10 February 2017

NIA Call for Evidence
National Infrastructure Commission
11 Philpot Lane
London
EC3M 8UD

Dear Sir/Madam,

The IET's response to the National Infrastructure Assessment Call for Evidence.

The IET is Europe's largest professional engineering and technology organisation. The members represent a wide range of expertise, from technical experts to business leaders, encompassing a wealth of professional experience and knowledge.

We have responded to the National Infrastructure Commission queries on Transport, Energy and Digital Communications for the National Infrastructure Assessment, call for evidence. This response has been compiled on behalf of the IET Board of Trustees by the IET’s Policy Panels.

If the IET can be of any further assistance please do not hesitate to contact me.

Yours faithfully,

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The IET welcomes the establishment of the new National Infrastructure Commission (NIC) established with the intention to provide an “unbiased analysis of the UK’s long-term infrastructure needs.” Coupled with a renewed interest in an Industrial Strategy, the establishment of the NIC indicates government willingness to invest in large infrastructure projects.

2. How should infrastructure most effectively contribute to the UK’s international competitiveness? What is the role of international gateways for passengers, freight and data in ensuring this?

Communications

- International competitiveness must be examined through the balance sheet of the nation, where changes over time are measured. Better use of data reporting and reuse of data must be encouraged with a review with ODI, ONS and all the UK regulators on how data can be opened up for innovation and investment.

- Digital development also allows more efficient use of resources. This is widely accepted in the energy field (i.e. the use of smart meters). UK should benchmark itself against other leading countries. Ofcom does this well for Communications but rarely acts on it as there is a lack of commitment from central government; this needs to be addressed. A provision of suitable bandwidth and latency is also necessary for competition in infrastructure.

Transport

- Fifteen percent of the cost of goods is to cover transportation cost. A more efficient transport infrastructure to reduce congestion will reduce prices, increasing the UK’s international competitiveness.

- Roads are congested, especially at certain times and locations, including rush hours in towns and cities, and motorways at Bank Holiday weekends. The congestion is estimated to cost £20Bn-£50Bn per year in the UK, and ten times this in Europe as a whole and in the US.

- There is also insufficient funding for road maintenance. As a result the national and local infrastructure is deteriorating. Road pricing technology is proven and is in use world-wide (although not on a national basis). Road building combined with efficient pricing would result in a higher economic return because mobility would be enhanced while congestion is reduced. The extra capacity would reduce the price needed to contain congestion and travel by car would be affordable for more people on lower incomes.¹ Air pollution can also be addressed by road pricing, as in the London Low Emission Zone and the proposed Ultra-Low Emission Zone.

Infrastructure needs to be seamless in terms of allowing passengers and freight to travel safely from where they are to where they need to be as efficiently as possible. Efficiency can be determined by:

- The cost (of travel and to the environment).
- How quickly the journey can be made (important for perishable goods, some people and some non-perishable goods).
- The smoothness of transition from one travel mode to another (especially if a person is frail or travelling with heavy baggage).
- The provision of data from which informed travel choices can be made for people and freight.
- The actual or perceived risks associated with the travel (i.e. does a parent allow a child to walk/cycle/use a bus to travel to school or is the risk too great so they take them themselves. How do they do this keeping time efficient?).
- International gateways should be better integrated internationally to ensure seamless onward travel.
- Gateways (international and domestic) are essential in fulfilling smooth transition from one travel mode to another for passengers and freight. Data gateways are essential to make sure informed travel choices can be made for people and freight.
- Freight gateways (consolidation centres) are in their infancy but at present not much has been done for the passenger.
- International gateways, especially for road freight, are also good points at which to detect foreign and potentially polluting vehicles entering the UK.

3. How should infrastructure be designed, planned and delivered to create better places to live and work? How should the interaction between infrastructure and housing be incorporated into this?

- Digital connectivity is of critical importance for promoting economic growth whilst planning national infrastructure. Good broadband connections can facilitate economic development in rural areas, lessening the need to commute. The House of Commons Scotland Affairs Committee noted that: “Access to broadband is an important issue far beyond its impact on the creative industries, but we have heard that poor internet access is a particular barrier to creative enterprises in rural Scotland. It is essential the UK and Scottish governments work together to ensure the successful rollout of broadband across Scotland.”

- The development of Ultrafast Broadband will drive development opportunities in regions where the uptake is fastest. Mobile phone coverage varies widely within the UK and must be tackled to sustain 5G, which will facilitate innovations in Autonomy and Internet of Things (IoT), making time more efficient and freeing up people’s time.

4. What is the maximum potential for demand management, recognising behavioural constraints and rebound effects?

- Future electricity demand will be impacted by so many drivers that it is very difficult to estimate the “maximum potential” for either demand reduction or spreading. Nevertheless, we are confident that the ability to manage electricity demand will be extremely valuable in the future. Also, as it involves little investment in capital equipment it is likely to be economically attractive. This subject is explored in detail in the call for evidence that BEIS and Ofgem published last year. The IET responded to this in detail and would be happy to provide our response to you if requested.

- Whether a rebound effect in electricity is problematic from an infrastructure perspective depends not on the total energy used, but on the timing of the use (does it increase network congestion?), and the carbon content of the energy at the time of use (why is it a problem if surplus wind or solar power is effectively “spilled” as a consumer lifestyle benefit?).

- Most rebound effects in energy are to do with domestic comfort levels (i.e. how warm you choose to keep your house), which also have a saturation characteristic (i.e. you might choose to warm your house to 23 degrees if it was 18 degrees, but you may not warm your house to 28 degrees if it was at 23 degrees).

- The issue is also linked to storage (it might appear in measurements as a rebound effect if additional energy is taken at times of low price, even though it is not), and to all the complexities of issues like the time of day when Electric Vehicles (EV) are charged.

5. How should the maintenance and repair of existing assets be most effectively balanced with the construction of new assets?

Energy

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3 https://www.gov.uk/government/consultations/call-for-evidence-a-smart-flexible-energy-system
In electricity networks there is already a strong emphasis on intelligent asset management and the optimisation of asset life, balancing risks with the consequences of failure. Adding smart capability with additional sensing and data processing will allow this to be developed further, but in so doing we might find new issues and limits with what in some cases are very old assets whose ageing characteristics we do not fully understand at present.

In many situations, it could be argued that the most valuable assets are the rights of way or physical sites that accommodate the electricity infrastructure, particularly in densely populated urban areas. A longer-term, more integrated approach to these assets should be investigated further. Replacing a life expired electricity cable like-for-like may be an inefficient use of a right of way, albeit one the regulatory environment might currently encourage.

Future planning in infrastructure development is key. There is value in installing a new cable of higher voltage rating, even if not fully utilised at present, to create optionality for greater capacity in the future. Maybe at the same time we should, as a matter of routine, also be considering the potential use of the right of way for district heating, water or data connections. Adding a communications fibre alongside a new power cable is likely to be an enabler for smarter network operations and new energy services as these invariably require data.

Transport

Modelling of economic activity (including traffic demand) should be used to develop predictive models involving asset construction and maintenance. In some cases longer life construction costs will be warranted in whole life costing models taking account of construction, use, repair and recycling.

When making investment decisions it is important to consider the following:

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<tr>
<th>Achieving a reduction in:</th>
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<td>• Total costs of operating the assets.</td>
<td>• Operating performance of the assets, (reduce failure rates, increase availability, etc.).</td>
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<tr>
<td>• Capital costs of investing in your asset base.</td>
<td>• Reputation of the organisation (irrespective of whether this is a national organisation such as Highways England or a local Authority or the private sector).</td>
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<td>• Potential health impacts of operating the assets.</td>
<td>• Regulatory performance.</td>
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<tr>
<td>• Safety risks of asset operation.</td>
<td>• Environmental impact of asset operating.</td>
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<td>• Legal risks associated with operating the assets.</td>
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A balance needs to be struck between financial performance (profit), operational performance (customer satisfaction) and risk (safety). For assets which are deemed to be critical, high operational performance is required and the tolerance to risk is low, which could result in low profit.
9. How can we most effectively ensure that our infrastructure system is resilient to the risks arising from increasing interdependence across sectors?

Communications

- Every communications system must, of course, incorporate redundancy to ensure resilience and tolerance of faults. Intelligent flexibility (modularity) is inherent to any properly designed network so, providing the infrastructure has indeed been correctly designed, changes to traffic patterns will not be an issue. This needs suitable bandwidth and latency.

- In addition to this there is scope to appoint a lead person in each national regulator to lead on infrastructure resilience and related interdependencies. Each regulator needs to accept this duty and work with the others in a more joined up way. International benchmarking for resilience should begin.

10. What changes could be made to the planning system and infrastructure governance arrangements to ensure infrastructure is delivered as efficiently as possible and on time?

Energy

- Transformational change is necessary for which a fragmented infrastructure system is no longer suited. Individual infrastructures must be examined as total end to end systems (including the parts in consumers’ hands and the hands of technology companies), and look at infrastructure as a whole as a system of systems.

- This has been explored by the FPSA\(^4\) project that provides evidence of pressing requirement to review and update industry change mechanisms and governance arrangements.

11. How should infrastructure most effectively contribute to protecting and enhancing the natural environment?

- Environmental costs and benefits must be factored into infrastructure decision making. Currently, infrastructure providers navigate around codified rules based on systems to provide compliant solutions. Approaches that value environmental costs and benefits should be explored further.

Transport:

13. How will travel patterns change between now and 2050? What will be the impact of the adoption of new technologies?

- A series of scenarios can be envisaged depending on whether disruptive technologies take hold. Important issues to consider in future scenarios are:

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\(^4\) [http://www.theiet.org/sectors/energy/resources/fpsa-project.cfm?origin=reportdocs](http://www.theiet.org/sectors/energy/resources/fpsa-project.cfm?origin=reportdocs)
- The impact of automation on travel patterns and use.
- The shared economy (uber/Lyft and others).
- Car ownership.
- Demand management and the importance of e.g. air quality.
- The success of moves to increase the share of public transport trips.

Future travel patterns in the UK will be driven by population growth and by increasing urbanisation. The impact of the adoption of new technologies, including the further development of mobile phone technology, will be significant in the consumer sector with the increased power and connectivity of smartphones, which facilitate new services such as ‘Mobility as a Service’.

Increased connectivity of vehicles will allow the advent of autonomous vehicles (AVs). However, these developments are in their early stages and predicting their impact is very difficult. For example, AVs have been predicted to both increase and to decrease road congestion.

“Travel patterns” include both frequency and distance of trips taken, as well as the mode of transport used. This covers both personal and commercial travel, including freight. Taking the different types of travel patterns into consideration:
- Personal travel: This is likely to grow mainly because families and friends are increasingly living further and further apart but there is still that desire and/or need to be there in person sometimes and to have new experiences. However, commuting travel (e.g. going to the same office everyday) will reduce providing that it is possible to undertake the work remotely.
- Commercial travel: There is a similar desire to that for personal travel desire for people working in businesses, i.e. there is a need for people who work in different locations to physically meet in order to create better relationships and work collaboratively to determine solutions.
- Freight travel: This will be influenced by a change in shopping habits to greater use of local shops and online shopping, and the uptake of freight consolidation centres to minimise trips in major urban areas.

14. What are the highest value transport investments to allow people and freight to get into, out of and around major urban areas?

- High quality, higher speed transport is required to link to domestic ‘gateways’, acting as transition points for inter-urban travel and travel to rural areas. This could be best implemented through use of road pricing, as outlined in Q2, which would be most effective in cost-benefit terms. Investment in digital infrastructure in also important to support the self-organisation of disparate transport needs.

15. What are the highest value transport investments that can be used to connect people and places, as well as transport goods, outside of a single urban area?

- As a general point better value will come from developments that separate modes from each other except at designed transport hubs, and separate...
slow-moving traffic from faster so cycling is kept apart from motorised driving and freight vehicles are kept apart from passenger on roads and rails.

16. What opportunities does ‘mobility as a service’ create for road user charging? How would this affect road usage?

- Specific answers to these questions are almost impossible as the assessed investment value and its cost will vary dramatically depending on location.

- As indicated in Q13, ‘Mobility as a Service’ is in the very early stages of development, and predicting its impact is very difficult at present, but the impacts are likely to be significant.

- There are no agreed standard definitions of Mobility as a Service (MaaS). However it would be accepted by most that it means a world in which there is no strong requirement to own personal transport assets such as cars; instead a mix of mobility solutions is purchased and used as a service.

- Individual transport services from public and private providers and across all modes are purchased through unified portals that offer trip planning, priced route choices and single account billing. Users might opt for pay-by-trip or make a monthly subscription. MaaS is usually seen as a passenger service but it applies just as well to the movement of goods.

- There are many approaches to calculating the road user charge depending on what is to be optimised. The main issue in Road User Charging (RUC) is public acceptability. However, RUC could be developed to support an economic and logical prioritisation of road use. If MaaS supports and enhances the “user pays” principle then some form of road pricing becomes the ultimate expression of user pays. MaaS provides an excellent opportunity to facilitate it technically, primarily due to the fact that it could be another add-on service.

- If MaaS is to be successful, especially in an urban context, then driving using personal vehicles must be one of the priced options. Some form of road user charging would seem to be unavoidable especially in countries where roads are free at the point of access. The charge model would not need to be a fairly precise location-based pay-per-Km (perhaps with added variability depending on time of day, engine size and type etc.). An Oregon-style set of payment options would be sufficient.

- However the introduction of RUC would need to be carefully considered as it could limit the take-up of MaaS in the UK. There is however the potential for early incorporation of a facility to pay tolls, etc. that are already in existence. Other early initiatives could include providing information to allow the traveller to compare travel options. For example: to compare the direct cost and time of personal car travel (fuel, wear and tear, insurance, VED), to the use of other forms of transport in order to start making people think when choosing their travel mode(s).

Digital Communications:
17. What are the highest value infrastructure investments to secure digital connectivity across the country (taking into consideration the inherent uncertainty in predicting long-term technology trends)? When would decisions need to be made?

- Designing the network in a flexible and modular way will allow changes and upgrades to be achieved.
- Good (high bandwidth, low latency) communications are vitally important to the future success of the UK that any delay in decision making must be avoided.

18. Is the existing digital communications regime going to deliver what is needed, when it is needed, in the areas that require it, if digital connectivity is becoming a utility? If not, how can we facilitate this?

- No, definitely not. We are playing “catch-up” with our current UK infrastructure. In the same way as piece-meal implementation of the transport network quickly creates traffic blackspots and delays, short termism and a poorly arranged competitive framework for the digital communications system will not allow for the connectivity the UK needs. Low latency, high bandwidth networks are absolutely fundamental to our success.
- An Internet Exchange in every major city should also be a consideration, for example the initiative in Liverpool - IX Liverpool who are currently battling with the local council to use unused fibre in the ground to expand bandwidth and services to local citizens and businesses while contributing towards UK infrastructure resilience.
- If digital connectivity is simply viewed as a utility then the price pressure may deter investments. Pricing needs to reflect demand, and in some areas the coverage may not have the demand or the fibre backhaul.
- Competition shape will change over time, but is not based on network coverage alone – billing and customer care remain important; data security and devices too. Regulation tilts the field today in favour of international Internet players at scale versus network investors. Mobile and fixed networks (including Cable TV) have for too long been seen as separate for regulatory purposes.

Energy:

19. What is the highest value solution for decarbonising heat, for both commercial and domestic consumers? When would decisions need to be made?

- In 2015 heat represented 84% of domestic energy consumption and 61% of services (commercial) consumption. Consistent with the IET’s Energy
Principles\textsuperscript{5}, the first priorities should be to reduce demand through conservation (i.e. behaviour change) and efficiency (i.e. improving the thermal performance of our buildings).

- The primary source of heat (2015) came from natural gas (75\% domestic and 69\% services). Decarbonising heat will mean that the UK will need to stop using natural gas for heating. The alternatives to natural gas which are suitable for large scale deployment include electricity and district heating.

- In both cases there are very significant infrastructure repercussions such as the construction of new power stations, as well as upgrades to buildings. However, there are also very significant network repercussions. District heating will require pipe network to be installed involving substantial street works. As the low voltage electricity network will need to be reinforced to cope with the additional heating load this will also require substantial street works.

- Assessing these network costs is difficult because the UK has relatively little experience of constructing district heating networks and reinforcing low voltage networks. However, the main challenge is likely to be implementing a major nationwide programme involving street works and limiting the associated disruption to the public and businesses. For example, at present the UK is halfway through a programme to replace the iron gas mains with polyethylene pipework to 13 million homes and businesses. The Iron Mains Replacement Programme (IMRP) has been scheduled over 30 years in order to limit the annual rate of replacement to 3,580 km as this was judged to “represent an achievable level of replacement that would not cause excessive disruption to the public”. Both district heating network construction and electricity network reinforcement are likely to have a similar effect and so the timescale to transition from gas will probably also be measured in decades.

- A possible alternative to district heating and electrification of heat is hydrogen. This has recently been given serious attention\textsuperscript{6} and involves the repurposing of the low pressure gas network from natural gas to hydrogen. The IMRP has effectively meant that most of this will be “hydrogen ready” when it is completed as polyethylene pipe can be used for hydrogen. As a consequence there will be much less need for street works activity. However, there are many other issues that need to be examined before large scale deployment can be considered. For example, a step change in hydrogen production will be required and the primary feedstock is likely to be natural gas. The chemical process used produces CO2 as a by-product. This then needs to be captured and sequestered and hence a nationwide CCS infrastructure would be required.

- In terms of which has the highest value, despite numerous investigations, it is very difficult to conclude that one solution has a higher value than another. This is because the UK has no experience of deploying these technologies at scale and the many unexpected problems that might arise and need to be

\textsuperscript{5} http://www.theiet.org/factfiles/energy/energy-principles-page.cfm
addressed. They include unexpected costs, engineering difficulties, deployment challenges and resources with the requisite skills and expertise. Crucially it is not known how consumers are likely to respond to being transitioned from natural gas to an alternative and whether this can be on the basis of choice or if the transition will need to be mandated.

- Consequently, and assuming that the timescale for decarbonising heat will take 20 to 30 years to implement, consideration should be given to identifying a region in the UK to trial each of the technologies as soon as possible. The Smart Systems and Heat programme is taking an important step in this direction. The knowledge and experience gained is likely to lead to much better choices, particularly as there are other factors that need to be considered, e.g. type of buildings, geographic locations, etc.

20. What does the most effective zero carbon power sector look like in 2050? How would this be achieved?

- We would first clarify the note to the question. The work undertaken for DECC (now BEIS) by the IET and the Energy Systems Catapult through the Future Power Systems Architecture Project has demonstrated very clearly that the part of the electricity system on the consumer’s side of the meter is as important as the conventional generation, transmission and distribution infrastructure in delivering a decarbonised, resilient system.

- Activities ‘beyond the meter’ can already be seen to be changing and include new parties, new technologies and new commercial models. These are beyond the governance mechanisms of today’s sector, which results in frustration for the new parties who seek changes to long-established industry arrangements and present a growing threat to the security and integrity of local and national networks.

- This threat arises, for example, where high volumes of distributed resources (generation, demand, storage) may respond to automated signals such as Time of Use prices, resulting in loss of diversity that creates unacceptable step changes of demand or generation. This aggregated effect can overload networks or destabilise the national demand/generation balance.

- There are a range of pathway choices to decarbonise electricity. The optimum choice to decarbonise electricity is far from clear currently and must enable options to develop and for either the market or government to make choices in due course. Key issues include:
  - The extent to which technology companies and service providers enter the space, and bring new value propositions to consumers.
  - The role of electricity in the transportation sector, and whether electric personal transportation evolves as owned vehicles or shared autonomous vehicles (the two pathways would likely result in very different temporal and spatial patterns of charging). This could impact...
absolute and peak demands, where investment in electricity distribution should be directed.

- The role of electricity in space heating (which if extensive would create large increases in absolute demand and potentially even larger increases in peak demand).
- The role of hydrogen in space heating (extensive use make the need for large scale hydrogen production, which would drive a need for electricity infrastructure that would co-produce hydrogen and extensive hydrogen storage).
- The extent to which cities and communities start to drive the agenda for electricity (which if extensive would drive a more integrated system locally with less need for large central facilities).
- The effectiveness of energy efficiency improvement in existing building stock.
- Technological and cost improvements in storage, end-use and generation.
- The different timescales of technological and consumer product development (a few years) versus heavy infrastructure development (a decade or two).
- Effective and agile governance of the end to end system, with clarity of accountabilities for key issues such as system integrity and cyber security.
- End to end system co-ordination is an imperative not an option; to simply leave this to ad hoc and goodwill arrangements between today's incumbents at their respective boundaries, is unacceptable and would be a serious failure of today's policy makers and regulators.

21. What are the implications of low carbon vehicles for energy production, transmission, distribution, storage and new infrastructure requirements?

There are a range of means by which low carbon vehicles may be delivered, each of which has different implications, as set out below:

**Biofuel**

- A substantial shift to biofuel as a transport fuel would require minimal change to existing infrastructure. However, the feasibility of producing biofuel on this scale is unclear. It is currently difficult to see how this could replace more than 10-20% of current road fuel usage.

**Electricity**

- A major shift to electrify the vehicle fleet would have a profound effect on the electricity system, and this effect would be very different for shared AVs versus owned vehicles, or different again if the market were to evolve with shared vehicles that were not autonomous.

- It is far from clear which technology might win out and over what timescales, however it seems unlikely that AVs will deploy at scale over the next decade or so.
There would be a case to deploy public charging infrastructure, acknowledging the risk that it might become redundant in the future.

**Owned Vehicles:**

There are a number of different classes of impact, which are interrelated:

- On the generation capacity needed for these vehicles to be charged when owners want to charge them. Wholesale transfer of personal transport to electricity might roughly double total energy requirements from the electricity system and also creates significant increases in peak capacity requirements. However, a fuller integration with storage, especially at local level, could mitigate the capacity increase requirements significantly. EV charging, if coordinated through smart charging mechanisms, could provide a powerful and flexible source of demand management. Similarly, these vehicles could become a source of mobile storage and power infeed though 'vehicle to grid' services.

- On the distribution network, down to and including feeders at street level, mitigated to the extent possible by smart charging arrangements to stagger charging temporally. EVs are electrically quite unlike other electrical device currently in the hands of consumers, because their charging consumes significant amounts of power for long periods of time. Other high demand items in consumers' homes like electric showers consume high power but only for short times. The distribution network was not designed for loads of this nature, and it might take only a relatively small number of EVs charging to create overloads.

- On the need to provide public charging infrastructure, potentially including major electricity network reinforcement to locations where large numbers of people gather for relatively short time periods (football matches, shopping centres), and where consumers cannot provide their own charging (for example in cities where off-street parking is very limited).

**Shared Autonomous Vehicles**

- Charging would likely take place at times of low demand for vehicles and as far as possible at times of low electricity cost, so would be much better correlated to times of lower demand on the electricity system.

- Charging would likely take place in more centralised locations in urban areas (we foresee locations such as supermarket car parks or industrial estates becoming used for this purpose). These would typically be connected to distribution systems at higher voltages, obviating the need for mass distribution feeder reinforcement at local distribution voltage.

- Vehicle fleet owners would see commercial opportunity in their fleets acting as virtual or real power stations and providers of system services, this potential of electric vehicles might be easier to realise in this scenario.
There would be much less need for public charging infrastructure.

**Hydrogen**

- Hydrogen as a transport fuel is technically viable and has been demonstrated in automotive and public transport applications. The challenges are around the production and distribution of hydrogen and whether it might more beneficially be used in heating rather than transport.

- A substantial shift to hydrogen transport would have significant implications for energy infrastructure and for the electricity system.

- Firstly, a hydrogen distribution infrastructure would be needed by either making use of, or in parallel with, existing hydrocarbon infrastructures and recognising that a transition would not be instantaneous. Consumers would presumably continue to operate hydrocarbon vehicles for many years after hydrogen vehicles were brought to market and hydrogen vehicles would need a supporting infrastructure in place if they were to sell in numbers. The most likely applications seem to be in low emissions zones in larger cities.

- Secondly, a means of producing hydrogen at scale would need to be constructed which could in turn influence choices in the electricity sector. Carbon capture from fossil-fuelled power stations has stalled in development and application because it is uneconomic at present.

- If hydrogen production at scale became important, the role of carbon capture could be transformed, which could give thermal power a much greater role in electricity (and perhaps heating) than it might otherwise enjoy. Also hydrogen production is a potential (though quite costly) means to use excess wind or solar power, which might then allow rather more wind and solar to be connected than would otherwise be economic.

- If large amounts of hydrogen were to be stored as part of development of a hydrogen infrastructure for transport this could also open new opportunities for energy storage on the electricity system.