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

Dennis Hayter
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Gas Grid issues and Sectoral Integration

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Gas Grid Issues covered by HyLaw

HyLaw assessed TSO and DSO gas grid operations, covering:

• **Legal framework** (permissions and restrictions) applicable for hydrogen injection
• **Permitting** process to connect/inject hydrogen
• **Payment** arrangements (for transported/delivered gas and offtake by consumers of HNG blends)
• **Gas quality** requirements (limitations on H2 levels and measurement)
• **Safety** requirements for **connection/injection** of hydrogen
• **Safety** requirements regarding all levels / types of **end-user equipment**
Headline conclusions:

- There are **fundamental** legal and administrative **barriers** which hinder the injection of hydrogen into the Gas grid due to:
  - Legal complexity or absence of Permitting rules
  - Fragmentation of approaches; using established natural gas safety measures
  - Differing H2 concentration levels
  - Structural barriers and outright prohibitions
Context:

• Regulatory framework has been drawn up around natural gas
• Quality standards are based on gas calorific value / Wobbe Index, odorant, moisture, and other gases including hydrogen
• Adding hydrogen to the gas stream would change the calorific value, flow properties, density, flame speed, and interaction with pipeline materials – impacting:
  • Pipeline operational safety (materials and compressors, valves, etc)
  • Pipeline capacity (higher gas volume to meet required kWhrs)
  • Gas flow metrology (ISO 6976 as amended)
Hydrogen injection - legal framework

Context:

- charging and payment terms (gas shippers and domestic / industrial gas consumers)
- safe/efficient operation of domestic, commercial and industrial end user equipment (typically configured for a CV range)
- Network safety and operational procedures managed at the national level, but with overarching EU standards for gas appliances.
- Widely varying national limits for hydrogen concentrations in the gas grid
### Hydrogen injection (Permissible level)

<table>
<thead>
<tr>
<th>Legal framework ‘Acceptable’ H2 level (typically mandated by legislation)</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘<strong>Minimal</strong>’ H2 concentration at <strong>0.1% to 0.5% vol</strong> ⋆ (reflecting typical background concentrations in natural gas):</td>
<td>IT, LV, SE, UK</td>
</tr>
<tr>
<td>‘<strong>Low</strong>’ H2 concentration at <strong>1.0% to 4.0% vol</strong></td>
<td>FI, AT</td>
</tr>
<tr>
<td>‘<strong>Mid</strong>’ H2 concentration at <strong>6.0% vol</strong></td>
<td>FR</td>
</tr>
<tr>
<td>‘<strong>High</strong>’ H2 concentration at <strong>up to 10.0% vol</strong> ⋆ 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)</td>
<td>DE</td>
</tr>
<tr>
<td><strong>No formal H2 concentration rules but based on safety limits with reference to natural gas operations</strong></td>
<td>BE, BG, DK, ES</td>
</tr>
</tbody>
</table>
Hydrogen injection (Permissible level)

- There is a considerable variance in rules and procedures, where injection is actually allowed:
  - In some cases a requirement to blend down to a legal limit or safety dictated level prior to injection
  - Or in some cases to allow up to a full 100% hydrogen on injection (DE)
  - This though is acceptable only on the basis that a homogenous mixture can be achieved in a short distance (mixture in free–jet)
Hydrogen injection (Permissible level)

• No arrangements in place right now for amending hydrogen thresholds to meet energy sector de-carbonisation objectives

• However, a review of gas regulations in relation to gas grid hydrogen composition is underway in a number of MSs (BE, BG, FR, DE, IE, LV, UK)

• A number of gas network TSO and DSO operators are also carrying out work to understand wider implications of H2 addition (ES, NL, UK)
Status: H2 injection Permitting is typically considered on a case by case basis and with the involvement of multiple entities involved in the process.

Outcome: P2G plant are installed and operated on a time limited demonstration basis only, or ‘by exception’, such as the recent exemption given to the HyDeploy project at the University of Keele (UK).

This is not sufficient to provide a sound framework to create a business case for widespread P2G operation (or power-to-hydrogen for grid balancing and power-to-power for re-electrification).
Hydrogen injection (Conclusion)

There are **fundamental structural and operational barriers** that severely constrain, or prevent, permitting for grid connection for H2 injection:

- Divergent H2 concentration levels in the gas grid overall (transport & delivery)

- Divergent H2 concentration levels at injection level (pre-mixing or not)

- Fragmentation of the gas market and problems of ‘acceptability’ at international gas network connections as a barrier for the future.
Hydrogen injection (Conclusion)

- Transport, supply contracts, and billing arrangements are based on calorific value/Wobbe Index

- Adding H2 volumes to cross border gas flows would change calorific value and potentially the rejection of the gas flow unless agreed (under Intergovernmental Agreements) in advance

The framework for permitting Power to Gas (P2G) plant and grid connection/injection requirements between the hydrogen supplier and the gas grid operators should be included within relevant EU regulatory frameworks to ensure comparable treatment across the EU.
Recommendations

• Review technical and gas composition rules to establish legal pathways to support Power-to-Gas operations and increased hydrogen use in transmission and distribution gas networks

• A coordinated EU wide review of the safety and technical integrity limitations for hydrogen connection and injection into the gas grid
Recommendations

• **Link to initiatives** where significantly higher hydrogen thresholds that are being trialed (DE, FR, NL & UK)

• An **EU-wide basis for injection of H2 into the gas grid** should be a priority to ensure a ‘level playing field’ and the continuing operation of trans-national interconnecting gas pipelines
Payment issues

• There’s no payment framework in place for hydrogen transmission, covering connection fees and charges, or covering remuneration for hydrogen supplied/injected

• Payment (cost allocation) and tariff arrangements are typically based on conventional natural gas flows,

• As long as there are no pricing principles in place for otherwise regulated gas networks then P2G systems have no clear business case justification basis and may not proceed beyond demonstration projects.
Payment issues

There is an exception: Germany has a H2 Payment framework:

- **Hydrogen** and SNG fall under the definition of biogas, subject to the condition that they primarily originate from renewable energy sources

- Payment privileges/incentives are applicable only for the injection of renewable hydrogen and synthetic methane.
  - No feed–in costs
  - Grid connection costs borne by network operator: 75%, and by the connecting party (hydrogen supplier): 25%
  - For a connecting pipeline of ≥ 10 km the cost is borne 100% by the connecting party (hydrogen supplier).
H2 Quality requirements

• The calorific value of the gas measured in kWh is the consistent basis for billing gas (as transmission charge through and as remuneration payment for gas supplied to a customer)

But there’s no consistent framework for managing H2 injection and measuring gas quality conformity for HNG blends:

A consistent approach to managing and measuring HNG gas quality is necessary to avoid local barriers to P2G
H2 Quality requirements

• Selective stipulation of local/national arrangements for managing and measuring HNG gas quality based on unique measurement device equipment or/and use of selective local third party services would be a barrier to open gas market entry and block P2G activities.

• Note though that there is a legal obligation to check gas quality and if there is no calibrated hydrogen content measuring system (process gas chromatograph) installed for the local grid, the hydrogen content must not exceed 0.2 Vol.%.
Safety Requirements

• There’s no substantive body of experience on pipeline safety issues and additional requirements for injecting / carrying hydrogen rich gases in the gas grid

• Work to identify and address safety related aspects of H2 facility operation and transport of H2NG blends is underway in some countries (ES, NL, UK)

• The acceptable safe threshold for H2 addition will depend on pressure, the materials used, and the design of the pipeline equipment
Safety Requirements

• National approaches to managing gas safety and compliance requirements for grid connection and grid operation vary

• Studies on the risk associated with using hydrogen up to 100% by volume in a domestic dwelling have started:

  • (UK HyHouse case study) with extensive further work currently underway (HyDeploy, HyNet, Hy4Heat, Leeds21)
• A higher hydrogen composition means a change to gas calorific value, flame combustion properties, and heat characteristics for gas burning appliances

• Modification to, or replacement of, end-user gas equipment may be necessary for safe and efficient operation

• This is potentially ‘market critical’ - the current EU stock of domestic, commercial and industrial gas appliances is 470 million and growing (30 million+ units sold annually)
End user appliances

- Studies indicate that up to 10 vol% (DE) or up to 20 vol% (UK) of H2 addition could be used in modern gas appliances without adaptation of appliances

- The UK HyDeploy programme includes a trial to establish the potential for blending hydrogen up to 20 vol% without widely impacting end user equipment

- Experience of successful previous change from high H2 concentration to low H2 concentration in the early 1970's (e.g. Town Gas to North Sea Blend) – at relatively low cost and minor disruption (but only 44 million appliance units in the UK)
• An EU wide end user appliance assessment is essential:
  • Define the acceptable safety and operational threshold of end-user appliances (domestic, commercial, industrial)
  • Make a status quo supply chain assessment of economic impact if modifications are needed
  • Coordinate with the national initiatives to validate gas grid operation with significantly higher hydrogen thresholds (DE, FR, NL & UK) and where the impact on gas appliances is also assessed.
• GAD/GAR revision to allow (a transition to) higher hydrogen concentrations and changes under the GAR to H2 tolerant gas appliances
End user appliances – CNG vehicle fueling

- Potential conflict with the gas composition required for fuel supply to CNG vehicles (there are 3,351 CNG stations and 1,316,00 CNG powered vehicles in the EU)

  - H2 limit is max 2% due to restrictions for CNG vehicles according to UNECE regulation R110
  - German DIN 51624 has a threshold of up to 2 Vol.-% hydrogen for the vehicle fuel CNG.
  - If a CNG fueling station is connected to the respective part of the gas grid, the admissible hydrogen concentration for that local grid must not exceed 2 Vol.-%
  - Thereby the low H2 concentration where CNG stations are located acts as a local barrier to PtG
Next Steps for HyLaw?

Can / should we look deeper into this category?

- Formal and widely accepted definition of PtG
- Address safety concerns of H2 against natural gas
- Technical and gas quality issues for injection and use of hydrogen in EU gas networks
- Payment and tariff arrangements
- Need for gas appliance modification
- Implications for CNG vehicles (and CNG tanks) with a higher hydrogen content gas
Thank you