Hydrogen Readiness Labeling of Gas Appliances

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GAS EMERGING TECHOLOGIES PROGRAM (GET)

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Abbreviations and Acronyms

Abbreviation	Meaning
AGA	American Gas Association
CEC	California Energy Commission
CPUC	California Public Utility Commission
CSA Group	Canadian Standards Association
DOE	Department of Energy
FTC	Federal Trade Commission
GET	Gas Emerging Technologies
GTI	Gas Technology Institute
GHG	Greenhouse gases
HHIC	Heating and Hotwater Industry Council
NEEA	Northwest Energy Efficiency Alliance
SCG	SoCalGas
SME	Subject Matter Experts
UK	United Kingdom

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Executive Summary

The Gas Emerging Technologies (GET) program conducted a study to gather information on the steps required to implement a voluntary labeling program for hydrogen-blended natural gas appliances. This study was conducted to address the market gap for labeling end-use appliances for use with hydrogen blends. The purpose of this labeling roadmap will be to provide consumers with updated information on their natural gas appliances functionality and potential for hydrogen blends, in addition to indicating the future potential impact of the fuel supply transformation.

The first part of the study included a literature review on the hydrogen appliance labels developed by the Heating and Hotwater Industry Council (HHIC) in the United Kingdom (UK) to understand more about the pre-existing labels and hydrogen appliance standards in the UK marketplace. Subject matter experts (SMEs) were interviewed to better understand the hydrogen appliance market in the United States as well as barriers to implementing a labeling program. The key takeaways from these interviews found that most experts were generally supportive of the labeling roadmap, however there was division among the SMEs regarding the ideal way to label appliances for hydrogen blends.

The feedback collected from these interviews found three key market barriers that would need to be addressed prior to labeling end-use appliances for use with hydrogen blended natural gas. The first barrier involves the lack of certification and safety standards for hydrogen-ready gas appliances; the second barrier involves the lack of testing for hydrogen blends at high hydrogen percentages; and the final barrier is that the major hydrogen blended demonstration projects in the United States are still in their infancy. Energy efficiency implications of hydrogen blends were also investigated; however, researchers interviewed in this study found little to no difference in energy efficiency impacts depending on the appliance type and commented on the limited data published on energy impacts to date.

A roadmap consisting of ten tasks spanning five years was developed to address these market barriers to safely label end-use gas appliances in the United States. Each task lists likely organizations that may be involved in addition to a lead organization for each task. This study expects that if each of these key organizations work together and align themselves with a common goal, that a set of hydrogen-ready gas appliance labels can be developed to best serve the American appliance marketplace and its consumers.

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Introduction

The emergence of hydrogen and hydrogen blends are an active area of research. As California and the rest of the United States aims to transition toward the use of clean energy, the use of clean hydrogen has the potential to help meet a number of climate and air quality goals. It is expected that hydrogen blends will be added to the natural gas networks at low levels in the coming years. Increased percentages of hydrogen blends also have the potential to reduce greenhouse gas (GHG) emissions, which can help California reach its long-term climate goals.

Currently, there are no means for customers to understand the implication that the fuel supply transformation will have on natural gas appliances. Labeling natural gas appliances for use with hydrogen blends would provide the means to indicate the future potential impact of the fuel supply transformation on the equipment's functionality. Without a uniform label in place, it will be hard for consumers to make educated decisions about newer hydrogen-ready gas appliances and potentially hinder the introduction of newer, cleaner burning appliances designed to work with hydrogen blends.

Background

Climate change is one of the most challenging issues of our time. The growing need for cleaner fuel such as hydrogen to partially or fully replace natural gas, has emerged as a desirable alternative to lowering greenhouse gases and combating climate change. In 2021, U.S. Department of Energy's (DOE) earth shot announced the Hydrogen Shot to reduce the cost of clean hydrogen by 80% to $1 per 1 kilogram in 1 decade [1]. This DOE initiative, along with large scale hydrogen and natural gas blending demonstrations across the United States have accelerated research efforts into the impacts of hydrogen blending on customer end-use equipment. A major area of research revolves around the maximum hydrogen percentage threshold for natural gas appliances in order to require little to no modifications for hydrogen blending. A recent California Public Utility Commission (CPUC) study has found that hydrogen blends up to 5% in the natural gas system are generally safe with no impacts to appliances [2]. Other studies have found that hydrogen blends of up to 15% presented no operational challenges or issues while also decreasing CO_2 and GHG emissions as the hydrogen content increased [3].

With more than 187 million Americans using natural gas in their homes every day, the potential to add clean hydrogen to natural gas pipelines is an active area of research [4]. As more and more research emerge that support the safety and operational limits of hydrogen blending for end use appliances, manufacturers and consumers need a uniform way to understand what this means for their existing and future equipment. The proposed

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roadmap developed in this study can help address this barrier by providing recommendations to develop hydrogen-ready gas appliance labels.

Assessment Objectives

The objective of this study was to develop the framework for a labeling roadmap for hydrogen-blended natural gas appliances. This study addresses the following:

1) Investigate the UK hydrogen labels developed by the HHIC and any other relevant data including standards and laws regarding product labeling.

2) Interview subject matter experts to gather input on the hydrogen appliance market, hydrogen appliance standards, major demonstration projects and other market barriers.

3) Develop a roadmap for labeling hydrogen ready natural gas appliances that addresses market barriers.

1.0 UK Appliance Label Evaluation

The first model for standardized hydrogen appliance labeling was released by the Heating and Hotwater Industry Council (HHIC) in the United Kingdom (UK) in June 2022 [5]. The HHIC implemented this labeling standard based on tests and demonstrations funded by the Hy4Heat Research and Program initiative by the UK government as well as other stakeholder input. The Hy4Heat program was used to establish the feasibility, safety, and convenience of transitioning to zero-carbon hydrogen gas in residential and commercial gas appliances [6]. The program laid out an innovation pathway for the development of hydrogen appliances that detailed the steps to get to a fully function hydrogen ready appliance that can then be certified.

The PAS 4444 specification was developed by the British Standards Institution (BSI), to be used in the Hy4Heat program [6]. This specification created the first basis for a wide-scale standardization of hydrogen fueled appliances based on the current European and British standards. PAS 4444 serves as a guide for appliance manufacturers and other related entities regarding the functionality, safety, installation, operating, and servicing requirements for up to 100% hydrogen gas appliances [6].

The HHIC defined three product labels to be used with hydrogen appliances which are summarized in Figure 1. The labels are defined by a teardrop shape containing the chemical symbol of hydrogen gas followed by a different hydrogen percentage or symbol to differentiate one label from the other. The first product label is designated to be used with appliances that can run on up to a 20% hydrogen blend. The second label is intended for

appliances classified as “hydrogen-ready" [5]. This label indicates to manufactures and customers that the appliance is suitable to run on a 20% hydrogen gas blend with natural gas, however the appliance can be safely converted with the help of a trained engineer using the PAS 4444 specification guidelines to run on up to a 100% blend of hydrogen gas [5]. The final product label is intended for appliances classified as “100% Hydrogen”. This label will communicate to customers and manufacturers that the appliance can be sold for direct installation on a 100% Hydrogen gas network without the need for conversion. The HHIC also details that these labels be used on the gas appliance manufacturers website and their products.

1a. Hydrogen Blend 1b. Hydrogen-Ready 1c. 100% Hydrogen

Figure 1. Product Identification labels for Hydrogen Appliances [5]

The HHIC also outlined the conversion process required for Hydrogen-ready appliances. In order for manufacturers to submit the appliance to be labeled as hydrogen-ready, they must provide conversion instructions and any kits or components that would be required when submitting a risk assessment [5]. As part of this process, manufacturers must also test the hydrogen-ready appliances using current working practices for natural gas and convert a certain number of hydrogen-ready appliances to be tested under a hydrogen supply as part of their quality audit process [5]. The program identified the UK Gas Appliance Regulation to be the body responsible for assessing the conversion process and their approval would allow the use of the hydrogen-ready label to be used for specified gas appliances.

The hydrogen-ready label process also created the formal definition for hydrogen-ready products in the UK. Hydrogen-ready cooking appliances, heaters, and boilers are now defined as a gas appliance that “out of the box” are designed and approved to be installed for use with natural gas and, following a conversion and recommissioning process in situ, can then operate safely and efficiently using hydrogen [5]. The definitions of these specific appliances are supplied by the HHIC for the manufacturers and consumers knowledge.

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1.1 Hydrogen Ready Standards

The HHIC states that there are no installation standards available for hydrogen gas appliances. Normally, installation standards for appliances are handled by the British Standards Institute and the Institution of Gas Engineers and Manufacturers (IGEM) but these standards would need to be updated. This is not to be confused with the PAS 4444 specification that was primarily written for the Hy4Heat program which serves as a guide to be followed by appliance manufacturers regarding the requirements for manufacturing hydrogen appliances.

In the United States, appliance standards are handled by the Department of Energy's (DOE's) Appliance and Equipment standards program [7]. This program establishes the national minimum energy efficiency standards based on the DOE's described test procedures. It also supports the Federal Trade Commission's (FTC's) EnergyGuide and ENERGY STAR labeling and test program in coordination with the Environmental Protection Agency (EPA) [8]. In the state of California, the California Energy Commission (CEC) maintains the appliance regulations and standards as part of Title 20, also known as the appliance efficiency program. The current standards outline the energy requirements and test standards for appliances like water heaters, boilers, ovens, heat pumps, and clothes dryers [9]. This literature review has found that the CEC's Title 20 requirements, along with the DOE's EnergyGuide programs do not have any specifications available for hydrogen-ready gas appliances to date. Additionally, the CSA Group has also released a statement acknowledging that "at present there are no accepted standards in Canda or the US for fuel burning products using mixtures of natural gas and hydrogen for either residential or industrial applications" [21]. With the absence of such standards, efforts to amend current fuel burning standards to include hydrogen mixtures would be needed, in addition to certification programs for products and appliances that burn a mixture of both hydrogen and natural gas.

1.2 Hydrogen-Ready Appliance Database

The HHIC recommends a centrally held database that links each hydrogen-ready installation location with the manufacturer and part number of the required conversion kit to help with the conversion process [5]. Gas distribution networks would also require information regarding which residential or commercial properties have hydrogen ready appliances installed to know whether the appliance can be converted. The database would provide customers with data to be able to identify the hydrogen-ready appliance based on the model, make, and the serial number. The HHIC also recommends that the proposed database includes details of the conversion process and the location of the installed hydrogen-ready appliance.

A similar database is available in the United States that can be found under the ENERGY STAR™ website, which allows the consumer to find appliances based on different specifications. The ENERGY STAR™ product specifications search also details the development process for specific appliances [10]. This database could serve as an example for a new database for hydrogen products. In California, the CEC maintains the Modernized Appliance Efficiency Database System (MAEDbS) that could also be leveraged for use for hydrogen-ready appliances. Like the ENERGY STAR database, the MAEDbS allows consumers to apply filers and search for the specific appliance model they need. The MAEDbS database includes details on the energy efficiency ratio and the annual energy consumption for commercial and residential appliances.

2.0 Subject Matter Expert Interviews

Interviews were conducted to collect feedback from various subject matter experts about how appliances in the United States are performing with respect to different hydrogen blends, and to gain insight into what trade groups, labeling entities, and government organizations could be involved in developing a hydrogen labeling roadmap. Another expected outcome from these interviews was to gauge the market readiness for hydrogen blends and identify the next steps required to close the gap in the proposed roadmap.

2.1 Target Audience

A total of 29 stakeholders were interviewed for this study. In order to identify the appropriate experts to interview, a SME list was developed. The list was developed based on those who have experience researching hydrogen blends with efforts made to reach out to universities and national laboratories and other research institutes. Other organizations on the list were contacted based on their ability to develop standards and test procedures for gas appliances. Different gas utilities were identified in order to gain insight into different hydrogen blending demonstrations ongoing in the United States. Finally, other organizations were contacted based on their subject matter expertise with hydrogen and more specifically hydrogen labeling for gas appliances. The subject matter experts that were ultimately interviewed in this study belong to the various organizations listed below:

- Federal Trade Commission (FTC)
- ICF
- SoCalGas (SCG)
- Oak Ridge National Lab (ORNL)
- San Diego Gas & Electric (SDGE)
- Gas Technology Institute (GTI)

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- California Energy Commission (CEC)
- Northwest Energy Efficiency Alliance (NEEA)
- Cadeo Group
- Canadian Standards Association (CSA) Group
- University of California, Irvine (UCI)
- American Gas Association (AGA)
- Hawaii Gas
- Dominion Energy
- Heating and Hotwater Industry Council (HHIC)

Note that some of the other organizations we contacted declined to be interviewed.

2.2 Survey Questionnaires

There were two questionnaires used at different phases of the study. The first questionnaire was used for the initial subject matter expert interviews in order to ask a series of questions that would help piece together a roadmap. The second questionnaire was distributed later. The second one was in the form of a survey to gather feedback on the preliminary roadmap that was developed based on the SME feedback from the first set of questions asked during the interview process. The questions used for both the interviews and surveys can be found in Appendices 1 and 3 respectively. It is important to note that not all the questions developed for the interviews were asked for each interviewee due to the nature of the SME interviewed as some did not want to speak on certain topics or due to interview time constraints. Survey and interview participants were kept anonymous for this study and their opinions are not reflective of their entire organization.

2.3 Interview Process and Responses

Subject matter experts were interviewed across multiple organizations including government organizations, research institutions, trade groups, and utilities. Each interview conducted followed a Question-and-Answer format and all the detailed interview questions and answers can be found in Appendix 2.

The overall response from the subject matter experts interviewed was positive and cautionary. The interviewees were interested in the proposed roadmap for labeling hydrogen-ready appliances in California and offered their feedback and considerations based on their respective roles and organizations. The general responses from key interviews are broken down and summarized as noted by the following sections:

1) Summary of the organization's intent to support the labeling roadmap in California

2) Summary of the appearance of a hydrogen label and other label characteristics

3) Additional considerations and feedback on labels and end use equipment

4) Utility-specific feedback and comments on hydrogen blend testing and labeling

5) Government and trade organization specific feedback and comments on hydrogen blend testing and labeling

2.3.1 Summary of the organization's intent to support the labeling roadmap in California

Each interviewee had a different perspective on their organization's potential involvement in the hydrogen appliance labeling roadmap based on how their roles aligned within their organization. All the gas utility representatives interviewed thought that hydrogen labeling is an interesting idea and are generally supportive of labeling appliances. Research institutes expressed interest in hydrogen appliance labels and expressed support as well. Government organizations like the CEC maintained a neutral stance on hydrogen labels, as they are primarily driven by the legislature and only expressed interest in the labeling roadmap if there was legislation passed to require hydrogen labels. Trade organizations seemed interested, but some were still developing their stance on this topic. Some manufacturers like Rinnai and Honeywell have already declared specific products suitable for hydrogen blends [12,16]. Other manufactures do not yet want their names associated with hydrogen products.

2.3.2 Conflicting Opinions Among Interviewees

There were some conflicting opinions among the interviewees with respect to the timing and pace at which to develop hydrogen labels for end-use appliances. Generally, natural gas utilities think it is a good idea and believe it is best to get started early in terms of developing the roadmap for labeling hydrogen ready appliances. On the other hand, some subject matter experts were skeptical about labeling appliances too soon since there is still concern over safety and not enough testing has been done for higher blends above 20% hydrogen. Researchers and SME's interviewed from SCG, GTI, ORNL, and the CSA group have all expressed the need for further studies in terms of safety implications prior to labeling an appliance.

2.3.3 Summary of the appearance of a hydrogen label and other label characteristics

The feedback gathered from the interviews shows some division among stakeholders regarding the ideal way to label hydrogen compatible appliances. A lot of the experts interviewed have not given it much thought, and don't spend much time looking at labels.

These experts have noted that a typical customer will not spend a lot of time looking at labels either. So, it is important that the label grabs the customers' attention and conveys the message in an easy-to-understand manner. The subject matter experts were introduced to the labels developed by the UK and asked to comment on the three distinct labels and offer their feedback.

The interview with the FTC subject matter expert suggested looking into focus groups and customer surveys to come up with the best label design. The FTC SME suggested that adding more label categories compared to the UK's three different labels, would be more complicated and thus the less effective from a customer's point of view. The FTC SME suggested that the labeling roadmap include customer outreach and education as an important step for the organization leading the labeling to take into consideration.

There were a lot of varying opinions regarding the label characteristics. Some experts agree with the UK model and would ultimately follow it, while others don't see it as a good fit. Many of the interviewees from research institutions wanted to see a specific percentage on the label. Researchers at the GTI and SCG advised against the UK labels, especially the middle category since it seems too broad. They suggested that the UK labeling scheme makes sense because their country has announced the transition of certain networks to pure hydrogen with time, and it is okay for them to include the 20-100% label since there is an understanding that networks will be converted over time from one region to another. On the other hand, some believe that the 20-100% middle label does offer some flexibility, but it can also be confusing to the end-user.

The common denominator from every interview conducted was that the label would need to be as simple as possible. Many interviews suggested that future label efforts include customer focused groups to see what the average homeowner, handyman, or contractors are looking for and what their buying behavior is like. Additionally, they recommended using focus groups for different label designs to narrow down the one that is easiest to follow. In California, SCG hydrogen engineers and researchers want the label to be clear, simple to follow and read, and be backed by research so consumers can trust safety. Other suggestions included having a QR code on the label for the customer to scan for more information on the appliance's suitability for hydrogen. Other experts have suggested including information in the appliance operating booklet to let customers know about the appliance and its potential for hydrogen blends.

2.3.4 Additional Considerations and feedback on labels and end use equipment

Many interviews raised safety concerns and other considerations on hydrogen blending. One topic that came up is the need for hydrogen leak detectors in domestic or commercial areas where hydrogen blends become more available in the gas pipeline system. Most experts interviewed agreed that there needs to be more safety considerations and testing

at higher hydrogen percentage blends in order to safely market the appliance as hydrogen ready. Many pointed out that it makes sense for utilities to start with the first label and then add the other two over time since current research shows that a 0-20% blend for most appliances doesn't have any major impact on existing infrastructure.

SCG engineers have pointed out some safety concerns for higher blends that need to be addressed prior to labeling. At concentrations of hydrogen greater than 20% and depending on the type of appliance, there was flashback observed within SCG testing. Flashback is a common problem that arises with hydrogen – natural gas fuel mixtures. It occurs when the gas velocity becomes lower than the burning velocity due to flame propagation or combustion [15]. Flashback limits and solutions are an active area of research, however, there still needs to be more testing conducted to measure different failure modes for hydrogen appliances. SCG engineers called for more research to test the general appliance operations – such as what are the different adjustments that people can make to appliances prior claiming an appliance is ready for a hydrogen blend. Another important consideration is the lack of accelerated degradation testing on end use equipment that use hydrogen blends. Experts at NEEA and GTI suggested that this would be an important test to conduct prior to releasing a hydrogen ready appliance to the market.

2.3.5 Utility-specific feedback and comments on hydrogen blend testing

In California, SCG is leading the hydrogen blending research. The goal is to first conduct more demonstration projects before introducing Hydrogen into the infrastructure. There are currently two active demonstration projects underway in SCG territory to test every single component in the gas distribution system to test the impact of hydrogen. They predict about a 3–5-year effort before introducing blending into the actual natural gas infrastructure. SCG first needs to create a hydrogen blending distribution standard before introducing blends.

In the United States, Hawaii Gas is the leader when it comes to utilizing hydrogen blends in their gas network. Hawaii does not have access to natural gas and Hawaii Gas has been manufacturing synthetic natural gas since the 1970's using a steam reforming process. The process starts off with a feedstock of naphtha, which is a large hydrocarbon that then gets broken down to produce methane, which is a large component of natural gas. This process for producing synthetic natural results in a blend of methane with 10-12% hydrogen content. Hawaii Gas engineers made the decision to leave the hydrogen in the mix rather than remove it based on their experimentation which found that there would be very little performance or safety impacts to appliances made solely for natural gas. Since the 1970's, they have tested all the domestic gas appliance brands such as LG, Samsung, Kenmore, Wolf, Viking, GE, and Thermador. These gas appliances have been installed and used by customers in Hawaii without issues for over 50+ years. For the industrial and commercial

sectors, Hawaii Gas has used hydrogen blends with boilers, commercial cooking equipment, ovens, and flame feature appliances like tiki torches without any problems.

Hawaii Gas experts suggested a possible required system retrofit that might take place if a hydrogen-ready label similar to the UK model is used. They provided this feedback based on their experience converting from natural gas and propane devices within their territory. They suggested that if there are areas in the United States where a ~100% hydrogen blend becomes available, then the very same appliance, such as grills and outdoor burners that currently have conversion kits for natural gas to propane or vice versa would then need to have an additional conversion kit from natural gas to hydrogen. Currently, to convert between natural gas and propane on these appliances there are usually two things that need to be changed:

- The first is an appliance pressure regulator which delivers slightly different pressure to the burner.
- The second is a small brass fitting (orifice) which is located right at the burner tip. The orifice hole for a natural gas burner is a larger hole than the propane burner because propane has more heating value per volume than natural gas.

When converting from natural gas to hydrogen, hydrogen has less heating value than propane. Thus, when there is hydrogen or hydrogen blended gas above 20% by volume available for consumers, experts at Hawaii Gas noted that there will need to be another set of orifices developed. Hawaii Gas services technicians are trained to help change orifices from natural gas to propane and when hydrogen blends increase and a retrofit is needed, the Hawaii Gas experts suggested that their technicians will be trained on the hydrogen retrofit as well; therefore, it is likely that the California gas utilities would also have to train their technicians in hydrogen appliance retrofits when the suitable blend percentage becomes available.

2.3.6 Government and trade organizations have specific feedback and comments on hydrogen blend testing and labeling

To determine the likely body that would oversee appliance labeling and assist in the development of appliance test standards, we consulted with experts from governing bodies and voluntary trade organizations. In California, the CEC is the likely governing body that would be involved with developing testing standards for hydrogen appliances and labeling requirements. The CEC made it very clear that they would only be interested in labeling or developing standards for hydrogen ready gas appliances if that is the direction that the state wanted to go. Additionally, they can only do so if there was legislature passed that would require them to do so. If the legislature were passed, they agreed that they would be the logical standards making body to do so in the state of California. The legislation would have to be very specific and direct the CEC to develop a system of standards for hydrogen

blended gas appliances based on a high level of industry involvement. As it stands right now, there is no way that the CEC can do anything without a new statute to tell them to develop a standard. Alternatively, they would act if there were an industry standard that is somehow put in place or adopted at the DOE level, that might preempt the CEC in some way.

We consulted with and spoke to several members of other trade organizations during the interview process. The CSA Group is another likely body that can help develop standards for hydrogen ready gas appliances. Like the CEC, the CSA Group needs their customers or regulatory agencies to push them to develop testing procedures and standards for hydrogen appliances. The CSA has expressed interest in taking the lead role in end use hydrogen appliances and its components. They have planned to test appliances, and work on addressing the safety standards and what changes need to be made, however those plans are still in their infancy with a timeline they are not able to disclose.

3.0 Preliminary Roadmap

The purpose of the preliminary roadmap presented in this study is to outline a series of steps that would be required to label hydrogen-ready gas appliances. The roadmap will identify likely organizations that could be involved in addition to their potential roles and contributions. The roadmap will be supplemented by a timeline of key tasks that should take place prior to hydrogen-labels being released in the United States. The goal for presenting this roadmap, is to provide the organizations interested in participating in this labeling effort with a timeline of tasks and considerations that should be considered when developing a labeling system for hydrogen blends.

To better understand the process for developing a labeling roadmap in the United States, we consulted with the organization behind the development of the first set of hydrogen appliance labels in the United Kingdom (UK). The HHIC in the UK, is a trade organization whose members include manufactures of heat pumps, boilers, merchants, installers, and large businesses like the British Gas. The HHIC closely engages with the UK government in an advisory capacity, especially with hydrogen. The HHIC is also in the process of rewriting the European standards for certain appliances for hydrogen blend applications and 100% hydrogen use. They also engage closely with the British Standards Institution Group (BSI), which have developed standards for hydrogen-fired gas appliances known as the PAS 4444 standard [11]. These standards provide guidance for manufactures of hydrogen-fired gas appliances and manufactures of gas appliances that are designed to be converted to use hydrogen, as well as other oversight bodies that test appliances.

The main driver for the HHIC to develop hydrogen-ready labels for gas appliances was a result of an increasing number of UK manufactures stating that their products were

compatible with hydrogen blends. The HHIC received concerned opinions from their members and government organizations that if different manufactures were labeling their products as hydrogen ready with different labels, there could be an element of confusion and mis selling if the different appliance labels are not regulated. Thus, the HHIC wanted to ensure that the consumer had the ability to know what they are buying by regulating the labels. The HHIC had led several industry meetings and ultimately decided on the labels based on what several manufactures were using, as it made sense to go along with something similar to what the manufactures wanted than start from scratch.

The HHIC provided feedback on their experience which will be of use to the proposed labeling effort in the United States. They suggested that the responsible organization in the United States should try to release the labels first prior to manufactures releasing labels on their own. It was a lot harder in the UK to get all the manufacturers on board and agree on one label, especially after they released their own distinct labels and would later be told they had to change them. The HHIC also pointed out that several UK manufacturers sell their products in America, so for them it would be easier to have a similar label for their products in the United States as well. Ultimately, the **HHIC was a voluntary trade group that stepped up to guide manufacturers towards a common label for hydrogen ready appliances.** The proposed roadmap will draw heavily from HHIC's experience and suggestions in addition to the feedback from subject matter experts in the United States to develop a similar label for hydrogen-ready appliances.

3.1 Proposed Hydrogen Appliance Label Characteristics in the United States

This section will address the expected physical appearance of the appliance label suitable for hydrogen blends. It is expected that the institution which will later release these labels will use these findings as a guide to curate the appropriate label. Figure 1. displays the labels that the HHIC released for manufactures in the UK to adopt. The HHIC initially started with a Hydrogen-Blend label which is intended to be used for gas appliances up to a 20% hydrogen blend. Based on the interviews conducted in this study, experts are most interested in first developing a label set to a 20% hydrogen blend or lower to start out with. The HHIC then decided to add a hydrogen-ready appliance based on the data collected from the Hy4Heat program. This program established the feasibility and safety of replacing natural gas with hydrogen in residential and commercial buildings. Thus, the hydrogen-ready term was born based on the Hy4Heat program and its corresponding label is to be used on an appliance that can run with up to a 20% hydrogen blend but can be converted to 100% hydrogen at any given time. The final label that the HHIC released is for 100% hydrogen ready gas appliances. The HHIC had commented that the 100% Hydrogen label in

Figure 1 is not in use yet, however they wanted to release one for future applications. The HHIC picked the color green for its labels as it was easy to spot and market, in addition to green often being associated with renewable energy and fuel sources.

In the quest to identify the appropriate appliance label for gas appliances in the United States, we consulted with various subject matter experts in the industry. Based on the interviews conducted, there appears to be two options for developing appliance labels for hydrogen-ready gas appliances:

- Adopt the labels that HHIC has developed.
- Create new labels entirely for the US appliance marketplace.

The feedback gathered from the interviews had mixed feelings about which approach to pursue. Some experts agree with the UK model and would ultimately follow it, while others don't see it as a good fit. Many of the interviewees from research institutions wanted to see a specific percentage on the label instead of the second category of Hydrogen-ready labels like the HHIC uses. As previously noted, Researchers at the GTI and SCG advised against the UK labels, especially the middle category since they feel it is too broad. On the other hand, some experts believe that the 20-100% middle label does offer some flexibility, but it can also be confusing to the end-user.

Ultimately, all the experts interviewed agreed that the label should be as simple as possible and backed by research. Therefore, one component in the labeling roadmap shown later in Figure 3.0 will include customer focus groups consisting of homeowners, handyman, contactors, and commercial businesses in order to gauge what the average gas appliance user is looking for in a hydrogen label.

3.2 Existing Hydrogen Labels from US Manufacturers

While some manufactures in the United States are hesitant to reveal their intentions with hydrogen, other appliance manufactures in the United States such as Honeywell have already started to release labels to indicate that its appliance is ready for hydrogen blends. The label shown in Figure 2.0 was featured across a Honeywell webinar and pamphlet to advertise their Oxy-Therm FHR burner [12].

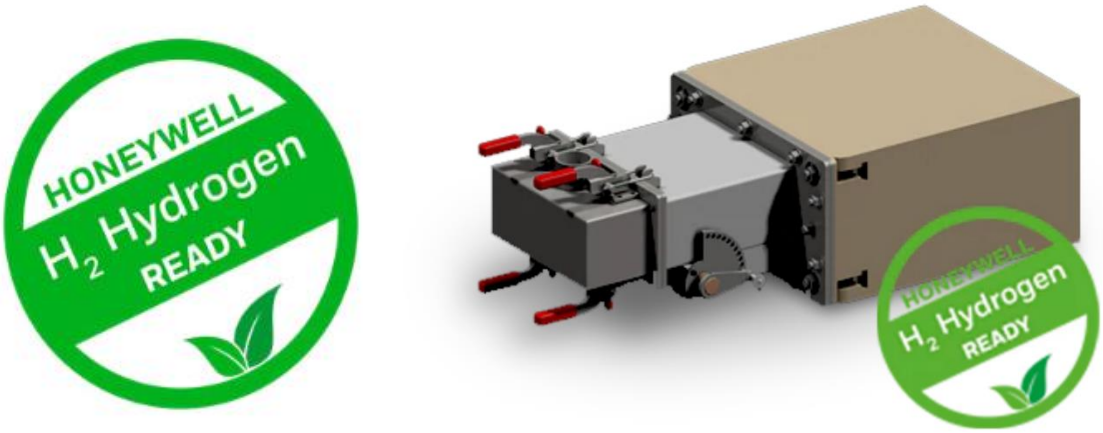

Figure 2.0 Honeywell Hydrogen Ready Label for their Oxy-Therm FHR Burner [12]

Similarly, to the HHIC labels, Honeywell opted for a green colored label that clearly displays element "H2" and "Hydrogen-ready" in addition to their name. However, unlike the HHIC definition for "Hydrogen-ready", Honeywell clearly states that this burner is only suited for up to 20% hydrogen blends. This can be a source of confusion for customers and manufacturers, especially those who serve the US market and the European market for gas appliances. The HHIC definition for hydrogen-ready refers to an appliance that can be later converted to 100% hydrogen gas. As the HHIC in the UK had warned, it is critical that all organizations in the United States decide on a common label for manufactures to use as early as possible. Different labels on appliances from various manufactures would be confusing and getting manufacturers to backtrack on labels they have already come up with will prove to be harder than agreeing on a set of labels early on.

3.3 Proposed Labeling Roadmap Coverage

The subject matter expert interviews were conducted as part of this study and were also used to help scope out organizations that would be best suited to lead the hydrogen labeling effort. A few of the government and non-government organizations that were considered to guide this effort in terms of standards development and labels include the California Energy Commission (CEC), the Federal Trade Commission (FTC), the CSA Group, and the Northwest Energy Efficiency Alliance (NEEA). The information collected from these interviews was used to construct a preliminary timeline to help guide this labeling effort.

3.4 Key Organizations Considered to lead Hydrogen Standards Testing and Labeling Roadmap

In California, the CEC is a possible governing body that could be involved with developing testing standards for hydrogen appliances and enforcing labeling requirements. As it stands now, the CEC is not able to push this labeling effort without a new state statue directing them to do so. Thus, the next step in determining the likely body that could accelerate this labeling effort was to get input from voluntary non-government organizations.

The FTC was considered at the federal level as a potential player to lead the labeling effort, however, the only way that the FTC would engage with anything related to labeling is if hydrogen fueled products on the market fell under the ENERGY GUIDE program. The FTC would then recognize that, and label hydrogen as another fuel listed on the ENERGY GUIDE label, however it would not promote one fuel over another. The consumer education office within the FTC was identified as a possible candidate for educating the average consumer about hydrogen labels. The FTC's main role would be to help consumers understand the meaning behind the appliance label and they would do so using different marketing strategies such as blog posts, QR codes, and websites that contain this information. The FTC also suggested that the organization to lead the labeling effort should include focus groups studies with consumer surveys to help guide the labeling process, which is later detailed in in the proposed roadmap.

Other likely voluntary groups to play a role include trade entities such as the CSA Group, and NEEA were consulted to determine the organization that would be best suited to lead this labeling effort. The CSA Group consists of over 10,000 members including volunteers, utilities, engineers, and manufactures which help them guide and develop standards. Given their diverse member base, it is likely that a balanced decision for a hydrogen label and appropriate safety and testing standards will emerge if the CSA Group leads this effort. We also consulted with the American Gas Association (AGA), who stated that any of the standards for gas appliances will eventually be adopted into fuel gas codes that are adopted by the rest of the nation. The AGA cautioned that any hydrogen ready appliance standard or label that California uses should match the standards on the national level. This underscores the general responses received from the subject matter expert interviews in which experts expressed **the importance that all parties involved agree to have one set of labels and standards for the entire United States and not distinct labels exclusive to California.** Since the CSA Group manages standards in the USA and Canada, several experts we interviewed agreed that they would be in the best position to implement standards and labels for hydrogen-ready appliances that can be shipped anywhere within the United States and potentially in Canada.

NEEA is an organization of utilities and other energy efficiency organizations that has extensive experience conducting market research on emerging technologies. NEEA's codes

and standards research division has produced numerous resources related to advancing energy codes and appliance standards. When we consulted with NEEA, they expressed that they are an organization that can help prepare the market for new codes and standards by working with manufactures. They are currently working on a market transformation study for hydrogen which will cover existing standards, safety, and test measures for appliances on the market that are safe to use with hydrogen. They expect this study to be published in early 2023. The findings of NEEA's hydrogen scoping study along with their interest in collaborating on the next steps with other involved organizations position themselves as an important player for pushing the proposed hydrogen labeling roadmap in the United States.

Utilities such as SCG, Dominion Energy, and Hawaii Gas, were consulted in this study to assess their involvement in the proposed roadmap. SCG experts warned against releasing hydrogen-ready gas appliance labels until after they have completed hydrogen appliance equipment testing and have wrapped up their demonstration projects in the next 3-5 years. This study found that utilities are focused on demonstrating safe blending practices with trusted data. Thus, it is likely that utilizes may play a key role in the customer outreach and education aspect of this roadmap once the proposed hydrogen appliance labels become available.

3.5 Gaps in Appliance Testing and Standards Development

The interviews conducted as part of this study also identified several crucial gaps that need to be addressed prior to labeling a gas appliance for use with hydrogen blended natural gas. The need for updated codes and standards, increased appliance testing, and lack of demonstration projects currently hinders the development of accurate and reliable hydrogen readiness labels that customers can trust.

The first gap is that there is a lack of standards in the United States for Hydrogen-Ready gas appliances. At present, there is no entity that can certify these appliances. Gas appliance manufacturers like Honeywell have been working with the European Technical Committee for Standardization by adjusting existing standards to cover hydrogen [13]. Honeywell has indicated that discussions are currently taking place as to what additional regulations need to be included for fuel gases with a high hydrogen content, with the European standards expected sometime in 2023. To safely label appliances in the United States, it is important that these standards are developed in the coming years.

This study has found that the organization that is best suited to lead this development is the CSA Group along with the assistance from other organizations like NEEA. A possible first step in this roadmap would be to review NEEA's hydrogen scoping study and identify the gaps in codes and standards for hydrogen equipment. The GTI has also called for updated codes, standards, and certification requirements in terms of safety, performance, and possibility efficiency and emissions in order to expand appliance testing.

The second gap is that research institutes and utilities would need to address how to conduct rigorous testing on hydrogen blends greater than 30%. The GTI has published results which found that certain appliances like furnaces and water heaters were able to tolerate up to a 30% hydrogen blend without any changes or issues [14]. The GTI plans on testing residential and commercial cooking equipment up to 30% in the coming years and has called for more research on expanding the scope of appliance types and looking into long term impacts of hydrogen blend. Similarly, NEEA has cautioned that there is a lack of accelerated degradation testing of gas appliances with hydrogen blends at greater than 30%. Overall, major research institutions and utilities like SCG expressed the need for more appliance testing in order to safely indicate to their customers that their appliance is suitable for hydrogen blends in the coming years.

In a report published by the California Public Utilities Commission (CPUC), researchers at the University of California, Riverside found that hydrogen blends up to 5% in the natural gas stream are safe without making any modifications to the system [2]. However, blends above 5% may require modifications of certain appliances like stoves and water heaters. The study found that hydrogen blends above 20% have a higher possibility of permeating plastic pipes, which can increase the risk of gas ignition outside the pipeline.[6] The study recommends that utilities in California engage in more live demonstration projects in order to gain more knowledge on the impact of hydrogen on any components in the natural gas system.

The final gap found that most of the major hydrogen blended demonstration projects in the United States are still in their infancy, with one exception being Hawaii Gas with over 50 years of blending experience. Other utilities across the United States are developing demonstration projects and community-based trials to test hydrogen blends, with SCG leading the way. SCG has begun construction of their [H2] Hydrogen Home project, which will run entirely on clean energy when fully built [17]. SCG and SDG&E are also engaged in hydrogen blending demonstration projects to blend hydrogen between 1-20% within their respective service territories. Additionally, a newly proposed SCG demonstration project in collaboration with the University of California, Irvine (UCI) would demonstrate a real-world environment of blending hydrogen into the existing gas grid on sections of the UCI campus beginning at 5% and gradually increasing up to 20% [18]. SCG engineers and experts interviewed in this study predict about 3-5 years for there to be reasonable, safe, and trusted data gathered from these demonstrations prior to engaging in blending.

Other utilities in the United States like Dominion Energy in Utah are beginning to blend hydrogen in a closed loop area beginning in Q1 of 2023 [19]. They have already tested 50 major types of residential appliances such as furnaces, water heaters, gas ranges, ovens, and space heaters of varying vintages and manufactures without any concerns at a 5% blend. The New Mexico Gas Company is also planning a demonstration project in early

2023 to test hydrogen blends into an isolated part of the company's distribution system beginning at 5%. CenterPoint Energy in the Midwest has begun blending up to 5% hydrogen with natural gas in downtown Minneapolis [20]. As more utilities across the country join California in hydrogen blending demonstration projects, the better equipped utilities will be better able to understand and overcome challenges posed by the shift to hydrogen blends before they commit to full-scale blending. Until these demonstrations are completed, customers in the continental US will not see hydrogen blends in their gas grid, and this will provide utilities with more time to address customers safety concerns as well as allow manufactures and standards organizations to address the respective gaps of labeling hydrogen-ready gas appliances and the related standards.

3.6 Proposed Timeline of Events leading up to Hydrogen-ready Appliance Labeling

A draft timeline of events leading up to the release of appliance labels for use with hydrogen blends is proposed in Figure 3.0. This timeline was constructed based on the feedback gathered from the SME interviews in order to address various market gaps leading up to the implementation of hydrogen-ready gas appliance labels**.** Based on all the interviews conducted, this study found that a voluntary trade organization, such as the CSA Group, is in the best position to lead the development of standards for hydrogen appliances and eventually release appliance labels based on industry input. The timeline is broken down into 10 different tasks that span a total of six years which are described below and summarized in Table 1.0.

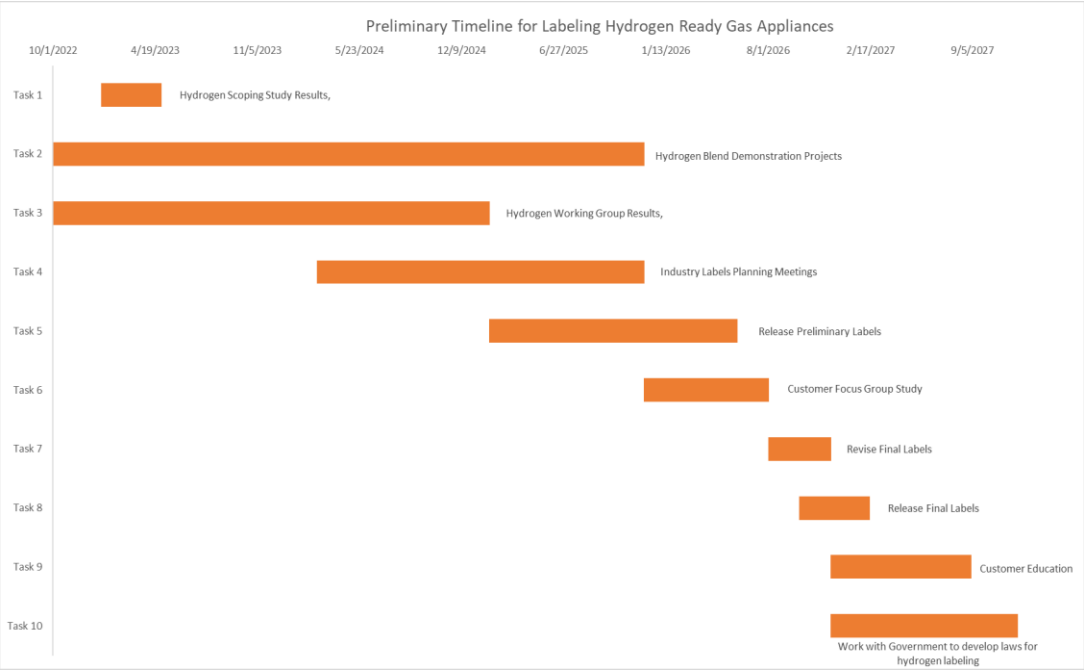

Figure 3.0 Proposed Timeline for Labeling Hydrogen-ready gas appliances

Task 1 of the proposed roadmap includes a thorough review of the Hydrogen Scoping Study results that NEEA is expected to release by the end of 2022 or early 2023. This study would provide organizations involved with this labeling effort with up-to-date information on the current standards for hydrogen related to installation and safety in addition to test measures for appliances on the market that are safe to use with hydrogen. This study will be a starting point for key standards organizations like the CSA Group in order to guide their efforts in developing standards in the coming tasks.

Task 2 will allow utilities to gather sufficient data and wrap up existing hydrogen blend demonstration projects. We expect SCG to continue to lead the nation in terms of appliance research and testing for hydrogen blends in their gas distribution network. SCG has indicated that their strategy at the end of this demonstration is to develop a hydrogen blending distribution standard before introducing blends throughout their network. It is expected that the CPUC would need to officially sign off on the blends prior to a full-scale implementation in a distribution network.

Task 3 is intended to allow the hydrogen working group lead by the CSA Group to investigate what type of changes need to be made to accessories and appliance standards for natural gas hydrogen blend delivery and the potential for 100% hydrogen appliances in the distribution system. Accessories include any valves, meters, piping systems, and connectors for appliances that are expected to run on hydrogen blends. This study also found that other working groups within the CSA are investigating safe levels for existing appliances and what markings for hydrogen may come out as a result of this investigation. They are also looking into what kind of tests, designs and safety functions that need to be placed into gas appliances in the distribution system prior to blending natural gas with hydrogen. The goal of this task in the roadmap is to help accelerate the development of any standards that will need to be in place prior to labeling an appliance for hydrogen blends.

Task 4 will consist of a series of meetings with industry involvement in order to gather feedback regarding the physical characteristics of hydrogen-ready appliance label(s) for the United States marketplace. Some organizations that could potentially be involved include different appliance manufactures, CSA Group, AGA, NEEA, CPUC, GTI, utilities, trade groups, other hydrogen subject matter experts and potentially the HHIC. The goal of this task is to agree on a preliminary label that all parties would be comfortable and in agreement with. Another expected outcome is to determine if the United States will follow the labels used in the UK or modify them based on the feedback gathered in this task.

For Task 5, the CSA Group, assisted by appliance manufacturers and NEEA should work together to release preliminary labels based on the findings from Tasks 1-4. The roadmap recommends engaging a marketing firm to develop the preliminary design. This task should also note the specific types of residential and commercial appliances in the US marketplace that would have to carry this label.

Task 6 will be a customer focus group survey facilitated by a marketing firm and study led by SCG, OEMs, other interesting utilities, and potentially the Bureau of Customer Protection at the FTC. The study should identify the average consumers buying behavior for hydrogen-ready gas appliances and gather feedback on the preliminary label released by the CSA Group in task 5. Customers that should be included in this study would be homeowners, handymen, contractors, and anyone who would be purchasing a gas appliance. The feedback from this survey can be later used to clarify and finalize labels and could impact future customer education and outreach.

Task 7 involves finalizing the labels based on the input and feedback received from the customer focus group survey conducted in Task 6. It is expected that the same marketing firm that does the customer focus study will help modify the labels as needed along with feedback and assistance from the CSA Group and other industry experts involved in this process.

Task 8 of this proposed roadmap will consider the results of the customer focus group survey and tailor any customer education and outreach events around the topic of hydrogen labels. The most suitable group to facilitate and lead this effort would be individual gas utilities with support from OEMs, as they know their customer base the best. On a federal level, the FTC's Division of Consumer Education office could release blog posts and a website targeted to educating the public on the new hydrogen labels. Other examples of customer education can include community-wide presentations, social media posts, or sending out pamphlets in the mail. This step will be left to the individual utility to identify the best way to alert customers to the new set of labels on gas appliances entering the marketplace based upon their familiarity with their customers. Utilities should also oversee the training of their servicemen and engineers on handling hydrogen ready appliances so that they will be better equipped to serve their customers as hydrogen blends become available.

In Task 9, the CSA Group will publish a set of finalized hydrogen-ready appliance labels like the way that the HHIC did and notify manufacturers and other interested organizations. The labels will consider the results from the customer focus group study in Task 6 and any other considerations needed to finalize the label and make it as easy as possible for all parties involved to implement and understand.

Task 10 involves a final and optional step which would be to work with government entities to push the development of a law requiring manufacturers to label their appliances with the labels developed from this optional roadmap. The DOE, which manages the test methodology portion of the ENERGYGUIDE labels, may be a key organization at the federal level that would likely adopt hydrogen labels once they have been released in the United States.

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A summary of the tasks featured in the preliminary timeline for labeling hydrogen-ready gas appliances is tabulated in Table 1.0.

Table 1.0 Summary of Labeling Road Map Tasks

Task #	Potential Organization (s) Involved	Potential Lead Organization (s)	Description and Expected Outcome	Estimated Duration
1. Hydrogen Scoping Study Results	NEEA, CSA Group, Manufacturers, Utilities, SME's	NEEA and CSA Group	Review NEEA's hydrogen scoping study. Identify gaps in standards, safety, testing for hydrogen ready gas appliances	4 months
2. Hydrogen Blend Demonstration Projects	SCG and other utilities across the US leading similar efforts	SCG	This task will allow utilities to research and demonstrate hydrogen blends within a controlled portion of their distribution network. Utilities are expected to gather sufficient data on hydrogen blend demonstration projects. SCG needs time to develop a hydrogen blending distribution standard.	3-5 years
3.Hydrogen Working Group Results	CSA Group, Gas Appliance Manufacturers, AGA, Utilities, NEEA, trade groups other SME's	CSA Group	The results from this working group would be to establish standards for hydrogen blends in gas appliances. The goal is that this information will help inform changes to new appliances, and certification standards moving forward.	2.5-3 years
4. Industry Labels Planning Meetings	CSA Group, Gas Appliance Manufacturers, AGA, Utilities, NEEA, GTI, HHIC, CPUC, DOE's building technology office, and other industry experts	SCG, CSA Group, NEEA	The goal of this task is to gather industry feedback from leaders in various organizations and eventually agree on a consistent label for hydrogen ready gas appliances for residential and commercial uses. Experts are expected to either adopt the HHIC label or agree develop a similar label for the United States and potentially Canada.	1.5-2 years

Task #	Potential Organization (s) Involved	Potential Lead Organization (s)	Description and Expected Outcome	Estimated Duration
5.Release Preliminary Labels	CSA Group, Appliance Manufacturers, NEEA, Marketing Firm	CSA Group	This task will consider the feedback from the meetings in Task4 and the findings in Tasks 1-3 in order to develop uniform labels. This task would also engage a marketing firm to help develop the labels. We anticipate this task may take more time for CSA to develop uniform label since they must test all the appliances.	1-1.5 years
6.Customer Focus Group Study	SCG, OEMs, FTC, and other Utilities across the United States	SCG	SCG would lead a customer focus group study based on the preliminary hydrogen ready appliance labels released by the CSA Group. The study should include customers like homeowners, contractors, plumbers, and those who use gas appliances and involve other utilities and equipment OEMs. The final goal is to collect feedback from customer focus group study in this step of the roadmap.	8 months
7. Revise Final Labels	SCG, CSA Group, Appliance Manufactures, Marketing Firm, other industry experts	CSA Group	This task will collect data and feedback received from the customer focus group study and modify the labels as needed.	6 months
8.Finalize and Publish Labels	CSA Group	CSA Group	Finalize the Hydrogen Ready Appliance Labels and any supporting standards. Labels should be ready for Manufactures to print on their appliances	1 year

Task #	Potential Organization (s) Involved	Potential Lead Organization (s)	Description and Expected Outcome	Estimated Duration
9.Customer Education	FTC, Gas utilities across the United States	Gas Utilities	Should happen at a local level based on utilities using websites, social media, news articles, brochures, email. Additionally, utilities should train their reps and technicians on hydrogen blends and hydrogen-ready appliances to better address their customer's needs.	8 months
10. (optional) Involve government	DOE and state organizations like the CEC	DOE	The final **optional** step in this roadmap is to codify hydrogen appliance labels into law, similarly to what the HHIC is trying to currently do with the UK government. The expected outcome is a Federal or State-level laws for hydrogen - labeling	1+ years

3.7 SME Input and Recommendation

A draft roadmap was sent out to the subject matter experts to elicit feedback and improve upon it for the final roadmap in this report. The feedback collected from the subject matter experts who have volunteered to review this preliminary roadmap was taken into taken into consideration and incorporated into the final preliminary roadmap. A survey tool was used to gather feedback. The survey tool developed is included in Appendix 3. There were limitations when collecting feedback for the final roadmap. We had a 9% response rate to the preliminary roadmap in general, and only a 3% response rate on the survey. The overall feedback was positive with most SME's expressing interest in receiving the final report when published.

Conclusions

This study aimed to propose a roadmap that has input from multiple stakeholders that would outline the considerations required to implement a hydrogen- ready appliance labeling program. A total of 29 SME's were interviewed for this study using a question-and-answer format to gather data. While the initial goal was to develop a labeling roadmap in the state of California, the vast majority of SME interviews suggested a more unified, broader labeling pathway that could be used throughout the entire United States and potentially even Canada.

The findings of the SME interviews were used to prepare a roadmap with a suggested timeline consisting of ten tasks that will be necessary to address the gaps of research, hydrogen-blend demonstration projects, label design development, and hydrogen-ready appliance standards development. The tasks are spread out over five years, with a lead organization designated to lead each task that was selected based on their suitability for the role. A draft roadmap was sent back for the SME's review and after a 9% review response rate, the final roadmap was developed using their input which address key market gaps in appliance testing, hydrogen standards development, and wide-scale hydrogen demonstration projects. The study concluded that a thorough investigation into the following tasks would be imperative to safely labeling gas appliances for hydrogen blends:

1) Hydrogen Scoping Results
2) Hydrogen Blend Demonstration Projects
3) Hydrogen Working Group
4) Industry Labels Planning Meetings
5) Release Preliminary Labels
6) Customer Focus Group Study
7) Final Hydrogen-ready Labels Revision
8) Finalize and Publish Labels
9) Customer Education
10) Government Involvement (optional)

The desired outcome at the end of this study will be for the interested organizations to use the information collected and presented in this roadmap as a tool to guide the accurate and safe development of hydrogen-ready gas appliance labels at the end-use level.

Appendices

Appendix 1. Interview Questions

General Questions developed for All SME's and Organizations:

1. Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?
2. How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?
3. How would you like to see a hydrogen-ready appliance labeled? (can explain the UK labels and what we can do differently. I would create this narrative first, along with the questions to everyone)?
4. Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?
5. If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?
6. Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.
7. Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?

Questions developed for the FTC:

1. What is the best way to display the new Hydrogen Gas appliance labels?
2. Should energy efficiency impacts for hydrogen ready appliances be included on the EnergyGuide label?
3. What role would the FTC play (if any) if DOE's federal standard or the EnergyGuide were updated to reflect the energy efficiency changes as a result of hydrogen blending?
4. What division within the FTC is responsible for developing a label design for gas appliances?
5. What division within the FTC evaluates the proposed label design for accuracy/content to ensure that customers are receiving the correct information?
6. Are there any legal issues with California developing labels with regards to federal or state standards, including preemption?

Questions developed for CEC:

1. How would we need to amend Title 20 to reflect hydrogen blends in gas appliances?
2. Can the modernized appliance efficiency database system (MAEDbS) managed by the CEC be leveraged to include hydrogen ready gas appliances?
3. Are there any legal issues with California developing labels with regards to federal or state standards, including preemption?

Questions developed for GTI:

1. Has the GTI evaluated the energy efficiency of hydrogen blended gas appliances either residential or commercial?

Questions developed for UK/HHIC:

1. What was the thought process behind the 3 distinct labeling criteria for hydrogen-ready gas appliances?
2. What were other labels that were considered during the process for coming up with the best way to label these appliances?
3. How has the general public/consumer response been about the labels since publishing them?
4. Is there a broader EU effort going on that you are aware of?
5. Any lessons learned from your experience that would help us?
6. Have manufacturers begun using the labels?

Questions developed for Appliance Manufacturers:

1. Have you started manufacturing/testing gas appliances that are suitable for hydrogen blends?
2. What are the key changes to a general gas appliance that needs to be made in order to operate at a higher hydrogen natural gas blend (s)?
3. Are manufacturers responsible for providing a retrofit kit in the future for customers to easily convert a gas appliance to handle >20% blend of hydrogen?
4. What relevant codes and standards does the manufacturer typically follow for gas appliances? Where would you expect information on hydrogen ready appliance standards to be when they are ready?

Questions developed for hydrogen blend appliance researchers/ end use testers/ RD&D SME's:

1. How would you like to communicate with customers what the benefits of your technology/research/work are?
2. What sort of information would the research team want to see on a hydrogen ready appliance label?

3. Do you know of any industry standards that would need to be updated or modified to reflect hydrogen blended appliances? /Have you come across any problems in terms of the appliance meeting industry codes or standards?
4. When hydrogen blends become available, above a 20% blend does this prototype need to be retrofitted in any way using a small tool kit to make it more suitable for greater % of hydrogen?
5. Has the research team/appliance manufacturer thought about how they would label this product for customers to understand what exactly they are buying and what efficiency benefits they would have?
6. ORNL specific: Do you have a contact for the appliance manufacturer that you will test your prototype with
7. Any specific energy efficiency impacts blending? (that is worth noting on an appliance label)
8. SCG: What is the timeframe for pushing H2 blends within the natural gas grid?
9. SCG: Do you anticipate certain regions will have H2 blends sooner than others

Appendix 2. Q&A responses

From the first round of interviews. Answers were paraphrases from actual responses unless quoted.

Stakeholder ID#001

1. Discuss findings on the UCI Low Nox Water Heater Retrofit for Hydrogen Blends Development
    - Answer: Looking to Improve the operational limits of hydrogen tolerance
2. Discuss findings on the UCI Catalytic Burner Retrofitted Water Heater Lab Demonstration
    - Answer: relative tolerance to hydrogen will be evaluated. provide insight into how these burners can help reduce carbon emissions from natural gas through use of hydrogen/natural gas blends.
    - Interviewee Suggestion: Investigate ethanol fuel blending and biodiesel fuel blending (E 85% in gasoline)
        i. Biodiesel – B5 and B99% biodiesel and some B100
        ii. H20% H40% H60% - interesting labeling suggestion for customers
        iii. Interview customers and focus group on customers (what is going to drive customers to choosing appliances,
        iv. Do they want to do something related to GHG for efficiency, (3/5 green trees) etc. environmentally appealing to some people).
3. Discuss ORNL Fuel-flexible, flameless appliance consumes blends of natural gas and hydrogen
    - They are developing a cooking appliance that can run on any blend of natural gas and hydrogen up to 100%.
    - They said that their prototype is designed to run on natural gas so you can install it today and it will already provide energy efficiency benefits
    - When hydrogen blends become available, after 20% blend does this prototype need to be retrofitted in any way using a small tool kit to make it more suitable for greater % of hydrogen?
    - has the research team thought about how they would label this product for customers to understand what exactly they are buying and what efficiency benefits would they have? Would this be marketed as a hydrogen blend appliance or hydrogen-ready appliance?
        - "Would need to reach out to #015 at SCG or ORNL directly for more details"

Interviewee Suggestions:

- CEC has done work on up to 20%, GTI doing work on up to 20% hydrogen.
- SCG hydrogen home – they bought a stove and tried to run on 20% hydrogen and caused problems- adjustment (20%)
- Consideration on BTU districts
  - SoCalGas gets gas from lots of different sources
  - Differences heating values for gas/ different energy content
  - BTU districts – typically gas is 994 BTU vs 987 BTU
    - Sometimes moving gas equipment causes that you have to "tune" not necessarily change the appliance
    - 20% would fall into "tuning" and not need to be retrofitted.

Stakeholder ID#002

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA?**
   - The department of energy supports the organization (ORNL)
   - Needs approval to get his quote to make sure he can speak on behalf of ORNL

2. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
   - Yes, it can
   - Would need to send email to see if his interview can be included

3. **When hydrogen blends become available, after 20% blend does this prototype need to be retrofitted in any way using a small tool kit to make it more suitable for greater % of hydrogen?**
   - No, the ORNL prototype can run with 0% H2 but it also produces less emissions compared to traditional burners
   - It Uses today's gas but use it more efficiently and with more emissions
   - Decreasing Nox
   - Emissions and efficiency benefits
   - Tested up to 85% hydrogen without making any changes.
   - Very flexible to accept any changes to % blend

4. **Has the research team/appliance manufacturer thought about how they would label this product for customers to understand what exactly they are buying and what efficiency benefits would they have?**
    - OEM: interested in hydrogen ready products but hesitant to associate their name
    - Arrangement: once the project is finished and the prototype is demonstrated, the OEM will come in and get all the details, evaluate the prototype on their own, and start sending those products for manufacturing.
    - "It's the manufacturer's choice on how to advertise/label the project"

5. **And what sort of information would the research team want to see on a hydrogen ready appliance label?**
    - The Carbon footprint of the end user will be drastically lower with hydrogen, but energy efficiency impacts might be the same
    - "no impact on efficiency" but lower carbon footprint
    - Pointing towards electrification
    - Customer messaging standpoint: "having to spend less money"

6. **Do you think that any industry standards would need to be updated or modified to reflect hydrogen blended appliances? Have you come across any problems in terms of the cooking appliance meeting industry standards or codes?**
    - Smith H20 heaters
    - Depends on the manufacture

Stakeholder ID#003

Discussion and Questions:

1. **What are some ways that the FTC can educate consumers on hydrogen gas appliance labels?**
    - "Consumer education office can play a part in this "
    - "When there are instances where we transition to different products, the FTC can release blog posts and customer education pieces"
    - "That's on an issue by issue basis."
    - "If the hydrogen blend appliances work, it would be viewed as covered products under the department of energy conservation standards program."
    - "If there are transitions related to pocket book issues or other things involved with consumer purchases they'll work on reach and effectiveness."

2. **What division within the FTC is responsible for developing a label design for gas appliances and evaluating the proposed design for accuracy/content to ensure that customers are receiving the correct information?**
    - EnergyGuide rule is done in Bureau of consumer protection
3. **What role would the FTC play (if any) if DOE's federal standards or the Energy Guide standards were updated to reflect the energy efficiency changes as a result of hydrogen blending?**
    - "If there were hydrogen fueled products on the market that fall under the ENERGY Guide program, the FTC rule would recognize that and required that they would be labeled accordingly."
    - "The Energy Guide program is very specific in that its providing objective information to consumers. Not promoting a product or fuel just denoting $/year spending for products"
    - "Hydrogen wouldn't be treated any differently from other products"
    - Products updated every 5 years
4. **What is the feasibility of including energy efficiency impacts for hydrogen ready appliances on the EnergyGuide label? Is it better to develop a new label for hydrogen ready gas appliances or integrate it into a section of the EnergyGuide label?**
    - "There is a section on the energy guide label that will tell you if it works on electricity or natural gas, so one would just need to identify hydrogen as a fuel."
    - "The energy guide label is not intended to promote particular fuels or anything, its really just to tell consumers how much its going to cost to run the products so they can make purchasing decisions."
    - Fuel % mentioned on energy guide maybe?
    - Current label should tell you if it works on electricity or natural to identify fuel
    - Doesn't promote particular fuels
5. **What would be the implications of developing a labeling process for H2 ready gas appliances in CA? And how might this impact the FTC? (ask to energy star)**
    - "There are lots of ways to do that campaign, whether it's through, you know, a label or marking or websites or QR codes or, you know, things like that. That's a lot of ways to get the word out for that. If the goal is just to alert people that you know these are products, are there certain products that, you know, the state or whatever it wants to "

- "FTC would help consumers understand (QR codes, other ways to get the word out) "
- "ENERGY STAR role is to promote high efficiency products, so if these appliances meet the energy stars requirements, then it can be listed on there. "

6. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
    - Answered overall

7. **How would you like to see a hydrogen-ready appliance labeled? (can explain the UK labels and what we can do differently. I would create this narrative first, along with the questions to everyone)?**
    - "Having spent many years on doing consumer research, Consumers spend very little time on whatever label you create. The Label needs to be very simple "
    - Communication should be easy for consumers
    - Need to look at focus groups/customer surveys to come up with best label design

8. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**
    - The more complicated the label the less effective
    - Talk to neighbor and see what they would think
    - "Clear and boring" usually gets the word across
    - More categories = more complicated= less effective the label is going to be.

9. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    - It is best to ask focus groups these questions.
    - Short qualitative study
    - "The worst labels are developed by a room full of SME's"
    - "It is better to do real focus group feedback when you have more concrete ideas and already have a label or two developed.

10. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous?**
    - Anonymous: (we consulted ftc staff)

11. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    - Yes (will get cleared to do)

Stakeholder ID#004

Discussion and Questions:

1. **Discussion on Overall Research Endeavors**
    - Researching low carbon fuels (ammonia or hydrogen)
    - Main focus on end-uses that are primarily combustion type devices
    - Industrial/commercial/residential testing
    - Pool heater, burners, water heaters.
    - New project with GTI (loosely thought of 3 tiers)
    - important to agree on common approach for labeling

2. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    - Good idea
    - Oven comes with a kit to work on propane – same with gas BBQ – similar kit for H2
    - Concerns about public perception?

3. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**
    - "A smaller set of labels is better"
    - "Being certified up to 20% is a super important tier (everything is ready for that)'that could be the first label rolled out"
        - Ready for retrofit.
        - How do we deem these appliances are ready for 20% (manufacturer thing, certification procedure)

4. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    - There is enough

5. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.**
    - Yes
6. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    - Yes
7. **Any specific energy efficiency impacts blending? (that is worth noting on an appliance label)**
    - "How many BTU's you can push through your control system"
    - "More H2 into natural gas the lobby index will decrease "
    - "Most devices are driven by fuel pressure"
    - "More H2- takes longer to heat water – haven't noticed a decrease in the energy. (at least its not getting worse) - needs more testing "
8. **What % of hydrogen blends have you tested?**
    - "Have tested certain appliances up to 100% hydrogen "
    - CEC report on different appliances that he can provide - can include in findings and roadmap
    - Conventional water heaters were not in the report
    - "Some start up challenges on storage water heaters even at 10-20%"
    - "Main challenges were on the startup process for appliances "
    - "Since then, we tested 7 additional water heaters and have pushed them over 20% without any modifications. "
    - "Next most limiting device was ovens (30-40%) need modifications after 30% blend was okay up to 20%"
    - Details of the burner determine the blend %.
    - "Up to 50% okay for low NOx water heaters "

Stakeholder ID#005

Discussion and Question:

1. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
    - "I mean, really what it would come down to was like Energy Star would be interested in in having that be part of their like emerging technologies or anything like that because they're trying t actively decarbonize a lot of the

appliances in the US and this isn't a one way to do it. We met with the Aga, the American Gas Association. "

- "Umm, back in like April and you know they they're always kind of flaunting this like big, you know, roadways research project that ICF actually completed for them a number of years ago. And you know, one of their main points is the whole shifting towards renewable mixed natural gas with hydrogen type infrastructure because if we have this huge gas infrastructure, we might as well use it. If we can still decarbonize at the same time, it's kind of the gist. "
- "Energy Star itself is trying to move away from having gas in general with like all the electrification that's going on, but they still do offer gas boilers and gas water heaters among like are they also do gas furnace just too I think, but you know they're trying to move kinda towards CPS, but if there is an alternative fuel, I think you know that has low NOx emission and stuff like that which I think hydrogen blended stuff does. I could see them being interested. So, you know that would be another tool to get that out there. "
- "But yeah, their goal mainly is to get towards electrification right now, but it's tougher where it's very cold. California is not one of those places. "

2. **Is the ENERGY STAR still interested in certifying appliances for hydrogen blends even if there is no impact to the energy efficiency and only lower greenhouse gas and NOx emissions.**

    - " It is something that is considered. We usually include lb of emissions that are saved and share that in the releases. Check the guiding principles for this stuff. It's mainly cost savings, emissions and efficiency, but if this is a new kind of thing like you know, they can have different efficiency levels based on because we have for example like in some programs we have oil, fuel and natural gas fuel, they're not held to the same standards. So imagine like a hydrogen infused natural gas which kind of have a little leeway in some ways because it's a newer product, it's more it's more I guess, less emissions, let's say more efficient. "
    - "Yeah. So they might have some interest there, but I think it's primarily cost efficiency and emissions that we consider."
    - "If these appliances are going to be expensive to consumers it might be less attractive. "

3. **How would you like to see a hydrogen-ready appliance labeled? (can explain the UK labels and what we can do differently. I would create this narrative first, along with the questions to everyone)?**

    - Help to be a simple as possible
    - Three sounds good

- "Keeps it simple as possible - And some of the stuff is just like if you talk to the average consumer, will they care about it? It's like maybe cause it's one of seven labels on there now you know you got Energy Star, they got the FTC label, they have the AHRI label, they it's all types of stuff you know. So just keep it simple and you know three works, it works. But if it needs to be one it just needs to catch people's attention. Now I think it will help. "

4. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be anonymous.**
    - No anonymous

5. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    - Potentially – yes

Stakeholder ID#006 and #007

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    a. Yes, would be interested

2. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
    b. Works on codes and standards
    c. "First will be thinking about it from a Safety standpoint of what are the things to be concerned about where the blends will take you and the issues that will be associated with that. "
        i. "Not sure who the actual agency would be that does the labeling but they work with ANC and ASHRAE and other bodies who make regulations. "
    d. Labeling can come from the government (energy STAR)
        i. "can come from a utility organizations (NEEA, CEE codes for performance labels")
    e. "Labeling can also come from industry groups (interviewee gave examples like AHRI, AHAM or similar groups that provide test certifications")
    f. "Sometimes agencies like AHRI are hesitant to push certain things, example: South coast air quality management made a rule about NOX and suddenly

AHRI is suddenly able to work with members to controlling NOx emissions with furnaces and water heaters "

g. "Long history of manufactures being hesitant to do that. Even manufactures that the GTI has worked with/works with is also hesitant because they don't want to be the one pushing it and generally the case where it finally happens is some kind of government regulation"
h. Paul: "may be different because the customers for manufactures are pushing them to understand what the impact of hydrogen blends are. - link in chat
    i. In the article, Renai, the market leader for tankless water heaters with ~15% market share as a category put out their own self certification last year to say that their entire tankless water heater product line can handle up to 30% hydrogen blended. "
    ii. "Not based on any certification, but they expressed that they can do this and that they are comfortable with their customers using a hydrogen blend. "
    iii. "There may be a time when it comes to manufactures being quiet about product development or not wanting to stir the pot when it comes to new regs. This seems to have been the case in the UK although over there is much more support from the federal government".

3. **How would you like to see a hydrogen-ready appliance labeled? (can explain the UK labels and what we can do differently. I would create this narrative first, along with the questions to everyone)?**

    i. #006: "And at least for me, that and I do think of this from a commercial foodservice sort of background, it's going to be what is the mix going to be around the country of the blends that are out there in terms of what labeling is, what labeling is need to be done. I think in many cases with many manufacturers, they just want sort of a yes or no, it's good or it's bad. "
        i. "But are we going to have like tiered labeling around the country where you're or the need for a going above say 20 or 30% or is it going to be more of OK, this one will work with hydrogen blends, this one don't use if you got hydrogen in your system".
        ii. "Same way they look very little at the kind of labels and in many cases here they're dependent upon their buyer groups for them to buy the appliances. So they will probably just tell them, you know, this is what I've got, get something that will work for me and not they're not going to want many choices."
    j. #007:" It's tough. The UK scheme makes sense because there are announced transitions of certain networks to pure hydrogen with time and it's OK for them to have this kind of 20% to 100% no man's land where there's an

understanding that networks will be converted over time and sort of from one region to another. We don't have that yet. And while it's good to have the flexibility that if you buy a product."

i. "With a 15 year lifetime that you allow for the eventuality that your utility may totally change your fuel mix, but that that puts the risk on the end user."
ii. "Where in the past transition from manufactured gases to natural gas, by and large, the utilities funded the replacement of most products out there, and that may still be necessary if the scheme doesn't address that. Yeah, it's really, it's hard to say because the manufacturers are waiting for the utilities to define the rules of the game here. "
iii. "And given that we are, we do not have a gas quality standard here in the US or in Canada, so its just tariff by tariff that creates a lot of uncertainty."
iv. Keep it simple!

4. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**

   k. Not a good idea
   l. UK scheme makes sense, its okay to have 20% - 100% where it can be converted over time
   m. We don't have that yet in the US, the 20%-100% is flexible for a 15 year appliance timeline
   n. Do not have a gas quality standard as a nation – lots of uncertainty.

5. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**

   o. Safety to use

6. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.**

   p. Both = yes

7. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**

   q. Yes, thanks.

8. **Is the GTI conducting any research on hydrogen blends, and have they looked into blending hydrogen in gas appliances?**
    - Extensive testing with blends up to 30%
    - Already tested furnaces and water heaters
    - Commercial service and residential cooking side
    - Going to start testing appliances up to 30%
    - Field and laboratory base testing – no red flags with end use equipment.
    - Going beyond 30%

9. **Differences between end use appliances**
    a. Have observed flashback with furnaces with the range of 0-30% that we have not seen with ultra low NOx or standard NOx water heaters
    b. Very strange conditions, in some cases weren't able to recreate it.
    c. Cooking equipment: burner design – some difference behavior.
        i. Grill testing- flame behavior observed that can be somewhat concerning based on flashback standpoint. Still pretty early in the testing, most of the standard burners haven't seen anything that is concerning.
        ii. Commercial food service burners are a much more diverse burner type set than what existed in furnaces and water heaters, certainly haven't tested all the different types but are getting there.
    d. #007 provided link to paper to provide information on water heaters and furnaces that were tested.

10. **Has the GTI evaluated the energy efficiency of hydrogen blended gas appliances?**
    - GTI has seen a Measurable change in efficiency in the product
        - Can go up or down depending on the product with increasing hydrogen in the blend
        - "It really Depends on the feature of the product and its controls "
        - Limited amount of data published on efficiency impacts
        - Working on projects to standard methods of tests for efficiency tests – hope to publish results soon. Tests like the AFUE tests for furnaces or uniform energy factor tests for water heaters to better get a sense of that across multiple products.
        - Yes there is a difference in energy efficiency – however it is a Small difference and can be up or down.
        - Same on commercial food side - we were about to start testing cooking efficiency and see if it is affected, as well as looking at the performance in

terms of the quality of the food that is being cooked and seeing if there is a difference.
    - "2 + years before study on flame appearance and cooking performance comes out."

11. Additional information on UCI/GTI hydrogen grouping study

- Grouping research results. They were not intended to be consumer facing.
- "But the sort of low, medium and high blending tiers were understood to be, uh, low. Your product requires no changes whatsoever up to this amount, medium blending would be possible that some changes to the product would be necessary, but these are small changes, maybe a component."
- "Maybe a change to the controls and then high blends would be this is a different device and you know for the domestic boilers that have been designed to be hydrogen ready from Bosh and others in the UK that that sort of in situ conversion to 100% is possible. "
- "That kind of conversion, at least I'm not aware of other examples of that being possible. There is no such thing as a hydrogen ready grill or dryer, for example, where a couple of components could be used to change."
- So we're, it would be hard for us to apply that low, medium and high system across all products.
- "But. Anyhow, That's how we are thinking of the results from this project, which is focused on commercial buildings and industry. And we are not involving use Irvine in this case, but they have, they have parallel work. We do have similar work in the, the residential and the restaurant space as well. So, I agree it's good to have a a common approach. The challenge is that. if you want to take a single number 20% for example. And established that as a cutoff. That will need to apply universally to fireplaces, stationary engines, and everything else and that might be hard to do."

12. Other Considerations

- Spent a lot of time on RD&D and codes and standards on existing and new certified equipment
- Coordination and collaboration with entities performing similar work in the EK, Europe, Japan, Australia.
- Some bodies looking into this in the US and Canada right now
- 20% discussion about
- Do we need to be prepared for 100%? - open questions right now.
- 3 tier projects
    a. More for grouping research results
    b. Low medium and high blending tiers

c. Low = no changes whatsoever up to this amount
d. Medium blending = some changes to a product would be necessary (component, control, etc)
e. High= different device altogether
f. For domestic boilers – conversion in UK is possible to 100%
g. No such thing as a hydrogen ready grill or drier where a couple of components to

- #006: "It gets harder though, as you start getting this to diversity of designs. Officially, a burner. I mean some industries, water heaters and furnaces. You don't have a lot of diversity in the designs of it. Commercial, foodservice and other ones that you have completely different uses for the same type of appliance. So even by appliance categories, it gets difficult to do at times. "

Stakeholder ID#008

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    a. "We will support that"

2. **Has there been any discussion within SDGE about a timeframe for pushing H2 blends within the natural gas grid?**
    a. Started a hydrogen team to work with SCG.
    b. Customer programs
    c. Advanced clean transportation
    - Lengthy discussion on the GTI (2019) Hydrogen Technology Center -GTI has partnership with LCRI (2nd website) or (LCRI)
    - Shared studies/papers regarding GTI's hydrogen research
        - Went over findings during discussion

Stakeholder ID#009

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    - "YES – doing it nationally is a plus"

2. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
    - "YES – testing procedures based on fuel/testing standards and right now hydrogen is in the mix"
    - "We need safety ratings and test procedures per appliance with like a 30% hydrogen rating in there (DOE) -
        - "Who would lead on it – they suggested the CSA group "
    - What organization either within ca or outside might be able to
    - "If its on the market today it has to pass the DOE standards and safety ratings"

3. **How would you like to see a hydrogen-ready appliance labeled?**
    - "The simpler the better"
    - Use it today and it's fine
    - Help decarbonize the grid.
    - Degradation over time? - very important

4. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**
    - Duplicating with UK kind of makes sense or we can maybe simplify it.

5. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be anonymous.**
    - Yes.

6. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    - Yes.

7. **GTI: had mentioned the NEEA can sometimes be involved with product labeling? Can you talk a little more about that if you can? I saw that the NEEA does work with different water heater specifications and codes and standards so is the NEEA able to work with manufacturers in any way to sort of push/encourage the adoption of labels?**
    - "Yes- working on a market transformation study"
    - "Can work with manufacturers"
    - Preparing the market for the new codes/standards/ trade allies

8. **NEEA hydrogen scoping study (standards, safety, test measures for appliances on the market that are safe to use with hydrogen)**
    - Trying to get this study published during early-mid November. Is there anything new to reference.
    - Literature review work for them: Eli Font (Cadeo consulting group) green hydrogen alliance distribution network view as well.
    - NOX= gti did some research that the US depending on appliance burners in stoves let in more atmospheric air than European counterparts so more efficient
        - Because more air, keeps the flame more cooler, keeps NOx emissions lower when you put in H2 – bring this up with GTI.
        - More research verification/testing may be a barrier labeling.

9. **Additional comments/feedback/considerations**
    - "WE would be interested in collaborating on next steps and making sure we are aligned, test procedures, ratings, getting manufactures on board to be thinking on the
    - The more entities saying the same thing the better." Uniformity.
    - Gap: there hasn't been a lot of accelerated degradation testing of hydrogen gas equipment
        - Are there components that fail? How we can identify those things?
        - CSA has done some hydrogen testing as well.
        - High Blend (60+) (good question for SCG) (30+ blend) block of grid for
        - Duplicating results

Stakeholder ID#010 and #011

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    - Long journey – better to get started earlier.

2. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    - Simple and understandable
    - If I see a label – certain range of hydrogen that it guarantees the safety and operation for that appliance.
    - Clear message, backed by research so consumers can trust safety.
    - "Simple 2x to follow and read."

3. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.**
    - Anonymous
4. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback? (optional)**
    - Of course
5. **Has there been any discussion within SCG about a timeframe for pushing H2 blends within the natural gas grid? Does it vary by region? New construction areas?**
    - "Yes – goal is to first do demonstration projects before introducing H2 into the infrastructure"
    - "Two active demonstration projects to test every single component in the system to test the impact of hydrogen"
    - "Next step to isolate a small section and blend hydrogen into the natural gas infrastructure in the distribution sector"
    - "3-5 years for conclusion before introducing blending into the actual natural gas infrastructure."
    - "Need to Create hydrogen blending distribution standard. That is SoCalGas' strategy right now."
6. **Is SCG testing hydrogen blended with natural gas in domestic/commercial gas appliances? Willing to share outcomes/results?**
    a. Wider scope study on hydrogen capable appliances
    b. Initially did 0-20% demonstration in situation city hydrogen study
        - Different points of interest on the operation of appliances
        - More research on safety standards
        - Higher concentrations – get flashback safety concern, leakage, hazardous conditions.
        - Wider variety of appliances and appliances – number of appliances at H2 home. With every appliance there are different features and variations to consider
        - Safety and test procedures
        - Need to fine tune appliances
        - Need to measure Different failure modes for hydrogen appliances
        - General operations – different adjustments people can make to their appliances. What are those parameters?

7. **Are you involved in the H2 home project in anyway? What % of H2 blends are appliances running on?**
    - Hydrogen engineering team – working on that different team.

8. **Is there any testing on the accelerated degradation of hydrogen blended gas appliances? How might this impact labeling**
    - Impact of hydrogen on blending up to 40-50% for longer period in the distribution sector.
    - have blended higher up to 50% on residential areas to measure safety/flashback within appliances.
    - Need guidelines.
    - Testing any component that is going to be exposed to hydrogen – study the impact of hydrogen on these components, longer time exposure. Take 2-3 years for these results.

9. **Discussion on UCR study funded by the CPUC**
    - UCR recommends supportive of live demo projects that's the only way to gain more knowledge on the impact of hydrogen on any components in the natural gas system
    - Below 5% no major impact on any component in the natural gas system.
    - For the distribution sector – 3 years CPUC for utilities to do live demo project to see impact of h2 on residential or commercial appliances.
        - GTI study published recently
            - Common appliances in North America (35% H2 blend up to)
            - CPUC website
            - Next step for CA is the live demo projects.

Stakeholder ID#012

Discussion and Questions:

1. **Energy Technology List**
    - "We run a scheme in the UK similar to ENERGY STAR in the U.S, called the Energy Technology List (ETL). In the revision this year to our new criteria for boilers we included the following information requirement. An information requirement is a yes/no entry by the manufacturer applicant (i.e. its not mandatory that your comply, just that you answer the question – users can then filter products on our online list, if they would like to procure a hydrogen ready boiler). You wont find this requirement published on the ETL website just yet, as our proposals are still draft, but we have consulted with industry

(i.e. manufacturers, trade associations) so we expect the Government to approve this. The information requirement reads:
- Information requirement
- Suppliers shall report the following parameters for each model, which will be published on the ETL Product Search:
- Whether the boiler is "hydrogen-ready." This term is a reference made in the BEIS Hy4Heat programme and refers to a gas boiler that can be installed as a natural gas appliance and then be converted to 100% hydrogen at a later date."

2. **What was the thought process behind the 3 distinct labeling criteria for hydrogen-ready gas appliances? Are you aware of any consumer focus group studies that were conducted in order to get a sense of what people want to see on this label?**
    a. HHIC did that within themselves – as manufactures.
    b. Manufactures claims are getting out of control and consumers getting confused
    c. Very low manufacturing base in the UK – boilers last manufacture hot spot in the UK.

3. **What were other labels that were considered during the process for coming up with the best way to label these appliances?**

4. **How has the general public/consumer response been about the labels since publishing them?**

5. **Is there a broader EU effort going on that you are aware of?**
    a. Not sure – UK leading.

6. **Any lessons learned from your experience that would help us?**

7. **Are you aware of any new test standards and safety measures that had to be developed in order to correctly label these appliances?**
    a. Fossil gas boilers and oil gas boilers in the UK there is mandatory third party testing
    b. Self-declared by manufacture
    c. Manufactures don't have to test every boilers

8. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    a. Yes

Stakeholder ID#013 and #014

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    - Neutral stance

2. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
    - CEC is the Logical standards making body for appliances in California
    - Legislature would have to tell them to create a system of standards for hydrogen blends
    - Built on a foundation
    - Cost effective and feasible
    - Nox condition
    - Need statute to develop that kind of standard.
    - Unless there is an industry standard. (DOE level)
      #013 "Well, see, I think the CEC is looking into this and we are funding studies on the blending at the end uses. I think we honestly have a skeptical view of how much of a solution that's going to be to our in our decarbonization journey."
        - "You know, certainly open to those projects. "
        - "Turning up some different answer, in a different direction but I think the concern about lock in and the fact that that blending at use devices is highly unlikely to get to 100% hydrogen ever. "
        - Means that that's a that that's something that's a pretty key. Element.
        - Because we have to get to 0 and so if it's not through blending.
        - "You know then then what do we do? Do we do we get to 80%, you know, or do we get 60% and do a bunch of sequestration or you know what? So I think there are those issues are. So I think we, you know we're looking at it, we're funding it and #014's on the on the call and their staff can talk about perhaps in with you separately about the particular projects that we funded and the status of those. "
    - "But we are, you know, we are definitely engaged in it and looking at it and I think have a leadership position and figuring it out California. "

3. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**

    a. Education is going to be really important
    b. Simple!!!!
    d. How much GHG reduction. In the label? Could be useful
    e. #014: "Well, I think, you know, education is going to be really important because I don't think very many homeowners have a clue about, you know, if you mix hydrogen or anything else in there. I mean."
    f. "If you know I see the you know the appliance labeling. You know, like when you buy a refrigerator or, you know, a dryer, it'll tell you at this clients uses X amount of kilowatt hours or this or it's a gas appliance. This amount of gas and how it compares to other people. So you know that kind of label you know is really simple and easy to understand. I don't know whether someone would even understand"
    g. Yeah, I'm buying this gas water heater. OK, so it can use 5% hydrogen blend, but then a lot of that, you know, depends on what their utility is providing.
    h. And so if their utility is providing something.
    i. "That's not even in there it I think it's just I I'm just kind of thinking about labels in general and then for consumers to really react to the label and breathe that information, it has to be simple and you know if it's not simple, people aren't going to understand what's at all about. Why should I even care?"
    j. I I mean, you know the people that.
    k. "You know, maybe on the percentage side, but I think they're also going to want to know, you know, how much GHG reduction. You know, we're putting hydrogen in here. And so if you buy this appliance, maybe it's using less greenhouse gas than, you know, if you went and bought a gas fired appliance or something and so and, you know, maybe that could result in. "
    l. Going to some other benefit, because I think even on greenhouse gas, you know people.
    m. "I mean they see it impacts of greenhouse gas- is reducing. A couple say 50 tons of greenhouse gases. Is that a big deal or not? You know? Is that like taking out X number of cars? You know, internal combustion cars off the road? I I mean, I I think a label has to be simple and you know right now you know, hydrogen is a relatively new thing for a lot of people. People hear about it more on the transportation side. I mean, when you have automakers, you know, having hydrogen fuel cell vehicles and, you know also in the hippie duty side. "

n. 'Yeah, people probably haven't thought very much about their appliances at this point. No other than you know there's. Yeah, there's a lot of utility programs providing incentives for heat pumps. You know the Bidens, inflation Reduction Act has, you know, some incentives there also for and so I think those are the kind of connections that people make. But even you know kind of convincing people to change out equipment. "
o. "You know, why are they going to be spending, $1000, to do this."
p. And you know, I think spelling all that out, I think you know.
q. "You know, one potential thing is, you know, people are very familiar with gas, you know, water, heating and a good percentage of the gas water heaters are, you know, gas and people are pretty comfortable with their gas, water heaters. And so, you know, convincing people to switch out to a different fuel."
r. Yeah. And you know, it's it's going to be different and maybe, you know, with hydrogen, you know, blends it's almost similar to gas and that.
s. That, you know, people are going to want to know. You know how? How's it going to impact my performance? You know my bill.
t. And I think the I think the GHG reductions you know is going to be important too.

4. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    a. They want reliability and low cost
    b. Also about economics

5. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.**
    c. Anonymous

6. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    d. Yes

7. **How would we need to amend Title 20 to reflect hydrogen blends in gas appliances? When hydrogen ready gas appliances become available, would the CEC consider doing customer outreach and education events to educate consumers on these appliances? Can the modernized appliance efficiency database system (MAEDbS) managed by the CEC be leveraged to include hydrogen ready gas appliances?**
    - "Well, I mean, I kind of, I guess I'd give the same answer. I mean if the if the legislature told us to do this to like create a rating, you know create a system to categorize. "
    - The ability of.
    - Device categories appliances to utilize blended hydrogen.
    - Then the maids we, you know. And we would have to have developed that regime and enforce it. Then the maids database would be a logical thing to expand into that space.
    - It you know it it, that's what it's kind of that's kind of what it's for.
    - So, but that would take resources. You know, we have to do a a bunch of change proposal and all that kind of stuff. So. So I I see this kind of as a new a new would be a new endeavor along the lines of our SB 49 load flexibility.
    - If the legislature told us to do this to create a system to categorize
    - They would have to develop that regime and enforce it.
    - Probably SB 49 new endeavor
        Standards making activity
        ii. Requires public database
        iii. 013: "Yeah, I mean, I mean, I think so we we would be the logical standards making body to do that. There, you know, that's why we exist this to make these kinds of standards, whether it's buildings, you know, plants efficiency, we're doing appliance load flexibility. Now we're creating a standard on that. And it the let the legislature essentially would have to tell us, develop a system of standards for hydrogen blend blends and it appliances. And you know, that would have that would be built on a foundation of of a process that that has a high level of involvement from industry. Because these technical questions would kind of be front and center and economic. And so if we were, you know, usually a a process like that is going to be tagged with the the term cost effective and feasible. And so any standard that we take forward? Is going to have to kind of meet whatever bar bars, you know, it's sort of. Conditions that the legislature would see fit to put in that legislation, you know, there maybe there would be a Knox condition of some sort. Right. So I think there's a, A, that that would. I don't really see a way we would do that without statute without new statute to tell us to develop that

kind of a standard. But certainly that's, I mean, if the state went that direction, I think that's that's the logical way we go"

8. **Would there need to be some sort of government involvement needed to tell the CEC to create standards and test procedures for labels?**
    - 013:" I think so. I mean, unless there's an industry standard that is somehow put in place or adopted at the DOE level. "
    - You know that might preempt us in some way.
    - "But if DOE does you know sort of do something along those lines, and then you know there is an interest I'll then then yeah, I think we would be the place. I also think there's a, you know there is a conversation going on out there in the broader hydrogen industry. "
    - "Umm. On these sorts of issues. I mean, there's one trying to look at labeling of hydrogen. Like I said, that is going to gauging on, you know, with a wide range just of hydrogen stakeholders to get away from the colors and get on to like, OK, carbon content of hydrogen kind of label that then allows off takers to know what the government content of the product they're buying actually is. "

9. **Are there any legal issues with California developing labels with regards to federal or state standards, including preemption?**
    - Are funding studies on blending at end uses
    - Skeptical view on how it can decarbonize
    - Concern about lock in and blending end use devices
    - Unlikely to get to 100%

10. **Up to what % of Hydrogen have you tested on end use appliances, and what have been the results so far? What changes to appliances need to be made to run on higher blends?**
    - Research project with GTI and UCI that is going to look at hydrogen blends commercial and industrial equipment (staying away from residential)
    - Looking into delivery of hydrogen
    - Issues with existing equipment
    - Hydrogen blends better with large

11. **Are you seeing a difference in how much hydrogen we can blend based on the appliance or even across different manufacturers?**
    - Boilers, furnaces,
    - UCI did a study looking into hydrogen blending.
    - Flame stability (stability issues)

12. **Is the CEC is the correct organization to release safety standards and test procedures for manufacturers to follow when it comes to hydrogen blends? IS there another body in California?**
    - AQMD would be the logical one. I mean they're the air quality agency and the Greenhouse Gas agency, so.
    - But they regulate knocks.
    - For example.
    - So they would want to test the heck out of these things.

13. **Does CEC have authority outside title 20 for labeling appliances?**
    - "Yeah, I mean, we could open a OII, I think we could do that and say OII that would order instituting investigation which is basically just like we're going to investigate this but create a record like ask people to file comments. What do you think which way should this go yada yada. And then that would then inform that would go out to the world and most likely informed the legislature to tell us what to do via statute. Right.If if the other, there would be some group of interested legislators. And they would want to. Sort of put a framework around that, that process. That's typically what happens. "

14. **Discussion on CEC project with GTI**
    - "we do have a research project underway with GTI, along with UC Irvine. That's going to be looking at hydrogen blends, and we're targeting the large commercial and industrial equipment.
    - We stayed away from the residential one primarily
    - I think it also looked at the potential delivery of that hydrogen and that all these appliances, you know if you start putting hydrogen in the pipeline and you know if people are using existing equipment, there could be some issues with that. So it would have to be you know everybody changing out in order to kind of do the lock step change. But we thought with large commercial and industrial where they have difficulty maybe electrifying. "

15. **Is the CEC more interested in electrification for domestic appliances? Is that kind of the route that you were thinking of or? Are hydrogen blends sort of still in the picture somewhere? Maybe? Maybe it's better in newer communities when where the appliances are new and the infrastructure is new and older communities. You're thinking electrification makes more sense or?**
    - a bottom line is it's all going to be about economics, right? And so, you know, for residential and small commercial.
    - You know you're looking at electrification, you know, versus hydrogen, biofuels, renewable, all these other alternatives.

- And from the consumer's perspective, you know they're going to care about, you know, if they want hot water, they're going to get hot water when they ask for it.
- And then you know the, you know, their bill is also going to be really important too. And so.
- I I think in the end you know it's.
- It's also about economics and you know what goes best? You know, with communities.

Stakeholder ID#015

Discussion and Questions:

1. **Are you supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    - Makes a lot of sense to do hydrogen labeling from the customer perspective
    - Going to be difficult for consumers to understand what the labels
    - Affect willingness to pay for certain products
    - From the customer perspective it's a good idea
    - Low medium high – be weary, sounds user friendly.
2. **How would your organization play a part in supporting the development/roadmap to labeling H2 ready gas appliances?**
    - Haven't had discussion on labeling
    - No short-term opportunity
    - Concerns over the metrics over energy efficiency, NOx and how its measured
    - Current metrics to calculate NOx doesn't make sense for hydrogen
    - Water heater measures NOx by dry weight (ppm/o2 concentration)
        - Because of the way fuel is wet from hydrogen increases the concentration so it makes it look like NOx is worse, but NOx doesn't change with hydrogen.
3. **How would you like to see a hydrogen-ready appliance labeled? (can explain the UK labels and what we can do differently. I would create this narrative first, along with the questions to everyone)?**
    - Would this label require any other regulatory reequipments.
    - "Manufacturer strategy - don't want to comment about it, its going to cost the manufacture in terms of product development, business standpoint don't want to advocate for the technology."

- RHEEM is looking into 100% hydrogen – leading in that market.
- See if rheem is open to talking and

4. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**
    - Having number on the label makes a lot of sense
    - Most people want to have contractors help them select appliances
    - Contractor is person able to educate the homeowner
5. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be anonymous.**
    - Anonymous
6. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    - Maybe

Stakeholder ID#019

Questions:

1. **Can you describe a little more about your involvement with the NEEA's hydrogen appliance scoping study.**
    - Hoping it would be ready by the end of the year.
    - Report should be published by the end of the year, which they can send to ICF to include on final report.
2. **What kind of appliances did you look into and what was the main research goal of the literature review?**
    - See the impact of hydrogen blending
    - Hy4Heat and what they have done
    - Netherlands have tested 100% hydrogen boilers
    - Research from GTI - have done a lot of lab testing , good NOX reductions.
    - Secondary research on results of testing hydrogen mixes or blends with existing appliances.
    - Utilities are testing in their testing centers. They were not looking into everything rigorously – flame is fine, no changes in temp etc. Very general research.

- For legacy appliances
- All the testing out there is saying that existing appliances work up to 20%, no impacts on appliances. No or minimal impacts on performances
- Because the research is so small in the US, mainly laboratory not in field. utilities need to do more research and testing in a real life setting in order to incorporate it into their grid.
- Safety issue needs to be addressed before utilities put it out in the public gas network
- If something bad happens with hydrogen blends –the stigma on hydrogen will go crazy
- Better to play it safe
- There has to be a lot of caution when approaching this.
- Investigation into

3. **Did you notice any variation with appliances? Or even differences between manufactures?**
    - No, Did not look into different performances on manufactures for same appliances and how they can perform. - not there at all this moment
    - Appliances specific Yes - vary on hydrogen blends – GTI and UCI research.
    - Last published research was boilers and furnaces with 30% hydrogen blend – minor things that need to be changed.
        - Table with measures and percentages.
        - Very early stage here.
        - GTI was recently awarded by CEC to look into implications of industrial/commercial equipment using hydrogen blends. - sole source nobody else applied for that.

4. **Should appliances be labeled by the % of Hydrogen they are able to tolerate? If so, how many categories of labels would be appropriate in CA without making it too difficult for consumers to understand? If not, what alternative approaches would you propose?**
    - Market is not ready for 100% hydrogen

5. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    - "Need so much education to be done public and those working in the industry"
    - "Need to decrease the stigma surrounding hydrogen"
    - Thinking about the percentage.

- Could create conflict and more questions as a consumer (how do you know what your system is)
- There are already commercially ready appliances in Europe that are hydrogen ready
- "Us needs to get manufactures to do something
- Or we start importing these appliances. Don't want US manufactures to lose the market. Motivation for them to push out hydrogen ready appliances."
- We don't know what is going to happen – we need to reduce emissions – renewable NG and hydrogen, some even electrification.
- Having appliances that can work up to 20% is the most likely. Checking the service area of the gas utility.

6. General Discussion

- - UK is the leading country
- - US utilities are only testing their facilities right now.
- Where is the research right now?
  - research is still in the starting point, more research coming out increasing hydrogen blending testing in appliances.
  - -market is not ready for 100% hydrogen label, people are not educated enough. That is an idea we need to shelf. People will have a lot of questions.
    - - in Europe there are already commercially available appliances that can be retrofitted, and you can get to a 100% hydrogen appliance.
    - - tried to reach out to manufacturers and couldn't get into contact with them to see what they are working on.
- CSA(produce standards in US and Canada)
  - is talking to stakeholders to see if there is a need to update the standards to create new standards .
  - they are not doing anything at the moment.
  - "reviewing the need to see if we have to do it"
  - no impact on safety and performance of appliances at 20%
  - gas utilities need to know exactly what they are doing and they know how much hydrogen they can use.
  - Gas utilities need an uptaker to move the hydrogen market forward.
    - They need to know if they are exactly at 5%, 20% etc. For gas output.
    - Gas utilities are the best uptaker.

Stakeholder ID#020

Discussion and Questions:

1. **Would the AGA be supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    a. Yes.

2. **Do you have any contacts with different government agencies (CEC, EPA, DOE, GTI) whose information you can provide for a potential interview for this study?**
    a. Will Hawaii Gas contact

3. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be anonymous.**

4. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    a. Yes.
    at a high level talk about the AGA and its role in terms of how it represents utilities

Discussion:

- Hydrogen Blend Working Group: Part of the working group at CSA looking into what type of proposals can be made to the accessories and appliance standards for natural gas hydrogen blend delivery and the potential for 100%H2 for appliances in the distribution system
    - "Yes, appliances and existing standards, anything that would be piped then you have the standards for propane appliances. "
    - "Accessories include = Valves, meters, piping systems (stainless steel tubing) - connectors = all appliances. "
    - "All have conversion kits to go from propane to h2 – add additional tests to hydrogen mixtures. "
    - "Appliances that must sell must have to be tested with that blend."
    - Any timeline for AGA / have testing started?
    - "We have no say – CSA will be determining the timeline not a rushed project but a priority."
- "Another group is looking at what is safe level for existing appliances, where it can be pushed to for brand new appliances, what are the markings for each of the levels that would come out of this. CSA does feel that having the different markings will be essential. If the product is only good for %, it needs

to be properly market so it can be safely installed and not causing unsafe conditions for the consumer. Safety considerations"

- "Another working group has done research projects and are comfortable saying that existing products can handle up to 20% hydrogen, they now want to take it to the next level and see where both existing and brand-new products will be able to handle. Look into what kind of tests, design and safety functions need to be put into those appliances in the distribution systems."
- "The CSA has also looked at what is happening in Europe and is proposing the English labeling before they roll it out. In alignment with what CSA is thinking."
- "The CSA wants to make sure the testing and the appliances can handle these different levels before they fully roll it out, but they would be alignment with what CSA is thinking"
- "CSA is doing testing right now on various appliances to figure out appropriate levels for more so the existing product."
- "They don't want gas utilities introducing blends too early
  - Gas utilities are very cautious about hydrogen unless they know that the appliance will function safely and appropriately for their customers
  - Manufacturers on the other hand are cautious about doing additional R&D and developing new products and developing higher hydrogen blended appliances or pure hydrogen appliances because they do not know what is going on in the world of natural gas. Will it still be here?
  - CSA taking it step by step"

Hawaii Gas

- They have been using 12-17% hydrogen blended with natural for over 50 years.
- They have not had to modify those appliances.
- Appliances have been working great between the 12-17% blend.

Next Steps for CSA:

- "The CSA is fairly comfortable, but they are initiating a meeting for hydrogen blend working group in order to move this forward another step"
- The manufactures, gas utilities, are all looking at how we can do it and how we can do it safely.
- Safety is the number 1 priority.
- For the labeling, will probably know more next week, but they so far intend to follow the English model.

5. **Have they investigated retrofitting tool kit or conversion system for appliances in order to change them for use with greater blends of hydrogen, and is the CSA the likely body that would be doing that or creating and updating standards to reflect that?**

    - "YES to everything asked."
    - "Appliances will be anything from gas range, water heater, furnace, dryer, anything that is piped."
    - "They also write the standards for propane appliances, and for many of those (furnaces, ranges, water heaters, fire places, outdoor cooking) they all have conversion kits to go from propane to natural gas or vice versa."
    - "The CSA would now add additional tests and requirements for the hydrogen mixtures and would require any appliance that the manufacture wants to sell as hydrogen ready or can accept up to a certain % of hydrogen blend, the appliance will then have to be tested with that blend and tool kit".
    - "The CSA would follow the same model when it comes out. Just like the other appliance standards, there will be instructions for marking and installation requirements, and instructions to convert the appliance from natural gas to hydrogen % or vice versa."
    - Same instructions and testing for hydrogen blends.
    - "For 100% hydrogen, it might end up being a companion standard, which is a brand-new standard using similar testing, but its going to have to be different because the hydrogen gas functions differently than hydrogen gas. (it is a much lighter gas and there is going to have to be modifications to the appliances if they are going to be 100% hydrogen from the perspective of safety and the perspective of aesthetics of it. Especially with gas ranges or fireplaces. Seamless for the consumer."

6. **Timeline for this testing? And Conversion process?**

    * The CSA US committee week is next week.

    - "In the USA the CSA manages the fuels and appliances program which includes natural gas and propane appliances and accessories and alternative energy vehicles. "
    - Every year they have in person meetings with all these committees
    - One of the working groups is the hydrogen working group.
    - Different task groups working on different things who would be reporting on their findings and hopefully they will have a roadmap of how to move forward with this.
    - What are the things we are looking at and what are the modifications to the standards that we need to develop in order for the appliance to function safely.

- "Very comfortable that up to 20% manufactures don't need to make any serious type of modification "
  - "Above 20% we don't know, and AGA CSA needs to look at what needs to be done to move forward".
  - "Timeline: AGA has no say, the CSA is the one that is determining what those timelines are".
  - "Not a rushed project, but it is a priority to get these things done. Hopefully by next year they can have protocols in place."

7. **Does the CSA – influence the AHRI in any way. -**
   a. "AHRI help maintain the CSA standards. AHRI itself does not develop standards for safety aspects. - standards for the energy efficiency sides. AHRI will have a voice in it. "
   b. "If CSA goes down the road for labeling, AHRI will have a voice in it but they aren't the only voice."
   c. "Other CSA members are engineers, other consumers, utilities so it will be a balanced decision that comes out of the CSA."
   d. Manufactures must support it because they are the ones putting the label on.
   e. If it is one label across the nation they will be so much happen.
      - Anything we put out -send to CSA to make sure that manufactures do not have separate labeling requirements for CA and its one consistent label for the US.
        - SoCalGas – leaders in developing hydrogen blend distribution.

Other Considerations:

- Going forward make sure to provide CSA with the GET report because they will keep this consistent.
- The standards themselves will be adopted into the fuel gas codes which are adopted by the rest of the nation.
- Those standards are referenced within those installation codes that are adopted.
- Don't want to do something different than a state is doing, so we want to make sure that CA roadmap is similar to CSA roadmap.
- "Don't want CA to have one set of requirements in the state level and then fuel gas level has different standard"
  - "We need to work together, to make sure that the standards at the national level match up with what we are doing in CA."
  - "Manufactures won't like it if they have one set of labels in CA vs. Rest of the US".
  - "One consistent label for any appliance that can be shipped anywhere I the US and Canada it would be the ideal goal."

Stakeholder ID#021, #024, #030, #031

Interview Questions:

1. **Would the CSA group be supportive of developing a labeling process for H2 ready gas appliances in CA? If so, why, and if not, why not?**
    a. From the standards side – we are leading efforts in terms of research – trying to identify what is necessary to revise standards and develop new standards
    b. CSA is Trying to take a lead role in end use appliances and its components
    c. Ultimately, it's a consensus-based process.
    d. Big players from a certification body standpoint are: CSA, Intertek, UL standards.
    e. Whatever we come up in terms of coverage to address hydrogen blends will be done in a consensus-based manner.
    f. CSA maintains standards in Canada and US.

2. **Has the CSA explored the idea of labeling/standards/test procedures for new or existing appliances that are ready for hydrogen blends?**
    a. In its infancy but moving rapidly. I don't yet have an idea on legacy and new products how the blends will work. More testing planned in the next coming years
    b. Haven't yet tested appliances within CSA yet, on hydrogen specifically.
    c. Labeling – far cry from that currently
    d. Like to see it covered in appliance standard to give clear direction on how to apply hydrogen and at what concentration, especially how it should be marked.
    e. Clear direction on how to apply hydrogen
    f. The research that we have seen – questions about the longevity of the appliances.
        i. We haven't validated yet up to 20%
        ii. Still some questions on safety controls to consider for hydrogen under 20%
    g. I am currently gathering test data for that to make a determination. And put forth a recommendation at the standard level. Standards will be updated to reflect what changes need to be made at the standards level at 20%-100%.

3. **Is the CSA aware of the UK proposed labels for hydrogen ready gas appliances? And If so, is the CSA interested in following that approach or looking into any other possible labels?**
    a. Too soon to tell based on their testing status.

4. **Has the CSA investigated a retrofitting tool kit or conversion system for appliances in order to change them for use with greater blends of hydrogen, and is the CSA the likely body that would be doing that or creating and updating standards to reflect that?**
    a. Blend and safe threshold is?
    b. What is the safe threshold is?

5. **Discussion on other factors/considerations we should investigate for the labeling roadmap in CA.**
    a. Some manufactures may have CSA do custom/research testing for them
    b. The standards committee may have the CSA group do testing.
    c. They need actual test data to make changes to the standards data itself
    d. As manufactures have a need for data, for how their products will perform with hydrogen blends, then they will have projects with them to do testing.
    e. They don't have a timeline to push the above, it is not up to the CSA to start. It is up to the customers, regulatory people, to have them to the testing/standards for them.
    f. Manufacturers are pretty quiet about it – its proprietary stuff they are working on. CSA has confidentiality agreements with all their manufacturer customers. They are all in a competitive environment and different manufacturers are trying to get their products ready sooner than others.
    g. From the standards perspective they are looking into visiting Hawaii gas for more information:
        i. Come up with a list of parameters to ask Hawaii gas
        ii. Warranty claims, PSE claims, AHJ issues, and what products they are using
        iii. Sample size of what appliances are being used in Hawaii
    h. Group within CSA called Hydrogen Working Group
        i. Working on all of the safety standards and what changes need to be done.
        ii. Right now concentrating on the blend, not 100% H2 and figuring out what the safe threshold is.
        iii. Utilities and AHJ's want to know what the safety threshold is for appliances in the field. Still figuring out what appliances can take without any issues. Next step is 100%, or convertible appliances.
        iv. Hoping that information will help inform changes to new appliances, and certification standards moving forward.
        v. The end goal is if you are certified for NG, you can be certified for blend. So not sure if new labels are needed specifically.

i. Fast path- manufacturers all have their own unique label. For CSA to have uniform label it will take time since they must test it. The downside to different labels means it can be confusing to customers.

6. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.**
    a. Anonymous

7. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    a. Yes

Stakeholder ID#022 and #023

Discussion and Questions:

1. **Can you talk more about the Hydrogen home projects, the blends you have tested and the performance of different gas appliances. Any safety considerations?**
    a. Hydrogen analysis center has done all the testing for appliances
    b. Situation city set up – they are able to hook up different types of equipment and run simulation testing on them
    c. Installing multiple gas appliances but the engineering analysis center doing the testing.
    - Not all appliances are installed in the hydrogen home.
        - We don't have a bunch of gas going into the home at the moment. Plan to add more later on.
        - They perform the test H2 home.
        - Starting at 5% working way up to 20% blend.

Discussion on Safety considerations:

- They have Installed hydrogen detectors with the home anywhere that there is a gas appliance to know if there is any leaking or issues with the equipment
- Carbon monoxide detectors – sometimes triggered in the presence of hydrogen
    - Question is whether leaks of blended gas would trigger carbon monoxide detectors within the home
- EAC Testing hydrogen detectors in the home to make sure to go off with blended gas.

- Should give them an answer to see if carbon monoxide detectors need to be modified in homes that accept blended gas.
- UK is using carbon monoxide detectors for their source of detection for hydrogen, UK has also built 100% hydrogen home.

2. **Have you conducted any accelerated degradation testing on this equipment to see how it will perform in a real life setting over the course of 10-15 years.**
    a. - EAC has not done this.

3. **What are some challenges that the engineering team anticipates when trying to test higher blends in the h2 home?**
    a. Flashback
    b. There is some equipment where you can't see the flame well so they had to rely on sound (ex popping for flashback). (30%) flash back
    c. Some appliances don't have flashback up to 50%, it depends on the piece of equipment
    d. 20% still similar enough to natural gas.

4. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    a. It would be Good to know if my appliance was good to a certain percentage
    b. "Currently working on Pilot project with UCI up to 20% campus there – still need approval from CPUC to start collecting funds."
    c. They will have to let homeowners know they are doing this testing in the area so they want homeowners to know if their appliance can run on this
    d. "Better to have 20% 30% blend, label based on numbers as opposed to low medium and high."
        i. "Hydrogen production has many color scales and it gets so confusing what each color means, the label should be straight forward for consumers to understand."
        ii. "We don't have a standard that establishes low- does it mean 5% or 20%. Therefore, unless we can create a standard, it is best to include the percentages on the label."

5. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be considered to be anonymous.**
    a. No

6. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback? (optional)**
    a. Yes. Willing to keep in touch.

Stakeholder ID#026 and #027

Discussion and Questions:

1. **How long has Hawaii been using Hydrogen blends in their natural gas grid?**
    a. 50 years
    b. "Conclusion that at 10-12% hydrogen content in the methane stream"
    c. Very little impact to appliances made for natural gas

2. **Have you noticed any wear and tear on appliances that would be out of the ordinary with hydrogen blends or is everything that you would expect if it were appliances that ran solely on natural gas?**
    a. No, operating as normal.

3. **Has Hawaii Gas done any accelerated degradation testing on hydrogen blended gas appliances?**
    a. "50+ years with no challenges or impact to appliances"

4. **Any plans to blend more hydrogen into the gas supply? Any impacts or safety considerations to appliances?**

5. **Have consumers had to make any chances to household safety detectors like alarms such as installing a hydrogen detector or are regular carbon monoxide detectors sufficient for use with hydrogen blended appliances?**
    a. Don't have furnaces
    b. Need for CO is accompanied by furnace
    c. We don't even see CO sensor
    d. Even for pipeline leak detection equipment- use standard industry flame ionization unit looking for methane.
    e. Not using sensor specific for hydrogen

6. **How would you like to see a hydrogen-ready appliance labeled? (can explain the UK labels and what we can do differently. I would create this narrative first, along with the questions to everyone)?**

7. **If you were a consumer, what would you want your appliance label to tell you about the potential for hydrogen blends?**
    a. "0-20% more of an education or a statement"
    b. "Intermediate step, discomfort - I think there would be a challenge to get the market of gas operators in the United States and market of manufactures to agree on what that really means."
        i. 20-100 – split middle category into maybe 60% blend because there is big difference between 20-100%.
        ii. It's a big jump from 20-100 and there might be more steps along the way from a safety standpoint.
    c. Step to 100% makes sense

8. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be anonymous.**

9. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    a. Yes

10. **Discussion on Hawaii's Hydrogen Blending**
    - S&G plan – in Hawaii we don't have access to natural gas from drilling, no oil or NG resources in Hawaii in the ground
    - We started making synthetic natural gas because it's methane – same molecule as regular NG, but make it by reforming molecules from larger hydrocarbon – start of with naphtha (cocktail of larger hydrocarbons)
        - Steam reforming process – breaking hydrocarbon into smaller hydrocarbon – ends up with a blend of methane and 10-12% hydrogen
        - It started going this back in the early 1970s in Oahu for almost 50 years.
        - We made the decision back then to leave the hydrogen in the mix rather than remove it
        - Before the decision was made, experimentation and calculation was done in the 1970s and came up with the conclusion that at 10-12% hydrogen content, there would be very little performance or safety impact to appliances made for natural gas
    - Consumer didn't really realize that the hydrogen was there and there was no impact to how their appliance worked. For the consumer they just wanted to know if their appliance would work.

- Over the 50 years – practically every appliance we have seen has been able to accept the hydrogen blend without performance or safety issues, which is now consistent with recent research that suggests 20% hydrogen is where some of the performance by some appliances can be affected by hydrogen.
- "All the domestic brands, LG, samsung, kenmore, wolf, viking, GE, thermadore, all those appliances have been installed and used by customers without issues for over 50 years"
- On the industrial side they have used boilers, Commercial cooking equipment, ovens, flame feature appliances like tiki torches and firebowls.
- The only equipment that has had an issue is internal combustion engine – in particular made by "caterpillar" when they first installed the engine, they did tell the designers that the gas is a little different. they worked with the manufactuer to tune the engine to use the blended gas.
    - However, not enough experience tuning the engine
    - Predetonation occured
    - In the Compression stage when the fuel and air mixture is compressed, before ignition, it heats up during compression and it would heat up to the ignition temperature of the hydrogen, meaning that the mixture would explode in the cylinder before it is supposed to.
    - When that happens basically two cylinders are firing at the same time and something has got to give, so the valve stems were cracking.
    - Not typical residential or commercial appliance.
- Typical appliances = Folks will buy natural gas appliances off the shelves, bring it home and plug it in and it will work fine with
- They just tell customers Make sure you buy an appliance for natural gas., don't mention hydrogen part, they are thinking they are consuming natural gas.
- Hawaii Also serves a market for propane- any home depot would have a conversion kit for natural gas and propane version for a gas range.
    - If there are areas in the united states where 100% is available, then the very same range would have a natural gas, propane, and hydrogen version.
    - May be as it is now to convert between natural gas and propane on these appliances there are usually two things that need to be changed.
      1. Appliance regulator –delivers slightly different pressure to the burner
      2. small brass fitting (orifice) - located right at the burner tip. The orifice hole for a natural gas burner is a larger hole, smaller hole for a propane burner because propane has more heating value per volume than natural gas.

- going from natural gas to hydrogen, hydrogen is even less heating value than propane. - When there is hydrogen gas available for consumers to access, there will be another set of orifices.
- Hawaii gas services techs are trained to help change orifices
- Some customers move from an area using propane to an area using natural gas w hydrogen and they say they want to keep their Viking range, but they bought it for propane and now they want to use natural gas
  - They can order a kit from Viking to change those orifice fittings
  - When hydrogen gas becomes available, there will be another set of orifices that you can change on those appliances to make hydrogen ready.

Stakeholder ID#028 and #029

Discussion and Questions:

1. **What are the H2 blend levels that Dominion Energy has tested and how have appliances responded?**
   a. Phase 1 last year (training village) - small houses with appliances and did hydrogen testing over there
   b. Phase 2 – selected closed loop area in Utah to blend H2 in Utah in Q1 of next year.
   c. Appliance compatibility – have you noticed any variation across manufacturers or different types of appliances?
      i. The testing we did was all residential appliances
      ii. 50 varying types, vintages, varying manufactures, didn't see issues or concerns with any of them during testing.
      iii. Multiple furnaces, multiple water heaters, gas ranges, ovens, space heaters.

2. **DO consumers need to make any changes to household safety detectors like alarms such as installing a hydrogen detector or are regular carbon monoxide detectors sufficient for use with hydrogen blended appliances?**
   a. Didn't specifically test out what you need in a home
   b. Did install hydrogen sensor for the training village just to be on the safe side
   c. Never had a leak detected
   d. Haven't looked into what homeowners need to do specifically.

3. **Any safety concerns/considerations for appliances in residential/commercial settings? Ex. Smoke detectors, hydrogen sensors need to be replaced or modified?**

4. **How would you like to see a hydrogen-ready appliance labeled? What would you want your appliance label to tell you about the potential for hydrogen blends?**
    a. The limit of hydrogen should be mentioned on the label
    b. Manufactures need to change the appliances/retrofit for higher hydrogen limits

5. **Have you done any consumer studies/outreach on hydrogen blends and what has been the general response/feedback? Any safety concerns from a customer's point of view?**
    a. People are open to it, happy about decarbonization
    b. Didn't have a lot of questions or concerns
    c. However, still in the process of that outreach haven't had that feedback.

6. **Would you permit your name/organization to be released as part of this study. Alternatively, your responses will be anonymous.**
    a. Not name

7. **Would you be willing to review a draft proposal for the proposed labeling approach and provide your feedback?**
    a. Yes

Stakeholder ID#032 and #033

Discussion and Questions:

1. **What was the thought process behind the 3 distinct labeling criteria for hydrogen-ready gas appliances?**
    a. Why they did it – the number of manufactures in the UK coming out and stating that their product was hydrogen ready was drastically increasing.
    b. There were concerns from HHIC membership and government organizations that it could lead to an element of misselling if different manufactures were labeling different products as hydrogen ready/had different labels to do so.
        i. HHIC wanted to ensure that the consumer knew or had the ability to know what they are paying for and getting.
        ii. Has several industry meetings about this

iii. Logos – Based on what several manufacturers that were already using, so it made sense to go with something that was already similar to what manufacturers wanted.

c. Process: there was some confusion in the UK marketplace when different manufacturers had different labels. A common uniform label is easier.
   i. Term hydrogen ready comes from hy4heat program. They decided that the hydrogen ready appliance is a conversion appliance, which differs from the hydrogen blend label. This was based on the hy4heat program in the UK.
   ii. 100% for future appliances end up with the 3rd logo, they wanted a third logo for future applications. Won't be used just yet.
   iii. Came up with a shape and color that was in the middle of what manufactures were already using, so that they didn't have to make a lot of changes to their labels.
   iv. Easy to spot and market – green color.

2. **What were other labels that were considered during the process for coming up with the best way to label these appliances?**
   a. Other labels include the diversity in the label design that different manufactures had already been using in the UK. However, the HHIC narrowed it down to one label for all manufactures to use.

3. **How has the general public/consumer/manufactures response been about the labels since publishing them?**
   a. No customer response
   b. Have not done any customer focus groups on the label physical characteristics

4. **Is there a broader EU effort going for hydrogen labeling on that you are aware of?**
   a. EHI – European heating industry
   b. UK manufacturer market is comprised of primarily Germanic, French, Dutch manufactures in the UK
   c. At the moment there isn't, but since HHIC is a member of the EHI, they have interest in doing what the HHIC is doing in the UK. They expect other nations to do this by default.
   d. Nothing is coming through yet, still early since they only released the labels today.

5. **Any lessons learned from your experience that would help us?**
    a. Try to agree and release the labels first before manufactures start playing around with different labels, and then it will be harder for all manufactures to be on board or get them to change the label.
    b. Some UK Manufactures are selling their products in America, so for them it would like to be the same label.
    c. Reach out to UK/European manufactures to see what their plans are in America.
    d. Burner Systems International – can take that technology and offer hydrogen ready technology in the states.

6. **Have manufacturers begun using the labels? Is this voluntary effort at this point?**
    a. Some have begun using the label.
    b. "HHIC plans on being involved with a government consultation in the near future to discuss hydrogen ready appliances. The government in the UK is very keen on doing something mandatory in terms of labeling so when the consultation takes place it is likely that there will be a law requiring it."
    c. Polyethylene/Polyethene material is now being used in UK, they had to swap out all of their old iron/steel pipes for plastic/polyethylene which is more suitable for hydrogen blends.
    d. Catering industry association in touch with the HHIC to let them know that they are using the same label for commercial food equipment.

7. **Information on HHIC:**
    a. HHIC is a trade organization in the UK, whose members include manufactures of heat pumps, boilers, merchants, installers and large businesses like the British Gas.
    b. The HHIC engages with the UK government closely at an advisory capacity, especially with hydrogen.
    c. HHIC is in the process of rewriting the European standards for boilers for hydrogen blend applications and also 100% hydrogen.
    d. Have a temporary document held by BSI for test appliances. A number of appliances have already been developed like boilers, cooking appliances, furnaces, and commercial heaters.

Appendix 3. Survey Questions

Stakeholder Feedback Survey: Proposed Roadmap for Hydrogen Readiness Labeling

The survey will take approximately 4 minutes to complete.
Note: This is a comprehensive study to investigate the feasibility and approach to implementing a labeling process in CA and the rest of the United States to label gas appliances for use with hydrogen blended natural gas. ICF is conducting this study through their Gas Emerging Technologies (GET) program under the administration of SoCalGas. GET is a collaboration between California's investor-owned utilities to advance promising energy-efficient technologies. The purpose of this survey is to collect stakeholder feedback on the proposed labeling roadmap. We would greatly appreciate your thoughtful response on this matter.
(Website: California Statewide Gas Emerging Technologies Program | California Energy Programs (cagastech.com))

...

1. Does the proposed timeline to develop a set of hydrogen ready appliance labels make sense?

Enter your answer

2. How appropriate is the CSA group as the lead organization to develop hydrogen ready appliance standards and labels?

Enter your answer

3. Are there any other stakeholders that you feel should be engaged in this roadmap and why?

Enter your answer

4. Are there any other technology gaps that should be noted?

Enter your answer

5. Do you have any other comments/concerns related to this proposed roadmap for labeling hydrogen-ready gas appliances?

Enter your answer

6. Name and email address

Enter your answer

7. Would you be interested in receiving a copy of the Final Report published as part of this comprehensive research study?

- ◯ Yes
- ◯ No

Submit

Never give out your password. Report abuse

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