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POTENTIAL FOR HYDROGEN DRIVEN GREEN MOBILITY TRANSITION IN THE CAMP DE TARRAGONA REGION OF CATALONIA SPAIN.

FINAL MASTER PROJECT

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Abstract.

With global temperatures rising and tourism numbers growing, hydrogen is a potential alternative fuel to tackle the global emergency crisis. How is it being incorporated into tourism mobility around Europe and in the region of Camp de Tarragona, part of the Costa Daurada tourist destination where a hydrogen valley has been formed. Research into hydrogen valleys and the hydrogen economy, local mobility, and industry data will be analysed to form an overall opinion on the economic, carbon footprint emission of hydrogen and if and how it could be used within the local tourism sector in the region.

Keywords

Tourism growth, climate change, sustainable tourism, hydrogen valley, mobility transitions, green hydrogen, value chain.

1. Introduction

This thesis is the result of a research project carried out in collaboration with the University Institute for Research in Sustainability, Climate Change and Energy Transition, (*IU-RESCAT*) at the *University of Rovira i Virgili,* Tarragona, Catalonia, Spain. The purpose of this thesis is to evaluate how partners of the local hydrogen ecosystem, the *Hydrogen Valley of Catalunya* are working together with the local tourism sector of Camp de Tarragona on the implementation of hydrogen as an alternative fuel for mobility purposes. The thesis analyses what elements of the tourism industry of Camp de Tarragona could be 'hydrogenised' in the future, feasibly and impactfully in terms of CO2 emission reductions and economic benefits.

Tourism is growing around the world as people are given more opportunities to travel and the tourism sector on all levels supports growth by building and adapting infrastructure to welcome more visitors. Camp de Tarragona is located on the Spanish Mediterranean coast and is one of many destinations around the world facing climate change pressures. "In 2022, Catalonia was the most visited region by international tourists in Spain with over 14.9 million people visiting from abroad, roughly 1.65 thousand more than the visitors welcomed in the Balearic Islands" (Statista 2023).

There are many global sectors responsible for producing negative impacts on our natural environment. The travel and tourism industry is accountable for considerable environmental damage through the travel impacts from tourist accommodation, general living habits derived from the expectations of tourists, lack of environmental awareness and for the purpose of this work, tourism mobility. There is an urgency to move away from fossil fuels and move to alternative fuels, one of them is hydrogen. Camp de Tarragona is located within the *Hydrogen Valley of Catalonia* and is therefore a potential alternative fuel for the local region and its booming tourism sector.

The Covid 19 pandemic brought a two-year period of negative growth to the tourism sector but in 2023, the pandemic seems to have been forgotten and tourist numbers are growing more than ever before. Current tourism sector negative developments are common knowledge and are researched by numerous specialists, governing bodies, and associations around the world. However, even though this knowledge is open and publicly accessible to all, tourists continue to travel, burning fossil fuels in

order to reach their destinations around the world. Thus, creating damaging emissions that are resulting in climate change.

At the climate change conference COP 25 in Madrid 2019 an extremely significant document was released stating the facts particularly relevant to this work "transport-related emissions from tourism are expected to account for 5.3% of all man-made CO2 emissions by 2030, up from 5% in 2016" (UNWTO, 2019). In addition to this, the *International Energy Agency IEA* presented a report on tackling climate change and although it admits that the road is not an easy one to follow it is possible "requiring all stakeholders – governments, businesses, investors and citizens – to take action this year and every year after so that the goal does not slip out of reach". (IEA. 2021). Alternative fuels for mobility are available but they require support, innovation and action, a transition to a greener planet does not simply happen without investment and dedication.

While tourism is clearly adding to the effects of climate change, it is also a victim. "Since weather and climate have a decisive influence on the travel season and the choice of holiday destinations, the tourism industry is highly dependent on them" (Climate Adapt 2023). If areas and destinations become off limits in the future, unable to visit, then the tourism sector will seriously suffer from these effects as destinations will simply become uninhabitable or unattractive to tourists. Climate change effects on destinations are already apparent, skiing in the European alps of France or Austria is less accessible and more vulnerable than ever before with snow from glaciers simply melting away. Spain is reporting record breaking temperatures, just this year in April 2023, 10-15 degrees hotter than usual April temperatures. Spain relies immensely on tourism, but if the temperatures continue to rise, it may affect some tourists' perceptions of the destination. "Spain has been suffering from drought since 2022 and in April 2023. Just a quarter of the usual rain fell" (World Economic Forum 2023). In the same report reservoirs are reported at being at only 25% of their capacity, particularly alarming considering that the tourist summer season is rapidly approaching. Tourists visiting Spain rely on water to cool themselves down, to enjoy the pool and ice in their drinks on the beach, it is very hard to imagine sun sea and sand tourism, popular in the Costa Daurada area, if these basic needs of tourists will not be able to be met in the future. Currently tourists do not notice the restrictions that the residents of Catalonia are subjected to before the summer season has started and after it has ended. Forest fires are becoming increasingly problematic throughout the world and in Europe, in Spain, Portugal and Greece, for example, forcing tourists to evacuate their accommodation and putting them in danger whilst on holiday. In Evia, Greece, at the height of the summer season in 2021, drastic events took place forcing tourists to evacuate the destination resulting in an effect that "people were hesitant to visit us, fearing that the environmental disaster would prevent them from relaxing". (Guardian, 2021).

Climate change, according to scientists, environmental researchers, and experts around the world, is happening at drastic extremely disturbing rates, posing an incredible threat to our planet and therefore its people and the environment that we live in. The *United Nations* has clearly advised society that climate change is a global emergency, one that needs action and simply cannot be denied. In 2015 an international treaty was created and signed by 175 countries in 2016. The treaty is called the *Paris Agreement*, it calls for global unity in tackling climate change. The purpose of the treaty is still present to this day – to reach NetZero - to limit global gas emissions in order to stop temperatures reaching 1.5 degrees and above by 2050, with the aim of preventing the warming of the planet, rising sea temperatures, melting glaciers, forest fires, flooding, and extreme weather conditions in general. In addition to the *Paris agreement* the EU reacted with additional plans, The *European Green Deal* compromising the *Fit for 55 Policy*.

At a *IU-RESCAT* seminar at the *URV* in March 2023, meteorological climate change expert of *Copernicus data store*, Carlo Buontempo expressed his concerns for rising temperatures indicating that at current rates the 1.5-degree limit is predicted to be met in 2034, sixteen years ahead of the crisis schedule.

With such predictions the goal of society is to reduce greenhouse gas emissions using whatever methods available, ensuring that we keep and adhere to targets. Tourism creates CO2 emissions and tourism numbers are rising dramatically. In reaction to this and considering the size of the industry and its negative future environmental predictions, the tourism sector has a considerable role to play in preparing the sector for the future, without delay. Now is the time to find innovative solutions, for sectors, governance, and society to react and protect the planet, after all `there is no planet B'.

2. Literature Review

Tourism growth and environmental impacts

As Gössling & Scott (2018) claim "emissions from global tourism continue to grow rapidly, in stark contrast to the mitigation needs outlined in the Paris Climate Agreement and stated emission reduction ambitions of the sector". Several Global and European policies and agendas have been introduced in recent years to help various business sectors and the public to tackle the global crisis. However, it is often questioned just how these advice papers and regulations can help aid the tourism sector especially when the *United Nations Sustainable Development Goals* for example are written to "to end poverty, protect the planet and ensure prosperity for all by 2030. The Agenda influences tourism policy even though the Agenda resolution only mentions tourism three times" (Hall 2019). Scott & Gössling (2022a) make a further claim that in the tourism sector there are gaps "what these overarching knowledge gaps demonstrate clearly is that the tourism sector is currently unprepared for the enormous knowledge requirements of the transition to climate resilient tourism development". There is general confusion within the sector regarding current and future net zero policies, generally suggesting that they "would require tourism to reinvent itself at both global and destination scales, requiring major and immediate upsurge in research and innovation, new cross-sector integrated and internationally co-operative policy innovation, novel demand management strategies, and a massive ongoing investment in infrastructure and technology deployment" (Scott & Gössling 2022b).

Public awareness and sustainable tourism

Tourism moves people from one destination to another, opening up the world through the wide array of opportunities, that without various available means of transport would not be possible, "tourism is a collection of social and economic activities with high energy and carbon intensity and in expansion, for these reasons its effect on climate change is expected to grow considerably in the future" (Rico et al 2018). As an aid to the public confronted with a global crisis, there are three basic assumptions to be adhered to "we are in a climate emergency, it's human-made, and we can do something about it". (Berners-Lee 2020). Although it is difficult to generalise and one cannot speak for everyone in society, there is an increasing interest in public knowledge of environmental awareness. "An ever-growing movement of the younger generation is demanding that global leaders take urgent climate action. Moreover, a growing number of actors, from governments to civil society organisations, as well as

private businesses at the local, national and global level are engaging in discussions and committing to mitigating and adapting to the effects of climate change" (UNWTO 2019). Berners–Lee (2020) explains how CO2 emissions affect the planet and therefore the whole of society, "If we're serious about really addressing climate change, we need to become energy and carbon literate, and get to grips with the implications not only of our choices but also the bigger infrastructures which underpin the things we consume".

Advice to travellers ranges from staying at home, not to travel, or one option would be to "look for a hotel with good energy management, minimisation of laundry and a general sense of care of resources" (Berners-Lee 2020). In terms of transport again there are several options; cruise tourism has received negative recognition in terms of energy efficiency "travel by ferry is better than flying but luxury cruises are not, mainly because the space requirement per person is huge and therefore so is the fuel use per person" (Berners-Lee 2020). The type of holidays tourists engage in is entirely up to the individual but sustainable nudges or general education can lead tourists to think differently before they book. Of course, facts and figures are often ignored especially if the economical price is attractive or the need to visit a destination outnumbers the social and ethical perspectives "as we escalate the pressure on consumers, through additional information about the deterioration of tourist destinations, their reaction may be to not accept the need to change their behaviour. They may actually attempt to ignore the threat, seek justifications for not changing their behaviour and potentially consume more of the resources now acutely known to be under threat, until these are depleted" (Font & Hindley 2016).

Considering that Camp de Tarragona is mainly considered to be a sun, sea and sand (3S) destination an estimation of "the total carbon footprint of leisure travel within the EU at 139 million tons of CO2e per year on average over the period 2010–2018, split almost equally between domestic (70 million tons) and international travel (69 million tons). The carbon intensity of travel per trip and per kilometre for 3S tourism is also the highest" (Laroche 2023). Tourism is growing mainly due to its accessibility and affordability; aviation and budget airlines certainly play a role in this social change. As well as 3S holidays, city trips are becoming more attractive for tourists and is apparent in the neighbouring city of Tarragona (Barcelona) "Barcelona is a clear example of the European trend toward short city touristic trips, where many tourists use low-cost airline companies and platforms to rent cheaper accommodation from particulars" (Rico et al 2018).

An awareness of how much CO2 such journeys are leaving behind is more common now especially through the introduction of carbon offsetting when booking travel journeys, especially common on airline booking websites as planes emit the most CO2 emissions and are the most popular form of tourist transport to and from a destination. "One ton of kerosene produces 3.1 tons of CO2 as well as water vapour and nitrogen oxide. Some airline companies have developed corporate environmental impact; for example, improving in aircraft technology, collaborating in social and environmental projects and compensating emissions are the most common strategies" (Rico et al 2018).

CO2 footprint and emissions awareness exists, although extremely few written academic articles exist comparing transport modes and how various alternative fuels and methods of transport could help reduce CO2 emissions of tourists. Other ways in which the suppliers can help the consumers are rarely discussed, mainly due to current energy transitional timing through the lack of clear policies and solutions as mentioned above. "Besides internal motivations, external factors such as the presence or absence of airports and train stations, deals on flights or holiday packages in certain destinations also contribute to shaping the spatial patterns of travel for different holiday styles" (Laroche 2023). Nudges towards sustainability are an effective way of encouraging tourists to consider certain

products, offering more sustainable options in general as described by Font & Hindley (2017) “offering alternatives that provide equally fulfilling but less impacting, holidays, or by positively framing the benefits of the more sustainable options in relation to the purchasing attributes sought by consumers may prove more effective”.

Within available sustainable tourism literature there tends to be a common feature about infrastructure and policies,” first, an improvement of infrastructures and more appropriate policies and strategies may have a relevant impact on the sustainability of mobility patterns not only of residents but also of visitors” (Zamparini & Vergori 2021). A tourist with a high level of moral obligation toward environmental conservation is more likely to conduct Pro-Environmental Behaviour (PEB). However, policy makers have a great impact on tourist behaviours as suggested by Font & Liu (2021) “rather than striving to promote all sorts of PEBs, they could focus on encouraging low effort PEBs, which are easier to engage in”.

Considering the current situation “the available literature makes it clear that there can be no sustainable tourism if we as a sector and society fail on climate change. The evidence is that climate change already affects tourism regionally, through diverse impacts on natural and cultural heritage and changes in demand patterns” (Scott & Gössling 2022).

Tourism mobilities and the hydrogen revolution

When referring to a hydrogen valley one way of doing so is to call it a hub or an ecosystem. One additional way of describing it could be as a cluster “the presence of a cluster of related industries in a location will foster entrepreneurship by lowering the cost of starting a business, enhancing opportunities for innovations and enabling better access to a more diverse range of inputs and complementary products” (Delagado et al 2010). A general realisation exists that as with any new technology, at the beginning the costs are high, a product needs time to develop and through time and collaboration achievements can be made. This is especially true with hydrogen, now a relatively new green transitional concept but “as fuel cell applications grow, the cost will be notably lower. As they become an increasingly more attractive option, the number of their applications will also rise” (de Troya et al 2016).

In terms of modern-day hydrogen valley literature this author has detected a considerable lack of research literature covering this topic. In addition to this, there is a void of literature when connecting hydrogen valleys directly to tourism and this author has not been able to find one single piece of evidence on this topic. With regards to hydrogen as an alternative energy and a direct connection to tourism, not connected to hydrogen valleys, very few academic articles are available, but they do exist. Recent advances in hydrogen fuel cell technologies combined with cost reductions in wind and solar power generation have created new opportunities for green hydrogen as a means of reducing transport emissions in tourism. One reference to island tourism and their economies relates to the Island of Tenerife and their hydrogen rental cars which have been introduced as an economical mode of tourist transport. However, a common problem with hydrogen mobility in the early stages are Hydrogen Refuelling Stations (HRS), the lack of such stations can lead to mobility issues and a general lack of knowledge is apparent regarding the implementation of hydrogen as an alternative fuel “while hydrogen presents an opportunity for energy transition, the societal acceptance and perception of key stakeholders are vital to the deployment and diffusion of hydrogen technologies” (Emodi et al 2021).

Hydrogen for mobility purposes within a green transition is a relatively new concept, there are mixed views as to whether this is the future of energy and how a transition will be achieved particularly when considering the economic impact as mentioned by Trattner et al (2022) "Technically, hydrogen applications and electrochemical machines are well developed, they function reliably and are ready for the market. Their so far higher costs have to be reduced by mass production and further specific research". A hydrogen transition is favoured by many as playing an important role in a green transition, away from fossil fuels "now we must continue to change the driver to hydrogen, which is the start of the hydrogen age, in which the use of hydrocarbon fuels (fossil fuels) will decrease exponentially while the use of hydrogen energy will increase" (Chakraborty 2022).

With regards to mobility, there are doubts as to whether hydrogen is the answer to all mobility solutions. The green transition could well involve an array of different alternative fuels providing different solutions. People can choose depending on their needs, the performance that their vehicle requires, the environmental impact and economical position of the user. Straubinger (2022) writes that "electric mobility is often seen as an important part of the solution, as enroute emissions immediately go down. This is especially true in urban environments, where technological solutions for electric transport are already available". Whatever the future holds, it is important that we reduce transport emissions from mobility, hydrogen is one possible means of enabling a green transition but to what extent is not yet certain. "Sustainable mobility is described as a transportation system that is ubiquitous, effective, clean, and ecologically beneficial. Whilst transportation does not have its own sustainable development goals (SDGs), it is critical for accomplishing other SDGs in order to reach desired growth and development" (Chakraborty 2022).

Tourism & local mobility

Camp de Tarragona forms parts of the popular sun sea and sand tourist destination of Costa Daurada. "The economic base of the area is mainly built upon industrial activity, particularly linked to the petrochemical sector, and the tourism sector" (Domènech et al 2020). Tourists arrive in the area using a variety of transport modes, all of which have an environmental impact on the local area. Although it can be said that aviation and marine transport are covering a much wider distance therefore it is difficult to include them in local CO2 emission calculations, they do land and depart locally, use onshore cold ironing energy services and fly or sail into local air space or maritime areas. For example, cruise ships, ferries and all marine transport are responsible for high CO2 emissions nearing port locations "approx. 70% of ship emissions occur within 400 km of coastlines, and ship emissions further travel in the atmosphere over several hundreds of kilometres" (Akako-Saksa 2023).

It is often believed that tourists stay in one place, one destination, their accommodation hub although studies by Domènech et al (2023) prove this is not the case "most of the detected profiles usually undertake side-trips to surrounding attractions, and only two of the detected profiles show more static behaviour traditionally associated with sun-and-sand destinations". In terms of environmental damage and CO2 emissions, it is not only important to see how tourists arrive and depart but how tourists move around the area, using which mode of transport. If regional tourist movement is carried out by non-sustainable public transport, or private vehicles not using alternative fuels, this could potentially increase CO2 levels of the region, "the mobility of tourists at their destination is an activity that has so far received very little attention from researchers in comparison with that afforded to the transport mode used to travel from their point of origin to their destination" (Gutiérrez & Miravet 2016). In addition to this, the region is dependent on seasonality, changes to mobility schedules is a

common occurrence in the Camp de Tarragona Region, increasing the frequency of journeys, especially during the summer season, this is an additional reason for sustainable transport "the contribution of local public transport to promote more sustainable mobility patterns in tourist destinations which help to mitigate any environmental impact that may be caused by the increased flows"(Domènech & Gutiérrez 2017).

Economic impacts of new ventures, i.e., a transition to hydrogen mobility has an incredible impact on regional decisions of change within destinations. As this is an area that has many gaps within the literature, especially when introducing a hydrogen mobility transition. The economic transition could be approached using "input-output modelling and aggregated income multipliers are clearly an important step forward compared to other techniques… they are quite useful for evaluating the effects of new investment projects that basically affect the demand side of the economy". (Llop & Arauzo-Carod 2012).

3. Objectives and Research questions

Unless innovative progressions to alternative fuels, eradicating fossil fuels are made and implemented into society, further environmental damage is inevitable. Individuals can play their part in the global emergency by analysing their carbon footprint emissions, but they still want to travel, especially as the world is more accessible now than ever before and the need for travel is greater than ever. As a result of this, extreme measures of approach from the tourism sector are required. A strong need of the implementation of innovative environmental and economical solutions to curb growing tourism emission predictions of the future. The *UNWTO* at *COP25* called for "enhanced cooperation between the transport and tourism sectors to effectively transform tourism for climate action". (UNWTO 2019). Alternative fuels for tourism mobility are available, one of them being hydrogen.

The main objective of this research is therefore to investigate alternatives for tourism within the Camp de Tarragona region to decarbonise the sector by using hydrogen. Considering the aforementioned problem areas of the growth of tourism, the urgency of climate change initiatives, tourism mobility, and the need for approach changes from the tourism sector on various levels of governance and innovation, this research has been instigated. The research questions for this research are as follows:

1. How aware are tourists of their CO2 footprint when travelling?
2. How is green hydrogen as an alternative fuel being used for tourism mobility purposes around the world, especially in Europe?
3. What is the purpose of a Hydrogen Valley in connection with tourism, where and how do they function?
4. What are the drivers and barriers economically and environmentally for Hydrogen mobility in the Camp de Tarragona region?
5. How is the Hydrogen Valley of Catalonia benefiting the local tourist industry of the Camp de Tarragona region?

4. Methodology

To address the research questions quantitative and qualitative analysis methods using local, national, and global data were immobilised. A series of informal yet informative conversations were organised

with experts and stakeholders on a local, national, and European level as one method of data collection. Informal conversations often snowballed to further conversations with other relevant representatives all of which supported the research process by deepening personal knowledge in the areas of hydrogen, hydrogen for mobility as well as tourism on a local, national, and European scale.

For a consistent quantitative data analysis *Excel* software was used to arrange and simulate the data as necessary. Data simulation was particularly useful for areas where data did not exist, due to lack of regional coverage for a particular transport mode or alternative energy vehicles not operating in the region. Actual and simulated data was then presented in the form of graphs and pie charts.

Qualitative data was sourced by means of local, national, and European interviews with numerous influential representatives from various backgrounds related to hydrogen and tourism. Contacts were made either in person, using a snowball effect, by email or via social media contacting methods. Interview duration lasted between 20 to 60 minutes and mainly took place online or in written form. Each interviewee was sent the questions in advance. Sourced information was transcribed and then added to qualitative data software, arranging themes into codes and grouping codes where necessary to extract the heavily weighted data significant in order to support the research questions. Different interview categories were assigned covering different regional, national, and European subjects.

Quantitative analysis

To identify the ways in which tourists move to, from and around the area of Camp de Tarragona, public mobility data was acquired from various sources, provided by local and national, public, and private companies and associations. Networking with various local experts led the author to data access and availability, particularly connected to *IU-RESCAT*

The data was taken from various sources, including official local statistic databases. Tourist movement was then calculated using available data or simulated in the case of a lack of data.

As a model the author used a previous regional work on tourism mobility by Domènech et al 2023 *Tourist profiles and intra-destination visiting preferences in a mature coastal destination: More than beach*. The research of this work is focussed on an accommodation hub, culminating the local popular coastal towns of Salou, Cambrils and La Pineda (Vila-seca). Setting a central pivotal point was a useful tool to monitor tourist movement to and from the hub and additional tourist movement during their stay at the hub. From this it was possible to estimate the kilometres travelled by tourists to the area annually. Using these calculations and applying multiplication factors obtained from the website *goclimate* and *UK Gov,* a CO2 footprint was obtained for global and per capita of tourists.

Using these calculations, a yearly economic estimation for regional road transport was estimated including the required tonnes of hydrogen per year and the total cost of ownership for new on road vehicles powered by hydrogen. For this quantitaive study, the years 2018 and 2019 have been evaluated since the years 2020-2022 are considered atypical due to the Covid pandemic.

Qualitative analysis

A qualitative analysis interview process was instigated in order to gain an overall perception of the use of hydrogen for mobility and tourism currently and in the future. The purpose of using this method

was for the author to gain an actual up to date insight into both the hydrogen and tourism sectors to be able to support the purpose of the research questions that form the basis of this work. Direct access to the proposed circles gave insight into past, current, and future progressions in the research areas not only locally but on a national and European level. Personal, targeted thematic interviews that gave insight into sectoral collaboration opportunities, gaps, constraints, drivers, and barriers on all levels of environmental and economic progress.

A series of qualitative analysis interviews of local, national, and European hydrogen valley, hydrogen mobility leaders and tourism mobility associates were conducted. Web scraping was instigated to find the relevant areas and to enter hydrogen mobility circles. The use of social media where necessary was used to build up a professional research basis using the business contact networking programme, *Linkedin* to make new, targeted contacts. Where possible for the region of Camp de Tarragona and the Hydrogen Valley of Catalonia, web scraping was a favoured method along with the availability of *URV* and *IU-RESCAT* contacts, associates, and representatives where possible. A snowball effect of contact building was a common feature of this work, leading to additional interviews with influential local, national, and European representatives, experts within their specialist knowledge areas.

Interviews were grouped into various interview categories, depending on the background, experience, and location of the interviewees. Four or five interview questions were sent in advance via email to each interviewee after they had confirmed their participation. Each question varied slightly to fit the individual profile of the representative and their association, business, or relationship to hydrogen for mobility and tourism. Altered questions are indicated in this work with *. All video call interviews took place over the online platforms *Teams* or *Zoom*.

Personal attendance at various local meetings was possible, giving the author the opportunity to immerse herself into a local stakeholder environment, especially useful as the author does not originate from the Camp de Tarragona area. Meeting attendance within the region took place, for example, at the *Blue Hydrogen Economy* meeting organised on 10th March 2023 by the Tarragona Provincial Council, in Salou and the internal URV *Hydrogen Decarbonisation Congress* in Tarragona on 28th April 2023. In addition to this as an internee, *IU-RESCAT* departmental meetings with other relevant research group partners were attended and useful for internal *URV* and *IU-RESCAT* networking.

For obtaining an up-to-date perspective of how the tourism sector and mobility in general is preparing for a green transition, the author attended the *UITP Global Public Transport Summit* in Barcelona on 5th June 2023. Internationally, the *World Hydrogen Summit (WHS) in Rotterdam* 9th - 11th May 2023 was also attended. Attendance of the WHS resulted in direct attendance at the *Hydrogen Mobility Europe* Project Final Conference, a separate seminar solely concentrated on hydrogen mobility. It is here where three influential interview candidates, high level hydrogen in Europe experts with immense knowledge of hydrogen for mobility in Europe were approached.

Contact with European hydrogen valley, *Hydrogen Valley of Catalonia* and *Green Hysland* Mallorca representatives were obtained using mainly web scraping and *Linkedin*. In addition, local *URV & IU-RESCAT* connections or hydrogen valley partners often gave support in obtaining direct contact with various stakeholders. An objective of this work was to gain direct access to the tourism sector which was possible through *TUI* and *Green Hysland*.

Interviews were transcribed and then coded using the qualitative data analysis software *Quirkos*. The data was then analysed thematically using coding to form themes. The software *Quirkos* creates

bubbles depending on the size and the amount of relevant data added that can then be analysed through the software's categorical framing and presented in the results section of this work. The software also creates word clouds depending on the repetitive nature of the interview themes and is a feature of this work.

Where possible analytical methodology was used to research relevant academic papers and media sources, proofing regional as well as European and international hydrogen mobility and tourism progressions. Primary and secondary data collection as well as intense web scraping was used throughout, proving to be particularly useful especially due to the limited academic research available.

5. Background data and information

In our changing world, energy resources due to technological developments and society requirements are moving and developing to meet current and future demand. A global Governmental awareness of greenhouse gas emissions, the Covid 19 crisis and more recently the war in the Ukraine have considerably changed the way the planet looks to its energy sources. In general, there is a large-scale interest in alternative fuels, a realisation of the independence they can provide countries throughout the world, making use of their natural assets where possible and creating new cross border contacts. The awareness of an urgency to move away from fossil fuels is common knowledge, aided now by an abundance of different fuel types that could potentially be used by the tourism industry, alternative fuels to fossil fuels; sustainable aviation fuels (SAFs), electricity and hydrogen among many others. For this project, the author is concentrating on green hydrogen as a zero-emission alternative fuel. SAF can also be created using green hydrogen and therefore is included in this writing when discussing aviation travel later in the work.

Hydrogen production

Green Hydrogen is produced using renewable energy, wind and solar. It is the hydrogen that is required for the cleanest green transition possible. Renewable energy from solar panels and wind farms is used to split hydrogen from water, in the electrolysis process. Green hydrogen used for transport emits ZERO CO2 emissions and only water as a by-product.

In addition to green there is blue hydrogen, which is a low carbon variant created using mainly natural gas, carbon capture and storage procedures. The worst of all hydrogen forms produced, and unfortunately still being used, is grey hydrogen. This is the most damaging and unfortunately in some countries, popular form of hydrogen to date. It is created by burning fossil fuels, coal or natural gas and creates extremely harmful carbon dioxide and NOx gasses. However, as mentioned, considerable work is being carried out across the energy sector around the world with a focus on global and European production of green hydrogen to reduce global warming emissions that are pumped into the world`s atmosphere. Again, this thesis is written with the assumption that the energy available is green and is commented on where necessary if there is an awareness that this is not the case.

Hydrogen for tourism mobility

When it comes to transport, there are several ways to use hydrogen. It can be used as an energy source in hydrogen combustion engines (H2ICE), more commonly in current times using Fuel Cell (FC) systems or used in the production of SAFs. Hydrogen can therefore be used to power numerous

vehicles which are or can be potentially used in the tourism industry, fuelling trains, planes, boats, buses, and cars etc, transporting tourists to and from destinations around the world, as an alternative to current fossil fuel, CO2 emitting transport modes.

The Camp de Tarragona region

The Tarragona region – named Camp de Tarragona in the national planning documents, and delimited as the metropolitan region including the two mid-sized cities of Tarragona and Reus, their coastal areas and rural hinterland – both cities are rich in history. Tarragona is a port city with a population of 134,883 residents (Idescat 2023), it is the capital of the Province of Tarragona. The city dates to ancient Roman times and is included in the World Heritage List for this account. Archaeological historical sites are still on view to this day, making it an important cultural destination, pulling tourists to the area. The neighbouring city of Reus has a population of 106.741 residents (Idescat 2023), again it is an important historical destination once famous for being at the centre of the liquor trade and on a par with London and Paris as being an important economical centre of commerce in the late 1700s, early 1800s. Reus is a popular destination for followers of the Spanish architect Antoni Gaudi. Tourists make the journey from Barcelona to visit the birthplace of the historical figure.

The region of Camp de Tarragona has its very own airport, Reus Airport and a port, it is widely renowned for its golden beaches of the internationally renowned sun sea and sand Costa Daurada holiday destination and the world-famous theme park attraction*, Port Aventura*, the most popular, most visited theme park in Spain. Tourists visit from Spain, Europe, and the rest of the World especially in the summer months when the summer weather offers appealing holiday temperatures to tourists. According to *FEHT Tarragona, the Federation of Business, Hotels and Tourism of Tarragona*, 20.9 million overnight stays were recorded pre-Covid 19 pandemic in 2019 and approximately 5.5 million visitors visited the region of Tarragona (FEHT 2022). The destination in addition boasts a world acclaimed wine region, Priorat, beautiful mountain ranges, villages, and churches as part of its inland and coastal beauty.

As well as being a region with numerous tourist attractions and travel related interests, it is also the location of one of Spain's largest petrochemical industries originating from the 1960's. According to the Chemical Parks in Europe website “Tarragona houses the largest chemical hub in southern Europe with annual production of 20 million tons” (Chemical Parks in Europe. 2023). As a tourist visiting the region one cannot ignore the industrial landscape when arriving and transferring within the area. The Petrochemical Industry in Tarragona lives and works alongside the tourism industry, both function in their own right.

Camp de Tarragona region is built up of five counties (comarques): Camp de Tarragona, Alt Camp, Conca de Barberà, Priorat and Tarragonés. Baix Penedès is often included as being part of the Camp de Tarragona region especially for Autoritat Territorial de la Mobilitat del Camp de Tarragona (ATM) mobility data.

Figure 1. Camp de Tarragona & author´s own five 'comarques' creation using My Maps by Google.

Over the years, as common with industry areas in general, the petrochemical area of Tarragona can be held responsible for producing considerable amounts of greenhouse gas emissions but as petrochemical businesses around the world change their names to 'energy companies', promises of renewable environmental energy production are very much the rage. This welcomed transition is changing the reputation of the industry. Times are changing, the sector is reacting to the global climate crisis and the implementation of a hydrogen valley in the local area is certainly one solution to enable a green transition. As one sector intends to change its habits, the purpose of this work is to investigate how the tourism sector intends to do the same and if and how the sectors collaborate in the global green transition.

Hydrogen Valleys and the Hydrogen Valley of Catalonia

A hydrogen valley (H2V) is an ecosystem or a hub, a way of local stakeholders joining together with one common interest, collaborating to gain knowledge and support, therefore enabling a project and common idea to grow and develop. The author relates this to being comparable to a cluster. Industrial clusters originally date back to Alfred Marshall (1842–1924) a UK economist who whilst studying at *Cambridge University*, realised the concept and benefits of connecting industrial businesses and stakeholders and centring them around a university, using ever expanding nurtured knowledge and expertise to grow together. A Hydrogen Valley (H2V) is in the opinion of the researcher, a modern-day form of a 'Marshallian Cluster', with various partners working together to produce a hydrogen value chain. A value chain offering the tourism sector alternative energy possibilities, especially with regard to transport as centred on in this work.

H2Vs are becoming increasingly popular, originating first as a European concept with the first hydrogen valleys being located in Europe. Although H2Vs date back to around 2015, the first EU funded valley was *Heavenn* in Groningen, Northern Netherlands. According to the *Mission Innovation*

hydrogen platform website (Clean Hydrogen Partnership, 2023) there are 81 H2Vs around the world in 32 different countries (not including the Hydrogen Valley of Catalonia).

The national Spanish energy company *Repsol*, along with many other petrochemical companies, are heavily involved in Spanish hydrogen valley funding and implementation. The value chain of hydrogen has 4 stages: production, distribution, storage and end use. End use is the part where the tourism sector potentially joins the chain.

Figure 2. Hydrogen Value Chain, Repsol.

As seen in Fig 2. important partners of hydrogen valleys are transport representatives. HVs vary but as evident in the diagram; airports, rail, ports, car and bus companies are potential partners and they connect the region locally, nationally and internationally.

The *Hydrogen Valley of Catalonia (H2ValCat)* was formed in October 2020 with the main objective of decarbonising Catalonia´s chemical and industrial industry. Originally a small-scale initiative formed online during the Covid 19 pandemic, it has grown rapidly with current partner affiliates of, 172 companies, 42 public institutions, 22 associations and clusters, and 13 research and knowledge centres. The *University of Rovira i Virgili* is the main academic powerhouse of the cluster, a cluster that is a mix of public and private multi sector and multi-stakeholders. *H2ValCat* considers itself to be an association, responsible for managing its various partners. According to Jordy Cartanyá, one of the original founders of the *Hydrogen Valley in Catalonia*, *Heavenn* in the Northern Netherlands was the basis and foundation for the *H2ValCat*. Located in an industrial area similar to *H2ValCat*, it was strongly focused, even in the beginning, on green mobility, as suggested in the promotional video, "the theme of mobility applies to the entire Heavenn region". The end uses of hydrogen for the hydrogen valley in terms of mobility are cars, buses, trucks and ships. “By bringing together hydrogen production, distribution, storage and local-end use, the goal is to demonstrate how this hydrogen valley could (through the use of green hydrogen across the value chain) reduce carbon emissions as well as potentially benefit businesses along its value chain” (New Energy Coalition 2020).

CO2 emissions in Europe and Catalonia

CO2 emissions measure carbon dioxide in the air. Carbon footprints are a measure for working out greenhouse gas emissions and relating them to human activity. Overall CO2 emissions in Europe are decreasing as industries and stakeholders adapt to new regulations and trends. Fig 3. shows greenhouse gas emissions (tonnes of CO_2 equivalent per capita) in Catalonia, Spain, and the European Union-27 (member countries) 1990–2020. In 2020 a significant drop in emissions occurred due to the Covid 19 pandemic. Leading up to 2020 there was a steady decrease in emissions, interesting to see however is that this drop was more visible in the EU and Spain than in Catalonia. How Catalonia could change this situation in the future is part of this research.

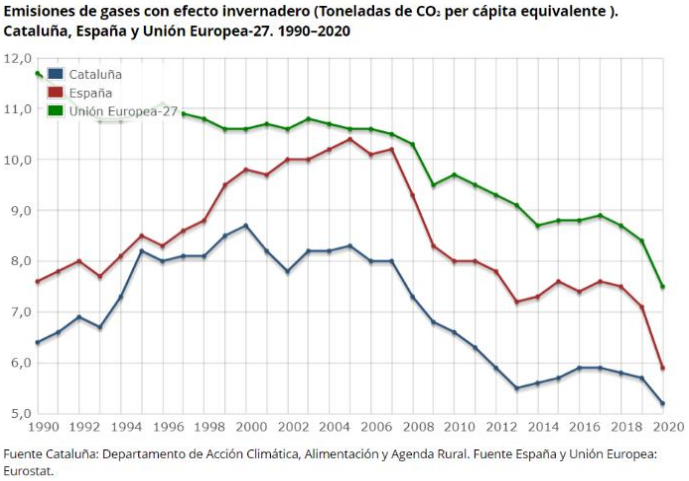


Figure 3. CO2 per capita EU, Spain & Catalonia.

6. CO2 emission from Mobility and Tourism.

As clearly stated in the *World Tourism Organisation UNWTO* and *World Transport Forum (ITF)* report (2019) tourism popularity and therefore emissions are rising dramatically with an expected growth of tourism accounting for 5.3% of all man-made emissions by 2030. This is a predicted growth, see Fig 4, of 25% from 2016 levels of 1567 Mt of CO2 to 1998 Mt of CO2. Affordable air travel, increased connectivity, new technological advances, new business models and easier visa application are some aspects responsible for continuous growth both in international and domestic tourism over the past decades, making present day and future travel more available for all. As described in the report by Zurab Pololikashvili, the Secretary-General of the *UNWTO* "one of the main challenges facing the tourism sector today is the need to decouple its projected growth from the use of resources and greenhouse gas (GHG) emissions" (UNWTO 2019). The report analyses the sector and the various modes and frequency of transport used by the tourism sector. A clear conclusion of the report is that the transport sector requires a ´high ambition scenario´ with considerable change enabling a transformation of the whole sector resulting in low emission, efficient transport solutions. It is a realisation that the tourism sector has a considerable need to work together with the transport sector to move towards a greener, sustainable zero emission future.

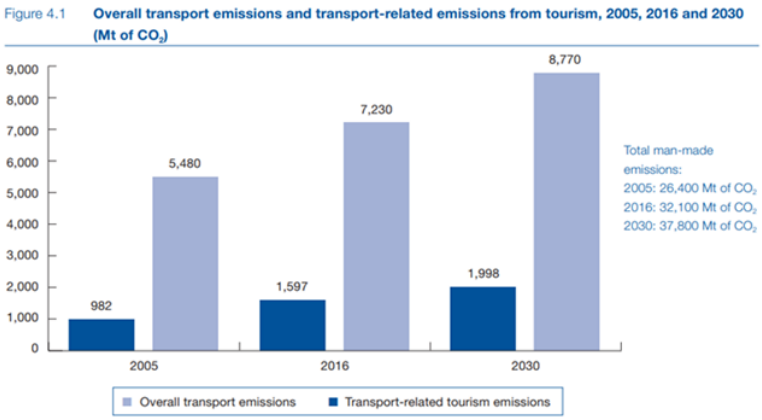
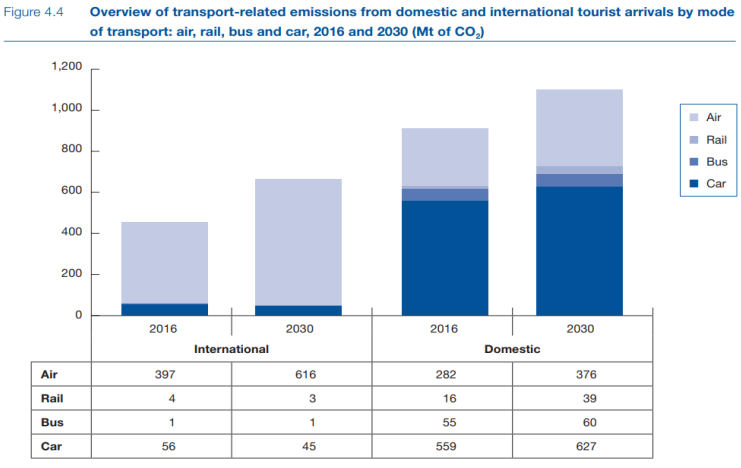


Figure 4. Overall Transport CO2 emissions

The way tourists move around is depicted in Fig 5. that also shows the difference globally of tourism transport distribution. Rail is and will remain the least CO2 intensive mode of transport, in terms of emissions, closely followed by bus transport. Cars are currently the most CO2 intensive mode of transport domestically (within country borders), but this should not increase, staying more or less the same by 2030 due to vehicle electrification and fuel improvements. Despite expected fuel efficiency improvements for aircrafts, the average CO2 emission factor is expected to surpass that of cars by 2030.



	International		Domestic	
	2016	2030	2016	2030
Air	397	616	282	376
Rail	4	3	16	39
Bus	1	1	55	60
Car	56	45	559	627

Notes: New tourism-related transport demand model developed for this study.
Sources: Based on UNWTO, ITF, IEA, IATA and Amadeus data.

Figure 5. Tourism related Emissions.

How tourists move around domestically as seen in Fig. 6. Air travel (29%) and rail (17%) demand is expected to increase by 2030 and car (42%) and bus transport (12%) modes are expected to decrease. Cars as a mode of transport are however still expected to be the most used form of transport in 2030.

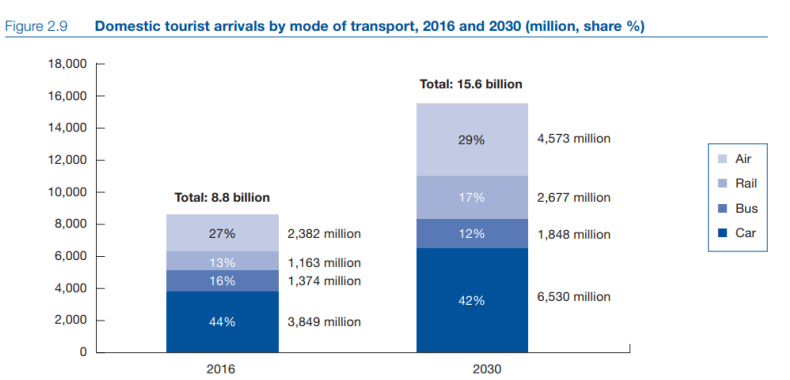


Figure 6. Domestic tourist arrivals by mode of transport 2016 & 2030.

7. Value Chain in Tourism

The tourism value chain with reference to this work, is focused on the local geographical area of Camp de Tarragona. It is the order and organisation of the actors and suppliers involved in providing the customers with their tourism experience when they visit the region. Stakeholders, partners, and suppliers responsible for the resources and activities the destination offers to tourists, the various tourism products. Important levels and stages of a tourism value chain are transport, accommodation,

Figure 7. Tourism Value Chain

excursions, and leisure (Fig7.). Destination Managers (DMO) oversee the planning, coordination, and marketing of a destination, making it attractive and functional economically and environmentally for tourists as well as residents. Ways of which local suppliers could aid to a 'greening up' of the local value chain on the Mediterranean coast would be a particular area of interest. Camp de Tarragona has its various tourism resources, natural assets, beach, natural heritage, wine region etc. It also has various supplies providing services to the tourism industry; transport services, hotels, restaurants, tour operators and tourist experiences with the theme park Port Aventura for example, attracting around 3.5 million visitors on average a year.

Considering that Camp de Tarragona is located directly in the geographical location of a hydrogen valley, there is potential on all levels of the local tourism value chain for the possible implementation of hydrogen into the tourism sector. A value chain is decided by the products on offer to the actors

at a destination, and what they have to promote to the incoming tourists. The main areas where hydrogen could be implemented in the tourism value chain are for transport as discussed in this work, accommodation and for excursions in various ways. For accommodation, hydrogen can be used as a form of power to heat or cool buildings, swimming pools and for cooking etc. One main area within a destination is tourist passenger transportation and the distribution of goods. In a sustainable tourism value chain, this is the case of transporting tourists to and from their destinations using mobility that emits zero CO2 emissions and therefore preserves the visited destinations, protecting them from tourism and growing global numbers of tourists. In order to connect tourism mobility and hydrogen in the Camp de Tarragona area there would be a need for hydrogen supplies from the local hydrogen valley, hydrogen infrastructure in the means of hydrogen refuelling stations (HRS), hydrogen transportation services and most importantly as in any successful value chain, stakeholder collaboration. As seen in Fig. 7. in the outer layer, planning, operations, investments, and monitoring play an important role in creating the functional running of the tourism value chain, relying greatly on local stakeholder involvement. As indicated in Fig. 7. functionality of the outer layer has a direct impact on the functionality of the inner layer, all stakeholder partners in the chain play an important role resulting in successful sustainable destinations.

8. Hydrogen as a possible zero emission mobility fuel for Tourism

Hydrogen is a light, versatile gas that can be stored and transported, used alone as a fuel or combined with electricity through fuel cell technologies. Hydrogen is easy to tank, a similar refuelling experience as to putting petrol or diesel in a car, taking approximately 5 minutes for a full tank as opposed to current EV charging times of around 8 hours. Batteries in general contain highly precious elements, lithium for example which is difficult to source and mine. In addition to this, society is creating excessive amounts of old and used batteries which currently in present times are not being recycled or re-used. This is an incredibly large area of further research and developments in this area will have a huge impact on which direction society and technology will go in the future. Hydrogen can be used in existing combustion engines (an advancing process), to make SAF fuel as discussed earlier, or as a fuel supply for hydrogen fuel cell vehicles. Hydrogen does not require overhead electricity infrastructure and is therefore adaptable and versatile, especially for city destinations, or awkward geographical locations in general. Another important feature of hydrogen is that in terms of emissions, hydrogen goes into the vehicle, and the emissions coming out in the end is only water. Some of the current alternatives for hydrogen mobility are explained below.

H2 Planes and airport ground transport

Hydrogen for aviation is still a relatively new topic but one that is rapidly growing in technological advances, developments, and experience. Hydrogen is believed to play an important role in the future of aviation, resulting in a fuel that only emits water and zero CO2 emissions. Considering that aviation, as seen above in the *UNWTO* reports, is a particularly alarming CO2 emitting sector especially relating to tourism growth and tourist flying emissions, advances in this area are strongly desired. In terms of hydrogen powered jet engines, they are not yet operational although they are destined for the future. Global aviation company *Airbus* are designing the world's first zero emission hydrogen powered commercial aircraft set to be in operation by 2035. Future aircrafts will be a mixture of SAF powered engines which are already operational and added to current aircraft fuels, fuel-cell, and hydrogen powered vehicles. In terms of actual hydrogen powered fuel cell planes, smaller aircraft are currently technically more advanced. A 6-seater plane, *Hydrogenius plane* flew for the first time in 2020 using

a hydrogen fuel cell system. *Zeroavia* is a UK/USA company that strongly believes in green sustainable, zero emission flying. Currently focusing on smaller aircraft that could be useful for transferring passengers for short journeys from one airport to another for example, leaving behind zero negative emissions. As opposed to a standard aeroplane, *Zeroavia* planes feature a propeller system which in addition provides limited noise emissions as opposed to standard day aircraft. *AGS Airports* in Aberdeen, Glasgow and Southampton, UK, are currently planning on developing zero emission flights stating that the "development of hydrogen-powered aircraft has the potential to completely revolutionise aviation, and it is becoming an increasingly viable option for regional and short-haul aircraft" (Future Flight 2022).

H2 Trains

Germany is home to the world's first fleet of hydrogen powered passenger trains and has introduced a national *H2goesRail H2 train campaign*. They favour hydrogen trains to electric as they see them as an environmentally friendly alternative with no charging times. `Fast refuelling´ is a very important part of the energy transition as transport companies simply cannot afford to lose time whilst waiting for batteries to recharge (a maintenance that current day batteries require), this being a plus point for hydrogen trains where electrification is difficult to install. Another advantage of hydrogen fuel cell trains is that they ¨have an exceptionally long range of up to 1000 kilometres at a maximum speed of 140km/h between refuelling—ten times farther than battery powered electric trains". (Morgenstern, 2021). Trials are also taking place in other European countries; Austria, Poland, Sweden, and the Netherlands as stated by the H2Train manufacturer *Alstrom* "emission free mobility is one of the most important goals for ensuring a sustainable future" (CNN 2022).

H2 Cruise Ships and ferries

Considerable innovative progressions have been made and are continuing in terms of hydrogen as an alternative fuel for the marine industry. Offering clear advantages against marine diesel spills and pollutants being dumped in the sea. Hydrogen cruise ship manufacturing technology is experiencing exciting developments that are piloted or in operation in several EU destinations. In Norway, *Northern Xplorer* offers tourists hydrogen and electric combined fuelled vessels, creating tourism experiences that are "discovering the world with the least possible footprint while creating sustainable economies" (Northern Xplorer 2023).

One cruise ship company of significance in the hydrogenation of the cruise industry is the Spanish company, *Mediterranean Shipping Company, (MSC). MSC* is a member of the *Hydrogen Council*. In terms of hydrogen mobility, *MSC* hydrogen vessels are in a development process and the focus on using hydrogen as an alternative fuel in their fleet is certainly there. As announced in an *MSC Group* press conference in July 2021 where they met to discuss the building of the ´first oceangoing hydrogen powered cruise ship', "green hydrogen holds great potential to contribute to the decarbonisation of the shipping industry, including cruising, whether in its pure form or as a hydrogen-derived fuel" (MSC 2021).

Passenger ferries are turning to hydrogen as a powerful efficient means to power vessels. Norway's *Norled* is leading the way with the world's first liquid hydrogen powered ferry, a fuel as the company mentions that is usually used to carry out space missions. The ferry can transport 299 passengers and 80 cars between Hjelmeland and Nesvik. "When we know that this ferry will change the story with regard to the use of hydrogen in the maritime industry, we want the design to reflect it. We are therefore pleased that the final design expresses power, innovation, and safety". To produce the

vessel, *Norled* worked in collaboration with several partners "Building the world's first hydrogen holiday requires expertise from different environments" (Norled 2023). In Rotterdam, Netherlands, S*wimH2* has built the world´s first hydrogen powered water taxi*,* able to transport up to 12 passengers*.* As the company comments on their website: "the maritime industry has an enormous emissions footprint. This needs to change to save our planet" (SwimH2, 2023).

H2 buses

Hydrogen buses use hydrogen fuel cells to power them. Depending on the manufacturer and model, they currently have a range of about 500 km on a single tank, as recently seen at the *UITP Transport* Conference in Barcelona where the newest hydrogen buses were presented including the world premiere of the *eCitaro* Fuel Cell bus from *Mercedes Benz*. Refuelling of all hydrogen buses is very fast, and can be completed within minutes, similar to that of fuelling combustion engine vehicles in the past at petrol stations. Aberdeen, London, Birmingham in the UK and Cologne, Germany all have hydrogen buses in operation. Aberdeen was the first city in the world to host a fleet of hydrogen powered double decker buses, operational since 2021. These buses have a typical range of about 300 km and again, can be refuelled fast "our zero emission buses will support our journey to clean air and show our commitment to Aberdeen's path to a cleaner, greener, climate positive city. Each vehicle plays a major role in reducing Aberdeen's carbon footprint by saving 84 tonnes of carbon per year, per bus - which means healthy, happy communities with quiet streets" (First Bus 2023). Hydrogen buses are already in operation in Barcelona.

H2 Rental Cars

At Teesside Airport, Darlington, UK, as part of its Hydrogen transport hub initiative, it offers hydrogen powered fuel cell vehicles for hire at the airport. It works in partnership with the American car rental company *Enterprise* using hydrogen vehicles from *Toyota*, the *Mirai.* H2 cars that can travel around 500 km and charged in a maximum of 5 minutes can be hired by tourists landing at the airport and used for visiting the surrounding area. Tourists can enjoy long range 'hassle free charging' travel that leaves behind zero CO2 carbon footprint emissions throughout their stay. In California USA, an area which is looked upon by hydrogen mobility experts and enthusiasts in Europe due to its rapidly growing hydrogen ecosystem, they also have a car sharing company - *Stratos Share*. All vehicles are powered by hydrogen and therefore only emit water. Cars are available to rent for people arriving at San Bardidino International Airport, Riverside Municipal Airport, at downtown locations and hotel locations within California.

H2 Taxis

Hydrogen taxi fleets are operational and appearing in cities all over the world and in Europe. Paris for example has taxi fleets provided by *Hype* and *Hysecto*. Copenhagen in Denmark has taxis from *Drivr*, and London from *Green Tomato*. Exciting and innovative hydrogen projects are available for tourists and residents to use, transporting them around cities creating zero CO2 emissions. *Green Tomato cars* in London are in addition to their regular services use of transporting Londoners and visitors around the capital city, they are providing H2 vehicles to be used by the emergency services, providing extremely important hydrogen response vehicle mobility.

H2 Motorbikes and scooters (mopeds).

As recently featured as a headline in H2 digital news bulletins, Japanese mobility engineers *Kawasaki, Suzuki, Honda* and *Yamaha* are focussing on hydrogen powered engines for small mobility with the intention of decarbonising society. Scooters (mopeds) are very popular with tourists and are often a favourite to rent, especially in Asian countries. A speedy, economic way to visit a city and with a hydrogen fuel cell scooter, emission free with long zero charge distance possibilities.

Mob-ion, a French company, is aware of the importance of zero emission mobility without losing distance. "An acronym for Très Grands Trajets (Very Long Journeys), the TGT earns its name from that 248-mile (399 km) maximum range" (Ride Apart 2021). Perfect for exploring cities and regions without drivers having to worry about range anxiety which is common at present with electric scooters. In addition to this, the company has realised that not everyone who rides a scooter has a battery charger at home or even the time required to charge a battery. The power comes from hydrogen in canisters, which can be purchased on route from selected suppliers as and when required and simply clipped into place and exchanged. The scooter offers freedom to explore as well as emitting zero CO2 emissions.

H2 bicycles

Hydrogen bikes do not require long charging and are perfect for lengthy journeys and distances with their wide range possibilities. The *FC Pedelec* from *Alpha* can drive 135-150 km depending on the terrain etc and has a charging time of 2 minutes at a hydrogen refuelling station. In the Loire Valley, Les Châteaux à Vélo (The Châteaux by bicycle) offers 400 km of cycle trails especially attractive to tourists. Bicycle circular routes range from around 7 km to 56 km offering a cycling experience for all levels and interests. The route travels between historic Châteaux along idyllic scenic cycling paths and trails giving tourists an opportunity to discover the beauty of the region, with little effort and an abundance of power when travelling on a H2 bicycle. Again, the main advantage is that the rider can do the longest circular route of the region on a single hydrogen application without the cyclist having to worry about refuelling or re-charging as would be the case with a standard e-bicycle. *Pragma* bicycles are expensive to buy but through rental practices they are made economically available as a tourism experience, introducing to tourists a new form of innovative energy, and putting it into practice.

H2 Winter Resort Transport

In Austria, winter tourism is an important area of economic gain as well as sustainable environmental gain, especially in recent years. Hydrogen fuel cell snowmobiles *HySnow* were first introduced at the *FIS World Cup* international skiing event in February 2020. In Alpe d´Huez in the French alps a similar innovative hydrogen venture is taking place powering snow groomers, the heavy-duty machines that prepare the slopes for skiers. In summer when their snow services are not required, the charging facility of the machines can be used to generate other vehicles and provide energy to buildings etc. In addition to this, the region has hydrogen buses prepared for winter terrain and with hydrogen not being affected by cold winter temperatures, all vehicles provided are reliable during extreme low temperatures in winter months.

H2 Trams

Hydrogen trams are in service mainly in Asian cities and provinces in South Korea, China and soon to be in operation in Japan. According to the *Hyundai Rotem Tech* website "one tram can carry as many as three buses and 174 cars. Trams are good for carrying over 3,000 passengers an hour (up to 12,000 passengers) and tend to require less costs when the driving distance increases". As stated earlier regarding H2Trains, hydrogen fuel cell trams also do not require overhead wiring and can be easily installed in complex cities. "The introduction of hydrogen fuel cell trams is expected to improve the mobility in cities, thereby solving the endemic problems of mega cities such as air pollution and traffic congestion". (Hyundai 2023).

There are currently no trams operating to date in Europe, but definite interest. The City of Bath, UK, for example has proposed a pioneer tram project in their city to be run on hydrogen instead of electricity. A tram would be particularly useful for the old historic city as explained by the Bath Area Trams Association: "The overhead wire-free, hydrogen tram would be ideal for Bath. At the moment, Baths' vaults are being damaged by the number of heavy buses in use" (BBC 2020). Infrastructure for electric trams is a costly venture as the entire range of the tram has to be electrified with additional overhead wiring, supplementary to the tram tracks that have to be laid.

An example of a hydrogen Ecosystem connected to tourism mobility.

Green Hysland hydrogen valley in Mallorca is one of very few H2 valleys working directly together with tourism. Mallorca is an island destination most popular for offering sun, sea and sand tourism. In 2022 it attracted 11.44 million tourists. (Europapress 2023). Therefore, in terms of end users, not only the residents benefit from green hydrogen transitional developments but the tourists visiting the destination. "Mallorca first in the world to have Hydrogen powered transport for tourists". (Mallorca Bulletin 2023).

The German multinational travel and tourism company, *TUI* is a partner of the *Green Hysland* project and has been from the early stages, as commented by the CEO of *TUI* Sabastien Ebel "we wish to continue this line of work by a government with which we have collaborated for years to improve tourism" (Majorca Daily Bulletin 2023). An important aspect of *Green Hysland's* success is its collaboration of cross collaboration value chains, connecting hydrogen with tourism for example, a principle that has been present from the beginning of the project. An important partner of the project, *the* energy company *Enagás* and their chairman, Antonio Llardén stated: "Projects such as Green Hysland and its set up in Mallorca demonstrate the importance of coordinating and cooperating to move the decarbonisation process forward. Thanks to consortium, the entire value chain is represented in the project, which ensures both the deployment of infrastructure for the production of green hydrogen and its end-uses" (Recharge 2022). End uses in Mallorca include H2 buses and ground transport within the airport for inbound and outbound passengers as well as transfer buses to and from the airport to accommodation on the island. In addition, a hotel in Palma is supplied with a power system, as well as a municipal building in Lloseta and a hydrogen fuel cell power supply at the Port of Palma Ferry Terminal. Although the project of Green Hysland is still a pilot project in the early stages, it is developing a successful ecosystem of significant size and through its collaboration with local governance and destination stakeholders, it is able to move and develop with the project from the very early stages.

9. Challenges and degrowth awareness of the H2 economy

Hydrogen Refuelling Stations (HRS)

When it comes to refuelling transport, one of the most important factors is the availability and accessibility of fuel. New technologies require infrastructure from the beginning, a growing network offering range coverage to prevent drivers from suffering from range anxiety, the fear of running out of fuel before reaching a destination or refuelling station. Refuelling a hydrogen vehicle relies very much on infrastructure which in the current early implementation stages can certainly pose problems. However, it is an area of development and there is evidence of considerable progression within Europe. Currently in Europe the situation is as described in the HRS map of Europe, Spain is not featured in detail on the map with up-to-date coverage. In fact, it is difficult to find an updated HRS map, especially in the south of Europe, due to lack of updated infrastructure but also lack of facilities compared to the north of Europe. *H2LIVE* is a platform favoured and used by hydrogen mobility drivers. According to *H2LIVE*, Germany is currently the leader in HRS infrastructure with 91 charging stations in operation and a further 18 planned. Spain´s HRS coverage is featured on the *H2Stations* website and is more detailed as seen in Fig. 9 and Fig, 10.

Yellow flags indicate planned HRS locations and the green flags current operational ones. A clear comparison is visible compared to the rest of Europe, there are considerably less flags in Spain, less density of hydrogen infrastructure.

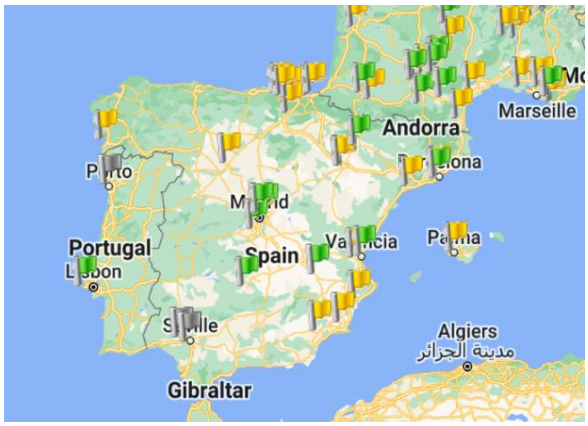


Figure 8. Hydrogen Refuelling Stations Spain H2Stations.

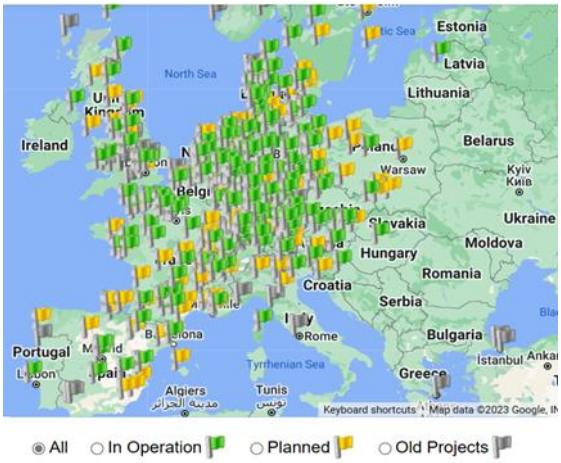


Figure 9. Hydrogen Refuelling Stations Europe H2 Stations.

H2 cost

An official report from the Spanish Government was released in 2020, a strategic plan for the introduction and future plans of incorporating renewable hydrogen into Spanish industry and society, *Hoja de hidrógeno*. The plan is designed to be updated and reviewed every three years; an updated version is awaited. The 2020 report states that one objective will be to promote the competitiveness of renewable hydrogen. "The cost of production is one of the main barriers to the development of projects in the renewable hydrogen value chain. It is especially relevant to identify levers and incentives that make it possible to promote pilot projects and, once their potential has been demonstrated, promote and incentivize the development of technology on a larger scale so that costs

gradually decrease". "There is currently a dearth of tax breaks and economic/environmental incentives to drive the development of renewable hydrogen projects" (Gobierno de España, 2020). There is no doubt that hydrogen prices in Spain are currently high and that the future economic drivers of a hydrogen economy rely on demand.

As described earlier when discussing clusters, clusters in history have shown society that collaboration can have a dramatic effect on functionality, this is strongly the case with hydrogen as an alternative fuel. The more it is implemented, the more stakeholder involvement, the more extreme the price reductions in the future will be.

Sustainable de-growth

As opposed to sustainable development, sustainable degrowth in terms of the hydrogen economy exists, especially in these relatively early stages of an energy transition. There are engineers and scientists who argue that hydrogen is not the answer for the huge emission reducing green transition. Critics question the sustainability of hydrogen for mobility, especially compared to electric, zero emission vehicles, that run solely on electricity and do not require hydrogen. Current challenges are: production and the need for achieving more efficient electrolysers to a high production scale, storage and distribution, a need to investigate on material-based storage systems other than only compression and cooling, and finally the materials for Fuel Cell manufacturing like platinum, nickel and rare earths. FC components are almost as critical as lithium, graphene and cobalt for battery vehicles and require continuous investigation and testing on using more abundant materials. Dr Cebon, a Cambridge University Professor argues the purpose of hydrogen, if we can use electricity. Hydrogen uses vast amounts of electricity to create a chemical reaction and split the hydrogen from water. "Similarly, it takes about 2.6 times more electricity to power a hydrogen fuel cell bus compared to the electricity used for an electric version of the same vehicle". Use green H2 only for the things we can't electrify. The letter argues that developing a green hydrogen industry "is vital — but only for things we can't electrify" (Recharge News 2021).

Again, there is limited academic material written in favour or against hydrogen mobility for tourism. However, in terms of hydrogen for mobility, there appears to be more academic articles and media coverage in favour as opposed to against hydrogen as a green energy source of the future.

10.Hydrogen Safety and regulations within tourist destinations

Hydrogen is a gas that is odourless, it is highly flammable and susceptible to leakage. In the past, one disastrous historical accident occurred, the *Zeppelin* hydrogen passenger airship, the *Hindenburg* caught fire in 1937. Although a considerable amount of time has passed since this tragic event, public awareness of hydrogen being dangerous still exists to this day.

Public awareness is in general low, a lack of education in the current technological developments of hydrogen, including its safety and possibilities for use in society as part of the green energy transition are certainly lacking. It is undoubtable that hydrogen transport methods on the market today have been subject to rigorous safety tests. There is no doubt that technology and therefore safety have advanced miraculously over the past 80 years. In fact, hydrogen safety and monitoring has increased considerably especially in the last 5 years since hydrogen has received a great deal of attention, particularly due to the increase in hydrogen valleys and through various industry handling and innovation. As discussed by Dr Endrius Cocciolo, part of *CEDAT and IU-RESCAT* at the *URV*

Decarbonisation Conference, hydrogen uses for a green transition is a whole new area of research and is currently in a development process. An area of considerable significance concerning hydrogen as an alternative fuel is the fact that every country globally has to comply with individual national regulations. In the European Union, the EU 1994/34 and the EU Regulation number 134 applies to the harmonised policy for safety in explosive atmospheres and FC vehicles construction. However, the rules of application may differ within the EU individual countries. The author personally met the environmental lawyer specialising in public, environmental and urban planning law, Sarah Kellou at the *Hydrogen Mobility Europe* Project Final Conference in Rotterdam and discussed exactly this topic, "green hydrogen is a new sector mixing regulatory challenges and opportunities. As the actual rules are mostly national, especially on security issues, EU law will be essential in the construction of the market." (Kellou 2023).

Specialist working groups throughout Europe, *CEDAT* for example, are currently generating the suitable standards for hydrogen vehicles and destinations. Local law representatives are generally unsure of how to incorporate hydrogen safety regulations into society and require further help and assistance. It is a process, but through collaboration and hands on experience, knowledge of how to approach the subject of safety and regulations of hydrogen is developing.

In neighbouring Aragon, the hydrogen project *Foundation for the development of New Hydrogen Technologies in Aragon* is training its fire brigade as well as other firefighters from Spain about hydrogen technology and safety. The *HyResponder* safety project is funded by the *Fuel Cells and Hydrogen Joint Undertaking (FCH JU) (Clean Hydrogen Partnership)* with the intention of educating firefighters in hydrogen safety and emergency response.

11.Quantitative data analysis

11.1 Camp de Tarragona mobility

Plane

Reus Airport is the only airport located in the Camp de Tarragona region. It is a popular airport with sun sea and sand tourists especially in the summer season with low-cost airline charter flights from mainly the UK, Ireland, and Spain. The airport is a seasonal airport that have the most passengers in the summer months. It is located ca. 13 km away from the city of Tarragona and 3 km outside the city centre of Reus. From Reus Airport, Camp de Tarragona's coastal town of Salou is ca 12 km away, a journey time by car of around 15 minutes.

Planes from the following airline companies fly into Reus Airport: *Jet2, Ryanair, TUI, Sunwing Airlines, TUI Airways, Tyrol Air Ambulance* and *Vista Jet Malta*. According to the database, *Spanish Airport Guide,* In 2022, total of 911,827 passengers flew in and out of Reus Airport, a 482% increase from the covid pandemic lockdown period in 2020/21. The airport is run by *AENA* which is a network of 46 airports mostly in Spain. *Aena* is a public airport and a subsidiary of the Spanish aviation concern *Enaire*.

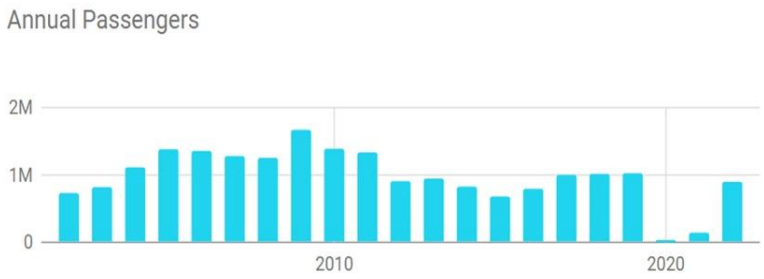


Figure 10. Reus Airport. Airport statistics.

Train

Camp de Tarragona is the name of a high speed *Renfe* train station connecting Tarragona regionally and nationally to Catalonia's capital Barcelona, Spain's capital, Madrid and many other destinations, Lleida and Zaragoza etc.

The station is located outside of the city of Tarragona, about 8km away, connected to the downtown city area by means of road transportation (bus, car or taxi). There are several local regional train stations within the Camp de Tarragona region, as indicated on this map Fig.11.

Figure 11. Camp de Tarragona Train connections.

Boat

Camp de Tarragona has a Port, *Port de Tarragona*. The port is an important strategically located port on the Mediterranean coast and is the second largest port in Catalonia after Barcelona. The port is a busy freight port as well as a cruise port to the city of Tarragona and the region of Camp de Tarragona. Pre covid pandemic passenger numbers in 2019 according to the *Tarragona Cruise Port* (2023) show that *Port de Tarragona* received a total of 128,089 passengers, 96,616 in transit and 31,473 as turnaround passengers. There are currently no ferry services or taxi boat services at the port.

Bus

There are many local bus services running in the Camp de Tarragona region, the main ones: *EMT (Urban Public Transport of Tarragona), Expès.cat, Hife, Izaro, Penedès, Plana* and *Reus Transport Public*. The different companies offer different services to the residents and tourists of the area.

Services include, the transport of passengers from the coastal areas of the region to and from the inland areas as well as servicing various tourist attractions with increased popularity during the summer months, including popular airport and city shuttle services.

Car

According to the *Directrius de planejament urbanístic de l'àmbit metropolità del Camp de Tarragona, El futur del Camp* from the Generalitat de Catalunya (2022) cars are the most popular means of transport in the area outside of the city. In the cities, walking is the favoured way to move around.

11.2 Local data analysis.

According to *FEHT tourism data relating data from l'observatory de Turisme d'Eurecat,* more than 5 million tourists are arriving in Tarragona per year. *INE* (2019) state that more than half of the tourism is local or Spanish tourism, people living in Spain.

As mentioned in Miravet el al. (2021) 40% of tourists choose buses or trains for transportation to the region from other locations, approx. 40% are travelling with their own car or rental car, 20% are arriving by plane to Reus airport and only 3% are using the port of Tarragona, ferry as a mode of transport to the region.

Figure 12. Total Tourist arrivals & Mobility. Author´s creation. Based on Miravet et al (2021).

Based on the work of the local authors; Domènech, Paulino, Miravet, & Gutiérrez (2023) , tourists are also moving around the region during their stay they do not just stay in one location. Fig 13. shows the mobility within the area of Camp de Tarragona, connected to the central pivotal point of the accommodation hub: Cambrils, Salou and Vila Seca.

For this quantitative research, an estimation of the number of kilometres tourists are travelling by various modes of transport each year has been done. The mobility can be split between transportation to and from the accommodation hub and the mobility that occurs during their stay.

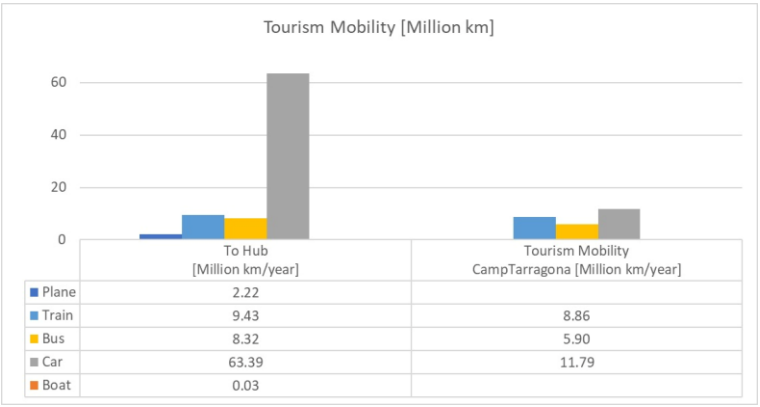
Figure 13. Tourism Mobility. Author's creation. Based on Domènech et al. (2023)

Specific data generated implies limitations. First limitation is the lack of complementary information about the displacement itself. There is no data on the motivation for the trip, frequency, traveller profile or connections with other means of transport. Second limitation is the specific touristic data related to Camp de Tarragona, therefore data from the whole Tarragona region has been taken for evaluation.

The following assumptions and estimations have been taken into consideration:

- Hub is the place of stay, accommodation (hotel, apartment, camp site).
- Tourist arrivals to Camp de Tarragona – a 100km distance is used for emission calculations.
- Tourists arriving by plane & boat are always using public transport to arrive at the hub.
- Flight capacity 100 passengers. Boat capacity 1000 passengers
- Approx. 20% of tourists arriving by car are using the car to visit other sites during their stay.
- Approx. 20% of tourists arriving by other means of transport are using public transportation to visit other sites during their stay.

The figure 14. shows the graph with the approximated km during a year done by the tourists.



	To Hub [Million km/year]	Tourism Mobility CampTarragona [Million km/year]
Plane	2.22	
Train	9.43	8.86
Bus	8.32	5.90
Car	63.39	11.79
Boat	0.03	

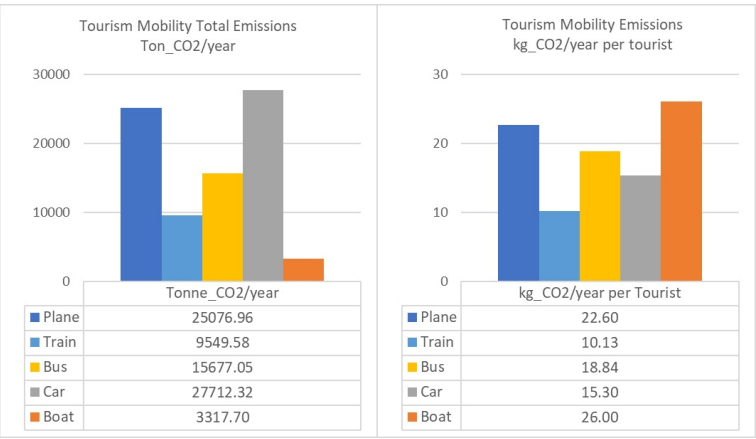
Figure 14. Tourism mobility km/year. Author's creation.

The estimation shows more than 110 million km of tourist transportation a year. Taking into account that boat and planes are transporting many people, we can see that the highest amount of km are done by car, bus and train. With this data, the calculation of CO2 emissions can be estimated in the next section.

11.3 Carbon Footprint of current Camp de Tarragona Transport

With the already estimated number of km a year (150 million km), a quantitative CO2 emission for each mode of transport has been calculated. A carbon footprint estimation for the various modes is taken from published EU and other public websites. Available data from *GoClimate.com (2023)* has been taken as a reference and introduced as a multiplier of factors to the number of kilometres. It is clear that public transportation has different correction factors related to the number of transported people, which also have been considered. Correction factors by number of passengers have been applied according to the published report *El Futur del Camp section 1.3.1 Mobilitat and UK.Gov* "Conversion factors 2019: condensed set" per person as follows: Plane 142gCO2/km, Train 46gCO2/km, Boat 300gCO2/km, Bus 108gCO2/km and Car 80gCO2/km. The assumptions and calculations can be seen in the Appendix. In the next figure we can see the result of estimated CO2 emissions global and per capita.

In total more than 80,000 Tonnes of CO2/year for all touristic transportation sectors in the Camp de Tarragona might be subject for decarbonisation in Camp de Tarragona. According to the *GenCat Catalonia GHG Emissions Cat 2021_v2023*, 1.5 Million Tonnes CO2/year (see table in appendix) are emitted by the transportation sector in the whole Tarragona.



	Tonne_CO2/year
Plane	25076.96
Train	9549.58
Bus	15677.05
Car	27712.32
Boat	3317.70

	kg_CO2/year per Tourist
Plane	22.60
Train	10.13
Bus	18.84
Car	15.30
Boat	26.00

Figure 15. Total tourism CO2 emissions and per capita. Source: Author´s own estimation

The above calculated figures for the tourist mobility in the camp of Tarragona, represent approximately a 5% of the total emissions of the whole transportation sector in Tarragona. Planes and boats need to follow specific targeted decarbonisation plans, especially as the number of tourists are expected to increase. To decarbonise at least 50% of tourism transport by road (including bus, rental car, taxis and a proportion of private cars) and assuming a consumption of 8kg/100km for each mode of transport, an estimated amount of 4000 Tonnes of hydrogen per year will be required.

11.4 Economic analysis of current Camp de Tarragona Transport

The author of this work states that it was impossible to predict the overall costs and benefits of introducing hydrogen mobility to the region in the present day. However, it was possible to simulate data and figures to create a predicted economic view of the future situation. One thing that is certain is that the sector must be decarbonised in the future for environmental reasons.

Economic estimation of Hydrogen Production

From an investment perspective it is important to define the necessary hydrogen production and its cost. The cost of hydrogen production is expected to be reduced considerably with time, years, due to technological maturity and engineering investment.

Planes and boats are following very clear EU policies for sustainable fuel processing guidelines involving hydrogen. These vary depending on sustainable fuel and EU involvement which is changing with sustainable fuel production developments. The advantages for the environment are clear and if the production maturity is reached by 2050 the cost of production might not significantly affect travellers.

As we see in the diagram Fig 16. The production costs of hydrogen will decrease with time, in a mid-level scenario the cost of hydrogen in 2050 will be between 3 and 4 euros per kg.

The road and train transportation sector can be decarbonised using hydrogen produced locally. To calculate the overall cost of hydrogen production we can multiply the required hydrogen amount (4000 Tonnes) per year by the 2050 predicted production costs.

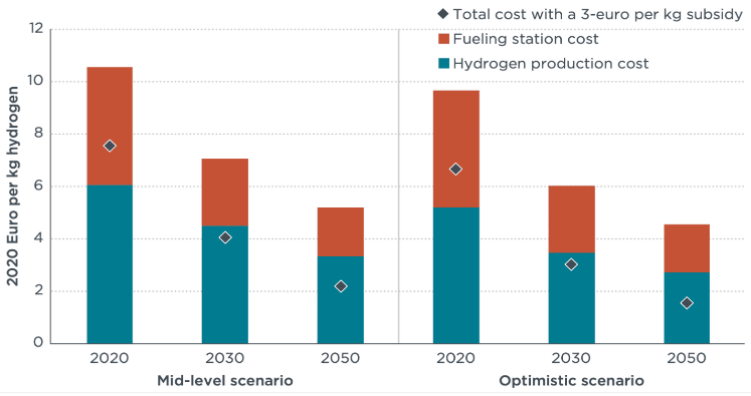


Figure 16. Actual & future costs of hydrogen.

Economical estimation of TCO for Hydrogen Vehicles

The Total Cost of Ownership for Hydrogen vehicles is split into Passenger Cars and Commercial vehicles, and it is applicable to the touristic sector concerning rental cars, taxis and buses.

Looking at this promising scenario for 2030, the maturity of technology for FC, H2 ICE and Battery will be very similar. The choice of sustainable vehicles will be based on efficiency and reliability.

Estimations and assumptions for this graph can be seen in the Appendix.

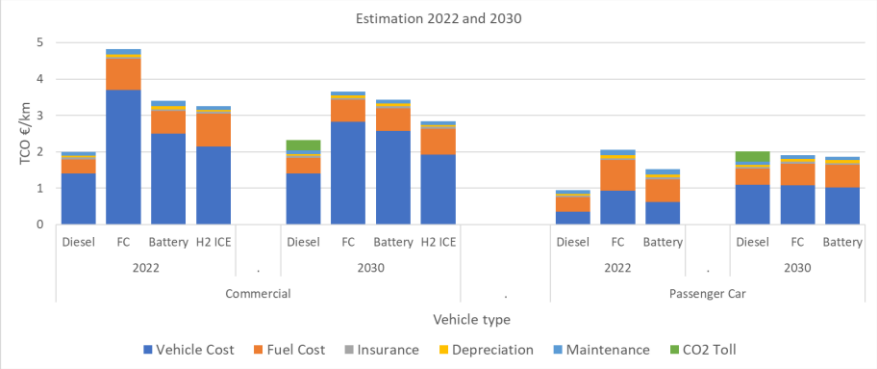


Figure 17. Author´s own estimation based on several internet publications.

Economic estimation of local benefits

The investment in hydrogen will increase the production and technology, which may be applicable not only for the automotive sector but also for use in other domestic applications in all economical areas.

In terms of local benefits and economic boosting of the tourism sector and its transition to hydrogen, a more exhaustive analysis could be based on the Kynesian relations of the four main components: consumption, investment, government purchases, and net exports. The increase in local benefit and demand, would be increased from the evolution in one of these four components. It is important to consider the wide availability of EU funding subsidies currently available especially focussed on a transition to hydrogen. In addition to this the many opportunities for public and private funding.

The model proposed by *URV* professors and members of *IURESCAT,* Maria Llop and Arauzo-Carod in the article "*Economic impact of a new museum on the local economy: "the Gaudí Centre""* (2012) uses the Keynesian income multiplier model. Applying this calculation model may give a more detailed guideline to capture the direct and indirect effects of tourism assets on the local income.

12.Qualitative Research Interviews

A total of ten interviews were carried out featuring interview candidates from leading European hydrogen businesses and associations, hydrogen valleys of Europe, local *H2ValCat* representatives and a sustainability representative of a tourism company connected directly to a hydrogen valley. Each candidate was sent the questions in advance. The interviews were then carried out online or in written form. All featured qualitative interviews focussed indirectly on the research questions and concentrated on the following areas: public awareness of their CO2 footprint when travelling, hydrogen mobility for tourism, purpose of a hydrogen valley in relation to tourism, environmental and economical drivers and barriers a valley can bring to a local destination. For interviews with local representatives of the Hydrogen valley of Catalonia, a focus was also placed on the valley´s collaboration with tourism in the area of Camp de Tarragona.

12.1 Leading hydrogen in Europe representatives

I. Valerie Bouillon-Delporte. Hydrogen Ecosystem Director, Michelin. First Vice President of the French H2 National Association.

Valerie Bouillon-Delporte (VBD) for the purpose of this interview) in addition to her current roles was the former President of *Hydrogen Europe* and chair of *Fuel Cells and Hydrogen Joint Undertaking (FCHJU)* now called - *Clean Hydrogen Partnership*. She is a highly respected expert in European hydrogen circles. Through her hydrogen roles in France, she is not only aware of hydrogen progressions in the world and in Europe but is in addition extremely knowledgeable on hydrogen mobility progressions in France, especially through her above-mentioned high level positions with *Michelin* and the *French H2 National Association*. The interview took place online on Friday 2nd June 2023.

II. Darko Levicar, Director of Transport Policy Hydrogen Europe.

As the Director of transport Policy at *Hydrogen Europe,* Darko Levicar (DL for the purpose of this interview) is responsible for hydrogen mobility and is therefore a leading figure and extremely knowledgeable on current transport policies within Europe. *Hydrogen Europe* is an association with over 470* (mentioned in the interview) members, over 25 EU regions and over 30 National associations. It represents the European hydrogen industry and its stakeholders with the main focus of creating a zero-emission society. Part of Hydrogen Europe's mission is to "bring together diverse industry players, large enterprises and small and medium-sized enterprises, national hydrogen associations, non-governmental organisations, regional public authorities and other relevant organisations which support the delivery of clean hydrogen and fuel cells technologies in line with the vision and mission of Hydrogen Europe" (Hydrogen Europe 2023). The interview took place online on Thursday 25th May 2023.

III. BO Svane Chief Executive Officer DRIVR Hydrogen Taxis

Bo Svane (BS for the purpose of this interview) as the CEO of *Drivr* was heavily involved with introducing hydrogen for mobility operations in Denmark. The company currently has 100 hydrogen taxis in Copenhagen. He has previous experience working for *Toyota* with whom *Drivr* use as a partner for their hydrogen taxi fleets. The interview took place on Tuesday 16th May 2023.

IV. Qualitative interview results

The following questions were the basis for the interviews with the individual members of this target group, each question strongly focussed on the research question key incentives; **1**. How do you see the tourism sector as a partner for supporting the green hydrogen transition in these early stages? **2**. How do your partners engage with the tourism industry and other relevant stakeholders to raise

awareness and foster collaboration on hydrogen mobility initiatives? **3**. What are the main challenges and opportunities for developing hydrogen mobility solutions for tourism destinations? **4**. In your opinion, how aware are people of travelling sustainably? Are sustainable destinations more attractive for tourists and if so, why? **5**. Can you give an example of a hydrogen valley in Europe that is working together to produce a successful hydrogen mobility outcome, successful in terms of economic and environmental benefits?

Figure 18. Quirkos Report Results Leading Hydrogen Europe Representatives.

Common themes from the interviews were coded into 5 categories as seen here in Fig. 18, : collaboration, tourism sector, opportunities, sustainability awareness and successful hydrogen valleys. Opportunities for tourism gave the strongest most weighted results, with 38 comments/themes relating to opportunities for the hydrogen economy and tourism. In general, when asked if the tourism sector is involved and considered in the early stages of a hydrogen mobility transition the answer was no, not directly. However, as seen in the results, this does not mean to say that the tourism sector is isolated and therefore not included in transitional development, quite the contrary, “we are completely open, we are, even so flexible still, even though we have more than 470 members, we are still so flexible that if a certain topic becomes important for our members, we can still open a new working group in which we tackle that specific problem and if, let's say, tourism will be the next big topic, we can tackle it in a separate working group and then link it together” (DL).

The current impression is that all three interviewees indirectly consider the tourism sector as a transition partner in these early stages, this theme was generally continued throughout all of the interviews. “hydrogen mobility is not to be limited to tourist organisations. First, it's getting it out there, no? It's building the infrastructure, making it more popular and then this will sort of come along” (VBD). “Mobility is going to develop by itself. I mean it's not going to develop for tourism differently than it's going to develop for others, but in tourism you have a lot of mass transport” (DL). The opinion of a supplier was “well, that's a tricky question. So we're actually not planning it. But if you think about it, one of the most important customers that we have is the hotel industry” (BS). The tourism sector has parallel requirements to other sectors, tourism is an end user of transport but “you do not create specific vehicle applications just for tourists. When you rent a car, it's a normal car. When you take a train, it's a normal train. When you take a plane, it's a plane. You don't create a specific plan for tourism” (VBD).

Figure 19. Quirkos Report. Common themes Leading Hydrogen Europe representatives.

All comments indirectly consider the tourism sector in the transition, it is not part of the initial planning, not a partner in the early stages, only in rare cases. According to the interviewees, there are very few cases to date where the tourism sector is actively involved in the H2 transition, for example, the *Green Hysland* project in Mallorca, a new concept of a hydrogen ecosystem in Crete was mentioned by DL, and VDB mentioned the H2 cycle hire venture in the Loire region (as mentioned previously in this work).

Green Hysland is described as a "practical example on how a tourist area submits a sort of hydrogen value project in order to benefit from hydrogen to decarbonate its footprint" (VDB). Collaboration was a common topic, especially connected to opportunities, early involvement generally seen as being more productive in the early stages than in the later stages of a project "I know for Crete for example, it's their full commitment together with the government and together with the regional government and they want to build this and they're now getting eyed by many different stakeholders like the cruise ship operators. So, they want to be chipped in, in the project, because once it's built, if you're not there during the creation of this project or this valley, I mean, you are waiting in line. The first one is already there, they are covered" (DL).

Port involvement was a common feature, mentioned many times in terms of collaboration and opportunities, ports are seen as holding great potential for a H2 transition, "the ports are going to be the new energy hubs of Europe. So, energy is going to come in, all the hydrogen being imported from other regions is either going to come in by pipelines or going to come in by ships" (DL). In addition, airports will play an important role in the transition and are already planning for the future, especially the bigger airports for "when the hydrogen planes are coming in, what Airbus is saying after 2035, like the big airports are already thinking and they're allocating space for the hydrogen refuelling of planes…a topic coming maybe a little bit later to the smaller airports" (DL).

An important feature was the price of sustainability, this strongly connected to the research questions of this work, "if you know that there are some destinations which have made more efforts than others in order to offer you less impact when you are spending your holidays on an island, I think that's a very valuable argument for the people who take interest in that. And provided that it doesn't cost a hell of a lot of money, additional money" (VDB). The financial aspect is seen as being important for consumers and has an impact on their behaviour, "so for private customers, they don't care. Frankly, they just want to get from A to B as easy and cheap as possible. That's so boring, but that's the reality". (BS). The current price of hydrogen is high, but with collaboration and promotion, for example, H2

taxis will be a strong practical promotional tool at the *Paris Olympics* games. Early involvement in general is encouraged "the first movers are always taking higher risks. But also, they're getting more out of it" (DL). Even the experts do not know where a hydrogen transition is leading, but again they are all open, open to collaboration and involvement, willing to give this zero emission tool all the support possible in order to provide society alternative modes of transport, a future away from fossil fuels "I mean, it's not a silver bullet, hydrogen, but there are many areas for which it could be used. So you need to find the right application…" (VBD).

12.2 Hydrogen valley representatives of Europe

The following questions were the basis for the interviews with the individual members of this target group, each question strongly focussed on the research question key incentives; **1**. How did you see the tourism sector as a partner for supporting the green hydrogen transition in the early stages of the Teesside Hydrogen Valley*? **2**. How does Innovate UK* and your partners engage with the tourism industry and other relevant stakeholders to raise awareness and foster collaboration on hydrogen mobility initiatives? **3**. What are the main challenges and opportunities for developing hydrogen mobility solutions for tourism destinations in the UK? **4**.In your opinion, how aware are people of travelling sustainably? Are sustainable destinations more attractive for tourists and if so, why? **5**. Can you give an example of a hydrogen valley in Europe (including the UK*) that is working together to produce a successful hydrogen mobility outcome, successful in terms of economic and environmental benefits?

i. Teesside Hydrogen Valley, UK.
Sarah Tennison. Head of Clean Growth Strategy and Impact- Innovate UK

Saran Tennison (ST for the purpose of this interview) established and led the *Teesside collective 2015* and the *Northeast and Yorkshire Net Zero hub*, responsible for the net zero transition of an industrial and high energy using region. Her work has resulted in the forming of a UK prominent hydrogen valley that has realised the uses of hydrogen mobility for the local region of Teesside. Sarah now works for *Innovate UK*, where she is responsible for developing the *UKs Net Zero Strategy*, working with innovation programmes of clean growth with the purpose of maximising impact. The interview took place online on Tuesday 6th June.

ii. Hydrogen Valley Aberdeen, Scotland.
Fiona Landy. Delivery Manager at Hydrogen Accelerator and Scottish cities Alliance.

Fiona Landy (FL for the purpose of this interview) has an abundance of experience leading the *Scottish Cities Alliance Strategy*, 'Kickstarting Hydrogen Economy across Scottish Cities'. She is an expert on the implementation of hydrogen throughout Scotland and therefore has been heavily involved with the implementation of hydrogen buses through the *FCH-JU JIVE/JIVE 2 (Clean Hydrogen Partnership)* funding submissions, resulting in the operation of H2 buses in Aberdeen, Glasgow and Dundee. Through her position at *Hydrogen Accelerator* Fiona Landy is creating a hydrogen ecosystem in St Andrew´s, Scotland. The Interview took place online on Tuesday June 6th June 2023.

iii. Hydrogen Valley Catalonia H2ValCAT

Maria Antonia Santacreu Llovera. Project Portfolio Manager.

Maria Antonia Santacreu Llovera (MSL for the purpose of this interview) is an engineer with considerable experience working in the energy sector. She is managing the portfolio of partners and the general aspects of the tasks that relate and develop the *Hydrogen Valley of Catalonia*, as discussed above. The interview took place on Wednesday 7th June.

iv. Qualitative interview results

Here we see again that opportunities came out as the strongest result connecting hydrogen to tourism. Asked how they see/saw the tourism sector as a partner for their respective hydrogen valleys in the early stages, again a common feature was that it was not directly considered, but indirectly. "So, it's really kind of business models around transport rather than specifically tourism destinations" (ST). Only FL representing Scotland spoke about the direct involvement of tourism through sustainability awareness being important for Scotland, especially considering Scottish environmental interests as a society, something that is taken into consideration when building hydrogen ecosystems in general. "I think in Scotland, it's such a small country, that generally, citizens really get it, so tourists will really get it. The Scots are very proud of their country, so they want to show off to its best" (FL).

Figure 20. Quirkos Report Hydrogen Valley Representatives of Europe.

From the *Hydrogen Valley of Catalonia´s* point of view on mobility and tourism, "we are not that much focussed on tourism. That is a second order of all these mobility applications. That doesn't mean that it's not a second order of magnitude because there are companies like transport companies, like the buses or others and the city councils themselves. So those are some of the members that can be then involved or more directly connected to the tourism sector" (MSL). In relation to Teesside, "I guess when we think about the hydrogen sector in Tees Valley, it was more around a jobs angle rather than a visitor angle. Because I think everything, we were looking at was more industrial application or transport application. It was very much around developing that industrial centre and building on the industrial strengths to provide a national service" (ST). Teesside like *H2ValCat* is an industrial area but it is not so reliant or focussed on tourism as the region of Camp de Tarragona. It does however have the neighbouring Yorkshire Moors and popular UK seaside attractions nearby, for example Redcar with approximately 13 km of sandy beaches.

Figure 21. Quirkos Report Common Themes Hydrogen Valley representatives of Europe.

All three interviews mentioned about the opportunities hydrogen and tourism potentially have and a common topic especially involving airports and ports. Although not a tourism destination directly Teesside does have an airport of a similar size to Reus and it is heavily involved with the local hydrogen valley. It has H2 rental cars at the airport, ground transport and an onsite hydrogen refuelling station HRS. In Scotland, as mentioned before in this work, an H2 innovative company *Zeroavia* are working together with Scottish airports in addition to this there is a keen interest in innovation concepts and concerns interested in connecting the mainline of Scotland to the islands using H2 as a fuel source, zero emission hydrogen transport due to its environmental benefits important for the conservation of the area. One company that is also collaborating in Scotland is the local innovative company *Loganair.* "Airports need to be identifying where they're going to source their sustainable aviation fuel, and in what volumes, and then also how that infrastructure's going to work between different airports as well. So, there's kind of a big international dimension I think when it comes to that" (ST). The importance of marine transport and green ports was a common topic in these interviews and the overall H2 transitional progression. Again, collaboration is important, this bringing many innovative opportunities.

The hydrogen hub of St Andrews is a partner of the *HyseasIII* Port collaboration, focussing on renewable hydrogen energy for the Scottish Isles. Green ports are seen as being a key factor of the future according to FL. In a neighbouring city of Tarragona, Valencia, MSL mentioned the *H2 Ports* project, a pilot project that is connected to EU funding "they have this project in cooperation with the Clean Hydrogen Partnership". A key word connected to all opportunities is funding, EU funding and mentioned by each representative. FL of Scotland talked about her dismay when Scotland left the EU due to Brexit "not just the funding, it's that collaboration. You're bringing European cities together. They've all got the same problems. And in terms of trying to, you know, how do we do this? When you're working with the collective, it makes such a difference because you're bringing hydrogen suppliers, you're bringing bus OEMs, operators, all the people that actually matter are all engaged, they're all there"(FL). In terms of funding "I guess the challenge of hydrogen transport is the need for infrastructure and transport solutions of which, you know, they are more expensive, but potentially funding is available" (ST). EU funding potentially is available for *H2ValCat*, however the situation is currently difficult as "we don't own the project. We are an association of the members. And we might in the future participate more actively in projects, but not as owners, maybe as members of the project that help promote the members". (MSL).

12.3 Hydrogen Valley Catalonia prominent business representatives

The following questions were the basis for the interviews with the individual members of this target group, each question strongly focussed on the research question key incentives; **1**. Diputació de Tarragona* is part of the Hydrogen Valley of Catalonia; how does hydrogen play a part in the present and future plans of the provincial council's Tourist Board*? **2**. How do you see the role of hydrogen mobility in transitioning the future of tourist travel within the area of Camp de Tarragona? **3**. From visitor feedback, how important is sustainable travel for tourists visiting the area, how do you feel they would accept hydrogen mobility? **4**. How do you collaborate and coordinate with other stakeholders and partners of the Hydrogen Valley Catalonia; research institutions, energy providers, transport operators etc*?

i. Marta Ferrero Muñoz. Director of Tourism at Tarragona Provincial Council (Patronat de Tourisme Diputació de Tarragona)

Marta Ferrero Muñoz (MFM for the purpose of this interview) as the Director of Tourism is responsible for promoting the tourist brands of Costa Daurada and Terres de lÉbre. The *Patronat de Tourisme* is an autonomous body of the Provincial Council, that works together with tourism agents in the local area defining a positioning strategy for the Costa Daurada and Terres de l'Ebre destination brands, in relation to the promotion and sales of tourist products at both destinations¨. The interview was carried out in written form.

ii. Gloria Vallcorba Fornesa – Associate Director of Plana. Josep Albert Vallcorba Plana - CEO of Plana

Plana (PLA for the purpose of this interview) is a local family business, led by Josep Albert Vallcorba Plana and Gloria Vallcorba Fornesa. *Plana*, is an important mobility representative of the Camp de Tarragona region used regularly by residents and tourists dispersed throughout the year. Amongst the many transport services provided, the company provides services to and from the local airports of Reus and Barcelona to the accommodation hub. Plana is a partner of the H2ValCat. The interview was carried out in written form.

iii. Carmen Esquius. Generated Gases, H2 for Mobility and Energy Transition Business Development Manager Southern Europe at Carburos Metálicos.

Carmen Esquius (CE for the purpose of this interview) is a chemical engineer working with *Caburos Metálicos and* is particularly involved with their H2 for Mobility and Energy business developments. *Movem Tarragona (We move Tarragona)* is a company campaign initiative promoting sustainability and innovation in the area of Tarragona. In addition to this Carburos Metálicos is the initiator of a hydrogen refuelling station (HRS) that will be strategically located near to the AP-7 motorway and the Mediterranean corridor. The interview was carried out in written form followed by a brief informal telephone conversation.

iv. Qualitative interview results

It is interesting to see that in comparison to the previous interviews, the overall resulting topic and themes are decreasing in numbers from five to three themes, not intentionally. On a local level as seen in Fig. 22. it is encouraging to see is that opportunities still outnumber the other categories and that uncertainly has suddenly become one of the three main themes.

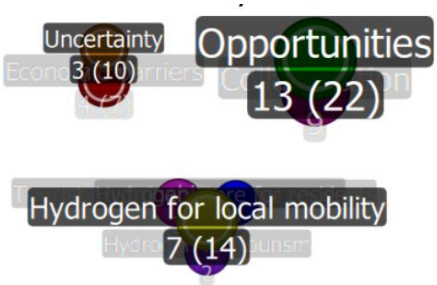


Figure 22. Quirkos Report. H2ValCat prominent business representatives.

Common with all of the previous interviews is the overall opinion of tourism, that it is not currently directly connected to the H2 transition, but the partners as interviewed here are proud partners, and keen to get involved on different levels of involvement. "If Tarragona is the place where the process of transformation of Hydrogen takes place, we can work with them to find the uses for the tourism industry, apart from the mobility; in hotels, aquatics parks or campsites" (MFM). ¨

"At Plana, we are analysing with which public transport services we could start a transition to green hydrogen energy. We believe that a good option to start with would be to carry out express services with this type of vehicle" (PLA). "H2 Valley of Catalonia gives visibility about different projects across Catalonia giving the opportunity to be part of it" (CE).

Figure 23. Quirkos Report. H2ValCat prominent business representatives common themes

Carburos Metálicos are already quite involved with H2 projects concerning mobility as mentioned above. However, for a transport company like *Plana* there are understandably many aspects to consider when facing a complete fleet renewal and a possible transition to H2 mobility, mainly economic barriers therefore uncertainty. We have seen from the previous interviews the availability and importance of funding, "the Public Administration should analyse the partial subsidisation of this model of bus to promote the development of greener public transport services. In this way, public transport operators would not be forced to choose between sustainability and financial stability. In fact, the European Union launched the Next Generation funds, one of the objectives of which is to promote the ecological transition" (PLA).

12.4 Green Hysland Tourism, Mallorca

Arantxa Garcia Lis. Head of Sustainable Development TUI Musement TUI Group. Metropolitan Region of Palma de Mallorca.

Arantxa Garcia Lis through her work at *Tui* is extremely involved with the *Green Hysland* hydrogen ecosystem in Mallorca, a project discussed previously in this work. All quotes in this section are from Arantxa Garcia Lis. *Green Hysland* is directly working together with the tourist sector through their hydrogen collaboration ventures with *TUI. A*ccording to *TUI´s* sustainability page on their website,

Figure 24. Quirkos Report Green Hysland TUI.

they suggest that "we use our scale and influence for the sustainable transformation of travel. Together with our partners we strive to continue to positively contribute to local communities, reduce our environmental footprint and create experiences that are authentic and sustainable" (TUI Group 2023). The interview was carried out in written form.

Unintentionally the thematic categories have reduced to two categories: opportunities and challenges. For *TUI* is it clear to split up the situation into one of the two categories, with challengers for the first time outnumbering the opportunities. As discussed earlier*, Tui* has hands on experience working with hydrogen and tourism, and both connected to a hydrogen ecosystem.

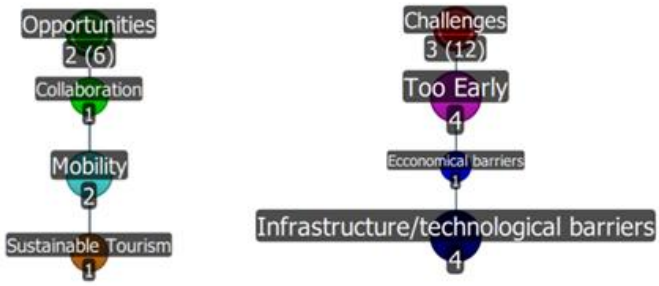


Figure 25. Quirkos Report. Green Hysland TUI Common Themes.

"The main opportunities are the actual development of a Hydrogen plant in Mallorca and the possibility it gives us to use hydrogen as an alternative source of energy for our operations". Collaboration has been an important part of *TUI´*s involvement in the *Green Hysland* as well as early involvement, "at *TUI Group,* we learned about the Hydrogen project in Mallorca in different meetings with the local government and we decided to explore our options to support this initiative. It is all in very early stages, but we believe it is important to show our commitment and support all efforts from destinations to reduce emissions, as that is also an important part of our sustainability agenda".

As mentioned before, there does appear to be some challenges, lack of available vehicles, infrastructure, and costs. As mentioned in this work, current costs connected to new technology; "there are no standard prices in the market yet for vehicles and we need to understand the amounts of hydrogen needed for our operations in order to also calculate the cost of using hydrogen versus other fuel options available in the market". There seems to be an incredible amount of forward planning in orchestrating a pioneering project of this scale, *Green Hysland* is a pioneer in using hydrogen technology for tourism, they are paving the way for others who follow in their tracks, it can only get easier with time.

Figure 26. Quirkos Report. Green Hysland TUI word cloud.

The main challenges currently are "operational and infrastructure challenges as it is a very new area and it has not been trialled before, so we'll need to be learning by doing". "The lack of availability of hydrogen powered vehicles in the market at present, as it is a relatively new technology for ground transport and many alternatives won't be available until summer 24 or even summer 25". All this aside, the project is still in its infancy, but they are extremely committed especially for their clients "we know that our clients like to know about what TUI is doing to reduce our / their footprint and they always ".

Common repeating words as seen in this word cloud Fig. 26. connected to hydrogen are; early, stages, planning, mobility, development, challengers, destinations, cost etc. Again, establishing a new technology is never easy, being the first but as Darko Levicar from Hydrogen Europe says above, "the first movers are always taking higher risks. But also, they're getting more out of it" (DL).

13. Insights, scenarios, and proposals

13.1 Potential of H2 uses for tourism mobility in Camp Tarragona

Camp de Tarragona is the perfect tourism destination featuring a port, an airport, regional and international train services, local and national bus services as well as motorways, main roads and secondary roads. The following hydrogen mobility options could certainly be available to be used in the Camp de Tarragona with the support and infrastructure of a fully functioning hydrogen valley. In this section of the work all the above local, national, and European research analysis is culminated to find economic, environmental and other drivers and barriers for tourism mobility in the area of Camp

de Tarragona. What is feasible economically, environmentally, and otherwise; technically concerning infrastructure and perspectives etc from the perspective of the valley.

H2 Planes and ground transport - Reus Airport

Economic, environmental, and other drivers

As seen in Mallorca, *Green Hysland*, Camp de Tarragona is a tourist destination of equal popularity, if not more that potentially could follow the same model of incorporating end use hydrogen implementation into the tourism value chain, all suggestions resulting in ZERO CO2 emissions being released into the local atmosphere.

Hydrogen has potential at *Reus Airport* for powering ground transport at the airport using hydrogen from the local hydrogen valley. Internal airport guests and luggage transfer vehicles operating within the airport and terminal buildings. Hydrogen could eventually be used for heating, cooling and in the running of the airport. In addition to this, hydrogen to fuel planes could well be introduced and expanded as well as regulated SAF for the aeroplanes landing and taking off from Reus airport. SAF regulations are being introduced as EU airport regulations are required to use 2% of SAF fuels by 2025. The percentage of SAF usage is intended to rise to 70% by 2050, a transition that the airport will eventually have to comply with according to EU current day law. Airbus has introduced a *Hydrogen Hub at Airports* strategic plan leading to 2035. Airbus planes fly into Reus Airport. "We believe hydrogen is one of the most promising decarbonisation technologies for aviation. This is why we consider hydrogen to be an important technology pathway to achieve our ambition of bringing a low-carbon commercial aircraft to market by 2035" (Airbus 2023).

CESDA, the neighbouring aviation school, part of the *URV*, is a member of the *H2ValCat* and a supporter of the hydrogen transition. In an informal conversation with Toni Vallès, Head of PhD research at *CESDA,* the possibility of using *Reus Airport* for a trial pilot hydrogen project was discussed in order to prepare the airport for future global world aviation plans. Such a venture could well be possible if the airport, *CESDA* and *H2ValCat* were able to work together on a proposal for a collaboration with *Airbus*. A partnership could offer funding for the transition of *Reus airport* to prepare it financially and in terms of hydrogen safety regulations and practices for the future hydrogen transition. An additional encouraging driver would be a *Hyport* EU project inclusion application leading to funding and transitional support for airports. Further potential is that the airline *Vueling* is a partner of the H2ValCat and flies in and out of *Reus Airport*.

Economic, environmental, and other barriers

One main barrier to this scenario of move involvement between the H2Val and tourism in the Camp de Tarragona region is that *Reus Airport* is not part of the *H2ValCat*.

Tourism companies are not members of the *H2ValCat,* for example *TUI* with 22 touristic hotels in the accommodation hub and an airline flying into Reus airport. Understandably, *TUI* is not a Catalan business concern, located only in Catalonia, however neither are many other partners of the *Hydrogen Valley of Catalonia: Repsol, Enagás, Messer* and *Vueling* etc*. Reus Airport* is small, they can import 2% of SAF easily responding to 2025 EU Airport SAF regulations.

H2 Train Services - Camp de Tarragona

Economic, environmental, and other drivers

Hydrogen trains are particularly useful and effective for covering areas where electricity lines cannot be constructed, many due to geographical disabilities or even economic barriers.

Spanish rail companies *Renfe* and *Adif* servicing Camp de Tarragona are part of the EU/*Clean Hydrogen Partnership* funded European project - *HCH2RAIL*.

Non-electric train coverage is currently covered by diesel trains as opposed to hydrogen. According to *Renfe´s* website, it is clear to see that they currently favour electric trains but as they suggest, they are ´looking for alternatives´. Rail companies are important for the tourism industry, tourists arriving to, travelling throughout, and departing a destination. If train companies were a part of the *H2ValCat* along with tourism industry sector representatives, interesting partnerships could be established offering economic and financial benefits in the long run as the value chains of the hydrogen transition and the tourism value chains grow together.

Economic, environmental, and other barriers

Both of these rail companies have services in the Camp de Tarragona region; however, they are not part of the Hydrogen Valley.

H2 Cruise Ships - Port Tarragona

Economic, environmental, and other drivers

The *Port of Tarragona* is an important member of *H2ValCat* and now houses the headquarters of the local ecosystem. Cruise ships that run on hydrogen emit ZERO CO2 emissions. With hydrogen fuelled vessels only emitting water this is particularly attractive environmentally and eventually economically as Camp de Tarragona´s sun sea and sand beach tourism beaches will be clean and free from current emitted fossil fuels polluting the beach and the sea, an attractive pull for tourism to the area, preserving local tourism for the future. *Mediterranean Shipping Company (MSC)*, a chartered ferry company sailing into *Port Tarragona* is committed to the decarbonisation of the cruise sector, cruise ships being a significant CO2 carbon footprint emitter. In July 2021 *MSC* explained how they are going to make the transition to hydrogen by "working in partnership with a wide range of ship yards, suppliers, manufacturers and other organisations and investing in different upcoming technologies and solutions for its fleet" (MSC 2021). According to an informal conversation with Jordi Anglés, the Commercial Manager at the *Port of Tarragona*, the Port has an internal working group focussed on its collaboration with *H2ValCat*, they are looking for pilot projects. They currently do not have hydrogen projects planned but are open to ideas. After the damaging effects of the Covid 19 pandemic, the Port is regaining its strength. when this has been accomplished, they plan to instigate more hydrogen uses within the Port facilities.

Although the Port is not actively using hydrogen in its infrastructure or services to date, there is a keen willingness to be involved with the hydrogen transition when the timing is right. The Port is proud of its close connection to the *H2ValCat* and is very focussed on achieving sustainable EU goals and therefore doing whatever it can to head towards zero emission mobility for a sustainable global transition. In the opinion of the researcher a membership of the *Clean Hydrogen Partnership* could

prove to be a beneficial venture for the *Port of Tarragona* as they fund and lead the *H2Ports* programme. This would not only lead to possible funding as a financial driver for many different partners of the *H2ValCat* especially the Port, but for the collaboration and cross border partnership possibilities - *H2Ports*. The EU backed programme which is currently working together with the neighbouring *Port of Valencia*. As heard first hand in the interview with Darko Levicar of *Hydrogen Europe,* that all ports especially will be more involved in the hydrogen transition particularly in the future, hydrogen will be transferred and transported, and the main source of transport will be by boat. There is great potential for the *Port of Tarragona* to work in collaboration with the *Port of Valencia*.

Economic, environmental, and other barriers

In terms of hydrogen infrastructure, EU regulations insist that the *Port of Tarragona* along with other EU ports must have electrification for power - ´on power supply´ (ONP) by 2030, something that the Port is very much focussed on at the moment. The Port is part of the *TEN-T,* Transport network for the EU. As electrification is currently the main focus, they have no hydrogen infrastructure or hydrogen bunkering systems in place to date.

These developments are currently estimated to take hold at a later date, from around 2030 and are especially relevant for the service vessels at the Port rather than for the larger vessels. The *Port of Tarragona* is building a new building, an addition to their current operational cruise terminal. The establishment of this building is important for the future progressions of the Port, hoping to bring in more ferry crossings and passengers and is expected to be more established in the next 2-3 years, by 2026. Collaboration possibilities between the *Port of Tarragona* and the *Port of Valencia* (*H2Ports*) are questionable as discussed informally with Katarina Muse Ivan Petar Yovchev of *Hydrogen Europe*, the *Port of Tarragona* may be seen as a competitor for the H2 transition in the Mediterranean coastal region. This is an unknown area and an area of further investigation but one to contemplate.

H2 buses - Camp de Tarragona

Economic, environmental, and other drivers

Hydrogen buses are being introduced in the city of Tarragona. Following local media reports, 3 hydrogen fuel cell buses from the maker *Caetano* were ordered in May 2022, supported by *EU Next Generation funds.* According to Jordi Fortuny *EMT* (Municipal Company of Public Transport of Tarragona) President “The three hydrogen buses will be electrically motorised and will be between 10 and 12 metres long. These vehicles will enter service to replace three Euro III diesel buses, which are 18 years old” (Diari de Tarragona 2022). In addition to this, local news of additional hydrogen powered buses for Tarragona were announced in September 2022. Again, the *EMT* initiated a tender of service for 35 hydrogen fuel cell buses including maintenance, repair and supply of the fleet. The contract, according to the local newspaper *Diari Més*, has an “estimated contract value of 38,169,600.00 euros and has a maximum expected duration of 14 years” (Diari Mes 2022). As stated in the same article “One of the advantages of this action, apart from the rejuvenation of the fleet, is the decoupling of the operating costs of the service provided by the *EMT* from the evolution of the price of oil and electricity, at the same time that it will represent an important qualitative and quantitative leap in favour of the fight against climate change and air pollution in our city”. In terms of funding, cities around Europe EU funding programmes are available, for example *JIVE, JIVE 2* and *MEHRLIN*, part of

the *Clean Hydrogen Partnership*. *Hife* according to *the H2ValCat* interview are planning to incorporate hydrogen into their bus fleets.

In terms of airport transfer buses, travel companies – *Tui* for example provide return transport from the airport to the accommodation in *Green Hysland* Mallorca. *TUI´*s airline flies into *Reus Airport* and the company has 22 hotels in the accommodation hub destination of Salou. This would be an excellent opportunity for hydrogen tourist transportation to and from the accommodation hub to *Reus Airport* resulting in ZERO CO2 emissions as well as financial benefits as mentioned above with a 'decoupling from oil and gas prices´. Local bus companies, for example *Plana*, run airport transfers to and from the accommodation hub to the airport; they would benefit from the introduction of hydrogen vehicles to their bus fleet. As described in the interview responses, the company is keen to get involved and see many possibilities especially for their express services which service the accommodation hub of the Camp de Tarragona region. An additional area that could be developed in terms of hydrogen mobility and maritime tourism is a shuttle bus connection connecting the cruise terminal to the city.

Economic, environmental, and other barriers

As *EMT* are making positive developments and changes, *Plana Bus* for example, as featured in this work, are contemplating on change. They are members of the *H2ValCat*, are keen to get involved but are hindered mainly due to concerns of economic costs for the operator and the user. There is a lack of funding support to help local companies, especially partners of the *H2ValCat*. As suggested in the interview, a lack of public administration guidance. Barcelona received *JIVE* funding that was used to fund their recent fleet of hydrogen buses, active in the city since April 2022. *H2ValCat* is not a partner of the *Clean Hydrogen Partnership*, initiator of the *JIVE* funding schemes. Regarding port transfer buses, current bus services at the *Port of Tarragona* are run by several local bus companies and therefore the Port is unable to instigate this even though the will for hydrogen buses is there.

H2 Rental Cars - Camp de Tarragona

Economic, environmental, and other drivers

Buying a fleet of cars is cheaper than for individuals to buy single passenger cars. Important is the accessibility to new technologies enabling a faster, effective hydrogen mobility economy transition, building and expanding infrastructure for hydrogen mobility.

As found at Teesside Airport, UK with the hydrogen rental car venture from *Enterprise Car Rentals* and *Toyota*. Hydrogen powered fuel cell vehicles have potential for the area of Tarragona and could be an opportunity for Reus airport and the tourist board to provide ZERO CO2 emission H2 mobility for visitors not only transferring to the accommodation hub but visiting the area of Camp de Tarragona. A partnership with a hydrogen vehicle rental company would support the funding of such an innovative project. *Toyota* for example is a partner of *H2ValCat.*

Economic, environmental, and other barriers

H2 refuelling infrastructure throughout the region - current lack of HRS.

H2 Taxis - Camp de Tarragona

Economic, environmental, and other drivers

As quoted by Executive Director of the *Clean Hydrogen Partnership*, Bart Biebuyck, "Hydrogen is the ideal fuel for taxis because of the long-range, intensive use and short recharging time," (Euroactiv, 2022). Taxis in the Camp of Tarragona region are mainly run on diesel fuel emitting CO2. Hydrogen taxis would emit ZERO CO2 emissions and emit only water. Several hydrogen taxi companies and initiatives are operating all over Europe as mentioned in this work, offering inspiration and knowledge on fleet transition. Companies are looking for cities to pilot hydrogen taxi innovative ventures. As heard first hand from the hydrogen taxi company Drivr in this work, they are looking for possible cities to introduce a fleet of 100 taxis and that they are very interested in expanding to the Spanish market. As suggested, there are several taxi companies looking to expand including Spanish concerns. Some companies supply the fleet and the HRS infrastructure. *Drivr* taxis are connected to the *Clean Hydrogen partnership* in terms of advice, initiation, and funding. *Toyota*, (a partner of *H2Val*Cat) provide *Toyota Mirai* hydrogen vehicles to many taxi concerns (other car manufacturers and vehicle models however are available). Possible partnerships with existing Camp de Tarragona taxi companies resulting in fleet renewal and sustainable vehicle marketing (H2 taxis driving around the city etc), would improve the image of Camp de Tarragona as a sustainable destination for residents and people visiting the area.

Economic, environmental, and other barriers

The size of Tarragona as a city, if it can warrant 100 taxis. Existing Tarragona taxi companies would not benefit from outside taxi companies coming into the region and taking their business.

Other barriers are hydrogen infrastructure, vehicle availability and current costs of hydrogen.

H2 flight taxis – Camp de Tarragona

Economic, environmental, and other drivers

A novel idea that could be attractive to residents and tourists visiting the area. *CESDA Aviation School* is supportive of innovative ideas. A partnership with *CESDA* could be implemented as flight taxis are small aircraft, offering training opportunities and education to *CESDA* pilots.

Quick transfers to national airports, useful for business people visiting the area of which there are many, especially connected to the energy industry of the region. Possible sponsorship available from local business concerns. Environmentally friendly aviation transport producing ZERO CO2 emissions for the local region. This would be a novel start-up business opportunity for a local business.

Economic, environmental, and other barriers

The technology is not advanced enough to make this a regular feature of the area. Lack of H2 infrastructure at *Reus Airport* and *CESDA*. Current cost and availability of the vehicles and hydrogen.

Hydrogen Motorbikes and scooters - Camp de Tarragona

Economic, environmental, and other drivers

Scooter rental services (mopeds) could be offered to residents and tourists providing a convenient long-distance mode of regional transport. Economic drivers when buying fleets rather than individual vehicles. Again, a novel idea for the area, especially useful for tourist dispersion throughout the region, benefiting other tourist destinations particularly inland destinations where parking etc. is difficult due to the availability of land for adequate parking spaces. *Yego* electric scooters are available in many European cities, including Barcelona. A similar venture but with hydrogen scooters in the *H2ValCat* would be a novel start-up business opportunity for a local business or for a business similar to *Yego* looking to move into hydrogen mobility. *Yego* scooters are currently only available to use in specific areas of inner cities, restricted areas, not outside of the city. This is mainly due to their battery power distance range. With a hydrogen scooter the entire region of Camp de Tarragona could be explored without the tourist having to worry about range with a distance of up to 400km as opposed to maximum 100km on an electric scooter travelling at 45kmh.

Economic, environmental, and other barriers

Lack of HRS infrastructure and cost of vehicles and hydrogen.

H2 bicycles - Camp de Tarragona

A local city development is that the city of Reus is going to introduce *Ganxeta* electric rental bikes into the city's infrastructure starting in October 2023. In terms of sustainability and zero emission transport this is positive move for the city of Reus. However, an electric bicycle infrastructure has been chosen as opposed to a hydrogen energy source within the region of *H2ValCat*.

Economic, environmental, and other drivers

Xavier Delclòs Alio, a specialist in local mobility conducted a survey and one of the topics was to find out how long people ideally like to travel on a manual bike. In an informal online meeting between this author and Xavier Delclós Alio, local mobility and the survey results were discussed. The results apparently suggested that for a journey time of over 30 minutes, survey participants prefer to use an electric bike. Electric bikes are an excellent invention, especially for inner city travel in cities like Tarragona which has many steep hills. However, electric bikes need to be charged for long periods of time, depending on the terrain, temperature, and the weight of the rider. Hydrogen bikes on the other hand do not require long charging times and are perfect for long distances. The *FC Pedelec* from *Alpha* compared the charging time and capacity of a conventional Li-ion electric e-bike (360Wh battery) with their hydrogen bicycle, that can travel 150 km as opposed to 50km and charges in 2 minutes as opposed to 210 minutes (Pragma 2023). A tourist with a hydrogen bike could travel extensive distances throughout the region visiting the neighbouring towns of Reus and Tarragona from the accommodation hub as well as being able to travel inland towards the wine region of Priorat a destination that encourages tourism, has limited public transport and parking, a return journey that would not be possible on a single charge. Hydrogen fuel cell technology allows the easy functionality of ascending hilly regional terrain, something that electric bicycles do not allow.

An inter municipality Camp de Tarragona connection would economically benefit other destinations within the region, dispersing tourists from the accommodation hub throughout the region. A

hydrogen bicycle route would be a zero-emission tourist attraction as seen and mentioned in this work regarding H2 bicycle rental in the Lóire Valley of France. Neighbouring Terres de l`Ebre, offers a manual or electric bicycle route, Via Verde (Green Trail) and is a tourist attraction for the region that has won many sustainable tourism awards. A possibility would be to join and expand bicycle routes creating an extended inter regional tourist experience, one where tourists would benefit from the distance capacities of H2 bicycles. Such a venture would be possible through stakeholder and partner support of the *H2ValCat*, in addition to it being an opportunity for a local start-up company. An extension, inter municipal and inter regional bike infrastructure would create sustainable destinations and attract sustainable eco-friendly tourism by preserving the region as well as benefiting the local residents. There is currently an increased interest in the positive aspects and popularity of cycling as a trend, something that is becoming more appealing and popular to tourists around the world.

Economic, environmental, and other barriers

Camp de Tarragona is a vast area with limited bicycle infrastructure connecting the cities and the entire region, an area where car travel is still the favoured choice of mobility for travelling out of the cities. Without a functional regional bike infrastructure, inter municipal or inter regional cycling options are not possible. Hydrogen infrastructure and current costs of hydrogen.

H2 Trams - Camp de Tarragona

An important progression to mention regarding future mobility within the area of Camp de Tarragona is the recently proposed tram project, *CampTram*. Fig 27. A tram line connecting the region with 47 stations and 46 km of track. The project will run on electricity and be operated and maintained by the 48-million-euro tenders, Catalonian train company *Ferrocarrils de la Generalitat de Catalunya (FGC)*. It will connect Cambrils to Tarragona, servicing Vila Seca and Reus. According to the local operator *ATM, Camp de Tarragona public transport,* it will transport 9.5 million passengers a year. President Aragonès, the President of the Generalitat commented that "The Camp de Tarragona tram represents a before and after of public transport and a real improvement in sustainable mobility" (ATM, 2023). There is no doubt that after analysing local mobility data, especially Camp de Tarragona documentation that proves that the car is the most favoured form of transport out of the cities, an additional transport service is required to transport passengers more frequently throughout the region of Camp de Tarragona, and that this proposed version is a good environmentally sustainable mobility solution for the area.

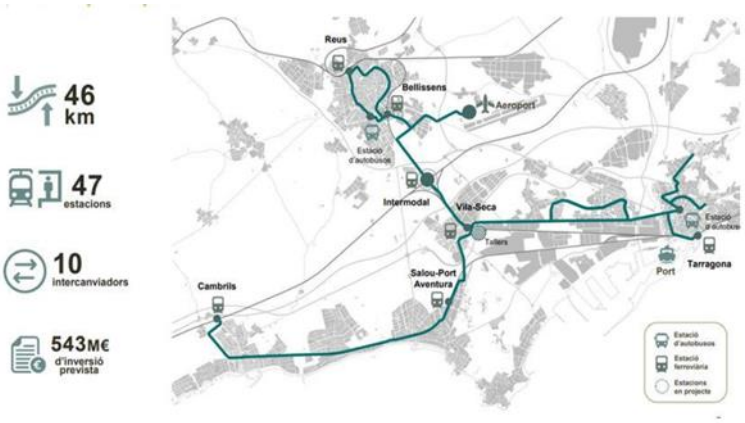


Figure 27. TramCamp Project proposal.

However, the question resulting from this research is the choice of an electrified tram over a hydrogen tram project. A H2 tram operating system would also be a viable option, especially considering that the tram lines would run directly through the *Hydrogen Valley of Catalonia* where several of its partners are located.

Economic, environmental, and other drivers

A hydrogen tram in the long run will be more economical for the region, especially when building the infrastructure which would not require overhead electricity lines and could reuse, where present, old existing tracks and result in placing additional tracks which would even be possible in awkward geographical locations. The service would run on local hydrogen of *H2ValCat*, not only supporting the growth economically and environmentally of the H2 Valley but also of the entire region. It would be able to run for more hours, in all weathers covering all terrains and would not require the use of surges of electricity from the regional electricity grid which could well occur if everything, all of the services become electrified in all cities. There are numerous funding opportunities currently available from the European Union especially for the implementation of hydrogen mobility. An innovative hydrogen project of this innovative competence within an existing hydrogen valley would gain attention on a European level, would benefit the local area and most probably be awarded financial support from the numerous EU mobility funding schemes available, aiding the implementation, service and maintenance stages of the venture. As stated above, the investment costs for the current proposed *CampTram* are 543 million euros. According to Bath UK who have made a proposal for a hydrogen tram to be installed in the city, the Bath Area Trams Association stated that "early analysis claims a kilometre of track could be built for £7m rate, a fraction of the £25m needed for conventional heavy trams, although there would be significant sums on top for legal, engineering and planning work" (BBC 2020). A further area of research would be to calculate the *CampTram* project costs based on an electric infrastructure, power and service and compare it to a hydrogen run tram service in a hydrogen valley. Considering that old existing railway lines for example between Salou and Cambrils could be re-used and would not need electric overhead wiring as mentioned above.

Economic, environmental, and other barriers

Legal Costs and knowledge. Hydrogen infrastructure and current costs of hydrogen.

H2 Infrastructure - Camp de Tarragona

For all the above to function, hydrogen mobility as discussed previously in this work requires infrastructure. The number of HRS locations in Spain is limited but it is growing due to exciting and innovative projects. In Camp de Tarragona as part of their *Movem Tarragona* mobility campaign to promote sustainable mobility and innovation within the region, *Carburos Metálicos* is building the first public HRS in Tarragona at the entrance to the Riu Clar industrial estate. It is currently in the building phase and after a recent update from the interviewee Carmen Esquius, it is set to open next year in 2024. The location of the public HRS is near to the main road A-27 and the motorway AP-7, built strategically in order to connect to other mobility infrastructure locations within the region ¨the port of Tarragona and the Mediterranean corridor will be key to promoting the transport of passengers and goods by road by means of hydrogen (H2) throughout the region. In addition to being of renewable origin, the H2 dispensed will be produced in Tarragona¨ (Carburos Metálicos 2022).

End uses create demand; demand leads to expansion. If mobility as mentioned above is implemented within the region there will be a considerable need of HRS expansion, aided by the functionality of *H2ValCat.*

13.2 EU Funding possibilities

The *Clean Hydrogen Partnership* is the main EU funding body for Hydrogen Valley initiatives. They are connected and manage many other funding and collaboration projects as discussed in this work; *JIVE Buses, H2Ports etc*. Members and affiliates benefit from pivotal EU hydrogen collaboration with other hydrogen valleys etc. national and cross boarder hydrogen partners. This also leads to an inclusion on all internet portals etc., HRS websites and key networking platforms. In addition to this there is the *RE Power EU*, this is a separate funding project but again connected to the *Clean Hydrogen Partnership*. The possibility of funding from the *ETS Innovation* fund was discussed with Katarina Muse and Ivan Petar Yovchev of *Hydrogen Europe*, and the *European Development Fund. Next Generation Funds* are available in Camp de Tarragona, the distribution of these is a case of further research, they generally react to demand depending on the various sectors.

Calls for funding are relatively spontaneous, a dedicated team is required to keep on top of the calls, to apply when possible and to provide the appropriate documentation. The interviewees suggested that this is not an easy task as the applications especially for EU funding are rigorous as mentioned by Sarah Tennison and Fiona Landy, however, as we have seen and spoken to hydrogen valley representatives that have benefitted from them, funding is available, and applications are granted.

The more sectors joining together, the more opportunities for funding on all levels are available, funding that can then be collaborated and added to form a budget of various means, equipment, materials, application end users etc, not just one sector within a H2Val.

14.Conclusions

An encouraging fact is that change is happening, and that the world is dramatically moving away from fossil fuels, turning to alternative fuels and yes, hydrogen is one of them. In general, as a result of this research and in answer to the first research question, it is clear to see that tourists are aware of their CO2 footprint but that the travelling society in general is not prepared to change its habits. Price wins over sustainability as heard on many occasions. If it is possible to travel sustainable at the same price, then the interest of destination preservation is interesting for tourists. Hydrogen Valleys are capable of improving a destination´s reputation which in the long run, if the price of hydrogen is reduced through collaboration, could make a difference as to where a tourist decides to travel. The future of tourism could well be dependent on which holiday is more sustainable and the best value for money. The world of tourism in the future should not be a reason for tourists to stop travelling.

Following on with the second research question, there are many ways in which green hydrogen is being instigated into mobility, many modes of transport are adapting to hydrogen as an alternative fuel, hydrogen mobility is more technically advanced now than ever before. Hydrogen engineers, innovative companies and associates are embracing the change, working hard to push for a sustainable transition, one that requires end uses to create demand. Without end uses the transition will not move forward, and will stay in a somewhat stagnant position, not developing into the huge

potential that hydrogen mobility has for the future of mobility and therefore for the future of tourism. Tourism can potentially use all the H2 modes of transport mentioned in this writing. In some cases, as shown, tourism is connecting with H2 mobility through the use of H2 buses and taxis for example in cities. Such ventures have an impact on tourism, not directly in most cases but as a positive side effect with considerable potential.

In Mallorca it is clear to see how the hydrogen valley is being used for tourism mobility purposes giving a perfect example for research question number 3. *Green Hysland* is a pioneer in this field, yet they stand alone. The project however even in its early stages proves that hydrogen valleys have the potential to connect to tourism. A successful hydrogen value chain from a H2 valley, supplies the tourism sector with power from its end uses. As seen in Mallorca, tourism as a sector is welcome, even in the beginning, they were encouraged to get involved. A successful hydrogen valley is a collaboration of partners from all different sectors joining together, pushing for one goal. A hydrogen valley is an ecosystem that grows stronger through regional involvement.

Locally in the *Hydrogen Valley of Catalonia*, hydrogen and tourism are not connected. The potential to do so is there but it has not yet been directly considered, even though it is welcome as a common feature of all H2 transitional ventures. The fourth research question was based on local H2 uses and economical and environmental barriers. The interviews gave first hand evidence that local partners of the valley showed uncertainty, with their main concern connected to economic barriers. It is evident to see that there is a lack of funding and guidance*, H2ValCat* partners of the valley are unsure how to react and so they wait for advice and support which is lacking. A transition to H2 mobility is extremely costly and for companies for example, *Plana*, impossible without financial support. They mention the need for guidance and support of the public administration. There are many silent partners in the Hydrogen valley of Catalonia or in terms of tourism, very few representatives if at all. *H2ValCat* is an association, it is not able to push for funding in its current status. Funding would be available to them, but it would require considerable dedication to obtain it and they would need to change the umbrella system identity of the association that they are currently working under in order to make the H2ValCat a legal entity. This currently serves as an economical barrier but one that could be adapted and changed in the future. In response to environmental barriers, a change to green hydrogen within the valley would drastically reduce the CO2 emissions for the region.

In response to the fifth research question, the *Hydrogen Valley of Catalonia* could potentially offer the tourism sector an abundance of benefits but currently this is blocked. As Marta Farrero Muñoz of the local tourist board suggested in her interview, they are not directly involved with the valley even though they have many collaborative ideas, encouraging ways to make hydrogen part of the region and a feature for tourists. This work has shown the important role that tourism plays in the region of Camp de Tarragona, an extremely important economic and environmental one, as shown in the number of annual tourist arrivals. Transport hubs are a vital part of the transition and therefore should ideally be part of the hydrogen valley from the early stages. Airports and Ports are pivotal for change, have a huge impact on the local society and on tourists, providing them with services during their stay. It may not be evident now but as seen in this work, the aviation and marine industries will be heavily involved in using or transporting hydrogen in the not-so-distant future. An inclusion and active role within a hydrogen valley is significant from the very early stages, especially in supporting other partners of the valley, learning, and growing together. The author understands that there are doubts concerning hydrogen as an alternative fuel and that it is not solely considered as being the green transition answer. As Valerie Bouillon-Delporte said in this work, “it's not a silver bullet, hydrogen, but there are many areas for which it could be used. So you need to find the right application”. This

author has made it very clear how important it is for the tourism sector to look and find green transitional solutions, hydrogen is exactly this, an alternative fuel that can potentially decarbonise a growing CO2 emitting sector and a provider of many different applications of various forms and sizes. As we have witnessed from this writing, a green H2 transition will not just happen alone, it needs support from all levels, including direct involvement from the tourism sector. We have heard that transport generally evolves currently with or without the tourism sector, but again the hydrogen value chain hinges on end user demand.

On a local level and something that could eventually benefit the tourism sector through additional educational impact on *H2ValCat*; is the increased involvement of the *URV*. It is evident that the university is an important partner of *H2ValCat* and is heavily involved even offering a master´s course on the topic of hydrogen. Science, technology, and engineering departments of the *URV*´s are represented and connected to the hydrogen valley but what about tourism? The *URV* has a prominent Tourism and Geography department with masters and PhD courses on offer. In this work, the importance of dissemination has been shown, education is vital in finding solutions and building awareness. There is great potential for other faculties to be more involved with the hydrogen valley especially from a tourism approach. Maybe students have the innovative solution and ideas as to how to promote and introduce H2 into the local regional value chain.

Following the objectives of this work, extreme measures of approach from the tourism sector are required to curb growing tourism emission predictions of the future. In the interviews all participants talked about opportunities of which there are many. We are all in this together, in the words of Bo Svane, Drivr who completely believes in the future of hydrogen as he adds more taxis to the city of Copenhagen and is looking for possible further destinations, “go big or go home”! The experts interviewed in this work are unable to predict the future, but they can create possibilities by building associates and societies to join all levels and interest of the hydrogen transition together. As learnt in this research, collaboration creates opportunities, regionally and beyond border possibilities. A scale up of hydrogen involvement on all levels of the hydrogen value chain in undoubtably required and visible as a result of this research. An early and dedicated involvement is required from all business sectors, this has the ability to create change, leading to an increase in H2 production and therefore a decrease in price beneficial to mobility, especially tourist mobility emitting zero CO2 emissions. We need to act together, not wait for others to make the first move. Hydrogen could well be the answer to aid the future of tourism, to allow people to continue to travel without economic and environmental barriers, to help the planet, preserving it for future generations. Options are limited, we should at least give the available ones the best chance possible. In the words of Federico Paravicini, Fuel Cell Business Manager, *Toyota Motor Europe*, at the close of his presentation speech at the *Hydrogen Europe Conference in May 2023* “we are all facing a giant swimming pool, who jumps first? We all need to jump together, synchronised”!

Figure 28. Swimming Pool Motivation.

15. Future research needs and opportunities

Considering that the EU has a strong hydrogen strategy planned, and the importance and urgency of alternative fuels for travel in the future, further research into how existing research frames are working with the tourism sector would be an interesting topic to investigate. Ways in which tourism could be more involved in the transition, especially through the aid of EU funded projects for example the *Horizon EU 2030*, *Connecting Europe Facility for Transport (CEF-T)* and *the European Regional Development Fund (ERDF)*. The author is very interested in issues related to climate change and global warming; the above-mentioned funds support the same principles.

In this work a focus was given to the end uses and value chains, considering that the hydrogen used for tourism is green. Further research is to differentiate the hydrogen origins, regional hydrogen production studies within hydrogen valleys enabling a more exact picture particularly through personal interest of how environmentally friendly a transition to green hydrogen is - well to wheel. Regional, national, and European electrification methods in connection to the environment. Just how green is the energy that we use and how this can be improved to protect the planet, improving the tourist appeal, and protecting destinations.

Further research is to investigate how the tourism sector collaborates with hydrogen valleys to find ways in which tourism and hydrogen collaboration can be accelerated in the future. There is a void of literature relating to hydrogen valleys and tourism and therefore an opportunity for further research.

Detailed research into the green hydrogen transition in Catalonia. It is underway, using regional produced renewable energy sources or green hydrogen locally or it is transported from other Catalonian locations, Arragon, Zaragosa for example. Desalination projects are also in place, innovative projects using sea water electrolysis to make renewable green hydrogen, further research into the blue economy.

Circular, local tourism economies connected to green hydrogen. Ways in which all aspects of the value chain can be used, no waste resulting in protection of the planet, sustainable tourism.

The situation is constantly changing, more up to date academic writing is required. Further research into the technological and practical uses of hydrogen mobility, feasibility and connecting this to the tourism sector.

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Annex

All documents from the annex can be found in the following link:

https://drive.google.com/drive/folders/1JYJc7Bg_1YF638bqcekxpUNjcCB7n70F?usp=drive_li