Hartford Hydrogen Station Geodesign Workshop Final Report

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Executive Summary

On October 7, 2019, the Connecticut Fuel Cell Coalition hosted a workshop on hydrogen station mapping for the Greater Hartford region. The workshop was led by a team from Arizona State University, the University of Nevada, Reno, and the University of Southern California as part of a project funded by the National Science Foundation that is studying consumer uptake of hydrogen fuel cell vehicles (FCVs) and hydrogen refueling station network planning strategies nationwide. Seventeen local and national stakeholders in the transportation, energy, and environmental fields representing industry, government, universities, and non-profit organizations participated. The participants used an online collaborative mapping ("geodesign") tool called Collablocation to propose, vet, negotiate, and recommend a network of hydrogen refueling stations to support the initial rollout of hydrogen fuel-cell vehicles in the area. After three stages of modeling and negotiation, the workshop reached consensus on six stations to add to the existing station in Wallingford and the station under construction on Leibert Road north of downtown Hartford at the I-91 Jennings Road exit. The group recommended a first phase consisting of three new stations in Glastonbury, Manchester, and West Hartford, primarily to serve the consumer FCV market. Common strengths of the first three locations were good access to and from busy freeways, locations near major trip generators and employers, and proximity to residential populations matching known early adopter demographics. A second phase would add stations near Bradley International Airport, Cromwell, and Plantsville. The group agreed that priority next steps beyond this initial mapping workshop include: continued collaboration, government leadership, public-private funding, prioritizing green sources of hydrogen, and being ready to submit proposals for station development.

Goals

The overarching goal of this workshop was to help advance adoption of FCVs in the greater Hartford region. The greatest challenge facing the emerging zero-emission alternatives to gasoline and diesel vehicles is the lack of public refueling and recharging stations. The main purpose of this workshop, therefore, was to engage local, regional, and national stakeholders to collaboratively develop a strategic plan for an initial network of hydrogen stations in the Hartford metropolitan area. Important secondary goals included scoping to identify the interests and values of stakeholders and developing an ongoing working partnership among industry, government, universities, and non-profit organizations to continue the momentum generated here. Finally, an additional goal was to demonstrate the value of geodesign methods and tools for rapid and effective development of realistic strategies and recommendations.

Background

Hydrogen FCVs are electric vehicles with a high-pressure tank of compressed hydrogen, a fuel-cell stack that generates electricity from hydrogen, and an electric motor to power the car. Passenger car FCVs can fill up in roughly five minutes (similar to gasoline refueling times) and travel 300-400 miles on a full tank. Toyota, Honda, and Hyundai are the leading makers of FCVs that fit 4-5 passengers. In addition to the sedans and hatchbacks currently available, other companies currently produce or will soon introduce fleet vehicles including buses, shuttles, and various sizes of trucks and vans. Hydrogen FCVs, which emit only water vapor, offer a zero-emission alternative to battery-electric vehicles. Unlike battery electric vehicles and plug-in hybrid electric vehicles that consumers can recharge at home or work, FCVs can only be refueled at hydrogen refueling stations. A network of conveniently located public hydrogen stations is thus essential for initiating FCV adoption by consumers.

Hydrogen stations vary by whether they source their hydrogen from centralized or distributed generation. In the centralized model, stations rely on hydrogen delivered by tankers from larger production plants. In the distributed model, stations generate their own hydrogen on site either from natural gas steam reforming or electrolysis of water. Stations can also be co-located with an industrial process that produces hydrogen as a primary product or byproduct. Stations also include a hydrogen storage tank, a compressor, and pumps delivering 5,000 psi (for large vehicles) of 10,000 psi (for passenger cars) hydrogen gas via hoses with locking nozzles. Typically, hydrogen refueling stations do not need the kind of substantial on-site upgrades to the electric distribution system, power generation, or battery storage that might be needed for BEV commercial recharging stations. If electrolysis is powered by on-site solar panels or green electricity from the grid, then FCVs offer a zero-emission "well-to-wheels" transportation option.

California's FCV market has grown from 157 vehicles and 25 public stations at the end of 2015 to 7,700 vehicles and 41 retail stations by November, 2019 (https://cafcp.org/by_the_numbers). Automakers and energy companies are targeting the New York-Boston corridor for the next rollout of stations and FCVs in the US. The existing and under-construction stations in Hartford serve as connector stations between New York and Boston and support stations for early fleet demonstrations and applications in the area. The region also boasts some prominent companies in the emerging hydrogen industry, including Nel Hydrogen (a supplier of pumps and electrolyzers to station developers) and US Hybrid (a supplier of technology for converting heavy-duty diesel and natural gas vehicles to hydrogen). With an active fuel cell coalition, major aerospace, technology, and insurance companies, world-class colleges and universities, EPA air quality concerns, and a state that has joined the Transportation Climate Initiative compact, the Hartford region has significant potential as one of the next markets for FCVs in the Northeast US.

Methods

The workshop employed a method of participatory planning or collaborative mapping known as geodesign (Steinitz, 2012). Geodesign consists of three interrelated components:

1. Workshop participants with local knowledge and industry expertise from different stakeholder perspectives
2. An easy-to-use mapping platform that participants can use to visualize relevant map layers, add and delete stations in different locations, save and test their solutions using scientific data, and share and compare solutions across different breakout groups.
3. A structured workshop process for the participants to use the tool to converge towards a consensus recommendation by the end of the workshop (see diagram below).

Participants at the Hartford hydrogen station workshop used an online geodesign platform called Collablocation, developed at Arizona State University (Kuby et al., 2018). As an online website, (https://collablocation.shinyapps.io/home and click on the Projects tab), Collablocation can be run from any computer with a browser and internet connection, both during a workshop and afterwards. In addition to being able to run the Hartford application built for this workshop, Collablocation is available free and open-source (github), and can be adapted by other GIS programmers to other regions.

The Hartford application incorporates several key data layers:

- Candidate sites for new hydrogen stations, which represent locations at or near existing gasoline stations in the Hartford region.
- Three primary map layers representing population, traffic volume, and trip origins and destinations, using data from the Capital Region Council of Governments.
- Three primary performance metrics based on the population, traffic, and trip data within a user-defined 1-10 mile radius of each candidate site.
- Other map layers relevant to hydrogen station siting, such as natural gas pipelines and dealerships of car companies that make FCVs.
- Map layers from CCAT's online mapping tool, including potential hydrogen users, opportunity zones, and fleet vehicle heat maps (http://chfcc.org/hydrogen-fueling-station-planning-tool/).
- Solutions from three different optimal facility location models for five or ten stations based on the metrics above.

Stakeholders

To begin the workshop, participants representing a variety of organizations were divided into four stakeholder groups:

Industry	Government	University	Hydrogen Research and Advocacy
Toyota Nel Hydrogen Keller Williams Realty	CT Dept of Energy and Environmental Protection CT Dept of Transportation CT Green Bank City of Hartford Planning and Zoning	UConn Geography (3) UConn Engineering (2) Tunxis Community College (2)	CT Fuel Cell Coalition Argonne National Laboratory/Clean Cities Coalition US Hybrid

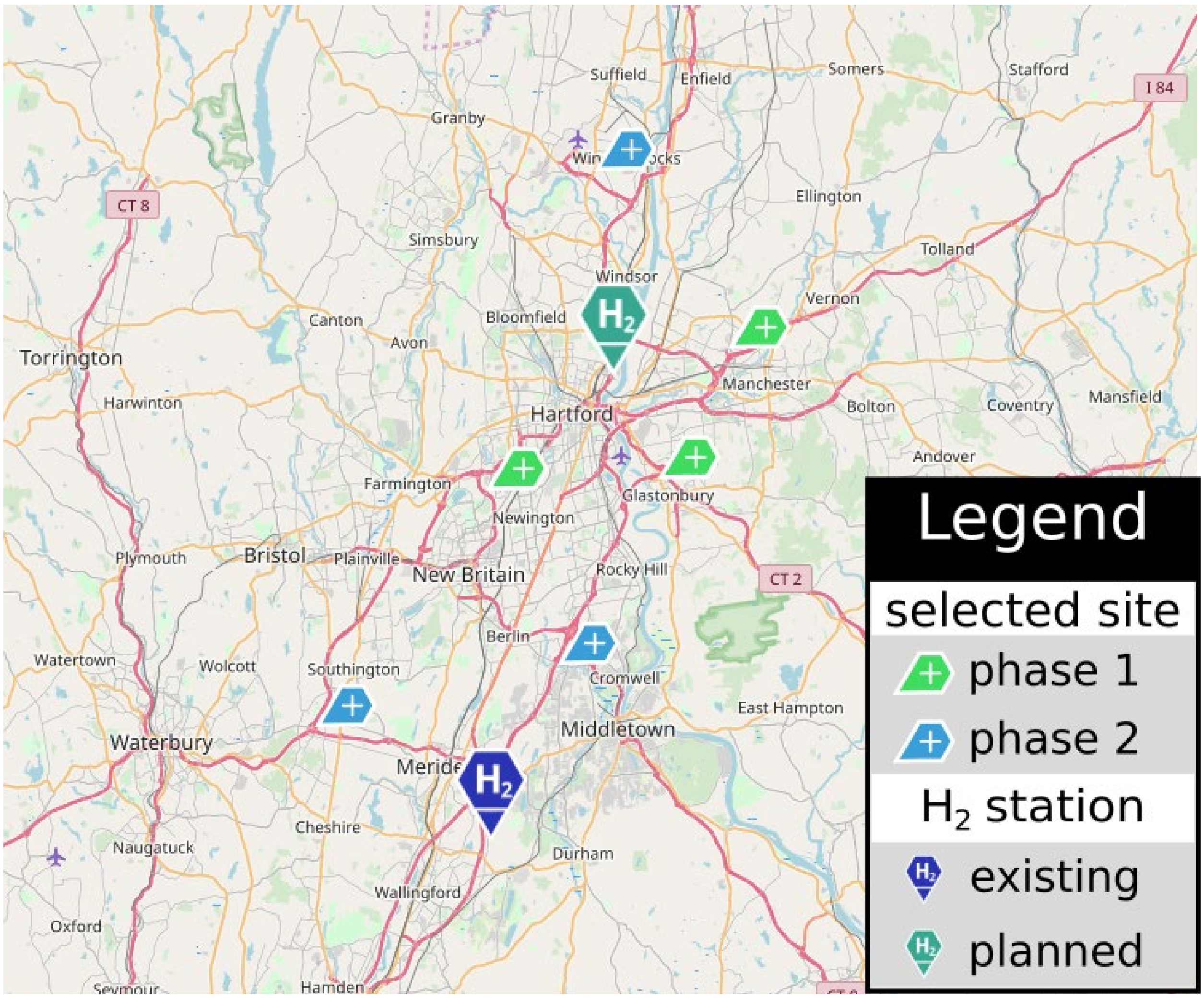
Each group's first task was to identify the key considerations, constraints, and concerns regarding hydrogen station siting as seen from their stakeholder perspective and explain them to the other groups. Since many groups identified similar factors, they are combined into a single list below.

Transportation-Related	Land Use-Related	Energy-Related	Other
Highway access Long-distance connectors Fleets Bus/car interaction Routes (O-D vs out-and-back)	Demographic Employment Destinations Setbacks, footprints, parking Safety perceptions	Renewable sources and ability of H2 to store excess renewable Capacity Pressure needed for diff. vehicle types Redundancy (supply interruptions, equipment problems) Zero-emission electricity credits	Funding Permitting & Zoning varying by state and local jurisdiction Regulations Tunnel restrictions Fire & safety

After Stage 1, each group estimated the degree of alignment of their maps and strategies with those of the other three groups. Based on that, the Government and University groups were combined for Stage 2, as were the Industry and Hydrogen Research and Advocacy groups. Then, in Stage 3, all participants merged into a single group for developing a final consensus.

Recommendations

The initial charge to the breakout groups was to recommend eight additional approximate locations for new stations to add to the existing unmanned station in Wallingford and the station under construction on Leibert Road north of downtown Hartford. The participants almost universally agreed that the prospect of building eight new stations would be unlikely during the early stages of the introduction of FCVs to the Hartford region, citing budget and permitting concerns. In Stage 3, then, the group settled on recommending two phases of station construction, which would add three stations in each phase.



Map showing existing, under construction, and recommended stations

The table below lists the two current stations and the three recommended locations for each phase of development, along with the key strengths and weaknesses cited for each one. The general consensus was that the three additional stations in the first phase should be sufficient to move Hartford from a FCV demonstration area and connector site between Boston and New York to a realistic market where automakers could begin selling and leasing FCVs.

Information about Existing, Under-Construction, and Recommended Stations

Approximate Location	Nearby Gasoline Stations	Strengths Cited	Weaknesses Cited
Phase 0 - Existing and Under Construction Stations Open to the Public			
Wallingford, CT Nel Research Parkway near I-91		Accessible from I-91 Short detour from Wilbur Cross Pkwy, I-691, US-5, CT-66, 68, and 15. Midway between Hartford and New Haven Near potential fleet adopters	
Hartford, CT I-91 & Liebert Rd.		Near Transit Facility Near auto mall Accessible from I-91 Short detour from I-84 and I-I-291. Near potential fleet adopters.	
Phase 1 – Highest Priority Locations (in alphabetical order)			
Glastonbury	7-11, Mobil, Cumberland Farms, Stop&Shop, Shell	Accessible from CT-2 & CT-3. Short detour from I-91 Near Pratt & Whitney First adopter demographics, Whole Foods, mall Connector to New London	Not a major fleet hot spot
Manchester Buckland Hills Mall Area	Mobil, Shell, BJ's	Accessible from I-84 Short detour from I-291, I-384 Major trip generator Commercial center and Trader Joe's Connector to Boston	Not a major fleet hot spot
New Britain CT-9 New Britain Ave./Hartford Rd.	Sunoco, Costco	Accessible from I-84 Short detour from Near Blue Back Square mall Near UConn Health, CCSU First adopter demographics, Whole Foods and Trader Joe's	Not a major fleet hot spot Not realistic to site in Blue Back Square, so sited in less congested area
Phase 2 – Second-Priority Locations (in alphabetical order)			
Bradley International Airport, Ella Grasso Turnpike	Pride, Mobil, Valero, Sunoco	Accessible from CT-20 Airport fleet vehicles, including taxis, shuttles, rental cars, baggage carts, buses	Good sites lacking directly off I-91 near airport, so sited near airport itself 3 miles from I-91
Cromwell I-91 & Berlin Rd.	Sunoco, Mobil	Accessible from I-91 and CT-9 Near Middletown and Berlin, Wesleyan College	
Plantsville CT 322	Mobil, Bouchard, Gulf	Accessible from I-84 and I-691 Near Southington, Waterbury, Meriden	

		Connector to New York, Danbury, Waterbury	

Several important factors emerged with respect to station capacities. The three Phase 1 stations could have a smaller footprint since they are targeted mostly at consumer vehicles rather than trucks and buses. California is now building stations 400 kg/day and larger because of fuel shortages at smaller stations. Building two or more modular 200 kg/day pumps and/or electrolyzers at a single station would improve throughput during busy times of day and also protect against equipment failures at one pump. While scaling station capacity with rising demand would save money up front, expanding capacity is difficult because it requires taking stations offline for 3-6 months. It may therefore be better to add capacity by building an additional station nearby to provide redundancy and expand geographic coverage and visibility, even though it would be costlier.

Next Steps

After reaching consensus on station deployment recommendations, participants discussed next steps needed to help realize their vision. Some of the key points included:

- Government leadership (but not ownership of stations) is important.
- Funding is a challenge in the early stage because of the chicken-and-egg dilemma. Public-private partnerships and government incentives and subsidies could help. VW Settlement funds are a possibility but there is a need to plan beyond that. Coordination of timing with vehicle rollout is essential.
- Station developers should have sites and plans ready for when funding becomes available.
- OEM timing for delivery of FCVs, cost and lease details of the FCVs, and dealer support for market demand for the FCVs are critical to match fueling with vehicle purchases and consumer operation.
- Start planning for green hydrogen sources: offshore wind is a possible source.
- Distributing contact lists, useful links, and map results in GIS format to participants.

Post-Workshop Participant Survey Results

At the end of the workshop, participants completed a survey to assess the utility of the platform and workshop design. On a scale from 1 to 9, with 9 being the highest, average scores ranged from 7.4 to 8.1 (Table 1).

Respondent Satisfaction with:	Mean	Median	Minimum	Maximum
Workshop Design	8.1	8	7	9
Stage 3 (final) Solution	7.7	8	5	9
Comprehensiveness of Factors Generated During Workshop	7.7	8	5	9
Level of Knowledge Exchange Between Participants	7.8	8.5	6	9
Ease of Use of Geodesign Platform	7.4	7	6	9
Technical Analytic Capacity of Geodesign Platform	7.4	7	6	9

Conclusions

The 17 participants at the geodesign workshop reached a consensus to recommend six new targeted locations for new hydrogen stations, to be sited and built in two phases of three stations each. The three highest-priority stations are concentrated towards the center of the Hartford region, radiating east and west of downtown Hartford near I-84 in Manchester and West Hartford/New Britain and south near CT-2 in Glastonbury. Together with the Leibert Road station north of downtown near I-91 and the Nel Hydrogen station in Wallingford near I-91 towards New Haven, they make a viable cluster of five stations with sufficient redundancy and regional travel coverage on major urban freeways and through routes. By adding these three consumer-oriented stations near major trip generators and residential areas with proven demographics to the two initial fleet-oriented stations, the proposed network of five stations would offer sufficient support for early consumer and fleet adopters of FCVs. Following that, the next three stations would be located near Bradley International Airport, in Cromwell near I-91 and CT-9, and in Plantsville near I-84 and I-691. These next three stations would offer additional coverage of fleets, inter-city and commuting routes, job and shopping concentrations, and residential areas. The participants rated the workshop experience and Collablocation geodesign tool as generally effective, especially in promoting knowledge sharing, considering many relevant factors, and ultimately producing a good solution.

Building out a small but strategically placed network of hydrogen stations would provide people and companies in greater Hartford with a viable alternative for convenient, zero-emission driving. The commercialization of FCVs and station would, in turn, enhance economic growth in Connecticut through the development, manufacture, and deployment of fuel cell and hydrogen technologies and associated fueling systems.

References

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