

# UNATTENDED HYDROGEN VEHICLE FUELING CHALLENGES AND HISTORICAL CONTEXT

Hamilton, J.<sup>1</sup>, Harris, A.<sup>2</sup>, Keller, J.<sup>3</sup>

<sup>1</sup> Safety, Education, Codes & Standards Program Manager, California Fuel Cell Partnership, 3300 Industrial Blvd. Ste. 1000 West Sacramento, CA, 95691, USA [jhamilton@cafcp.org](mailto:jhamilton@cafcp.org)

<sup>2</sup> Technical Director, Air Liquide Hydrogen Energy US LLC, 275 Shoreline Drive #505 Redwood City, CA 94065, USA [aaron.harris@airliquide.com](mailto:aaron.harris@airliquide.com)

<sup>3</sup> President and CEO, Zero Carbon Energy Solutions, Inc., 3534 Brunell Dr. Oakland, California, 94602, USA [Jay.O.Keller@gmail.com](mailto:Jay.O.Keller@gmail.com)

## ABSTRACT

Hydrogen fueling in the US is unattended activity although this precedent is not without several challenges that have been addressed in the past decade. This paper provides the recent history and the generic safety case which has established this precedent for hydrogen. The paper also explores the longer history of unattended gasoline fueling and attempts to help place hydrogen fueling into the longer history of fueling personal vehicles.

## Introduction

The safety requirements in the United States for fueling of personal vehicles are complex and dynamic. The complexities are the result of decades of changes and the regional, state or even local decisions. Public officials must strike the delicate balance of public safety and consumer demands in regard to self-service fueling of personal vehicles. Alternative fuels such as compressed natural gas (CNG), hydrogen, and electricity must find a similar balance while also considering the rich history and evolving safety requirements of traditional liquid fuels.

Most would be surprised to learn that at one time self-service gasoline fueling was effectively outlawed in the United States. Even today at least one state (New Jersey) and some cities still prohibit self-service. Many more jurisdictions require an attendant to be onsite during fueling. The prohibition and subsequent legalization of self-service fueling in the US can be traced from 1930 and is still changing in 2019. [1] Meanwhile mobile gasoline services offering concierge filling at your workplace, commonly referred to as “wet hosing”, are a growing business concept, particularly in the hot house of new technology, Silicon Valley. Still further, traditional gasoline stations are adapting to changes in consumer demands, mobility systems, and technology. Again, alternative fuels must consider these changes as part of the strategy for energy transition offerings.

This paper will consider the impacts of both the lessons of history and the current changes of traditional gasoline fueling in the context of hydrogen only, however these lessons are applicable to all alternative fuels, in general.

The landscape is dynamic, to simplify the communication of this article we will need a few defined terms. “Self-service” will mean all instances when a member of the public (anyone of legal driving age) directly

uses the fuel dispenser. “Unattended” will mean instances when that member of the public (anyone of legal driving age) performs that fueling when there is no other person at the service station.

## **Short and Specific History of Gasoline Fueling**

In the early days of automobile fueling gasoline was sold in the way it's predecessor, kerosene, had been sold; by the pail at the pharmacy or general store. This slowly evolved as entrepreneurs developed businesses to sell gasoline from mobile bulk containers. There were even bulk sales opportunities with pricing wars which lead to the dispensing of gasoline directly from rail cars. In 1896 the first automobile was sold in the US. [2] By 1905 the first purpose-built gas station was built in St. Louis. Station development grew and the service aspect of the fueling remained an integral part of the business. In 1930 self-service stations began opening and in the same year legislation in Indiana prohibited self-service. [3]. Safety concerns were cited as the rationale for the legislation, however commercial interests certainly played a role. That legislation in 1930 started several decades of public debate and a patchwork of regulations across the United States. “A survey in August 1948 showed self-service to be illegal in nine states – Illinois, Indiana, Louisiana, Maine, Michigan, Ohio, Oregon, Pennsylvania, and Tennessee – and in many cities and towns in California, Idaho, North Dakota, and South Dakota. Four other states were poised to pass prohibitions should self-service appear.” [4] In some instances, neighboring cities might have opposite positions on self-service.

By the 1950's, and the establishment of the interstate highway system, the automobile became synonymous with American culture. This opened opportunity for technical innovation in safety to overcome the political barriers established in the 1930's and 1940's. In 1957, “The first automatic hold-open latch/shut-off valve is approved by the NFPA Sectional Committee on General Storage of Flammable Liquids and later by UL (Underwriters Laboratories). This innovation allows fueling to continue while attendants take care of the drivers' other needs, such as washing the windshield or checking the oil. It also reduces the likelihood of spills if untrained drivers pump the fuel.” [5]

The experience of the safety innovations and necessity for easy access to vehicle fuel for all facets of daily life lead to the establishment of unattended stations, with the first such station opening in 1964 in Colorado.

A 1950 report from the American Society of Planning Officials [6] cited pros and cons of self-service stations. Cons ranged from fire and explosion hazards due to customers smoking while filling and being more likely to spill gasoline, to customers creating a hazard with their own vehicle as they are not trained (like the attendants) to recognize needed repairs or defects in the vehicle. Additionally, the customer (especially an elderly or female one) would not wipe their windshield and therefore “fail to protect his own driving vision”. It was also argued that undue traffic congestion will result in a higher rate of accidents.

The same report, however also included rebuttal to those cons; that customers who are paying for fuel are less likely to spill it and that spillage is not an important factor in fire and explosion, only accounting for five percent of fires. An attendant at a self-serve has a ‘supervisor’ role and can order someone to extinguish a cigarette, and that self-services “claim they have used safety innovations such as safety-nozzle hoses, central control switches, etc., to guard against fire and explosion.”

Station owners in the late 1960's began to challenge self-service bans across the country. In 1967 the New York Supreme Court overturned local ordinances. In other states, station owners offered self-service illegally in an attempt to force lawsuits. In 1969 the Fire Marshals Association of America supported self-

service but limited that support to attend; station employee onsite during fueling. From 1967 to 1970 the number of self-service stations in the US grew from around 1,000 to around 4,600. [7]

The 1973 OPEC oil embargo against the United States accelerated the trend toward self-service. Overwhelmed stations couldn't provide full service to long lines of angry customers and self-service stations offered discounted fuel due to lower labor costs. The public outcry pushed many states to lift bans on self-service. [5]

In 2019 there are around 120,000 fueling stations in the US. Self-service is allowed in every state except New Jersey. [5] Oregon is in the process of lifting its decades long ban on self-service. Legislation has already passed to lift the ban on small rural communities, and further legislation is being considered to fully remove the ban statewide. [8] Some cities, notably Milford, Massachusetts did not allow self-service until 2019; a self-service pump opens May 4, 2019. [9] Completely unattended fueling is still somewhat regionalized. Mostly western and southern states allow unattended service with many states in the east requiring an attendant to be present when fueling is conducted.

In looking at hydrogen self-service in California, there are several key lessons stand out from the history described above. First, states that operate independently tend to group regionally to manage safety related topics. The argument that “this is how it is done in California and it is safe there” will not win favor in other regions and in fact those regions still behave differently than California for traditional fuels. Second, safety concerns may require some technical advancements to eliminate potential hazards, regardless of the likelihood. This was the case for gasoline. Once an automatic shutoff was developed, the key argument against ‘untrained persons’ dispensing fuel became less about safety and more about preference. Third, these changes occurred over decades with some changes still occurring today. The hydrogen infrastructure industry at large should consider the regional differences and plan for regional strategy rather than attempting to make a homogeneous regulatory landscape prior to deployment.

## **Status of unattended, self-service hydrogen fueling**

Hydrogen retail fueling may be in its infancy, but it enjoys many benefits from the decades of gasoline fueling infrastructure development, particularly with regard to the establishment of self-service and unattended fueling. Millions of hydrogen fuelings have already occurred. The fueling activity is as safe as gasoline fueling. The story is not complete, however; it is early in the market development and there are still opportunities for technology improvement. The strong safety performance is not without many years of efforts at establishing robust codes and standards, strict compliance by infrastructure providers, educated regulators, and leveraging experience from recent developments, namely CNG.

For those unaware of the process, hydrogen dispensed for light duty vehicles requires a nozzle, hose, breakaway coupling connected to a dispenser which provides fuel at a specified flow rate and gas temperature. To perform a fueling the user initiates the payment, connects the nozzle to the vehicle, and initiates the fueling. The dispenser then automatically conducts the fueling. At the end of the fueling, the dispenser prompts the user to remove the nozzle. Once the user removes the nozzle, then the dispenser completes the sale.

Hydrogen refueling does not face the same burden that gasoline did. Hydrogen enters the market when self-service fuel dispensing is well known to most users (except those noted above in Oregon, New Jersey and Milford, MA). Hydrogen also presents differences that improve the safety of the fuel transfer. For example, hydrogen as a high-pressure gas cannot transfer without a leak tight connection between the

vehicle and the nozzle. As such the connection is also designed to remain connected while under pressure, therefore the fuel is removed prior to disconnecting the nozzle from the vehicle. Thus, there is much less opportunity to form a flammable gas cloud around the point of transfer.

While there is much effort in harmonizing the requirements of the safety codes and standards, there are certainly some globally regional differences. An example of this are the integrity checks in the US as required by NFPA 2, the Hydrogen Technologies Code. The fueling protocol includes a small pulse of gas upon connection of the nozzle to the vehicle; this is global. If the nozzle is not correctly attached to the vehicle receptacle, the station/dispenser will not initiate the fueling process. In the US, the station must also pause at prescribed points during the fueling process and determine if there are any leaks in the system. Other places in the world, like Europe or Japan, do not require these integrity checks (other than at the start of fueling).

Innovations in hydrogen refueling technology are certain to evolve, including those that improve safety. Some that have already been implemented including that hydrogen inherently requires an automatic shutoff; one cannot disconnect the nozzle from vehicle when under pressure from fueling. This, among other safety-related specifics (like redundant isolation) are programmed as a part of the station's automatic controls.

Innovations for gasoline, which further improved the safety case, included the safety latch mentioned previously, and the automatic shutoff. Once the customer activates the dispenser operation (either by removal of the nozzle or by lifting a small lever), and inserts the nozzle into the vehicle, they flow the liquid gasoline by pulling up on the nozzle handle. The automatic shutoff feature in the nozzle (a venturi) prevents overfilling of the vehicle fuel tank, and spillage. [10]

## **Self-service around the world**

In the US, full service was popular in all markets as part of the overall tradition and practical economic motivation. Full service could 'upsell' other services and attract customers as competition spurred market growth. Slowly economics shifted as the vehicle ownership saturated. Self-service was seen as a new method to cut costs and thus offer discounted prices.

Much like the states in the US, self-service and full service is a patchwork of regulations throughout the world. While many of the early hydrogen markets are located in areas where self-service is already allowed in gasoline (with the obvious exception of New Jersey) and therefore hydrogen self-service is likely allowed. Hydrogen providers might consider carefully other markets. China, for example has a mix of full and self-service gasoline outlets. Mexico does not allow self-service and Brazil outlawed self-service in 2000.

Germany claims the first fueling station in Wiesloch when Bertha Benz, wife of Karl Benz, filled her newly invented automobile from a pharmacy. [11] Germany still allows self-service. Similarly, hydrogen fueling stations operate as self-service.

Japan lifted a ban on self-service in 1998 as part of broad deregulation efforts in the mid to late 1990's. Today about 10,000 out of 32,000 gasoline station are self-service. Hydrogen self-service is only just allowed, as of 2018, and even then, the user must be trained by the station operator and can only fill at that station. [12] The Ministry of Economy, Trade and Industry will continue to evolve regulations including self-service as part of a long-term hydrogen fueling strategy [13]

Korea started self-service for gasoline in the late 2000's; most gasoline fueling is done by the attendant. Kim and Kim noted an increase in self-service in Korea in response to economic concerns surrounding the global economic crisis in 2008. [14] The authors used this trend in analyzing the economic benefits of self-service versus full service. Currently, regulation dictates that trained personnel do all hydrogen fueling in Korea. This may change as there is an awareness of what other countries are doing and there seems to be a real interest in self-service hydrogen fueling. [15]

## **Future trend of fueling with respect to gasoline**

Assuming alternative fuels, and specifically hydrogen, continues to follow the trends of more traditional fuels, new methods of getting and paying for fuel are on the horizon. In California's Silicon Valley there is a relatively novel way to fuel one's car that is referred to as concierge fueling. It is modeled after a well-known method used for diesel fleets known as "wet hosing" (also known as mobile fueling, fleet fueling, or on-site fueling.) Wet hosing is the process of fueling large commercial vehicles from tank trucks that are driven to locations where trucks that require fuel are not in-use can be stationed. As a Class II Combustible Fluid, diesel has been the only type of fuel that wet hosing services offer. [16] Gasoline is classified as a Flammable Liquid, and as such has not been approved for mobile fueling, until recently. The concierge fueling concept will very likely be adapted for hydrogen as well, given that some technical and regulatory challenges are overcome.

## **Conclusion**

Self-service and unattended fueling has a long history with many changes over the years. Gasoline fueling is a patchwork of requirements stemming from this long history. All alternative fuels, and especially hydrogen should expect no less. Hydrogen enters the market in the midst of a patchwork and must therefore prepare to adapt to local requirements rather than expecting a homogenous, harmonized set of requirements. One should not consider only the local requirements but should appreciate and understand the history and the future for traditional fuels.

## **References**

1. Robert Bradley Jr. Part I <https://www.masterresource.org/self-service-service-station-bans/self-service-gasoline-the-long-fight-for-legalization/>
2. History Channel <https://www.history.com/topics/inventions/automobiles>
3. NACS <https://www.convenience.org/Topics/Fuels/The-History-of-Fuels-Retailing>
4. Robert Bradley Jr. Part II <https://www.masterresource.org/self-service-service-station-bans/self-service-bans-1947-51/>
5. NACS <https://www.convenience.org/Topics/Fuels/The-History-of-Self-Fueling>
6. American Society of Planning Officials [https://planning-org-uploaded-media.s3.amazonaws.com/legacy\\_resources/pas/at60/pdf/report15.pdf](https://planning-org-uploaded-media.s3.amazonaws.com/legacy_resources/pas/at60/pdf/report15.pdf)
7. Robert Bradley Jr. Part III <https://www.masterresource.org/self-service-service-station-bans/self-service-takes-hold/>
8. Oregon Self Service Laws <https://www.malheurenterprise.com/posts/5472/fill-er-up-rural-lawmakers-want-to-see-changes-at-the-pump-in-oregon>
9. Milford Gets Its First Self-Serve Gas Station <https://patch.com/massachusetts/milford-ma/milford-gets-its-first-self-serve-gas-station>
10. Automatic safety shutoff <https://auto.howstuffworks.com/gas-pump5.htm>

11. Germany Gasoline Stations <https://www.mygermancity.com/wiesloch>
12. Personal communication: T. Ikeda, HySUT
13. Japan hydrogen station self-service <https://asia.nikkei.com/Politics/Japan-to-push-hydrogen-stations-for-fuel-cell-autos>
14. Kim, Dae-Wook and Jong-Ho Kim, “Self Service Station and Competition in Retail Gasoline Markets” IIOC Paper, 2010
15. Personal communication: T. Gomez, K. Lee, Hyundai-Kia America Technical Center, Inc.
16. Wet hosing <https://gaubertoil.com/product-knowledge/is-wet-hosing-a-good-idea-for-your-fleet/>