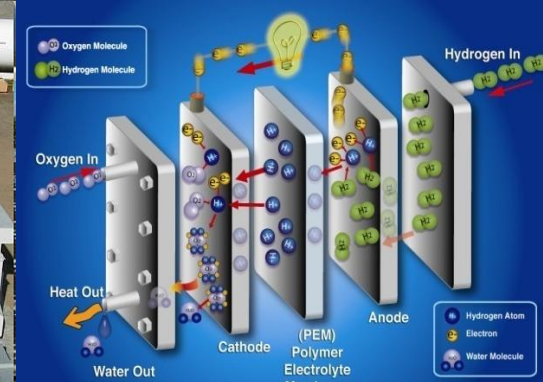


# Fuel Cell Technologies Office Webinar



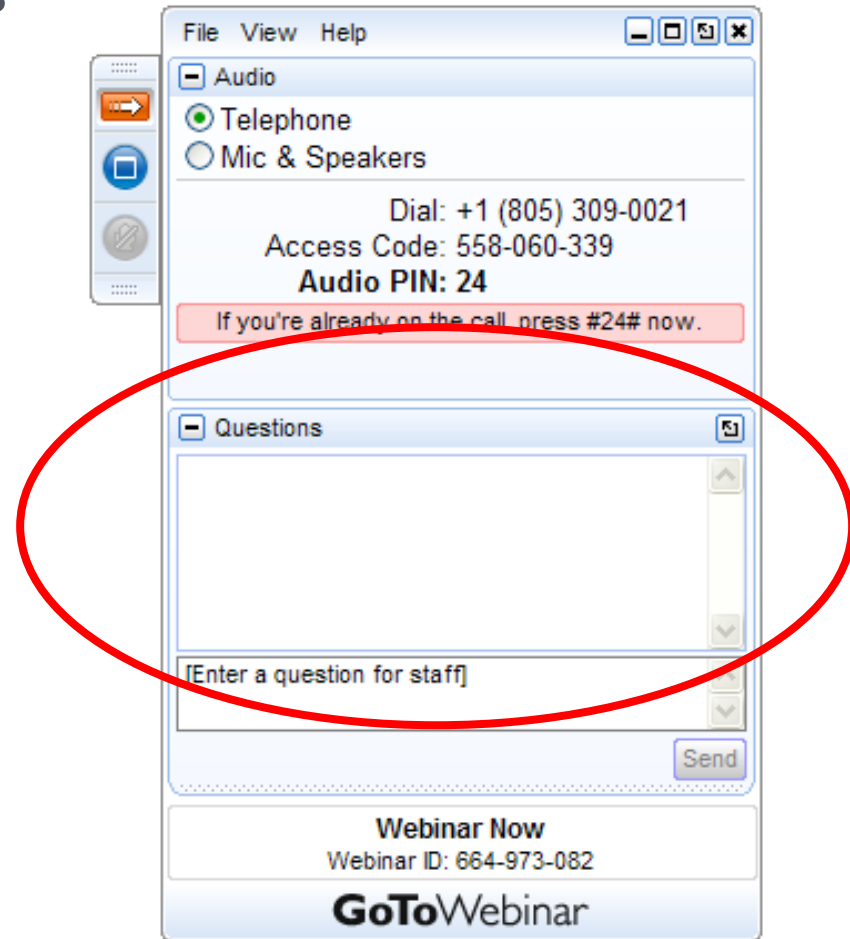
## U.S. DOE-FCTO H-Prize Competition Drives Innovation with SimpleFuel

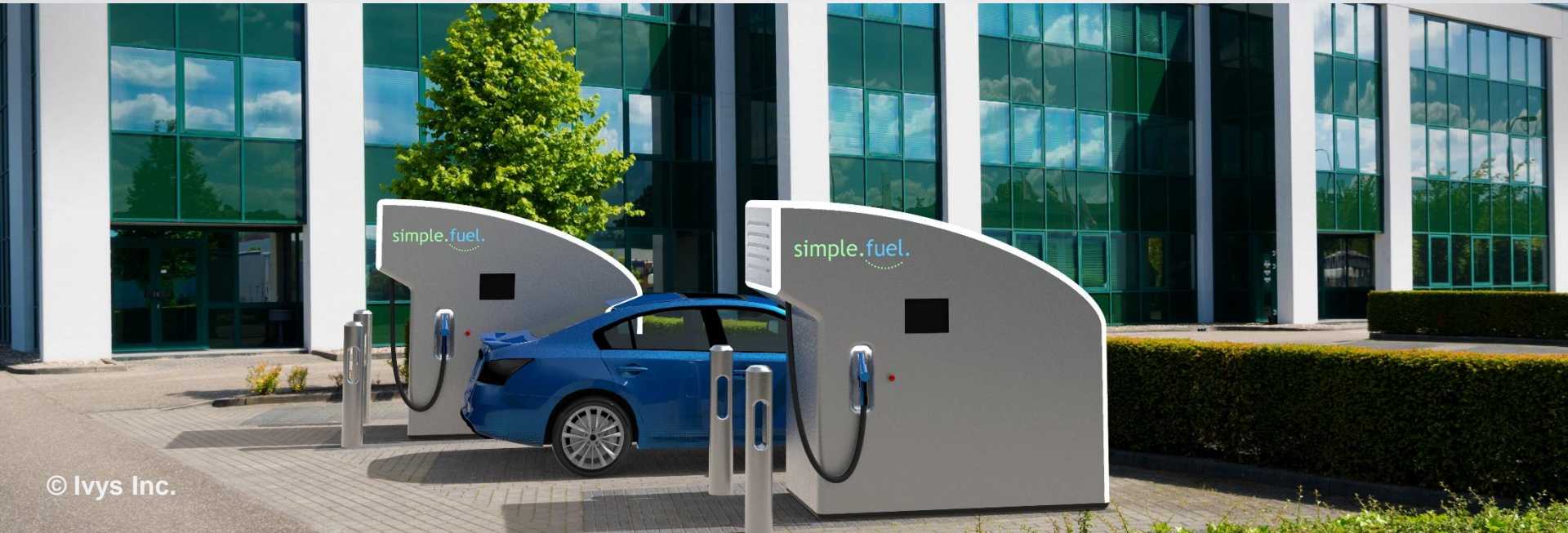
March 16, 2017

Darryl Pollica, CEO & Founder  
Chris O'Brien, CTO

Ivys Energy Solutions

- Please type your questions into the question box





© Ivys Inc.

# U.S. DOE-FCTO H-Prize Competition Drives Innovation with SimpleFuel™

*The Driver:  
create enabling solutions  
to increase FCEV adoption*



*The Impetus!*

**H<sub>2</sub>refuel**

U.S. Department of Energy



# Role of H-Prize Competition

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

## H-Prize created as part of the Energy Independence & Security Act of 2007

- Goal is “to advance the research, development, demonstration, and commercial application of hydrogen energy technologies.” (PLAW 110-140, Sec. 654)
- Initiative of DOE EERE Fuel Cell Technology Office
- Administered by the Hydrogen Educational Foundation, a 501(c)(3) non-profit organization
- Hydrogen infrastructure was focus of 2014-2016 round of H-Prize, titled “H2Refuel” targeting innovative solutions for home & community-based hydrogen refuelers for FCEVs
- Competition-based...promotes American Innovation!



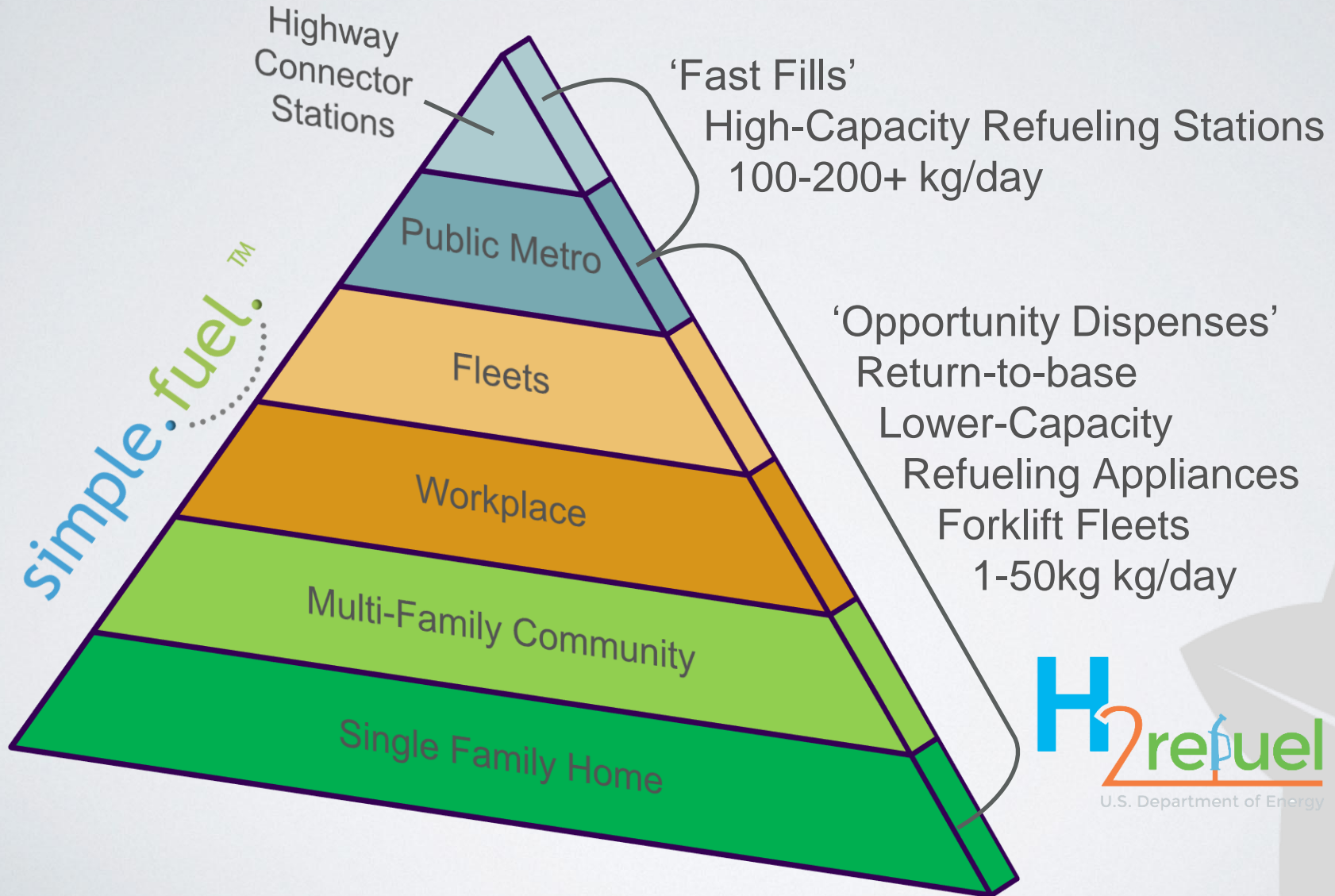
## Tenets of SimpleFuel's Design Approach:

- Safety First, Beyond Compliance
- Compact & Easy to Install
- Cost Effective
- Easy to Use, Friendly & Approachable
- Networkable (Distributed & Digital)
- Customer excitors!



PRIZE CRITERIA (HOME)	WEIGHT	MINIMUM SCORE	MAXIMUM SCORE
Dispensing Pressure	3	350 bar or higher	700 bar or higher
Tested Availability	2	80% or higher	98% or higher
Installed System Cost	2	\$25k/kg or less*	\$5k/kg or less
Dispensing Time (1 kg)	1	10 hours or less	30 mins or less
Standard Fills per Day (1 kg)	1	1 or more	5 or more
Direct User Cost per kg	1	\$20 or less	\$8 or less

*\*Home category allowed a maximum installed system cost of \$35k/kg if no team satisfied minimum score target*





# The Essential Ingredient: TEAM



30+ Years in  
System  
Integration &  
Deployment

300+ Hydrogen  
Compressors in  
Fueling, Proven

3000+  
Electrolyzers  
Deployed in  
Service,  
Cost Effective &  
Robust



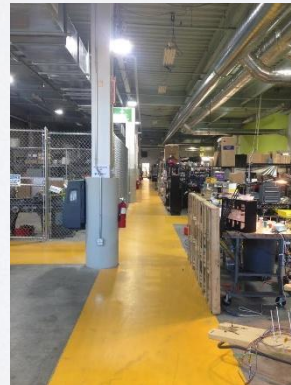
## Ivys' Role in the Hydrogen Industry

- Ivys' members led the development of a compact, on-site SMR appliance (Nuvera PowerTap™)
- Responsible for the safe deployment of 8 Nuvera H2 forklift stations (24/7 mission critical operations)
- Helped establish 1<sup>st</sup> H2 FCEV refueling station in Massachusetts (2009)
- Developing state-of-art H70-T40 dispenser systems (DOE Award #DE-EE0007273)
- Active Hydrogen Codes & Standards Participation

Ivys Energy Solutions, Inc., building on decades of experience in the hydrogen fuel cell industry, is developing innovative technologies and products to make a fundamental impact on automotive hydrogen refueling infrastructure, and enabling the successful near-term rollout of fuel cell vehicles.

**Team Leader of SimpleFuel™, winner of DOE's \$1M H2Refuel H-Prize competition**

**Development Location:**



# PDC's Industry leading H2 experience

- Over 300 compressors in global H2 Energy Applications and growing weekly, representing over 60% of the world Market for all applications.
- Unparalleled excellence in Hydrogen Energy!
- Vertically integrated manufacturing- 95% in-sourced.
- Best in customer support servicing a global client base.
- Spare Parts always in stock.





...leveraging centers in

## A portfolio of innovative products thanks to 13 years of R&D...

### H<sub>2</sub> production units



A full range: Small, medium and large-scale hydrogen production units (electrolyzers)

→ Years of experience in producing hydrogen through water electrolysis, a mature technology

### H<sub>2</sub> solid storage units



A disruptive, green, safe and large scale solution

→ Exclusive technology for storing hydrogen in solid form



## ... addressing 2 main high-growth markets

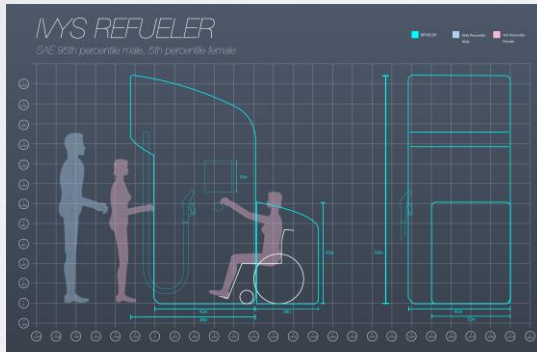
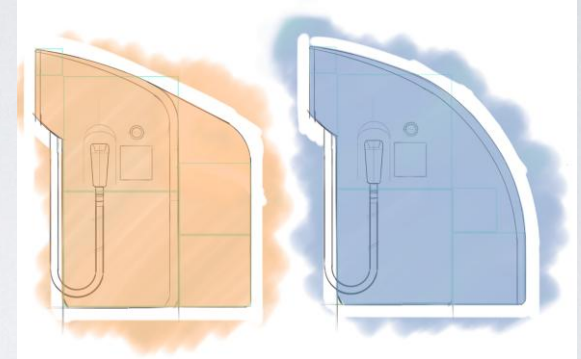
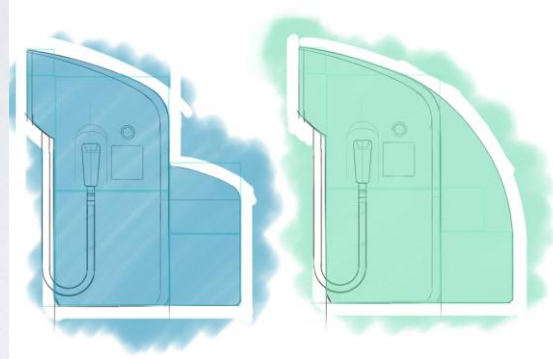
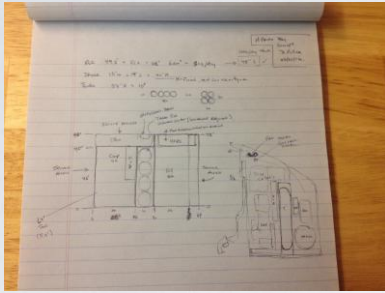


Industry



Energy & Mobility







# On-site Hydrogen Refueling Solution

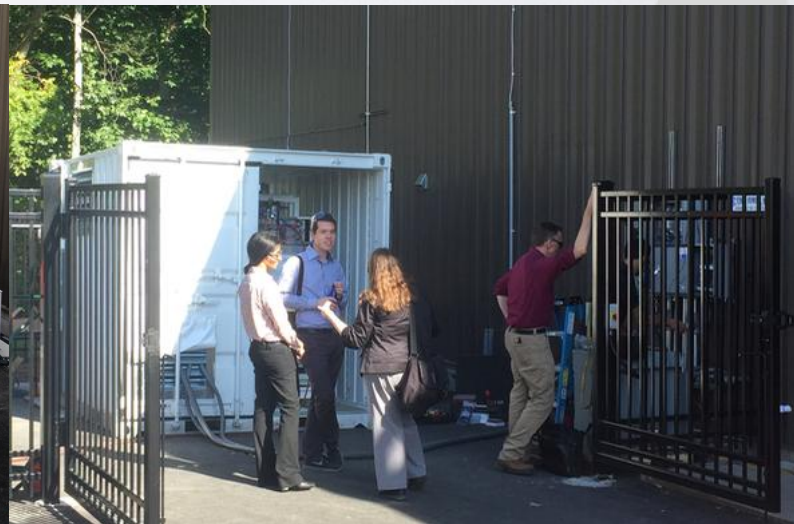
## New class of *Refueling Appliance*

- 5 kg/day, 700 bar H<sub>2</sub> delivery solution
- 'Drop-in' installation, small footprint
- Modular & scalable for evolving market
- 'Opportunity Dispense' in 5-15 minutes
- Cost competitive to gas & liquid delivered
- Uses water & electricity ⇒ renewable H<sub>2</sub> option
- Serves both automotive and forklift markets



simple.fuel.™ is a partnership between Ivys Energy Solutions, McPhy Energy NA and PDC Machines Inc. to develop a compact, on-site hydrogen refueling solution





simple.fuel.™

*Community Outreach  
Warwick-Bucks County First  
Responder Visit (Aug. 23)*







simple.fuel.™

Community Outreach  
Local School Education







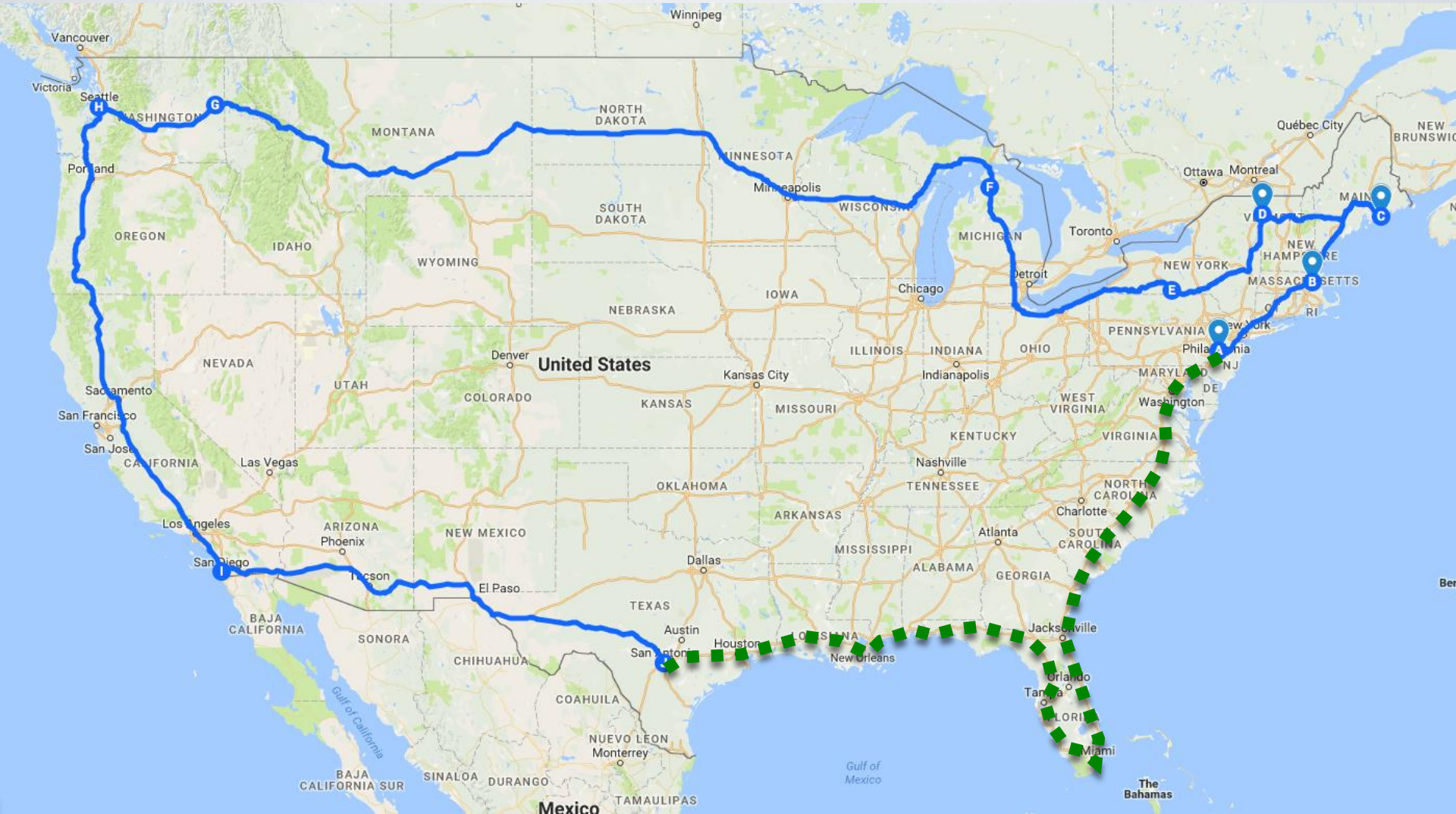
simple.fuel.™

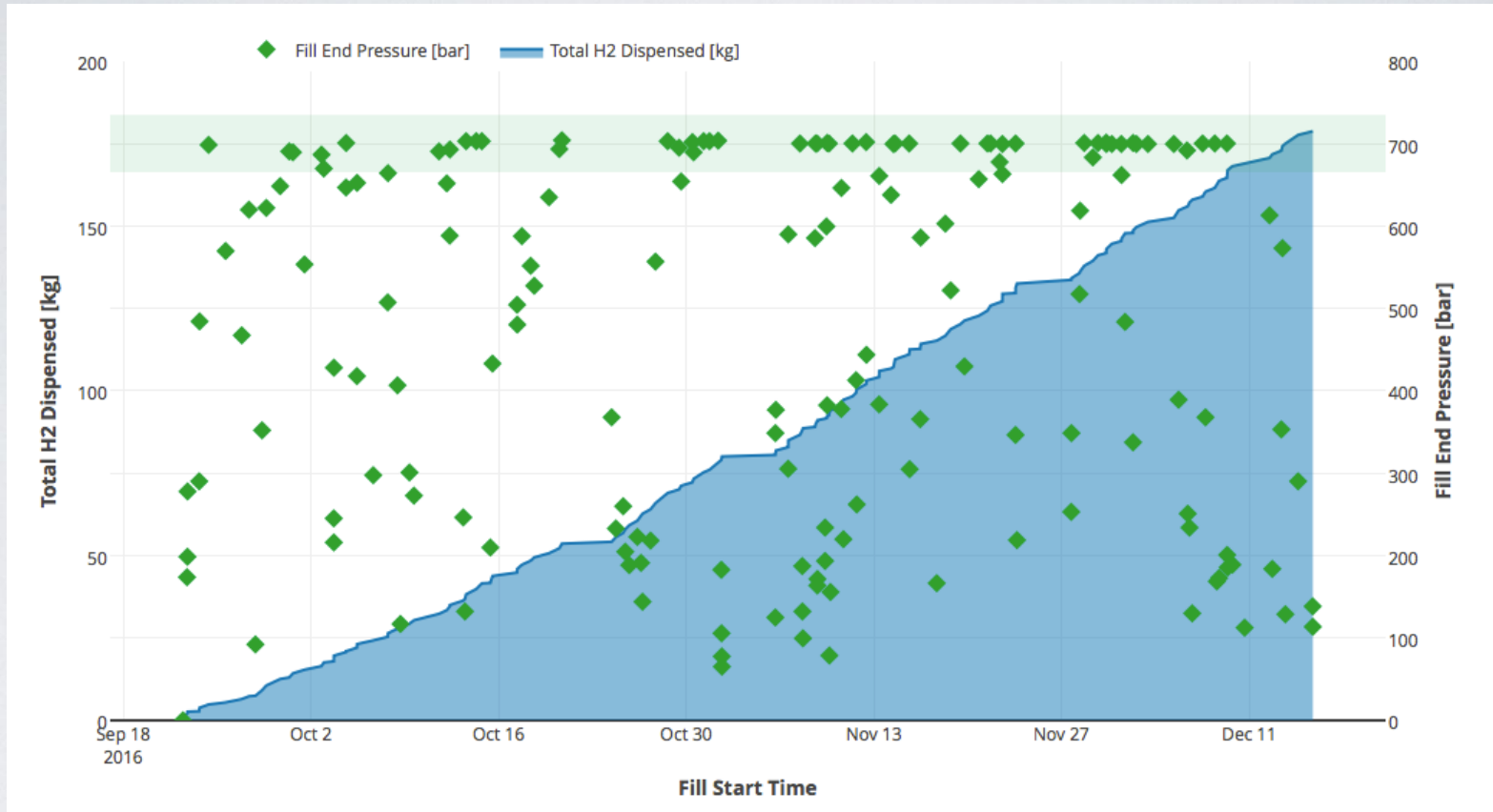
Open House  
Nov. 9<sup>th</sup>, 2016

simple.fuel.™



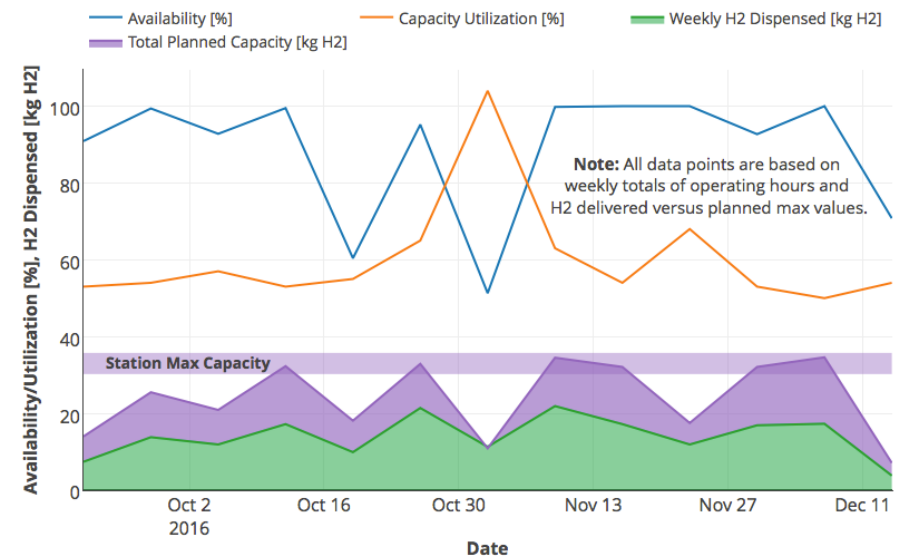
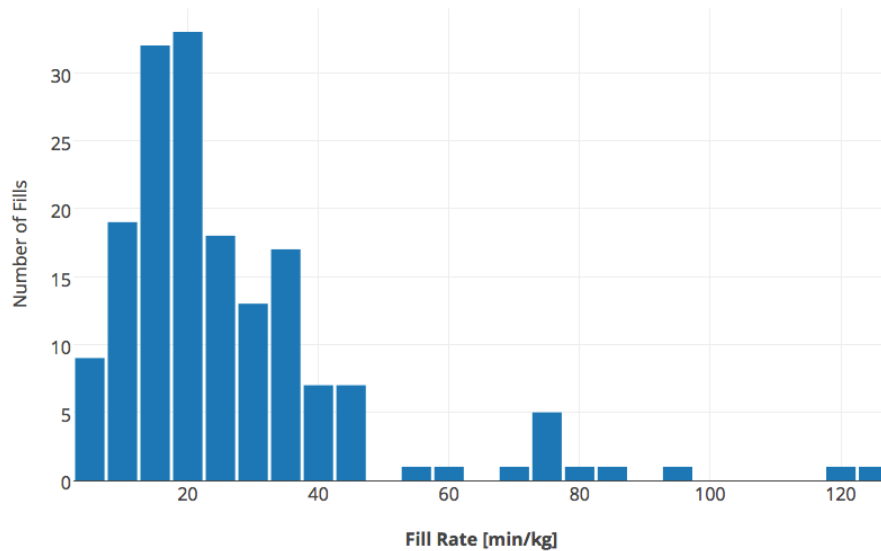
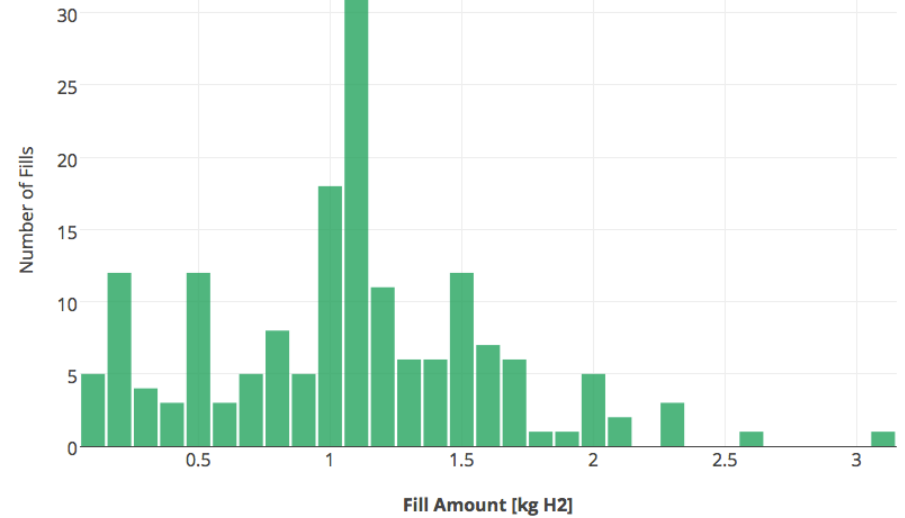
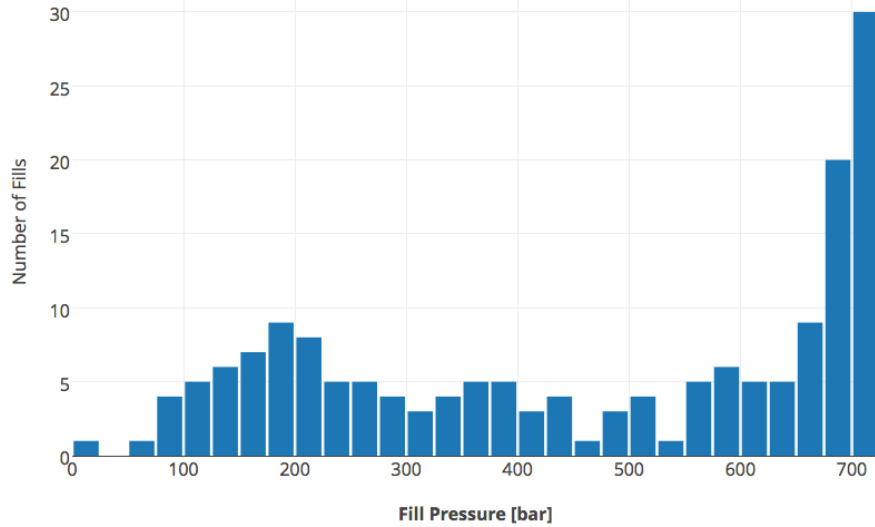
Data as of 11/18/2016

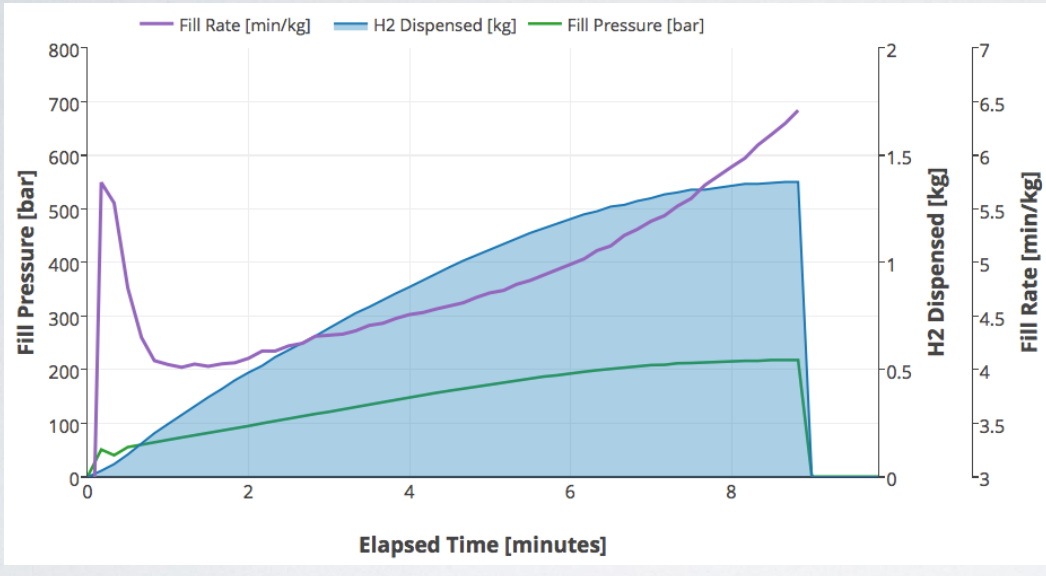




### Rigorous Product Evaluation:

- ✓ 700 bar, 5 kg/day SimpleFuel appliance testing with Hyundai Tucson FCEV
- ✓ More than 200 fills demonstrated to 4 – 7 kg class automotive tanks
- ✓ Furthering collaboration from multiple OEMs to validate product
- ✓ Supporting ISO/SAE Ambient-Class Standards Development

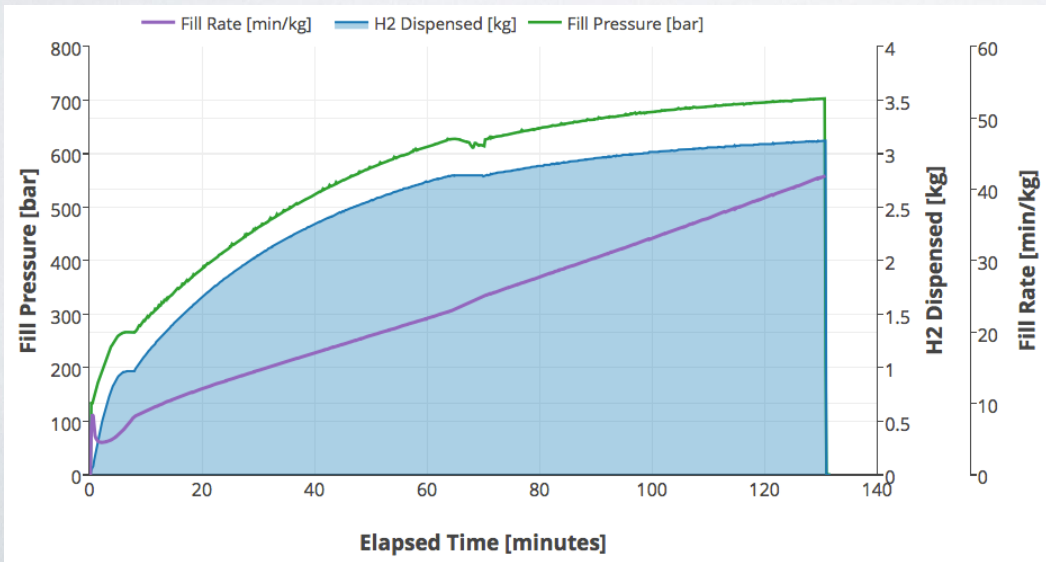




**'Opportunity' Dispense**

**Smaller Mass Dispensed**  
**Lower Final Pressure**  
**Fastest Fill Rates**

Target application: Quick range addition, managed fleet fueling

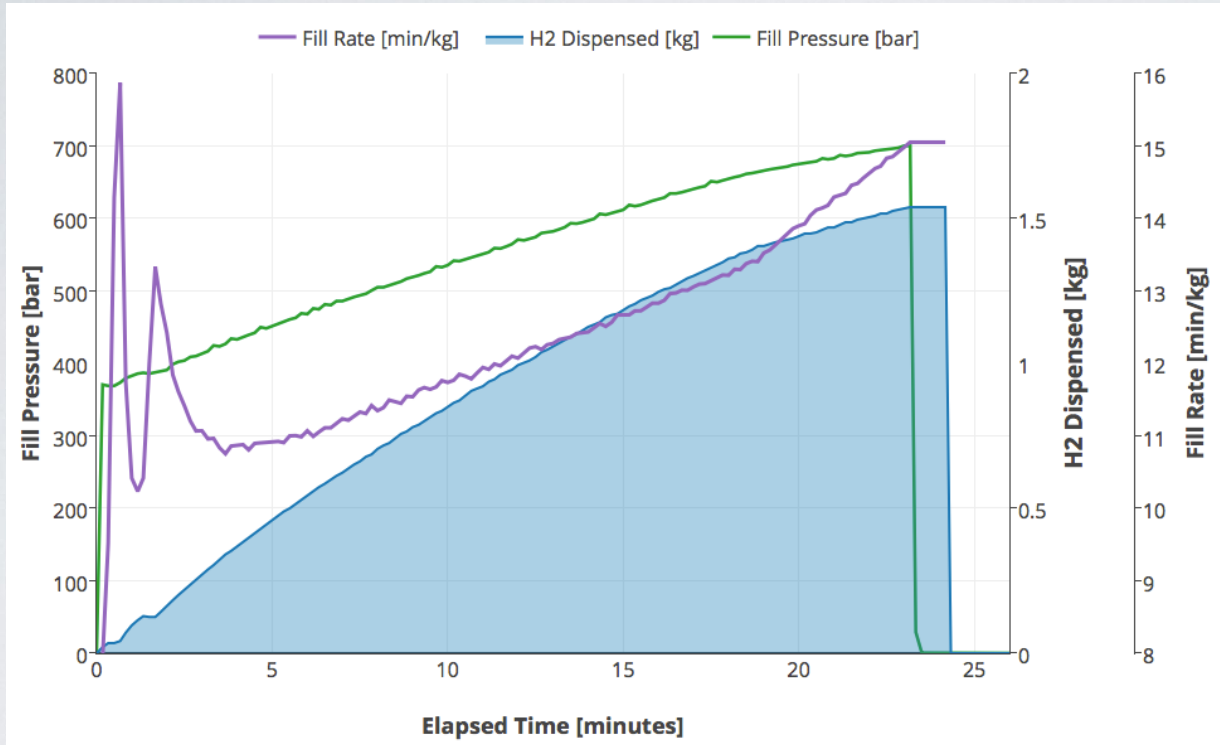


**'Full Fill' Dispense**

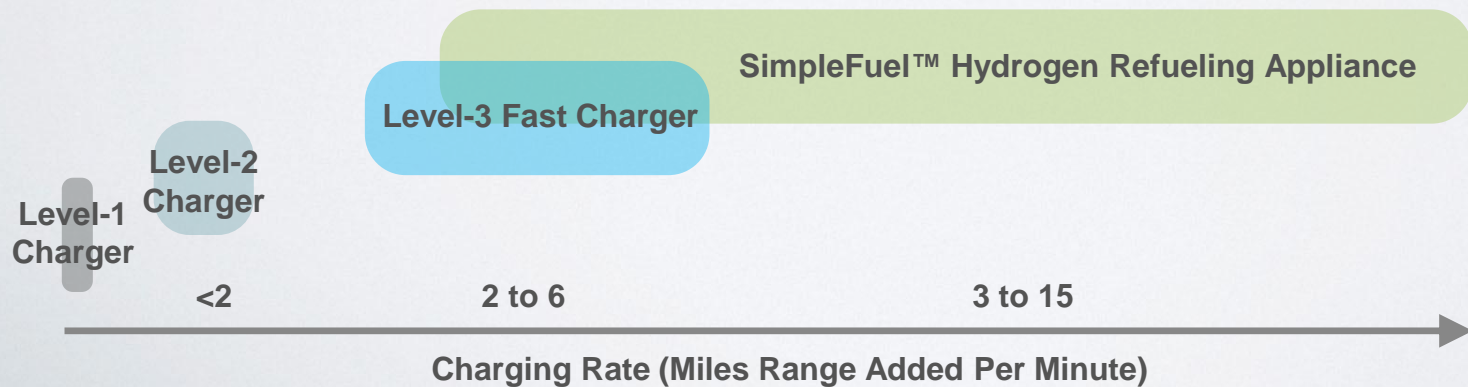
**Large Mass Dispensed**  
**Full Tank to 700 bar**  
**Fill Rate Slows During Fueling**

Target application: 'Slow charge' complete fill, overnight/shop fueling





*The SimpleFuel™ appliance provides a competitive vehicle range fill-time to that of the fastest chargers*





# Installation Requirements

## Basic site installation requirements for drop-in install:

- ✓ Power per specification
- ✓ RO Water Supply – sized for single or multiple systems
  - ✓ Vents: H2 and O2 per specification
  - ✓ Vehicle Impact Protection – Bollards
- ✓ Detail design review by U.S. Hydrogen Safety Panel Members
- ✓ Standard home install/cost provided by expert panel member(s)

## Commercialized product is under-going an appliance certification



Valued Quality. Delivered.



Intertek



# Periodic Inspection & Maintenance

Service Interval / Service Type	6 Mo. Inspection/ Clean/ Replace as Needed	1-Year Inspection/ Clean/ Replace as Needed	1-Year Replacement	5-Year Replacement
<b>Electrolyzer</b>				
Inlet Water Filter	X		X	
Pressure Equalizers	X		X (Internal Seal)	
Electrolyte Solution		X		X
Cell Stack				X
<b>Compressor</b>				
Oil System	X		X (Filter)	X (Oil)
Diaphragms			X (QTY 2)	
<b>Gas Purification &amp; Dispensing</b>				
Dryer Guard Filter		X		
Dispenser Filter		X		
Water Separator Filter	X		X	
Ventilation Air Filter	X			

Service cost typically  $\leq$  2-4% of capital cost per year; year-5 involves stack replacement



# Prototype Appliance Key Performances



700 bar  
Automotive H2 Appliance

*Product suite can support a managed fleet of 10 to 20 FCEVs with 5-15 minute opportunity fills*

Dispense Pressure	Daily Capacity	Fueling Rate (typ.)	Hydrogen Quality
<b>700 bar</b>	<b>5 (or 10) kg H2/day</b>	<b>5 – 30 min/kg H2</b>	<b>Meets SAE J2719 / ISO 14687-2</b>

Power Consumption	RO Water Consumption	Noise	Dimensions
<b>19 (or 29) kWe max</b>	<b>3 (or 6) L/h</b>	<b>&lt; 70 dBa at 1m</b>	<b>2.03m W x 1.07m D x 2.08m H</b>

Installed System Cost	Direct User Cost
<b>&lt;\$35k/kg</b>	<b>&lt;\$15/kg</b>

*Values in **bold** represent the tested 5kg H2/day H-Prize prototype of SimpleFuel™*

*H2 Refuel H-Prize Winner*  
*Satisfied all technical and cost criteria*  
*including 3 month performance test*  
[www.hydrogenprize.org](http://www.hydrogenprize.org)



simple.fuel.



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*Enabling Your Residential  
Fueling Solution  
Always depart with a full tank*



simple.fuel.™

*Enabling On-road Fleet  
Charging of FCEV's  
Allow your team to  
GO GREEN!*

simple.fuel.™



*Enabling Fueling at  
Service Centers  
Enhance customer  
experience and  
retention*

simple.fuel.™





*Enabling Distributed Fleet  
Fueling Networks*

*Easily expand your green fleet  
footprint and customer reach*

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# Acknowledgements

*The SimpleFuel Team would like to thank:*



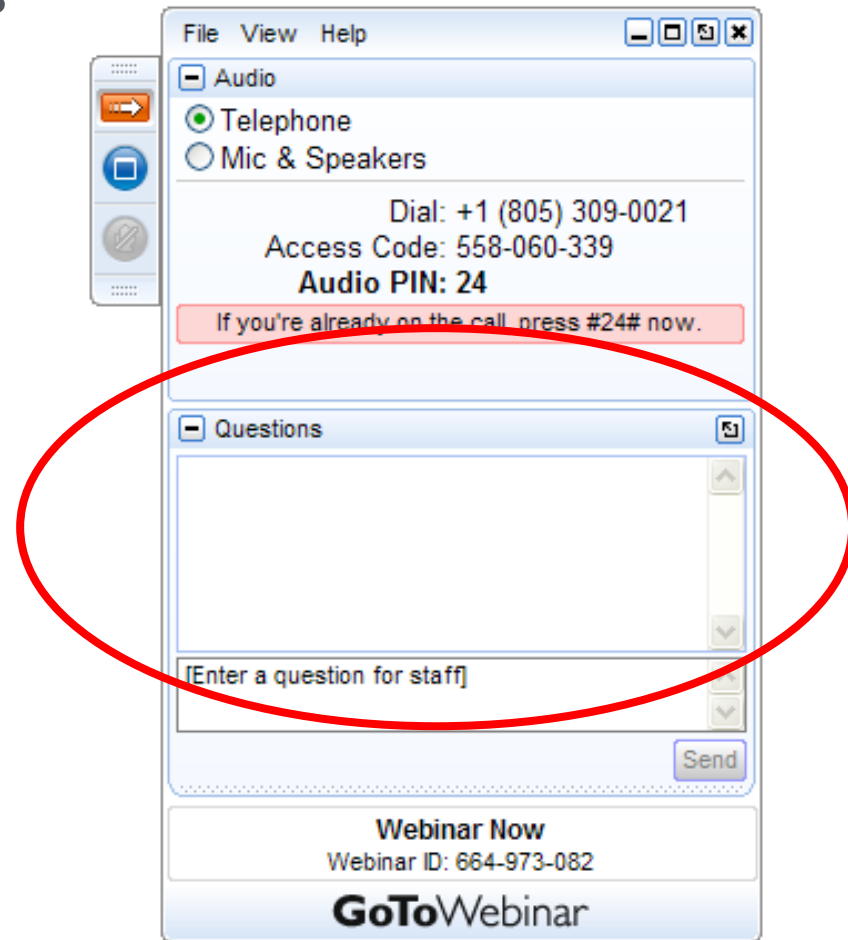
Energy Efficiency &  
Renewable Energy



**HYUNDAI**



- Please type your questions into the question box



# Thank you

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