INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 39 (2014) 7460–7466

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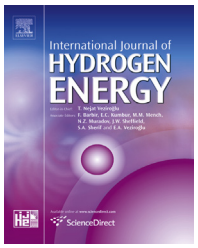

Development of a hydrogen fuelling infrastructure in the Northeast U.S.A.

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ABSTRACT

Development of critical selection criteria was undertaken, identifying locations for possible hydrogen refuelling stations depending on population density, demographics and traffic density. This identified suitable locations for the initial installations of refuelling stations when the first hydrogen fuel cell vehicles became commercially available. This was continued through the three time phases to implement an expanding network of refuelling stations to service demand and ensure consumer convenience.

As well as identifying refuelling station locations, sourcing of hydrogen which will supply these stations was investigated. The technologies selected for hydrogen production were; steam methane reforming, water electrolysis, and coal or biomass gasification. Existing natural gas, coal and biomass infrastructures were considered for hydrogen generation and supply; whilst additional large wind farms could represent production of hydrogen during off peak hours when electricity demand is low and therefore the price is at its lowest, making it economically attractive.

Introduction

The project proposes the implementation of a hydrogen refuelling infrastructure for the Northeast U.S., including major population hubs Boston, New York City, Philadelphia and Washington D.C. A development timeline plan is presented from 2013 to 2025 for the construction of a hydrogen refuelling and production network. The timeline was broken down into three sections, Phase I (2013–2015), Phase II (2015–2020) and Phase III (2020–2025).

Criteria development

In order to locate the positions, numbers and types of refuelling stations to form a hydrogen network, criteria need to be developed in order to provide a selections process. These criteria and the weighting they are given will change and evolve through the different phases, and often within a phase there are different criteria relating to priorities and numbers of station falling under each priority.

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http://dx.doi.org/10.1016/j.ijhydene.2014.03.003
0360-3199.

Criteria for selection and justification

The main criteria need to be identified and given priority during the different phases of development. The following sections identify key criteria that must be assessed in order to achieve a functional, cost-effective and efficient role out of a hydrogen infrastructure.

Traffic density
Traffic density can provide a pivotal piece of information in assessing the locations of individual refuelling station or routes that should be developed. However, in assessing the development of the network it provides information on the end-goal of the project during Phase III and when combined with information such as population density and income distribution for Phase II. It is vital that key routes are identified and supplied with refuelling access, traffic density data is one of the best methods identify these routes.

Population density
Another important factor for the use of hydrogen vehicles is population density. With an estimated 300,000 vehicles in use by 2030, facilitating and refuelling these vehicles leads to a need to identify where they are to be kept. In addition there is a need to provide for convenient consumerism during the later phases of network development which includes positioning locations within a certain distance of the majority of consumer's place of residence.

Land cost & income distribution
Another factor to consider is exactly how much of the local population would be able to purchase and use a hydrogen vehicle. Even with the level of market penetration that is anticipated, fuel cell cars would still be expensive and only available to certain tiers of consumers. As such, it would it beneficial to have a higher number of stations in the areas that are most affluent and therefore, would have greater access to HFCVs. So when looking at this criteria, both local land price and local income distribution is important to identifying key locations. In addition the cost of purchasing land, or leasing land for the construction of hydrogen refuelling stations is an important factor in determining the cost benefit analysis of each station.

Geographical demands
When considering potential fuel station locations local geographical demands must be considered. This can be broken down into several components. Firstly, it is of paramount importance to ensure an even spread of stations across a given area/route as possible. Secondly, it is important to study existing gasoline/diesel/LPG stations to look for opportunities in retrofitting existing stations and thirdly, to consider local opportunities for supplying hydrogen.

Marketing, outreach and research facilitation
The need to facilitate marketing, outreach and research during network development has an interesting effect on the placement of locations, especially during the early phase of the network development. Not only is there a need for marketing, outreach and research to instigate awareness, increase demand and reduce costs but also areas which welcome these projects are likely to help facilitate the construction of sites and use them as they develop. This makes locating these areas important as they provide benefits to certain locations. In addition it is important to know existing projects as not to interfere with their on-going deliverables but also as to not repeat previous work.

Hydrogen costs
As mentioned under geographical demands above each location is subject to a fluctuation in the price of hydrogen, whether that because of logistical considerations or due to the methods of production that best suits the local area. In either case the cost at which hydrogen can be supplied at a given location is an important factor to the viability of a given location.

Weighting of criteria

During the development of the network the weighting of each criteria (and in some cases additional criteria) will evolve. As such, it is outlined below, how in this project the weightings have been given during each phase of network development.

Phase I: minimum required for initial travel
The weighting criteria during Phase I should be focused on the geographical locations of the stations with the aim of completing a skeleton network which facilitates a journey from Boston to Washington creating the opportunity to enhance research, outreach and educational programs. An example of this is shown in Fig. 1.

During Phase I there will be relatively few cars. The initial phase will also be focused on consumer awareness and publicity. The creation of a hydrogen highway is a good publicity focused goal; it will make a hydrogen network seem a viable alternative to conventional fuel. The exact locations of the refuelling points should be situated to facilitate research or to enhance outreach and educational projects, reducing costs through research and stimulating demand through outreach and marketing. This leads to two main criteria for choosing locations during Phase I: criteria 1 being the suggestion of locations that facilitate a complete journey between Washington and Boston; criteria 2 being the exact location of sites, located as such to enhance research or marketing projects.

Phase II: targeted deployment for early markets
Phase II sees the need to expand the hydrogen refuelling infrastructure from the minimum required for a network between Boston and Washington to a targeted distribution of refuelling sites across the Northeast seaboard. This sees the weighting of the criteria for selection move from a bias towards pure geographic consideration to a bias towards facilitating the demand of the early adopter markets. The main criteria bias in this instance is towards traffic density, income distribution and location of fleet bases (see Fig. 2).

Phase III: convenient consumerism
By 2020, a sufficient placement and distribution of hydrogen refuelling stations will be located through the