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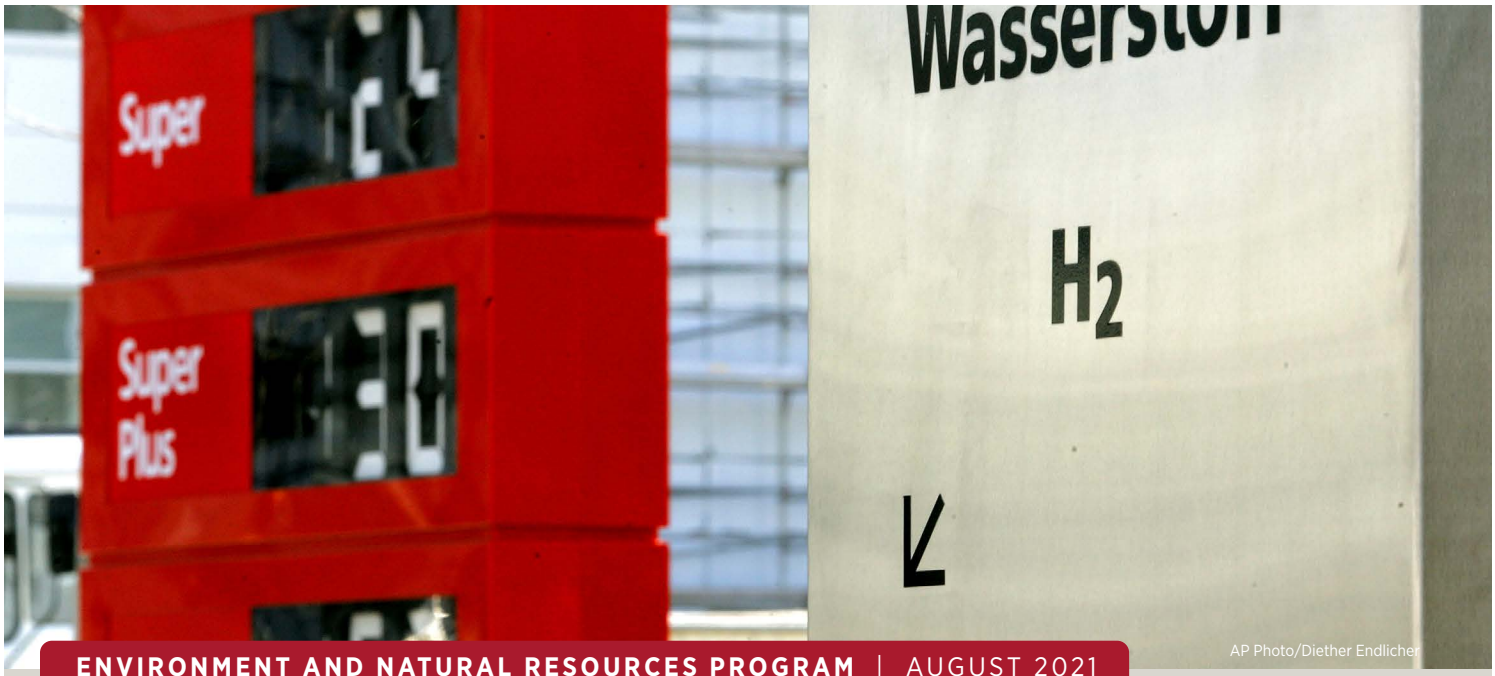

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Hydrogen Deployment at Scale: The Infrastructure Challenge

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Clean hydrogen is experiencing unprecedented momentum as confidence in its ability to accelerate decarbonization efforts across multiple sectors is rising. New projects are announced almost every week. For example, an international developer, Intercontinental Energy, plans to build a plant in Oman that will produce almost 2 million tons of clean hydrogen and 10 million tons of clean ammonia.[1] Dozens of other large-scale projects and several hundred smaller ones are already in the planning stage. Similarly, on the demand side, hydrogen is gaining support from customers. Prominent off-takers such as oil majors like Shell and bp, steelmakers like ThyssenKrupp, and world-leading ammonia producers like Yara are working on making a clean hydrogen economy a reality.

1 The Guardian (2021), "Oman plans to build the world's largest green hydrogen plant" https://www.theguardian.com/world/2021/may/27/oman-plans-to-build-worlds-largest-green-hydrogen-plant, accessed June 2021.

Despite the optimism surrounding clean hydrogen, key uncertainties remain. One of hydrogen's attractions is that it can provide carbon-free energy in multiple sectors—transport, heating, industry, and electricity generation. But this advantage also creates uncertainties. The infrastructure needed in an economy in which hydrogen is primarily used as a transport fuel is very different from one in which its primary value is as a heating fuel. Today no major hydrogen pipeline networks exist,[2] and no liquified hydrogen ships are in commercial operation. There is a true chicken and egg problem. If there is no infrastructure to move hydrogen, will investments in supply and demand happen at the pace needed to meet national decarbonization targets? This challenge raises an even more pressing question: what should be the respective roles of the public and private sectors in deploying enabling infrastructure at scale?

While market economics must be the driving force behind production and demand decisions, regulatory incentives will play a pivotal role in both shaping and deploying enabling infrastructure at scale. Realizing hydrogen's full potential will require careful policy consideration to address competing needs. It is essential to plan for the future now, since the effects of policy choices made today will be felt decades in the future. For example, building a pipeline network to deliver hydrogen to homeowners who have yet to install hydrogen-fueled stoves and heating systems would be financially disastrous. Hence, synchronizing infrastructure investments with growth in supply and demand will be essential but will be very challenging.

An ongoing debate is how hydrogen will be delivered to demand centers, or in other words, what will be the preferred energy carrier. One option would be to generate carbon-free power and transmit it to residential, commercial, and industrial users. The electricity would then be used to produce hydrogen directly onsite. This approach eliminates hydrogen transmission costs at the expense of overburdening power grids already constrained by the need to transport increasing shares of renewable energy. Another option would be to pipe hydrogen directly to customers. While not impacting power grids, this approach requires upgrading existing natural gas pipelines to allow for increasing shares of hydrogen or building new hydrogen-dedicated infrastructure.[3] Each of these options would cost billions, and each would face significant risks in the form of uncertain markets, operations, and regulatory regimes.

Countries without existing natural gas networks will need to invest in new hydrogen pipelines or upgrade their power grids. The most viable solution will depend on the required volumes and the geographical distribution of production and demand sites. In extreme synthesis, pipelines are

2 Except for limited regional pipeline systems in the United Stated and Europe owned by merchant producers serving captive markets.

3 Unless new technologies, such as membranes able to separate natural gas from hydrogen, will become available in the near future.

usually the most cost-efficient solution when volumes are large, and many demand centers are located along the pipeline route.

Admittedly, the use of natural gas infrastructure could significantly lower the overall cost of transporting hydrogen, both in terms of reduced investment in pipeline infrastructure and avoided investment in the expansion of the electricity grid. Still, a careful case-by-case evaluation is needed to determine the technical and economic feasibility of competing options together with the overall value chains implications of a transition from natural gas to hydrogen.

In the early stages, hydrogen could be blended at low percentages with natural gas in existing networks, in most cases without the need for any upgrades. However, even this approach comes with challenges and costs due to the regional nature of natural gas systems. While some networks and uses can manage higher hydrogen shares, others can deal with only limited percentages. Furthermore, from a market perspective, countries have different blending limits, significantly hindering cross-border trade opportunities. In later stages, either new infrastructure or the widespread conversion of existing gas networks and end uses (industrial, commercial, and residential) to pure hydrogen would be required.

But herein lies the ultimate challenge of operationally managing the final step in this conversion process. It is a never-addressed point that reiterates the importance of solid policy guidance for a hydrogen economy to fully take off: the conversion to pure hydrogen would require all end uses in the distribution zone —including residential appliances— to be ready almost overnight. However, how this process should work from an operational point of view is unclear. What is clear, though, is that the public and private sectors will need to coordinate their activities at the planning, financing, and implementation stages.

From a global market perspective, governments will need to proactively synchronize national regulatory regimes so that hydrogen can flow between countries. Within countries, regulators and policymakers will need to address key challenges, such as:

- how to define the regulatory regime, ownership, and sharing of enabling infrastructure
- how to incentivize customers to install new uses, compensate for rendering existing equipment worthless, and handle conflicts of stakeholders not cooperating in the transition
- how to synchronize demand ramp-up, production build-out, and infrastructure availability, especially given that natural gas demand might not decline complementary to hydrogen rise
- how to ensure uninterrupted energy supply to end-users, particularly residential consumers, during the transition process

To stimulate the needed investments from the private sector, policymakers and regulators will need to create a leveled playing field with clear market structures and regulations, recognizing the pros and cons of all alternatives and a concerted effort to synchronize investments in supply, demand, and infrastructure. Only in this way can we avoid replicating the system-wide inefficiencies which characterized regional approaches to the deployment of new energy infrastructure.

This policy brief is the fourth in the Mission Hydrogen series, a collaboration with the Italian Institute for International Political Studies (ISPI) on the future of hydrogen for the G20.

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