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Reprint of: Renewable hydrogen supply chains: A planning matrix and an agenda for future research

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ABSTRACT

Worldwide, energy systems are experiencing a transition to more sustainable systems. According to the Hydrogen Roadmap Europe (FCH EU, 2019), hydrogen will play an important role in future energy systems due to its ability to support sustainability goals and will account for approximately 13% of the total energy mix in the coming future. Correct hydrogen supply chain (HSC) planning is therefore vital to enable a sustainable transition, in particular when hydrogen is produced by water electrolysis using electricity from renewable sources (renewable hydrogen). However, due to the operational characteristics of the renewable HSC, its planning is complicated. Renewable hydrogen supply can be diverse: Hydrogen can be produced de-centrally with renewables, such as wind and solar energy, or centrally by using electricity generated from a hydro power plant with a large volume. Similarly, demand for hydrogen can also be diverse, with many new applications, such as fuels for fuel cell electrical vehicles and electricity generation, feedstocks in industrial processes, and heating for buildings. The HSC consists of various stages (production, storage, distribution, and applications) in different forms, with strong interdependencies, which further increase HSC complexity. Finally, planning of an HSC depends on the status of hydrogen adoption and market development, and on how mature technologies are, and both factors are characterised by high uncertainties. Directly adapting the traditional approaches of supply chain (SC) planning for HSCs is insufficient. Therefore, in this study we develop a planning matrix with related planning tasks, leveraging a systematic literature review to cope with the characteristics of HSCs. We focus only on renewable hydrogen due to its relevance to the future low-carbon economy. Furthermore, we outline an agenda for future research, from the supply chain management perspective, in order to support renewable HSC development, considering the different phases of renewable HSCs adoption and market development.

1. Introduction

Many countries have defined strategic tasks for reducing fossil-based energy sources to achieve emission goals. In this context, hydrogen presents an exciting opportunity to pursue ambitious climate and environmental policies for seeking clean fuels or, generally, low-carbon technologies for society. Hydrogen strategies and roadmaps have been proposed and updated to facilitate the adoption of hydrogen supply chains (HSCs) in, among others, Japan, Korea, the USA, the UK, Canada, Norway, and the EU (Canadian Government, 2020; DOE, 2020; FCH EU, 2019; Intralink, 2021; Japanese Government, 2017; Norwegian Government, 2020; UK Government, 2021). Countries are in different positions in terms of developing their hydrogen economies; while some see a strong need to import hydrogen, others see a high potential for exporting hydrogen. Accordingly, hydrogen is expected to constitute about 13% of the energy mix in the EU by 2050 (FCH EU, 2019), and by 2050 the hydrogen economy is estimated to represent US$750 billion in the USA and US$2.5 trillion in the global market (DOE, 2020).

Among these developments to reduce the dependence on fossil-based processes, particular attention is paid to the so-called renewable HSCs, where hydrogen is produced by water electrolysis, using electricity from renewable sources such as solar, wind, hydro and geothermal ones (in the text we refer to them as renewable feedstock (Li et al., 2019)). However, the development of renewable HSCs is still immature, and the

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planning of renewable HSCs is challenging due to the following operational characteristics.

In addition to the wide spectrum of applications, such as the transport industry, the steel and iron industry, the chemical and refinery industry, and buildings, there are various forms of renewable feedstocks for producing hydrogen which are characterised by high uncertainty in terms of their availability and performance. Moreover, hydrogen can be produced in large volumes in a centralised production facility or in small volumes in local systems. Depending on the geographic location and types of applications, hydrogen can be stored in different forms, and thus transported via different logistics means, such as trucks, pipelines, compressed tanks, liquified tanks, etc. Storage is paramount in operating renewable HSCs. In fact, hydrogen can be seen both as a final product and as an energy carrier, for example, to store electricity, both in terms of time and space. On the one hand, hydrogen storage can be used strategically to shift demand and supply across seasons, while on the other hand, storage is also used as a buffer for smoothing short-term supply and demand mismatches due to operational uncertainty. Furthermore, to achieve energy and economic efficiency, hydrogen needs to be integrated with energy systems, both in terms of feedstocks and applications, and an international perspective is needed to consider where supply and demand are generated.

Therefore, renewable HSCs are complicated, due to their potential diversity (types of stages, such as feedstock, production, storage, distribution, and application) and extensions (scaling of the supply chains and integration with other supply chains). There is a need to investigate the planning of HSCs, as a set of tasks which support decision-makers identifying alternatives within the supply chain processes (sourcing, production, storage, distribution, and market and sales), and selecting the most appropriate ones to satisfy a set of goals or objectives (Stadtler et al., 2015), such as cost, efficiency and safety. Moreover, the design and operations of renewable HSCs and therefore their performance are also affected by market development and technology selection, and vice versa. In this context, making renewable HSCs more complicated, technologies used for feedstock, production, storage, and distribution still have different maturity levels or technology readiness levels (TRLs), which impact the adoption and market development of renewable HSCs. Existing renewable HSCs are often used for pilot and demonstration purposes, whereas scale-up renewable HSCs are rare but imminent. To increase TRLs and facilitate the adoption of large-scale renewable HSCs, policy-making bodies are currently (beginning of the 2020s) funding research and development activities (Griffiths et al., 2021), with the aim of achieving stable growth for market activation, and eventually maturity, with a time horizon between 2020 and 2050.

Boosted by the availability of research funding, studies on hydrogen have mainly developed from a technological perspective, as methods, technologies, materials, among others for hydrogen production, storage and distribution. Largely pushed by the recent technological advances and the widespread adoption of renewable energy, this perspective is one of the main research topics for hydrogen production and use systems (Griffiths et al., 2021; Hong et al., 2021). These studies have resulted in knowledge contribution to the development approaches, methods, models, and technical design aiming at achieving the most suitable and efficient technological solutions to address HSC challenges (El-Emam and Özcan, 2019). The analysis of technology conditions has mainly focused on technical practices and performance of specific methods for hydrogen production, storage and distribution. For example, Bolat and Thiel (2014) and Muresan et al. (2013) have focused their research on hydrogen production systems, while Gallardo et al. (2021) have investigated renewable hydrogen production based on solar technologies. Hurskainen and Ihonen (2020), Lahnaoui et al. (2021) and Mingolla and Lu (2021) have proposed a technological assessment of hydrogen distribution and transport for both hydrogen and its derivatives.

However, some review studies scoping the HSC have been published, focusing mainly on two research streams: (i) the approaches and the models to achieve the optimal configuration of HSCs or of their single stages, and (ii) environmental impact assessments in terms of ecological performance and CO_2 emission factors.

Concerning the first stream, Dagdougui (2012) investigated different approaches to HSC planning focusing on methods and models for the stages' designs, such as production, storage, and distribution. Agnolucci and Mcdowall (2013) focused on the analysis of hydrogen infrastructures within the HSC on a spatial scale from national to regional and local scales for transport sector application. Li et al. (2019) presented a comprehensive review of HSCs considered as a whole and of single stages, proposing system analysis, solution approaches, and optimization-based models for planning HSCs within the transport sector.

Concerning the second research stream, Bhandari et al. (2014) analysed the environmental impact of different hydrogen production technologies through a life cycle assessment (LCA) analysis, while Maryam (2017) also focused on performance measures, such as cost minimization and environmental impact reduction. Balcombe et al. (2018) reported the decarbonisation potential associated with the stages of HSCs' encompassing feedstocks and hydrogen production, and El-Emam and Özcan (2019) reviewed large-scale clean hydrogen production by providing an economic and environmental assessment of the existing and most promising technologies. Recently, Griffiths et al. (2021) proposed a comprehensive review of hydrogen production and utilization for different applications by considering a sociotechnical perspective to assess the industrial decarbonisation process.

Even though these reviews have summarised hydrogen studies, they lack a comprehensive overview of the planning problems and tasks which are essential for decision-makers for managing the forthcoming dynamic development of renewable HSCs from a supply chain (SC) management perspective. Given the specific renewable HSC operational characteristics and uncertainty, directly applying the traditional approaches to supply chain planning to renewable HSCs seems insufficient. Moreover, the design and operation of a renewable HSC depend on the current phase of renewable HSC adoption and market development and how mature the technologies are, but both are still characterised by high uncertainty due to renewable HSCs' potential diversity and extensions. Thus, when designing a renewable HSC, long-term and short-term perspectives on uncertainty need to be included, and studies of renewable HSCs should adopt a dynamic view.

The contribution of this study is twofold. First, we introduce a planning matrix with related planning tasks for renewable HSCs. The planning matrix is developed by adapting the well-established matrix introduced by Stadtler et al. (2015), through a synthesis of the content analysis-based literature review of renewable HSCs. Second, we present an agenda for future research to support the selection of proper solutions to planning tasks, outlining the promising topics and areas in emerging renewable HSC studies. This agenda considers the main goals defined by hydrogen strategies and roadmaps, and describes changes based on the different phases of the adoption and market development of renewable HSCs. We present a comprehensive overview of potential problems and methodologies that operations and supply chain managers and researchers need to address in the future.

The remainder of this paper is structured as follows (see Fig. 1). Section 2 defines the stages of renewable HSC superstructures (feedstock, production, storage, distribution, and application) and the main existing pathways. Section 3 describes the methodology used for the data collection, adopting a systematic and structured approach (a systematic literature review). Section 4 presents an analysis of the state of the art of renewable HSCs, covering various articles distributed over time, journals and processes in renewable HSC. Section 5 synthesizes the content analysis of the literature identifying the various planning tasks for renewable HSC with respect to time horizons and processes in renewable HSC and highlighting the current challenges. Then, in Section 6, we present the impact of the renewable HSC adoption and market development on the definition of objectives and goals that decision-makers set for the identified planning tasks. In Section 7, we present

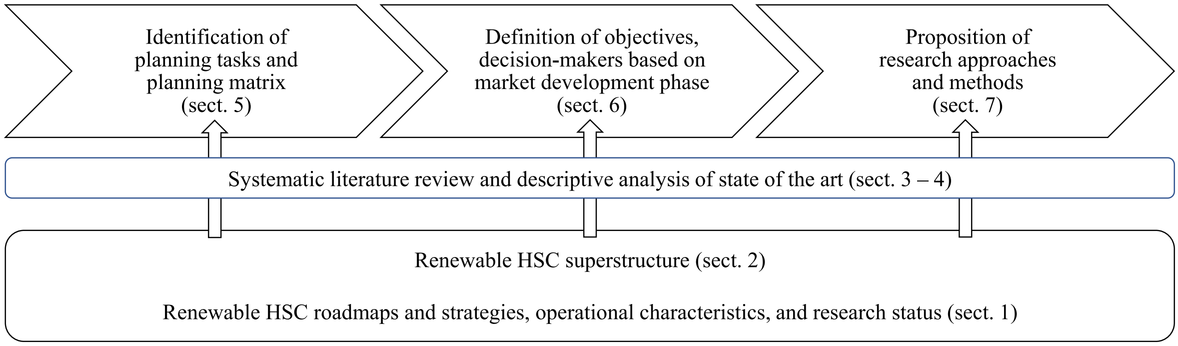

Fig. 1. Planning of renewable HSCs: structure of the research.

future research approaches and methods needed to support the decision-making process in finding the most appropriate solutions. Finally, Section 8 concludes the study.

2. Superstructure of renewable HSC

Currently, most hydrogen production uses fossil-based processes, which account for approximately 94% of total production (Nordic Energy Research, 2022). As clean hydrogen will achieve the sustainability goals, we focus on the new development of renewable-based production methods and thus exclude HSCs emphasizing fossil-based production. We note that one renewable alternative of hydrogen is biomass gasification with carbon capture and storage; however, this technology needs further development and its industrial production will not begin until the 2030s or later (UK Government, 2021). Thus, in this study, we focus on the potentially cleanest technology pathways of renewable hydrogen, where hydrogen is produced by water electrolysis, using electricity from renewable sources such as solar, wind, hydro and geothermal ones (renewable feedstock). However, we have to be aware of the ongoing debates about the taxonomy of green, blue and grey hydrogen (Climate Weekly, 2022; S&P Global, 2022). In the reviewed literature, there is no consistent definition of renewable hydrogen; for instance, green hydrogen is interchangeably referred to as renewable hydrogen (Griffiths et al., 2021).

There are plenty of potential applications for hydrogen, such as fuel for fuel cell electric vehicles (FCEVs) and electricity generation, feedstocks in industrial processes (steel, chemical and glass production), and heating for buildings. All these applications need structured and diffused renewable HSCs, which cover operations from different feedstocks through several stages, such as production, storage, and distribution, to supplying hydrogen for final applications (see Fig. 2). This superstructure represents the foundations of renewable HSCs.

As illustrated in Fig. 2, in a renewable HSC, various renewable sources as solar, wind, hydro and geothermal ones, are converted into electricity used for water electrolysis. Hydrogen can be produced with or without an electricity grid. In the former case, hydrogen production may

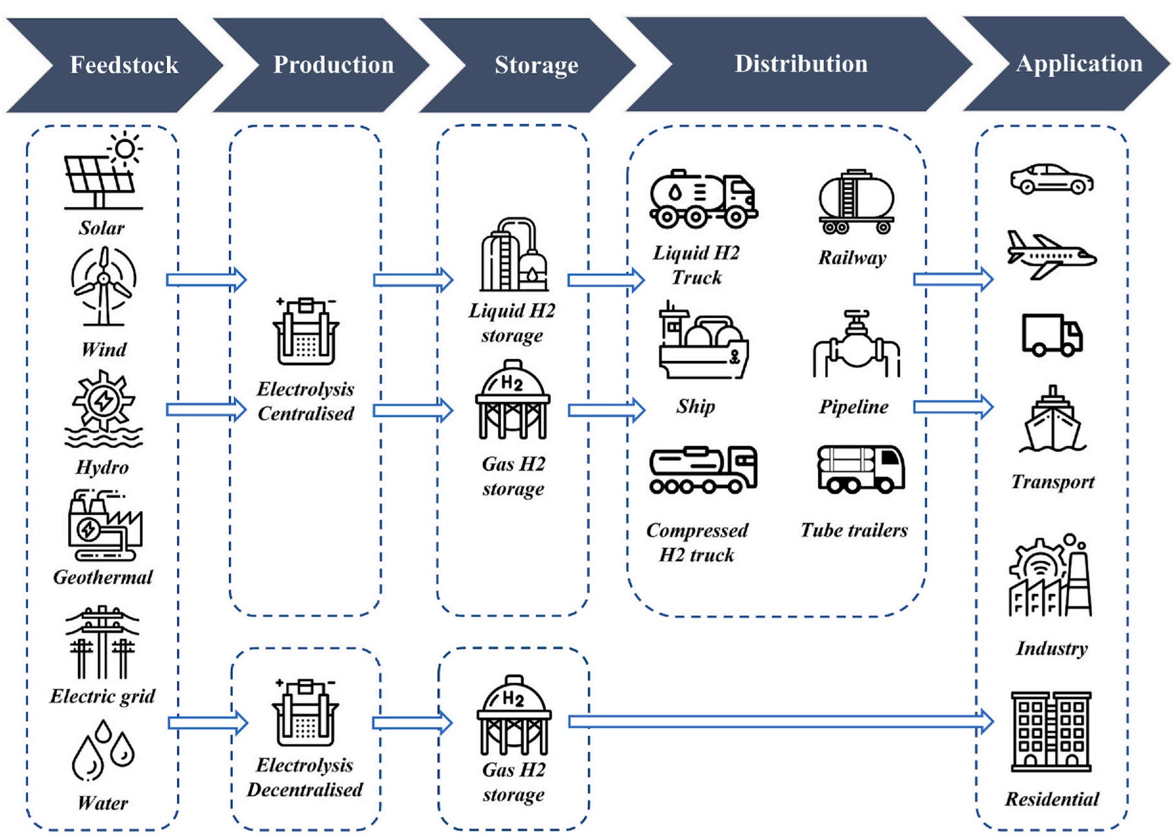

Fig. 2. Superstructure of renewable HSCs.

need to compete for supply, as electricity is often used for other purposes. In the latter case, supply disruption is common. Thus, hydrogen production without an electricity grid needs to manage the uncertainty of feedstock availability, but its advantage lies in the assurance of clean sources.

To satisfy the demand for hydrogen, the renewable HSC needs to be configured with a proper distribution network to transport hydrogen from the production sites to the points of use.

A decentralised electrolyser involves both onsite production for stand-alone and self-sustaining end-users/customers and distributed production consisting of facilities placed close to the point of use (Griffiths et al., 2021). Generally, production is often attached to wind power or solar photovoltaic (PV) systems, which implies small-scale production and thus potentially more expensive production and investment costs per unit of hydrogen produced (Tang et al., 2022). However, this setting is characterised by cheaper distribution costs due to short distances; preferably, it should be combined with storage solutions where compressed hydrogen is temporarily kept.

On the other hand, a centralised electrolyser, which is realised in combination with a large-scale power plant (such as a hydropower plant or other alternatives), implies an abundant and cheap electricity supply (Tang et al., 2021). However, due to the distance between the production and application sites, the distribution cost can be expensive. A preferable form of distribution comprises gaseous hydrogen via pipelines or liquid hydrogen via trucks and ships.

The application aspect can also influence the settings of hydrogen distribution. In the transport sector, for example, refuelling stations for FCEVs or bunkering stations for hydrogen-fuelled vessels are required to cover broad areas of interest. In the industrial and residential sectors, points of use are sparser and more concentrated within industrial clusters and residential areas. The selection of the distribution mode needs to be synthetized with the volume of transported hydrogen and the spatial-scale area covered by the supply chain, namely regional transport (from production sites and terminals placed in different regions), local transport (same regional area) and local distribution (between refuelling stations and terminals in the same region).

Due to the intermittent availability of renewable feedstocks and random demand along the distribution network, hydrogen storage systems have to maintain supply during peak demands and to provide a resource reservoir when demand is low while production continues. Hydrogen can be stored and transported in different ways, depending on its state (gas or liquid). Hydrogen in gas form is kept at a high pressure at about 350–700 bars, whereas liquid hydrogen needs a cryogenic temperature, meaning additional energy consumption in the liquidation process. Also, hydrogen can be stored in the forms of adsorption (on the surfaces) and absorption (within) on other solids, such as metals or chemical compounds. While liquid hydrogen can be transported via railways, ships and road by trucks, compressed hydrogen is often transported via pipelines, tube trailers, and compressed gas trucks. Also, hydrogen storage often occurs in several stages to fulfil the various purposes of renewable HSCs.

From the above description, it is clear that these stages are characterised by planning problems that operations and supply chain managers have to face (e.g., which feedstock to select, where to locate production, how to operate storage facilities, etc.). A commonly used framework in supply chain management to describe the main planning problems and corresponding tasks is the supply chain planning matrix (Stadtler et al., 2015). This matrix categorises the planning problems and tasks in accordance with two dimensions: (i) the supply chain processes of procurement, production, distribution, and sales, and (ii) the planning horizons, namely long-term and mid-/short-term. More specifically, the unique supply chain processes are matched with the supply chain stages: the feedstock, production, storage, distribution, and application stages correspond to sourcing, production, storage, distribution, and market and sales processes, respectively.

However, due to the unique operational characteristics of renewable HSCs and their adoption and market development, the planning matrix for traditional supply chains is inadequate to represent and summarise the different renewable HSC-related planning problems and tasks. Therefore, a new planning matrix needs to be developed specifically for renewable HSCs, and this represents one goal of the current study, in addition to the definition of an agenda for future research.

3. Research methodology

To develop a renewable HSC planning matrix, we conducted a systematic literature review (SLR) as the content analysis, since it ensures the replicability of the study, improves the traceability of the arguments and ensures the validity and reliability of the results (Sudusinghe and Seuring, 2022). Specifically, in carrying out the SLR, we followed the three-step guidelines provided by Tranfield et al. (2003).

Step 1 – Planning the review

In this step, we identify the need, prepare the proposal and develop the protocol for the SLR. Specifically, the need and proposal for the SLR were described in the previous sections, while for the SLR protocol, we adopted the PRISMA protocol (Moher et al., 2009).

Step 2 – Conducting the review

The review was conducted according to the PRISMA protocol (see Fig. 3). In this step, we first collected relevant articles using the Scopus database in two separate searches. Scopus was selected mainly because of its broad coverage of journals in management, engineering and environmental sciences (Ahi and Searcy, 2015).

The first search adopted a two-group keyword structure with the purpose of collecting multiple large-scale keywords to consistently cover the published works related to HSCs. The first group (group A) consists of the keyword that defines the search context of this analysis, namely ‘hydrogen’, while the second group (group B) consists of the keywords that characterise the search scope, namely ‘supply chain*‘, ‘logistic*‘, ‘production management’, ‘operations management’, and ‘supply network*‘. The logical operators ‘AND’ and ‘OR’ were used to generate the search strings within ‘Title, Abstract and Keywords’ (e.g. ‘[keyword of Group A] AND [keyword of Group B OR another keyword of Group B]’). We limited the search to articles in English and within the following subject areas: ‘energy’, ‘engineering’, ‘chemical engineering’, ‘environmental science’, ‘computer science’, ‘material science’, ‘business, management and accounting’, ‘mathematics’, ‘social science’, ‘multidisciplinary’, ‘decision science’, and ‘economics, econometrics, and finance’. This first search resulted in 1154 articles (see Fig. 3).

The second search was then conducted to overcome the potential limitation of the first search: The choice of the specific keywords can be overly limiting in providing good coverage of the investigated area of interest, thus resulting in an incomplete set of articles. In the second search, only ‘hydrogen’ was used as a keyword, and the search was limited to articles published in the 70 most relevant journals dealing with supply chain management and operations management in the following subject categories: business, management and accounting (all); computer science (all); computer science applications; decision sciences (all); economics and econometrics; engineering (all); industrial and manufacturing engineering; information systems and management; management science and operations research, strategy and management; and transport. The selection of the journals was based on authors' experience, the selection is presented in Appendix A. The second search resulted in a total of 996 articles, which, combined with the results of the first search, led to a total of 2133 articles (after removing duplicates).

We then screened these articles according to the following inclusion criteria:

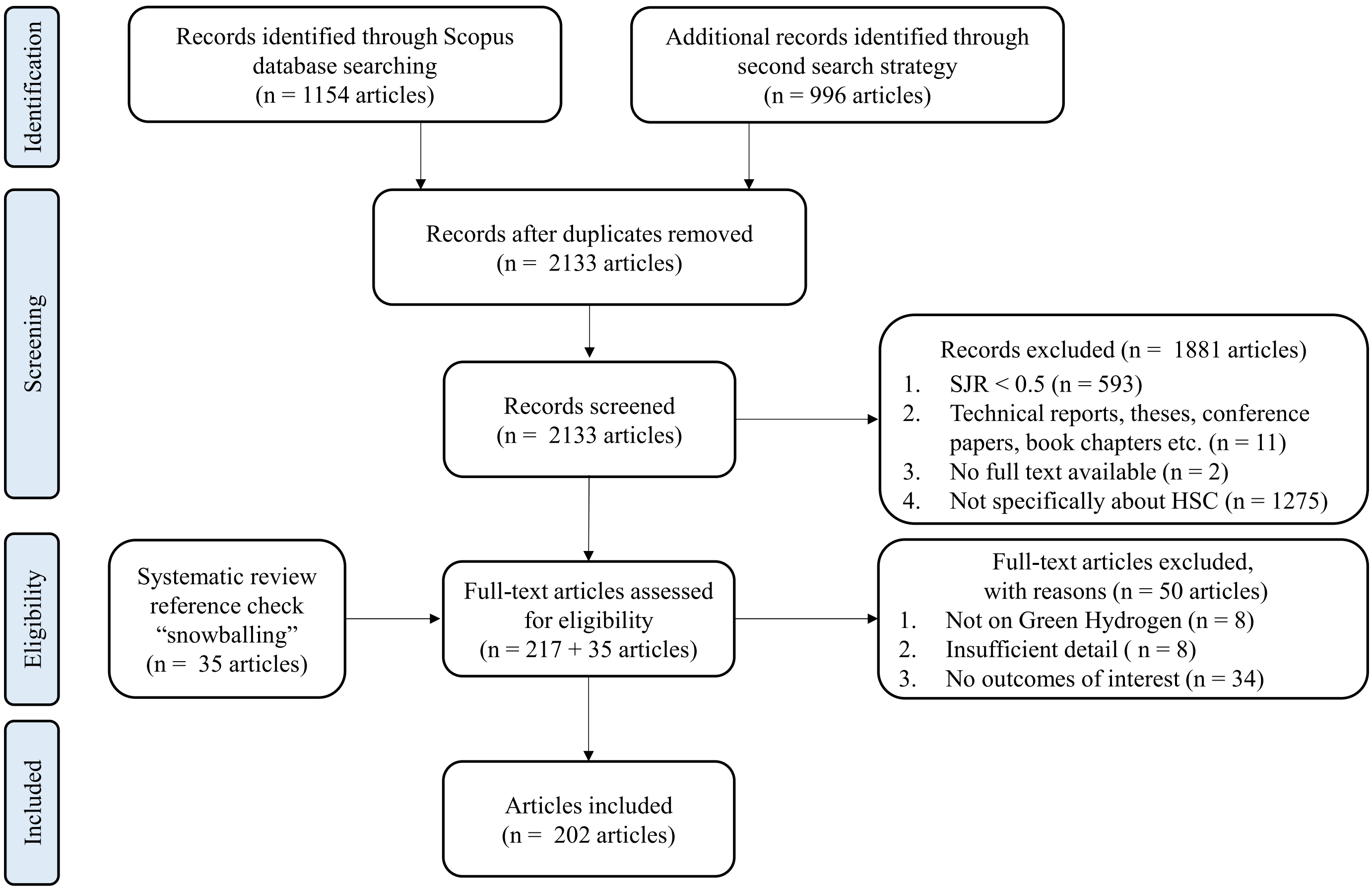

Fig. 3. PRISMA protocol diagram.

i. Journal articles: Only journal articles (original research articles or reviews) were considered, while conference papers, book chapters, technical reports, etc. were excluded.
ii. Scimago Journal Rank (SJR) index: Only articles published in journals with an SJR index greater than or equal to 0.5 were considered.
iii. Full text availability: Only articles with full text availability were considered.
iv. Renewable HSC: Only articles focusing on renewable HSCs were considered; this was determined by screening titles and abstracts.

It is worth mentioning that to ensure the reliability and objectivity of the results, point iv was executed independently by two authors of this study. This approach is not new in the field of SLRs (Duriau et al., 2016; Seuring and Gold, 2012). Also, Seuring and Müller (2008) stated that *'this is the minimum requirement, but given the time-consuming process, it is somehow unrealistic to include more than this'*. When the two authors had different judgments, the related articles were assessed in a discussion involving all the authors until a final consensus was reached. At the end, the article set was reduced to 217 articles.

The full texts of the articles were then read by all the authors to confirm suitability for the topic (renewable HSCs) and discarded if irrelevant. This step resulted in 167 articles.

Lastly, a snowballing procedure was conducted, whereby additional relevant articles were extracted from the references of the eligible articles. These new articles were then evaluated, limiting the selection to those in English and screening their contents considering Criteria i–iv. In the end, 35 additional articles were considered eligible, and this led to a total of 202 articles to be included in the SLR (see Appendix B).

Step 3 – Reporting and dissemination

In this step, we first presented the results of the descriptive analysis (Section 4), where we indicated how the selected articles were distributed over time and over journals. Moreover, we distributed the articles according to the categories used in the content analysis (Section 5). The content analysis represents the second part of this step, in which we analysed the content of the articles based on categories deductively derived from the SC planning matrix (Stadtler et al., 2015). These correspond to the SC processes of the SC planning matrix (i.e., sourcing, production, storage, distribution, and market and sales), with each divided into the two levels of planning horizons (i.e., long-term and mid-/short-term). Specifically, since the aim of the content analysis is to support the development of a renewable HSC planning matrix, this was considered a logical choice. Such a deductive categorisation represents common practice in literature reviews for situations in which the literature on the topic already exists (Seuring et al., 2021; Seuring and Müller, 2008). As stated by Beske et al. (2014), this approach contributes to the *'external validity as the research design is set up in a rigorous manner and transparently described'*. Moreover, to ensure reliability and objectivity in the categorisation, the same approach was adopted in conducting the review (see Step 2 – Conducting the review) that was applied for the categorisation. As described above, the results of the content analysis were then used to build the planning matrix presented in Section 6.

4. Descriptive analysis of the state-of-the-art on renewable HSCs

As illustrated in Fig. 4, interest in research on renewable HSCs has increased over the years, especially after 2015 with the signing of the Paris Agreement, which aims to substantially reduce global greenhouse gas emissions to limit global warming (European Commission, 2016). Relevant to this perspective is the statement by Daryl Wilson, the

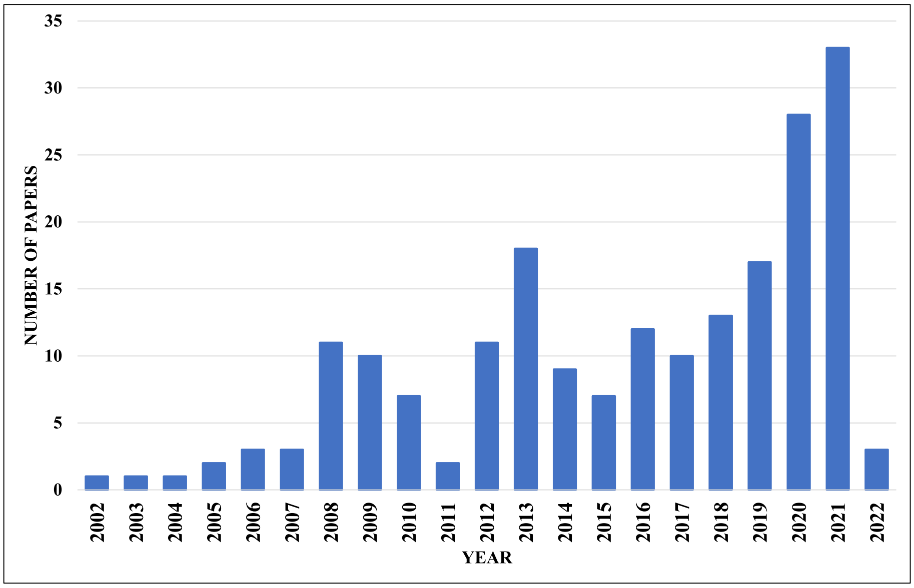

Fig. 4. Distribution of articles over time.

executive director of the Hydrogen Council: '*Hydrogen is absolutely critical to the realisation of our decarbonisation goals as set out in the Paris Agreement […] We need hydrogen from the standpoint of moving our energy around in the new energy economy*.'

However, despite the increased interest in renewable HSCs, a very limited number of articles have been published in journals with domain topics in supply chain management and operations management (e.g., the *International Journal of Production Economics*). In fact, most of the articles are published in energy- and environment-related journals (the *International Journal of Hydrogen Energy*, the *Journal of Cleaner Production*, *Energy*, etc.). Fig. 5 presents the journals with the number of articles published in descending order. The category 'Others' groups all remaining articles.

Of the 202 articles, 16 were identified in journals within the supply chain management domain. Four articles were found in the *European Journal of Operational Research* (André et al., 2013; Bapna et al., 2002; Lim and Kuby, 2010; Schulte Beerbühl et al., 2015), three in *Transportation Science* (Daziano and Achtnicht, 2014; Kang and Recker, 2014; MirHassani and Ebrazi, 2013), two each in the *International Journal of Production Economics* (Finnah and Gönsch, 2021; Kostin et al., 2015), *Transportation Research Part C: Emerging Technologies* (Brey et al., 2016; Crönert and Minner, 2021) and *Transportation Research Part E: Logistics and Transportation Review* (Li et al., 2021; Parker et al., 2010), and finally one article each in *Computers and Industrial Engineering* (Woo and Kim, 2019), *Expert Systems with Applications* (Torreglosa et al., 2016) and *Production and Operations Management* (Glenk and Reichelstein, 2020).

The lack of a supply chain management perspective in hydrogen studies was also confirmed by the topics of the articles. Only 24% of the articles (48 out of 202) considered all five processes of the HSC (i.e., sourcing, production, storage, distribution, and market and sales) (see Fig. 6). Moreover, considering the same figure, it is also interesting to note that the majority of articles deal with long-term supply chain planning tasks, confirming that we are still in the early investigation phase, when strategic decisions mainly focus on renewable HSC adoption and market development.

5. Planning tasks in renewable HSCs

As mentioned before, the selected articles were classified according to the different SC processes (i.e., sourcing, production, storage,

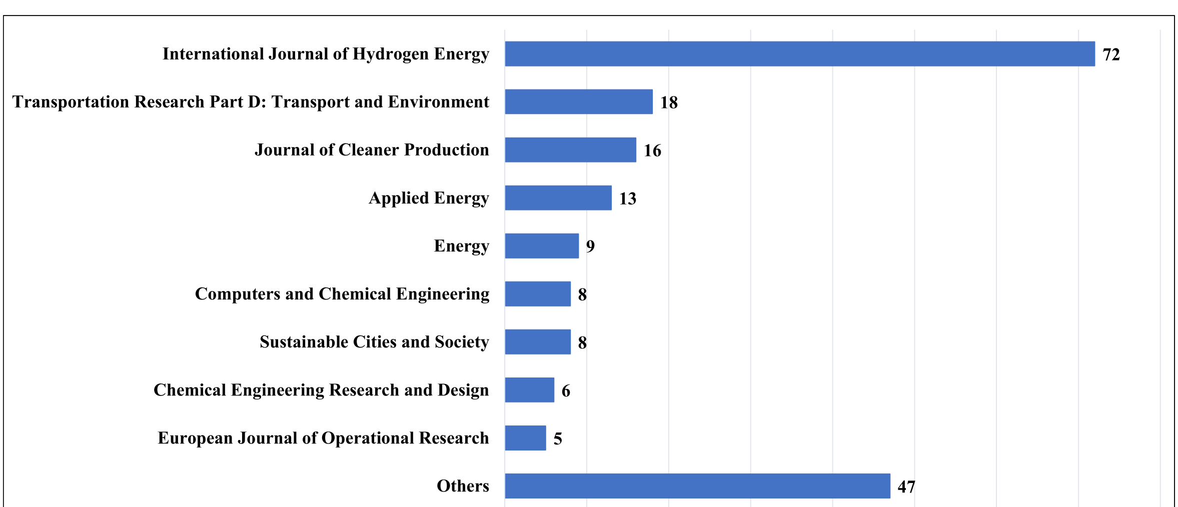

Fig. 5. Distribution of articles over journals.

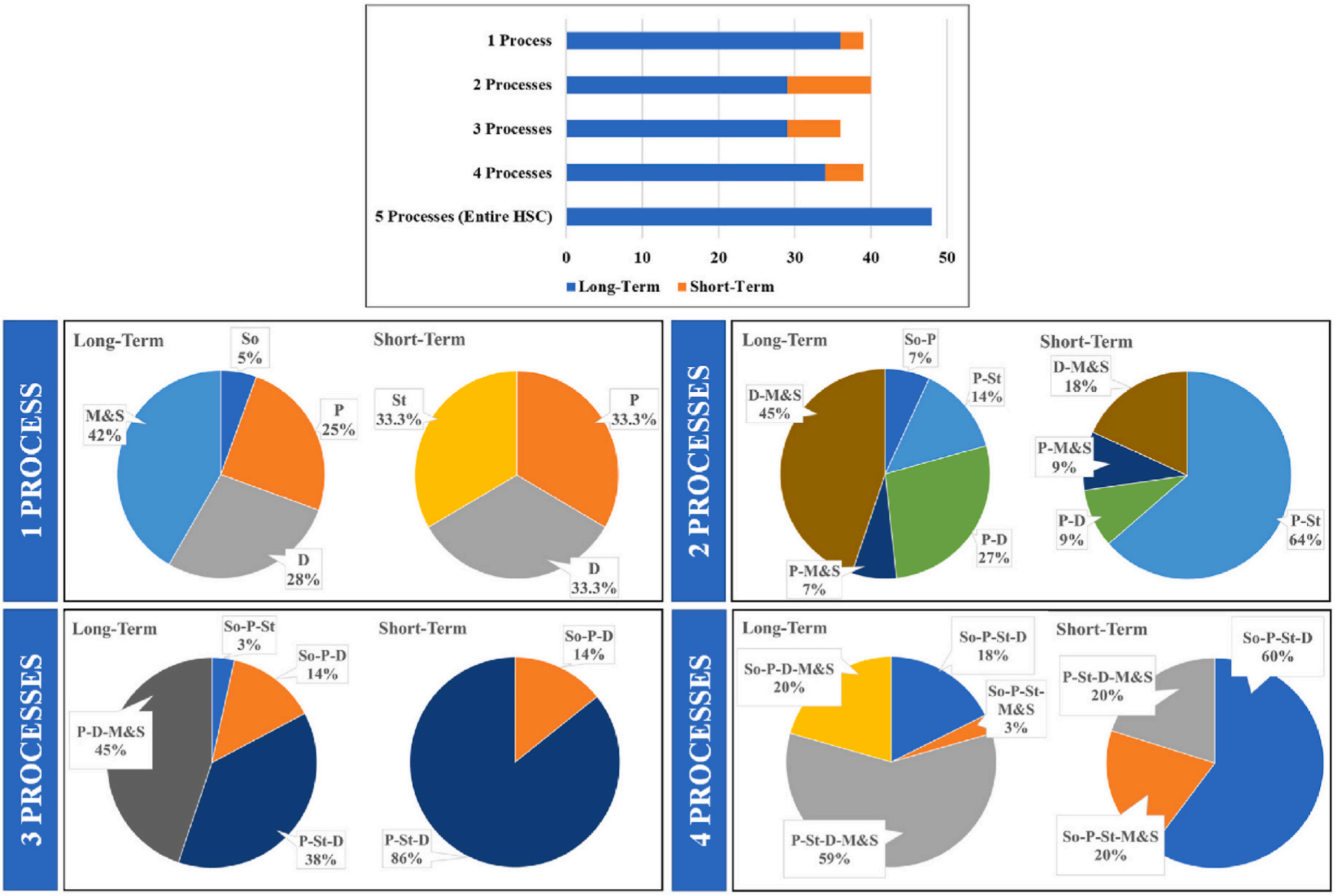

Fig. 6. Topics considered by the articles. So = sourcing; P = production; St = storage; D = distribution; M&S = market and sales.

distribution, and market and sales) and the two planning horizons (i.e., long-term and mid-/short-term) of the SC planning matrix. Below we summarise the current state of the art for each of these categories, and we analyse these from an SC management perspective. Our aim is to identify the different planning tasks, and the associated challenges, and subsequently we define the planning matrix for renewable HSCs.

In the following, Section 5.1 deals with long-term planning tasks, while Section 5.2 deals with mid-/short-term planning tasks.

5.1. *Long-term planning tasks*

This section reports the current research dealing with long-term planning tasks. Specifically, we discuss each process in renewable HSC. As discussed before, each process is often linked to other processes, and hence the last subsection deals with the whole renewable HSC.

5.1.1. *Sourcing*

Generally, hydrogen can be produced via water electrolysis using different renewable energy sources, such as solar, wind, hydro and geothermal. As illustrated in Fig. 6, sourcing has never been studied alone but always in combination with other renewable HSC processes, particularly the production process. Choices in the sourcing process, in fact, strongly impact planning tasks in the production process, such as the type, location and size of facilities (Almansoori and Shah, 2012; Cantú et al., 2021). A typical planning task in the sourcing process is the selection of the best feedstock from an economic perspective (Tseng et al., 2005), often integrated with planning tasks in the production process. Almansoori and Betancourt-Torcat (2016), for example, determined the most economic production technologies based on different available sources. In the existing literature, authors have mainly adopted the MILP modelling approach, which includes the analysis of the geographical location, availability and quantity issues in problem settings (Almansoori and Shah, 2009; De-León Almaraz et al., 2015).

Researchers have recently started considering sourcing from existing energy systems and infrastructures. For example, Almansoori and Shah (2012) considered the alternatives of importing feedstocks from neighbouring grids or external sources (e.g., another country) instead of building new production facilities. A similar study was conducted by Mohseni and Brent (2020). Multiple sourcing, together with the safety stock of energy sources, represents a potential solution to deal with feedstock uncertainty (as a consequence of intermittent renewables, such as solar and wind sources).

Finally, another emerging research topic is the inclusion of environmental impacts on feedstock choices, for example, adding environmental constraints in MILP (Almansoori and Betancourt-Torcat, 2016), adopting multi-objective MILP techniques (Carrera and Azzaro-Pantel, 2021a), and including environmental protection policies (e.g. CO_2 taxations) into the model (Han and Kim, 2019).

In conclusion, planning tasks related to sourcing have to consider two main challenges. The first is the availability and quality over time of different sources, their location and accessibility, and their price in relation to the energy market and long-term agreements with suppliers (Almansoori and Shah, 2012). The second is the uncertain features of these sources, in the light of which it could be interesting to establish sources' portfolios and resource pooling principles to reduce supply risk.

5.1.2. *Production*

As discussed before, the production process is often evaluated together with the sourcing process, since these are closely interconnected. Moreover, as indicated in Fig. 6, the production process is often also coupled with the storage and/or distribution processes. As reported by various authors (Agnolucci et al., 2013; Almansoori and Betancourt-Torcat, 2016; Cantú et al., 2021), typical planning tasks in the production process relate to the number, locations, technologies, and scales of hydrogen production facilities. These decisions are usually made through MILP models that consider, among others, trade-offs between establishing facilities and transport links (Almansoori and Shah, 2012), or through GIS modules embedded within the MARKAL model (Balta-Ozkan and Baldwin, 2013). Also, some studies have considered different hydrogen demands to reflect the different phases of hydrogen adoption (Ball et al., 2007; Dayhim et al., 2014; Talebian et al., 2019), because different demands *'lead to significant changes in the structure and cost of the optimal supply chain network'* (Almansoori and Shah, 2012). These studies confirmed the high impact of the hydrogen adoption level on the production process, and more generally on the whole renewable HSC: In the initial phase, when the adoption level is low, small onsite decentralised production is convenient, since it is more expensive to transport small amounts of hydrogen than to produce it in small-scale units; however, in later phases, when the adoption level increases, centralised larger-scale production capacities are more economical, leveraging economies of scale. Situations can, however, change if existing electricity grids are used. When distribution and transmission costs are avoided, centralised production becomes convenient, also in the initial phase. Nevertheless, in this case one concern is whether hydrogen can be defined as renewable, as this depends on the source of electricity in the grid.

Another factor affecting the number and locations of production facilities is technology maturity, but its impact on production decisions has barely been studied. Two related studies (but still not essentially targeted) are those of Chen et al. (2021) and Wu et al. (2021). The authors investigated the impact of different electrolysers' lifetime on the choice of production method and location. Demirhan et al. (2021) further investigated the effect of reducing electrolysers' costs related to technology maturity.

Finally, another current topic includes not only economic considerations but also environmental and safety considerations in the models for the production stage (Al-Breiki and Bicer, 2021; Almansoori and Betancourt-Torcat, 2016; De-León Almaraz et al., 2015).

In conclusion, the above-mentioned planning tasks are complex, as they are affected by certain significant factors. The selection of electrolyser technology and its production capacity is not straightforward. On the one hand, there is the desire to exploit as much as possible the sources' availability, selecting an electrolyser whose capacity matches the peak availability of sources (Almansoori and Betancourt-Torcat, 2016). On the other hand, this would result in redundant electrolyser capacity and a long return of investment (Balta-Ozkan and Baldwin, 2013). Therefore, it is critical to investigate the trade-off of investment cost in electrolyser capacity to balance the availability of feedstocks and the idle time of the electrolyser.

Similarly, the other main planning tasks are complex, for example, the location of the production facilities, which cannot be considered alone since it impacts the form of the distribution. As mentioned by Almansoori and Shah (2012), electrolysers can be located close to the feedstocks, and the produced hydrogen can be distributed via a complex network (for example, in transport sector application, a centralised production with distribution to refuelling stations). Alternatively, electrolysers can be installed close to the point of use with a more straightforward distribution mode (for example, in industrial sector application, the hydrogen production could be a local installation within the steel production facility).

Finally, these planning tasks are further influenced by the hydrogen adoption level and by the technology maturity, which have however been overlooked in the literature and represent one of the main challenges that renewable HSC managers have to face.

5.1.3. Storage

The main role of storage is to withstand any demand/supply fluctuation. In fact, as stated by Tlili et al. (2020), the role of hydrogen storage is twofold: '*on the one hand, it allows ensuring a seasonal storage in order to cope with the variability of renewable energy resources. On the other hand, hydrogen storage is a key component of the hydrogen supply chain allowing to bridge between discontinuous production and demand, exhibiting non-matching profiles*'. Typical planning tasks related to hydrogen storage involve the type and number of facilities, facilities' capacities, and facilities' locations (Almansoori and Betancourt-Torcat, 2016), and these problems are usually solved with MILP models (De-León Almaraz et al., 2015; Güler et al., 2021).

Another planning task is related to the type of storage form. Hydrogen, in fact, can be commonly stored in two ways, as compressed hydrogen in high-pressure tanks and as liquid hydrogen in liquid tanks. The former is characterised by a lower energy volumetric density than the latter, but despite the special requirements for the vessel material, it involves relatively lower capital and operational costs (Agnolucci et al., 2013; Yang et al., 2021).

The planning tasks related to this process (i.e. storage type, facilities' locations, etc.) depend on the hydrogen adoption (hydrogen demand volume, location, etc.), and the tasks are interconnected with the decisions in the production and distribution processes (De-León Almaraz et al., 2015). For example, Yang et al. (2021) found that storing (and distributing) gaseous hydrogen is convenient when the demand is low and the distance to the point of use is short, while storing (and distributing) liquid hydrogen is more efficient and suitable for large-scale and long-distance transport. Similar results have been reported by Talebian et al. (2019) and Tlili et al. (2020). However, to make liquefied hydrogen solution operationally feasible and economically viable, technological advancements are still needed for a reduction in the capital and operational costs of liquefying hydrogen (Reuβ et al., 2017), or in the maturity of new technologies to store hydrogen, such as liquid organic hydrogen carriers (LOHC), hydrides, etc. (Reuβ et al., 2017; Tlili et al., 2020).

It is worth mentioning that the major studies regarding storage often deal with economic analysis, while environmental analysis has only recently raised concerns (Cantú et al., 2021; Kazi et al., 2021; Kim et al., 2021). However, what has completely been overlooked is safety analysis, which is particularly important in the case of liquid hydrogen, as a consequence of the boil-off problem (Al-Breiki and Bicer, 2021). Furthermore, as stated by Agnolucci and Mcdowall (2013), it would be interesting to include an analysis of the real lifetimes of facilities.

In conclusion, planning tasks related to this process depend on several factors. First of all, the location of storage facilities depends on the scope of storage (Woo et al., 2016): If the storage function aims to handle overproduction during the availability peak of feedstocks, it should be installed close to the production facility; while if the storage function is to buffer the fluctuation in demand, it should be installed close to the point of use. Also, storage can be seen along the distribution to balance the flows. Moreover, due to the seasonality of feedstocks, a renewable HSC may also need to consider strategic storage (Tlili et al., 2020).

Furthermore, the different planning tasks related to the storage process are interconnected, both in relation to the tasks and with the decisions taken in the production and distribution processes: As an example, the location of storage facilities depends also on their capacities, as well as on the type of hydrogen stored (liquified or compressed gas), and the decision is also affected by the distribution network (Yang et al., 2021; Xu et al., 2022).

Finally, we need to be aware of the impact that technological advancements and market development aspects have on these planning tasks. Technological advancements, for example, will lead to a reduction in capital and operational costs for liquefied hydrogen, hence rendering it more convenient, affecting not only the planning tasks related to the storage process, but also to the other processes.

5.1.4. Distribution

From a long-term perspective, the distribution process plays a vital role in effectively designing renewable HSCs. Typical planning tasks in the distribution process concern the identification of the most efficient and effective hydrogen transmission mode, and the choices are closely related to other renewable HSC processes (Johnson and Ogden, 2012). This was evident in Fig. 6, which illustrated that the distribution process is often discussed together with other processes in renewable HSC. The main factors affecting the choice of transmission and distribution modes are the physical states and the spatial and temporal hydrogen demands, in other words, the travel distance from the production site to the end-users and the hydrogen demand profile.

Similar to the storage process, hydrogen can be transported as a liquid or compressed gas. With the former, the major transmission methods are tankers via railways, roads or ships, while with the latter, hydrogen is moved via high-pressure pipelines, tube trailers or railway tube cars. Some articles have investigated the most cost-effective means of transporting hydrogen at scale. In this regard, based on distance and demand, compressed gas is preferred for short distances and at a small scale of hydrogen, while, as the values of these two factors increase, first liquid hydrogen is preferred, then giving way to gas hydrogen via pipelines, which is the most prominent option at large scale and for massive quantities (Reuβ et al., 2019; Griffiths et al., 2021; Lahnaoui et al., 2021). Exploiting existing infrastructures, such as natural gas grids, is an emerging and economically viable opportunity to boost hydrogen-based transition and reduce the costs of the distribution. In this case, its practical application faces some limitations related to pipeline material degradation and structural integrity (Cerniauskas et al., 2020; Quarton and Samsatli, 2020). Regarding related studies, current challenges focus on environmental and safety perspectives. The environmental impact assessment in terms of ecological performance and CO_2 emission factors is discussed in an LCA analysis (Wulf et al., 2018) or carbon emission measurement (Reuβ et al., 2019). Several articles have discussed risk-related technical issues by considering hydrogen infrastructure safety performance, especially in terms of material properties (structures containing hydrogen whether in liquid or gas state), since several damage mechanisms, such as embrittlement and fatigue crack propagation, could occur for existing infrastructures (Ratnakar et al., 2021).

Finally, a recent research stream has focused on the potential conversion of hydrogen to other chemicals, such as ammonia or LOHC, since they can be stored under ambient conditions without the need for high pressure, resulting in a cost reduction (Bano et al., 2018; Hurskainen and Ihonen, 2020).

Moreover, to include the final application stage in the distribution stage, another related decision concerns the refuelling station. The major challenge is on the location and size of hydrogen refuelling stations, since the goal is to select appropriate geographic locations where a certain number of facilities can be arranged to meet determined end-users' demand, taking into consideration economic, environmental, technological, social, and energy constraints. To achieve this, several approaches are discussed, such as the MARKAL model (Gül et al., 2009), the flow-refuelling location model (FRLM) (Zhao et al., 2019), and the flow-capture location model (FCLM) (Crönert and Minner, 2021).

To summarise, one of the main planning tasks related to the distribution process is the selection of the hydrogen transmission mode. This decision depends on several factors, namely the available technologies, the volume of hydrogen in the supply chain, the distances to cover, and whether the hydrogen is liquified or compressed (Johnson and Ogden, 2012). Moreover, this planning task is interconnected with decisions on storage capacity and locations (De-León Almaraz et al., 2015). As with the storage process, it is important to consider the yield factor related to the process duration and potential leakages.

Finally, this planning task, together with the decisions regarding the location of refuelling stations or other points of use, are affected by the market development aspects (Zhao et al., 2019; Li et al., 2019).

5.1.5. Market and sales

Today hydrogen has become a particularly attractive option in a variety of new applications, such as the transport, residential, and industrial sectors for heat and power generation. In particular, the most prominent use lies in the transport industry, employed as FCEVs (public and personal transport) and internal combustion engines (limited to shipping and aviation) (Janic, 2008; Logan et al., 2020; Hensher et al., 2022). However, although its current practical use is rather limited in scope, very promising scenarios are on the horizon, leading to a rapid transition to a hydrogen economy. To boost this transition, more efforts are required to reduce the uncertainty in the estimation of hydrogen demand, which is a key aspect impacting the renewable HSC structure and thus other renewable HSC processes. For instance, the choice of centralised or decentralised production, as well as distribution modes, is strongly affected by the demand profile, since, when growth in hydrogen demand is expected, centralised production with a pipeline network is preferred. According to Li et al. (2019), three different approaches are adopted to forecast hydrogen demand: (i) the adoption of a logistic substitution curve, that is, an S-shaped diffusion curve to describe hydrogen market development as a function of time and number of adopters (Almansoori and Shah, 2009; Agnolucci and Mcdowall, 2013); (ii) the adoption of socio-economic factors estimated at spatial and temporal scale (Dayhim et al., 2014; Moreno-Benito et al., 2017); and (iii) a method based on a MARKAL/TIMES model, where the energy system model and a SC model is integrated, aimed at evaluating both infrastructure deployment, cost, and techno-economic specification (Agnolucci et al., 2013).

Specifically, long-term demand forecasts are crucial for market and sales, and these correspond to forecasting the market development. In addition to business, economic, political, and competitive factors (Li et al., 2019), which are included in traditional SCs, the level of adoption of hydrogen technology also significantly affects market and sales. Therefore, substantial investigation is needed when it comes to demand forecasts and their long-term projections.

5.1.6. The whole renewable HSC

As discussed in each process in renewable HSC, the planning tasks at each process both influence and are influenced by those at other processes in renewable HSC. For example, the distribution mode selected (truck, railway, pipeline, etc.) depends on the location of the production facilities with respect to the location of the point of use. On the other hand, the distribution mode determines whether liquid or gaseous hydrogen should be stored. Hence, it is critical that the renewable HSC design takes place with a holistic view, considering all the processes in renewable HSC, instead of being solely based on a single process. This is the only approach to ensure that the renewable HSC is optimised, and over the years, researchers have begun to understand this. Since the first study of Almansoori and Shah (2006) on HSC design, where only three processes were considered (i.e., production, storage, and distribution), an increasing number of studies have included all five processes (Cantú et al., 2021; Carrera and Azzaro-Pantel, 2021a; Moreno-Benito et al., 2017).

Moreover, researchers are suggesting multi-period analysis in designing renewable HSCs (De-León Almaraz et al., 2015; Han and Kim, 2019): renewable HSCs are optimised not just for a specific period but for an extended period, in other words, renewable HSCs are designed considering increasing hydrogen adoption. In fact, from the literature it emerges that the main factor influencing renewable HSC design is the level of hydrogen adoption. High investment costs for certain infrastructures (e.g. pipelines) are sustainable only if hydrogen adoption is high (Griffiths et al., 2021). Similarly, economies of scale are achievable only when the hydrogen demand is high (hence, when hydrogen adoption is high) (Agnolucci and Mcdowall, 2013). At the time point when hydrogen adoption is low, renewable HSC design is different to achieve cost efficiency (e.g., solutions with low investment costs have to be preferred), and therefore the profitability of renewable HSCs is questioned. In fact, Tlili et al. (2020) reported that at the beginning of hydrogen deployment, government incentives are crucial to help industries overcome the 'death-valley'. They reported that an increase in hydrogen adoption from 1% to 5% led to a reduction in the cost of hydrogen of around 25%. Common incentives reported in the literature are CO_2 taxes (Cho et al., 2016; Contaldi et al., 2008). Another alternative to reducing the initial costs of renewable HSC development is integrating the renewable HSC with existing infrastructure. Cerniauskas et al. (2020) reported that reassigning a gas pipeline to deliver hydrogen would lead to a 30% cost reduction in distribution (transmission) in comparison to a newly built hydrogen pipeline. Furthermore, to reduce hydrogen costs, it is important also to consider the possibility of integrating the renewable HSC with other energy systems; in this way, it is possible to reduce the initial investment by avoiding the establishment of new feedstock facilities (Almansoori and Shah, 2012) and by improving the utilization of production, since renewables' intermittent feature will be mitigated (Won et al., 2017).

In the light of the above, we can summarise that a key aspect for an efficient renewable HSC is its cooperation. It is critical that the processes of a renewable HSC are integrated and correlated (Cantú et al., 2021). As there are different stakeholders and decision-makers who may influence or own various facilities of a renewable HSC, it is important to investigate the cooperation mechanisms and thereby strengthen the SC links, for instance, to achieve the proper configuration (vertical integration). Moreover, a renewable HSC needs to be integrated with other energy systems using electricity or providing energy carriers with other supply chains, where the by-products (for instance, oxygen) of a renewable HSC can be used. Thus, it is also important to find the right cooperation among supply chains (horizontal integration). Finally, the renewable HSC cooperation mechanisms are dynamic, that is, they depend on increasing hydrogen adoption.

Table 1 presents a summary of the planning tasks and the open challenges for each process in renewable HSC.

Table 1
Summary of the long-term planning tasks and open challenges of each process in renewable HSC.

HSC process	Planning tasks	Challenges
Sourcing	Selection of the best feedstock from an economic perspective	Sources' availability and quality over time Sources' location and accessibility Sources' costs Sources' uncertainty
Production	Selection of number, locations, technologies, and scales of production facilities	Trade-off investment costs Interconnected to other processesRenewable HSC adoption and market development Technology maturity
Storage	Selection of number, locations, type, and capacity of storage facilities Selection of hydrogen form	Interconnected to other processes Potential leakagesRenewable HSC adoption and market development Technology maturity
Distribution	Selection of distribution structure Selection of hydrogen form	Interconnected to other processes Potential leakagesRenewable HSC adoption and market development Technology maturity
Market and sales	Selection of most suitable market applications Long-term demand forecasts (sales planning)	Uncertainty in the estimation of hydrogen demandRenewable HSC adoption and market development
Whole renewable HSC	Evaluation of the cooperation mechanisms for vertical and horizontal integration	Renewable HSC adoption and market development

5.2. Mid-/short-term planning

This section discusses current research dealing with mid-/short-term planning tasks. Despite the limited number of studies on mid-/short-term planning tasks (see Fig. 6), there are still studies to be reported, as in the previous section, that have focused on the identification of the main mid-/short-term planning tasks and the associated challenges. Similar to long-term planning, the last subsection deals with the whole renewable HSC.

5.2.1. Sourcing

With the mid-/short-term planning horizon, the typical sourcing planning tasks deal with the selection of the feedstock, that is, the procurement strategy (Dagdougui et al., 2012). Due to the intermittent features of renewables, such as wind and solar power, the supply availability and consequently the cost of generating electricity both vary considerably (Tang and Rehme, 2017). Therefore, a procurement strategy can have economic benefits. Won et al. (2017) demonstrated that integrating multiple intermittent energy sources and dynamically selecting sources led to a substantial cost reduction, of between 30% and 63%, compared to systems with a single and dedicated energy source. Similar results were reported by other authors (Demirhan et al., 2021; Khojasteh, 2020; Yuansheng et al., 2021).

Another important planning task is defining contracts with suppliers. In the electricity market environment, the price can be decided beforehand, based on forecasted electricity prices, or it can follow market trends (MansourLakouraj et al., 2021), where it is possible to leverage demand-side management, as suggested by Mansour-Saatloo et al. (2020) and Seyyedeh-Barhagh et al. (2019). However, it should be noted that such decisions should present a holistic view of the whole renewable HSC, since the strategic adoption of hydrogen storage systems to deal with intermittent feedstocks cannot be neglected (Seyyedeh-Barhagh et al., 2019).

To summarise, the main planning tasks in mid-/short-term sourcing are twofold, namely defining the procurement strategy and defining contracts with suppliers. The former deals with the short-term selection of sources from a supplier portfolio, with the aim to compensate for daily fluctuations in availability and price (Won et al., 2017). The latter deals with setting the price (flat vs. variable, based on the electricity market), the total amount and the general conditions of supply (MansourLakouraj et al., 2021). This is often challenging because it is affected by two main aspects, which are the forecasting of feedstock availability and the price of energy sources. Specifically, the electricity price represents a crucial aspect to be investigated. In fact, renewable HSCs will be increasingly integrated with other energy SCs in the future, and interdependencies between supply chains will affect each other, with consequences for the coordination and allocation of resources.

5.2.2. Production

The main planning tasks include planning and scheduling production. In particular, according to Van Den Heever and Grossmann (2003), typical planning decisions are whether each plant operates in each planning period and the hydrogen production levels for each plant in each planning period. Typical scheduling decisions concern the exact production rate in each scheduling period and which customer to produce for (which refuelling station to serve). Similar mid-/short-term planning tasks were reported by other authors (Demirhan et al., 2021; Li et al., 2008; Yang et al., 2021). These decisions are closely linked to the forecasted availability, source prices, and demand. We also need to be aware that hydrogen production often needs to passively follow sources' availability. Due to the difficulties of forecasting, Van Den Heever and Grossmann (2003) have suggested that production planning and scheduling should be integrated. Also, to overcome the limitation that planning and scheduling have different time scales, they have suggested a rolling horizon approach.

As with the sourcing process, decisions here should also consider storage configurations (Yang et al., 2021). Moreover, it is important to include maintenance activities in production planning, but this has only been discussed to a limited extent (Woo et al., 2016; Yang et al., 2020).

In conclusion, the main tasks in the planning process are the planning and scheduling of production: Given the plan to use production resources (i.e., whether each plant operates in each planning period and the hydrogen production levels for each plant in each planning period), the weekly and daily (up to hourly) scheduling of production based on the actual performance of the electrolyser are decided. As in traditional SCs, these decisions are often challenging because of the difficulties in forecasting. Contrary to traditional SCs, as described above, forecasting availability and the prices of sources are very complicated (Van Den Heever and Grossmann, 2003). Furthermore, the planning tasks are closely connected to tasks in other planning processes, for example storage. Finally, these planning tasks should be integrated with monitoring, control, and maintenance of production plants.

5.2.3. Storage

Due to the spatial and temporal gap between production and demand, hydrogen storage is crucial (Reuβ et al., 2021). As described under the long-term planning tasks, storage is pivotal for coping with fluctuations and uncertainties in demand and supply (Woo et al., 2016). Typical mid-/short-term planning tasks are capacity planning and inventory management, which aim to determine which storage system(s) to use, their hourly inventory level, as well as their hydrogen consumption and filling rates (Yang et al., 2020). Moreover, another important aspect to be considered is the leakage and/or absorption of hydrogen from hydrogen storage systems (Xu et al., 2022). Gaseous hydrogen can leak from containers and can be absorbed by the container itself. Liquid hydrogen can leak as a consequence of the boil-off problem (Al-Breiki and Bicer, 2021). The leakage increases as the hydrogen, whether gaseous or liquid, is stored longer. Besides being a potential safety and environmental hazard, this also represents a yield or quantity loss issue, which needs special attention as an inventory management aspect (O'Dwyer et al., 2022; U.S. Department of Energy). Furthermore, storage-related decisions should also consider the operational costs of feeding in and releasing out hydrogen from the storage (Al-Breiki and Bicer, 2021; Liu et al., 2010). Finally, although the maintenance requirements for storage systems are high, their impact on capacity planning has not been discussed in the literature (Garcia et al., 2016; U.S. Department of Energy).

In conclusion, knowing the size and capacity of storage systems from long-term planning tasks, the mid-/short-term planning tasks are quite related to resource capacity planning and inventory management in terms of how much to fill different tanks and for how long. The main challenge of these tasks is that they should consider the yield factor related to potential leakages (O'Dwyer et al., 2022). Moreover, there is a clear link between the performance of the storage system and its monitoring, control, and maintenance.

5.2.4. Distribution

The mid-/short-term planning tasks here are related to the scheduling and routing of hydrogen distribution from the production site or storage system to the final point of use (He et al., 2021a, 2021b). In particular, since the selected articles mostly deal with the transport sector, refuelling stations are considered as the final point of use. For instance, Reuβ et al. (2021) proposed an optimization model to connect the production site and the fuelling stations by including the factors of distance, time, and cost. In addition, their model also considered the refuelling stations' demand and production sites' capacity.

Sometimes, these mid-/short-term planning tasks are integrated with the long-term ones (e.g., decisions about the siting of the refuelling stations). In this case, researchers have focused on traditional location routing problems. This is the case with Kang and Recker (2014), who *'developed a facility location problem with full-day scheduling and routing considerations'*. Their study indicated the importance of integrating long-and mid-/short-term planning tasks, since decoupling the two levels by adopting only a location model *'significantly overestimate[s] the number of stations required'*. Moreover, the planning tasks of this process are interconnected with the planning tasks of other processes, especially production and storage (Yang et al., 2021).

To summarise, in this process, decision-makers should plan the transport between stages, in particular from electrolysers to storage and from storage to point of use, based on the distribution modes and their capacity selected in long-term planning. Daily and weekly, decision-makers should schedule deliveries according to routing policies (Kang and Recker, 2014). The complexity of these tasks is that they are linked and interconnected to both the long-term distribution planning tasks and the mid-/short-term planning tasks of other processes (especially other production and storage tasks) (He et al., 2021a; Yang et al., 2021).

5.2.5. Market and sales

As we have seen, hydrogen demand, both in terms of quantity and variability, has a high impact on the mid-/short-term planning tasks (Li et al., 2018). However, despite this important factor, no study has discussed related issues, such as forecasting methods. Similarly, there is no study on mid-/short-term sales planning.

5.2.6. The whole renewable HSC

As discussed before, processes in renewable HSCs are interconnected with each other, and this is also valid for mid-/short-term planning. Therefore, typical mid-/short-term planning tasks (e.g., resource capacity planning) require a holistic perspective, where the interdependencies of the different planning processes are considered. Production planning, for example, is affected not only by internal aspects (e.g., maintenance planning), but also by aspects related to the sourcing process, such as sources' availability and variable prices, since these can limit the production rate. Storage capacities should consider internal aspects (e.g. problems of leakage and boil-off gas (O'Dwyer et al., 2022)). Sometimes distribution modes (trucks, pipelines, etc.) not only serve as a distribution but also as a storage function. In fact, He et al. (2021a) proposed a flexible scheduling and routing model in which hydrogen trucks serve as both distribution and mobile storage in order to '*make intermittent electrolytic H_2 production more competitive by providing extra spatiotemporal flexibility*'. They reported a decrease of the hydrogen cost by 9%, thanks to a reduction of the required trucks and stationary storage capacities of 83% and 165%, respectively. Van Den Heever and Grossmann (2003) suggested a similar idea of viewing pipelines as storage. However, studies that adopt a holistic perspective are still lagging.

In conclusion, the different mid-/short-term planning tasks need to be integrated, and a holistic view is essential for the success of renewable HSCs. This, however, complicates the decision-making process. Moreover, renewable HSC managers have to be aware that, contrary to traditional SCs, in renewable HSCs the different planning tasks are mainly supply-driven, since sourcing availability is an important influential factor (Reuβ et al., 2021). In the light of this, inventory management is crucial, both at the sourcing level (feedstock inventory management) and at the production level (H_2 products' inventory management), to smooth the material flow and the energy flow along the entire renewable HSC.

Table 2 presents a summary of the planning tasks and the open challenges for each process in renewable HSC.

6. Planning matrix for renewable HSCs

The synthesis of content analysis has allowed us to determine the planning tasks for the different time horizons and processes in renewable HSC involved, which are summarised in the renewable HSC planning matrix presented in Fig. 7.

Due to the uncertainty of technology and unclear renewable HSC adoption and market development, even though there is an expectation

Table 2
Summary of the mid-/short-term planning tasks and the open challenges at each process in renewable HSC.

HSC process	Planning tasks	Challenges
Sourcing	Selection of the procurement strategy Definition of contracts with suppliers	Sources' condition (price of energy sources, forecasting of feedstock availability, etc.)
Production	Planning and scheduling production	Forecast sources' availability, prices, and demand Interconnected to other processes Integration with maintenance
Storage	Resource capacity planning Inventory management	Potential leakages Interconnected to other processes Integration with maintenance
Distribution	Scheduling and routing of distribution	Interconnected to long-term distribution planning tasks Interconnected to other processes
Market and sales	Sales planning	No study on mid-/short-term sales planning
Whole HSC	Resource capacity planning Inventory management	Planning tasks are supply-driven

of a high demand for hydrogen in the future, the growing path of renewable HSCs is undecided. As mentioned above, previous literature focused on these aspects investigating the impact of technology uncertainties and demand development on the structure and cost of renewable HSCs. While in this section, we discuss how the adoption of renewable HSCs and, consequently, the phases of their market development will imply different objectives and stakeholders involved in the decision-making process for each planning task.

As renewable HSC scale-up is essential for reducing the cost and thereby the market price, there is a chicken-and-egg issue, that is, how to create incentives for stimulating the expansion on both sides of hydrogen supply and demand. For instance, for fuel cell (FC)-enabled vehicles, the market development of vehicles should cope with the design of renewable HSCs, so that the size of the hydrogen infrastructure fits its demand growth. On the one hand, a renewable HSC needs a significant investment in infrastructure and a critical mass for its development, for instance production, storage, and distribution facilities to support refuelling stations, for its application. Hydrogen distribution costs will remain significant if key infrastructures are lacking. Therefore, renewable HSC investors would like to see a strong demand for FC-enabled vehicles and thereby hydrogen. On the other hand, FC-enabled vehicle producers would like to expand the market and production only if there is sufficient support for operating the vehicles, in other words, a network of refuelling stations. But, without a scale-up demand, there is a lack of incentives for renewable HSC infrastructure investment. In addition, there is technology uncertainty with regard to

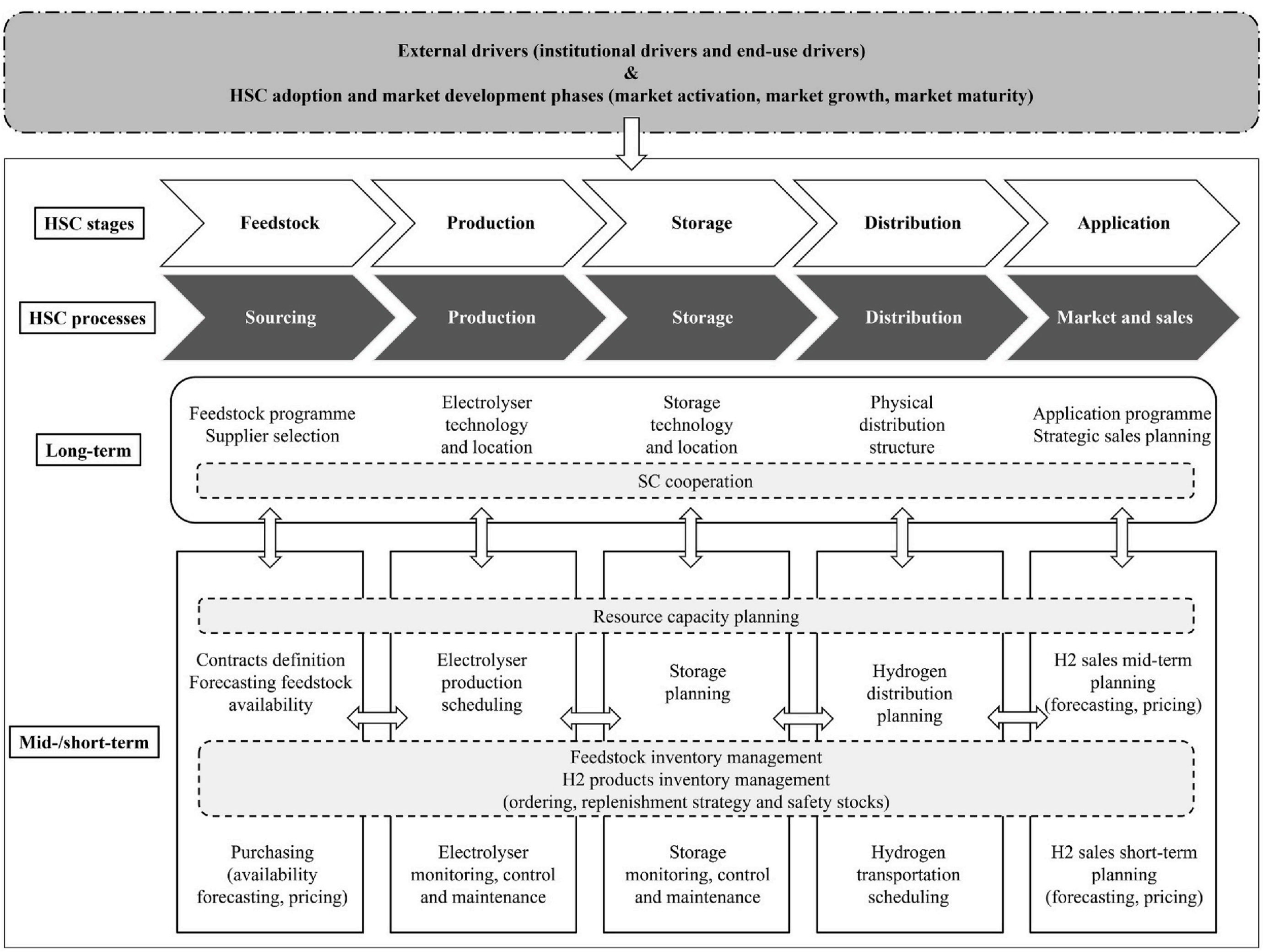

Fig. 7. Planning matrix for renewable HSCs.

the development of renewable HSC infrastructure and stages. Even though some technologies are ready, some need to be proven at scale while others still need to be tested and proved.

Fig. 7 presents renewable HSCs as a sociotechnical system (Griffiths et al., 2021), highlighting how the SC planning tasks identified in previous section, and the adoption of renewable HSCs are affected by external drivers, both institutional drivers and end-users. As discussed in the introduction, many countries are developing roadmaps and strategies (institutional drivers, for example cap and trade or carbon tax programmes) to enhance the adoption of renewable HSCs. Also, end users are driving the adoption of renewable HSCs with an increasing awareness of the need for a sustainable future, also stimulated by new incentive schemes from governments.

These drivers have a relevant impact on defining the objectives of planning tasks introduced in the previous section and consequently affect the supply chain configuration and operations (Griffiths et al., 2021). First, external drivers impact factors that characterise the adoption level, such as the hydrogen demand volume and renewable HSC scale (regional to national/international). Second, as different decision-makers and stakeholders are involved, the external drivers impact specific objectives that support the selection of solutions to the planning tasks previously defined.

Understanding the stakeholders' objectives is essential for the successful market development of renewable HSCs. Below we summarise the different phases of market development and how renewable HSC planning tasks are affected (see also Table 3):

- *Market activation:* Currently (2020–2030), we are in the early phases of adoption of renewable HSCs, where actors are innovating and activating the market, creating new opportunities and new challenges. Here, the main stakeholders involved are governments, R&D institutions, and major players in the energy and transport sectors. Their goal is to develop and demonstrate the feasibility and applicability of renewable HSCs through the implementation of mature technology. In these phases, there are strong incentives and investments to support the main objective of first adoptions with first network infrastructures, led by early adopters. Knowledge should be obtained to stimulate and understand how renewable HSCs penetrate markets. Efficiency, cost, and impact on emissions are secondary indicators that are monitored to indicate future directions.
- *Market growth:* According to the roadmaps and strategies, in the next decade (2030–2040), when the market has been activated and the first renewable HSCs are in operation, there should be a phase of constant market growth, where the role and presence of government institutions will diminish to support the extension of initial networks, while R&D institutions will focus on developing more mature technologies (more efficient and reliable), while the adoption of renewable HSCs is driven by market policies, where different actors (producers, distributors, and investors) compete with the main goal of positioning themselves in the market, extending the network infrastructure and services, following traditional market policies and demands/requirements. Here, the main indicators used by these stakeholders are market share, cost, efficiency, and service level, while governments can support the adoption with some policies to incentivize the use of green hydrogen and so pursue the continuous reduction of emissions.
- *Market maturity:* Finally, from 2040 to 2050, there should be a phase of mature market development, where the competition between renewable HSCs will be based on cost, efficiency, and service level, since the environmental purpose has mainly been reached. The main objective will be to keep the renewable HSCs operations up and running. The economic growth here is based on technological leadership, but the operations of renewable HSCs will still be affected by external factors related to the market policies in particular in energy sector (such as electricity price, feedstock availability, etc.). Governments will probably act as observers, and in the case of disruptions or extraordinary events in the energy sector, they will intervene considering the different energy supply chains involved.

7. Agenda for future research

After defining the decision problems as planning tasks (Section 5) and how their solutions depend on the different objectives influenced by stakeholders involved along the different phases of renewable HSC adoption and market development (Section 6), we discuss the potential approaches and propose an agenda for future research on renewable HSC planning.

- *Extended renewable HSC design modelling.* Modelling approaches (both material flow-based and energy-based) need to consider the whole renewable HSC (vertical integration) and its relationship with existing energy supply chains (horizontal integration). In addition to the material flow, financial/economic flow and information in conventional supply chains, it would be interesting to investigate how to combine energy flow and possibly emissions along entire renewable HSCs. This gives a new direction from the supply chain management perspective. Here, storage has a paramount importance and role to keep energy stored compensating for the high level of uncertainty, so

Table 3
Summary of the impact of different phases of market development on HSC planning tasks.

	Market activation 2020–2030	Market growth 2030–2040	Market maturity 2040–2050
Main stakeholders	Governments R&D institutions Major players in the energy and transport sectors	Producers Distributors Investors	Producers Distributors
Secondary stakeholders	Producers Distributors Investors	Governments R&D institutions	Governments R&D institutions Investors
Objectives	Development of first adoptions with first network infrastructures	Positioning in the market, extending the network infrastructure and services	Keeping operations up and running efficiency
External drivers	Strong incentives and investments from governments for first adoptions Limited impact of market demands/requirements – mainly from early adopters	Strong market policies and demands/requirements Dedicated incentives from governments for boosting impact on emissions Market policies and user demands/requirements	Strong market policies and demands/requirements Dedicated energy policies from governments for increasing resilience
Primary KPI	Feasibility and applicability of renewable HSCs	Market share	Cost Efficiency Service level
Secondary KPI	Cost Efficiency Impact on emissions	Cost Efficiency Service level Impact on emissions	Impact on emissions

it is mandatory to include the inventory management problem as central in the design and operations of renewable HSCs to find an optimal trade-off.

- *Multi-objectives and multi-decision makers' approaches.* There are many stakeholders in the development of renewable HSCs with various concerns regarding the performance of renewable HSCs, especial in the initial phase of renewable HSC adoption (see Table 3). Current studies seldom clearly distinguish these differences, often with conflicting concerns, such as the ownership of the hydrogen costs (see chicken-and-egg puzzle). The environmental performance concern, from a government perspective, adds even more complexity (Carrera and Azzaro-Pantel, 2021b). Risk and safety in renewable HSCs are other important aspects to be considered in some operations along renewable HCSs, such as storage, transport, and bunkering (Fazli--Khalaf et al., 2020). Multiple objective approaches are mandatory to comprehend the different objectives that the different stakeholders have. The approaches also support multiple decision-makers in finding the most appropriate solutions, thereby providing guidelines for designing policy support schemes to stimulate renewable HSC adoption.
- *Robust renewable HSC design.* Future research should focus on the development of decision support systems that can guide stakeholders in selecting the most appropriate configurations based on the evolution of the adoption level, in other words, decisions which not only provide a sound outcome at the decision timepoint, but also prepare favourable options when the future event (such as the selection of technology) has been revealed (Güler et al., 2021). Alternatively, we should consider the possible dynamic expansion of capacity (electrolyser and other facilities) by using diffusion models. As the TRL and market development are changing over time, the decision of capacity and location should open options for future increases. Option and real option models could be used for such investigations. Also, the impact of government incentive schemes (for example, cap and trade, carbon tax, and R&D funding), development of technologies and their maturity, integration with existing infrastructure (i.e. existing pipelines), and the different levels of competition/cooperation among the actors in the supply chain need to be considered in a multi-scenario analysis where uncertainties about their evolution are included to find the most robust configuration (Cho et al., 2016; Contaldi et al., 2008). In short, along with the TRL and market development, we need develop a vision for renewable HSC adoption pathways.
- *Feedstock-driven supply chain.* The production of green hydrogen is strongly related to the availability and quality of feedstocks. The feedstock supply of hydrogen, such as solar and wind power for electricity, is often uncertain. This may not be the case in a traditional SC, as the supply can usually be stably maintained, for instance, in a typical manufacturing SC. Hydrogen production is more supply-driven than demand-driven according to current supply chain studies. The selection of the feedstock portfolio has still not been thoroughly investigated, and uncertainties in quantity, quality, and cost need to be included in the renewable HSC configuration and operations (Han and Kim, 2019). In the long term, climate changes can also impact feedstock availability, so studies should consider external factors in a dynamic way. As supply fluctuation is an important feature of a renewable HSC, it is also interesting to investigate the reverse bullwhip effect, that is, how information disruption affects the supply chain operation but with the source of impact from the upstream of a supply chain.
- *Case studies and data accessibility.* Current studies mostly highlight long-term planning instead of short-term planning, for instance, network designs of hydrogen production and distribution. Facing the pressure of developing cleaner energy systems, scholars are investigating various settings of renewable HSCs. However, data on hydrogen applications is often missing in these studies (Agnolucci et al., 2013), or in some better situations there are limited examples of hydrogen applications. Lacking benchmark operations systems and data makes the analysis at the detail (short-term) level less thorough. Also, the validation of models is often missing in current studies, including the validation of assumptions concerning the links between long- and mid-/short-term planning. Typical cases at different stages of the renewable HSC should be presented. Due to the current low level of adoption, most of the data still come from experimental or small-scale applications, and they need to be adapted to predict the potential evolution of technology in terms of performance and cost.
- *Transition to other industrial applications.* The transport sector still dominates the main focus of renewable HSC studies. The common structure of a renewable HSC includes wind, solar and hydro sources (small scale) as the feedstock, electrolyser, compressed tube storage, and distribution (refuelling stations). These studies present new knowledge about renewable HSCs. On the other hand, there are fewer studies on hydrogen applications in the steel industry or buildings, which have different features of demand, requirements of distribution, etc., and are worth investigating in the future. Identifying the similarities and differences between HSCs in different sectors is important. There should be a general HSC framework with emphasis on vertical and horizontal integration, in order to cohere renewable HSC adoption.
- *Integrated resource capacity planning.* Weekly and daily plans need to consider the variability in supply and demand, as well as integration with other energy supply chains and applications (Won et al., 2017). Specifically, integration with the electricity market and the price of electricity should be a relevant factor in planning, since these factors impact all the phases of the supply chain. Overall resource capacity planning is preferable instead of a local optimal solution at each stage (feedstock, production, storage, and distribution). This requires advanced and more complex models that need to be validated using data from applications. Hydrogen production is more likely a continuous process (such as the refinery and chemical process), but hydrogen distribution could still be either a discrete or continuous process. Control theory should play a role in short-term planning and scheduling to cope with the processes. When the level of the hydrogen pathway adoption is relevant, data-driven approaches can be applied to find quick, effective, and robust solutions to planning problems.
- *Extended inventory management models.* As storage and distribution are major activities in HSCs, future research should extend the traditional inventory management models to include features of renewable HSCs, such as the integration of material flow and energy flow, volume versus mass of stocked hydrogen, lifetime and duration of stocked hydrogen, storage performance (i.e. % leakage), and risk and safety issues in storage and operations (O'Dwyer et al., 2022). A renewable HSC can also be viewed as a feedstock-driven supply chain, therefore the intermittent and uncertain supply should be highlighted by extending the insights of existing inventory management models (Weitzel and Glock, 2018). In addition, in planning and controlling storage in HSC, we should pay extra attention to the time interval of modelling, as operations and market trading practice provide information updating and decisions on an hourly basis (Finnah and Gönsch, 2021). However, existing studies often assume a large time interval (daily and weekly), because stochastic modelling such as the Markov decision process is more challenging (Fokkema et al., 2022; Schrotenboer et al., 2022).
- *Combined forecasting modelling.* Supply and demand forecasts are affected by several factors, thus advanced modelling based on data-driven approaches should be developed to overcome the limitations of traditional time-series forecasting. For example, environmental conditions impact feedstock availability and local incentives for hydrogen adoption and pricing policies for the electricity sector impact the final demand for hydrogen. Weather forecasts and the evolution of the electricity market are among the other external

factors to be included in forecasting models for feedstock and hydrogen demand. Scenario analysis is an alternative for providing settings for long-term forecasting and planning, whereas data analytics and data mining could provide some insight into supply and demand patterns, thereby supporting short-term forecasting.

8. Conclusion

To achieve a fossil-free energy system in the future and reduce emissions, countries are initiating and investing in hydrogen research and development as well as their infrastructures. Because of these strategies for more sustainable solutions, we are at a time point welcoming the potential scale-up of renewable HSC operations. Along with these opportunities, we also encounter challenges, which include the operational characteristics of renewable HSCs, uncertainty of technology, the impact of national roadmaps and strategies, and market development, among others.

Against this background, we have introduced for the first time a renewable HSC planning matrix, where the different planning tasks are identified. Specifically, the planning tasks are determined based on the content analysis of the literature review, and they are reported with respect to two planning horizons, namely long-term and mid-/short-term, and with regard to the different planning processes in renewable HSC (sourcing, production, storage, distribution, and market and sales). From the analysis of planning tasks, it emerges that: (i) it is important to consider jointly the planning tasks related to the different processes, since these are interconnected, and (ii) the adoption of renewable HSCs and market development are important factors which impact the definition of planning tasks. Based on the content analysis, we were able to derive a research agenda.

Our content analysis indicates that the function and planning tasks of sourcing, production, storage, distribution, and market and sales should be considered jointly. However, designing and operating a renewable HSC is not easy, as there are many influential factors and choice alternatives at each stage of the renewable HSC to determine the final choices. The renewable HSC adoption and market development are important factors that impact the definition of planning tasks and decision-makers' objectives in the planning process. Specifically, we need to understand the various concerns of stakeholders along with the development pathways, and therefore introduce accordingly appropriate objective functions and assumptions in modelling the supply chain management.

The derived research agenda is encouraging, as the development of renewable HSCs opens new areas for research and investigation. We may need to incorporate incentive schemes in renewable HSCs (Nordic Energy Research, 2022) so as to improve the coordination of the system in initiating a renewable HSC operation. Also, along with the dynamic development of renewable HSCs, we may apply real-option models and diffusion models to examine investment alternatives, so that infrastructure expansion can cope with market development and technology readiness. Subsequently, renewable HSC development becomes business-driven. Also, some mid-/short-term planning problems have not been tackled, for instance, the yield and quantity losses in hydrogen storage and distribution, which provide opportunities to extend inventory management studies. The addition of energy flow provides another lens to view a supply chain. It should facilitate the performance measure of the system but could also complicate the analysis. Our research agenda should provide guidelines for those scholars interested in improving renewable HSCs. Moreover, it should provide insights and overview of the challenges of the renewable HSCs planning tasks useful for both managers directly involved in the design and management of renewable HSCs and managers whose companies are strongly energy-dependent.

This study also has some limitations. We have focused mainly on electrolyser-based production, but we have not considered carbon capture and storage systems. Furthermore, we have indicated the importance of integrating other energy systems, but these energy systems (for instance, electricity) are often viewed as external inputs to renewable HSCs. Nevertheless, we have not stressed that a scale-up renewable HSC may affect the electricity production and market, largely due to the relatively small scale of renewable hydrogen in the current situation. These concerns will affect hydrogen operations and therefore renewable HSCs. Some future discussions of these aspects should be welcomed to support the transition to a low-carbon future energy system and society.

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Appendix A

Table A1
List of the 70 most relevant journals used in the SLR

List of Journals	
Advances in Production Engineering and Management	Journal of Manufacturing Systems
Annals of Operations Research	Journal of Manufacturing Technology Management
CIRP Annals - Manufacturing Technology	Journal of Operations Management
Computers and Industrial Engineering	Journal of Purchasing and Supply Management
Computers and Operations Research	Journal of Rail Transport Planning and Management
Computers in Industry	Journal of the Operational Research Society
Decision Sciences	Management Science
EURO Journal on Transportation and Logistics	Manufacturing and Service Operations Management
European Journal of Operational Research	Manufacturing Review
Expert Systems with Applications	Mathematical Methods of Operations Research
Flexible Services and Manufacturing Journal	Mathematics of Operations Research
IEEE Transactions on Systems, Man, and Cybernetics: Systems	Naval Research Logistics
Industrial Management and Data Systems	Omega
International Journal of Advanced Manufacturing Technology	Operations Management Research
International Journal of Logistics Management	Operations Research
International Journal of Logistics Research and Applications	Operations Research Letters
International Journal of Management Science and Engineering Management	Operations Research Perspectives
International Journal of Operations and Production Management	OR Spectrum

(*continued on next page*)

Table A1 (*continued*)

List of Journals	
International Journal of Physical Distribution and Logistics Management	Production and Operations Management
International Journal of Production Economics	Production Planning and Control
International Journal of Production Research	Public Transport
International Journal of Shipping and Transport Logistics	Research in Transportation Business and Management
International Journal of Sustainable Transportation	Robotics and Computer-Integrated Manufacturing
International Journal of Systems Science	Supply Chain Forum
International Journal of Systems Science: Operations and Logistics	Supply Chain Management
International Journal of Transportation Science and Technology	Sustainable Cities and Society
International Transactions in Operational Research	Transport Reviews
Journal of Advanced Transportation	Transportation
Journal of Air Transport Management	Transportation Research Part C: Emerging Technologies
Journal of Business Logistics	Transportation Research, Part A: Policy and Practice
Journal of Cleaner Production	Transportation Research, Part D: Transport and Environment
Journal of Engineering and Technology Management - JET-M	Transportation Research, Part E: Logistics and Transportation Review
Journal of Environmental Economics and Management	Transportation Research, Series B: Methodological
Journal of Management	Transportation Science
Journal of Manufacturing Processes	Transportmetrica A: Transport Science

Appendix B. LIST OF 202 SELECTED ARTICLES

1. Agnolucci P., Akgul O., McDowall W., Papageorgiou L.G., 2013. The importance of economies of scale, transport costs and demand patterns in optimizing hydrogen fuelling infrastructure: An exploration with SHIPMod (Spatial hydrogen infrastructure planning model). Int. J. Hydrogen Energy 38, 11189–11201. https://doi.org/10.1016/J.IJHYDENE.2013.06.071.

2. Agnolucci P., Mcdowall W., 2013. Designing future hydrogen infrastructure: Insights from analysis at different spatial scales. Int. J. Hydrogen Energy 38, 5181–5191. https://doi.org/10.1016/J.IJHYDENE.2013.02.042.

3. Al-Breiki M., Bicer Y., 2021. Comparative life cycle assessment of sustainable energy carriers including production, storage, overseas transport and utilization. J. Clean. Prod. 279, 123481. https://doi.org/10.1016/J.JCLEPRO.2020.123481

4. Almansoori A., Betancourt-Torcat A., 2016. Design of optimization model for a hydrogen supply chain under emission constraints - A case study of Germany. Energy 111, 414–429. https://doi.org/10.1016/J.ENERGY.2016.05.123.

5. Almansoori A., Shah N., 2012. Design and operation of a stochastic hydrogen supply chain network under demand uncertainty. Int. J. Hydrogen Energy 37, 3965–3977. https://doi.org/10.1016/J.IJHYDENE.2011.11.091.

6. Almansoori A., Shah N., 2009. Design and operation of a future hydrogen supply chain: Multi-period model. Int. J. Hydrogen Energy 34, 7883–7897. https://doi.org/10.1016/J.IJHYDENE.2009.07.109.

7. Almansoori A., Shah N., 2006. Design and Operation of a Future Hydrogen Supply Chain: Snapshot Model. Chem. Eng. Res. Des. 84, 423–438. https://doi.org/10.1205/CHERD.05193.

8. André J., Auray S., Brac J., De Wolf D., Maisonnier G., Ould-Sidi M.M., Simonnet A., 2013. Design and dimensioning of hydrogen transmission pipeline networks. Eur. J. Oper. Res. 229, 239–251. https://doi.org/10.1016/J.EJOR.2013.02.036.

9. André J., Auray S., De Wolf D., Memmah M.M., Simonnet A., 2014.Time development of new hydrogen transmission pipeline networks for France. International Journal of Hydrogen Energy, 39(20),10323–10337.

10. Andresen L., Bode C., Schmitz G., 2018. Dynamic simulation of different transport options of renewable hydrogen to a refinery in a coupled energy system approach. International Journal of Hydrogen Energy, 43(42),19600–19614.

11. Balcombe P., Speirs J., Johnson E., Martin J., Brandon N., Hawkes A., 2018. The carbon credentials of hydrogen gas networks and supply chains. Renew. Sustain. Energy Rev. 91, 1077–1088. https://doi.org/10.1016/J.RSER.2018.04.089.

12. Ball M., Wietschel M., Rentz O., 2007. Integration of a hydrogen economy into the German energy system: an optimizing modelling approach. Int. J. Hydrogen Energy 32, 1355–1368. https://doi.org/10.1016/J.IJHYDENE.2006.10.016.

13. Balta-Ozkan N., Baldwin E., 2013. Spatial development of hydrogen economy in a low-carbon UK energy system. Int. J. Hydrogen Energy 38, 1209–1224. https://doi.org/10.1016/J.IJHYDENE.2012.11.049.

14. Bano S., Siluvai Antony P., Jangde V., Biniwale R.B., 2018. Hydrogen transportation using liquid organic hydrides: A comprehensive life cycle assessment. J. Clean. Prod. 183, 988–997. https://doi.org/10.1016/J.JCLEPRO.2018.02.213.

15. Bapna R., Thakur L.S., Nair S.K., 2002. Infrastructure development for conversion to environmentally friendly fuel. Eur. J. Oper. Res. 142, 480–496. https://doi.org/10.1016/S0377-2217(01)00309-5.

16. Bersani C., Minciardi R., Sacile R., Trasforini E., 2009. Network planning of fuelling service stations in a near-term competitive scenario of the hydrogen economy. Socio-Economic Planning Sciences, 43(1),55–71.

17. Bhandari R., Trudewind C.A., Zapp P., 2014. Life cycle assessment of hydrogen production via electrolysis – a review. J. Clean. Prod. 85, 151–163. https://doi.org/10.1016/J.JCLEPRO.2013.07.048.

18. Bolat P., Thiel C., 2014 Hydrogen supply chain architecture for bottom-up energy systems models. Part 2: Techno-economic inputs for hydrogen production pathways. International Journal of Hydrogen Energy (2014), 39(17),8898–8925.

19. Booto G.K., Aamodt Espegren K., Hancke R., 2021. Comparative life cycle assessment of heavy-duty drivetrains: A Norwegian study case. Transportation Research Part D: Transport and Environment, 95,102836.

20. Brey J.J., Brey R., Carazo A.F., Contreras I., Hernández-Díaz A.G., Gallardo V., 2006. Designing a gradual transition to a hydrogen economy in Spain. Journal of Power Sources, 159(2),1231–1240.

21. Brey J.J., Carazo A.F., Brey R., 2012. Using AHP and binary integer programming to optimize the initial distribution of hydrogen infrastructures in Andalusia. International Journal of Hydrogen Energy, 37(6),5372–5384.

22. Brey J.J., Brey R., Carazo A.F., Ruiz-Montero M.J., Tejada M., 2016. Incorporating refuelling behaviour and drivers' preferences in the design of alternative fuels infrastructure in a city. Transp. Res. Part C Emerg. Technol. 65, 144–155. https://doi.org/10.1016/J.TRC.2016.01.004.

23. Brown T., Schell L.S., Stephens-Romero S., Samuelsen S., 2013. Economic analysis of near-term California hydrogen infrastructure. International Journal of Hydrogen Energy, 38(10),3846–3857.

24. Cantú V.H., Azzaro-Pantel C., Ponsich A., 2021. A Novel Matheuristic based on bi-level optimization for the multi-Objective design of hydrogen supply chains. Comput. Chem. Eng. 152, 107370. https://doi.org/10.1016/J.COMPCHEMENG.2021.107370

25. Carrera E., Azzaro-Pantel C., 2021. A methodological design framework for hydrogen and methane supply chain with special focus on Power-to-Gas systems: Application to Occitanie region, France. Comput. Chem. Eng. 153, 107386. https://doi.org/10.1016/J.COMPCHEMENG.2021.107386

26. Carrera E., Azzaro-Pantel C., 2021. Bi-objective optimal design of Hydrogen and Methane Supply Chains based on Power-to-Gas systems. Chem. Eng. Sci. 246, 116861. https://doi.org/10.1016/J.CES.2021.116861

27. Cerniauskas S., Grube T., Praktiknjo A., Stolten D., Robinius M., 2018. Future Hydrogen Markets for Transportation and Industry: The Impact of CO2 Taxes. Energies, 12(24), 4707.

28. Cerniauskas S., Jose Chavez Junco A., Grube T., Robinius M., Stolten DOE, 2020. Options of natural gas pipeline reassignment for hydrogen: Cost assessment for a Germany case study. Int. J. Hydrogen Energy 45, 12095–12107. https://doi.org/10.1016/J.IJHYDENE.2020.02.121.

29. Chaudry M., Jayasuriya L., Jenkins N., 2021. Modelling of integrated local energy systems: Low-carbon energy supply strategies for the Oxford-Cambridge arc region. Energy Policy, 157, 112474.

30. Chen Q., Gu Y., Tang Z., Wang D., Wu Q., 2021. Optimal design and techno-economic assessment of low-carbon hydrogen supply pathways for a refuelling station located in Shanghai. Energy 237, 121584. https://doi.org/10.1016/J.ENERGY.2021.121584

31. Chen Y., Melaina M., 2019. Model-based techno-economic evaluation of fuel cell vehicles considering technology uncertainties. Transportation Research Part D: Transport and Environment, 74, 234–244.

32. Chisalita D.A., Petrescu L., Cormos C.C., 2020. Environmental evaluation of european ammonia production considering various hydrogen supply chains. Renewable and Sustainable Energy Reviews, 130,109964.

33. Cho S., Woo Y.B., Kim B.S., Kim J., 2016. Optimization-based planning of a biomass to hydrogen (B2H2) system using dedicated energy crops and waste biomass. Biomass and Bioenergy 87, 144–155. https://doi.org/10.1016/J.BIOMBIOE.2016.02.025.

34. Contaldi M., Gracceva F., Mattucci A., 2008. Hydrogen perspectives in Italy: Analysis of possible deployment scenarios. Int. J. Hydrogen Energy 33, 1630–1642. https://doi.org/10.1016/J.IJHYDENE.2007.12.035.

35. Contreras A., Guervós E., Posso F., 2009. Market penetration analysis of the use of hydrogen in the road transport sector of the Madrid region, using MARKAL. International Journal of Hydrogen Energy, 34(1), 13–20.

36. Copado-Méndez P.J., Blum C., Guillén-Gosálbez G., Jiménez L., 2013. Large neighbourhood search applied to the efficient solution of spatially explicit strategic supply chain management problems. Computers and Chemical Engineering, 49, 114–126.

37. Crönert T., Minner S., 2021. Location selection for hydrogen fuel stations under emerging provider competition. Transp. Res. Part C Emerg. Technol. 133, 103426. https://doi.org/10.1016/J.TRC.2021.103426

38. Dagdougui H., 2012. Models, methods and approaches for the planning and design of the future hydrogen supply chain. Int. J. Hydrogen Energy 37, 5318–5327. https://doi.org/10.1016/J.IJHYDENE.2011.08.041.

39. Dagdougui H., Ouammi A., Sacile R., 2012. Modelling and control of hydrogen and energy flows in a network of green hydrogen refuelling stations powered by mixed renewable energy systems. Int. J. Hydrogen Energy 37, 5360–5371. https://doi.org/10.1016/J.IJHYDENE.2011.07.096.

40. Dayhim M., Jafari M.A., Mazurek M., 2014. Planning sustainable hydrogen supply chain infrastructure with uncertain demand. Int. J. Hydrogen Energy 39, 6789–6801. https://doi.org/10.1016/J.IJHYDENE.2014.02.132.

41. Daziano R., Achtnicht M., 2014. Forecasting Adoption of Ultra-Low-Emission Vehicles Using Bayes Estimates of a Multinomial Probit Model and the GHK Simulator on JSTOR. Transp. Sci. 48, 671–683.

42. De-León Almaraz S., Azzaro-Pantel C., Montastruc L., Boix, M., 2015. Deployment of a hydrogen supply chain by multi-objective/multi-period optimization at regional and national scales. Chem. Eng. Res. Des. 104, 11–31. https://doi.org/10.1016/J.CHERD.2015.07.005.

43. De-León Almaraz S., Azzaro-Pantel C., Montastruc L., Domenech S., 2014. Hydrogen supply chain optimization for deployment scenarios in the Midi-Pyrénées region, France. International Journal of Hydrogen Energy, 39(23), 11831–11845.

44. De-León Almaraz S., Azzaro-Pantel C., Montastruc L., Pibouleau L., Senties O.B., 2013. Assessment of mono and multi-objective optimization to design a hydrogen supply chain. International Journal of Hydrogen Energy, 38(33), 14121–14145.

45. Demirhan C.D., Tso W.W., Powell J.B., Pistikopoulos E.N., 2021. A multi-scale energy systems engineering approach towards integrated multi-product network optimization. Appl. Energy 281, 116020. https://doi.org/10.1016/J.APENERGY.2020.116020

46. Domínguez I., Contreras A., Posso F., Varela F., 2015. Simulation of the operation of a fleet of materials handling and transport vehicles, powered by fuel cells. International Journal of Hydrogen Energy, 40(24), 7678–7688.

47. Durango-Cohen P.L., McKenzie E.C., 2018 Trading off costs, environmental impact, and levels of service in the optimal design of transit bus fleets. Transportation Research Part A: Policy and Practice, 114, 354–363.

48. Ehrenstein M., Galán-Martín Á., Tulus V., Guillén-Gosálbez G., 2020. Optimizing fuel supply chains within planetary boundaries: A case study of hydrogen for road transport in the UK. Applied Energy, 276, 115486.

49. El-Emam R.S., Özcan H., 2019. Comprehensive review on the techno-economics of sustainable large-scale clean hydrogen production. J. Clean. Prod. 220, 593–609. https://doi.org/10.1016/J.JCLEPRO.2019.01.309.

50. Emonts B., Reuβ M., Stenzel P., Welder L., Knicker F., Grube T., Görner K., Robinius M., Stolten D., 2019. Flexible sector coupling with hydrogen: A climate-friendly fuel supply for road transport. International Journal of Hydrogen Energy, 44(26), 12918–12930.

51. Endo E., 2007. Market penetration analysis of fuel cell vehicles in Japan by using the energy system model MARKAL. International Journal of Hydrogen Energy, 32(10–11), 1347–1354.

52. Farag H.E.Z., Al-Obaidi A., Khani H., El-Taweel N., El-Saadany E.F., Zeineldin H.H., 2020. Optimal operation management of distributed and centralized electrolysis-based hydrogen generation and storage systems. Electric Power Systems Research, 187, 106476.

53. Fazli-Khalaf M., Naderi B., Mohammadi,M., Pishvaee M.S., 2020. Design of a sustainable and reliable hydrogen supply chain network under mixed uncertainties: A case study. Int. J. Hydrogen Energy 45, 34503–34531. https://doi.org/10.1016/J.IJHYDENE.2020.05.276.

54. Finnah B., Gönsch J., 2021. Optimizing trading decisions of wind power plants with hybrid energy storage systems using backwards approximate dynamic programming. Int. J. Prod. Econ. 238, 108155. https://doi.org/10.1016/J.IJPE.2021.108155

55. Fraile A., Larrodé E., Magreñán A., Sicilia J.A., 2016. Decision model for siting transport and logistic facilities in urban environments: A

methodological approach. Journal of Computational and Applied Mathematics, 291, 478–487.

56. Gabrielli P., Charbonnier F., Guidolin A., Mazzotti M., 2020. Enabling low-carbon hydrogen supply chains through use of biomass and carbon capture and storage: A Swiss case study. Applied Energy, 275, 115245.

57. Gallardo F.I., Monforti Ferrario A., Lamagna M., Bocci E., Astiaso Garcia D., Baeza-Jeria T.E., 2021. A Techno-Economic Analysis of solar hydrogen production by electrolysis in the north of Chile and the case of exportation from Atacama Desert to Japan. International Journal of Hydrogen Energy, 46(26), 13709–13728.

58. Gerboni R., Grosso D., 2016. Testing future hydrogen penetration at local scale through an optimization tool. International Journal of Hydrogen Energy, 41(48), 22626–22634.

59. Gim B., Boo K.J., Cho S.M., 2012. A transportation model approach for constructing the cost effective central hydrogen supply system in Korea. International Journal of Hydrogen Energy, 37(2), 1162–1172.

60. Glenk G., Reichelstein S., 2020. Synergistic Value in Vertically Integrated Power-to-Gas Energy Systems. Prod. Oper. Manag. 29, 526–546. https://doi.org/10.1111/POMS.13116.

61. Gondal I.A., Sahir M.H., 2012. Model for biomass-based renewable hydrogen supply chain. International Journal of Renewable Energy Research, 2(3), 408–415.

62. Griffiths S., Sovacool B.K., Kim J., Bazilian M., Uratani J.M., 2021. Industrial decarbonisation via hydrogen: A critical and systematic review of developments, socio-technical systems and policy options. Energy Res. Soc. Sci. 80, 102208. https://doi.org/10.1016/J.ERSS.2021.102208

63. Guerrero de la Peña A., Davendralingam N., Raz A.K., DeLaurentis D., Shaver G., Sujan V., Jain N., 2020. Projecting adoption of truck powertrain technologies and CO2 emissions in line-haul networks. Transportation Research Part D: Transport and Environment, 84, 102354.

64. Guillén-Gosálbez G., Mele F.D., Grossmann I.E., 2010. A bi-criterion optimization approach for the design and planning of hydrogen supply chains for vehicle use. AIChE Journal, 56(3), 650–667.

65. Gül T., Kypreos S., Turton H., Barreto L., 2009. An energy-economic scenario analysis of alternative fuels for personal transport using the Global Multi-regional MARKAL model (GMM). Energy 34, 1423–1437. https://doi.org/10.1016/j.energy.2009.04.010.

66. Güler M.G., Geçici E., Erdoğan A., 2021. Design of a future hydrogen supply chain: A multi period model for Turkey. Int. J. Hydrogen Energy 46, 16279–16298. https://doi.org/10.1016/J.IJHYDENE.2020.09.018.

67. Gunawan T.A., Williamson I., Raine D., Monaghan R.F.D., 2021. Decarbonising city bus networks in Ireland with renewable hydrogen. International Journal of Hydrogen Energy, 46(57), 28870–28886.

68. Hajimiragha A., Fowler M.W., Cañizares C.A., 2009. Hydrogen economy transition in Ontario - Canada considering the electricity grid constraints. International Journal of Hydrogen Energy, 34(13), 5275–5293.

69. Hajjaji N., Pons M.N., Renaudin V., Houas A., 2013. Comparative life cycle assessment of eight alternatives for hydrogen production from renewable and fossil feedstock. Journal of Cleaner Production, 44, 177–189.

70. Han J.H., Ryu J.H., Lee I.B., 2012. Modeling the operation of hydrogen supply networks considering facility location. International Journal of Hydrogen Energy, 37(6), 5328–5346.

71. Han J.H., Ryu J.H., Lee I.B., 2013. Multi-objective optimization design of hydrogen infrastructures simultaneously considering economic cost, safety and CO2 emission. Chemical Engineering Research and Design, 91(8), 1427–1439.

72. Han S., Kim J., 2019. A multi-period MILP model for the investment and design planning of a national-level complex renewable energy supply system. Renew. Energy 141, 736–750. https://doi.org/10.1016/J.RENENE.2019.04.017.

73. He C., Sun H., Xu Y., Lv S., 2017. Hydrogen refuelling station siting of expressway based on the optimization of hydrogen life cycle cost. International Journal of Hydrogen Energy, 42(26), 16313–16324.

74. He G., Mallapragada D.S., Bose A., Heuberger C.F., Gencer E., 2021. Hydrogen supply chain planning with flexible transmission and storage scheduling. IEEE Trans. Sustain. Energy 12, 1730–1740. https://doi.org/10.1109/TSTE.2021.3064015

75. Hensher D.A., Wei E., Balbontin C., 2022. Comparative assessment of zero emission electric and hydrogen buses in Australia. Transp. Res. Part D Transp. Environ. 102, 103130. https://doi.org/10.1016/j.trd.2021.103130.

76. Hoffrichter A., Miller A.R., Hillmansen S., Roberts C., 2012. Well-to-wheel analysis for electric, diesel and hydrogen traction for railways. Transportation Research Part D: Transport and Environment, 17(1), 28–34.

77. Hong X., Thaore V.B., Karimi I.A., Farooq S., Wang X., Usadi A.K., Chapman B.R., Johnson R.A., 2021. Techno-enviro-economic analyses of hydrogen supply chains with an ASEAN case study. International Journal of Hydrogen Energy, 46(65), 32914–32928.

78. Huang J., Li W., Wu X., Gu Z., 2021. A bi-level capacity planning approach of combined hydropower hydrogen system. Journal of Cleaner Production, 327, 129414.

79. Hugo A., Rutter P., Pistikopoulos S., Amorelli A., Zoia G., 2005. Hydrogen infrastructure strategic planning using multi-objective optimization. International Journal of Hydrogen Energy, 30(15), 1523–1534.

80. Hurskainen M., Ihonen J., 2020. Techno-economic feasibility of road transport of hydrogen using liquid organic hydrogen carriers. Int. J. Hydrogen Energy 45, 32098–32112. https://doi.org/10.1016/J.IJHYDENE.2020.08.186.

81. Hwangbo S., Heo S.K., Yoo C., 2018. Network modeling of future hydrogen production by combining conventional steam methane reforming and a cascade of waste biogas treatment processes under uncertain demand conditions. Energy Conversion and Management, 165, 316–333.

82. Hwangbo S., Lee I.B., Han J., 2016. Multi-period stochastic mathematical model for the optimal design of integrated utility and hydrogen supply network under uncertainty in raw material prices. Energy, 114, 418–430.

83. Hwangbo S., Lee I.B., Han J., 2017. Mathematical model to optimize design of integrated utility supply network and future global hydrogen supply network under demand uncertainty. Applied Energy, 195, 257–267.

84. Hwangbo S., Nam K.J., Han J., Lee I.B., Yoo C.K., 2018. Integrated hydrogen supply networks for waste biogas upgrading and hybrid carbon-hydrogen pinch analysis under hydrogen demand uncertainty. Applied Thermal Engineering, 140, 386–397.

85. Ingason H.T., Pall Ingolfsson H., Jensson P., 2008. Optimizing site selection for hydrogen production in Iceland. International Journal of Hydrogen Energy, 33(14), 3632–3643.

86. Islam M.A., Gajpal Y., ElMekkawy T.Y., 2021. Mixed fleet based green clustered logistics problem under carbon emission cap. Sustainable Cities and Society, 72, 103074.

87. Janic M., 2008. The potential of liquid hydrogen for the future “carbon-neutral” air transport system. Transp. Res. Part D Transp. Environ. 13, 428–435. https://doi.org/10.1016/j.trd.2008.07.005.

88. Johnson N., Ogden J., 2012. A spatially-explicit optimization model for long-term hydrogen pipeline planning. Int. J. Hydrogen Energy 37, 5421–5433. https://doi.org/10.1016/j.ijhydene.2011.08.109.

89. Kamarudin S.K., Daud W.R.W., Yaakub Z., Misron Z., Anuar W., Yusuf N.N.A.N., 2009. Synthesis and optimization of future hydrogen energy infrastructure planning in Peninsular Malaysia. International Journal of Hydrogen Energy, 34(5), 2077–2088.

90. Kang J.E., Recker W., 2014. Strategic Hydrogen Refuelling Station Locations with Scheduling and Routing Considerations of Individual Vehicles. Transp. Sci. 49, 767–783. https://doi.org/10.1287/TRSC.2014.0519.

91. Kazi M.K., Eljack F., El-Halwagi M.M., Haouari M., 2021. Green hydrogen for industrial sector decarbonisation: Costs and impacts on hydrogen economy in qatar. Comput. Chem. Eng. 145, 107144. https://doi.org/10.1016/J.COMPCHEMENG.2020.107144

92. Khojasteh M., 2020. A robust energy procurement strategy for micro-grid operator with hydrogen-based energy resources using game theory. Sustain. Cities Soc. 60, 102260. https://doi.org/10.1016/J.SCS.2020.102260

93. Kim A., Lee H., Brigljević B., Yoo Y., Kim S., Lim H., 2021. Thorough economic and carbon footprint analysis of overall hydrogen supply for different hydrogen carriers from overseas production to inland distribution. J. Clean. Prod. 316, 128326. https://doi.org/10.1016/J.JCLEPRO.2021.128326

94. Kim J., Lee Y., Moon I., 2008. Optimization of a hydrogen supply chain under demand uncertainty. International Journal of Hydrogen Energy, 33(18), 4715–4729.

95. Kim J., Moon I., 2008. Strategic design of hydrogen infrastructure considering cost and safety using multiobjective optimization. International Journal of Hydrogen Energy, 33(21), 5887–5896.

96. Kim M., Kim J., 2016. Optimization model for the design and analysis of an integrated renewable hydrogen supply (IRHS) system: Application to Korea's hydrogen economy. International Journal of Hydrogen Energy, 41(38), 16613–16626.

97. Kim M., Kim J., 2017. An integrated decision support model for design and operation of a wind-based hydrogen supply system. International Journal of Hydrogen Energy, 42(7), 3899–3915.

98. Kluschke P., Nugroho R., Gnann T., Plötz P., Wietschel M., Reuter-Oppermann M., 2020. Optimal development of alternative fuel station networks considering node capacity restrictions. Transportation Research Part D: Transport and Environment, 78, 102189.

99. Kostin A., Guillén-Gosálbez G., Jiménez L., 2015. Dimensionality reduction applied to the simultaneous optimization of the economic and life cycle environmental performance of supply chains. Int. J. Prod. Econ. 159, 223–232. https://doi.org/10.1016/J.IJPE.2014.09.018.

100. Krishnan V., Gonzalez-Marciaga L., McCalley J., 2014. A planning model to assess hydrogen as an alternative fuel for national light-duty vehicle portfolio. Energy, 73, 943–957.

101. Krzyzanowski D.A., Kypreos S., Barreto L., 2008. Supporting hydrogen based transportation: Case studies with Global MARKAL Model. Computational Management Science, 5(3), 207–231.

102. Kuby M., Lines L., Schultz R., Xie Z., Kim J.G., Lim S., 2009. Optimization of hydrogen stations in Florida using the Flow-Refuelling Location Model. International Journal of Hydrogen Energy, 34(15), 6045–6064.

103. Lahnaoui A., Wulf C., Heinrichs H., Dalmazzone D., 2018. Optimizing hydrogen transportation system for mobility by minimizing the cost of transportation via compressed gas truck in North Rhine-Westphalia. Applied Energy, 223, 317–328.

104. Lahnaoui A., Wulf C., Dalmazzone D., 2021. Optimization of Hydrogen Cost and Transport Technology in France and Germany for Various Production and Demand Scenarios. Energies, 14. https://doi.org/10.3390/EN14030744.

105. Lane B., Shaffer B., Samuelsen S., 2020. A comparison of alternative vehicle fueling infrastructure scenarios. Applied Energy, 259, 114128.

106. Lee D.H., 2014. Development and environmental impact of hydrogen supply chain in Japan: Assessment by the CGE-LCA method in Japan with a discussion of the importance of biohydrogen. International Journal of Hydrogen Energy, 39(33), 19294–19310.

107. Li B., Roche R., Paire D., Miraoui A., 2018. Coordinated scheduling of a gas/electricity/heat supply network considering temporal-spatial electric vehicle demands. Electr. Power Syst. Res. 163, 382–395. https://doi.org/10.1016/J.EPSR.2018.07.014.

108. Li J., Lin J., Zhang H., Song Y., Chen G., DIng L., Liang DOE, 2020. Optimal Investment of Electrolyzers and Seasonal Storages in Hydrogen Supply Chains Incorporated with Renewable Electric Networks. IEEE Transactions on Sustainable Energy, 11(3), 1773–1784.

109. Li L., Al Chami Z., Manier H., Manier M.A., Xue J., 2021. Incorporating fuel delivery in network design for hydrogen fueling stations: Formulation and two metaheuristic approaches. Transp. Res. Part E Logist. Transp. Rev. 152, 102384. https://doi.org/10.1016/J.TRE.2021.102384

110. Li L., Manier H., Manier M.A., 2020. Integrated optimization model for hydrogen supply chain network design and hydrogen fueling station planning. Computers & Chemical Engineering, 134, 106683.

111. Li L., Manier H., Manier M.A., 2019. Hydrogen supply chain network design: An optimization-oriented review. Renew. Sustain. Energy Rev. 103, 342–360. https://doi.org/10.1016/J.RSER.2018.12.060.

112. Li Z., Gao D., Chang L., Liu P., Pistikopoulos E.N., 2008. Hydrogen infrastructure design and optimization: A case study of China. Int. J. Hydrogen Energy 33, 5275–5286. https://doi.org/10.1016/J.IJHYDENE.2008.06.076.

113. Lim S., Kuby M., 2010. Heuristic algorithms for siting alternative-fuel stations using the Flow-Refuelling Location Model. Eur. J. Oper. Res. 204, 51–61. https://doi.org/10.1016/J.EJOR.2009.09.032.

114. Lin Z., Chen C.W., Ogden J., Fan Y., 2008. The least-cost hydrogen for Southern California. International Journal of Hydrogen Energy, 33 (12):3009–3014.

115. Lin Z., Ogden J., Fan Y., Chen C.W., 2008. The fuel-travel-back approach to hydrogen station siting. International Journal of Hydrogen Energy, 33(12), 3096–3101.

116. Logan K.G., Nelson J.D., Hastings A., 2020. Electric and hydrogen buses: Shifting from conventionally fuelled cars in the UK. Transp. Res. Part D Transp. Environ. 85, 102350. https://doi.org/10.1016/j.trd.2020.102350.

117. Logan K.G., Nelson J.D., McLellan B.C., Hastings A., 2020. Electric and hydrogen rail: Potential contribution to net zero in the UK. Transportation Research Part D: Transport and Environment, 87, 102523.

118. Lucas A., Neto R.C., Silva C., Silva C.A., 2013. Energy supply infrastructure LCA model for electric and hydrogen transportation systems. Energy, 56, 70–80.

119. Maleki A., Khajeh M.G., Rosen M.A., 2017. Two heuristic approaches for the optimization of grid-connected hybrid solar–hydrogen systems to supply residential thermal and electrical loads. Sustainable Cities and Society, 34, 278–292.

120. MansourLakouraj M., Niaz H., Liu J.J., Siano P., Anvari-Moghaddam A., 2021. Optimal risk-constrained stochastic scheduling of microgrids with hydrogen vehicles in real-time and day-ahead markets. Journal of Cleaner Production, 318, 128452.

121. Mansour-Saatloo A., Mirzaei M.A., Mohammadi-Ivatloo B., Zare K., 2020. A Risk-Averse Hybrid Approach for Optimal Participation of Power-to-Hydrogen Technology-Based Multi-Energy Microgrid in Multi-Energy Markets. Sustain. Cities Soc. 63, 102421. https://doi.org/10.1016/J.SCS.2020.102421

122. Markert F., Marangon A., Carcassi M., Duijm N.J., 2017. Risk and sustainability analysis of complex hydrogen infrastructures. International Journal of Hydrogen Energy, 42(11), 7698–7706.

123. Maryam S., 2017. Review of modelling approaches used in the HSC context for the UK. Int. J. Hydrogen Energy 42, 24927–24938. https://doi.org/10.1016/J.IJHYDENE.2017.04.303.

124. Matsuo Y., Endo S., Nagatomi Y., Shibata Y., Komiyama R., Fujii Y., 2018. A quantitative analysis of Japan's optimal power generation mix in 2050 and the role of CO2-free hydrogen. Energy, 165, 1200–1219.

125. McKenzie E.C., Durango-Cohen P.L., 2012. Environmental life-cycle assessment of transit buses with alternative fuel technology. Transportation Research Part D: Transport and Environment, 17(1), 39–47.

126. Mingolla S., Lu Z., 2021. Carbon emission and cost analysis of vehicle technologies for urban taxis. Transportation Research Part D: Transport and Environment, 99, 102994.

127. MirHassani S.A., Ebrazi R., 2013. A Flexible Reformulation of the Refuelling Station Location Problem on JSTOR. Transp. Sci. 47, 617–628.

128. Mohseni S., Brent A.C., 2020. Economic viability assessment of sustainable hydrogen production, storage, and utilization technologies integrated into on- and off-grid micro-grids: A performance comparison of different meta-heuristics. Int. J. Hydrogen Energy 45, 34412–34436. https://doi.org/10.1016/J.IJHYDENE.2019.11.079.

129. Mojtaba Lajevardi S., Axsen J., Crawford C., 2019. Comparing alternative heavy-duty drivetrains based on GHG emissions, ownership and abatement costs: Simulations of freight routes in British Columbia. Transportation Research Part D: Transport and Environment, 76, 19–55.

130. Moreno-Benito M., Agnolucci P., Papageorgiou L.G., 2017. Towards a sustainable hydrogen economy: Optimization-based framework for hydrogen infrastructure development. Comput. Chem. Eng. 102, 110–127. https://doi.org/10.1016/J.COMPCHEMENG.2016.08.005.

131. Morrison G.M., Kumar R., Chugh S., Puri S.K., Tuli D.K., Malhotra R.K., 2012. Hydrogen transportation in Delhi? Investigating the hydrogen-compressed natural gas (H-CNG) option. International Journal of Hydrogen Energy, 37(1), 644–654.

132. Muresan M., Cormos C.C., Agachi P.S., 2013. Techno-economical assessment of coal and biomass gasification-based hydrogen production supply chain system. Chemical Engineering Research and Design, 91(8), 1527–1541.

133. Murthy Konda N.V.S.N., Shah N., Brandon N.P., 2011. Optimal transition towards a large-scale hydrogen infrastructure for the transport sector: The case for the Netherlands. International Journal of Hydrogen Energy, 36(8), 4619–4635.

134. Niknam T., Kavousi-Fard A., Ostadi A., 2015. Impact of Hydrogen Production and Thermal Energy Recovery of PEMFCPPs on Optimal Management of Renewable Microgrids. IEEE Transactions on Industrial Informatics, 11(5), 1190–1197.

135. Nunes P., Oliveira F., Hamacher S., Almansoori A., 2015. Design of a hydrogen supply chain with uncertainty. International Journal of Hydrogen Energy, 40(46), 16408–16418.

136. Ochoa Bique A., Zondervan E., 2018. An outlook towards hydrogen supply chain networks in 2050 — Design of novel fuel infrastructures in Germany. Chemical Engineering Research and Design, 134, 90–103.

137. Robles O., Billoud G., Alfonso A., 2019. Optimal Design of a Sustainable Hydrogen Supply Chain Network: Application in an Airport Ecosystem Open Archive Toulouse Archive Ouverte. 7(21).

138. Ogden J., Nicholas M., 2011. Analysis of a "cluster" strategy for introducing hydrogen vehicles in Southern California. Energy Policy, 39(4), 1923–1938.

139. Ogumerem G.S., Kim C., Kesisoglou I., Diangelakis N.A., Pistikopoulos E.N., 2018. A multi-objective optimization for the design and operation of a hydrogen network for transportation fuel. Chemical Engineering Research and Design, 131, 279–292.

140. Ozawa A., Kudoh Y., Kitagawa N., Muramatsu R., 2019. Life cycle CO2 emissions from power generation using hydrogen energy carriers. International Journal of Hydrogen Energy, 44(21), 11219–11232.

141. Page S., Krumdieck S., 2009. System-level energy efficiency is the greatest barrier to development of the hydrogen economy. Energy Policy, 37 (9), 3325–3335.

142. Parker N., Fan Y., Ogden J., 2010. From waste to hydrogen: An optimal design of energy production and distribution network. Transp. Res. Part E Logist. Transp. Rev. 46, 534–545. https://doi.org/10.1016/J.TRE.2009.04.002.

143. Penev M., Zuboy J., Hunter C., 2019. Economic analysis of a high-pressure urban pipeline concept (HyLine) for delivering hydrogen to retail fueling stations. Transportation Research Part D: Transport and Environment, 77, 92–105.

144. Qadrdan M., Saboohi Y., Shayegan J., 2008. A model for investigation of optimal hydrogen pathway, and evaluation of environmental impacts of hydrogen supply system. International Journal of Hydrogen Energy, 33(24), 7314–7325.

145. Quarton C.J., Samsatli S., 2020. Should we inject hydrogen into gas grids? Practicalities and whole-system value chain optimization. Appl. Energy 275, 115172. https://doi.org/10.1016/J.APENERGY.2020.115172

146. Ren J., Manzardo A., Toniolo S., Scipioni A., 2013. Sustainability of hydrogen supply chain. Part I: Identification of critical criteria and cause–effect analysis for enhancing the sustainability using DEMATEL. International Journal of Hydrogen Energy, 38(33), 14159–14171.

147. Ren J., Manzardo A., Toniolo S., Scipioni A., 2013. Sustainability of hydrogen supply chain. Part II: Prioritizing and classifying the sustainability of hydrogen supply chains based on the combination of extension theory and AHP. International Journal of Hydrogen Energy, 38(32), 13845–13855.

148. Ren J., Toniolo S., 2018. Life cycle sustainability decision-support framework for ranking of hydrogen production pathways under uncertainties: An interval multi-criteria decision making approach. Journal of Cleaner Production, 175, 222–236.

149. Ren L., Zhou S., Ou X., 2020. Life-cycle energy consumption and greenhouse-gas emissions of hydrogen supply chains for fuel-cell vehicles in China. Energy, 209, 118482.

150. Reuβ M., Dimos P., Léon A., Grube T., Robinius M., Stolten D., 2021. Hydrogen Road Transport Analysis in the Energy System: A Case Study for Germany through 2050. Energies 2021, 14. https://doi.org/10.3390/EN14113166.

151. Reuβ M., Grube T., Robinius M., Preuster P., Wasserscheid P., Stolten D., 2017. Seasonal storage and alternative carriers: A flexible hydrogen supply chain model. Appl. Energy 200, 290–302. https://doi.org/10.1016/J.APENERGY.2017.05.050.

152. Reuβ M., Grube T., Robinius M., Stolten D., 2019. A hydrogen supply chain with spatial resolution: Comparative analysis of infrastructure technologies in Germany. Appl. Energy 247, 438–453. https://doi.org/10.1016/J.APENERGY.2019.04.064.

153. Rezaei M., Khalilpour K.R., Jahangiri M., 2020. Multi-criteria location identification for wind/solar based hydrogen generation: The case of capital cities of a developing country. International Journal of Hydrogen Energy, 45(58), 33151–33168.

154. Rits V., Kypreos S., Wokaun A., 2004. Evaluating the Diffusion of Fuel-Cell Cars in the China Markets. IATSS Research, 28(1), 34–46.

155. Robles J.O., Azzaro-Pantel C., Aguilar-Lasserre A., 2020. Optimization of a hydrogen supply chain network design under demand uncertainty by multi-objective genetic algorithms. Computers & Chemical Engineering, 140, 106853.

156. Robles J.O., Azzaro-Pantel C., Garcia G.M., Lasserre A.A., 2020. Social cost-benefit assessment as a post-optimal analysis for hydrogen supply chain design and deployment: Application to Occitania (France). Sustainable Production and Consumption, 24, 105–120.

157. Rose P.K., Neumann F., 2020. Hydrogen refuelling station networks for heavy-duty vehicles in future power systems. Transportation Research Part D: Transport and Environment, 83, 102358.

158. Rosenberg E., Fidje A., Espegren K.A., Stiller C., Svensson A.M., Møller-Holst S., 2010. Market penetration analysis of hydrogen vehicles in Norwegian passenger transport towards 2050. International Journal of Hydrogen Energy, 35(14), 7267–7279.

159. Sabio N., Gadalla M., Guillén-Gosálbez G., Jiménez L., 2010. Strategic planning with risk control of hydrogen supply chains for vehicle use under uncertainty in operating costs: A case study of Spain. International Journal of Hydrogen Energy, 35(13), 6836–6852.

160. Sabio N., Kostin A., Guillén-Gosálbez G., Jiménez L., 2012. Holistic minimization of the life cycle environmental impact of hydrogen infrastructures using multi-objective optimization and principal component analysis. International Journal of Hydrogen Energy, 37(6), 5385–5405.

161. Samsatli S., Staffell I., Samsatli N.J., 2016. Optimal design and operation of integrated wind-hydrogen-electricity networks for decarbonising the domestic transport sector in Great Britain. International Journal of Hydrogen Energy, 41(1), 447–475.

162. Samsatli S., Samsatli N.J., 2019. The role of renewable hydrogen and inter-seasonal storage in decarbonising heat – Comprehensive optimization of future renewable energy value chains. Applied Energy, 233, 854–893.

163. Schulte Beerbühl S., Fröhling M., Schultmann F., 2015. Combined scheduling and capacity planning of electricity-based ammonia production to integrate renewable energies. Eur. J. Oper. Res. 241, 851–862. https://doi.org/10.1016/J.EJOR.2014.08.039.

164. Schwoon M., 2007. A tool to optimize the initial distribution of hydrogen filling stations. Transportation Research Part D: Transport and Environment, 12(2), 70–82.

165. Seo S.K., Yun D.Y., Lee C.J., 2020. Design and optimization of a hydrogen supply chain using a centralized storage model. Applied Energy, 262, 114452.

166. Seyyedeh-Barhagh S., Majidi M., Nojavan S., Zare K., 2019. Optimal Scheduling of Hydrogen Storage under Economic and Environmental Priorities in the Presence of Renewable Units and Demand Response. Sustain. Cities Soc. 46, 101406. https://doi.org/10.1016/J.SCS.2018.12.034.

167. Sgobbi A., Nijs W., De Miglio R., Chiodi A., Gargiulo M., Thiel C., 2016. How far away is hydrogen? Its role in the medium and long-term decarbonisation of the European energy system. International Journal of Hydrogen Energy, 41(1), 19–35.

168. Shamsi H., Tran M.K., Akbarpour S., Maroufmashat A., Fowler M., 2021. Macro-Level optimization of hydrogen infrastructure and supply chain for zero-emission vehicles on a canadian corridor. Journal of Cleaner Production, 289, 125163.

169. Shayegan S., Hart D., Pearson P., Joffe D., 2006. Analysis of the cost of hydrogen infrastructure for buses in London. Journal of Power Sources, 157(2), 862–874.

170. Southall G.D., Khare A., 2016. The feasibility of distributed hydrogen production from renewable energy sources and the financial contribution from UK motorists on environmental grounds. Sustainable Cities and Society, 26, 134–149.

171. Stephens-Romero S.D., Samuelsen G.S., 2009. Demonstration of a novel assessment methodology for hydrogen infrastructure deployment. International Journal of Hydrogen Energy, 34(2), 628–641.

172. Stephens-Romero S.D., Brown T.M., Kang J.E., Recker W.W., Samuelsen G.S., 2010. Systematic planning to optimize investments in hydrogen infrastructure deployment. International Journal of Hydrogen Energy, 35(10), 4652–4667.

173. Stöckl F., Schill W.P., Zerrahn A., 2021. Optimal supply chains and power sector benefits of green hydrogen. Scientific Reports, 11(1), 1–14.

174. Strachan N., Balta-Ozkan N., Joffe D., McGeevor K., Hughes N., 2009. Soft-linking energy systems and GIS models to investigate spatial hydrogen infrastructure development in a low-carbon UK energy system. International Journal of Hydrogen Energy, 34(2), 642–657.

175. Sun H., He C., Wang H., Zhang Y., Lv S., Xu Y., 2017. Hydrogen station siting optimization based on multi-source hydrogen supply and life cycle cost. International Journal of Hydrogen Energy, 42(38), 23952–23965.

176. Sun H., He C., Yu X., Wu M., Ling Y., 2019. Optimal siting and sizing of hydrogen refuelling stations considering distributed hydrogen production and cost reduction for regional consumers. International Journal of Energy Research, 43(9), 4184–4200.

177. Sun K., Li K.J., Zhang Z., Liang Y., Liu Z., Lee W.J., 2021. An Integration Planning for Renewable Energies, Hydrogen Plant and Logistics Center in the Suburban Power Grid. IEEE Transactions on Industry Applications.

178. Tafakkori K., Bozorgi-Amiri A., Yousefi-Babadi A., 2020. Sustainable generalized refuelling station location problem under uncertainty. Sustainable Cities and Society, 63, 102497.

179. Talebian H., Herrera O.E., Mérida W., 2021. Policy effectiveness on emissions and cost reduction for hydrogen supply chains: The case for British Columbia. International Journal of Hydrogen Energy, 46(1), 998–1011.

180. Talebian H., Herrera O.E., Mérida W., 2019. Spatial and temporal optimization of hydrogen fuel supply chain for light duty passenger vehicles in British Columbia. Int. J. Hydrogen Energy 44, 25939–25956. https://doi.org/10.1016/J.IJHYDENE.2019.07.218.

181. Tittle D., Qu J., 2013. The implications of using hydrocarbon fuels to generate electricity for hydrogen fuel powered automobiles on electrical capital, hydrocarbon consumption, and anthropogenic emissions. Transportation Research Part D: Transport and Environment, 18(1), 25–30.

182. Tlili O., Mansilla C., Linβen J., Reuβ M., Grube T., Robinius M., André J., Perez Y., Le Duigou A., Stolten DOE, 2020. Geospatial modelling of the hydrogen infrastructure in France in order to identify the most suited supply chains. International Journal of Hydrogen Energy, 45(4), 3053–3072.

183. Torreglosa J.P., García-Triviño P., Fernández-Ramirez L.M., Jurado F., 2016. Control based on techno-economic optimization of renewable hybrid energy system for stand-alone applications. Expert Syst. Appl. 51, 59–75. https://doi.org/10.1016/J.ESWA.2015.12.038.

184. Tseng P., Lee J., Friley P., 2005. A hydrogen economy: opportunities and challenges. Energy 30, 2703–2720. https://doi.org/10.1016/J.ENERGY.2004.07.015.

185. Van Den Heever S.A., Grossmann I.E., 2003. A strategy for the integration of production planning and reactive scheduling in the optimization of a hydrogen supply network. Comput. Chem. Eng. 27, 1813–1839. https://doi.org/10.1016/S0098-1354(03)00158-3.

186. Wickham D., Hawkes A., Jalil-Vega F., 2022. Hydrogen supply chain optimization for the transport sector – Focus on hydrogen purity and purification requirements. Applied Energy, 305, 117740.

187. Won W., Kwon H., Han J.H., Kim J., 2017. Design and operation of renewable energy sources based hydrogen supply system: Technology integration and optimization. Renew. Energy 103, 226–238. https://doi.org/10.1016/J.RENENE.2016.11.038.

188. Woo, Y.B., Cho S., Kim J., Kim B.S., 2016. Optimization-based approach for strategic design and operation of a biomass-to-hydrogen supply chain. Int. J. Hydrogen Energy 41, 5405–5418. https://doi.org/10.1016/J.IJHYDENE.2016.01.153.

189. Woo Y.B., Kim B.S., 2019. A genetic algorithm-based matheuristic for hydrogen supply chain network problem with two transportation modes and replenishment cycles. Comput. Ind. Eng. 127, 981–997. https://doi.org/10.1016/J.CIE.2018.11.027.

190. Wu Y., Deng Z., Tao Y., Wang L., Liu F., Zhou J., 2021. Site selection decision framework for photovoltaic hydrogen production project using BWM-CRITIC-MABAC: A case study in Zhangjiakou. J. Clean. Prod. 324, 129233. https://doi.org/10.1016/J.JCLEPRO.2021.129233

191. Wu Y., He F., Zhou J., Wu C., Liu F., Tao Y., Xu C., 2021. Optimal site selection for distributed wind power coupled hydrogen storage project using a geographical information system based multi-criteria decision-making approach: A case in China. Journal of Cleaner Production, 299, 126905.

192. Wulf C., Kaltschmitt M., 2018. Hydrogen Supply Chains for Mobility—Environmental and Economic Assessment. Sustainability, 10(6).

193. Wulf C., Reuβ M., Grube T., Zapp P., Robinius M., Hake J.F., Stolten D., 2018. Life Cycle Assessment of hydrogen transport and distribution options. J. Clean. Prod. 199, 431–443. https://doi.org/10.1016/J.JCLEPRO.2018.07.180.

194. Xu X., Hu W., Liu W., Du Y., Huang Q., Chen Z., 2022. Robust energy management for an on-grid hybrid hydrogen refuelling and battery swapping station based on renewable energy. J. Clean. Prod. 331, 129954. https://doi.org/10.1016/J.JCLEPRO.2021.129954

195. Yáñez M., Ortiz A., Brunaud B., Grossmann I.E., Ortiz I., 2018. Contribution of upcycling surplus hydrogen to design a sustainable supply chain: The case study of Northern Spain. Applied Energy, 231, 777–787.

196. Yang C., Ogden J.M., 2013. Renewable and low carbon hydrogen for California-Modeling the long term evolution of fuel infrastructure using a quasi-spatial TIMES model. International Journal of Hydrogen Energy, 38(11), 4250–4265.

197. Yang G., Jiang Y., You S., 2020. Planning and operation of a hydrogen supply chain network based on the off-grid wind-hydrogen coupling system. International Journal of Hydrogen Energy, 45(41), 20721–20739.

198. Yang Y., Ma C., Lian C., Zhang Y., Pang X., 2021. Optimal power reallocation of large-scale grid-connected photovoltaic power station integrated with hydrogen production. Journal of Cleaner Production, 298:126830.

199. Yeh S., Farrell A., Plevin R., Sanstad A., Weyant J., 2008. Optimizing U.S. Mitigation Strategies for the Light-Duty Transportation Sector: What We Learn from a Bottom-Up Model. Environmental science & technology, 42(22), 8202–8210.

200. Yuansheng H., Mengshu S., Weiye W., Hongyu L., 2021. A two-stage planning and optimization model for water - hydrogen integrated energy system with isolated grid. J. Clean. Prod. 313, 127889. https://doi.org/10.1016/J.JCLEPRO.2021.127889

201. Zhang Y., Hu G., Brown R.C., 2014. Integrated supply chain design for commodity chemicals production via woody biomass fast pyrolysis and upgrading. Bioresource Technology, 157(28).

202. Zhao Q., Kelley S.B., Xiao F., Kuby M.J., 2019. A multi-scale framework for fuel station location: From highways to street intersections. Transp. Res. Part D Transp. Environ. 74, 48–64. https://doi.org/10.1016/j.trd.2019.07.018.

References

Agnolucci, P., Mcdowall, W., 2013. Designing future hydrogen infrastructure: insights from analysis at different spatial scales. Int. J. Hydrogen Energy 38, 5181–5191. https://doi.org/10.1016/J.IJHYDENE.2013.02.042.

Agnolucci, P., Akgul, O., McDowall, W., Papageorgiou, L.G., 2013. The importance of economies of scale, transport costs and demand patterns in optimising hydrogen fuelling infrastructure: an exploration with SHIPMod (Spatial hydrogen infrastructure planning model). Int. J. Hydrogen Energy 38, 11189–11201. https://doi.org/10.1016/J.IJHYDENE.2013.06.071.

Ahi, P., Searcy, C., 2015. Measuring social issues in sustainable supply chains. Meas. Bus. Excell. 19, 33–45. https://doi.org/10.1108/MBE-11-2014-0041/FULL/PDF.

Al-Breiki, M., Bicer, Y., 2021. Comparative life cycle assessment of sustainable energy carriers including production, storage, overseas transport and utilization. J. Clean. Prod. 279, 123481 https://doi.org/10.1016/J.JCLEPRO.2020.123481.

Almansoori, A., Betancourt-Torcat, A., 2016. Design of optimization model for a hydrogen supply chain under emission constraints - a case study of Germany. Energy 111, 414–429. https://doi.org/10.1016/J.ENERGY.2016.05.123.

Almansoori, A., Shah, N., 2006. Design and operation of a future hydrogen supply chain: Snapshot model. Chem. Eng. Res. Des. 84, 423–438. https://doi.org/10.1205/CHERD.05193.

Almansoori, A., Shah, N., 2009. Design and operation of a future hydrogen supply chain: multi-period model. Int. J. Hydrogen Energy 34, 7883–7897. https://doi.org/10.1016/J.IJHYDENE.2009.07.109.

Almansoori, A., Shah, N., 2012. Design and operation of a stochastic hydrogen supply chain network under demand uncertainty. Int. J. Hydrogen Energy 37, 3965–3977. https://doi.org/10.1016/J.IJHYDENE.2011.11.091.

André, J., Auray, S., Brac, J., De Wolf, D., Maisonnier, G., Ould-Sidi, M.M., Simonnet, A., 2013. Design and dimensioning of hydrogen transmission pipeline networks. Eur. J. Oper. Res. 229, 239–251. https://doi.org/10.1016/J.EJOR.2013.02.036.

Balcombe, P., Speirs, J., Johnson, E., Martin, J., Brandon, N., Hawkes, A., 2018. The carbon credentials of hydrogen gas networks and supply chains. Renew. Sustain. Energy Rev. 91, 1077–1088. https://doi.org/10.1016/J.RSER.2018.04.089.

Ball, M., Wietschel, M., Rentz, O., 2007. Integration of a hydrogen economy into the German energy system: an optimising modelling approach. Int. J. Hydrogen Energy 32, 1355–1368. https://doi.org/10.1016/J.IJHYDENE.2006.10.016.

Balta-Ozkan, N., Baldwin, E., 2013. Spatial development of hydrogen economy in a low-carbon UK energy system. Int. J. Hydrogen Energy 38, 1209–1224. https://doi.org/10.1016/J.IJHYDENE.2012.11.049.

Bano, S., Siluvai Antony, P., Jangde, V., Biniwale, R.B., 2018. Hydrogen transportation using liquid organic hydrides: a comprehensive life cycle assessment. J. Clean. Prod. 183, 988–997. https://doi.org/10.1016/J.JCLEPRO.2018.02.213.

Bapna, R., Thakur, L.S., Nair, S.K., 2002. Infrastructure development for conversion to environmentally friendly fuel. Eur. J. Oper. Res. 142, 480–496. https://doi.org/10.1016/S0377-2217(01)00309-5.

Beske, P., Land, A., Seuring, S., 2014. Sustainable supply chain management practices and dynamic capabilities in the food industry: a critical analysis of the literature. Int. J. Prod. Econ. 152, 131–143. https://doi.org/10.1016/J.IJPE.2013.12.026.

Bhandari, R., Trudewind, C.A., Zapp, P., 2014. Life cycle assessment of hydrogen production via electrolysis – a review. J. Clean. Prod. 85, 151–163. https://doi.org/10.1016/J.JCLEPRO.2013.07.048.

Brey, J.J., Brey, R., Carazo, A.F., Ruiz-Montero, M.J., Tejada, M., 2016. Incorporating refuelling behaviour and drivers' preferences in the design of alternative fuels infrastructure in a city. Transport. Res. C Emerg. Technol. 65, 144–155. https://doi.org/10.1016/J.TRC.2016.01.004.

Canadian Government, 2020. Hydrogen Strategy for Canada – Seizing the Opportunities for Hydrogen [WWW Document]. URL. https://www.nrcan.gc.ca/sites/nrcan/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf. accessed 4.24.2022.

Cantú, V.H., Azzaro-Pantel, C., Ponsich, A., 2021. A Novel Matheuristic based on bi-level optimization for the multi-Objective design of hydrogen supply chains. Comput. Chem. Eng. 152, 107370 https://doi.org/10.1016/J.COMPCHEMENG.2021.107370.

Carrera, E., Azzaro-Pantel, C., 2021a. A methodological design framework for hydrogen and methane supply chain with special focus on Power-to-Gas systems: application to Occitanie region. France. Comput. Chem. Eng. 153, 107386 https://doi.org/10.1016/J.COMPCHEMENG.2021.107386.

Carrera, E., Azzaro-Pantel, C., 2021b. Bi-Objective optimal design of hydrogen and methane supply chains based on power-to-gas systems. Chem. Eng. Sci. 246, 116861 https://doi.org/10.1016/J.CES.2021.116861.

Cerniauskas, S., Jose Chavez Junco, A., Grube, T., Robinius, M., Stolten, D., 2020. Options of natural gas pipeline reassignment for hydrogen: cost assessment for a Germany case study. Int. J. Hydrogen Energy 45, 12095–12107. https://doi.org/10.1016/J.IJHYDENE.2020.02.121.

Chen, Q., Gu, Y., Tang, Z., Wang, D., Wu, Q., 2021. Optimal design and techno-economic assessment of low-carbon hydrogen supply pathways for a refueling station located in Shanghai. Energy 237, 121584. https://doi.org/10.1016/J.ENERGY.2021.121584.

Cho, S., Woo, Y. bin, Kim, B.S., Kim, J., 2016. Optimization-based planning of a biomass to hydrogen (B2H2) system using dedicated energy crops and waste biomass. Biomass Bioenergy 87, 144–155. https://doi.org/10.1016/J.BIOMBIOE.2016.02.025.

Contaldi, M., Gracceva, F., Mattucci, A., 2008. Hydrogen perspectives in Italy: analysis of possible deployment scenarios. Int. J. Hydrogen Energy 33, 1630–1642. https://doi.org/10.1016/J.IJHYDENE.2007.12.035.
Crönert, T., Minner, S., 2021. Location selection for hydrogen fuel stations under emerging provider competition. Transport. Res. C Emerg. Technol. 133, 103426 https://doi.org/10.1016/J.TRC.2021.103426.
Dagdougui, H., 2012. Models, methods and approaches for the planning and design of the future hydrogen supply chain. Int. J. Hydrogen Energy 37, 5318–5327. https://doi.org/10.1016/J.IJHYDENE.2011.08.041.
Dagdougui, H., Ouammi, A., Sacile, R., 2012. Modelling and control of hydrogen and energy flows in a network of green hydrogen refuelling stations powered by mixed renewable energy systems. Int. J. Hydrogen Energy 37, 5360–5371. https://doi.org/10.1016/J.IJHYDENE.2011.07.096.
Dayhim, M., Jafari, M.A., Mazurek, M., 2014. Planning sustainable hydrogen supply chain infrastructure with uncertain demand. Int. J. Hydrogen Energy 39, 6789–6801. https://doi.org/10.1016/J.IJHYDENE.2014.02.132.
Daziano, R., Achtnicht, M., 2014. Forecasting adoption of ultra-low-emission vehicles using Bayes Estimates of a multinomial Probit model and the GHK simulator on JSTOR. Transport. Sci. 48, 671–683.
De-León Almaraz, S., Azzaro-Pantel, C., Montastruc, L., Boix, M., 2015. Deployment of a hydrogen supply chain by multi-objective/multi-period optimisation at regional and national scales. Chem. Eng. Res. Des. 104, 11–31. https://doi.org/10.1016/J.CHERD.2015.07.005.
Demirhan, C.D., Tso, W.W., Powell, J.B., Pistikopoulos, E.N., 2021. A multi-scale energy systems engineering approach towards integrated multi-product network optimization. Appl. Energy 281, 116020. https://doi.org/10.1016/J.APENERGY.2020.116020.
DOE, 2020. Department of Energy Hydrogen Program Plan [WWW Document]. URL. https://www.hydrogen.energy.gov/. accessed 4.24.2022.
Duriau, V.J., Reger, R.K., Pfarrer, M.D., 2016. A content analysis of the content analysis literature in organization studies: research themes, data sources, and methodological refinements: organ. Res. Methods 10, 5–34. https://doi.org/10.1177/1094428106289252.
El-Emam, R.S., Özcan, H., 2019. Comprehensive review on the techno-economics of sustainable large-scale clean hydrogen production. J. Clean. Prod. 220, 593–609. https://doi.org/10.1016/J.JCLEPRO.2019.01.309.
European Commission, 2016. Paris Agreement [WWW Document]. URL. https://ec.europa.eu/clima/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en. accessed 4.24.2022.
Fazli-Khalaf, M., Naderi, B., Mohammadi, M., Pishvaee, M.S., 2020. Design of a sustainable and reliable hydrogen supply chain network under mixed uncertainties: a case study. Int. J. Hydrogen Energy 45, 34503–34531. https://doi.org/10.1016/J.IJHYDENE.2020.05.276.
FCH EU, 2019. Hydrogen Roadmap Europe - A Sustainable Pathway for the European Energy Transition. https://doi.org/10.2843/249013 [WWW Document].
Finnah, B., Gönsch, J., 2021. Optimizing trading decisions of wind power plants with hybrid energy storage systems using backwards approximate dynamic programming. Int. J. Prod. Econ. 238, 108155 https://doi.org/10.1016/J.IJPE.2021.108155.
Fokkema, J.E., uit het Broek, M.A.J., Schrotenboer, A.H., Land, M.J., Van Foreest, N.D., 2022. Seasonal hydrogen storage decisions under constrained electricity distribution capacity. Renew. Energy 195, 76–91.
Gallardo, F.I., Monforti Ferrario, A., Lamagna, M., Bocci, E., Astiaso Garcia, D., Baeza-Jeria, T.E., 2021. A Techno-Economic Analysis of solar hydrogen production by electrolysis in the north of Chile and the case of exportation from Atacama Desert to Japan. Int. J. Hydrogen Energy 46, 13709–13728. https://doi.org/10.1016/J.IJHYDENE.2020.07.050.
Garcia, D.A., Barbanera, F., Cumo, F., Di Matteo, U., Nastasi, B., 2016. Expert opinion analysis on renewable hydrogen storage systems potential in Europe. Energies 9 (963 9), 963. https://doi.org/10.3390/EN9110963, 2016.
Glenk, G., Reichelstein, S., 2020. Synergistic value in vertically integrated power-to-gas energy systems. Prod. Oper. Manag. 29, 526–546. https://doi.org/10.1111/POMS.13116.
Global, S.&P., 2022. Inclusion of Nuclear in EC Sustainable Power Taxonomy Boon for Hydrogen: Trade Body [WWW Document]. URL. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/010722-inclusion-of-nuclear-in-ec-sustainable-power-taxonomy-boon-for-hydrogen-trade-body. accessed 4.25.2022.
Griffiths, S., Sovacool, B.K., Kim, J., Bazilian, M., Uratani, J.M., 2021. Industrial decarbonization via hydrogen: a critical and systematic review of developments, socio-technical systems and policy options. Energy Res. Social Sci. 80, 102208 https://doi.org/10.1016/J.ERSS.2021.102208.
Gül, T., Kypreos, S., Turton, H., Barreto, L., 2009. An energy-economic scenario analysis of alternative fuels for personal transport using the Global Multi-regional MARKAL model (GMM). Energy 34, 1423–1437. https://doi.org/10.1016/j.energy.2009.04.010.
Güler, M.G., Geçici, E., Erdoğan, A., 2021. Design of a future hydrogen supply chain: a multi period model for Turkey. Int. J. Hydrogen Energy 46, 16279–16298. https://doi.org/10.1016/J.IJHYDENE.2020.09.018.
Han, S., Kim, J., 2019. A multi-period MILP model for the investment and design planning of a national-level complex renewable energy supply system. Renew. Energy 141, 736–750. https://doi.org/10.1016/J.RENENE.2019.04.017.
He, G., Mallapragada, D.S., Bose, A., Heuberger, C.F., Gencer, E., 2021a. Hydrogen supply chain planning with flexible transmission and storage scheduling. IEEE Trans. Sustain. Energy 12, 1730–1740. https://doi.org/10.1109/TSTE.2021.3064015.
He, G., Michalek, J., Kar, S., Chen, Q., Zhang, D., Whitacre, J.F., 2021b. Utility-scale portable energy storage systems. Joule 5, 379–392. https://doi.org/10.1016/J.JOULE.2020.12.005.
Hensher, D.A., Wei, E., Balbontin, C., 2022. Comparative assessment of zero emission electric and hydrogen buses in Australia. Transport. Res. Transport Environ. 102, 103130 https://doi.org/10.1016/j.trd.2021.103130.
Hurskainen, M., Ihonen, J., 2020. Techno-economic feasibility of road transport of hydrogen using liquid organic hydrogen carriers. Int. J. Hydrogen Energy 45, 32098–32112. https://doi.org/10.1016/J.IJHYDENE.2020.08.186.
Intralink, 2021. The Hydrogen Economy South Korea [WWW Document]. URL. https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf. accessed 4.24.2022.
Janic, M., 2008. The potential of liquid hydrogen for the future "carbon-neutral" air transport system. Transport. Res. Transport Environ. 13, 428–435. https://doi.org/10.1016/j.trd.2008.07.005.
Japanese Government, 2017. Basic Hydrogen Strategy [WWW Document]. URL. https://policy.asiapacificenergy.org/node/3698. accessed 4.24.2022.
Johnson, N., Ogden, J., 2012. A spatially-explicit optimization model for long-term hydrogen pipeline planning. Int. J. Hydrogen Energy 37, 5421–5433. https://doi.org/10.1016/j.ijhydene.2011.08.109.
Kang, J.E., Recker, W., 2014. Strategic hydrogen refueling station locations with scheduling and routing considerations of individual vehicles. Transport. Sci. 49, 767–783. https://doi.org/10.1287/TRSC.2014.0519.
Kazi, M.K., Eljack, F., El-Halwagi, M.M., Haouari, M., 2021. Green hydrogen for industrial sector decarbonization: costs and impacts on hydrogen economy in Qatar. Comput. Chem. Eng. 145, 107144 https://doi.org/10.1016/J.COMPCHEMENG.2020.107144.
Khojasteh, M., 2020. A robust energy procurement strategy for micro-grid operator with hydrogen-based energy resources using game theory. Sustain. Cities Soc. 60, 102260 https://doi.org/10.1016/J.SCS.2020.102260.
Kim, A., Lee, H., Brigljević, B., Yoo, Y., Kim, S., Lim, H., 2021. Thorough economic and carbon footprint analysis of overall hydrogen supply for different hydrogen carriers from overseas production to inland distribution. J. Clean. Prod. 316, 128326 https://doi.org/10.1016/J.JCLEPRO.2021.128326.
Kostin, A., Guillén-Gosálbez, G., Jiménez, L., 2015. Dimensionality reduction applied to the simultaneous optimization of the economic and life cycle environmental performance of supply chains. Int. J. Prod. Econ. 159, 223–232. https://doi.org/10.1016/J.IJPE.2014.09.018.
Lahnaoui, A., Wulf, C., Dalmazzone, D., 2021. Optimization of hydrogen cost and transport technology in France and Germany for various production and demand scenarios, 2021 Energies 14, 744. https://doi.org/10.3390/EN14030744. Page 744 14.
Li, Z., Gao, D., Chang, L., Liu, P., Pistikopoulos, E.N., 2008. Hydrogen infrastructure design and optimization: a case study of China. Int. J. Hydrogen Energy 33, 5275–5286. https://doi.org/10.1016/J.IJHYDENE.2008.06.076.
Li, B., Roche, R., Paire, D., Miraoui, A., 2018. Coordinated scheduling of a gas/electricity/heat supply network considering temporal-spatial electric vehicle demands. Elec. Power Syst. Res. 163, 382–395. https://doi.org/10.1016/J.EPSR.2018.07.014.
Li, L., Manier, H., Manier, M.A., 2019. Hydrogen supply chain network design: an optimization-oriented review. Renew. Sustain. Energy Rev. 103, 342–360. https://doi.org/10.1016/J.RSER.2018.12.060.
Li, L., Al Chami, Z., Manier, H., Manier, M.A., Xue, J., 2021. Incorporating fuel delivery in network design for hydrogen fueling stations: Formulation and two metaheuristic approaches. Transport. Res. Part E Logist. Transp. Rev. 152, 102384 https://doi.org/10.1016/J.TRE.2021.102384.
Lim, S., Kuby, M., 2010. Heuristic algorithms for siting alternative-fuel stations using the Flow-Refueling Location Model. Eur. J. Oper. Res. 204, 51–61. https://doi.org/10.1016/J.EJOR.2009.09.032.
Liu, C., Zhang, J., Xu, Q., Gossage, J.L., 2010. Thermodynamic-analysis-based design and operation for boil-off gas flare minimization at LNG receiving terminals. Ind. Eng. Chem. Res. 49, 7412–7420. https://doi.org/10.1021/IE1008426/ASSET/IMAGES/LARGE/IE-2010-008426_0008 (JPEG).
Logan, K.G., Nelson, J.D., Hastings, A., 2020. Electric and hydrogen buses: Shifting from conventionally fuelled cars in the UK. Transport. Res. Transport Environ. 85, 102350 https://doi.org/10.1016/j.trd.2020.102350.
Mansour-Saatloo, A., Mirzaei, M.A., Mohammadi-Ivatloo, B., Zare, K., 2020. A risk-averse hybrid approach for optimal participation of power-to-hydrogen technology-based multi-energy microgrid in multi-energy markets. Sustain. Cities Soc. 63, 102421 https://doi.org/10.1016/J.SCS.2020.102421.
MansourLakouraj, M., Niaz, H., Liu, J.J., Siano, P., Anvari-Moghaddam, A., 2021. Optimal risk-constrained stochastic scheduling of microgrids with hydrogen vehicles in real-time and day-ahead markets. J. Clean. Prod. 318, 128452 https://doi.org/10.1016/J.JCLEPRO.2021.128452.
Maryam, S., 2017. Review of modelling approaches used in the HSC context for the UK. Int. J. Hydrogen Energy 42, 24927–24938. https://doi.org/10.1016/J.IJHYDENE.2017.04.303.
Mingolla, S., Lu, Z., 2021. Carbon emission and cost analysis of vehicle technologies for urban taxis. Transport. Res. Transport Environ. 99, 102994. https://doi.org/10.1016/J.TRD.2021.102994.
MirHassani, S.A., Ebrazi, R., 2013. A flexible reformulation of the refueling station location problem on JSTOR. Transport. Sci. 47, 617–628.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ 339, 332–336. https://doi.org/10.1136/BMJ.B2535.

Mohseni, S., Brent, A.C., 2020. Economic viability assessment of sustainable hydrogen production, storage, and utilisation technologies integrated into on- and off-grid micro-grids: a performance comparison of different meta-heuristics. Int. J. Hydrogen Energy 45, 34412–34436. https://doi.org/10.1016/J.IJHYDENE.2019.11.079.

Moreno-Benito, M., Agnolucci, P., Papageorgiou, L.G., 2017. Towards a sustainable hydrogen economy: optimisation-based framework for hydrogen infrastructure development. Comput. Chem. Eng. 102, 110–127. https://doi.org/10.1016/J.COMPCHEMENG.2016.08.005.

Muresan, M., Cormos, C.C., Agachi, P.S., 2013. Techno-economical assessment of coal and biomass gasification-based hydrogen production supply chain system. Chem. Eng. Res. Des. 91, 1527–1541. https://doi.org/10.1016/J.CHERD.2013.02.018.

Nordic Energy Research, 2022. Hydrogen, electrofuels, CCU and CCS in a nordic context [WWW Document]. https://doi.org/10.6027/NER2022-02.

Norwegian Government, 2020. The Norwegian government's hydrogen strategy - towards a low emission society [WWW Document]. URL. https://www.regjeringen.no/no/id4/. accessed 4.24.2022.

O'Dwyer, C., Dillon, J., O'Donnell, T., 2022. Long-term hydrogen storage—a case study exploring pathways and investments. Energies 15, 869. https://doi.org/10.3390/EN15030869, 15, 869.

Parker, N., Fan, Y., Ogden, J., 2010. From waste to hydrogen: an optimal design of energy production and distribution network. Transport. Res. Part E Logist. Transp. Rev. 46, 534–545. https://doi.org/10.1016/J.TRE.2009.04.002.

Quarton, C.J., Samsatli, S., 2020. Should we inject hydrogen into gas grids? Practicalities and whole-system value chain optimisation. Appl. Energy 275, 115172. https://doi.org/10.1016/J.APENERGY.2020.115172.

Ratnakar, R.R., Gupta, N., Zhang, K., van Doorne, C., Fesmire, J., Dindoruk, B., Balakotaiah, V., 2021. Hydrogen supply chain and challenges in large-scale LH2 storage and transportation. Int. J. Hydrogen Energy 46, 24149–24168. https://doi.org/10.1016/J.IJHYDENE.2021.05.025.

Reuß, M., Grube, T., Robinius, M., Preuster, P., Wasserscheid, P., Stolten, D., 2017. Seasonal storage and alternative carriers: a flexible hydrogen supply chain model. Appl. Energy 200, 290–302. https://doi.org/10.1016/J.APENERGY.2017.05.050.

Reuß, M., Grube, T., Robinius, M., Stolten, D., 2019. A hydrogen supply chain with spatial resolution: Comparative analysis of infrastructure technologies in Germany. Appl. Energy 247, 438–453. https://doi.org/10.1016/J.APENERGY.2019.04.064.

Reuß, M., Dimos, P., Léon, A., Grube, T., Robinius, M., Stolten, D., 2021. Hydrogen road transport analysis in the energy system: a case study for Germany through 2050. Energies 14, 3166. https://doi.org/10.3390/EN14113166, 2021 3166 14.

Schrotenboer, A.H., Veenstra, A.T.T., uit het Broek, M.A.J., Ursavas, E., 2022. A Green Hydrogen Energy System: optimal control strategies for integrated hydrogen storage and power generation with wind energy. Renew. Sustain. Energy Rev. https://doi.org/10.1016/j.rser.2022.112744.

Schulte Beerbühl, S., Fröhling, M., Schultmann, F., 2015. Combined scheduling and capacity planning of electricity-based ammonia production to integrate renewable energies. Eur. J. Oper. Res. 241, 851–862. https://doi.org/10.1016/J.EJOR.2014.08.039.

Seuring, S., Gold, S., 2012. Conducting content-analysis based literature reviews in supply chain management. Supply Chain Manag. 17, 544–555. https://doi.org/10.1108/13598541211258609/FULL/PDF.

Seuring, S., Müller, M., 2008. From a literature review to a conceptual framework for sustainable supply chain management. J. Clean. Prod. 16, 1699–1710. https://doi.org/10.1016/J.JCLEPRO.2008.04.020.

Seuring, S., Ali Yawar, S., Land, A., Usman Khalid, R., Sauer, P.C., 2021. The application of theory in literature reviews-illustrated with examples from supply chain management. Int. J. Oper. Prod. Manag. 41, 1–20. https://doi.org/10.1108/IJOPM-04-2020-0247.

Seyyedeh-Barhagh, S., Majidi, M., Nojavan, S., Zare, K., 2019. Optimal scheduling of hydrogen storage under economic and environmental Priorities in the presence of renewable units and demand Response. Sustain. Cities Soc. 46, 101406 https://doi.org/10.1016/J.SCS.2018.12.034.

Stadtler, H., Kilger, C., Herbert, M., 2015. Supply Chain Management and Advanced Planning: Concepts, Models, Software, and Case Studies. Springer Texts in Business and Economics, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-55309-7. Springer Berlin Heidelberg.

Sudusinghe, J.I., Seuring, S., 2022. Supply chain collaboration and sustainability performance in circular economy: a systematic literature review. Int. J. Prod. Econ. 245, 108402 https://doi.org/10.1016/J.IJPE.2021.108402.

Talebian, H., Herrera, O.E., Mérida, W., 2019. Spatial and temporal optimization of hydrogen fuel supply chain for light duty passenger vehicles in British Columbia. Int. J. Hydrogen Energy 44, 25939–25956. https://doi.org/10.1016/J.IJHYDENE.2019.07.218.

Tang, O., Rehme, J., 2017. An investigation of renewable certificates policy in Swedish electricity industry using an integrated system dynamics model. Int. J. Prod. Econ. 194, 200–213. https://doi.org/10.1016/J.IJPE.2017.03.012.

Tang, O., Rehme, J., Cerin, P., Huisingh, D., 2021. Hydrogen production in the Swedish power sector: considering operational volatilities and long-term uncertainties. Energy Pol. 148, 111990 https://doi.org/10.1016/J.ENPOL.2020.111990.

Tang, O., Rehme, J., Cerin, P., 2022. Levelized cost of hydrogen for refueling stations with solar PV and wind in Sweden: on-grid or off-grid? Energy 241, 122906. https://doi.org/10.1016/J.ENERGY.2021.122906.

Tlili, O., Mansilla, C., Reuß, M., Grube, T., Robinius, M., André, J., Perez, Y., Le Duigou, A., Stolten, D., 2020. Geospatial modelling of the hydrogen infrastructure in France in order to identify the most suited supply chains. Int. J. Hydrogen Energy 45, 3053–3072. https://doi.org/10.1016/J.IJHYDENE.2019.11.006.

Torreglosa, J.P., García-Triviño, P., Fernández-Ramirez, L.M., Jurado, F., 2016. Control based on techno-economic optimization of renewable hybrid energy system for stand-alone applications. Expert Syst. Appl. 51, 59–75. https://doi.org/10.1016/J.ESWA.2015.12.038.

Tranfield, D., Denyer, D., Smart, P., 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. Br. J. Manag. 14, 207–222. https://doi.org/10.1111/1467-8551.00375.

Tseng, P., Lee, J., Friley, P., 2005. A hydrogen economy: opportunities and challenges. Energy 30, 2703–2720. https://doi.org/10.1016/J.ENERGY.2004.07.015.

UK Government, 2021. UK Hydrogen Strategy [WWW Document]. URL. www.gov.uk/official-documents. accessed 4.24.2022.

n.d. U.S. Department of Energy, Hydrogen Storage Challenges [WWW Document]. URL. https://www.energy.gov/eere/fuelcells/hydrogen-storage-challenges. accessed 4.24.2022.

Van Den Heever, S.A., Grossmann, I.E., 2003. A strategy for the integration of production planning and reactive scheduling in the optimization of a hydrogen supply network. Comput. Chem. Eng. 27, 1813–1839. https://doi.org/10.1016/S0098-1354(03)00158-3.

Weekly, Climate, 2022. EU colour-blind on hydrogen, [WWW Document]. URL. https://www.climatechangenews.com/2022/02/18/eu-colour-blind-hydrogen-climate-weekly/. accessed 4.25.2022.

Weitzel, T., Glock, G.H., 2018. Energy management for stationary electric energy storage systems: a systematic literature review. Eur. J. Oper. Res. 264, 582–606.

Won, W., Kwon, H., Han, J.H., Kim, J., 2017. Design and operation of renewable energy sources based hydrogen supply system: technology integration and optimization. Renew. Energy 103, 226–238. https://doi.org/10.1016/J.RENENE.2016.11.038.

Woo, Y. Bin, Kim, B.S., 2019. A genetic algorithm-based matheuristic for hydrogen supply chain network problem with two transportation modes and replenishment cycles. Comput. Ind. Eng. 127, 981–997. https://doi.org/10.1016/J.CIE.2018.11.027.

Woo, Y. Bin, Cho, S., Kim, J., Kim, B.S., 2016. Optimization-based approach for strategic design and operation of a biomass-to-hydrogen supply chain. Int. J. Hydrogen Energy 41, 5405–5418. https://doi.org/10.1016/J.IJHYDENE.2016.01.153.

Wu, Y., Deng, Z., Tao, Y., Wang, L., Liu, F., Zhou, J., 2021. Site selection decision framework for photovoltaic hydrogen production project using BWM-CRITIC-MABAC: a case study in Zhangjiakou. J. Clean. Prod. 324, 129233 https://doi.org/10.1016/J.JCLEPRO.2021.129233.

Wulf, C., Reuß, M., Grube, T., Zapp, P., Robinius, M., Hake, J.F., Stolten, D., 2018. Life Cycle Assessment of hydrogen transport and distribution options. J. Clean. Prod. 199, 431–443. https://doi.org/10.1016/J.JCLEPRO.2018.07.180.

Xu, X., Hu, W., Liu, W., Du, Y., Huang, Q., Chen, Z., 2022. Robust energy management for an on-grid hybrid hydrogen refueling and battery swapping station based on renewable energy. J. Clean. Prod. 331, 129954 https://doi.org/10.1016/J.JCLEPRO.2021.129954.

Yang, G., Jiang, Y., You, S., 2020. Planning and operation of a hydrogen supply chain network based on the off-grid wind-hydrogen coupling system. Int. J. Hydrogen Energy 45, 20721–20739. https://doi.org/10.1016/J.IJHYDENE.2020.05.207.

Yang, Y., Ma, C., Lian, C., Zhang, Y., Pang, X., 2021. Optimal power reallocation of large-scale grid-connected photovoltaic power station integrated with hydrogen production. J. Clean. Prod. 298, 126830 https://doi.org/10.1016/J.JCLEPRO.2021.126830.

Yuansheng, H., Mengshu, S., Weiye, W., Hongyu, L., 2021. A two-stage planning and optimization model for water - hydrogen integrated energy system with isolated grid. J. Clean. Prod. 313, 127889 https://doi.org/10.1016/J.JCLEPRO.2021.127889.

Zhao, Q., Kelley, S.B., Xiao, F., Kuby, M.J., 2019. A multi-scale framework for fuel station location: from highways to street intersections. Transport. Res. Transport Environ. 74, 48–64. https://doi.org/10.1016/j.trd.2019.07.018.