

What needs to be considered when developing a low carbon energy system that uses hydrogen?



Introduction

How can hydrogen be used in low carbon energy systems for a whole city? One of the key issues in demonstration projects is that because of the relatively small scale at which they are developed, they are not economical due to high capital cost and sometimes high energy costs. Each demonstration scheme focuses on a different issue depending on the location, for example:

- operating in cold or hot climate,
- combining hydrogen and renewables
- using hydrogen for public transport
- use of hydrogen from biomethane
- use in rural or urban areas

The prospect of a low carbon city would have to take into account the “big picture” and address a number of these issues at once. It would demonstrate how individual projects could fit into wider energy networks.

A city approach would allow more co-ordinated action. Use of term “city” is nominal: it does not just mean a legally incorporated municipality. It is intended to encompass a variety of “localities” or “local communities” – in terms of size (terrain), population, density and demographics – that constitute the first levels of community development on a continuum that build up to the “national” or “federal” level. A larger scale approach that is more holistic and whose systems are more integrated can show how low carbon energy systems incorporating hydrogen in a city might be economically viable. The cost of supporting technologies and of the hydrogen products themselves would fall due to mass roll out. ‘Waste’ heat or power could be used elsewhere.

Approaches may be different in the developing and developed world or on greenfield or brownfield sites however the same questions will need to be addressed.

The lack of continuous funding for each project is a recurring theme in all the demonstration projects, and the reality is that some do not reach completion or do not prove their viability. Building the development of low carbon energy systems and hydrogen into the everyday planning processes of a city would remove such financial uncertainty and help make such energy systems an economic reality.

What are the most economic ways to build such low carbon energy systems and incorporate them into the development of a city?

The aim of this paper is to demonstrate the breadth of what needs to be considered and the level of co-ordination required if the following questions are to be answered:

- *If cities are to incorporate low carbon or renewable energy and hydrogen into their planning processes, what are the questions that should be posed?*
- *Who needs to be involved with what roles?*
- *What coordination is required?*

This paper is therefore for:

- City planner and administrators
- Energy and transport industry
- Engineers and staff developing new technologies

It is important to harness the expertise of those with experience in developing innovative products and infrastructure. Successful models of development could be adopted for hydrogen systems. This may involve different areas or levels of government working together.

Key Areas

The key areas to consider are the provision of heat, power and transport but many other issues are linked to these fields.

Renewable power generation

At a city level the sizes of generation could be:

- Stand-alone units in housing
- Small units for a cluster of dwellings or a community within a locality
- Centralized but small-scale generating sites

Generation could be for heat, power or combined heat and power (CHP).

Role of Hydrogen

For each of these applications, hydrogen could play the following roles:

- ⇒ A fuel for stand-alone units in housing for CHP, for larger generating units or for transport
- ⇒ As a means of storage for excess renewable power
- ⇒ As reformed fuel from biomethane or biofuels. This could use gas from sewage or municipal or industrial waste

Storage for Nuclear Power and Carbon Capture from Fossil Fuels

Role of Hydrogen

- ⇒ Hydrogen can be created from reformed fossil fuels, this is carbon neutral if the carbon is stored.
- ⇒ Excess nuclear energy can be stored as hydrogen.

Transport

For a city to develop low carbon integrated transportation it is essential to make efficient use of the resources available which will mean an integrated programme of development that considers the use of:

- Mass transit systems including trains, trams and buses
- Low carbon cars and lorries

Role of Hydrogen

- ⇒ Hydrogen can fuel all these types of transport or be combined with battery power or biofuels.

Planning Considerations

If the city is already constructed, changes to the energy infrastructure will be made in a step by step fashion. Planning authorities and local councils will need to make sure that every opportunity to move towards a low carbon energy system is exploited. They will have to answer the following types of questions.

Planning - Electricity supply

Technical considerations

The generating infrastructure and energy networks are likely to be developed by a range of bodies including city administrations, energy suppliers and network operators. The structure of the industry varies between countries.

What are the resources available e.g. wind, solar, biofuels, sewage, waste, hydro, wave and tidal?

If electricity is supplied by renewables:

- How should intermittent supplies be smoothed/stored?
- What are the advantages of batteries or hydrogen?
- If hydrogen is used how will it be created?
- If hydrogen is used how will it be stored?
- What will the stored energy be used for - transport or power?

If hydrogen is from reformed fossil fuels:

- At what scale is the reformation: large power station, small generators, domestic?
- Where can the carbon be stored?
- How is the carbon transported to the storage?

If the hydrogen is from excess nuclear power:

- How is the hydrogen used?
- How is it transported to the site of use?

How does planning influence these choices and encourage the best available technology?

- What should be mandatory in planning policies?
- Is there a clear process for safety and permits?
- How does planning facilitate the storage of carbon from reformed fuels?
- How does a city area link up with a nuclear power station to supply hydrogen?

If there are small hydrogen rings or areas where hydrogen is used, how do they interact with other power supplies?

Planning - Transport

Technical considerations

Planners will have to consider how best to use the energy resources available to them for transport. This cannot be considered in isolation but will need to be taken in conjunction with decisions over the supply of electricity:

- If hydrogen is used, what are the most appropriate resources, electricity (nuclear or renewables?), reformation or biofuels? Should biofuels or electricity be used directly?
- Where will the storage for the energy be and how is this built into planning policy?
- If localised reformation of fossil fuels is used, how will the carbon be captured and stored?
- If public transport is provided by the private sector, what influence does local government have, how can it work in partnership?

Is there a standard permitting procedure for hydrogen?

If there are small hydrogen rings or areas where hydrogen is used, how do they interact with other transport links or power supplies?

Planning - Hydrogen supply

If hydrogen is used how will it be supplied?

- Pipelines
- Onsite reformation
- Onsite electrolysis
- Trucked in

What types and size of storage will be used?

Should there be a plan for installing a hydrogen pipe network for the city, how will it be extended? Will developers be required to link to it/extend it?

Planning - Joined up approach

How can the supply of heat and power to businesses and homes be co-ordinated with transport?

- What role might hydrogen play in this co-ordination?
- What savings can be made from a co-ordinated approach?
- What planning policies are needed?
- Can government owned buildings be used as a nucleus for energy generation or refueling infrastructure?
- If reformed fossil fuels are used, what is the best scale reformation to be carried out if the use of the hydrogen for heat, power and transport is co-ordinated? How does the need to store the carbon affect this decision?

How can plans for a low carbon energy system/use of hydrogen be incorporated into long-term development plans?

Can a standard design be achieved for filling stations?

Education

Developing a low carbon energy system will require new ways of working and understanding new technologies. Training and awareness raising will be important for a smooth role out and for public acceptance.

- Who requires training within government structures – e.g. planners, treasury departments?
- What education and training is needed outside government?

Optimum Sizes?

The answers to the questions previous may vary with the size of the city, town or region.

- Is there an optimum size for low carbon energy systems?
- Should similar sized cities/town work together in a cluster to cut costs?
- Should different sized town work together – smaller towns 'piggybacking' cities?

Economic Consideration

What measures can be taken to reduce the costs of the chosen technologies or achieve maximum benefit for the local economy?

What economic measures can be used to encourage mass take-up?

- Mandate/support certain technologies?
- Use public procurement of certain technologies?
- Use grants, soft loans, tax breaks?
- Can public-private joint funding initiatives?
- Financing/tax districts?

Can the energy systems of a city be used to attract business or industry?

How can local suppliers and industries be supported?

Role of business

- What is the role of large corporations?
- What is the role for SMEs and social enterprises?
- Can mass role out in towns provide markets to attract big business?
- How does a city benefit from big business whilst ensuring local SMEs and innovations are not driven out?

Improving the information

Much of the information that councils or cities would need is available in IEA Hydrogen Implementing Agreement work or in EU projects but it may be difficult to find. City or council representatives may not know where to access the information or may find the format difficult to use. In order to facilitate the technical progress and the development of the industries that the IEA and EU projects aim to support, they must actively engage with local and regional government to provide the necessary information and demonstrate the 'global approach' that is needed.