HyLAW - Hydrogen Law and removal of legal barriers to the deployment of fuel cells and hydrogen applications

UK National Policy Paper

Main Author(s): Dennis Hayter

Status: Final – December 2018
Dissemination level: Public

The HyLAW project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 737977. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research

Grant Agreement No 737977

Acknowledgments, Disclaimer

Acknowledgments

The HyLAW project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 737977. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

Disclaimer

Despite the care that has been taken while preparing this document, the following disclaimer applies: The information in this document is provided as is and no guarantee or warranty is given that the information is fit for any particular purpose. The FCH JU and the European Union are not liable for any use that may be made of the information contained herein. The user thereof employs the information at his/her sole risk and liability.

The author acknowledges the invaluable assistance of the Scottish Hydrogen and Fuel Cell Association, the UK Hydrogen & Fuel Cell Association and the Greater London Authority – Hydrogen London, for the UK specific aspects of the HyLaw programme data collection and collation. The author, however, remains responsible for all errors and omissions within this National Policy Paper.

Contents

HyLaw UK National Policy Paper

Contents **Page**

Introduction

Purpose

Under the HyLaw project each project partner is due to prepare a National Policy Paper setting out the key findings of relevance to the recent and current regulatory framework applicable to fuel cell and hydrogen applications and the extent to which legal barriers have constrained their deployment and commercialization – at a national level. Further updates are due to be made to the National Policy Paper on at least an annual basis through to 2021, in conjunction with updates to the HyLaw database.

HyLaw Methodology

HyLaw stands for Hydrogen Law and removal of legal barriers to the deployment of fuel cells and hydrogen applications. It is a flagship project aimed at boosting the market uptake of hydrogen and fuel cell technologies providing market developers with a clear view of the applicable regulations whilst calling the attention of policy makers on legal barriers to be removed.

The project brings together 23 partners including 18 Member States from Austria, Belgium, Bulgaria, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, Norway, Poland, Romania, Spain, Sweden, Portugal, the Netherlands and United Kingdom. The project is coordinated by Hydrogen Europe: see https://hydrogeneurope.eu/

The HyLaw partners have through extensive research, interviews and legal analysis identified the key legislation and regulations relevant to fuel cell and hydrogen applications and legal barriers to their commercialization.

Introduction

HyLaw Methodology - coverage

Eight main application areas covered under the HyLaw programme. These included:

- **Production of hydrogen -** at both Centralised and Localised levels, via Electrolysis, Steam-Methane reforming, and H2 liquification)
- **Hydrogen storage-** as a pressurised gas / liquified / or via metal hydride storage
- **Transport and distribution of hydrogen -** covering road transport in cylinders and tube trailers of bulk hydrogen gas / metal hydride stored hydrogen and liquified hydrogen
- **Hydrogen as a fuel** – as used in refueling infrastructure for mobility purposes
- **Vehicles** – for mobility / transport activities with cars, buses and trucks; and with motorcycles, quadricycles, and bicycles; Marine 'vehicles' **/** vessels **-** boats and ships
- **Electricity grid issues -** for electrolysers, for connection the electrolyser to the e-grid and electrolysers in 'Power to Gas' functions
- **Gas grid issues –** at both the DSO and TSO transmission network level
- **Stationary power** – small scale stationary fuel cells

In the planning of, and during the early project stages, additional application areas were considered, including large scale stationary fuel cells, rail, material handling equipment, aircraft (manned and UAVs), underground hydrogen storage, hydrogen pipelines, H2 usage in industry (such as steel making), and co-processing of renewable hydrogen in refineries for production of conventional fuels. However, time and resource limitations prevented detailed assessment of these areas and should be covered in a future project.

Introduction

Each of the eight application areas set out above included multiple Legal and Administrative Processes (LAPs) as sub-categories and each with further questions relating to those LAPs, along with details of the relevant and applicable European Regulations and Directives, and National laws and regulations (whether based on the transposition of European Regulations and Directives or passed into law by national government).

All such detail forms part of the **HyLaw on-line database** which provides individual and multi country comparative data by application, by LAP, and by severity of the barrier: see https://www.hylaw.eu/database

A further publicly available deliverable is D4.1 – Cross Country Comparison: Analysis of Differences and Commonalities between Countries. This is the main analytical report of the HyLaw project and provides a systematic, cross-country analysis of the legal and administrative processes (LAPs) in all partner countries. By comparing the situations reported on a country by country basis the report considers whether each legal and administrative processes under the scope of the Hylaw project can be considered to be a barrier and to investigate the primary causes creating the barrier.

Recommendations to key stakeholders, including: local and regional authorities, Member States administrations, The European Commission, and international organisations, as well as industry players, were developed and are presented within the D4.1 report.

Details of the EU regulations and directives that impinge on the eight Applications covered are set out in Deliverable D4.4, which is also available on-line: D4.4 EU regulations and directives which impact the deployment of FCH technologies

For details please see https://www.hylaw.eu/info-centre

Conclusions & Recommendations

UK Hydrogen and Fuel Cell Status

The UK has been an 'early mover' in the fields of fundamental research, component and system development, production, manufacturing and deployment and use of hydrogen and fuel cell technologies (HFC) across multiple portable, transport and stationery power applications.

Indeed, the UK can lay claim to creating the scientific foundation to subsequent HFC activities via the pioneering work of Sir William Grove, who in 1842 developed the first fuel cell, also referred to as a 'hydrogen battery'. The UK now has an established and growing industry based on and around HFC technologies utilised in a spectrum of applications running in the UK, and increasingly supplied for use on a global basis.

But use of H2 as a fuel puts the HFC sector in the context of utilising a legally classified hazardous product which is dangerous to transport (Category 1 'Extremely Flammable Gas' dangerous / hazardous product), dangerous to store (above 5barg) and dangerous to decant / fuel / refuel – or in the case of Power to Gas, to inject and blend into a gas stream.

Inevitably, and not unreasonably, regulatory frameworks have considered HFC activities as a category to be treated as a high risk concern. However, when coupled with a degree of uncertainty or misconception as to the exact nature of the hazards involved in generating, storing, transporting and using hydrogen, legal and administrative controls and limitations have been imposed to the extent that have been unreasonable and constraining.

The HyLaw approach was framed to identify and assess the wider legal and administrative framework and for HFC activities, to highlight legal and administrative actions that have been unreasonable and constraining and provide recommendations to ameliorate and remove those actions which are, or which may increasingly become, barriers to HFC deployment.

Conclusions & Recommendations

Conclusions and Recommendations

Hydrogen production:

- At the high volume centralised scale where the majority of hydrogen is consumed on site or by adjacent industrial activities there are no legal and administrative concerns and no recommendations for regulatory amendment made.
- With an increasing demand for hydrogen for distributed HFC activities then increased 'localised' production would be expected. The local production format may vary but is expected to be electrolyser based – for H2 supply to mobile refuelers; depot based H2 cylinder replenishment and distribution; or other forms of local H2 supply. UK land use planning permission and related production site regulatory arrangements are aligned with large scale production and there is no 'simplified process' for low volume production and storage
- A 'Blue Book' approach provides a possible template for developing guidelines for assessing, in particular, localised hydrogen production in the regulatory context of local planning and safety related control frameworks to facilitate increased demand for hydrogen production
- The regulatory anomaly whereby production of hydrogen at any scale in Scotland is considered as an Industrial Activity and thereby regulated by Pollution Prevention and Control Regulations (PPC), should be addressed to provide a common UK wide approach

Hydrogen storage:

- From a legal and administrative perspective hydrogen storage is considered as chemical storage of flammable and dangerous (industrial) gases. Permitting for hydrogen storage is partly related to the type of storage and storage volume (and may fall under Hazardous Substance regime at 2 tonnes or under the COMAH Directive at 5 tonnes)

Conclusions & Recommendations

Conclusions and Recommendations

Hydrogen storage:

- A more widespread acknowledgement and understanding of hydrogen use, as a fuel – not an industrial gas, for multiple applications would aide recognition of the supply chain involved in hydrogen production, storage and supply activities; a virtual ‘hydrogen office’ that supported the deployment of hydrogen fuel infrastructure could make a substantive difference in addressing current barriers
- The ‘Blue Book’ approach would be equally applicable as a template in the context of local planning and safety related control frameworks to facilitate local hydrogen storage

Transport and distribution of hydrogen:

- Overall, the provisions for transport of dangerous goods by road are standardised in ADR and implemented across the EU through harmonised transposition of Directive 2008/68. Hydrogen is treated as for other flammable gases and no recommendations for change of the existing legal and administrative framework is made. Equally, no change is proposed to the requirements covering construction, testing, type approval and certification of hydrogen transportation equipment
- However, the standards for compressed hydrogen receptacles have been developed for a relatively small market volumes and short delivery distances. New materials and production technologies are available for increasing the capacities of the cylinders and tubes, improving the payload of hydrogen trailers and allowing hydrogen delivery at larger scales. Therefore, the existing standards need to be revised and adapted. This also applies to smaller portable cylinders and supply / distribution to dispersed customers. In particular, the complexity and requirements for vehicle and H2 storage equipment adherence under ADR is a barrier as the threshold at which full ADR compliance is required is relatively low and should be addressed

Conclusions & Recommendations

Conclusions and Recommendations

Hydrogen as a fuel

- Hydrogen was recognised in the UK as a transport fuel in 2016 – covering hydrogen used both with a fuel cell and for combustion in a dual fuel vehicle
- There is currently no common definition of green (or renewable) hydrogen as an alternative fuel. It is recommended that the UK support adoption of a **Guarantee of Origin** (GoO) system for green (renewable) and low carbon hydrogen should be established at EU level (e.g. via the CertifHy project)
- A GoO certification of hydrogen should include the carbon intensity and other relevant parameters (e.g. renewable origin) as for electricity in order to encourage the production and use of hydrogen from low carbon and/or renewable processes. Also, the renewable origin of the hydrogen should be transferrable independently of the molecules to which it relates (subject to reasonable conditions pertaining to mass balance and avoidance of double-counting)
- The Addendum to the code of practice "Design, construction, modification, maintenance and decommissioning of filling stations" (The Blue Book) to enable co-location of hydrogen refueling stations with petrol facilities: Energy Institute – 2017 has been of fundamental advantage to the sector and has been used also as a benchmark for non co-located HRS facilities. It is a potential template for developing guidelines covering other regulatory, planning, safety and control frameworks
- Mobile refueling offers strategic refueling benefits in supporting HFC deployment generally (including NRMM and stationary power systems). An assessment should be made as to whether cost effective technical solutions are available to avoid current regulatory barriers to greater use of mobile refueling

Conclusions & Recommendations

Conclusions and Recommendations

Vehicles:

- There are no substantive UK issues regarding type approval for cars, truck and buses. Regulations have been implemented for L category motorcycles, tricycles and quadricycles and these specifically apply to the type approval of hydrogen combustion and hydrogen fuel cell vehicles – but there is very limited experience with deployment of L category vehicles (just the Suzuki Burgman in the UK) so underlying issues may not yet have arisen
- A clear and unified set of rules for service and inspection companies working with FCEV and hydrogen powered vehicles is needed for both sets of cars, truck and buses and L category motorcycles, tricycles and quadricycle
- There is uncertainty on the part of vehicle operators and car park owners/tunnel authorities as to the regulations for hydrogen powered vehicles in tunnels and in using car parks. A 'Blue Book' approach is recommended for setting out a coherent basis (in the regulatory context of local planning and safety related control frameworks) for allowing hydrogen powered vehicles to use car parks and tunnels nationally
- The Hylaw recommendations for the Marine sector, for which the UK could participate as such vessels are proposed for operation in UK waters, include the development of rules for type approval of Hydrogen and Hydrogen Fuel Cells vessels; the clarification of rules for the landing and bunkering of hydrogen; and the development of operation and maintenance of HFC vessels

Conclusions & Recommendations

Conclusions and Recommendations

Electricity grid issues

- The connection of an electrolyser to the e-grid is not an issue for the UK. However the current UK and EU legal framework has no provision for P2G systems under either e-grid or gas grid common rules for grid and market access (along with transmission, distribution, and supply arrangements) and there is no coherent regulatory approach to P2G systems in place
- To ensure wider utilization of electrolysers and PtG plant in the provision of ancillary services he operational framework and technical capabilities (and merits) need to be harmonized and framed to meet all applicable EC regulatory frameworks. This should similarly be framed for the UK

Gas grid issues

- The UK has been a leader in evaluation of decarbonising grids/heat – alongside initiatives to validate gas grid operation with significantly higher hydrogen thresholds being trialed in DE, FR, I & NL. But there is no apparent coherence as to how these are being configured and if/how common technical, safety and regulatory issues are being addressed to define a wider ‘safe and practical basis’ for adoption across the EU. This should be a priority to ensure a ‘level playing field’ for P2G deployment and avoidance of local barriers to P2G services
- There is no formal, clear and coherent payment framework in place in the UK and across Partner MSs for hydrogen transmission, covering connection fees and charges, or covering remuneration for hydrogen supplied/injected. While no pricing principles are in place for otherwise regulated gas networks to provide a level of clarity on valorization of hydrogen rich gas flows (up to and beyond the current highest limit of 10%vol H2), then P2G systems have a limited business case justification and may not proceed beyond demonstration projects

Conclusions & Recommendations

Conclusions and Recommendations

Gas grid issues

- Arrangements for bio-gas that have recently been established and cover real time measurement, monitoring and reporting arrangements may provide a template for a carry-across to hydrogen / H2NG mixtures and should be considered for amendment and adoption by regulators
- A coordinated **EU wide review of the safety and technical integrity limitations for hydroge**n connection and injection into the gas grid needs to be linked with a review of the current regulatory framework shaping gas grid operations and pathways to enhanced hydrogen utilization
- There is no clear position on the threshold at which end-user appliance design and individual component changes will need to be made at different hydrogen concentration levels and varying legal code strategies could be applied. The Hy4Heat programme includes this coverage and the outcomes of this aspect of the programme would assist other gas network operators and safety bodies in making appropriate regulatory modification

Stationary power

- An overarching support policy is crucial for the large-scale deployment of the FC micro-CHP systems. Only Germany has put in place an extensive support mechanism for FC micro-CHP systems. Financial incentives for high-efficiency cogeneration plus funding for the purchase of stationary fuel cells up to 5 kW has been implemented. There is only limited experience of FC micro-CHP system deployment in the UK

Conclusions & Recommendations

Conclusions and Recommendations

Stationary power

- Wider HyLaw recommendations that have applicability for the UK include
  - Recognition of fuel cell micro-CHP systems as one of the key technologies able to deliver greenhouse gas emission reductions, energy savings, integration of renewable energy sources and smart grid solutions (the UK RHI – FIT scheme provided partial coverage)
  - Simplified grid connection procedures and guaranteed access to the grid for electricity produced from high-efficiency micro-CHP systems, as well as supportive measures for the produced electricity
  - FC micro CHP systems should be accepted as an eligible technology in the national public procurement rules for purchase of products with high-efficiency performance in the government buildings.

Application 1: Hydrogen Production at a centralised or local level (via Steam-Methane Reforming, Electrolysis, and with/without H2 liquification)

Image courtesy Air Liquide – centralised
SMR plant supplying 2200 tonnes H2 pa (primarily for supply to an adjacent polymer plant)

Image courtesy Linde – H2 'local' production from wind farm to hydrogen including on-site storage

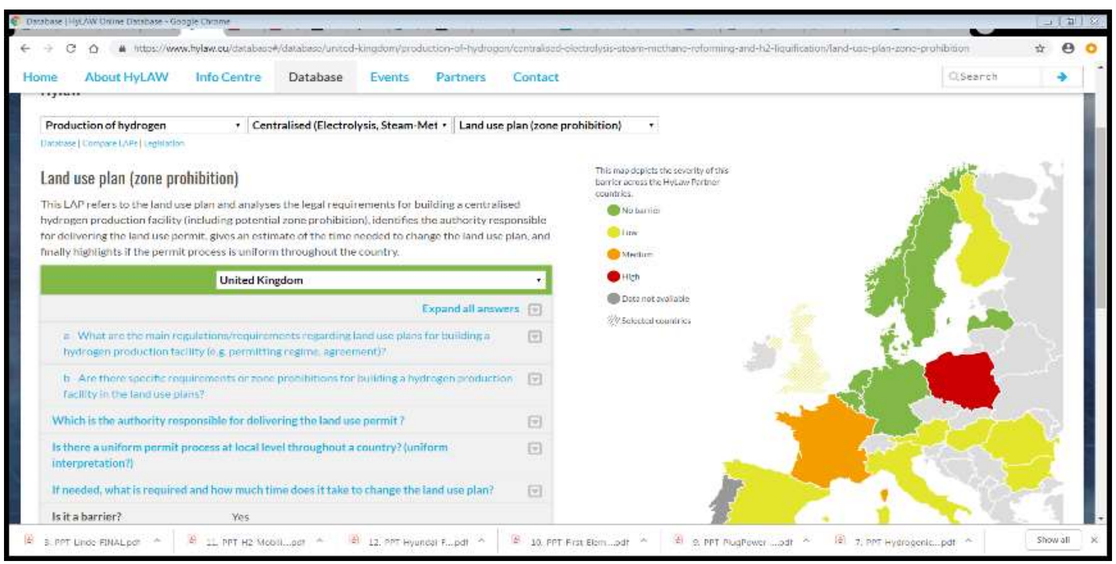
Hydrogen Production - centralised

Assessment – Centralised hydrogen production

- Around 55 million tonnes of hydrogen is produced globally each year; the majority (~94%) of which is produced for on-site or adjacent consumption as a feedstock for refining and petro-chemical processing, for fertilizer production and industrial purposes (see Hydrogen Scaling Up – Hydrogen Council, November 2017). SMR production at 'centralized' industrial sites with natural gas as the base input is the most typical production method
- A similar proportion of hydrogen is generated via SMR and utilised on site for feedstock and industrial purposes in the UK, with relatively little hydrogen being transported and utilised away from central production sites
- Hydrogen production at a high volume centralized site is classified as an industrial activity and any new development is subject to formal (industrial) land use planning approval and site permitting (typically requiring an Environment Impact Assessment) under the Town & Country Planning Act for England & Wales (and Town and Country Planning (Scotland) Act, 2006)
- The production of Hydrogen is impacted at EU level by three legislative acts:
  - the SEVESO Directive,
  - the ATEX Directive
  - Directive 2010/75/EU on industrial emissions.
- These acts have been transposed into UK law and set significant obligations on plant design and on operators involved in the production of hydrogen, as well as on the equipment (and manufacturers thereof) used in the hydrogen production process

Hydrogen Production - centralised

- Further, subject to the quantity of hydrogen storage on a production site then:
  - at >2 tonnes the Planning Hazardous Substances regime comes into effect, and
  - at >5 tonnes the Control of Major Accident Hazards (COMAH) 2015 regulations come into effect
- From the HyLaw assessment of centralized production for the UK, the scale of the activity and recognition of the industrial site preparation and potentially hazardous activity involved, has shown that there is no fundamental concern with the current regulatory framework and its applicability for large scale, centralized hydrogen production
- However, it is noted that the time and resources involved in the planning and permitting process for centralised production can be extensive and that this represents an operational / economic barrier to new production capacity development



HyLaw database – showing comparative position across partner member states indicating centralised H2 production as not being unduly problematic, except for Poland

Hydrogen Production - localised

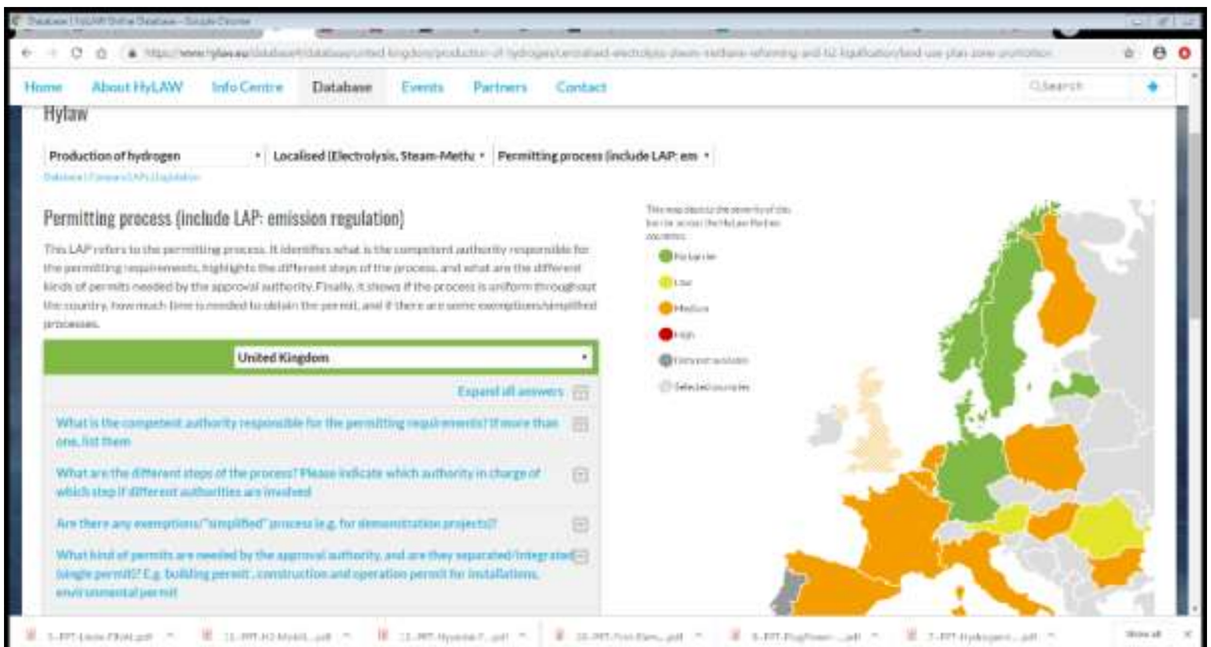
Assessment – localised hydrogen production

- To date there has been only limited 'localised' hydrogen production and local hydrogen distribution, although there have been exceptions based on technology validation and demonstration projects (e.g. Scotland and the BIG HIT Orkney's project)
- However, the demand for local hydrogen production is expected to increase significantly to support 'local' demand for mobility, stationary and mobile (NRMM) applications. The localised hydrogen production format may vary but is expected to be electrolyser based – for H2 supply to mobile refuelers; depot based H2 cylinder replenishment and distribution; or other forms of local H2 supply
- There is a challenge for localised hydrogen production though, in that land use planning (and associated zoning limitations or exclusions) do not generally distinguish between hydrogen production methods. Large scale industrial production pathways and smaller scale production via electrolysis face similar planning restrictions
- Zone prohibitions and administrative practice should recognise that hydrogen production can take place in different ways. Given that some methods (electrolysis) have little environmental impact and generate little to no emissions, they could be treated differently from a land use planning perspective.
- Thus it is important that legal and administrative procedures recognise the differences and distinguish between the various methods, allowing planning authorities to leverage and potentially incentivise production of hydrogen through relatively safe, low environmental impact methods
- While lower H2 production and related storage volumes would ease (or remove) some aspects of Hazardous Substances and COMAH regulation compliance and permitting, there is no 'simplified process' for low volume production and storage - it is relative to the site and site specific / operational safety risks.

Hydrogen Production - localised

Assessment – localised hydrogen production

- However the production of hydrogen at any scale in Scotland is considered as an Industrial Activity, regulated by Pollution Prevention and Control Regulations (PPC), the Scottish transcription to implement the requirements of the EU Industrial Emissions Directive (IED, which adds time and cost to the permitting process (taking several months and costing £30k to £50k with ongoing reporting requirements)
- As there is no simplified process and the National land use planning and regulatory framework must be followed this can be prohibitive to smaller scale localised H2 generation projects with the implication that a widespread deployment of small scale generation sites will not happen easily due to planning and consent risks



HyLaw database – showing comparative position across partner member states for localised H2 production and permitting processes with most partners indicating a medium level of severity in achieving permitting (Sweden, Norway, Denmark, Latvia and Germany reporting no barrier to permitting

Hydrogen Production - localised

Recommendations – localised hydrogen production

- The absence of simplified processes for small quantity localised H2 production leads to restrictive procedures which may discourage investment in local, distributed, hydrogen production
- Guidelines for mandatory permitting steps prior to and during the development stage, with reference to EU directives that need to be applied when a hydrogen production unit is installed are essential. This form of guideline document should differentiate between hydrogen production methods (SMR, electrolysis, gasification, waste H2 gas, etc.) in order to highlight their differences and applicability at the proposed scale of operation
- The relative success of the 'Blue Book' (https://publishing.energyinst.org/topics/petroleum-product-storage-and-distribution/filling-stations/guidance-on-hydrogen-delivery-systems-for-refuelling-of-motor-vehicles as produced by the Association for Petroleum and Explosives Administration (APEA), British Compressed Gases Association (BCGA) and the Service station panel of the Energy Institute (EI)) in setting out a coherent basis for Hydrogen Refueling Stations (HRS) design, development and operation in the UK provides a possible template for developing guidelines for assessing, in particular, localised hydrogen production in the regulatory context of local planning and safety related control frameworks to facilitate increased demand for hydrogen production

Application 2: Hydrogen storage- as a pressurised gas / liquified / or via metal hydride storage

Image courtesy Air Liquide – industrial gaseous hydrogen storage

Image courtesy Linde – H2 storage pre-distribution

Hydrogen Storage

Assessment – Hydrogen Storage

- Hydrogen storage has typically taken place only in conjunction with hydrogen production – as a temporary stage between output and transfer/delivery to a direct usage / process activity, or prior to onward distribution; or in conjunction with a user in temporary storage and intending to drawdown the hydrogen over time
- Hydrogen storage in tanks / cylinders in vehicles is not covered under this HyLaw application (see instead under application 3 (hydrogen transport and distribution) or application 5 (Vehicles)). This application is specific to site land use planning and permitting where hydrogen storage occurs. There is no liquid hydrogen storage in the UK at this time (although liquid hydrogen is transported to the UK from Rotterdam for supply to the Tower Gateway bus depot near Stratford, East London, which is converted to gaseous hydrogen for on-site storage)
- From a legal and administrative perspective hydrogen storage is considered as chemical storage of flammable and dangerous gases and land use plans often relegate such activities to industrial zones, in accordance with the view that hydrogen is an industrial gas
- UK regulations and permitting is partly related to the storage volume (and therefore may fall under Hazardous Substance regime at 2 tonnes, or under the COMAH Directive at 5 tonnes), and partly based on the type of storage – whether storage cylinders are classified as pressure vessels and in which case the Pressure Equipment Directive (PED) (2014/68/EU) applies to the design, manufacture and conformity assessment of stationary pressure equipment with a maximum allowable pressure greater than 0,5 bar, as transposed into UK law and became effective on 19 July 2016. PED compliance would therefore be a requisite for site permitting
- From a land use perspective the hydrogen storage site has to be within an appropriate zone (not impinging on any residential zones) and land use approval is dependent on demonstrating compliance with all design and use requirements, and safety requirements and separation distances, for potentially hazardous flammable / explosive industrial gasses

Hydrogen storage

Assessment – Hydrogen Storage

- For large scale hydrogen production sites internal safety distances / separation distance between production and storage is required to mitigate the effect of a foreseeable incident and incident escalation; this is similarly required in principle for small scale hydrogen storage purposes

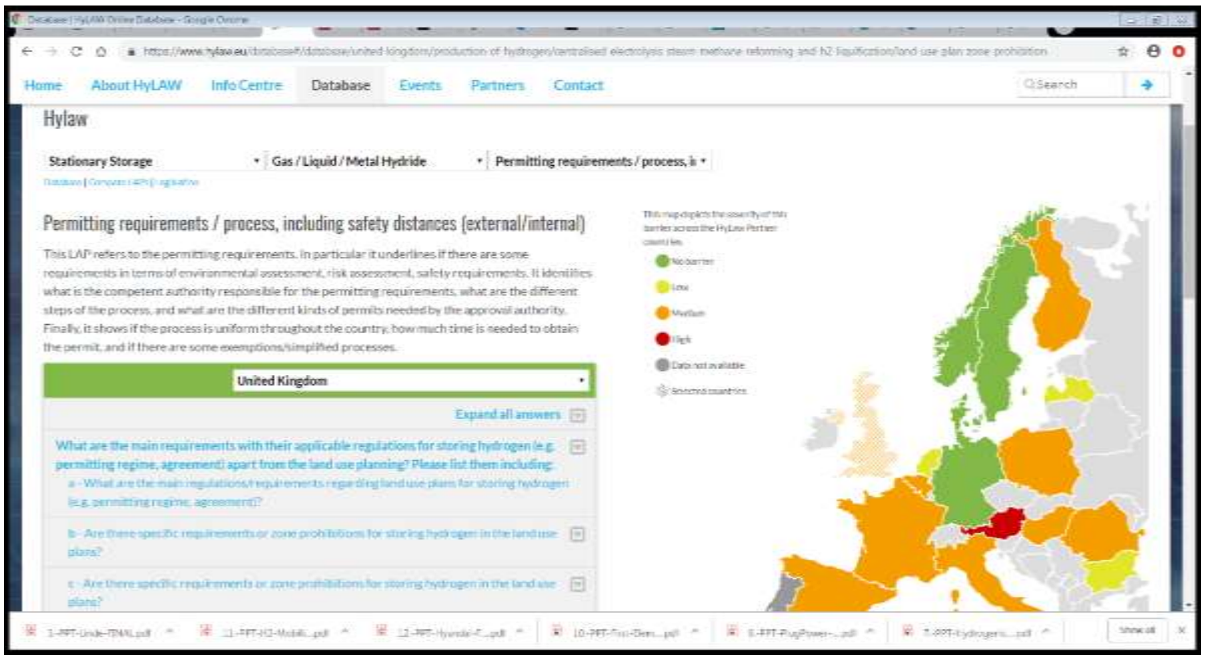
Recommendations – Hydrogen Storage

- With the increased use of hydrogen in various commercial applications (e.g. as a fuel, sold in hydrogen refueling stations or consumed by micro-CHP's and other applications such as gensets and NRMM), the storage of hydrogen should be possible in all areas where the application consuming hydrogen can be located
- Subjecting hydrogen storage to risk assessments, in accordance with the SEVESO and ATEX Directive is in line with the purpose and intention of these acts
- However, the application of the EIA and SEA Directives and other environmental permitting can result in a disproportionate administrative burden on projects intended to bring hydrogen applications to market.
- In addition, the process itself (involving several permits, provided by different authorities, and requiring undue time and effort) imposes economic costs on operators and can delay commercial deployment
- The permitting processes for the storage of hydrogen should be simplified and streamlined. – whenever possible (e.g. Risk assessment, Health and Safety, etc.) and the provision of such assessments should be integrated with a view to minimising duplication of effort and administrative procedures, but still maintaining a high level of safety and environmental protection
- In this context the 'Blue Book' approach (already implemented for HRS applications), recommended for setting out a coherent basis for localised hydrogen production (for application area 1 above), would be equally applicable in the regulatory context of local planning and safety related control frameworks to facilitate localised hydrogen storage

Hydrogen storage

Recommendations – Hydrogen Storage

- Ideally, the storage needs of hydrogen applications will require hydrogen storage outside industrial zones and the UK regulatory framework should be adapted accordingly
- A more widespread acknowledgement and understanding of hydrogen use, as a fuel, for multiple applications would aide recognition of the supply chain involved in hydrogen production, storage and supply activities; a virtual ‘hydrogen office’ that supported the deployment of hydrogen fuel infrastructure could make a substantive difference in addressing current barriers



HyLaw database – showing comparative position across partner member states for hydrogen storage, with most partners indicating a medium level of severity in achieving permitting (Sweden, Norway, Denmark and Germany reporting no fundamental barriers, but Austria indicating a significant barrier

Application 3: **Transport and distribution of hydrogen -** covering road transport in cylinders and tube trailers of bulk hydrogen gas / metal hydride stored hydrogen and liquified hydrogen

Image courtesy Air Liquide – pressurised gaseous hydrogen tube trailer for transport

Image courtesy BOC & Intelligent Energy – gaseous hydrogen tube trailer for transport and on-site supply

Image courtesy Air Liquide – pressurised gaseous hydrogen cylinder storage for distribution

Hydrogen transport and distribution

Assessment – transport and distribution of hydrogen

- Hydrogen stored under pressure (above 5 barg) is legally classified as dangerous to transport and is included in the list of dangerous goods (Category 1 'Extremely Flammable Gas' H220, or as a compressed gas 'May Explode if Heated') in Annex A to the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)
- Dangerous goods are those substances and articles the transport of which by road is prohibited by, or authorized only in certain circumstances by, Annexes A and B to the ADR
- 'Transport' means any road transport operation performed by a vehicle on the territory of at least two ADR Contracting Parties, within, or between, the territories of EU Member States, including the activity of loading and unloading of dangerous goods, covered by Annexes A and B; and 'Vehicle' means any motor vehicle intended for use on the road, having at least four wheels and any trailer associated with it
- HyLaw considered four areas of potential regulatory issue:
    - Road planning and specific requirements for transported hydrogen (and if the regulations are different from other types of gas);
    - Restriction of road transport (e.g. tunnels, bridges, parking, other);
    - Permitting process / requirements for drivers/transporting company and equipment (trailer);
    - Quantity and Pressure limitations on transported hydrogen
- **Road Planning - route allocation** does not take place in the UK
- **Restrictions** - hydrogen carriage is excluded through 10 UK tunnels that have category C, D, or E limits on the transit of ADR substances deemed flammable / explosive cargoes, including hydrogen. Only A risk category tunnels can be used at anytime and B category tunnels may have time restrictions as to when they can be used

Hydrogen transport and distribution

Assessment – transport and distribution of hydrogen

- Parking restrictions apply throughout the UK (subject to quantities of compressed hydrogen (beyond 333l) per transport unit in packages (when carrying only hydrogen on board) and this prevents use of any public car parks and separated parking areas at motorway service centres must be used; these restrictions are in line with other hazardous goods
- **Permitting** – under ADR, UK participants in the carriage of dangerous goods are obliged to take ‘appropriate measures according to the nature and the extent of foreseeable dangers, so as to avoid damage or injury or to minimize their effects’. Also, ‘persons employed by the participants, shall be trained in the requirements governing the carriage of such goods appropriate to their responsibilities and duties’
- Specifically, drivers must be fully trained and that there are regular updates to training. The transport company must also ensure that the vehicle meets ‘design, construction and use’ standards for the specific hazardous cargo (or mixed loads) to be carried and that the correct markings and signs are displayed in the correct locations. It must also ensure that drivers carry the correct ADR paperwork on each and every journey and follow the correct ADR procedures; and that all required safety equipment is installed, regularly inspected and fit for emergency use – to be approved by the UK Health & Safety Executive
- For ADR permitting purposes, the transport equipment shall conform to the requirements for a delivery vehicle, the cargo itself must also be clearly marked with the UN number corresponding to the dangerous goods contained. The outer packaging must clearly and legibly display the letters ‘UN’ followed by the relevant code for that substance or article. One or more hazard labels must be attached to indicate the type of hazard in the form of a symbol

Hydrogen transport and distribution

Assessment – transport and distribution of hydrogen

- Also for ADR permitting purposes, the ‘vehicle’ must meet ‘design, construction and use’ standards for the specific hazardous cargo (or mixed loads) to be carried and the UK VCA (vehicle certification agency) is the authority to check and certify this when the vehicle is new and entering service, and then on an annual basis to ensure continuing compliance
- **Quantity and Pressure:** There are no specific limits to H2 in transportable H2 cylinders – provided that the cylinder and pressure regulator valve meets required pressure Directive standards / ISO standards and are CE marked
- The Pressure Equipment (Safety) Regulations apply in the UK to the design, manufacture, conformity assessment and periodic reassessment of transportable cylinders, tubes, cryogenic vessels and tanks for transporting gases; it also covers associated valves and includes both refillable and non-refillable cylinders. It applies to existing equipment as well as new equipment introduced since the Pressure Equipment Directive (implemented in the UK in 2001). Existing equipment is checked for compliance during annual periodic assessments. Aspects of the design, production and testing of the equipment are the subject of a large number of harmonized standards.
- Transportable Pressure Equipment Regulations 2009 (formerly TPED) have been fully updated and the legislation effectively now implements the requirements of the European agreement concerning the carriage of dangerous goods (ADR); Equipment previously made to those standards and specifications may continue to be used in Great Britain as long as it subject to a proper test and inspection regime – for which the DfT is the UK "Competent Authority“ and the VCA administers the system for the appointment of bodies for the conformity assessment and periodic inspection of Transportable Pressure Equipment

Hydrogen transport and distribution

Assessment – transport and distribution of hydrogen

- Current limitations in volume and pressure of high pressure receptacles used for hydrogen transport by road are not appropriate to deliver large quantities of hydrogen to large refuelling stations or other (industrial) end users. These limitations represent a structural barrier and therefore the current standards have to be revised and changed as to allow higher vessels capacities (pressure and volume)

Recommendations – transport and distribution of hydrogen

- The provisions for transport of dangerous goods by road are standardised in ADR and implemented in all partner countries through harmonised transposition of Directive 2008/68. Hydrogen is treated in the same way as other flammable gases and no recommendations for change of the existing legal an administrative framework is made
- The requirements covering construction, testing, type approval and certification of the equipment for transportation of dangerous goods and in particular for hydrogen are detailed, regulated and standardised in ADR, TPE and a number of technical standards. The application and implementation of the rules is harmonised across the EU Member states and no legal or operational barriers could be identified and no recommendations for improving the existing legal framework conditions are made

Hydrogen transport and distribution

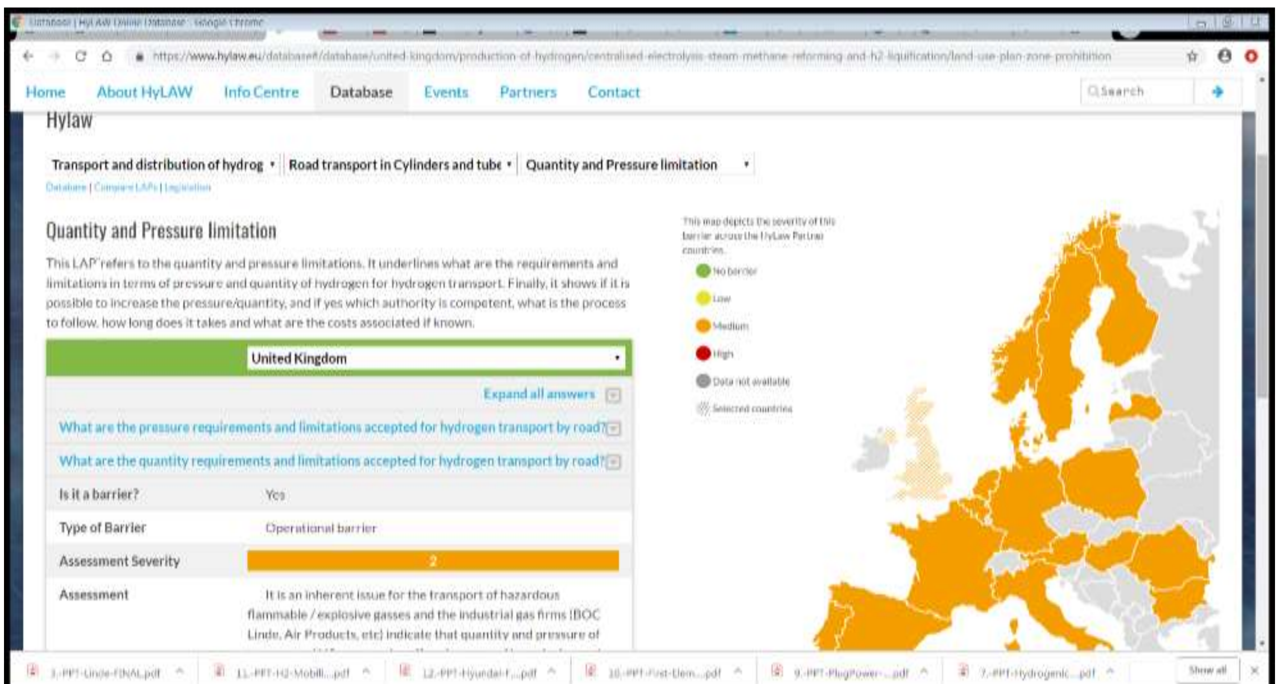
Recommendations – transport and distribution of hydrogen

- Safety and adherence to the ADR framework is an inherent issue for the transport of hazardous flammable / explosive gasses. Mainstream industrial gas firms in the UK indicate that quantity and pressure of transported H2 are a trade-off against the cost of introducing and running new equipment and against operational planning for HRS supply and supply to industrial H2 users
- Current standards for compressed hydrogen receptacles have been developed for a relatively small market volumes and short delivery distances. New materials and production technologies are now available for increasing the capacities of the cylinders and tubes, improving the payload of hydrogen trailers and allowing hydrogen delivery at larger scales. Therefore, the existing standards need to be revised and adapted. This also applies to smaller portable cylinders and supply / distribution to dispersed customers
- New entrants and those with new transportable H2 refuelling systems have reported that the complexity and requirements for vehicle and H2 storage equipment adherence under ADR is a barrier – particularly as the threshold at which full ADR compliance is relatively low; just 16 'Genie' cylinders of 424g of H2 per cylinder (6.8kg of H2 overall) requires ADR compliance for vehicles, markings, drivers and operations
- It has also been noted by industry that the Pressure Equipment Regulations, which cover the cylinders and other storage tanks used for hydrogen transport, are onerous and that there may be country specific requirements for tank testing rather than a uniform testing regime across the EU

Hydrogen transport and distribution

Recommendations – transport and distribution of hydrogen

- Changing standards is a slow process and requires continuous involvement towards building an industrial consensus for improving of existing volume and pressure limitations of hydrogen receptacles in view of the revisions of the existing ISO standards for gas pressure vessels designated as cylinders, for tubes in composite materials and for composite tubes and it is recommended that the UK take an active role in seeking such revisions to facilitate cost effective hydrogen transport and distribution both at scale and at lower volumes for 'local' hydrogen fuel utilisation



HyLaw database – showing comparative position across partner member states for quantity and pressure issues in the transport and distribution of hydrogen indicating a 'medium' barrier experienced across partners

Application 4: **Hydrogen as a fuel** – as used in refueling infrastructure for mobility purposes

Image courtesy Air Products – first UK publicly accessible HRS (for HyTEC) at Heathrow

Image courtesy Air Products – first publicly accessible HRS on a supermarket forecourt at Hendon

Image courtesy ITM and Shell – first co-located HRS at a conventional fuel station on the M25 at Cobham

Hydrogen as a fuel and refueling infrastructure

Assessment – Hydrogen as a fuel

- HyLaw covered three areas within this Application:
  - Legal status and Certificates of Origin
  - Hydrogen quality and measurement requirements
  - Hydrogen Refueling Station (HRS) permitting and safety requirements
- **Legal Status**: Hydrogen was recognised in the UK as a transport fuel in 2016 – covering hydrogen used both with a fuel cell and for combustion in a dual fuel vehicle (although there is a difference in duty payable for hydrogen combustion fuel)
- The UK Road Transport Fuel Obligations Order was amended in 2007 to transpose elements of the EU Renewable Energy Directive 2009/28/EC; it was amended further in 2013 to implement requirements of articles 7a-e of the Fuel Quality Directive; Motor Fuel (Road Vehicle and Mobile Machinery Greenhouse Gas Emissions Reporting Regulations 2012 Part of the UKs transposition of the Fuel Quality Directive 2009 and transposes Articles 7a to 7e, and Annex IV, of Directive 98/70/EC
- **Certificates of Origin**: The most recent version of the Fuels Quality Directive introduces a definition for renewable transport fuels which would also apply to hydrogen. However, there is currently no binding or voluntary, uniform certification of origin system at European level
- The absence of a common definition of green (or renewable) hydrogen can be a barrier to implementation of (green) hydrogen as an alternative fuel. Divergent national approaches may jeopardize the free movement of (green) hydrogen across borders while the absence of Guarantee of Origin (GoO) scheme hinders the development of a green (renewable) hydrogen market which may reduce the overall environmental benefits of hydrogen in all application areas (mobility, energy, industrial feedstock)

Hydrogen as a fuel and refueling infrastructure

Assessment – Certification of Origin

- Directive (Eu) 2015/1513 Of The European Parliament and of The Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the **use of energy from renewable sources**
- The Fuel Quality Directive defines “renewable liquid and gaseous transport fuels of non-biological origin” as “liquid or gaseous fuels other than biofuels whose energy content comes from renewable energy sources other than biomass, and which are used in transport”.
- Alternative Fuels Infrastructure Directive (AFID) establishes a common framework of measures for the deployment of alternative fuels infrastructure in the Union in order to minimize dependence on oil and to mitigate the environmental impact of transport and sets out minimum requirements for the building-up of alternative fuels infrastructure, including refueling points for hydrogen Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure (AFID)
- Under AFID, Member States which include hydrogen refueling points accessible to the public in their national policy frameworks shall ensure that, by 31 December 2025, an appropriate number of such points are available, to ensure the circulation of hydrogen-powered motor vehicles, including fuel cell vehicles, within networks determined by those Member States
- The AFID was transposed in the UK in October 2017. However, the transposition for UK hydrogen refueling points includes only the reference to ISO 17268 for refueling nozzles – to ensure standardisation of relevant equipment

Hydrogen as a fuel and refueling infrastructure

Recommendations – Hydrogen as a fuel and Certification of Origin

- The HyLaw wider recommendation is that a **Guarantee of Origin** (GoO) system for green (renewable) and low carbon hydrogen should be established at EU level (e.g. CertifHy project). This could be achieved, for example, in the context of the revision of the Renewable Energy Directive (RED II), it's implementing acts and national transposition acts
- UK support for and participation in a GoO system would assist in building momentum for adoption and EU wide implementation
- The GoO certification of hydrogen should include the carbon intensity and other relevant parameters (e.g. renewable origin) as for electricity in order to encourage the production and use of hydrogen from low carbon and/or renewable processes
- The renewable origin of the hydrogen should be transferrable independently of the molecules to which it relates (subject to reasonable conditions pertaining to mass balance and avoidance of double-counting)

Hydrogen as a fuel and refueling infrastructure

Assessment – Fuel Quality

- There is currently no UK legal requirement for hydrogen fuel suppliers to provide H2 at a specific purity level
- Conformity to international standards for H2 as an industrial gas / high purity gas as covered in standard ISO 14687 is / can be specified by UK users while ISO 4687-2:2012 and SAE J2719_201511 currently specify purity standards for fuel cell applications with 99.97% overall hydrogen purity and allowable levels of key constituents – potential contaminants
- Most countries adhere (from a regulatory perspective) to the standards laid down within ISO 14687-2 and ISO 19880–1, however, different approaches have been adopted and the ISO norm typically forms the basis for the quality control, but that checking on all the possible contaminants is both difficult and costly. In practice measurement is done on key contaminants which are checked continuously. However, due to the associated costs, not all contaminants named in the ISO norm are checked
- A new standard for hydrogen quality measurements is under development: ISO/DIS 19880–8 Gaseous hydrogen – Fueling stations – Hydrogen quality control. It is expected (as of mid 2018) that the standard will be endorsed soon.
- The aim of the new standard is to develop a practical implementing method for hydrogen quality control in which minimum analysis requirements of impurities are specified per hydrogen supply chain, as well as the frequency at which the analyses should be performed

Hydrogen as a fuel and refueling infrastructure

Recommendation – Fuel Quality

- The wider HyLaw perspective is that although not harmonised, in most countries where HRS are present, a procedure for fuel quality measurement is in place. A competent authority is assigned and the responsible party for the quality of the fuel is set
- However, the technical means to verify the purity in accordance with the applicable standards are not widely available. A strict enforcement of such requirements would place disproportionate costs on certain parts of the hydrogen value chain which will further delay the deployment of hydrogen technologies
- UK industry (as hydrogen fuel producers and consumers) are aware / involved in aspects of ISO 4687 and SAE J2719, and the new ISO/DIS 19880–8 developments and there are no UK specific recommendations made on fuel quality

Assessment – measurement of dispensed hydrogen

- Accurate measurement of hydrogen fuel dispensed to a vehicle (or other customers) is required for pricing / user charging purposes
- It is also required for fiscal purposes in the levying of applicable fuel duty and sales taxes, where this occurs
- However, refueling stations must store hydrogen in accordance with the worldwide accepted standard SAE J2601, with nominal working pressures of 700 bar and a temperature range of -40 °C (pre-cooling) to 85 °C (maximum allowed vehicle tank temperature)
- These operating conditions mean that it is difficult to provide sufficient traceability in flow metering measurements, which will need to be taken into account when developing hydrogen compliant meters.
- The development of flow meters for use at refueling stations must also be compatible with OIML R 139-1, which is the regulation for the equipment used to 'deliver compressed gases (natural gas, hydrogen, biogas, etc.) as fuel into fuel cell vehicles, small boats and aircraft'. This standard currently specifies that the flow meter must provide a relative accuracy of 1% (which is not achievable with commercially-available meters). A new work item proposal (NWIP) has been issued by OIML TC8 SC7 to develop a dedicated OIML standard for flow metering at hydrogen refueling stations
- This is a global challenge and at this point some FCEV suppliers have been offering inclusive hydrogen supply to obviate the need for accurate volume measurement

Hydrogen as a fuel and refueling infrastructure

Recommendation – measurement of dispensed hydrogen

- Accurate measurement of hydrogen fuel dispensed for pricing / user charging purposes and/or levying duty and taxes is a sector challenge globally
- However, flow meters are under development which could meet dispensed hydrogen measurement purposes
- The provision for measurement of dispensed hydrogen is expected, as for other fuels, to fall under the UK Weights and Measures Act 1985 (and the Units of Measurement Directive transposed by the Units of Measurement Regulations 1986 (SI 1986/1082) as amended), or other appropriate legislation, and will be required for implementation in the near to medium term
- There is no immediate recommendation for the UK to take specific action to advance this. In fact, the high cost of installing accurate measurement systems may act as a cost barrier to small scale hydrogen supply activities during early deployment and commercial operation. Dispensation to allow selective supply, without high measurement accuracy, could be considered (as a support action) for the near to medium term

Hydrogen as a fuel and refueling infrastructure

Assessment – refueling infrastructure planning and permitting

- The HyLaw assessment is that in most countries, on-site production of hydrogen (even when produced from non-emitting methods such as water electrolysis) results in the HRS being classified as an industrial activity, hence such an HRS would only be permitted in an area designated as an industrial zone, significantly reducing the convenience level of users and severely limiting the business case for development of HRS's with on-site production
- When considering the process for permitting of construction and operation of an HRS, there are very few countries where the regulations specifically cover H2 HRS
- HRS operators face uncertainty during permitting: there is no standardized approach by the administration for the interpretation of the applicable regulation, which can lead to non–uniform interpretation by different authorities,
- High safety requirements: authorities exercise a high degree of precaution in the face of limited experience with hydrogen technologies and interpret general (industrial) regulations by imposing the "maximum" safety related level prescribed
- Duplication of efforts without added safety benefits: typically every new HRS project is treated on a case by case basis which increases the necessity of individual (case–by–case) modelling, calculation, planning, etc. Designs which have been deemed safe already could be replicated at lower administrative and economic cost, however this does not appear to be the case in most countries and authorisation procedure for HRS with on–site production is cumbersome and, in some cases, prohibitive

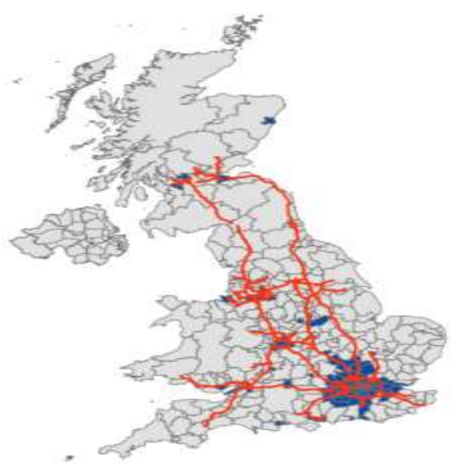
Hydrogen as a fuel and refueling infrastructure

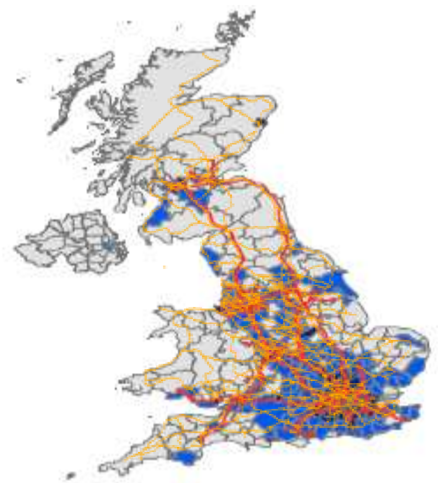
Tier 1 roads
Tier 2 roads
Tier 1 centres
Tier 2 centres
Tier 3

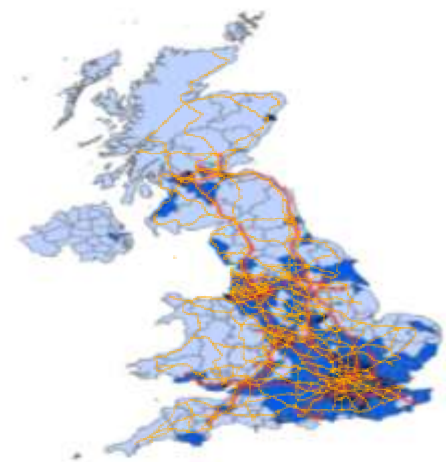
Seeding of Tier 1 regions[1] – major cities and connecting roads

Coverage extended to Tier 2 regions and all major roads <2025

Full population coverage 2030







~65

Initial seeding in **major population centres**

~330

Extend coverage to enable close-to-home refuelling to **50% of the population** and long distance **travel**

~1,150

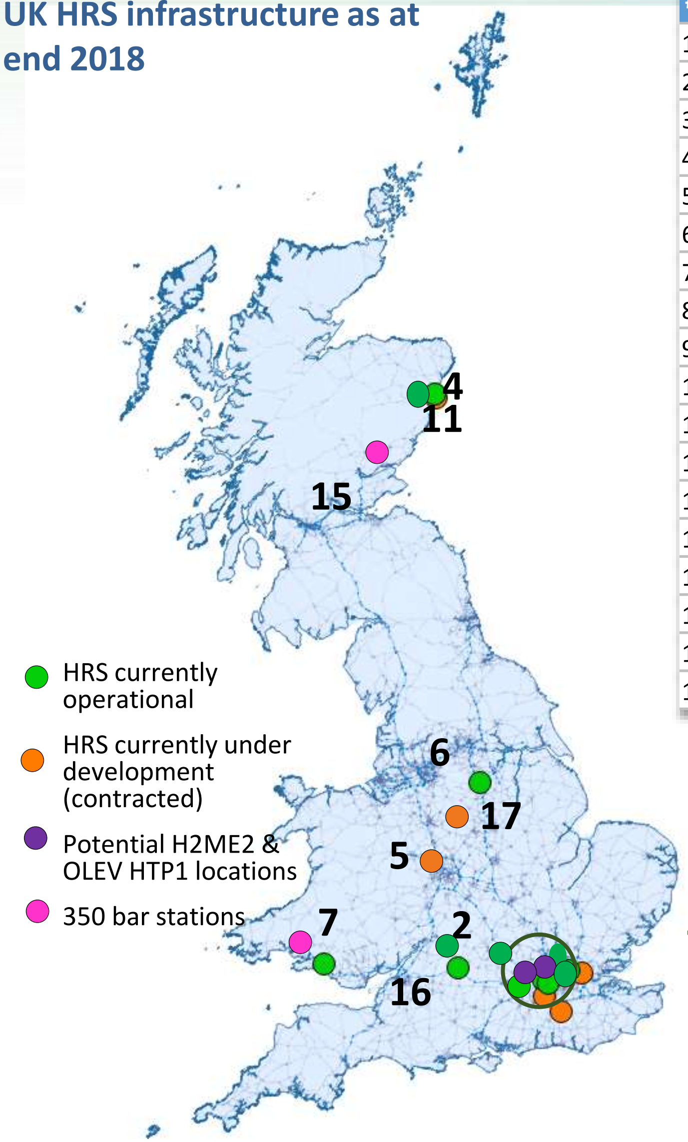
Extend close-to-home refuelling to the **whole of the UK,** including less populated regions

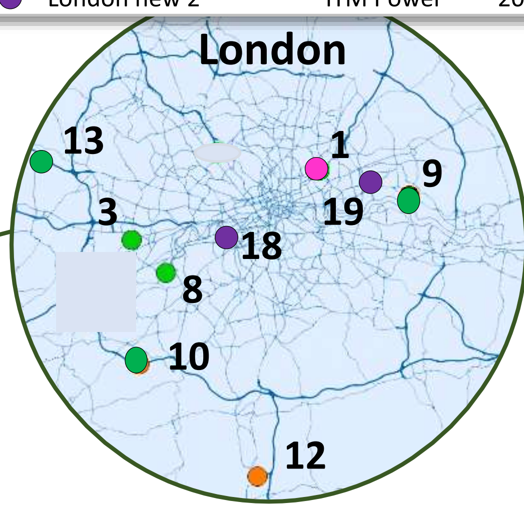
UKH2Mobility – forecast of UK HRS coverage

Hydrogen as a fuel and refueling infrastructure

UK HRS infrastructure as at end 2018

#	Location	Operator	Capacity	Pressure	Source	Launch
1	Lea Interchange, London	Air Products	320 kg/day	Bus only 350 bar	Delivered SMR	2011
2	Swindon, Honda	BOC	200 kg/day	350 &700)bar	On-site WE	2011, 2014
3	Hatton Cross, London	Air Products	80 kg/day	350 & 700 bar	Delivered SMR	2012
4	Kittybrewster, Aberdeen	BOC	360 kg/day	350 & 700 bar	On-site WE	2015, 2018
5	Birmingham, Bus and car	ITM Power	1,200 kg/day	350 & 700 bar	On-site WE	[2019]
6	AMP, Sheffield	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2015, 2016
7	Baglan, South Wales	Uni of S. Wales	35 kg/day	350 bar	On-site WE	2011
8	NPL, Teddington	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2016
9	CEME, Rainham	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2016
10	Shell, Cobham, London	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2017
11	Tullos, Aberdeen	Hydrogenics	80 kg/day	350 & 700 bar	On-site WE	2017
12	Shell, Gatwick, London	ITM Power	80 kg/day	350 & 700 bar	On-site WE	[2018]
13	Shell, Beaconsfield	ITM Power	80 kg/day	350 & 700 bar	On-site WE	2018
15	Fife	BOC	50kg/day	350 bar	Delivered H2	2017
16	Swindon, J Matthey	ITM Power	80kg/day	350 & 700 bar	On-site WE	2018
17	Derby, Shell	ITM Power	80kg/day	350 & 700 bar	On-site WE	[2019]
18	London new 1	ITM Power	200kg/day	350 & 700 bar	On-site WE	[2019]
19	London new 2	ITM Power	200kg/day	350 & 700 bar	On-site WE	[2019]





† Excludes small-scale HRS in Birmingham, Coventry, Glamorgan (Glyntaff), Orkney,, Loughborough, Nottingham, University of South Wales.

Details courtesy of Element Energy and ITM Power on behalf of UKH2Mobility

Hydrogen as a fuel and refueling infrastructure

Assessment – refueling infrastructure planning and permitting

- The UK HRS experience has been, initially, 'patchy' with long delays in obtaining new site permission, with the involvement of multiple parties, and the need for acceptance of limitations / conditions in return for planning consent
- Site permitting is partly based on the extent to which there is on-site H2 production and the volume of H2 storage; if H2 storage is >2 tonnes volume then permitting under Hazardous Substances controls will apply and full Control Of Major Accident Hazards (COMAH) regulations will apply for related consent if over 5 tonnes storage on site
- Local authority permission will also take into account approval by the local Fire Brigade and for HRS construction and operational requirements by the UK HSE (Health & Safety Executive) for hazardous installations
- There is a significant 'overhead' for the sector and restricts the ability to rollout HRS in main urban areas – but it is considered inevitable / acceptable in the context of refuelling facilities for a potentially hazardous substance
- The Addendum to the code of practice "Design, construction, modification, maintenance and decommissioning of filling stations" (The Blue Book) to enable co-location of hydrogen refueling stations with petrol facilities: Energy Institute – 2017 has been of fundamental advantage to the sector
- The BCGA Blue Book requirements (access points, separation distances, layout, signage, emergency procedures, etc) are also used as a benchmark for non co-located HRS facilities

Hydrogen as a fuel and refueling infrastructure

Recommendations – refueling infrastructure planning and permitting

- The wider HyLaw recommendations are that:
  - Hydrogen refueling stations (with or without on-site production) are explicitly treated in the same manner as conventional refueling stations from the perspective of land use plans and zone prohibitions
  - Emission free (e.g. via electrolysis) production of hydrogen should be excluded from the scope of legislative acts (e.g. EU and national laws) which currently cover the production of hydrogen
  - To reduce the risk of unequal treatment from a land-use plan perspective, HRS should fall under the same NACE code as conventional refueling stations, i.e. 47.30 - Retail sale of automotive fuel.
  - The production of H2 below a certain threshold of direct emissions should be addressed separately from high volume industrial production of hydrogen
- The UK has been a leader (along with Germany, Denmark and Netherlands) in compiling and publishing guidance on key design and safety related features, including separation distances, for HRS, and in particular for co-located HRS on existing conventional liquid fuel station sites.
- A formal guide for HRS approval procedures has also been published in Germany (*Approval Guidelines for Hydrogen Refueling Stations*, prepared by the national organization for Hydrogen and Fuel Cell Technology) and it is recommended that this also be undertaken for the UK
- Mobile refueling offers strategic benefits in supporting FCEV (and other vehicle) operations in conjunction with the (gradual) deployment of fixed HRS, but faces separate regulatory challenges with regard to their own refueling and use of storage cylinders (non-ADR - EC79 and ADR - TPED). Mobile refuelers are being used elsewhere to seed local vehicle fleet introduction and could also be used for NRMM and stationary power systems. An assessment should be made as to whether cost effective technical solutions are available to avoid current regulatory barriers to allow greater use of mobile refueling in the UK

Application 5: **Vehicles** – for mobility / transport activities with cars, buses and trucks; with motorcycles, quadricycles, and bicycles; marine vessels - boats and ships

Image courtesy Hyundai – Nexo FCEV 2019

Image courtesy Suzuki – Intelligent Energy; FC Burgman as tested by London Metropolitan Police

Eidesvik Viking Lady - one of the first H2/fuel cell ships in commercial operation (2009)

Vehicles

Assessment - introduction

- The HyLaw application area for Vehicles covers two vehicle categories: cars, buses and trucks; motorcycles, quadricycles and bicycles
- It also covers the Marine sector. The Rail sector was not formally covered under HyLaw
- For Vehicles the key legal and administrative provisions and procedures covered are for
  - Type approval and registration of hydrogen powered vehicles
  - Requirements for maintenance and service in comparison with conventional vehicles
  - Whether undue restrictions are imposed on hydrogen powered vehicles using the road infrastructure and parking facilities to ascertain whether there are legal, operational and economic barriers hindering deployment
- The coverage of Marine vessels reviews the wider regulatory stricture and current equivalent of ‘type approval’ for hydrogen fuel and hydrogen or/and fuel cell based propulsion systems

Vehicles – cars, buses, trucks

Assessment – Cars, buses trucks - Legal framework – type approval

- Directive 2007/46 79 (to be replaced by a Regulation with effect from 1 September 2020) establishes a framework for the type approval of motor vehicles classes M (passenger cars and buses), N (trucks), O (trailers), and of systems and components intended for such vehicles. The Directive 2007/46 is substantially transposed in all partner countries, including for the UK, in 2011
- The vehicle safety issues are covered by Regulation (EC) No.661/2009 80, on the general safety of motor vehicles (General Safety Regulation). The Framework Directive is amended by Regulation (EC) No. 79/200981 (Hydrogen Safety Regulation) with the aim to specify harmonized safety requirements for hydrogen powered vehicles based on an internal combustion engine or a fuel cell. It contains general requirements for the type approval of hydrogen systems and components
- Detailed technical specifications and test procedures implementing the general provisions of the Hydrogen Safety Regulation are laid down in the Commission Regulation (EU) No. 406/201082 (Hydrogen Safety Implementing Regulation). In addition, the Framework Directive lists a number of separate technical Directives, EU Regulations and UNECE Regulations the vehicle must comply with in order to obtain type approval. The UNECE Regulations listed in Part II of Annex IV are recognized as being equivalent to the corresponding separate Directives or Regulations in as much as they share the same scope and subject matter
- The UK Vehicle Certification Agency (VCA) is the designated UK Approval Authority and acts as a Technical Service for all type approvals to automotive EC Directives and most UN Regulations
- There are no UK issues with type approval of FCEVs for operation in the UK. Buses have been accepted under IVTA. It is understood there is, as yet, no WVTA template for fuel cell trucks. It is also understood that here are issues with type approval of hydrogen-ICE vehicles, in the context of the testing regime required to achieve EWVTA

Vehicles – cars, buses, trucks

Assessment – Cars, buses trucks - Legal framework - service & maintenance

- The EU Roadworthiness package consists of three directives:
    - Directive 2014/45/EU on periodic roadworthiness tests,
    - Directive 2014/47/EU on technical roadside inspections for commercial vehicles and
    - Directive 2014/46/EU on vehicle registration documents
- The Roadworthiness package extends the scope of existing testing to new categories of vehicles, as well as lays down new requirements for the standard and quality of testing, test equipment and skills and training of testing personnel. Testing facilities and equipment used in testing centres should fulfil the requirements set out for carrying out roadworthiness tests. A training system including initial training and periodic refreshers or an appropriate examination should be introduced Directive 2014/45/EU of the European Parliament and of the Council of 3 April 2014 on periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC
- Under Directive 2014/45/EU each Member State shall ensure that vehicles registered in its territory are periodically tested by testing centres authorized by the Member State. Directive 2014/45 is transposed into national legislation of the partner countries
- There are no mandatory service / maintenance requirements for FCEVs in the UK. Only the standard vehicle MOT testing applies (the first such test being 3 years after registration of the vehicle and annually thereafter). The FCEV / bus vehicle manufacturer therefore specifies the service and maintenance regime and provide for facilities, trained personnel and serviceable components to ensure individual vehicles/fleets continue to meet roadworthiness requirements. The Driver and Vehicle Standards Agency (DVSA) and Traffic Commissioners oversee roadworthiness requirements for passenger carrying vehicles

Vehicles – cars, buses, trucks

Assessment – Cars, buses trucks - restrictions

- For road going operations there are no restrictions on FCEV and hydrogen combustion vehicle movement
- There are 10 UK road tunnels which apply ADR restrictions and which can also restrict use by certain types of alternatively fuelled vehicles
- However, FCEVs which are equipped with EC79 rated hydrogen storage (for transportation of the gas as a source of fuel for the vehicle within which it is located - i.e. its fuel tank) and have EWVTA, are not restricted from use of these tunnels
- Fuel cell buses currently operating in London (which have UK IVTA only) are routed to avoid tunnels
- The Channel Tunnel currently prohibits the carriage of FCEVs on the Shuttle (together with LPG and CNG powered vehicles) although there is no legal basis for this prohibition
- There are no legal restrictions on FCEVs and hydrogen combustion vehicles being parked in conventional parking stations although car park operators can apply specific limitations, in particular for underground car parks; restrictions do apply for FC and hydrogen powered buses and trucks

Vehicles – cars, buses, trucks

Recommendations - Cars, buses trucks

- As a general HyLaw finding, and although Directive 2007/46 79 (to be replaced by a Regulation with effect from 1 September 2020) establishes a framework for the type approval of motor vehicles, there remains varying national approaches to implementation.
- Therefore further harmonization of the implementation of the type approval requirements and procedures for hydrogen powered vehicles across the EU is recommended and this would be assisted by the newly adopted Regulation 2018/858, which provides inter alia the establishment of a new advisory body intended to coordinate activities related to the enforcement of type-approval legislation.
- Similarly, while the EU Roadworthiness package has clear guidelines and requirements varying national approaches to implementation exist and a clear and unified set of rules for service and inspection companies working with FCEV and hydrogen powered vehicles is needed
- This would include developing guidelines and manuals for hydrogen powered vehicle service and maintenance companies and testing centres including specific requirements for work with high pressure gases and on high voltage electricity systems (for FCEVs and FC range extended EVs), precautionary measures for work in workplaces where potentially explosive atmospheres may occur and provisions for staff qualification. The guides should also provide instructions for dealing with different types of emergency situations
- There is uncertainty on the part of vehicle operators and car park owners/tunnel authorities as to the regulations for hydrogen powered vehicles in tunnels and car parks. A ‘Blue Book’ approach (as already implemented for HRS applications), is recommended for setting out a coherent basis (in the regulatory context of local planning and safety related control frameworks) for allowing hydrogen powered vehicles to use car parks and tunnels nationally

Vehicles - motorcycles, quadricycles, bicycles

Assessment – motorcycles, quadricycles, bicycles

- L category vehicles comprise seven vehicle subcategories including powered cycles and two-wheel mopeds (L1e), three wheel mopeds (L2e), two (L3e) and three wheel motorcycles (L4e), powered tricycles (L5e), and light (L6e) and heavy (L7e) quadricycles
- Each subcategory is further distinguished, making up a total number of 25 sub-subcategories. The diversity of types, powertrains, and utility patterns of these vehicles makes this category as one of the most diverse
- Regulation (EU) No 168/2013 and its delegated and implementing acts comprise a comprehensive package of measures for the safety, emissions control and placement on the market of motorcycles, tricycles and quadricycles
- It specifically applies to the type approval of hydrogen combustion and hydrogen fuel cell vehicles L category
- There is very limited experience with deployment of L category vehicles; The Suzuki Burgman fuel cell scooter was approved under EWVTA and is currently in fleet trial operation with the Metropolitan Police with day to day service provided by the Metropolitan Police and additional service provided by Suzuki (and fuel cell powertrain system service provided by Intelligent Energy)
- The key challenges for the L1e sector have been related to availability of hydrogen refueling facilities and the interface between a ‘small fill’ H2 cylinder (current HRS provision is for refueling cylinders of 2kg H2 and above) – and thereby the necessity of using a mobile re-fueler (which as indicated in application 4 have had a separate set of issues to be resolved)

Vehicles - motorcycles, quadricycles, bicycles

Recommendations - motorcycles, quadricycles, bicycles

- EU legislation regulating the type approval of L category vehicles and in particular of hydrogen powered vehicles is in force, but the national type approval authorities and bodies do not have extensive practical experience with this types of hydrogen vehicles.
- Minimising the possibility for different interpretation and application of type approval requirements by national type approval authorities is important. Coordinated activities (under the newly adopted Regulation 2018/858), and exchange of information via the management of the new Forum for exchange of Information and Enforcement aimed at harmonisation of the type approval process for vehicles M and N categories, could facilitate the unified implementation of the type approval procedures for hydrogen powered L category vehicles
- L category motorcycles, bikes and quadricycles are currently excluded from the requirements of periodical roadworthiness inspections at EU level although new legislation from 1 January 2022 will cover the requirements for roadworthiness testing to the two-and three wheel motorcycles, powered tricycles and heavy quadricycles, with a design speed exceeding 25 km/h and an engine displacement of more than 125 cm3 (subject to Member State acceptance – they have the right to exclude them from testing and adopt alternative safety measures for technical control of these vehicles)
- Develop guidelines and manuals for service and maintenance of hydrogen powered motorcycles and quadricycles including specific requirements for work with high pressure gases and on high voltage electricity systems (for FCEV), include precautionary measures for work in workplaces where potentially explosive atmospheres may occur and provisions for qualification of the staff

Vehicles - Marine

Assessment - Marine

- Maritime transport emits around 1000 mill tons of CO_2 annually - about 2.5% of global GHG emissions (3rd IMO GHG study) and shipping emissions are predicted to increase between 50% and 250% by 2050
- The IMO, as the global body for shipping, is planning to reduce CO_2-emissions by 50% to be achieved by 2050
- The IMO also has oversight of key international conventions: the International Convention for the Safety of Life at Sea SOLAS, and the International Convention for the Prevention of Pollution from Ships MARPOL; and more recently, the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels - IGF Code – which came into effect in January 2017, mainly for LNG but opens up for use of other gases or low-flashpoint liquids, through "Alternative design"
- For any new marine vessel design safety, reliability and dependability shall be equivalent to that of new and comparable conventional systems across 18 additional functional requirements and for which risk and explosion studies required
- Requirements for fuel cell installations will be added as a new part E to the Code (2024)
- Hydrogen specific requirements are not yet on the agenda in IMO/CCC
- IGF Code, SOLAS, MARPOL implemented through EU Directives: Directive 2014/90/EU, on marine equipment; Directive 2009/45/EC, on safety rules and standards for passenger ships; Directive 2009/16/EC and Directive 2013/38/EU, on port State control; Directive 2012/18/EU – "SEVESO Directive“; Directive 2014/34/EU – "ATEX Directive"
- National Maritime Authorities have areas of responsibility, in most cases via international rules and standard, which have been transposed through EU- and National legislation

Vehicles - Marine

As to design / type approval of hydrogen / hydrogen fuel cell vessels, there is a very clear barrier and regulatory gap

This map depicts the severity of this barrier across the HyLaw Partner countries.

- No barrier
- Low
- Medium
- High
- Data not available
- Selected countries

https://www.hylaw.eu/database#/database/vehicles/boats-ships

Vehicles - Marine

Assessment - Marine

- The "Alternative design“ route would follow “Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments” covering both the vessel, its functional equipment and fuel (Liquid and Compressed hydrogen) and for which there are no immediate ‘equivalents’
- Bunkering facilities for fuel supply are also considered an issue and is expected to require a comprehensive, quantitative risk assessment which may be function-based rather than set against specific requirements (where, e.g., the ISO 20519 – LNG standard might be applicable)

Recommendations - Marine

- The Hylaw recommendations for the Marine sector are based on three critical areas, for which the UK could participate:
- Develop specific rules for the type approval of Hydrogen and Hydrogen Fuel Cells vessels. This would necessarily involve the IMO, National Maritime Authorities, EMSA, the European Commission, and Class societies, CESNI (for inland navigation)
- Clarify and streamline applicable rules for the landing and bunkering of hydrogen. This would necessarily involve the European Commission, National / Regional and Local authorities, business assurance companies, standardization bodies
- Develop and share minimum requirements for the operation and maintenance of HFC vessels This would necessarily involve the National Maritime Authorities, EMSA, the European Commission, Class societies, the IMO, CESNI

Application 6: **Electricity grid issues** – for electrolysers, for connection of the electrolyser to the e-grid and electrolysers in 'Power to Gas' functions

Image courtesy Theuga– e-grid connected electrolyser from ITM approx. 300 kW and hydrogen output of 60 Nm^3/h

Image courtesy Theuga– e-grid connected electrolyser and PtG demonstration plant operation at Frankfurt/Main

Electricity Grid Issues – electrolyser connection

Assessment – electricity grid – electrolyser connection – legal framework

- Legal framework - Hydrogen production via e-grid connected electrolysis requires open and fair grid access. EU Legislation framework impacting grid access has been introduced via three ‘energy packages’
- Directive 96/92/EC (subsequently revoked by the third Directive as below) was based on Directive 96/92/EC (concerned common rules for the internal market in electricity, promoted the independence of the transmission system operator, and laid down the rules relating to the organisation and functioning of, and access to, the wholesale electricity market)
- Directive 2003/54/EC, (also subsequently revoked by the third Directive as below) was based on Directive 2003/54/EC (concerning common rules for the internal market in electricity (Electricity Directive)), focused on the concepts of unbundling and third-party network access)
- The third energy package comprised two Directives (Directive 2009/72/EC and Directive 2009/73/EC) and three Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009) to further open up the gas and electricity markets in the European Union with the separation of companies' generation and sale operations from their transmission networks (and thereby independent distribution networks). It also provided for the establishment of a National Regulatory Authority (NRA) for each Member State and for the Agency for the Cooperation of Energy Regulators (ACER) which provides a forum for NRAs to work together
- Complemented by Commission Regulation 2016/1388 for establishing a network code on demand connection – giving the legal basis for regulatory authorities to ensure that objective and non-discriminatory technical rules would establish minimum technical design and operational requirements for the connection to the grid system. It came into force on 7th September 2016 as binding and directly applicable in all Member States

Electricity Grid Issues – electrolyser connection

Assessment – electricity grid – electrolyser connection – legal framework

- The UK moved early on the opening and unbundling of electricity and gas markets to promote competition
- Electricity Act 1989 set out the overall framework for public supply and reorganisation of the electricity industry. Note that Scotland has separate, parallel arrangements and that nuclear power was assigned to a separate (public) company to operate in the generation sector. CHAPTER 29 - to provide for electricity market supply and to make new provision with respect to the supply of electricity through electric lines and the generation and transmission of electricty through networks and connections to those networks
- Utilities Act 2000 provided for the establishment and functions of the Gas and Electricity Markets Authority and the Gas and Electricity Consumer Council; to amend the legislation regulating the gas and electricity industries; and for connected purposes
- Gas and Electricity (Internal Markets) Regulations 2011 update to the DCUSA for the UK to reflect the modifications made to the standard conditions of the electricity distribution licences following implementation of the third energy package - Distribution Connection and Use of System Agreement (DCUSA) DCP110: Electricity and Gas (Internal Markets) – the DCUSA provides a single centralised document that relates to the connection to and use of the distribution networks and is a contract between generation distributors and suppliers in Great Britain
- Electrolyser connection is typically arranged via the relevant licensed electricity Distribution Network Operator (DNO) where the electrolyser is connected
- Common steps apply and the procedure is overseen – in the context of ‘access fairness’ and transparent pricing by the UK regulatory authority – the Office for Gas & Electricity Market (OFGEM)
- The typical HyLaw – and UK experience - is that there was no significant difference in connecting an electrolyser to the e-grid as for any other industrial or similar load and **no specific recommendations are made for the UK**

Electricity Grid Issues – Power to Gas plant

Assessment – electricity grid – Power to Gas plant

- An electrolyser based PtG facility would typically include an electrolyser directly connected to the e-grid or directly connected to a renewable energy system (wind, solar) to draw electricity for electrolyser operation (installed examples have a power consumption for the electrolyser of around 3-400 kW) to generate hydrogen. The hydrogen can be temporarily stored and then supplied to fuel cells, ICE turbines or other power-electric generation system, or injected into the gas grid.)
- The current EC legal framework has no provision for P2G systems under either e-grid or gas grid common rules for grid and market access (along with transmission, distribution, and supply arrangements) and no Partner Member State (including the more advanced regulatory frameworks implemented in Germany, France and Austria) has an established and coherent regulatory approach to P2G systems
- The HyLaw assessment is that where PtG operations do take place across Partner Member States it is 'by exception' or under a delineated / time specified demonstration programme, which requires a unique set of arrangements and negotiations across multiple regulatory and safety agencies and e-grid / gas grid network operators for permission to connect / operate. Otherwise, formal PtG operation is simply not permitted as an integrated system
- While there is no clear and unequivocal legal position for PtG facilities recognized across both e-grid and gas grid networks, PtG systems face a regulatory gap and a substantive barrier to PtG technology deployment

Electricity Grid Issues – PtG load balancing

Assessment – electricity grid – Power to Gas plant – load balancing

- An electrolyser based Power to Gas (PtG) plant could potentially operate to provide ancillary services and specifically for e-grid demand side load balancing ancillary services required to enable the integrity and stability of the transmission or distribution system, as well as the power quality (frequency and voltage), to be maintained within set network limits and which would typically be part of regulated (mandatory) network requirement.
- There are three recognized ancillary services, for which payment might be applicable to the PtG operator:
    - automatic Frequency Restoration Reserves (aFRR) - to enable the exchange of balancing energy from frequency restoration reserves and replacement reserves;
    - balancing energy from frequency restoration reserves with manual activation (mFRR);
    - frequency containment reserves (FCR)
- UK Electrolyser operation is in principle covered, specifically the turn down aspect of electrolyser operation (Demand Side Response)
- More generally, an electrolyser based PtG plant could provide a balancing service to ‘switch-on’ the electrolyser when the network has excess power (using electricity to generate hydrogen); and to generate power (using stored hydrogen or SNG) when the grid has less power than needed to maintain load/frequency
- This would necessarily exclude Primary Reserve provision (typically for large scale generators) and mainly cover Secondary Reserve provision – but a legal definition and system performance envelope is necessary for this

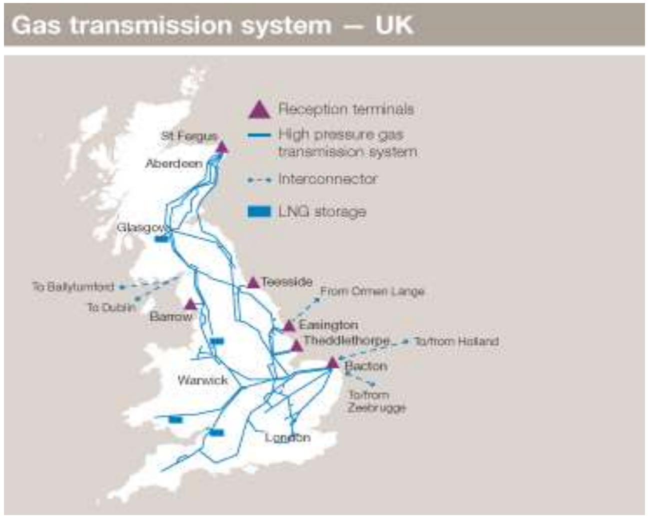
Electricity Grid Issues – PtG load balancing

Recommendation – electricity grid – Power to Gas plant – load balancing

- Electricity grid connection for electrolysers is understood and covered under most legal frameworks. Recognition of the basis for the provision of ancillary services via electrolysers is blurred, not well understood (on a technical and operational basis) and, in the HyLaw experience, interpreted differently across Partner states, such that electrolysers are mostly recognized as relevant technologies for ancillary services but not in PtG configuration.
- The lack of legal recognition of PtG systems flows through to permitting and siting arrangements for PtG associated hydrogen storage, with significant variations of treatment that would be applied, including the UK. This constrains the formulation of a coherent policy framework to support deployment through financial or other measures – even to avoid the potential for double charging of taxes and fees (only DE has measures to avoid double charging from gas and electricity networks and gives priority in gas network access by legally treating hydrogen and synthetic methane as biogas).
- Participation in ancillary services requires a minimum scale and early programmes may be sub-economic; a supportive legal framework is needed to encourage and sustain scale-up at the local, regional and national level
- To ensure wider utilization of electrolysers and PtG plant in the provision of ancillary services it is essential that the operational framework and technical capabilities (and merits) are harmonized and more coherently framed and should meet all applicable EC regulatory frameworks – and similarly for the UK

Application 7: **Gas grid issues** – at both the DSO and TSO transmission network level

UK terminals and gas transmission system comprise ~4,200 miles of pipeline



UK eight distribution networks and ~170,000 miles of pipelines

Gas Grid Issues

Assessment – gas grid – legal framework

- It is increasingly recognized that the injection of hydrogen from renewable sources in the natural gas network would effectively enhance the transport and storage capacities of the existing gas network infrastructure for indirect electricity transport, for energy storage and for meeting decarbonisation targets.
- There are however widely varying national approaches to managing natural gas composition for safety purposes (in transport, storage and in use by gas appliances) along with controls / provision for connecting hydrogen injection facilities
- European national gas grids and transmission/distribution networks have been liberalized and opened to market competition over the past 20+ years. Directive 2009/73/EC) and three Regulations (Regulation (EC) No 714/2009; 715/2009 and 713/2009) provides for access to gas markets and clear procedures applicable to granting authorisation for transmission, distribution, supply and storage of natural gas, including LNG.
- This does not immediately carry over to allowing network access for hydrogen injection and the process chain for PtG is more legally complex and there is no clear and unequivocal legal position for PtG, leading to a diversity of approaches to recognition of PtG plant and hydrogen injection at legally acceptable levels.
- While the legal framework has specific transmission level and distribution level Directives and Regulations, there is no specific coverage that regulates H2 injection that applies at either level across the EU and within the UK

Gas Grid Issues

Assessment – gas grid – legal framework - UK

The UK regulatory framework is set via:

- Gas Act 1996 (Privatisation and unbundling of the gas industry; limiting the market power of British Gas; extending competition to industrial and domestic markets to obtain benefits of competition in terms of market entry and in benefits to customers)
- Gas Safety Management Regulations 1996 (The GSMR sets the UK gas quality specification and the Wobbe index (WI) range appropriate for the UK, including a 0.1%vol H2 concentration limit)
- Pipeline Safety Regulations 1996 (Enacted ahead of EC Directives covering gas grids and safety requirements such as ATEX and subsequently updated in line with ATEX Directive 2014/34/EU)
- Utilities Act 2000 (Provided for the establishment and functions of the Gas and Electricity Markets Authority and the Gas and Electricity Consumer Council; to amend the legislation regulating the gas and electricity industries; and for connected purposes – subsequently to become the Office For Gas & Electricity Markets (OFGEM) as the sector Regulator)

Gas Grid Issues

Assessment – gas grid

- Regulatory frameworks have typically been drawn up around natural gas and network safety and operational procedures are managed at the national level with the TSO & DSO obliged to meet national technical and safety body requirements for operational infrastructure (pipelines, compression, valves and junctions, etc.) which have been configured and maintained over time to a specific gas quality standard (based on calorific value / Wobbe Index);
- Adding hydrogen, renewable or otherwise, to the gas stream would change the calorific value of the gas and thereby the basis for delivering gas under contract to major users or into distribution networks and require differing flow monitoring / measurement equipment and/or revisions to regulated national gas transmission pricing and payment terms – and may constrain international gas flow arrangements
- There are widely varying national limits for hydrogen concentrations in the gas grid, set either by primary legislation or in accordance with long standing safety standards or/and gas quality standards. These limits range from a 'minimal' background concentrations of hydrogen at 0.1%vol and up to 'high' concentrations of 6% or up to a maximum of 10%.vol.
- No gas network allows for 100% hydrogen in pipeline flows (100% H2 must be blended down to acceptable levels)
- Within HyLaw, some Partner MS have no specific concentration level set for hydrogen (BL, DK, BU, RO, ES) and/or follow locally stipulated safety requirements which would typically proscribe low H2 concentrations in the natural gas stream

Gas Grid Issues Hydrogen injection (Permissible level)

Legal framework 'Acceptable' H2 level (typically mandated by legislation)	**MS (HyLaw) Countries**
'Minimal' H2 concentration at **0.1% to 0.5% vol** ' (reflecting typical background concentrations in natural gas):	**IT, LV, SE, UK**
'Low' H2 concentration at **1.0% to 4.0%** vol	**FI, AT**
'Mid' H2 concentration at **6.0%vol**	**FR**
'High' H2 concentration at **up to 10.0% vol*** The applicable H2 threshold may fall below this, depending on down-stream consumers H2 tolerance and other factors (e.g. underground storages, large scale gas turbines, vehicle CNG cylinders type 1 / CNG refueling stations)	**DE**
No formal H2 concentration rules but based on safety limits with reference to natural gas operations	**BE, BG, DK, ES**

Gas Grid Issues

Assessment – gas grid

- Even where injection of hydrogen is permitted, there is a diversity of arrangements as to whether the injection level can be at 100% H2 (as in DE) or must be blended down to the acceptable gas quality / composition prior to injection
- There are no requirements formally in place now for amending hydrogen thresholds to meet energy sector de-carbonisation objectives (although RED II will cover gas networks)
- Initiatives to validate gas grid operation with significantly higher hydrogen thresholds are being trialed (DE, FR, I, NL & UK) but there is no apparent coherence as to how these are being configured and if/how common technical, safety and regulatory issues are being addressed to define a wider 'safe and practical basis' for adoption across the EU. This should be a priority to ensure a 'level playing field' for P2G deployment and avoidance of local barriers to P2G services
- There is no formal, clear and coherent payment framework in place across Partner MSs for hydrogen transmission, covering connection fees and charges, or covering remuneration for hydrogen supplied/injected
- While there are no pricing principles in place for otherwise regulated gas networks, and in particular for a level of clarity on valorization of hydrogen rich gas flows (up to and beyond the current highest limit of 10%vol H2), then P2G systems have no business case justification basis and may not proceed beyond demonstration projects

Gas Grid Issues

Assessment – gas grid issues

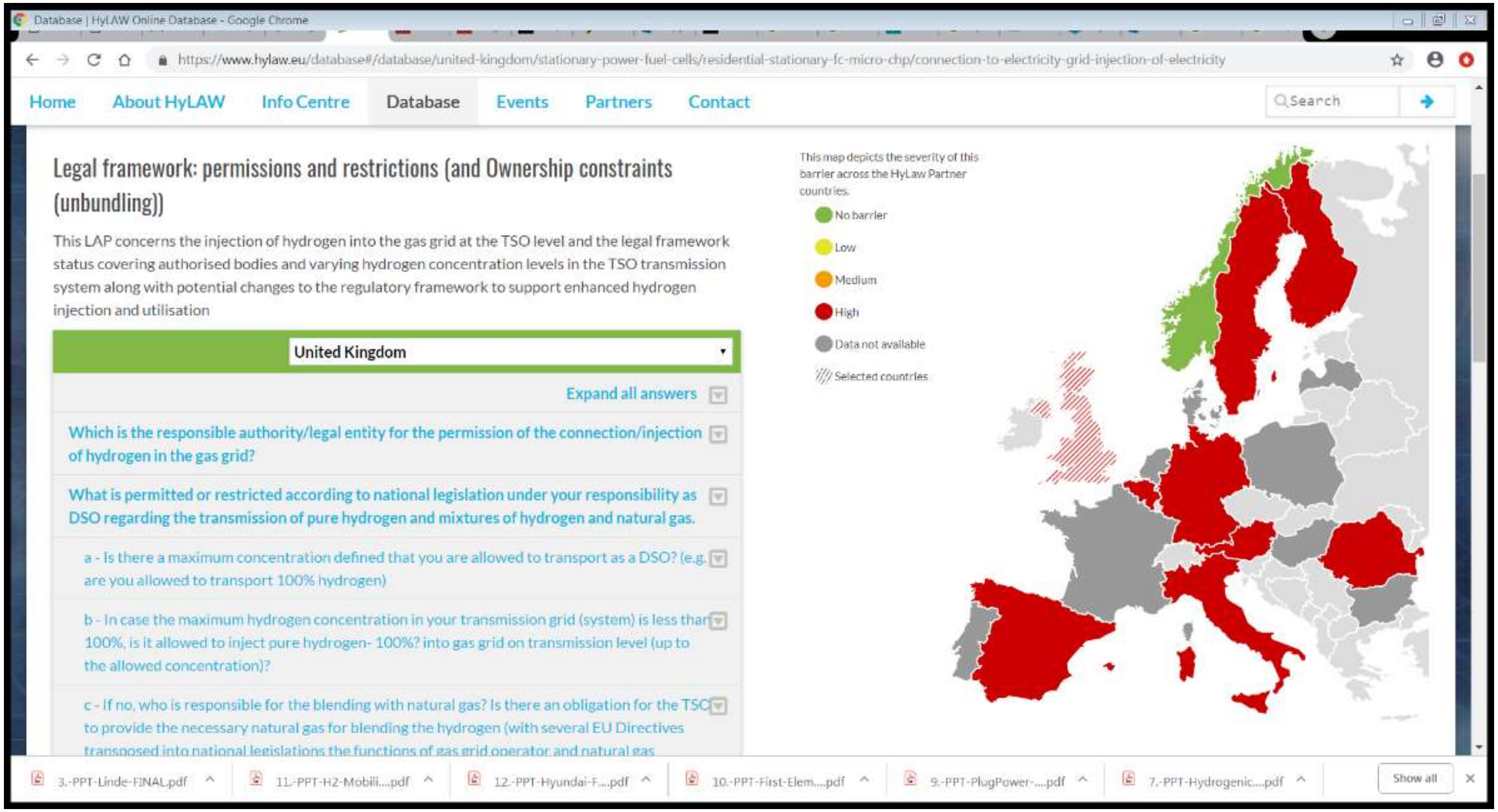
- There is considerable diversity across Partner MSs in their approach to grid connection arrangements for hydrogen connection facilities and the cost attribution thereof between different involved parties. Germany provides a potential template for a supportive payment framework where Hydrogen and SNG are already included in the definition of biogas in Energy Industry Act, subject to the condition that they primarily originate from renewable energy sources, so that the payment privileges/incentives are applicable only for the injection of renewable hydrogen, and the share of costs for gas grid connection follows a defined arrangement between the (PtG) operator and network entity
- There is no body of experience on safety issues and additional requirements for injecting hydrogen rich gasses into the gas grid. PtG is still a relatively new approach and of the 27 PtG projects currently underway (http://europeanpowertogas.com/projects-in-europe), most are mainly at the proof of concept and technical / operational / safety assessment stage
- Higher hydrogen compositions may require modification to, or replacement of, end-user gas equipment which had initially been designed for operation with conventional natural gas and the calorific value and flame and heat characteristics of the natural gas spectrum
- From a regulatory perspective, the Gas Appliance Directive (EU Gas Appliances Directive 90/396/EEC) and subsequently the Gas Appliance Regulations ((EU) 2016/426), covers all industrial and consumer appliances. The GAD/GAR defines (in generic format) the requirement to demonstrate that any gas–fired appliance (and the fittings intended to be incorporated within those gas appliances) to be sold in the EU are safe. It applies equally to all gaseous fuels including hydrogen, town gas, biogas, natural gas, propane and or butane to be used/burnt within a gas appliance

Gas Grid Issues

HyLAW

Assessment – gas grid issues

HyLaw database – showing comparative position across partner member states for gas grid issues and permission to connect / inject hydrogen – as a significant barrier experienced across most partners



Gas Grid Issues

Recommendations – Gas Grid issues

- A coordinated **EU wide review of the safety and technical integrity limitations for hydroge**n connection and injection into the gas grid needs to be linked with a review of the current regulatory framework shaping gas grid operations and pathways to enhanced hydrogen utilization.
- This should be linked with current national initiatives to **validate gas grid operation with significantly higher hydrogen thresholds** that are being trialed (DE, FR, NL & UK) and where there is no apparent coherence as to how these are being configured across common technical, safety and regulatory issues, to define a wider 'safe and practical basis' for regulatory framework adoption and network implementation, nationally for the UK, and across the EU
- A coordinated review of HNG measurement and administrative requirements across EU Member States is needed to identify a coherent basis for modified billing arrangements for hydrogen – which would take account of the differing calorific value of hydrogen blends and potentially pure hydrogen in the gas grid. Arrangements for bio-gas that have recently been established and cover real time measurement, monitoring and reporting arrangements may provide a template for a carry-across to hydrogen / H2NG mixtures and should be considered for amendment and adoption by regulators
- Establish a coordinated review of hydrogen gas safety requirements across EC Member States to identify a consistent basis for all relevant hydrogen safety and compliance matters (generation sites, blending, connection and injection and related equipment and operations) for hydrogen blends and potentially pure hydrogen flows in the gas grid

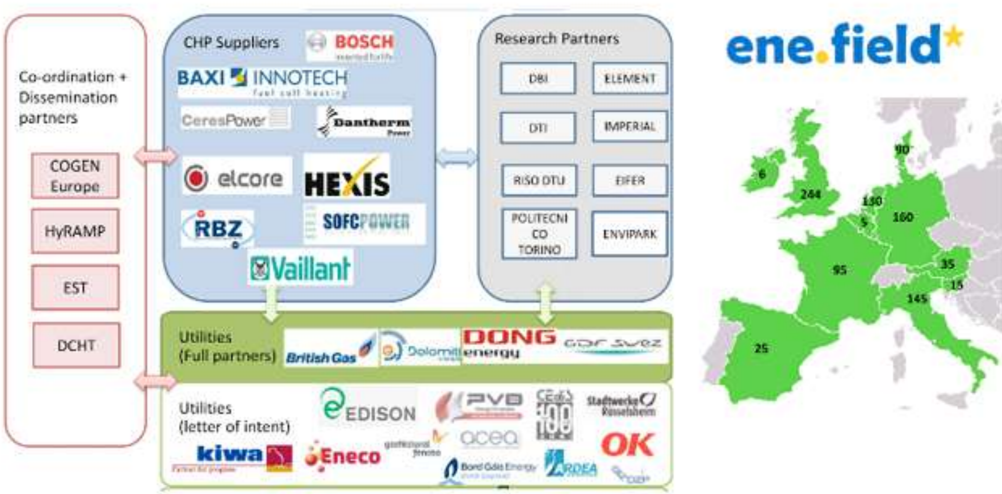
Gas Grid Issues

Recommendations – Gas Grid issues – end user appliances

- For end-user gas appliance equipment: there is no clear position on the threshold at which overall appliance design and individual component changes will need to be made to gas appliances at different concentration levels and varying legal code strategies could be applied (limit the hydrogen concentration at a specific point, eg 10vol.% or within a Wobbe index range and no change to GAR) or allow a transition to much higher hydrogen concentrations and require changes under the GAR to H2 tolerant gas appliances)
- An EU wide assessment is essential covering both the acceptable safety and operational threshold of current generation end-user appliances by main category (domestic, commercial, industrial) for higher levels of hydrogen in the gas stream in conjunction with a status quo supply chain assessment of economic impact if modifications are needed in certain categories of end-user equipment. This should be coordinated with the national initiatives underway to validate gas grid operation with significantly higher hydrogen thresholds that are being trialed (DE, FR, NL & UK) and where the impact on gas appliances is also assessed.
- CNG vehicles and CNG refueling stations: an EU wide assessment is needed to identify and assess the impact and implications of increased hydrogen levels in the gas stream and, as necessary, to identify a cost-effective alternative to gas quality modification at CNG vehicle re-fueling sites or/and for CNG cylinder specification and technical note revision. This needs also to be validated for the UK

Application 8: - small scale stationary fuel cells

Image courtesy FCHJU - ene.field project deployed some 1000 micro-chp units during the years 2012-2017



Small scale stationary fuel cells

Assessment – Small scale stationary fuel cells – legal framework

This application area deals with provisions and procedures for installation and connection of residential stationary fuel cells to the electricity and natural gas grids and to the electrical systems of the buildings - as well as the special requirements for additional equipment and professional qualification of installers. Large scale stationary power plant was not included in the HyLaw data collection and application review

- EU: The Energy Efficiency Directive 2012/27121 establishes binding measures for promotion of energy efficiency within EU and requires Member States to adopt simplified grid connection 'install and inform' procedures for micro-cogeneration units. In addition, there are provisions to ensure that the electricity grid operators in charge of dispatching the generating installations in their territory will:
    - provide priority or guaranteed access to the grid,
    - guarantee the transmission and distribution, and
    - provide priority dispatch of electricity from high-efficiency cogenerations
- UK: the domestic FC CHP system should have a CE marking ("the manufacturer of a fuel cell and its components, or their authorised representative, must ensure that the relevant EC directives are complied with; compliance with these directives is mandatory in the UK") which requires conformity with health and safety requirements set out in a number of EU directives (Pressure Equipment Directive; Low Voltage Directive; Electromagnetic Compatibility Directive; Gas Appliances Directive) and which requuires 'self certification' or via a notified body.
- There is also a British Standards: Fuel Cell Technologies. Stationary Fuel Cell Power Systems: Installation BS EN 62282-3-300:2012
- Otherwise there are no EU specific Directives or Regulations for the actual connection / installation applicable in the UK

Small scale stationary fuel cells

Assessment – for gas grid connected FC micro-CHP

- The number of installed FC micro-CHP units across Europe is still very limited
- There is no common EU framework for installation of FC micro-CHP units in the buildings or for their connection to the gas grids
- The qualification requirements for installers entitled to connect stationary fuel cells to the electrical systems of the buildings are similar. In general, the installations can be performed by professionals with an appropriate qualification for work with electric devices
- Connections to the gas grids must be made by trained and qualified installers. In some countries, the works can be provided only by the distribution network operator, in others the gas professionals must be approved by the gas network operator
- Typically, the requirements for connection of the FC micro-CHP units to the gas grids are stipulated by the distribution grid operators. There are various regulations and standards at national level related to the gas grid connection. No harmonised EU framework in regards to applicable standards and codes is in place
- However, it is considered that there are no substantive structural barriers or regulatory gaps associated with the gas grid connection requirements and procedures. There is also no issue with qualification requirements for professionals, performing the connections of stationary fuel cells to the electrical systems of the buildings or to gas networks. There is a broad expertise with gas based heating appliances and therefore no significant operational barriers are identified

Small scale stationary fuel cells

Assessment – for electricity grid connected FC micro-CHP

- There is no common EU framework for connection of stationary fuel cells to the electricity grids
- In general, the connection procedures among partner countries require the conclusion of a connection (injection) agreements with the local/ regional electricity network operator. Each network operator has a model text for connection contract and a number of templates to be completed
- Typically, connection requirements are generalised across all types of power generating units and are not specified for FC micro-CHP systems. In some areas the connection agreement requires extensive technical documentation and even a feasibility study, which may cause additional costs and delays. The time needed for signing of a grid connection agreement vary widely among the partner countries and may take up to six months
- The qualification requirements for installers entitled to connect stationary fuel cells to the electricity grid are similar across the HyLaw partner countries. They have to be trained and certified for work with electric devices and for live e-system work at a low voltage level. In some countries, they must be additionally approved by the local network operator

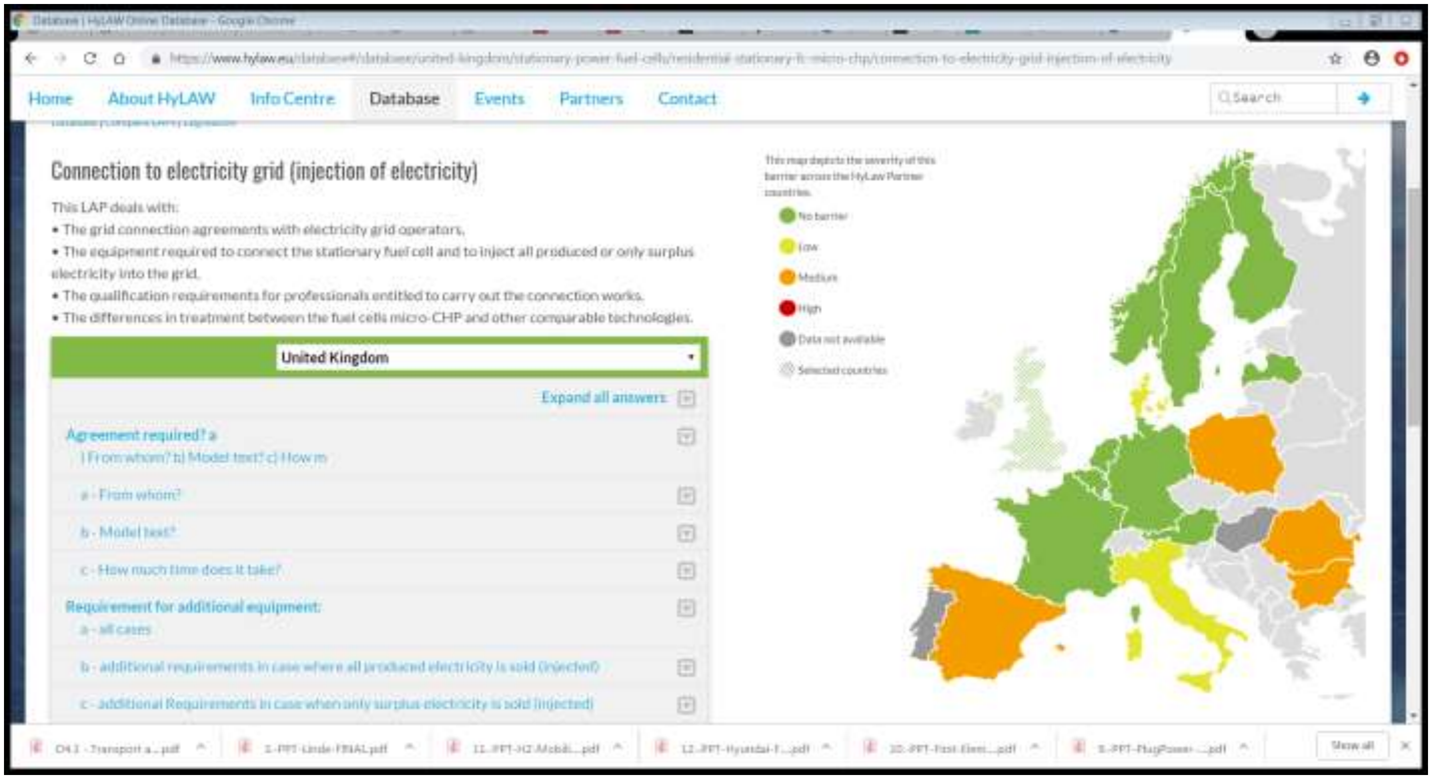
Small scale stationary fuel cells

Recommendations - Small scale stationary fuel cells

- The following recommendations have been made across the HyLaw partner coverage – and have applicability for the UK
- Develop and adapt coherent and long-term policy and legal framework for the widespread deployment of FC micro-CHP systems. Only a supportive policy and legal framework can accelerate the transition of the micro-CHP sector from an emerging technology to full-scale commercialisation.
- Fuel cell micro-CHP systems should be recognised as one of the key technologies able to deliver greenhouse gas emission reductions, energy savings, integration of renewable energy sources and smart grid solutions.
- Simplified grid connection procedures and guaranteed access to the grid for electricity produced from high-efficiency micro-CHP systems, as well as supportive measures for the produced electricity can further contribute to overcome the roll-out phase.
- In addition, the FC micro CHP systems have to be accepted as an eligible technology in the national public procurement rules for purchase of products with high-efficiency performance in the government buildings. The public sector constitutes an important driver to stimulate market transformation towards high-efficiency technologies. Buildings owned by public bodies account for a considerable share of the building stock and have high visibility in public life
- Acknowledge residential stationary fuel cells as an eligible technology under the Energy Savings obligations according to Energy Efficiency Directive

Small scale stationary fuel cells

HyLaw database – showing comparative position across partner member states for small scale stationary fuel cell connection - as either not barrier or not a significant barrier across most partners



HyLAW

Hydrogen law

Grant Agreement No 737977