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EmergingUK Hydrogen Economies:Policy/Urban andRegional Infrastructure‘Drivers’

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This working paper is one of a series of seven – detailed below - emerging from SURF's role as part of the UK Sustainable Hydrogen Energy Consortium. We welcome critically constructive feedback on these working papers.

Hodson, M., Marvin, S., Eames, M., (2004), *Technology Characterisation of the Hydrogen Economy*, Working Paper 1, SURF Centre, University of Salford, May.

Hodson, M., and Marvin, S., (2004), *Opening the 'Black Box' of the Hydrogen Economy*, Working Paper 2, SURF Centre, University of Salford, May.

Hodson, M., and Marvin, S., (2004), *Understanding Transitions to a Hydrogen Economy(-ies) with and through 'Regions'*, Working Paper 3, SURF Centre, University of Salford, October.

Hodson, M., and Marvin, S., (2005), *Re-Imagining Tees Valley in the Post-Industrial*, Working Paper 4, SURF Centre, University of Salford, May.

Hodson, M., and Marvin, S., (2005), *The 'Journey' to Wales' Hydrogen Economy*, Working Paper 5, SURF Centre, University of Salford, May.

Hodson, M., and Marvin, S., (2005), *London's Hydrogen Economy: Negotiating the 'Global', the 'Regional' and the 'Local'*, Working Paper 6, SURF Centre, University of Salford, May.

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1. Introduction

This paper takes as its focus a concern with the issues and ‘drivers’ underpinning regional attempts to develop ‘hydrogen economies’. In doing this it builds on a series of papers (Hodson and Marvin, 2005a; 2005b; 2005c; 2004a; 2004b; Hodson et al, 2004) which acknowledge a ‘gap’ in our understanding in addressing relationships between ‘generic’ ‘drivers’ of the hydrogen economy and more localised and regional motivations for, and manifestations of, the hydrogen economy. With this in mind we seek to develop understanding of urban and regional infrastructure ‘drivers’ for the hydrogen economy not in urban and regional ‘isolation’ but through developing the idea of ‘context’. Through seeing urban and regional governance of the hydrogen economy not as bounded but in relation to different scales of political activity manifest in particular places and initiatives, the key question is: **what are the key ‘drivers’ for UK urban and regional hydrogen economy development?**

In addressing this issue in this paper, we begin by briefly outlining a series of policy issues and ‘drivers’ often highlighted in debates around the hydrogen economy. We move on to highlight, through three key EU and UK policy and strategy documents, how these perspectives (often implicitly) view urban and regional hydrogen economy developments. In doing this we open up a possibility for comparison and evaluation of the ‘syntheses’ and ‘gaps’ between supranational and national understandings of the hydrogen economy in urban and regional settings and our own case study understandings from three case study ‘regions’.

In making this argument, and theorising the (dis-)connections between the ‘possibilities’ of the hydrogen economy and urban and regional contexts, we posit the importance and strengths of a dominant way of understanding the production of the hydrogen economy known as technology characterisation (TC), a viewpoint which often resonates with and informs national policy development. The strength of this approach is in its outlining issues around the technical capabilities and economic costs of hydrogen technologies and, thus, it is in many ways linked to the production of technology. This approach says little about particular places, yet there is a strong feeling that the hydrogen economy, if it develops, will do so in particular localities and regions. With this in mind we outline the notion of ‘context’ to inform a means of

understanding the different ways in which regions develop hydrogen economies, taking account of different scales of activity, both in terms of scales of policy and ‘formal’ politics and also a variety of other actors and institutions. From this we offer a discussion of a series of ‘drivers’ for informing understanding of urban and regional hydrogen economy developments. Finally, we conclude through exploring and evaluating the ‘syntheses’ and ‘gaps’ between different policy and strategy proclamations political of urban and regional hydrogen economy developments and these urban and regional ‘drivers’.

2. Policy and ‘Drivers’

This section outlines the ‘drivers’, interrelationships and pressures for a hydrogen economy in terms of ‘relevant’ policy contexts, here the EU in ‘global’ context, the UK Energy White Paper and subsequent attempts to develop a strategic framework for hydrogen energy in the UK. An important emphasis is on the relationship between national and supranational policies and strategies and developments and regions.

This is important as there have been numerous attempts to define the hydrogen economy, and infuse the concept with meaning (Dutton, 2002, Rifkin, 2002, POST, 2002). With this in mind, a broad definition of a hydrogen economy may be seen as concerned with a ‘widespread and diverse production and use of hydrogen’ (POST, 2002, p.1). The development of future hydrogen economies is generally seen to be underpinned by a number of ‘drivers’ with varying emphases in different international, national and local and regional contexts. These ‘drivers’ often concentrate on concerns related to widespread reliance on fossil fuels, including: reducing carbon dioxide emissions; confronting air pollution; increasing security of energy supply; and addressing industrial competitiveness. In terms of thinking about UK regions it is useful to understand and ‘unpick’ these ‘drivers’ in terms of the European Union (in a ‘global’ context), the UK policy context and the ways in which UK energy policy relates to regional developments.

2.2.1 Europe in a ‘Global’ Context

In terms of the European Union and policy there is particular emphasis on four issues; carbon dioxide emissions reduction and meeting obligations under the Kyoto agreement; addressing issues of energy security of supply; air quality and health

improvements; and the promotion of industrial competitiveness. Underpinning this in many senses are relationships ‘external’ to the European Union and in particular aspirations for ‘Europe’ to be a ‘leading world player’ vis-à-vis Japan and in particular the US. A key point to note, however, is that:

The proposed US support is around five to six times the level of public support anticipated for hydrogen and fuel cells in the European Sixth Framework Programme for Research. Even with the significant additional support from individual Member State programmes, the level of public support in Europe is still far below that in the United States. A substantial increase is therefore needed for Europe to compete with the US and Japan (European Commission, 2003, p.15).

Importantly the EU will meet this ‘global challenge’ by aspiring to match levels of investment through individual states and the EU. In view of these issues, and also the US advantage in government funding and resources, the European Commission set-up its High Level Group for Hydrogen and Fuel Cell Technologies in October 2002, where ‘the terms of reference for the group requested the preparation of a vision report outlining the research, deployment and non-technical actions that would be necessary to move from today’s fossil based energy economy to a future sustainable hydrogen-oriented economy with fuel cell energy converters’ (European Commission, 2003, p.5). An interesting issue is the involvement, in the High Level Group, of many senior executives of large corporations and their ‘sherpas’. That is to say, the High Level Group included high-ranking representatives of, for example, DaimlerChrysler, Renault, Shell, Johnson Matthey, Ballard and Siemens-Westinghouse which informed the production of the vision report.

From this context five issues were raised to address the issue: what can Europe do? (European Commission, 2003, pp.16-23). The first of these being a ‘political framework’ – with an emphasis on creating a ‘consistent European policy framework with a sustainable energy policy at its heart’ to take advantage of ‘the substantial long-term public and private benefits arising from hydrogen and fuel cells’ (European Commission, 2003, p.16). The development of policy, according to the report, should acknowledge the long-term focus of hydrogen economy developments and be underpinned by ‘significant’ public sector funding and a series of policy objectives.

Second, a ‘strategic research agenda’ – with the aim of ‘bring[ing] together the best research groups in Europe today’ and generating ‘a critical mass in terms of resources, effort and competencies to analyse and address non-technical and socio-economic issues, and solve the remaining technical barriers to the introduction of hydrogen and fuel cells’ (European Commission, 2003, p.17). This attempt at ‘coordination’ is an acknowledgement of the fragmentation of much EU research and development capacity. The interesting issue is how this notion of coordination positions the urban and regional within a network, operating at a number of scales, to inform a common ‘European’ research agenda involving a ‘broad range of stakeholders including academe, national, defence and contract (private) research centres, industry, end-users, civil society, Small and Medium-sized Enterprises, and public authorities at all levels – local, regional and European. It [the strategic research agenda] should also address broader international targets to ensure European technology will be internationally competitive’ (European Commission, 2003, p.19).

Third, a ‘European roadmap for hydrogen and fuel cells’ – which acknowledges and addresses ‘the complex range of options, [through offering] a framework for the introduction of hydrogen and fuel cells needs to be established’ (p.21) over the short and medium term to 2010, through the medium term to 2020 and in the medium and long term beyond 2020. The roadmap has a dominant emphasis on technological artefacts saying little specifically about the urban and regional. It does, however, suggest that in the ‘short and medium term’ there should be ‘early applications of hydrogen and fuel cells in premium niche markets, stimulating the market, public acceptability and experience through demonstration, and taking advantage of existing hydrogen pipeline systems’ (European Commission, 2003, p.21).

Fourth, a ‘European Hydrogen and Fuel Cell Technology Partnership’ underpinned by an Advisory Council. The Advisory Council was established in December 2003 and a European Hydrogen and Fuel Cell Technology Platform launched in January 2004 to ‘facilitate and accelerate the development and deployment of cost-competitive world-class European Hydrogen and Fuel Cell-based energy systems and technologies for application and transport, stationary and portable power’¹. The Platform operates

¹ https://www.hfpeurope.org/hfp/about_hfp [accessed 11th May 2005]

through a structure including an Advisory Committee (of a large industry presence, research, the European Commission, NGOs and representatives of national and regional government from numerous Member States), steering panels (with a strategic focus) and initiative groups (developed around specific initiatives and topics).

This structure is important in a number of ways in relation to the development of a 'European' hydrogen and fuel cells agenda, but in particular in terms of the ways in which it informs streams of funding from the Framework Programme. The key point of this is that: 'The Framework Programme and national programmes will remain the main public-funding instruments for research, development and demonstration, while regional aid projects could provide opportunities for larger deployment initiatives' (European Commission, 2003, p.21). This is an acknowledgment that:

Significant public sector involvement is critical to progress. Public sector funding is required to stimulate activity and share risks in research, development, and initial deployment (European Commission, 2003, p.16).

In many ways this agenda offers an implicit view of the urban and regional with an emphasis on 'markets', 'public', 'private', 'niches', 'demonstrations' the 'deployment' of technology and so on. With this in mind there was an important emphasis in Framework Six (FP6) on 'research' and 'deployment'. The total level of funding is difficult to calculate but, according to one key source², it included around 100 million Euro in the first call of FP6 and about 150 million Euro in the second call, with the potential for more to follow. The point being that 'it's grown...nearly exponentially over the last three Framework Programmes'. In terms of deployment a particular emphasis has been put on the development of 'hydrogen communities' (HyCom) and also a 'demonstration and pilot programme to extend the technology validation exercises into the market development arena, through a number of "lighthouse" demonstration projects' (European Commission, 2003, p.24). The idea behind HyCom was outlined by one key source, who told us that:

We've got larger demonstration activities that may combine transport and non-transport applications that may really lead us to a new type of project that would not be a market project or a commercial project but still a

² All quotes and citations are anonymised as agreed with interviewees in the negotiations to undertake the interviews.

demonstration project. But in size and scale...one could invent, kind of, hydrogen communities that, of course, they are not going to be 100 per cent hydrogen powered, but in which hydrogen...will play a very important role and then, to establish such a hydrogen community as a demonstration project so that we could learn more about how to move towards such a hydrogen economy.

Importantly, somebody closely involved with the setting up of the Platform suggested to us that the role of the Commission was as a ‘facilitator’:

I mean what you should appreciate is that when we set up the Platform, our view was as a facilitator as opposed to owning it and it is our ambition that really this is a stakeholder group...that it, of course, addresses what we are doing because we are the major funding body in view of hydrogen and fuel cell research and demonstration and that it will seek to develop a strategy which can be embracing things more than what the Commission might be interested in...Our interest, of course, is what their recommendations are to us, in terms of what research, demonstration, what other support activities like education and training...standards...regulations.

In this respect there are two key points to be noted in relation to regions (as we understand them here): 1) that different types of resources are available to the local and regional level, in addressing ‘European’ aims and objectives, particularly through the Framework Six Programme where numerous initiatives have been developed around the analysis of hydrogen pathways, storage, safety and end-use; 2) and there is a need for proactivity in engaging with such resources – which a commentator with a keen understanding of such processes told us the UK has not historically been good at.

2.2.2 The UK Energy White Paper

The UK Energy White Paper (DTI, 2003), *Our Energy Future*, provides an entry point to thinking about the hydrogen economy in the UK policy context. The White Paper offered an acknowledgment of a series of issues – environmental, in particular climate change; declining indigenous energy supplies; and ageing energy infrastructures – facing UK energy policy and posited a number of goals for addressing these issues. These included: cutting UK carbon dioxide emissions by 60 per cent ‘by about’ 2050 with ‘real progress’ by 2020; maintaining the reliability of energy supplies; the promotion of competitive markets both domestically and internationally in addressing ‘sustainable’ economic growth and improving productivity; and ensuring that every home is adequately and affordably heated.

A series of policy measures were set out in the White Paper which outlined a role for hydrogen and fuel cells as part of a future 'fuel mix' with an emphasis on the contribution of energy efficiency and renewables, but with a deferment of a decision on a possible future nuclear contribution.

In this the White Paper pointed out that:

We do not propose to set targets for the share of total energy or electricity supply to be met from different fuels. We do not believe Government is equipped to decide the composition of the fuel mix. We prefer to create a market framework, reinforced by long-term policy measures, which will give investors, business and consumers the right incentives to find the balance that will most effectively meet our overall goals (DTI, 2003, p.11).

In view of this, the White Paper outlined a role for hydrogen and fuel cells in which: 'Hydrogen looks likely to play a key role in future low-carbon energy systems' and in particular 'seems likely to play a key role in future transport technologies'. Support for this in the White Paper was detailed around a number of measures including, for example, the exemption of hydrogen from road fuel duty for a period to encourage its early development and take-up; support for fuel cell research; part-funding of the trialling of fuel cell buses by Transport for London in 2003 and the supporting hydrogen fuelling station being installed by BP; and working with London and other local and regional organisations on a wider network of demonstration trials, including linkages with existing local hydrogen distribution networks such as that on Teesside (DTI, 2003, p.71).

The shortcomings of the role outlined for hydrogen in the Energy White Paper were outlined to us by a commentator with a close understanding of the preparation of the White Paper, who suggested:

I think, speaking frankly, that although in the run up to the preparation of the Energy White Paper there was quite a lot of consideration given to hydrogen, probably it's the first time they've done so. Very little of that actually made it into the Energy White Paper. So what appeared was really sort of specific initiatives and I think much more, there certainly wasn't any sort of coherent framework for saying either the UK will move to a hydrogen economy or [not]. So I think the White Paper is still a significant driver in terms of the

priority given to environmental aspects, but it's not sufficient on its own in terms of hydrogen.

The Energy White Paper did, however, emphasise local and regional scales, suggesting that local authorities and bodies and also Regional Development Agencies (RDAs) 'make decisions that are vital for energy policy - for example on planning, regeneration and development, procurement, housing, transport and sustainable development' (DTI, 2003, p.116). The White Paper highlighted building on these relationships to 'develop a new package of measures to promote national objectives through local and regional decision-making'. In many senses this view suggests that the local and regional levels are sites for the implementation of nation policy measures.

This said, a further point raised in the White Paper was that: 'This will enable local and regional priorities to be better reflected in national policy. Over time a more proactive role will be developed for local and regional bodies in energy policy', for example through the development of regional energy or regional renewable energy strategies and targets and involving 'a partnership of regional chambers, RDAs, Government Offices in the Regions (GOs), local authorities and other stakeholders, such as businesses, unions and voluntary groups' (DTI, 2003, p.116). In particular, 'RDAs' role as the drivers of regional economic development means that they can make a significant contribution to meeting the energy policy objectives set out in this white paper' (DTI, 2003, p.116). The interesting issue this raises is that 'meeting energy policy objectives' in the regions becomes entwined with regional *economic* development and raises issues about the possible tension between economic development and a variety of environmental goals outlined in the White Paper.

The interface of the relationship between the centre and the regions was tasked to The Sustainable Energy Policy Network (SEPN). Understandings of the relationship between the centre and the regions in terms of energy policy, and hydrogen in particular, from the centre were numerous. For example, one commentator with a keen appreciation of the DTI suggested:

The question...as to whether or not the centre will co-ordinate the actions of different regions is a difficult one. And my own view would be that co-

ordination in the sense of information exchange yes, co-ordination in the sense of saying, well that must happen there and that must happen there sort of thing, is actually not the way things are currently going. There's more emphasis in DTI terms of devolving money and decisions to the regional bodies than taking decisions at the centre.

These attempts to build relationships and information exchange led one national level policymaker to tell us that:

[On] energy policy generally, we're trying to work much more closely with the regions... [we're] trying to develop a partnership framework with the RDAs on a number of fronts, energy is one of those...It's trying to find ways of working with the RDAs and the regions and indeed the devolved administrations...So, what they're trying to do is to find areas...we give them £100,000 a year each as a, sort of, energy promotion amount of money and what we're looking for...in my area we're trying to find regions that are interested in co-operating with us on [various] projects. We haven't got very far...we haven't had that discussion yet.

Yet at the same time another closely linked policymaker when asked as to their understanding of energy developments in the regions suggested that 'the information we have is pretty much based on those individuals who bother to come and see us'.

At the heart of these attempts to begin a process of working more closely with regions is a tension, according to another policy source:

In all areas to do with the regions we're trying to set central policy that will not constrain the regions, but equally we don't want to see regions competing with each other so it's, you know, that sort of balancing act.

With this in mind, a key point to note is the regional variability in terms of the energy agenda in that: 'Regions have focused on different aspects of energy policy according to existing priorities' (DTI, 2004, p.4). In many senses, although there was the aspiration in the White Paper to 'promote national objectives through local and regional decision-making', discussions with policymakers highlighted an uncertainty about the relationships between the centre and the regions. The role of the centre in relation to hydrogen was further developed through a strategic framework for hydrogen which acknowledged, often implicitly, a role for regions.

2.2.3 A Strategic Framework for Hydrogen

Moving on from the White Paper, and taking account of existing (if often fragmented) UK capabilities in relation to the hydrogen economy, DTI commissioned E4Tech, Eoin Lees energy and ElementEnergy to produce a strategic framework, for the period to 2030, for hydrogen energy in the UK addressing the question: ‘how should the UK engage with hydrogen economy activities for maximum benefit’? (E4Tech et al, 2004, p.8). A series of issues and recommendations emerged from the strategic framework report. These included the view that ‘post 2020 energy policy will follow the goals of safe, secure, affordable supply with minimal CO₂’ and that ‘hydrogen has the potential to make a significant contribution to the UK’s priorities in transport, much less in electricity and heat’. In addressing this a ‘total of 33 measures are needed to develop the six main hydrogen options for transport by 2030’ and ‘five main areas of support are needed to develop hydrogen options for the UK’ (E4Tech et al, 2005, p.15), including support for R&D, support for demonstration, support for commercialisation, the co-ordination of UK hydrogen activities and the creation of demand conditions for hydrogen.

The consultants commissioned were: E4 Tech, whose ‘goal is to assist our clients to achieve solutions that are technologically, economically and environmentally sound’ operating ‘at the interface between business, technology and policy’ (in particular fuel cells & hydrogen energy, biomass & waste for energy, sustainable buildings, distributed and renewable energy systems)³; Element Energy, ‘an engineering company specialising in the application of hydrogen energy technologies’ who, in terms of this report, ‘led the modelling of hydrogen energy chains and provided input to all other modules’; and Eoin Lees which ‘provides advice to companies and governments on matters relating to policy on the demand and supply side of energy’ and who ‘led the interviewing of policymakers and provided input to all other modules’ (E4 Tech et al, 2004, p.11).

The underpinnings to the framework were that the ‘UK’s priorities with regard to hydrogen were unclear making them hard to address for the purpose of achieving maximum overall benefit’, that ‘hydrogen energy support was provided by several initiatives in the UK, but a dedicated programme was not in place’ and that the ‘UK

³ http://www.e4tech.com/english/aboutus_intro.htm [accessed 20th May 2005]

had no clear means to engage in international activities' (E4Tech et al, 2004, p.8). The latter of these was important as the report claimed that from 33 separate measures it proposed only three would 'offer opportunities for the UK to gain by leading international development efforts' whilst '13 would be best achieved by co-operating in international activities led by others' (E4Tech et al, 2004, p.6).

In many ways the approach undertaken, although involving some interviews with policymakers and energy 'experts', showed many similarities with a technology characterisation approach (see Hodson and Marvin, 2004a), particularly in using an 'energy chain modelling approach'. In doing this: 'Six hydrogen chains for transport were identified that could meet the UK's objectives to varying extents' (E4Tech et al, 2004, p.36).

This technical and economic focus resonated with the views of policymakers and experts, where in a 'summary of views' from the interviews that there was a: 'Strong consensus that the UK needs to develop as many technical options as possible to tackle climate change because the political challenges of changing lifestyles to use less energy are more difficult' (E4Tech et al, 2004, p.23).

The interesting issue of the six hydrogen chains is that: 'This is not intended to be a forecast of how hydrogen will be used, nor a design for the UK energy system. It identifies where hydrogen could deliver against the main priorities for the UK' (E4Tech et al, 2004, p.39). The acknowledgement being that: 'The transition to hydrogen for each application will happen at different times and rates, and to different extents, in different places' (E4Tech et al, 2004, p.16). To take examples: 'Remote communities may be renewable hydrogen-powered'; 'Villages and rural areas may have some penetration, small at first'; 'Urban areas could be predominantly electric, with a small amount of hydrogen' (E4Tech et al, 2004, p.16).

A key issue is the extent to which the possibilities of the hydrogen economy converge and diverge with policy goals, in that: 'Numerous other applications for hydrogen have merit, though they do not meet major UK policy goals of energy security and CO₂ reduction'. These include, for example: 'Demonstrations and commercial application of vehicles for these reasons [low noise, low local emissions, etc] give

knowledge and revenue to support the development of the wider vehicle market – e.g. buses, forklifts’. The point being made that: ‘Without these nearer term approaches, there is a risk that the hydrogen energy sector will stagnate, limiting the development required for the use of FCVs by 2030’ (E4Tech et al, 2004, p.84)

So although the strategic framework was working to a ‘UK’ brief there was an acknowledged, if often implicit, role for regional and local level developments. This was captured in comments and claims such as: ‘Captive fleets are more practical early adopters for reasons of infrastructure’ (E4Tech et al, 2004, p.65) and ‘hydrogen could have a role for heating in niche applications’ (E4Tech et al, 2004, p.52).

An exercise in understanding ‘selected UK actors in hydrogen energy’ also had an implicit regional and local geography (E4 Tech et al, 2004, p.87). Claims, in the framework, which went further in addressing urban and regional aspects of UK hydrogen economy development were flagged in the report not as ‘recommendations’ but as ‘areas where the UK has the potential to be competitive’. These included in terms of hydrogen production:

The UK’s oil and gas industry expertise could be combined with regional interests in hydrogen for the development of experimental hydrogen infrastructures featuring production systems. This could provide strong learning-by-doing benefits which could be developed into products and services for export (E4Tech et al, 2004, p.90).

In storage and distribution, again in terms of potential rather than ‘recommendations’:

Regional strengths and interests in large scale storage and pipeline transport of compressed hydrogen could be built upon to provide marketable products and services. This could be combined with the creation of wider experimental hydrogen infrastructures (E4Tech et al, 2004, p.91).

Yet the report claimed that: ‘A major barrier is the absence of viable end uses for which to deploy hydrogen, which *requires UK action*’. That it is: ‘The UK [which] needs to develop the capability to deploy hydrogen to meet its long term policy goals’. In addressing this: ‘Initially the UK hydrogen energy sector requires commercial (or pseudo-commercial) end use applications to encourage it to invest in hydrogen development’, where fuel cell vehicles ‘should be demonstrated as they become

available’ (E4Tech et al, 2004, p.103, emphasis added). In undertaking demonstrations:

EU funding is critical for the initial demonstrations and this opportunity will expire soon. The use of hydrogen in transport beyond the demonstration stage must be encouraged by financial incentives (E4Tech et al, 2004, p.103).

In many ways the strategic view takes a technology characterisation view of the UK hydrogen economy emphasising key hydrogen transport ‘chains’ calculated and modelled in terms of technical capabilities and economic costs. The key issue is that whilst appropriation of the hydrogen economy zooms in and out of focus in the framework, through notions of ‘deployment’, ‘applications’, ‘demonstrations’, ‘potential’, ‘niches’ and so on, this says little directly about connecting this view of the production of the hydrogen economy with urban and regional contexts of appropriation.

Our aim here is to address this issue through outlining key underpinnings of UK urban and regional hydrogen economies and the extent to which they inform or are informed by national and EU level policy and strategies and the ‘syntheses’ or ‘gaps’ between the possibilities and manifestations of hydrogen economies.

The interesting issue here is that national energy policy provides a context through which regions may appropriate national and supranational policies in a variety of different ways depending on how regional partnerships are constituted in particular regions, how they understand the possibilities of the hydrogen economy, what their agendas in developing partnerships and so on. From these policy pressures, how do we think about the development of a hydrogen economy which links the production of the hydrogen economy (and its technical possibilities and economic costs) to regional contexts? And subsequently how do we understand the ‘drivers’ of hydrogen economies within these urban and regional contexts?

3. Producing the Hydrogen Economy

In analyses of the production of technology, technology characterisation (TC) is seen as an important means of generating political and policy support for technological

developments through outlining technical ‘possibilities’ and ‘options’ in relation to ‘costs’ – through ‘building blocks’, ‘options’ and ‘pathways’. Our analysis of emblematic TC documents (Hodson and Marvin, 2004a) claims that TC conceives of technological change through a process of narrowly framing understanding of what ‘relevant’ costs and technological possibilities are. We claim that this dominant way of narrowly characterising technological change in terms of the supply of technology would benefit from an appreciation of alternative ‘ways of seeing’ the development of hydrogen technologies, particularly in relation to ‘contexts’ of their appropriation, consumption and development. It also provides a basis for research which opens up the possibilities for sensitising policy interventions to contexts of appropriation and use in addition to technological characterisations of supply.

4. ‘Connecting’ the Production of the Hydrogen Economy to Regional Contexts

This raises the important issue of the hydrogen economy potentially developing differently in a variety of places. This was a common view amongst key ‘stakeholders’ with whom we talked, where for example a national level policymaker told us:

I’m very struck by the fact that you’re doing sort of a regional based thing because I think that’s very much how the hydrogen economy is going to evolve. I don’t think there’ll be a sort of a one size fits all approach. Not in the early stages anyway.

This leads to how we think about ‘regional contexts’ in relation to the technical and economic possibilities of the hydrogen economy. The issue primarily is one of ‘connecting’ technologies with contexts of their appropriation. In particular we accept, but seek to stretch, an emphasis in some Technological Transitions (TT) approaches on the co-evolution of technology and society (Geels, 2002) by asking: where and when are ‘society’ in addressing technological transitions? More specifically, in view of the ‘re-emergence’ of the region, in times of increased ‘globalisation’, but also the complex interpenetration of scales of governance manifest in ‘regional’ decision-making the issue becomes one of how and why particular representations - or attempts to re-imagine the region - through technological transitions are made visible? This links to a concern with the types of interests

involved in the production of these representations ('partnerships' in the language of the policy debate outlined previously), their expectations of technological transitions and the resources they can draw upon. It, furthermore, relates to any 'gap' between these technological anticipations, expectations and promises, embedded in a variety of regional contexts and attempts to territorially ground technological transitions. It is through this 'connection' of the possibilities of hydrogen economies with spatial and territorial contexts of their development that we offer a contribution to the debate and discussion around the hydrogen economy.

5. Outlining Key 'Drivers' of Regional Hydrogen Economies

The key question then becomes: **what are the key 'drivers' for UK urban and regional hydrogen economy development?** The critical point is that understanding hydrogen economy developments needs to address not only its possibilities but also the complex interpenetration of local, regional, national and international scales. This requires a focus on the importance of embedding and appropriating understandings of the hydrogen economy in particular regions. From a conceptual and theoretical approach we outlined previously (Hodson and Marvin, 2004b) and also in relation to issues emerging from three regional case studies in London, Wales and Tees Valley (Hodson and Marvin, 2005a, 2005b, 2005c) we wish to outline key regional/urban and infrastructure 'drivers' (see also Figures 1, 2 and 3). We do this through asking questions under three headings: (1) How are regional hydrogen economy developments represented? (2) How are these representations and visions of the hydrogen economy produced? (3) How does this relate to the development of hydrogen economy demonstrations etc?

5.1 REPRESENTATION & GOVERNANCE – Re-Imagining Regions

This section of the paper emphasises the importance of representations or visions of regional hydrogen economy development, or the ways in which this may involve re-imagining the region. In this respect, it deals with the governance of representations. In doing this there is a focus on three sets of 'drivers' emerging from the regional case studies and then a detailing of a number of key common issues from looking across the cases.

Figure 1: Representation and Governance ‘Drivers’

‘Driver’	London	Wales	Teesside
REPRESENTATION & GOVERNANCE – Re-Imagining Regions			
Issues/Problems Facing Region	<p>Issues of air quality, social equity, carbon emissions reduction and economic competitiveness</p> <p>MNC management of uncertainty and DGTREN focus on possibilities for systemic transport change</p>	<p>Relatively poor economic performance both on an urban and rural Wales-wide basis.</p> <p>The retention of jobs and economic activity related to the automobile and supply chains in south Wales</p>	<p>Decline of traditional industrial base, particularly chemicals and steel</p>
Perceived Possibilities & Expectations	<p>Development and preparation – the creation of conditions favourable to a London hydrogen economy</p> <p>Europe-wide FC bus demonstration projects in highly visible ‘leading’ cities as part of ‘test-cycle’</p>	<p>Exploring possibilities of hydrogen economy through the construction of networks and visions</p>	<p>Adapt existing physical and social infrastructure and skills base to appropriate perceived benefits of hydrogen economy</p>
Relationship Between Hydrogen Technology and Region	<p>‘Preparatory’ – creating a social context in the city-region</p> <p>‘Test-bed’ – the city-region as a ‘laboratory’</p>	<p>‘Exploratory’ – the journey to a vision and the production of manifest potentiality with and through the hydrogen economy in Wales</p>	<p>‘Adaptable’ – reconfiguring existing socio-technical networks and arrangements</p>
<p>Key issues</p> <p>The primary importance of addressing issues of economic competitiveness as well as systemic transport change, environmental and social equity agendas</p> <p>Lack of clarity and uncertainty – to varying degrees – as to the possibilities and potential of the hydrogen economy in addressing these issues</p> <p>Links to the extent to which capacity and capability within local networks is manifest or remains latent</p> <p>This underpins, and is underpinned by, view of the relationships between hydrogen & FC technology and regional contexts – ranging from ‘test-beds’, to ‘preparatory’ to ‘exploratory’ and ‘adaptable’.</p>			

5.1.1 Issues/Problems Identified as Facing a Region

The first ‘driver’ underpinning the development of regional hydrogen economies was related to **issues or problems identified as facing a region**. In London this was seen

as around a city-regional agenda of confronting issues of air quality, social equity, carbon emissions reduction and economic competitiveness. Through the CUTE project in London it was also viewed as related to the problems of managing uncertainty for multinational automobile and fuel corporations and on the focus of the European Commission's DGTREN for systemic transport change.

In Wales the problem was one of relatively poor economic performance both on an urban and rural Wales-wide basis. More specifically it was about the retention of jobs and economic activity related to the 'global' automobile industry and its supply chains in south Wales.

Whilst in the Tees Valley the dominant problem to be addressed was the decline of employment in its traditional industrial base, particularly chemicals and steel.

5.1.2 Perceived Possibilities and Expectations

This, then, related to a second 'driver' that being the **perceived possibilities and expectations** of the development of a hydrogen economy in addressing these issues and problems. In London this involved addressing the issues of air quality, social equity, carbon emissions reduction and economic competitiveness through the 'preparation' of a 'necessary' social context for the hydrogen economy – to the creation of social conditions favourable to a London hydrogen economy. Additionally, for the CUTE project the development of Europe-wide fuel cell bus demonstration projects in highly visible 'leading' cities, were seen as part of a 'test-cycle' informing MNC research and development and also understanding the 'transferability' of technologies across different European cities.

In Wales there was a move from the problem of relatively poor economic development to exploring, through a 'journey', the possibilities of a hydrogen economy through the construction of networks and visions in addressing this poor economic performance.

Whilst in Tees Valley addressing the decline of traditional sources of industrial employment was seen as requiring the adaptation of an existing physical and social

infrastructure and skills base to appropriate the perceived benefits of hydrogen economy

5.1.3 Relationship Between Hydrogen Technology and Region

Underpinning the relationship between issues or problems identified as facing a region and the perceived possibilities and expectations of the development of a hydrogen economy was another relationship, often implicit, this being the **relationship between hydrogen technology and the region**. This took a number of different forms from the ‘preparatory’ creation of a social context in the London city-region to seeing the CUTE project view of the city-region as a highly visible ‘laboratory’ or a ‘test-bed’.

In Wales the relationship was seen as a more ‘exploratory’ one where there was to be an unfolding process of understanding the ‘journey’ to a vision and the production of manifest potentiality with and through the hydrogen economy in Wales

Whilst in Tees Valley the view of hydrogen technology and the region was a more ‘adaptable’ one of reconfiguring existing socio-technical networks and arrangements in respect of the perceived possibilities of the hydrogen economy.

5.1.4 Key issues

From these three themes a number of **key issues** become apparent:

- There was a primary importance in regional hydrogen economy development of addressing issues of economic competitiveness as well as systemic transport change, environmental and social equity agendas. Underpinning this were attempts to mobilise particular views attributed to local and regional social, political, economic and industrial history.
- There was often a lack of clarity and uncertainty – to varying degrees – as to the possibilities and potential of the hydrogen economy in addressing these issues. That is to say there were a number of responses to the possibilities of the hydrogen economy citing a variety of possible ‘ends’.

- This clarity (or lack of it) links to the possibilities for mobilising capacity and capability within local networks and as to whether such capacity and capability is made manifest or remains latent. That is to say the creation of a clear ‘purpose’ or basis for developing a hydrogen economy is underpinned by but also relates to the types and degree of local engagement.
- This underpins, and is underpinned by, views of the relationships between hydrogen and fuel cell technology and regional contexts ranging from ‘test-beds’, to ‘preparatory’ to ‘exploratory’ and ‘adaptable’. Or views of this relationship which largely underplays the active role local and regional contexts may play (e.g. ‘test-beds’), or alternatively deals with building capacity and visions (e.g. in differing ways, the ‘preparatory’ and the ‘exploratory’), or is underpinned by local and regional adaptability (e.g. the ‘adaptable’).

5.2 PRODUCING GOVERNANCE – Mediating Representation and Performance

An important issue is in focusing on how these views of the issues and problems facing a region and the responses to them through various representations were produced. A focus on **producing governance** is to emphasise the partial and negotiated way in which hydrogen economies are envisaged in particular regions. In particular the emphasis is on who has the ability to attribute these sorts of meaning to regional hydrogen economies – in particular which institutions are involved? What types of relationships do they engage in with ‘others’ – including at a variety of political scales? This has important implications for the types of resources (financial, types of knowledge, political leverage, etc) which can be drawn upon.

Figure 2: Producing Governance ‘Drivers’

‘Driver’	London	Wales	Teesside
PRODUCING GOVERNANCE – Mediating Representation and Performance			
Key Institutions and their Adaptability	GLA – the development of ‘inclusive’ LHP Daimler-Benz and DGTREN – the development of a PPP	University-driven (part-funded by ERDF) – H2 Wales RDA-driven – Hydrogen Valley Initiative	Local authority-driven – Renew Tees Valley, funded from Sub-Regional (i.e. devolved RDA funding); also RDA through centre of excellence Centre for Process Innovation
Types of Interrelationships	Wide variety of institutions and interests in LHP – public, private, national government, etc	On-going negotiation and ‘journey’ – circulation and negotiation of ideas - drawing on a variety of relationships and ‘stakeholders’	‘Stitching-up’ regionally
Scales of Political Activity	Focus on developing a coherent city-regional agenda; Importance of proximity to national level via ‘goldfish bowl’; relationality and comparator cities	Wales-wide and south Wales specific – the confidence of a newly devolved ‘region’; looking outwards to Wales in Europe	Looking ‘outwards’ to DTI and attracting inward investors
Key Issues Different institutions take the lead in regional hydrogen economy development – with a variety of views of or different role within the region A variety of network forms of interrelationships underpin regional hydrogen economy development. These differ in size, interests constituting them and degrees of alignment Regional hydrogen economies are informed to different extents by a focus on different scales of political activity			

5.2.1 The Role of Key Institutions and their Adaptability

An important ‘driver’ of regional hydrogen economies related to **the role of key institutions and their adaptability**. In the London city-region, for example, the Greater London Authority (GLA) was a key institution in informing a particular representation of the London hydrogen economy on the basis of a series of issues and a political agenda (outlined above) which saw the development of an ‘inclusive’

London Hydrogen Partnership (LHP). In this sense the GLA informed both the production of the representation of the hydrogen economy but also began attempts to perform and manifest the hydrogen economy through the cultivation of an institutional innovation, the LHP.

Also in London a different form of key institution can be seen in the case of the London CUTE bus demonstration where Daimler-Chrysler, BP and the European Commission through DGTREN informed the production of a particular representation of the hydrogen economy from ‘outside’ of London but also then sought to perform a London hydrogen economy, again through the use of a different form of institutional adaptability – the development of a PPP

From the context of a university, H2 Wales sought to draw on part-ERDF funding which provided an almost Wales-wide focus on the hydrogen economy and thus the assembling of a large and wide-ranging network of ‘stakeholders’ in a Stakeholder Forum, with sub-networks of Demonstration Project Working Groups, guided by a Steering Group.

Additionally, in Wales, the Welsh Development Agency was a key institution in pursuing the development of a hydrogen economy in a more specific area of industrial south Wales. In addressing this there were numerous similarities and indeed overlaps in terms of the network approach outlined on a Wales-wide basis by H2 Wales.

The key institution in addressing the Tees Valley hydrogen economy was a local authority, Redcar and Cleveland Borough Council. The institutional innovation was a specific strategic intervention – Renew Tees Valley – encompassing the Tees Valley Hydrogen Project underpinned by sub-regional funding (i.e. devolved RDA funding). Additionally - through a ‘stitched-up agenda’ - a complimentary centre of excellence, the Centre for Process Innovation, as part of the regional development agency’s science technology and innovation strategy, Strategy for Success, began to address the commercialisation of fuel cell R&D through its Fuel Cell Application Facility.

5.2.2 Types of Interrelationships Generated

Of considerable importance were the **types of interrelationships generated** by these institutional adaptations and underpinned by particular representations of the hydrogen economy, as outlined above. So, for example, there were a wide variety of interests involved in the ‘inclusive’ LHP, including public, private, national government, and so on. This underpinned a lengthy process through which different understandings of the hydrogen economy, drawing on varieties of technical, environmental, business, etc, forms of knowledge were negotiated in the production of the LHP’s Action Plan.

The interrelationships underpinning the CUTE project were narrower than this and reflected the fact that this was addressing a specific transport demonstration. There was a core network of multinational interests (Daimler-Chrysler, BP) and the European Commission in a PPP added to by more local level interests in particular contexts, here London. The resources these actors were able to leverage (according to one source the costs of the initiative were split with DGTREN contributing around 21 million Euro of the 60 million Euro total) informed a particular test-bed view of the region, trumpeting a technology test-cycle and learning to inform future wide-scale systemic transport change.

In Wales the lack of clarity as to the specifics of how a hydrogen economy would address relatively poor economic performance, and the geographic scale of activities, led to a wide variety of interrelationships (for example encapsulated by the numbers and types of interests attending vision-building events such as that at Miskin Manor) and produced an ongoing negotiation of various forms of knowledge – a circulation and negotiation of ideas - drawing on a variety of relationships and ‘stakeholders’ on the ‘journey’ to Wales’ hydrogen economy.

In Tees Valley, interrelationships were underpinned by movements from the local level up and the regional level down to ‘stitch-up’ regionally a ‘common’ understanding of the hydrogen economy starting from different perspectives. Such a process involved drawing on forms of knowledge of the possibilities of economic regeneration, knowledge of the technical and market possibilities of fuel cell and

hydrogen technologies, knowledge of regional economic strengths and attempts to strategically align these and so on.

5.2.3 Scales of Political Activity

A further important issue was the extent to which these interrelationships connected different **scales of political activity** or otherwise. In London, through the GLA and the LHP there was a focus on developing a coherent city-regional agenda but in doing so there was an acknowledged importance of geographical proximity to national level policymakers via the ‘goldfish bowl’. In terms of the CUTE project there was an attempt to develop interrelationships which in many ways by-passed the national level to link the supranational and local and regional levels. There was also a focus on the comparative and competitive politics of ‘world’ and major cities both vying with one another and co-operating around common agendas.

In Wales the scales of political activity were both Wales-wide and south Wales specific in terms of the cultivation of networks but also with specific project group networks developed at the local level. These views sought to position Wales in terms of the confidence of a newly devolved Wales looking ‘outwards’ to Wales in Europe, through the development of networks and the bidding for Framework projects.

In Teesside the ‘stitching-up’ and aligning of agendas linked the local, sub-regional and regional scales together in informing a view of the adaptability of Teesside infrastructure in creating jobs, economic competitiveness and informing regional economic, science, technology and innovation strategies. There was also an emphasis on looking ‘outwards’ to DTI, in positioning the Tees Valley as a place where a government uncertain about the possibilities of the hydrogen economy could come and ‘play about’ in an area of existing and adapted expertise.

5.2.4 Key Issues

The above themes highlight a number of **key issues**:

- That different institutions take the lead in regional hydrogen economy development – with a variety of views of - or different role within - the region. The important issue with regard to hydrogen economy development is the

level of resources (financial, forms of knowledge) that are available to key institutions, the types of resource available to them in terms of relationships (or ‘social capital’) and the ways in which institutional innovations are both informed by these resource issues and have consequences in terms of future resources which may be cultivated in terms of processes of learning through hydrogen economy developments.

- This, in turn, links to a variety of network forms of interrelationships underpinning regional hydrogen economy development. These differ in size, interests constituting them and degrees of alignment and it is the negotiations of such interrelationships, with their variety of aspirations, expectations and understandings of the possibilities of the hydrogen economy, which informs the production of regional representations.
- These interrelationships are not territorially bounded. Regional hydrogen economies are informed to different extents by a focus on different scales of political activity. Indeed the entry of ‘external’ viewpoints into the development of regional hydrogen economies was a significant ‘driver’ in all cases. The importance of this – if one refers back to the views of the regions made, often implicitly, in a number of national and supranational contexts – is that this informs an *ongoing negotiation* between the often different expectations of regional hydrogen economy development across different scales and contexts of political activities.

5.3 PERFORMING GOVERNANCE – Manifestations of Regional Hydrogen Economies

The last section outlined issues related to the production of governance, which followed on from representations of governance. That is to say, there was a concern with the types of interests and motivations for developing regional hydrogen economies and the capability of these different interests to inform the symbolic meaning of what a regional hydrogen might look like and why. The issue then relates to the role of those involved in the production of governance in moving the idea of regional hydrogen economies from representation and possibility to their

manifestations and what ‘gaps’ there are, if any, between the two. In this respect there is an important focus on three ‘drivers’: the **role of ‘intermediary’ organisations**, **consequences** and **transferability**.

Figure 3: Performing Governance ‘Drivers’

‘Driver’	London	Wales	Teesside
PERFORMING GOVERNANCE – Manifestations of Regional Hydrogen Economies			
Role of ‘Intermediary’ Organisations	<p>LHP – Generation of wide-ranging network to create the ‘route-map’, know-how and know-who to support a London hydrogen economy</p> <p>PPP – Outside-driven network appropriated and embedded in particular place. Lack of intermediation initially between local people and MNC</p>	<p>H2 Wales – University led initiative seeking to produce networks from which sub-networks can negotiate the development and embedding of demonstration projects in a variety of local contexts</p> <p>HV Initiative – development of automobile industry supply chains with aim of retaining Wales’ position in relation to the global automobile industry</p>	<p>Tees Valley Hydrogen Project – between technology providers and a series of demonstration projects in different contexts</p> <p>Fuel Cells Applications Facility – between fuel cell R&D and their application</p>
Consequences	<p>A few small scale demonstration projects and a range of cultural and educational events to inform publics</p> <p>Relatively large-scale demonstration projects, driven through PPP, but encountering local protests</p>	<p>Few demonstrations beyond bids for funding – many in planning stages</p>	<p>From attempts at demonstration projects issues include: Appreciation of advantages of regional context; importance of engaging through education; a series of design & safety issues; importance of visibility; being distinctive through demonstration projects; importance of engaging local providers in training & also developing institutions to work between R&D & the market</p>
Transferability	<p>London-specific?</p> <p>Technology and the test-bed – technology as transferable between contexts where lessons are learned</p>	<p>‘Rolling-out’ the hydrogen economy across Wales. Wales as a ‘global showcase’ – technology exporter; Welsh technology in ‘global’ cars</p>	<p>The ‘experimental platform’ – transferability of the message that Teesside is the place to prototype the hydrogen economy</p> <p>‘Village fete’ – know-how and processes developed in Teesside can be used to embed the hydrogen economy in different regions (the importance of Teesside as 1st mover)</p>

Key Issues

Of importance the role of intermediary organisations between the production of hydrogen and fuel cell technologies and the various contexts of appropriation – what role might they and do they perform?

Various understanding of ‘transferability’ are highlighted: technological artefacts, know-how and processes, perceptions or images of regions.

Of importance is recognising the limited development of the hydrogen economy in relation to the above visions of re-imagination. But also that where development has taken place a number of issues are raised even in relation to small-scale demonstrations

5.3.1 Role of ‘Intermediary’ Organisations

Of interest in attempts to manifest the hydrogen economy in particular places was the **role of ‘intermediary’ organisations**. So, for example, the role of the LHP was in the generation of a wide-ranging network to produce a ‘route-map’, the know-how and know-who – the creation of a social context - to support a London hydrogen economy. In doing this the LHP positioned itself between the representation of the hydrogen economy in London and attempts to begin to create a social context for its ‘realisation’.

The PPP underpinning the CUTE project was an ‘outside’-driven network appropriated and embedded in a particular place. There were interesting issues related to its role which relied on very little apparent intermediation initially between local people and its MNC/DGTREN agenda. In many senses the availability of relatively plentiful resources, underpinning the ‘test-bed’ view of technology, dominated to the detriment of local-level engagement.

The role of H2 Wales was as a University-led initiative, with the resource implications of this. The relatively limited resources, particularly financial, was important in informing the motivations of Demonstration Project Working Groups as means of bring together sub-networks of the overall project with the basis of developing project proposals in particular local contexts to attract such financial resources from a variety of funders.

The Hydrogen Valley Initiative acted as an ‘intermediary’ organisation between the perceived competitiveness of the ‘global’ automobile industry and Welsh attempts to maintain their prominence in such a sector. The role of the HVI was in encouraging

the development of automobile industry supply chains with aim of retaining Wales' position in relation to the global automobile industry.

On Teesside two different organisations were developed to inform the manifestation of a hydrogen economy. The first of these, the Tees Valley Hydrogen Project, sought to position itself between technology providers and a series of demonstration projects in different contexts. The second, the Fuel Cell Applications Facility, took a role 'connecting' fuel cell R&D to potential markets for 'application'.

5.3.2 Consequences

These organisations and the roles they undertook resulted in a number of **consequences**, the first of which was that, across the case studies, there were only a few small scale demonstration projects and a range of cultural and educational events to 'educate' and 'inform' publics. This said, many demonstration projects were in the planning stage and reflected that the securing of financial resources was of key importance but also that this needed some investment in terms of the development of a vision or representation and the cultivation of networks to underpin this. Of the few demonstration projects there was relatively high visibility in terms of the large-scale demonstration projects, driven through PPP, but which encountered local protests. It is interesting to note that the 'big boys' here suffered few of the financial resource issues of other initiatives and as such the perceived 'necessity' to 'prepare' and create a social context may not have figured as prominently, a consequence of which can be seen in terms of the bus refuelling station controversy related to the CUTE project.

Where there were attempts to engage in demonstration projects, for example on Teesside, the important issues raised included an awareness or an appreciation of 'selling' the hydrogen economy in terms of the advantages of regional context. There was also a recognition of the importance of engaging with publics through education. A series of design and safety issues were raised as was the importance of visibility and being distinctive through demonstration projects. In addition there was an emphasis on the importance of engaging local providers in training and also developing institutions to work between R&D and the market

5.3.3 Transferability

This leads to some suggestions as to what was considered **transferable** from regional hydrogen economies. In many ways the city-regional agenda of the GLA was London-specific and not transferable. There was, however, a sense that perceptions of London in terms of it being a ‘world’ city and at the forefront of hydrogen economy developments was transferable. The CUTE project view of hydrogen economy development in terms of the test-bed suggests in many ways that it is the technology that is transferable between contexts where lessons are learned

In the Welsh case there was an unclear sense that through ‘rolling-out’ the hydrogen economy across Wales that technology was transferable. Furthermore, the notion of Wales as a ‘global showcase’ suggests the transferability of a particular vision of ‘new’, confident Wales as well as attempting to position Wales as a technology exporter. This view of technology transfer also resonated with the HVI initiative relating Welsh technology and expertise to ‘global’ cars.

In Teesside transferability operated, through the notion of the ‘experimental platform’, in terms of the transferability of the message to DTI that Teesside is the place to prototype the hydrogen economy. If Teesside was then a ‘first mover’ the ‘village fete’ – the know-how and processes developed in Teesside – was seen as being transferable in being used to facilitate embedding the hydrogen economy in different regions.

5.3.4 Key Issues

What these themes highlight are a number of **key issues**, including:

- The importance of (understanding) the role of ‘intermediary’ organisations between the production of hydrogen and fuel cell technologies and the various contexts of appropriation, but also their role between the ‘inside’ and the ‘outside’ of the region. That is to say how do ‘intermediary’ organisations mediate between national, supranational and multinational corporation interests and the regional and local levels? A key question is: what role do ‘intermediaries’ form and might they perform?

- Of importance is recognising the limited development of the hydrogen economy in relation to the above visions of re-imagining regions. But also that where development has taken place a number of issues are raised even in relation to small-scale demonstrations. There is a large ‘gap’ between the possibilities and claims about regional hydrogen economies and events on the ground. That is to say that an understanding of attempts to develop regional hydrogen economies provides the possibilities to sensitise some of the more grandiose visions of regional hydrogen economies to the constraints and opportunities of particular regional context and the availability of ‘relevant’ relationships and resources.
- There is a variability in understanding what may be ‘transferable’ from different regional and local contexts and to where. ‘Transferability’ was highlighted in terms of: technological artefacts, know-how and processes, perceptions or images of regions.

6. Conclusion

This paper has outlined the importance of thinking about regional hydrogen economies not only in terms of technical and economic possibilities but also in respect of appreciating the regional contexts within which such developments occur. It is important to acknowledge that such regional contexts are not bounded and fixed but are best understood as a ‘nested’, fluid and complex interpenetration of scales of activity – including those of a variety of supranational, national, regional and local actors such as government departments, consultants, regional development agencies, local authorities, EU DGs, and so on.

The importance of understanding not only technical and economic possibilities but also how this relates to regional contexts was pushed here in terms of a number of issues. The first of these was ‘purpose’, or **why** develop a regional hydrogen economy, and was understood through addressing the relationships between issues and problems facing a region, the possibilities of and response to the hydrogen economy and how understandings of the relationship between regions and hydrogen technology were thought about.

The second issue refers to relationships, or **who** was involved in regional hydrogen economy developments, **how** they were involved and what their motivations were, or **why**? This also relates to capability, or the types of resources they brought along (**what**).

The third issue is informed by performance, or the production of knowledge, action and forms of learning and how this related to the development of resources (**what** and **how**) in pursuit of a particular view of regional ‘purpose’ in the manifestation of a hydrogen economy and its consequences.

The key point to note is that there is a chasm between the representations of the hydrogen economy outlined in the case studies and manifestations of the hydrogen economy. The reasons for this are many and complex and whilst a start has been made in outlining key ‘drivers’ in the narrative above a continued and focused attention on regional contexts and ‘drivers’ of hydrogen economies is required.

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