**Critical Analysis Report of Hydrogen Application for Domestic Heating**

 **Author: Anas Ali**

1. **Abstract:**

30% of the world's total energy consumption originates from the building sector. Building energy use is responsible for 28% of all energy-related CO2 emissions. Hydrogen has the potential to accelerate the transition to green and renewable energy. The integration of hydrogen into domestic and industrial heating applications could be a breakthrough. In many large heating markets, hydrogen would likely need to cost between Euro 1.5 and 3.0/kgH2 to be competitive with natural gas. System safety, effectiveness, and environmental performance should be ensured by rigorous testing. A whole new distribution network needs to be established to replace the existing one. Higher upfront and running cost could be major challenges to develop consumer interests. It must compete with the existing and developing renewable energy systems as well. For a green and eco-friendly environment, Hydrogen without any doubts could be a reliable solution owing to its abundance and ease of production. But its applicability on a large commercial scale has some serious challenges including storage, distribution, and upfront cost management. To realize the potential for hydrogen usage in buildings and transition to the use of low-carbon hydrogen, policymakers, business leaders, and investors will need to work together. Consumers and the equipment service industry will also need to be more actively involved.

1. **Introduction:**

 The increasing environmental concerns and rapidly deteriorating fossil fuel resources demand a transition to sustainable, renewable, and eco-friendly energy resources. Hydrogen has the potential to significantly accelerate the process of ramping up green and renewable energy. The integration of hydrogen into domestic and industrial heating applications could be a significant technological breakthrough. 30% of the world's total final energy consumption originates from the building sector, with about three-quarters going toward cooking, hot water generation, and space heating. Building energy use is responsible for nearly 28% of all energy-related CO2 emissions worldwide. It is difficult to replace current heat sources with low-carbon alternatives and to decrease heat demand by making buildings more energy efficient. Blending hydrogen with natural gas or producing pure hydrogen from renewable sources are two ways that hydrogen could help with the energy transition. Currently, only 20% hydrogen-natural gas blend boilers are commercially available. The availability of 100% pure hydrogen boiler faces many challenges and is yet under the development stage.

1. **Current Development:**

 **Production:** The two main feasible low carbon hydrogen production options are:

* **Electrolysis Route**
* Acid Electrolysis - Alkaline Electrolysis -High Temperature Solid Oxide Electrolysis
* **Reformation Route**
* Steam Methane Reforming -Auto-Thermal Reforming -Gas Heating Reforming

**Commercial Technology:** Until this day only 20-80% hydrogen-natural gas blend boilers are available in market. This technology requires a little modification in currently available boilers. As hydrogen has high energy value per kg as compared to natural gas and result in high flame. The boilers need to be modified with a flame controller. The developments are on going for commercial applicable 100% hydrogen boilers.

**Transmission & Distribution:** Transporting hydrogen through pipelines, storage tanks, and cylinders is a crucial system-level consideration for transmission and distribution.

* **Cylinders & Storage Tanks**: This methodology is currently utilized for hydrogen distributions. It demands significant safety and environmental precautions. Hydrogen can be stored as liquid, cryo-compressed gas or highly compressed gas.
* **Pipelines**: For the mass scale distribution hydrogen can be injected directly into existing natural gas pipelines. Transporting hydrogen through pipes requires a greater volumetric flow than natural gas, as the energy content per unit volume is around a third that of natural gas. Therefore 6% by volume hydrogen can be injected directly into existing natural gas pipelines which is sufficient for current blend boilers. But for 100% pure hydrogen a separate pipeline network needs to be established.

**Cost:** The projected total residential cost of converting to hydrogen per property is between **£3,000 and £4,000** according to various research. Cost of heating appliances, cost of replacing hobs, ovens, or other gas appliances, cost of pipework, and labour costs are major considerations. The upkeep of current heating equipment will not cost anything more when 20% hydrogen blend is used. 100% Hydrogen boilers are anticipated to require more maintenance than a typical condensing gas boiler.

1. **Demand & Scope:**

 Cost-wise, it makes the most sense for district energy networks and rather big commercial buildings or building complexes to use 100% hydrogen in buildings via fuel hydrogen boilers. When combined with hydrogen, fuel cell and cogeneration technologies could be employed in district energy networks to improve power system balancing year-round, prevent significant seasonal peaks, and increase grid flexibility. Those district energy options, when coupled with large-scale heat pumps, could also significantly improve the overall effectiveness of heat production for buildings.

The possibilities for hydrogen conversion in the longer future will depend on several crucial elements, primarily hydrogen price and technology cost, for the larger buildings market, particularly for residential construction. In many large heating markets, hydrogen would likely need to cost between Euro 1.5 and 3.0/kgH2 to be competitive with natural gas.

1. **Challenges:**
* System safety, effectiveness, and environmental performance should be ensured by rigorous testing.
* A whole new distribution network needs to be established to replace the existing one.
* Higher upfront and running cost could be major challenges to develop consumer interests.
* It must compete with the existing and developing renewable energy systems as well.
1. **Conclusions:**

For a green and eco-friendly environment, Hydrogen without any doubts could be a reliable solution owing to its abundance and ease of production. But its applicability on a large commercial scale has some serious challenges including storage, distribution, and upfront cost management. To realize the potential for hydrogen usage in buildings and transition to the use of low-carbon hydrogen, policymakers, business leaders, and investors will need to work together. Consumers and the equipment service industry will also need to be more actively involved.

1. **References:**
* Iea. (n.d.). *The future of hydrogen – analysis*. IEA. Retrieved November 30, 2022, from https://www.iea.org/reports/the-future-of-hydrogen
* Castek, R., & Harkin, S. (2021, September 1). Evidence review for hydrogen for heat in buildings. Retrieved November 30, 2022, from https://era.ed.ac.uk/handle/1842/37964