PRESIDENTIAL
CLIMATE COMMISSION
TOWARDS A JUST TRANSITION

Green Hydrogen Dialogue Report

A PRESIDENTIAL CLIMATE COMMISSION ENERGY DIALOGUE REPORT

Thursday, 20 October 2023 11h00 – 13h00

This report is a high level summary of the virtual energy dialogue on green hydrogen, the full recording to the energy dialogue and presentations can be found on the PCC website.

The green hydrogen dialogue took place in the wake of the South Africa Green Hydrogen Summit that took place in Cape Town and soon after the parliamentary adoption of the Green Hydrogen Commercialisation Strategy (GHCS). This is an indication that government is looking to pursue green hydrogen as an economic sector and is committed to the development of this sector. Equally important are the concerns raised by the stakeholders, in particular civil society on the role of green hydrogen, the consultation process, the worker implications and job creation potential and how justice is going to be embedded in the development of this sector.

Procedural Justice

Following a request from stakeholders who attended the dialogue, the Presidential Climate Commission (PCC) has uploaded the documents and presentations that were referenced on the PCC website. The approved GHCS is available on the Industrial Development Corporation website; it has been made available eon the PCC green hydrogen energy dialogue webpage for reference purposes.

Moreover, stakeholders, in particular civil society were concerned about inclusivity and the need for meaningful consultation approaches. Additionally, communities should not only be consulted but also included in some of the decisions pertaining to project inception, use of land and their role in this development. As such, stakeholders made recommendations for a socio-economic framework for green hydrogen development.

Policy landscape

Government is making progress and working together across the various departments to forge ahead with regards to green hydrogen (low emissions and renewable hydrogen) development. This sectoral strategy is necessary, especially for a sustainable net zero economy and the emissions reduction of hard to abate sectors. Figure 1 provides an overview of the governments pathway and milestones achieved towards just industrialisation and the integration of green development.

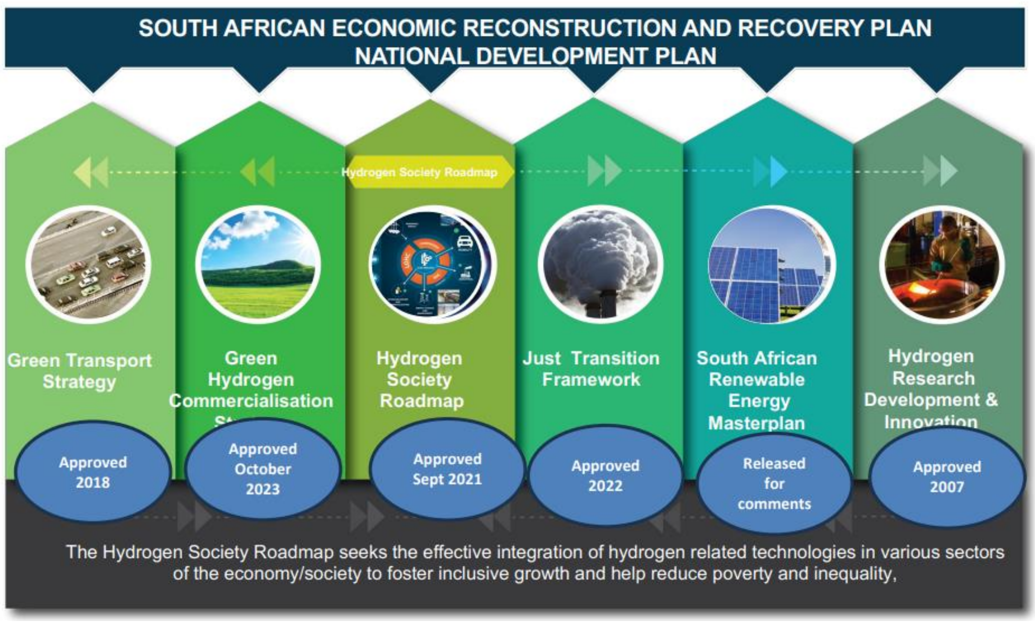


Figure 1: Overview of policies to support the green hydrogen economy[1]

[1] Maserumule, R. 2023. “Hydrogen Economy”. [Online] Available: https://www.climatecommission.org.za/events/green-hydrogen-dialogue [Accessed 09/11/2023]

The net zero economy has created quite a demand for green hydrogen. Therefore, the coordination within government and policy alignment is critical to enable the move towards a collaborative and complementary approach. This will benefit infrastructure development and maximised use thereof. Further, stakeholders noted the need to have strong policy implementation and enforcement, as failure to do this results in lack of progress.

The Green Hydrogen Value Chain for South Africa

Green hydrogen development is a market driven commercialisation determined by future markets that are being created between heavy emitters of the north and countries that have significant production potential. Green hydrogen at scale is being developed for export as these projects have a market and there is a premium provided to early movers as some countries will not be able to reach their net zero commitments should they not employ green hydrogen. Further, South Africa has a structural competitive advantage in the production of green hydrogen because of its expertise in the use of the Fischer Tropsch process. This has benefits for South Africa as an exporter and it also yields industrialisation and infrastructure build opportunities.

Figure 2 provides an overview of the green hydrogen value chain and its applications in South Africa. This also shows the domestic market potential in South Africa, however, the social partners will have to be educated on green hydrogen and where it is best to apply it. For example, the global transport sector is largely heading towards battery power and not green hydrogen for passenger vehicles. However, the industries such as mines can use green hydrogen in their mine haul trucks. Moreover, green hydrogen will support the future sustainability and net zero commitments of hard to abate sectors.

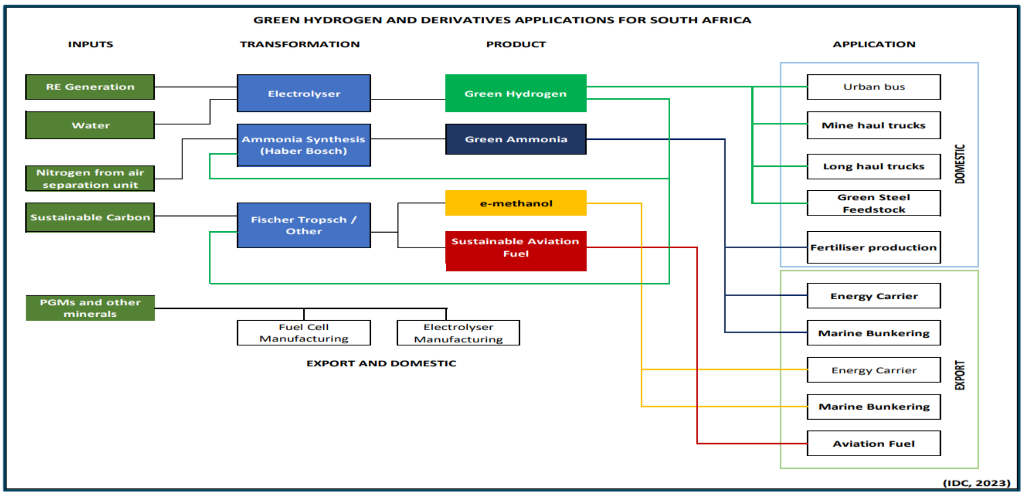


Figure 2: The green hydrogen value chain for South Africa[2]

The overall objectives of this industry were questioned and whether they address the principles of restorative justice, distributive justice and the redress of individuals and disenfranchised communities. As such, there were strong recommendations for industrialisation strategies that respond to the unique conditions of South Africa and its locals. Developers are tasked with delivering a project that is bankable, commercially viable and inclusive.

[2] Rooplal, M. 2023. "Green Hydrogen Commercialisation in South Africa". [Online] Available: https://www.climatecommission.org.za/events/green-hydrogen-dialogue [Accessed 09/11/2023]

Skills Requirements

The green hydrogen industry presents a new opportunity for South Africa, and this will also require new skills sets and the reskilling and upskilling of some existing skills sets. Skills is a key enabler for the industry and the skills required have been listed in the GHCS. In addition to this, the Department of Higher Education and Training (DHET) is working on a skills strategy which will inform the occupations across the value chains. Furthermore, the SETAs (EWSETA, CHIETA & TETA) have signed a MOU to work in collaboration towards skilling initiatives for green hydrogen.

Project Pipeline and Financing

Developing the green hydrogen sector will require coherence from government, industry, academia, and government. Coherence will foster international cooperation and potentially increase the number of projects reaching final close. This is important because green hydrogen can pay for some of the infrastructure that is required (for example transmission grid) and enable other projects to feed into the grid. Thus, green hydrogen will not be producing its own energy and will not compete with current electricity shortfall but can feed back excess energy into the grid.

Environmental Health and Safety

Stakeholders raised several concerns pertaining the safety of green hydrogen, its transportation and safety related to ammonia. With regards to regulatory issues in-terms of health and safety of green hydrogen, hydrogen is a gas that is currently being used in South Africa, one of the differences is that it is now being moved to the energy sector and might require new safety standards for each sector.

There were also concerns about the water intensity of green hydrogen production. Whilst green hydrogen will require significant quantities of water for production, the overall demand will be about 0.5% of the country’s water demand and desalination process will also be utilised.

Conclusion

Lastly, stakeholders who attended the energy dialogue were engaged and asked many questions which all could not be addressed during the dialogue. Therefore, the next section of this document includes appendices of compiled responses questions posed during the energy dialogue and we have asked for input from experts who participated in the dialogue and others. However, we will continue to build the information repository on green hydrogen and make efforts to provide more information and updates to the responses should there be additional information.

Appendix A: Energy dialogue – Responses to questions

Focus Area	Question	Response
Economic Development	What are the financial enablers for high-value SMEs in green hydrogen development?	Key to SMEs enablement is to partner with the large projects to enable offtake of SME products / services and thereby create a co-dependency between large projects and SMEs.
Environmental Health and safety	What are the cumulative impacts of storing hydrogen at ports? Will hydrogen be stored at ports?	It is not easy to store hydrogen, but hydrogen derivatives, like green ammonia, green methanol, green steel, or green kerosene, will be stored at ports. The energy density is high, so the storage does not have enormous environmental impact. There are safety risks involved, but these are known risks, as ammonia/methanol/kerosene have all been around and have been well mastered without incidences for many years. As a sidenote: hydrogen is a gas and highly compressible, so the storage happens across the entire value chain, but in particular in the pipelines ("line packing"). Several days or weeks of production capacity can be stored in the pipelines that way.
Export market	Is there an export market for green hydrogen and who are the potential off takers?	The export market is developing. Chile and Australia are front-runners, each wanting to leverage their solar and wind resources for renewable energy global super-power status. South Africa has similar resources and capability. Currently, the main market for Green Hydrogen is export, specifically the EU, Far East and the US, due to their progressive stance on climate change. (and lack of internal resources to generate green Hydrogen for their internal offtake markets). The EU, in particular, will make incentives available to countries and companies that can help them meet their carbon-neutral objectives. These incentives make it possible for countries and companies, like ours to develop the product, while catalysing local markets as well.

	Will the SA western coast be set up as the premier export environment or will there be multiple routes that incorporate existing infrastructure such as the routes present in the East Coast?	Multiple hubs have been identified in the GHCS including Western Cape and Eastern Cape amongst the others. We see a combination using existing infrastructure (such as the Eskom network) together with setting up an 'Export environment'. Going further, this can be expanded into e.g., a Green Hydrogen / ammonia pipeline network, not only for the West Coast (including Namibia), but a strategic pipeline network across the country to different hubs, and even to our Eastern ports.
Impact studies	Will an impact assessment study be done to determine ecosystem threats and impacts to indigenous people and ecosystems?	An EIA and impact assessment must be done for all projects of this nature, so as to quantify impacts and risks, with associated mitigation strategies.
Project Development	Is there an indication of the number of projects that reach financial investment decision and what can be done to increase this number?	This will be detailed in the JET-IP updated document when released to the public. (Further explanation is provided in Annexure B)
	Has the potential to develop green hydrogen in existing mining areas on the west coast been explored as opposed to green field development?	We are not aware of a project looking into this, but this is something we will look into.
	What are the opportunities for green hydrogen projects?	This is detailed in the GHCS and attached presentation. Key opportunities are re-industrialisation, infrastructure build, decarbonisation of hard to abate sectors (steel chemicals, transport), assist with renewable power in the grid by increasing grid stability, addressing the commercial market and opportunity to support the JET with proactive socio-economic development. Lastly low emissions and renewable hydrogen can improve South Africa’s balance of payments if the country is able to export hydrogen and ammonia to other parts of the world.
	What are the challenges associated with scaling up projects?	Challenges are infrastructure required to move green hydrogen is not readily available, green premium, awareness, high transportation cost of green hydrogen, confusion about water requirements, need to large amounts of RE, policy alignment and funding requirements. Trade is hindered by the lack of harmonized certification of environmental attributes of low-emission and renewable hydrogen. This barrier could be overcome with increased international cooperation and the mutual recognition of certification schemes.

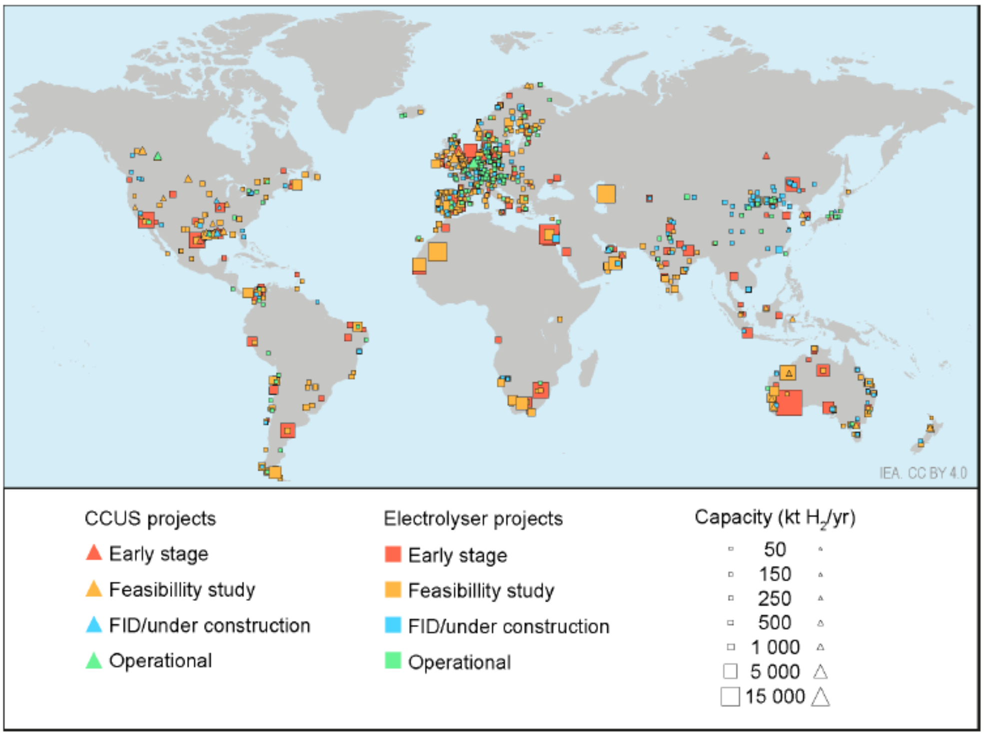
	What mitigation measures are being out in place to mitigate project failure risks?	Project risk management and all hazardous studies are a minimum requirement from all projects.
	Is it necessary for developers to specify their target market for project proposals (e.g., local versus international)?	Yes, as this is crucial in the bankability stage, to show investors the volumes required by off-takers. Bankability stage needs a power-purchase agreement or similar between producer and client/off-taker. This will be necessary, yes. Yes, the business cases are very specific. At least for a duration of 10-15 years, each project needs to have secured binding offtake, lacking which an investment decision is impossible. Some business cases target domestic decarbonization, such as safari lodges that would benefit from H2-powered vehicles, some target international decarbonization, such as the sale of green ammonia to a company operating in Germany, and some of mixed case, with offtake both domestically and international, such as the greening of the Secunda refinery or the Saldanha steel. Over time, the hard to abate sectors (heavy industry) will be relocating to where the hydrogen is cheapest, such as South Africa and Namibia.
Skills	Will the subject of green hydrogen be incorporated into the school curriculum?	At this stage we are not sure how information will be incorporated into school curriculum. We are aware that a revision by Basic Education is underway which will include a lot more on climate change and hopefully just transition.
	Are there plans/strategy for upskilling and reskilling workers to be part of the GH2 transition?	The DHET is working on a skills strategy which will inform the occupations across the value chains. The SETA (EWSETA, CHIETA & TETA) have signed an MOU to work in collaboration towards skilling initiatives for Green Hydrogen.
Skills & Economic Development	How is the GHCS addressing skills and economic development?	This is an integral part of the project development. Projects will need to show contribution to both community development and overall macroeconomic development. Skills development actions plans are detailed in the GHCS. Projects will also need to provide on the job skills training.

Waste Management	Does the GHCS make considerations on how to deal with end products like fuel cells?	Both the Hydrogen Society Roadmap and the GHCS include catalytic projects which support the domestic use of hydrogen. Fuels cells are identified as an important equipment in the value chain both for local production and for end uses in transport and power generation. The Hydrogen Valley includes the use of green hydrogen through nine catalytic projects. The nine catalytic projects in the use of low emission and renewable hydrogen in heavy duty trucks in mines, material handling at airports, powering public buildings and data centers, use of hydrogen and feedstock in chemical production as well as the use of hydrogen for fuel cell electric buses to support the decarbonization of public transport.
Water use - Desalination	Some hydrogen development process uses a desalination process, how does the desalination process deal with brine release, especially with the proposed 300% brine?	Careful consideration is made and planned for during this process. Brine can be released in specific areas with minimal impact, OR can be re-used for e.g., salt production. This needs careful planning during the early stages of the project. Developers have to take this into account, especially with consideration for the potential environmental impact.

Appendix B: Additional Response – Bankable projects

Is there any indication of the total number of projects that reach final investment decision and what can be done to increase these numbers?

Globally the number of projects which are announced for low emissions and renewable hydrogen continues to grow. Political support for the hydrogen economy is growing with just over 40 countries having announced hydrogen strategies with a few revising earlier versions. Annual production of low-emission and renewable hydrogen could reach just under 40 Mt by 2030, if all announced projects are realized. There are three main stages to a project which include early stage which is characterized by a public announcement, followed by a detailed feasibility study and then the final investment decision/under construction before a project become fully operational. Based on analysis conducted by the International Energy Agency only 4% of projects which have been announced have reached a final investment decision. Outlined in the table below is a schematic which shows projects globally including where they are in the cycle (Source: IEA Projects database).



There are many reasons why projects globally have not reached the final investment decision such as:

- Inflation is increasing capital and financial costs, threatening the bankability of projects across the entire hydrogen value chain, which are highly capital intensive.
- Governments have started to make funding available to support the first large-scale projects, but slow implementation of support schemes is delaying investment decisions.
- Electrolyser manufacturers have announced ambitious expansion plans however uncertainty for the demand is leading to a delay to these expansion plans.

Appendix C: Additional Response – Hydrogen at ports

Are there any impacts of storing hydrogen at ports, if so, what are the cumulative impacts?

In terms of hydrogen in the ports, it would depend on a few matters. We can have hydrogen for internal use and decarbonisation, or we can have hydrogen for export.

As part of internal use, there is potential to use hydrogen as a form of energy storage from excess solar and wind energy, maybe even ocean energy. This could be used to power buildings, tugboats, pilot boats and cranes via fuel cells. There could be an option to use hydrogen directly in combustion engines (or blended with diesel), there is also the option of converting the hydrogen to ammonia or methanol and this can also be used in combustion engines, etc. The storage requirements for hydrogen, ammonia and methanol would be small as internal use would need small quantities. Therefore, the footprint of these facilities would be small, and impact would be limited to making allowances for exclusion zones to minimize any risk of explosions. These could be controlled by the installation of fencing to control access, and these facilities would need to be located in areas that would not have any impact on employees or cargo operations. Other criteria regarding impacts would need to be guided by local and international regulations and standards.

When it comes to hydrogen export, it would need to be in the form of ammonia, methanol or liquid organic hydrogen carriers (LOHC) export in bulk. Hydrogen is not able to be exported as a gas and liquifying it is very expensive. You would then typically have tank farms, pipelines and berth loading facilities to facilitate the export of ammonia, methanol and LOHC. In terms of impact in the port, this then starts to become a tricky question as you would need to do detailed hazardous and impact risk studies. Ammonia is toxic and flammable, and methanol is also flammable. Therefore, the planning and placing of these facilities in the port needs to be carefully thought through as safety would be of high priority. There will need to be exclusion zones around the facilities, you will need to check compatibility with adjacent commodity exports in the port, etc. In a nutshell, detailed planning and hazard studies would be needed to determine the impact, and these could vary from port to port.

Appendix D: Additional Response – Hydrogen leaks

What technologies are being used to detect green hydrogen leaks?

The technologies for hydrogen detection leaks are based mainly on the usage of sensors. These sensors make use the following type of detectors: catalytic, electrochemical, and thermo-conductivity detectors. There are currently various hydrogen sensor technologies that are utilized in commercially available sensors[3][4][5][6][7][8]. Several performance parameters need to be considered when selecting suitable hydrogen sensors. The main performance parameters generally considered are accuracy, measuring range, response time (90 s), recovery time (10 s), operating temperature range, operating pressure range and ambient relative humidity (RH) range.

More specifically:

There are various types of hydrogen sensors available[9]. Catalytic sensors typically contain two platinum wire coils that are connected with a Wheatstone bridge. Both coils are coated with ceramic to form sensing beads. The one bead is impregnated with a catalyst that selectively catalyses the oxidation of hydrogen. The other bead serves the purpose of a compensating bead. When a voltage is applied to the sensor, the platinum coils heat up to around 500–550˚C. When the sensor comes into contact with hydrogen, the hydrogen will oxidize on the surface, resulting in a temperature increase and increase in the resistance of the platinum wire coil. The difference between the resistances of the two wire coils, as measured by the Wheatstone bridge, is linearly related to the concentration of hydrogen.
Electrochemical sensors typically contain two or three electrodes: the working electrode, reference electrode (three electrode sensors only) and counter electrode. These electrodes are stacked parallel to each other, separated by a thin layer of electrolyte. The working electrode is also in contact with the ambient air to be measured, normally via a gas diffusion layer. These sensors essentially operate on the same principle as fuel cells. Hydrogen is

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[3] Boon-Brett, L., G. Black, G., Moretto, P. and Bousek, J., A Comparison of Test Methods for the Measurement of Hydrogen Sensor Response and Recovery Times, *International Journal of Hydrogen Energy,* **35**, No. 14, 2010, pp. 7652-7663.
[4] Holstein, N., Krauss, W., Konys, J. and Nitti, F. S., Development of an Electrochemical Sensor for Hydrogen Detection in Liquid Lithium for IFMIF-DONES, *Fusion Engineering and Design,* 2019, In Press.
[5] Li, Z. *et al.*, Resistive-type Hydrogen Gas Sensor Based on TiO2: A review, *International Journal of Hydrogen Energy,* **43**, No. 45, 2018, pp. 21114-21132.
[6] Zhang, Z., Yin, C., Yang, L., Jiang, J. and Guo, Y., Optimizing the Gas Sensing Characteristics of Co-doped SnO2 Thin Film Based Hydrogen Sensor, *Journal of Alloys and Compounds,* **785**, 2019, pp. 819-825.
[7] Tchouvelev, A. V., Associates Inc. and Hydrogen Research Institute Inc., HMII Field Tests Safety Management Prescriptives and Emergency Response Requirements, Contract no. 11-T12, 2012.
[8] Bessarabov, D, Oelofse, S., and Human, G., Underground Mining Infrastructure for Clean Hydrogen Applications: Half Year Report, HySA Infrastructure report to Department of Science and Technology South Africa, 2016.
[9] Bessarabov, D, Oelofse, S., and Human, G., Underground Mining Infrastructure for Clean Hydrogen Applications: Half Year Report, HySA Infrastructure report to Department of Science and Technology South Africa, 2016.

oxidized when it comes in contact with the working electrode. At the counter electrode, the other molecule, such as oxygen, is reduced. This results in generation of an electrical current between the two electrodes, proportional to the hydrogen concentration. The reference electrode has a stable potential from which no current is drawn. It is used to eliminate interference from side reactions with the counter electrode[48101112] [2,6,8-10]. Semiconductive metal oxide sensors have an active material, usually SnO2, which is deposited on the substrate where two metal electrodes are placed. This enables measurement of the active layer resistance, which varies due to the chemical reaction that occurs at the surface of this active layer. The optimum operating temperature of the sensor is reached by heating it, using a resistive heating element placed on the other side of the substrate[8131415].

The principle of operation of optical sensors is based on the change in a sensitivity layer following hydrogen absorption. Micromirror-based sensors detect changes in reflected light due to the absorption of hydrogen, while optical fibre hydrogen sensors may operate in two ways. They can detect a change in light transmittance across an optical fibre due to a change in the absorption coefficient and refractive index. Optical fibre hydrogen sensors can exploit a special feature, known as surface plasmon resonance. Surface plasmons are surface electromagnetic waves that propagate in a parallel fashion along a metal/dielectric interface. On absorption of hydrogen, the resulting change in resonance energy of the surface plasmons may be detected[8161718].

Thermal conductivity sensors make use of the thermal conductivity of hydrogen, which differs significantly from that of clean air. Similar to catalytic sensors, these sensors also have two inert beads, connected with a Wheatstone, which measure the difference between the resistances of these beads. The one bead is sealed off and the other is in contact with the atmosphere. Both electrodes are heated. When the composition of the target gas changes, the rate of heat loss will change. This will lead to a change in the temperature of that bead

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[10] Fernandes, T. A., Kurhe, D. K., Chavan, A. A. and Jayaram, R. V., Recovery and Reuse of Palladium from Spent Glucometer Electrochemical Test Strips, *Hydrometallurgy,* **165**, 2016, pp. 199-205.
[11] Urban, S. *et al.*, Electrochemical Multisensor System for Monitoring Hydrogen Peroxide, Hydrogen and Oxygen in Direct Synthesis Microreactors, *Sensors and Actuators B: Chemical,* **273**, 2018, pp. 973-982.
[12] Leonardi, S. G., Bonavita, A., Donato, N. and Neri, G., Development of a Hydrogen Dual Sensor for Fuel Cell Applications, *International Journal of Hydrogen Energy,* **43**, No. 26, 2018, pp. 11896-11902.
[13] Boonbrett, L., Bousek, J. and Moretto, P., Reliability of Commercially Available Hydrogen Sensors for Detection of Hydrogen at Critical Concentrations: Part II – Selected Sensor Test Results, *International Journal of Hydrogen Energy,* **34**, No. 1, 2009, pp. 562-571.
[1414] Fisser, M., Badcock, R. A., Teal, P. D. and Hunze, A., Optimizing the Sensitivity of Palladium Based Hydrogen Sensors, *Sensors and Actuators B: Chemical,* **259**, 2018, pp. 10-19.
[15] Luo, Y., Zhang, C., Zheng, B., Geng, X. and Debliquy, M., Hydrogen Sensors Based on Noble Metal Doped Metal-Oxide Semiconductor: A Review, *International Journal of Hydrogen Energy,*
[16] Kim, K.-S. and Chung, G.-S., Novel Optical Hydrogen Sensors Based on 3C-Sic Membrane and Photovoltaic Detector, *Sensors and Actuators B: Chemical,* **193**, 2014, pp. 42-45.
[17] Sharma, A. K., Pandey, A. K. and Kaur, B., A Review of Advancements (2007–2017) in Plasmonics-Based Optical Fiber Sensors, *Optical Fiber Technology,* **43**, 2018, pp. 20-34.
[18] Sharma, A. K., Pandey, A. K. and Kaur, B., A Review of Advancements (2007–2017) in Plasmonics-Based Optical Fiber Sensors, *Optical Fiber Technology,* **43**, 2018, pp. 20-34.

and its resistance. This change in resistance is proportional to the change in the thermal conductivity of the gas, which is then used to determine the hydrogen concentration[819].

Typically, hydrogen sensors rated for hazardous environments are designed for safety actions (e.g., activating emergency measures when hydrogen is detected) at concentrations of 8%. However, there is a challenge: hydrogen sensors that could accurately measure hydrogen concentrations during small hydrogen leak at the lower concentrations are required and not easily available with the good accuracy. At the green hydrogen facilities it is necessary to be able to measure hydrogen concentrations >4% in order to obtain information on the flammable hydrogen concentrations at specified distances and orientations around a controlled hydrogen leak. Thus, there are two type of objectives and purposes: alarm purpose for a leak, or accurate measurements of the leak.

There is a technology with the limited use that involve special tapes with Pd salts that change colour upon the exposure to hydrogen. In case a hydrogen leak catches a fire, UV detectors are used, as flame of hydrogen is invisible.

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[19] Struk, D., Shirke, A., Mahdavifar, A., Hesketh, P. J. and Stetter, J. R., Investigating Time-Resolved Response of Micro Thermal Conductivity Sensor under Various Modes of Operation, *Sensors and Actuators B: Chemical,* **254**, 2018, pp 771-777.