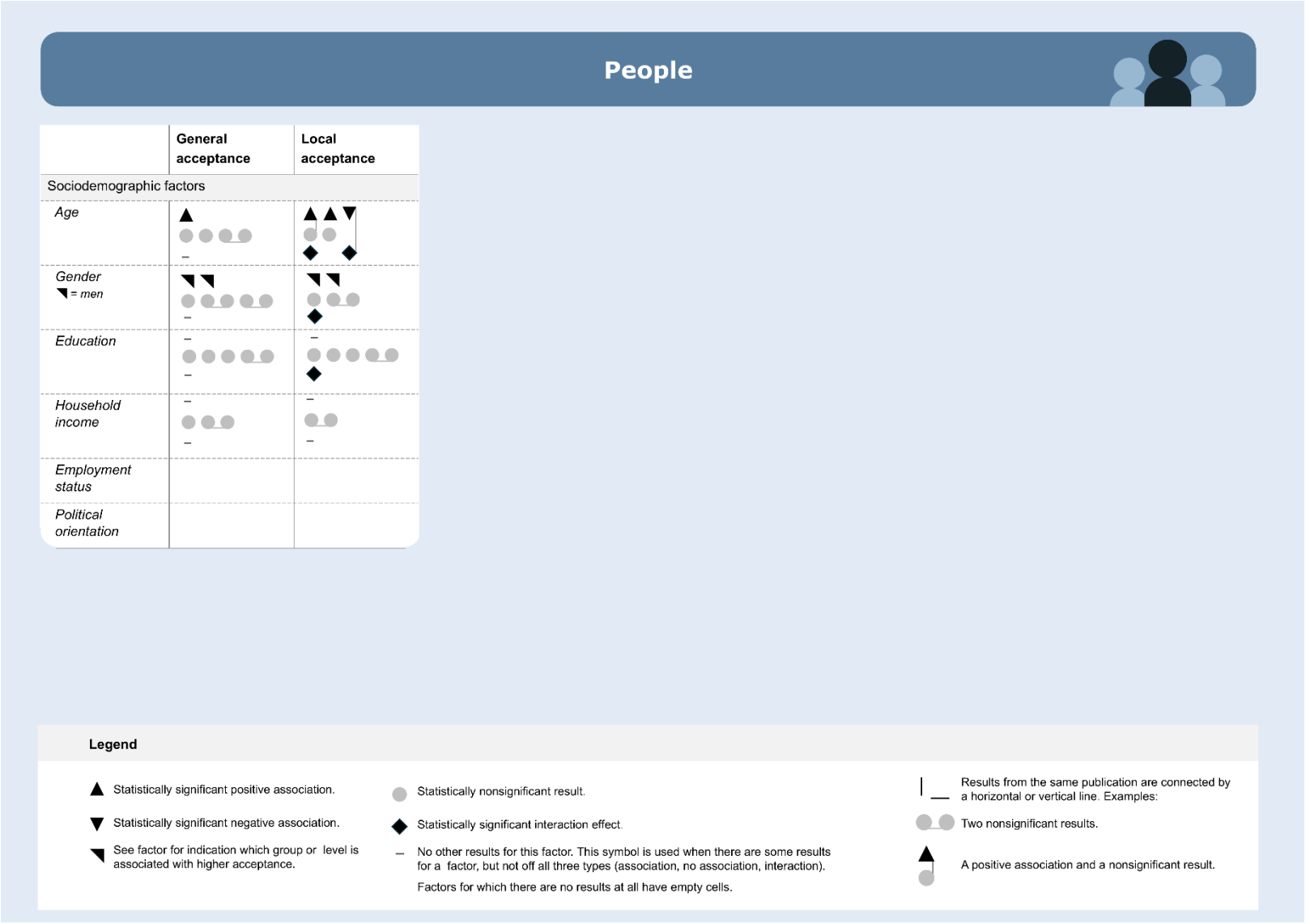


Figure 3.2 *Visualisation literature review results people-related factors*



4.4 Place-related factors

This section describes the factors in the place domain (**Box 3**), followed by the visualisation of the literature review results (**Figure 4**).

Box 3 *Factors in the place domain with their descriptions*

Urbanisation

The extent to which an area is urban or rural, typically reflected in population density, the built environment, and land use. Urban areas are generally more densely populated and developed, while rural areas have lower population density and more natural or agricultural land. The degree to which an area is urban or rural can be measured both objectively and based on individuals' own perceptions of their living environment.

Proximity

The distance between residential areas and existing or planned industrial infrastructure or activities. This includes both physical (objective) distance and perceived (subjective) closeness. Industrial infrastructure may be hydrogen-related or non-hydrogen-related.

Place attachment

The extent to which individuals feel emotionally and functionally attached to the place where they live. Place attachment is commonly understood as including both place identity (emotional or symbolic attachment to a place) and place dependence (the extent to which a place supports individuals' needs, daily activities, and goals).

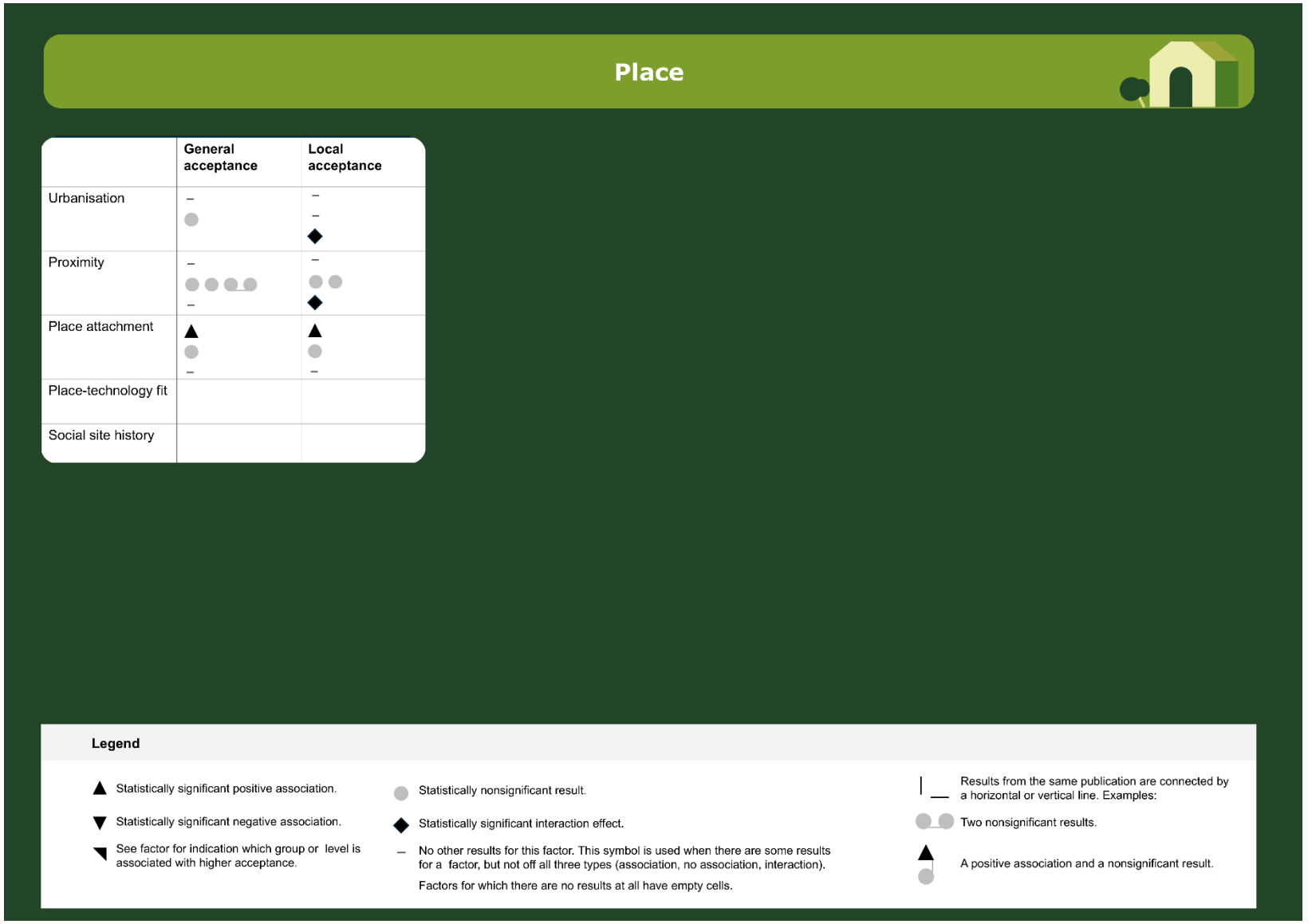
Place-technology fit

The extent to which individuals perceive a technology as fitting the characteristics, functions, and identity of the place where they live.

Social site history

The extent to which past experiences with non-hydrogen industrial activities, technologies, or organisations in a specific location or region shape current perceptions and acceptance of hydrogen developments. This includes both direct experiences and shared histories, such as earlier infrastructure projects, industrial activities, or the track record of organisations involved.

Figure 4 *Visualisation literature review results place-related factors*



4.5 Process-related factors

This section describes the factors in the process domain (**Box 4**), followed by the visualisation of the literature review results (**Figure 5**).

Box 4 *Factors in the process domain with their subfactors and descriptions*

Public participation in decision making

The extent to which individuals are involved in, have opportunities to be involved in, or express preferences regarding participation in decision-making and implementation processes related to hydrogen developments.

Participatory experience – prior experiences with participation processes and evaluations of those experiences.

Willingness to participate – individuals' willingness or interest in taking part in participation procedures related to hydrogen developments.

Attitudes toward participation formats – preferences regarding different forms of public participation (such as information provision, consultation, cooperation, or co-decision).

Justice perceptions

Evaluations of whether hydrogen developments and their governance are perceived as fair, appropriate, and legitimate. This includes how both the outcomes of hydrogen developments (such as the distribution of costs, risks and benefits) and the associated decision-making processes are assessed.

Distributive justice – perceptions of the fairness of how costs, risks, and benefits of hydrogen developments are distributed between actors, communities, or regions (such as end-use distribution, risks of energy colonisation).

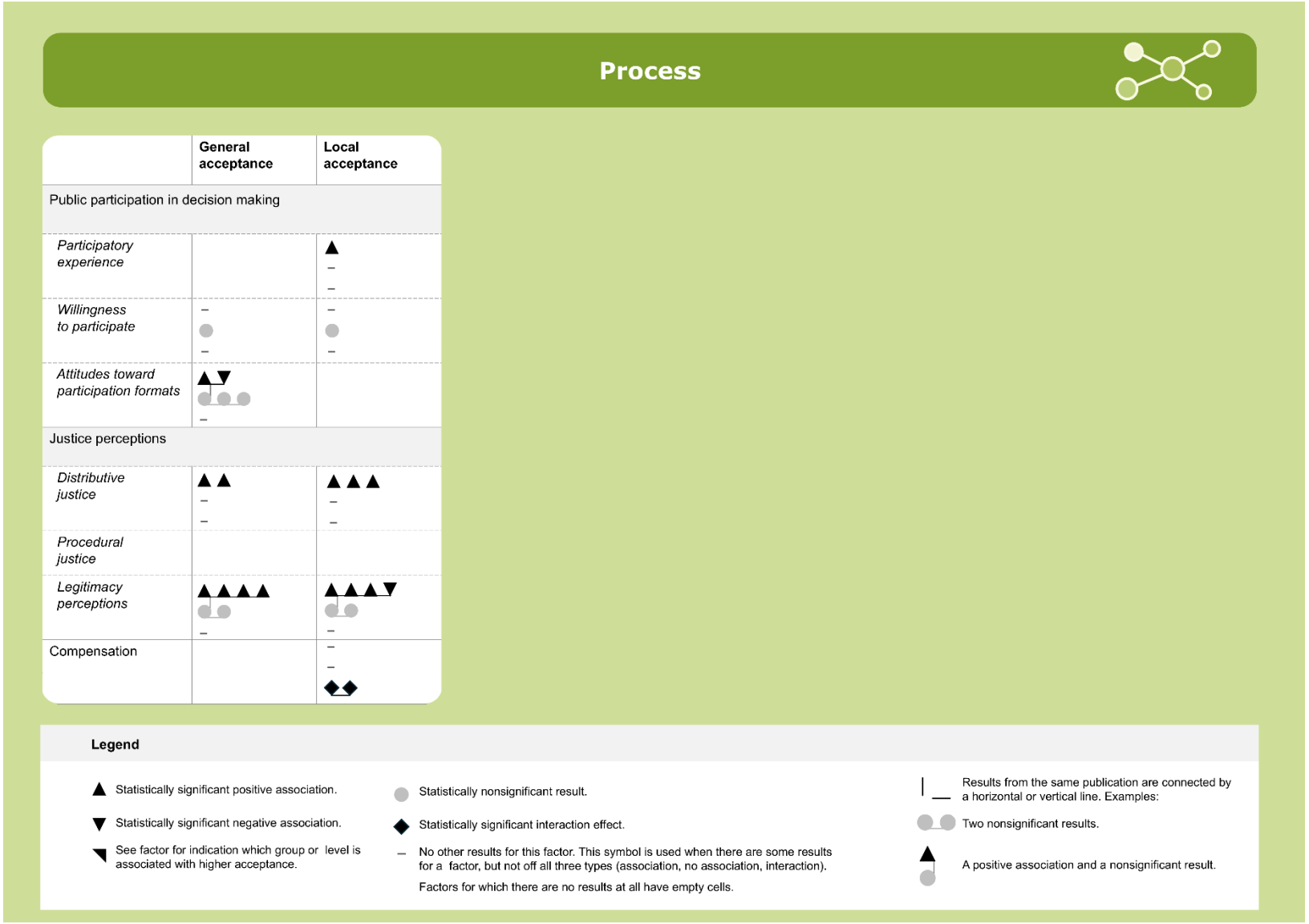
Procedural justice – perceptions of the fairness, transparency, and inclusiveness of decision-making processes surrounding hydrogen developments.

Legitimacy perceptions – evaluations of whether hydrogen developments and their governance are appropriate and justified, including cognitive, pragmatic, and moral legitimacy.

Compensation

Monetary payments or material benefits provided to individuals, communities, or regions to offset perceived nuisances, risks, or negative impacts associated with hydrogen developments (such as electricity discounts or compensation for property values loss).

Figure 5 *Visualisation literature review results process-related factors*



5 Expert perspectives

To complement the literature review presented in Section 4, this section includes expert perspectives from researchers and practitioners with expertise in public perceptions and acceptance of novel technologies. These perspectives are included to provide additional context and interpretation of the literature findings, and to highlight factors and considerations that are not yet (fully) captured in the available empirical evidence.

The perspectives are presented per domain—technology, people, place, and process—following the same structure as the literature review (Sections 5.1–5.4). Each perspective is attributed to its contributor by name. . An overview of all contributors and their areas of expertise is presented below.

The expert perspectives vary in nature and include theoretical reflections, insights from related empirical work, and professional observations or suggestions. They reflect the experts' professional judgement and are not based on a systematic empirical analysis.

Overview of contributing experts

- Dr. **Christine Boomsma**, Senior researcher Perception and Behaviour, National Institute for Public Health and the Environment; Seconded researcher, University of Amsterdam. Expertise: perceptions of energy technologies, public participation, risk perception, sustainable behaviour.
- Dr. **Emma ter Mors**, Associate Professor Social, Economic and Organisational Psychology, Leiden University. Expertise: factors influencing public perception and acceptance of energy technologies (including trust, fairness, compensation, community engagement).
- Prof. Dr. **Frenk van Harreveld**, Professor Social Cognition and Behavioural Influence in Relation to Sustainability and Safety, University of Amsterdam. Expertise: attitudes, uncertainty, risk perception, decision-making, sustainable behaviour.
- Prof. Dr. **Goda Perlaviciute**, Professor Public Acceptability of Sustainable Transitions, Expertise Group Environmental Psychology, Faculty of Behavioural and Social Sciences, University of Groningen. Expertise: public acceptability, values, public participation in decision making
- Dr. **Kornelia Konrad**, Associate Professor Faculty of Behavioural, Management and Social Sciences, University of Twente. Expertise: sociology of expectations, future-oriented discourses of emerging technologies (incl. hydrogen and fuel cells).
- Prof. **Olaf van Vliet**, Professor of Economics, Leiden University. Expertise: economic effects of structural transitions, political economy of structural transitions, socio-economic policy.
- Dr. **Sanne Akerboom**, Assistant Professor Regulation and Governance of the Energy Transition, Copernicus Institute of Sustainable Development, Energy & Resources, Utrecht University. Expertise: energy policy, just transition, governance & policy.
- Dr. **Sarah Elbert** & **Eva van Rij**, MSc. Researchers at the professorship Communication, Behaviour & the Sustainable Society, Center of Expertise Entrance, Hanze University of Applied Sciences, Groningen. Expertise: participation in the energy transition, behaviour change, societal processes.

5.1 Technology-related factors

Technological characteristics: Hydrogen colour

“This seems to be an important factor shaping public perceptions (see Palomo-Vélez and colleagues, 2025). People generally support “greener” energy sources more than fossil fuels (see Görsch and colleagues, 2025), which could explain why green hydrogen is the most preferred option, followed by blue hydrogen, and grey hydrogen being the least preferred option.” [Goda Perlaviciute]

“The general public tends to have the association with hydrogen as a green, sustainable technology. They respond more favourable towards green hydrogen as this fits with their preconceived notion of the technology. Learning about blue and grey hydrogen tends to evoke negative responses.” [Christine Boomsma]

Technological characteristics: Carrier type

“People may have negative associations with ammonia, for example. Although I am not aware of specific research on public perceptions of ammonia. The literature on risk perceptions, especially on so-called “dreadful risks” (see Slovic, 1987) would suggest that people’s perceptions of high risks (e.g. associated with ammonia) might colour their evaluations of any other related costs, risks, and benefits (affect heuristic). Future research could test whether there is a negative relationship between people’s perceptions of risks and benefits of, for instance, ammonia (i.e., the more risks, the less benefits they perceive) – such a negative correlation would point out to the possible affect heuristic.” [Goda Perlaviciute]

“To efficiently transport and store hydrogen other configurations might be used. Hydrogen may be stored and transported in the form of ammonia or LOHCs (Liquid hydrogen carriers). These carriers have different hazard properties. Literature in other fields has shown that people respond differently to different hazard properties (e.g. explosive, flammable, toxic). Therefore, risk perceptions and acceptance of hydrogen may be conditional on the type of hydrogen carrier that is chosen.” [Christine Boomsma]

Technological characteristics: Component of the hydrogen value chain

“I suspect that the general public is less sensitive to the differentiations of the value chain than experts for instance. A study on different stages of the value chain of natural gas in the Netherlands (production, transport, and use) found no differences across these stages – people basically hold certain overall evaluations of gas in general, without distinguishing much between the stages of the value chain (see Perlaviciute and colleagues, 2016). Yet future research could test whether the findings are similar or perhaps different for hydrogen.” [Goda Perlaviciute]

Technological characteristics: International orientation

"This relates to perceptions of fairness on a global level. If we import hydrogen that is for example produced in Saharan Africa, then it could be perceived as unjust if we then use it here without there being a sizable benefit to the countries where it is produced. " [Frenk van Harreveld]

“It is a very interesting factor that has hardly been addressed in public perceptions research but is highly relevant. Relates to perceived fairness (see emerging literature on energy (de)colonialism) and perceived geopolitical risks. The topic is particularly timely given the issues that European societies are facing with regard to gas imports from Russia and increasing risks from the US.” [Goda Perlaviciute]

"Against the backdrop of current geopolitical dynamics, the location of production (whether national or international) is expected to play an increasingly important role in terms of public acceptance." [Olaf van Vliet]

Perceived negative impacts: Health and safety risks and hazards

"Perspectives of risk are indeed based on probability and severity judgments, where people generally weigh severity more heavily than probabilities. This is in part due to the availability heuristic, with high severity outcomes (disasters) receive a lot of media attention which increases availability. This availability can then also impact likelihood perceptions (overestimating likelihood of events that one can easily imagine). Another bias that plays a role here is the illusion of control, where people are willing to accept more risk exposure when the risk is something they have a sense of control over as compared to risk under low personal control." [Frenk van Harreveld]

"Risk perceptions play an important role in shaping both national and local acceptance of energy and infrastructure projects. Concerns about risks to human health, the living environment, and the natural environment appear to be key drivers of public acceptance. It is important to distinguish between objective hazards and perceived risks, as public risk perceptions do not always align with expert risk assessments. Public acceptance is therefore largely shaped by how risks are interpreted and experienced by individuals and communities." [Emma ter Mors]

“Especially in circumstances where there is uncertainty around risks (which is often the case with novel technologies such as hydrogen), individuals make a distinction between hazard and risk appraisals. Regardless of the risk being uncertain, or because the risk is uncertain, people may think it is serious that the hazard (in this case hydrogen technology) is present in their local environment (or country).” [Christine Boomsma]

Perceived negative impacts: economic and financial costs

"This relates to perceptions of distributive fairness: Why should I suffer from these consequences with the benefits being distributed more broadly?" [Frenk van Harreveld]

"The perceived financial costs play an important role in the energy transition. Firstly, they could be a relevant factor in public acceptance. Secondly, many public policy instruments, such as subsidies and taxes, are related to the costs of the energy transition and therefore to public acceptance. This is also related to how the costs are distributed between firms, the government (taxpayers) and consumers." [Olaf van Vliet]

Perceived negative impacts: Energy system and transition risks

“People may be sceptical of the so-called end-of-pipe solutions that deal only with the symptoms of climate problems without tackling the roots of the problem (i.e., fossil fuels), and people may also be concerned that such end-of-pipe solutions deter governments and industry from finding real solutions (for example across countries, respondents tended to agree that solar radiation management might reduce politicians’’ and citizens’ mitigation efforts (see Contzen and colleagues, 2024).” [Goda Perlaviciute]

Perceived positive impacts: Economic and financial benefits

"The hydrogen transition could also have a positive (cost-reducing) impact on energy costs. It would be useful to distinguish between the short and long term here." [Olaf van Vliet]

Perceived positive impacts: Labour market benefits

"Perceived employment effects may play an important role in major transitions, such as the energy transition. In regions with relatively high unemployment rates in particular, expected increases in employment could contribute to public acceptance. In addition to regional variation, this effect may also depend on cyclical dynamics. In periods of very tight labour markets, increased demand for workers could negatively affect acceptance." [Olaf van Vliet]

5.2 People-related factors

Knowledge, awareness and familiarity

"Actual knowledge is often quite different from subjective knowledge. In any case, if people feel they know a lot about a risk, there is a lower correlation between trust in authorities in managing a risk and perceived risk than if they don't think they know a lot (see Siegrist & Cvetkovich, 2000). This suggests that when one knows little, one resorts to trust in authorities to manage the risk. If one thinks one knows a lot, one relies on trust less." [Frenk van Harreveld]

"Knowledge and awareness play an important but also sometimes overstated role in shaping acceptance of energy and infrastructure projects. While knowledge and awareness are clearly relevant, higher levels of knowledge or awareness do not necessarily correspond with higher acceptance. In some cases, greater understanding may reduce acceptance by correcting overly positive assumptions or misconceptions. Overall, the relationship between knowledge, awareness, and acceptance appears to be relatively weak to moderate and not necessarily direct, with effects often shaped by how knowledge and awareness influence risk perceptions, perceived benefits, and trust. At both national and local levels, public knowledge and awareness of hydrogen often appear limited, although awareness may increase as public and policy attention grows. It also appears that the type of knowledge and understanding people consider relevant does not always align with the knowledge experts prioritise." [Emma ter Mors]

“In our Hy-SUCCESS 4.2.2 task it is reasoned that the public and other (local) stakeholders have limited knowledge about hydrogen - what it is, what it can be used for and why that makes sense, for instance. This limits people to make an informed opinion about it, which has effects on decision-making processes as well, and whether these decisions are perceived as just or not. So, knowledge is an important factor at the basis of our research. We also investigated this in a previous project, Hydelta 2 (see HyDelta, n.d., Section WP10). An infographic was our final deliverable and starting point for our task in Hy-SUCCESS (see Elbert and colleagues, 2023).” [Sarah Elbert & Eva van Rij]

Trust

"I would distinguish between different components of trust: 1) competence/ability, 2) benevolence, 3) integrity. This is especially important as there is reason to believe (see Johnson & Slovic, 1995) that in the context of risks, people particularly desire for an authority that is high in ability (with integrity weighing less heavily). This also fits with compensatory control theory (see Kay and colleagues, 2009), which argues that when people experience low control, they want an authority that provides order and predictability and see that in an authority that is high in ability. I think that communicating uncertainty may be a way to express integrity, but when people are actually afraid, they probably want something else." [Frenk van Harreveld]

“We developed the social fingerprint approach, used as an instrument to give specific recommendations for participation in local contexts (see Herder and colleagues, 2024; Bouw and colleagues, 2022). Trust is part of the social fingerprint approach. We see that trust (in each other or in the municipality, in our case) is an important factor in participation processes, also as a part of the socio-historical context (see expert perspective for social site history). We can see how this also applies to societal acceptance processes regarding hydrogen, but we do not have specific experience with this.” [Sarah Elbert & Eva van Rij]

Trust in government and political actors

“This also relates to prior experiences with government and participation processes. Also, other related projects, without personal engagement, may have spillover effects. People think "if it happens in a certain way in another municipality, why would it go well here"” [Sanne Akerboom]

Trust in scientific institutions and researchers

"Trust in science is investigated extensively by Bastiaan Rutjens, who relates it to psychological distance to science, showing that in various domains (including tech), distance to science (uncertainty, social distance, physical distance) is related to lower levels of trust in science." [Frenk van Harreveld]

Values

“Research has showed relationships between values and the more established energy technologies (e.g., biospheric values positively associated with public acceptability of renewable energy sources and negatively associated with acceptability of nuclear energy; a reverse pattern of relationships for egoistic values). Because hydrogen is an emergent technology, it might be that people have not yet formed value-based judgements of hydrogen. Indeed, values are more likely to be related to acceptability of more familiar technologies (for example, nuclear) than less familiar technologies (e.g., CCS; see Görsch and colleagues, 2025). For future research, especially longitudinal, it would be highly relevant to test the relationships between values and acceptability of hydrogen, and how this relationship changes over time as people become more familiar with hydrogen, and/or comparing regions where people may have heard more about hydrogen (e.g., seaports).” [Goda Perlaviciute]

“We did not investigate this directly in Hy-SUCCESS or in relation to hydrogen at all, but generally we believe that values are an important determinant of behaviour change, as values are rooted in the person and are related to long-term and conscious change.” [Sarah Elbert & Eva van Rij]

Perceived control

“Perceived control influences acceptance of risks. People are willing to accept more risk exposure when the risk is something they have a sense of control over as compared to risk under low personal control. Perceived control is also very much related to perceptions of procedural fairness." [Frenk van Harreveld]

Environmental concern

“I suspect that people with high environmental concern are particularly concerned with how environmentally friendly hydrogen actually is (e.g., the colour of hydrogen might moderate the relationship between environmental concern and acceptability of hydrogen). Similarly, they may question what hydrogen is used for – if it is used for heavy industry that uses fossil fuels, people with high environmental concern may be less supportive.” [Goda Perlaviciute]

Attitudes towards the energy transition

“We developed the social fingerprint approach, used as an instrument to give specific recommendations for participation in local contexts (see Herder and colleagues, 2024; Bouw and colleagues, 2022). It partly consists of a questionnaire which also includes attitude towards the energy transition. It is the question to what extent this can be connected to acceptance of a new technique/development (we did not specifically measure this), but all in all this can be an important starting point of behaviour change (awareness / perceived urgency, in combination with knowledge and/or environmental concern).” [Sarah Elbert & Eva van Rij]

Media and public discourse influence

“With regard to the media cues, a communication student worked on the narrative that is now out there for hydrogen. Her analysis showed that the presentation of hydrogen in the Dutch media plays an important role in shaping public perceptions and acceptance. For example, she says the following about this: *The responses show that people mainly need clear explanations, concrete examples, and transparency about safety and feasibility. Acceptance therefore seems to be linked to the extent to which information is presented in an understandable and consistent manner. When reporting is contradictory or highly technical, it can reinforce doubt rather than increase understanding.” ... “Clear, concrete, and balanced reporting contributes to better understanding and increases the likelihood of social acceptance. However, when reporting is too technical, contradictory, or problem-oriented, it can reinforce uncertainty and delay acceptance.*

She also noticed that hydrogen is often linked in the media to political choices, subsidies, and geopolitical dependencies. According to her, this seems to lead to mistrust among part of the public." [Sarah Elbert & Eva van Rij]

"With respect to the extent hydrogen is at all discussed in public media, an assumption could be that the more it is discussed and the more in media with a broad public outreach, more people will at all be familiar with it and develop an opinion at all, be it rather positive or negative. With respect to framing, it is likely to matter how hydrogen is framed (primarily) in public discourse. Is it largely discussed as a 'green' technology, as a project of fossil industry, a 'colonial' technology, whether it is associated with local projects or global value chains etc. Value chain components are discussed as a factor among in the technology-domain, but within the factor of media influence, the question would be which of these components are more prominently discussed in public discourse." [Kornelia Konrad]

5.3 Place-related factors

Proximity

“My impression is that proximity plays a more limited role in shaping acceptance of energy and infrastructure projects than is often assumed, even though acceptance often appears to decrease when moving from the national to the local level. Based on my reading of the literature, proximity effects tend to be relatively small and inconsistent, with their direction varying across contexts and technologies. It is also important to distinguish between physical proximity and perceived or experienced closeness, as the latter may be more influential than objective distance alone. In addition, proximity appears to interact strongly with familiarity and experience, which may often be more decisive for acceptance. In many cases, proximity may matter primarily because it increases exposure over time, rather than because closeness itself directly drives opposition or support.” [Emma ter Mors]

Place attachment

"This makes me think of Moerdijk, a town that may entirely disappear within a few years to accommodate a chemical plant. This leads to a lot of turmoil in the community. Perhaps a case that can provide some relevant insight." [Frenk van Harreveld]

“We developed the social fingerprint approach, used as an instrument to give specific recommendations for participation in local contexts (see Herder and colleagues, 2024; Bouw and colleagues, 2022). Place attachment is also part of the social fingerprint questionnaire, for instance measured by how long people live in the place they live in and how satisfied they are with living there.” [Sarah Elbert & Eva van Rij]

Social site history

“Residents' previous experiences (with hydrogen or more broadly with energy transition developments) can play an important role. In our research, we always aim to place new developments within the local context: the specific circumstances of the residents', the history of the location, and previous experiences. In practice, we see these previous experiences, not only within the same subject area, but also in relation to relevant or similar governments or organisations, can have a strong influence on how residents respond to a new development (within the energy transition) in their environment.” [Sarah Elbert & Eva van Rij]

5.4 Process-related factors

Public participation in decision-making

"The way decisions are made and the extent to which people feel involved in decision making affects perceived procedural fairness and can influence public acceptability. It could also (partly) explain why people may be in favour of an energy technology in general but react negatively to specific local projects. Instead of the reductionist NIMBY approach, it is important to understand how the projects are governed and how local communities experience the decision-making process and their own role in it. Four factors are important for participatory decision making, the 4Ds: dialogue, diversity, deliberation, and decision-making power (see Perlaviciute, 2022). Future research could test how citizens experience the decision making on hydrogen on these four characteristics and how that, in turn, connects to their acceptability judgements." [Goda Perlaviciute]

“Community engagement plays an important role in shaping local acceptance of energy and infrastructure projects. Early, meaningful, consequential, and transparent engagement can help build trust, reduce perceived risks, and foster a sense of procedural and distributive fairness, all of which appear to strongly influence local support. However, engagement that is perceived as late, superficial, non-consequential, or non-transparent may undermine trust and legitimacy and can negatively affect local acceptance. Community engagement therefore appears to act directly on perceptions of legitimacy, fairness, and trust, making it a key lever for local acceptance.” [Emma ter Mors]

“Participation in governmental decision-making is very important, but also vulnerable. Governments need to carefully design these processes. There are some general lessons to consider when doing so, including early involvement (before a decision seems to be taken), whereas too early might be considered vague and abstract, whereby people do not feel engaged. So timing is very important. Also, the way in which people participate is important; after all, providing comments in text may be perceived as impersonal but participating in person takes time. This also often reduces possibilities for people with families for instance, risking limited participation. The response by the government is also important, people want to see actual engagement with their concerns, whereas most often the government ‘weeds’ out collective comments and unique comments, and also responds to those comments they deem important. This can be perceived as arbitrary to people. Overall, there is a very fine line between participation done correctly, and participation that may worsen the trust and acceptance of projects.” [Sanne Akerboom]

Justice perceptions

"It might be worthwhile distinguishing justice literature and perceived fairness literature. Justice literature distinguishes procedural, distributive, recognitional, and restorative justice. Yet, it focuses mostly on normative claims, while public perceptions of justice principles are rarely tested. Public perceptions research, on the other hand, shows that perceived fairness is important for acceptability, but rarely specifies which exact principles are tested. Future research could test the different justice/fairness principles more systematically. See, for instance, experimental research on perceived responsibility versus perceived capacity principles (Klebl and Stanley, 2025)." [Goda Perlaviciute]

Compensation

“Compensations can have different effects – from increasing acceptability to being perceived as “bribes” and fuelling resistance. Taking communities seriously and listening to them seems very important – compensations should be based on what the specific community really needs, acknowledging local values and identities, rather than just paying people off. Fair distribution is key, e.g. who gets compensated (compensating landowners only might trigger resistance from the larger community). Also, it is important whether or not financial compensation is coupled with participation in decision making. For instance, some good examples on wind energy developments in Denmark and other countries build on shared ownership, where local citizens not only hold financial shares in the project, but also have real influence on decision making (see Boudet and colleagues, 2025).” [Goda Perlaviciute]

Justice perceptions and compensation

“Justice perceptions are inherently personal, often implicit, and contested. Justice moreover is complex, and multi-faceted. It contains considerations such as fair processes, and compensation. Although the general society has started to articulate a need for a just transition as a condition for accepted transitions, there are very little ways to make various justice implications explicit, and open to discussion. There are no “rules of thumb” for what is considered a fair compensation, nor what considerations underlie the compensation. This makes it inherently complicated to deal with justice considerations. This often reenforces the tendency to focus on technological and financial elements of decision-making, worsening the gap between perceived justice implications and attention for it.” [Sanne Akerboom]

6 Conclusion

This report provides a structured overview of factors that may shape public acceptance of industrial hydrogen developments, combining insights from empirical literature and expert perspectives. It aims to support policymakers and researchers by identifying relevant factors, assessing the current state of evidence, and highlighting directions for further research.

6.1 Factors shaping public acceptance

This report identifies a broad range of factors that may shape public acceptance of industrial hydrogen developments, organised across four domains: technology-related, people-related, place-related, and process-related factors (Boudet, 2019). Together, these domains reflect the multi-dimensional nature of public acceptance.

Most identified factors fall within the technology-related and people-related domains, which together cover a wide range of individual, social, and technological aspects. The place-related and process-related domains are comparatively smaller but include factors that are well-established in the broader literature on public acceptance of energy technologies, such as place attachment, justice perceptions, and public participation.

The framework should be understood as a structured starting point for analysing public acceptance, rather than a complete or exhaustive overview. As the field develops, additional factors and refinements are likely to emerge.

6.2 Empirical evidence

The empirical literature based on studies conducted in Europe on public acceptance of industrial hydrogen developments remains limited in both volume and scope. While 21 publications met the inclusion criteria, the coverage of factors is uneven.

A small number of factors — most notably trust, knowledge and sociodemographic characteristics such as age, gender, and education — have been studied relatively frequently. This also applies to perceived positive and negative impacts, although this is not clearly reflected in the visualisations. In several studies, impacts are measured using broader composite scales that combine multiple types of impacts, making it difficult to attribute results to specific impact categories.

Other factors, particularly place-related factors, process-related factors, and technological system characteristics, are represented by only a small number of studies or are absent from the empirical literature.

The literature review focused on studies conducted in Europe. This improves comparability and ensures direct relevance to the Dutch and European policy context but also means that the findings reflect the European research landscape. Different patterns may emerge in other regions.

6.3 Interpretation of findings

The available studies provide useful insights into factors that may be associated with public acceptance, but several limitations should be considered.

First, the number of studies is still limited, and there is considerable variation in how factors and public acceptance are measured. As a result, it is not yet possible to draw firm conclusions about the relationships between specific factors and public acceptance.

Second, many studies rely on one-time cross-sectional survey data. This means that the reported relationships are correlational and do not allow for causal conclusions. It therefore remains unclear whether changes in a given factor would lead to changes in public acceptance.

Third, the visualisations are based on statistically significant associations ($p < 0.05$) and do not account for the strength of these relationships (effect size). As a result, all significant findings are treated equally and studies with large samples are more likely to be represented, even when the underlying relationships are relatively weak.

Despite these limitations, several observations can be made. In general, the direction of associations between factors and acceptance appears broadly similar for general and local public acceptance. Factors that are positively associated with one are often positively associated with the other.

At the same time, some studies indicate that these relationships may not operate in the same way across all contexts and groups. Interaction effects show that the association between a factor and public acceptance can depend on other factors or conditions. For example, the relationship between compensation and acceptance may differ across age groups (Jikiun et al., 2023). This suggests that factors may not influence public acceptance in the same way across all contexts and groups.

This nuance is also reflected in a difference observed between general and local public acceptance. While the overall direction of associations is broadly similar, interaction effects appear more frequently in studies on local public acceptance than in studies on general public acceptance. It is unclear whether this reflects differences in analytical approaches or differences in how factors operate at the local versus the general level. It remains an open question whether similar patterns would emerge if interaction effects were examined more systematically across both types of acceptance.

More broadly, most studies focus on direct relationships between individual factors and public acceptance. Less attention has been given to how factors interact with each other or to the processes through which acceptance develops over time, for example in response to new information, societal and technological developments, or specific events such incidents or media coverage. As a result, the currently available evidence considered in this report provides only a partial understanding of how public acceptance is formed and evolves.

These findings have important implications for policy and practice. Measures such as communication, participation, or compensation may not have uniform effects, but may depend on the specific context and the characteristics of the groups involved.

Further research is therefore needed to examine not only the relative importance of individual factors, but also how factors relate to and influence each other. For example, participatory processes may shape perceptions of fairness, which in turn may affect trust and ultimately public acceptance (Ter Mors & van Leeuwen, 2023). Understanding how such relationships develop over time, and how individuals weigh different considerations such as risks, benefits, and costs, remains an important area for future research.

Within the Hy-SUCCESS project, these questions will be addressed in subsequent research. Workstream 4.1 will examine causal relationships and the relative importance of factors using experiments and repeated-measures longitudinal survey data. The longitudinal survey design further allows for the study of how public acceptance develops and changes over time. Workstream 4.2 focuses on the role of information, public debate, and argumentation, including an analysis of how media and communication shape perceptions. Workstream 4.3 examines labour market-related aspects and their implications for public acceptance.

6.4 Overall contribution

This report contributes to an emerging field by focusing specifically on public acceptance of industrial hydrogen developments, rather than hydrogen applications broadly. It provides a targeted and up-to-date overview of relevant factors shaping public acceptance.

By combining insights from empirical literature with expert perspectives, the report captures both empirically studied factors and factors that are theoretically relevant but not yet well represented in the literature.

Together, the factor framework, literature overview, and expert perspectives provide a useful reference point for policymakers and researchers working on public acceptance of industrial hydrogen in Europe. They also offer a foundation for the further research within the Hy-SUCCESS project.

The insights from this report will be shared across Hy-SUCCESS workstreams and within the GroenvermogenNL work packages, supporting alignment between social, technical, legal, and economic perspectives on the hydrogen transition.

By bringing these insights together, the report supports the development of hydrogen systems and decision-making processes that take societal perspectives into account.

7 References

References marked with an asterisk indicate studies included in the literature review.

*Alsheimer, S. (2025). Does the public want green hydrogen in industry? Local and national acceptance of methanol and steel transitions in Germany. *Energy Research & Social Science, 121*, 103973. https://doi.org/10.1016/j.erss.2025.103973

*Barbier, L., & Agnoletti, M. (2023). Are French people ready to accept hydrogen underground storage? An answer through the distance from object model. *International Journal of Hydrogen Energy, 48*(52), 19792–19802. https://doi.org/10.1016/j.ijhydene.2023.02.077

*Boomsma, C., Zonneveld, M., & Neuvel, J. M. M. (2025). Publieke beelden bij een veilige en gezonde energietransitie. Deelrapport waterstof en ammoniak. RIVM-rapport 2024-0011. RIVM. https://doi.org/10.21945/RIVM-2024-0011

Boudet, H.S. (2019). Public perceptions of and responses to new energy technologies. *Nature Energy, 4*, 446–455. https://doi.org/10.1038/s41560-019-0399-x

Boudet, H., Hazboun, S., Haggett, C., & Batel, S. (2025). Going slow to go fast: Public response and engagement in renewable energy projects. *Nature Reviews Clean Technology*, *1*, 877–889. https://doi.org/10.1038/s44359-025-00116-3

Bouw, K., Wiekens, C., Elbert, S., & Faaij, A. (2022). How to plan for success? An exploration of social context factors in neighbourhood energy planning. *Energy Research & Social Science, 92*, 102761. https://doi.org/10.1016/j.erss.2022.102761

*Buchner, J., Menrad, K., & Decker, T. (2025a). Keep it local and safe: Which system of green hydrogen production in Germany is accepted by citizens? *Renewable Energy, 241*, 122366. https://doi.org/10.1016/j.renene.2025.122366

*Buchner, J., Menrad, K., & Decker, T. (2025b). Public acceptance of green hydrogen production in Germany. *Renewable and Sustainable Energy Reviews, 208,* 115057. https://doi.org/10.1016/j.rser.2024.115057

Contzen, N., Perlaviciute, G., Steg, L., Reckels, S. C., Alves, S., Bidwell, D., Böhm, G., Bonaiuto, M., Chou, L. F., Corral-Verdugo, V., Dessi, F., Dietz, T., Doran, R., Eulálio, M. do C., Fielding, K., Gómez-Román, C., Granskaya, J. V., Gurikova, T., Hernández, B., … Sütterlin, B. (2024). Public opinion about solar radiation management: A cross-cultural study in 20 countries around the world. *Climatic Change, 177*, 65. https://doi.org/10.1007/s10584-024-03708-3

Elbert, S., Wiekens, C., Vedder, K. & Sprenkeling, M. (2023). Sociale acceptatie van waterstof: Transport, toepassing en opslag. Infographic Hydelta 2.0. https://hbo-kennisbank.nl/details/hanzepure:oai:research.hanze.nl:publications/d8949d74-8b25-460a-8232-2d02a2629bac

*Emmerich, P., Hülemeier, A., Jendryczko, D., Baumann, M. J., Weil, M., & Baur, D. (2020). Public acceptance of emerging energy technologies in context of the German energy transition. *Energy Policy, 142*, 111516. https://doi.org/10.1016/j.enpol.2020.111516

*Glanz, S., & Schönauer, A. L. (2021). Towards a low-carbon society via hydrogen and carbon capture and storage: Social acceptance from a stakeholder perspective. *Journal of Sustainable Development of Energy, Water and Environment Systems, 9*(1), 1080322. https://doi.org/10.13044/j.sdewes.d8.0322

Görsch, R., Perlaviciute, G., & Steg, L. (2025). A systematic review of public acceptability and perceived impacts of eleven energy sources and mitigation technologies. *Global Environmental Change, 93*, 103014. https://doi.org/10.1016/j.gloenvcha.2025.103014

*Häußermann, J. J., Maier, M. J., Kirsch, T. C., Kaiser, S., & Schraudner, M. (2023). Social acceptance of green hydrogen in Germany: Building trust through responsible innovation. *Energy, Sustainability and Society, 13*, 22. https://doi.org/10.1186/s13705-023-00394-4

Herder, B., Beukers, E., Nijkamp, J. & Rusinovic, K. (2024). De zachte stad. In *Platform Stad en Wijk.* https://platformstadenwijk.nl/wp-content/uploads/2024/07/magazine-de-zachte-stad_platform-stad-en-wijk.pdf

*Hildebrand, J., Sadat-Razavi, P., & Rau, I. (2025). Different risks—Different views: How hydrogen infrastructure is linked to societal risk perception. *Energy Technology, 13*(2), 2300998. https://doi.org/10.1002/ente.202300998

*Huijts, N. M. A., Molin, E. J. E., & van Wee, B. (2014). Hydrogen fuel station acceptance: A structural equation model based on the technology acceptance framework. J*ournal of Environmental Psychology, 38*, 153–166. https://doi.org/10.1016/j.jenvp.2014.01.008

*Huijts, N. M. A., de Vries, G., & Molin, E. J. E. (2019). A positive shift in the public acceptability of a low-carbon energy project after implementation: The case of a hydrogen fuel station. *Sustainability, 11*(8), 2220. https://doi.org/10.3390/su11082220

HyDelta (n.d.). HyDelta 2. https://hydelta.nl/hydelta-2-0

IEA (2021). *Global Hydrogen Review 2021.* IEA, Paris. https://www.iea.org/reports/global-hydrogen-review-2021

*Jikiun, S. P., Tatham, M., & Oltedal, V. M. (2023). Saved by hydrogen? The public acceptance of onshore wind in Norway. *Journal of Cleaner Production, 408*, 136956. https://doi.org/10.1016/j.jclepro.2023.136956

Johnson, B. B., & Slovic, P. (1995). Presenting uncertainty in health risk assessment: Initial studies of its effects on risk perception and trust. *Risk Analysis, 15*(4), 485-494. https://doi.org/10.1111/j.1539-6924.1995.tb00341.x

Kay, A. C., Whitson, J. A., Gaucher, D., & Galinsky, A. D. (2009). Compensatory control: Achieving order through the mind, our institutions, and the heavens. *Current Directions in Psychological Science, 18*(5), 264–268. https://doi.org/10.1111/j.1467-8721.2009.01649.x

Klebl, C., & Stanley, S. K. (2025). Capacity versus responsibility: Wealth and historical emissions as determinants of support for climate aid policy. *British Journal of Social Psychology, 64*(3), e12899. https://doi.org/10.1111/bjso.12899

*Klösters, M., Westbeek, E., Wantenaar, S., & Schiele, J. (2024). The public perception of green hydrogen in the Netherlands: Report HyScaling project task 6.2 (TNO 2024 R10988). TNO. https://publications.tno.nl/publication/34642689/RC7rckao/TNO-2024-R10988.pdf

*Mehmeti, A., Elezi, E., Andoni, M., & Bezo, Y. (2025). Public perceptions, awareness, and social acceptance of hydrogen technologies in Albania. *Hydrogen, 6*(3), 62. https://doi.org/10.3390/hydrogen6030062

*Navajas, J., Badia, E., Sala, R., & Gonçalves, L. (2025). From vision to reality: A longitudinal qualitative study on Spanish stakeholder perceptions of hydrogen energy technologies. *Energy Research & Social Science, 127*, 104178. https://doi.org/10.1016/j.erss.2025.104178

*Palomo-Vélez, G., Perlaviciute, G., Contzen, N., & Steg, L. (2025). How company history and hydrogen type shape public trust and acceptability: A reputation management perspective. *Energy Research & Social Science, 127*, 104279. https://doi.org/10.1016/j.erss.2025.104279

*Parente, C., Teixeira, F., & Cerdeira, J. (2024). Stakeholders' perceptions of hydrogen and reflections on energy transition governance. *Energy, Sustainability and Society, 14*, 15. http://dx.doi.org/10.1186/s13705-023-00429-w

Perlaviciute, G. (2022). Contested climate policies and the four Ds of public participation: From normative standards to what people want. *Wiley Interdisciplinary Reviews: Climate Change, 13*(1), e749. https://doi.org/10.1002/wcc.749

Perlaviciute, G., Steg, L., & Hoekstra, E. J. (2016). Is gas perceived as sustainable? Insights from value-driven evaluations in the Netherlands. *Energy Research & Social Science, 20*, 55–62. https://doi.org/10.1016/j.erss.2016.06.002

*Sadat-Razavi, P., Karakislak, I., & Hildebrand, J. (2025). German media discourses and public perceptions on hydrogen imports: An energy justice perspective. *Energy Technology, 13*(2), 2301000. https://doi.org/10.1002/ente.202301000

*Schmidt, A., & Donsbach, W. (2016). Acceptance factors of hydrogen and their use by relevant stakeholders and the media. *International Journal of Hydrogen Energy, 41*(8), 4509–4520. https://doi.org/10.1016/j.ijhydene.2016.01.058

*Schönauer, A., & Glanz, S. (2022). Hydrogen in future energy systems: Social acceptance of the technology and its large-scale infrastructure. *International Journal of Hydrogen Energy, 47 (*24), 12251–12263. https://doi.org/10.1016/j.ijhydene.2021.05.160

Scovell, M.D. (2022). Explaining hydrogen energy technology acceptance: A critical review. *International Journal of Hydrogen Energy, 47*(19), 10441–10459. https://doi.org/10.1016/j.ijhydene.2022.01.099

Siegrist, M., & Cvetkovich, G. (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis, 20*(5), 713–720. https://doi.org/10.1111/0272-4332.205064

Slovic, P. (1987). Perception of risk. *Science, 236*(4799), 280–285. https://doi.org/10.1126/science.3563507

Ter Mors, E., & van Leeuwen, E. (2023). It matters to be heard: Increasing the citizen acceptance of low-carbon technologies in the Netherlands and United Kingdom. *Energy Research & Social Science*, *100*, 103103. https://doi.org/10.1016/j.erss.2023.103103

*Zaunbrecher, B. S., Bexten, T., Wirsum, M., & Ziefle, M. (2016). What is stored, why, and how? Mental models, knowledge, and public acceptance of hydrogen storage. *Energy Procedia, 99*, 108–119. https://doi.org/10.1016/j.egypro.2016.10.102


Hy
SUCCESS