

## **Micro Hydrogen™ for Portable Power** *Creating Opportunities for Governments to Spur the Hydrogen Economy*

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### **The Hydrogen Economy in the Palm of Your Hand**

What if thousands of citizens and employees in your state or province could begin using hydrogen fuel cell devices, today? What if the concern over hydrogen refueling could be solved – as simply as placing a small table-top refueling station in every coffee house or convenience store in the neighborhood? What if you wanted to instantly showcase your region as a leader in hydrogen power and fuel cell technology? This is possible today with public demonstrations and outreach projects using micro hydrogen™ fuel cell technology. And the money to make it happen already exists.

A portion of the monies for the many hydrogen fuel cell bus programs now in operation could place thousands of devices, such as two-way radios, flashlights, searchlights, portable power sources, range extension devices and more into the hands of the public today – all powered with micro hydrogen™ fuel cells. Such a move could jumpstart a mass market hydrogen economy.

Micro hydrogen™ may be described as the integrated™ combination of hydrogen fuel cell, 'on-board' hydrogen storage and electronics that together provide high energy density in small form factors suitable to power handheld devices and other portable applications. Micro hydrogen™ can already provide 3 Watts peak power and 1Watt average power, with an energy density of over 300Wh/l in a very small 25cc package –about the size and power of a lithium-ion battery. Just as important as power, micro hydrogen™ delivers the added benefits of long-run times, fast refueling, sustainable off-grid energy and a reduction in both greenhouse gas emissions from wall rechargers and disposable battery waste. Micro hydrogen™ fuel cells contain no toxic elements and emit only water vapor.

*Micro Hydrogen™ Fuel Cell Benefits*

- High power/energy density
- Fast refueling
- Long run-times
- Equivalent replacement of traditional battery-powered device
- Off-grid power
- Adaptable to multiple handheld/portable devices
- High cycle life
- Clean, safe, non-toxic hydrogen power (emits only water vapor)
- Fast path to fuel cell mass market

The typical government hydrogen fuel cell program to date has focused on hydrogen buses, which typically cost 5x their diesel cousins. As a 'carrot and stick' approach to improving local air quality and spurring both innovation and economies of scale in the hydrogen economy, several US states and cities in Canada and Europe, for example, are adding one or more hydrogen fuel cell buses to their public transportation fleet. Typically, these buses cost about \$3-\$4 million (US) each, are initially placed into limited route service and do not necessarily have the same service lifespan as their diesel counterparts. Micro hydrogen™ fuel cell powered devices, however, offer fully functional lifecycle replacements of existing applications.



Examples of products available today using micro hydrogen™ fuel cells.

Shown here: security flashlights and portable micro hydrogen™ power packs (for search & rescue lighting, 2-way radios and range extension)

There are numerous reasons that motivate governments to initiate a hydrogen fuel cell bus program. A single hydrogen bus delivers:

1. visibility – buses support outreach efforts of alternative transit options
2. reduced greenhouse gas emissions – a single zero emission hydrogen bus offers an immediate positive impact on the environment
3. practical experience – governments and manufacturers learn how these buses handle real-world usage

4. prestige – hydrogen fuel cell buses can convey a sense of prestige to political leaders and the larger community they service
5. innovation -- showcasing the region’s commitment to clean technology development

These are laudable goals. Governments should continue their hydrogen bus programs. Nonetheless, given the cost of a single hydrogen bus, say, \$3.5 million, along with the cost of a single central refueling station, add another \$1.5 - \$2 million, there is a bona fide opportunity for governments to earmark an equal amount to a complimentary hydrogen fuel cell program that could immediately impact thousands of users across an entire region.

Deploying micro hydrogen™ fuel cells for the same cost, governments can deliver equivalent or far greater visibility, usage, prestige, innovation, education and sustainability. Moreover, micro hydrogen™ fuel cell devices offer a more feasible path to mass market use. In addition, micro hydrogen™ potentially spares us from billions of disposable batteries and the electrical waste of millions of wall rechargers.

### Expanding the Hydrogen Economy

Public Hydrogen Programs	Micro Hydrogen™ fuel cell program	Hydrogen fuel cell bus program
Promote public use of hydrogen devices	✓	✓
Enable individual use of hydrogen products	✓	x
Public outreach and education	✓	✓
Foster regulatory changes in use and availability of hydrogen	✓	✓
Multiple locations	✓	x
Multiple users (000s)	✓	x
Support mass market hydrogen refueling infrastructure	✓	x
Reduce GHG emissions	✓	✓
Immediate possession of device	✓	x
Spur a scalable market in hydrogen fuel cell technology	✓	x

## A Highly Visible Alternative

In the United States, for example, a hydrogen bus program will directly impact a very limited number of riders. Most Americans typically drive a car to work, and most of them drive alone. Micro hydrogen™ devices, from flashlights to scanners to cellphone batteries, in thousands of hands, visible to thousands more, put into practical use every single day, are more likely to directly and indirectly impact the community at large and create a economy of scale for this technology. Few people ride a bus, fewer still ever drive one. Everyone, however, uses a flashlight, cellphone, walkie talkie, bike light, PDA or other portable device – and intuitively knows how to operate them.

Potentially thousands more lives will be touched, today and well into the future, by deploying portable devices with hydrogen fuel cells than with any comparable program.

Along with visibility, also comes environmental benefit. Most individuals (and governments) significantly underestimate the energy use of portable devices that have become so much a part of our daily work and personal lives. As one example: the US government estimates that as many as 1.5 billion external power adapters, those devices we use to recharge our cell phones and the like, are currently in use in the US alone. This adds up to 207 billion kWh/year, at a cost of \$17 billion per year (that's 6% of the nation's electric bill<sup>1</sup>). Despite ongoing efforts, these devices remain inefficient users of energy. There is an immediate opportunity to rid ourselves of such waste – using micro hydrogen™. The potential for replacing disposable batteries may offer an equally positive benefit.

### *Maximize Visibility of your Hydrogen Program Today*

- Branded mass market refueling stations – for example, one at every Starbucks™
- Thousands of users on day 1
- Fully functional replacements of their non-fuel cell counterparts
- Instant use, instant user credibility
- Impacts far more people
- Instant and tactile personal experience with fuel cell devices and hydrogen power
- No 'technician' (or licensed driver) required to operate

## By the Numbers

It is possible, today, to spend this same amount of money earmarked in government budgets for a single hydrogen fuel cell bus and put working hydrogen fuel cell

<sup>1</sup> US EPA, [www.energystar.com](http://www.energystar.com).

devices into the hands of thousands. These could include security officers, police, government administration, users throughout school districts, docks, warehouses, airports, wherever portable devices or off-grid power are required -- everywhere. Such an effort would truly showcase the government's commitment to sustainability, dramatically and immediately ramp-up the profile of hydrogen power and fuel cell technology, and teach millions of children and adults, by actual and indirect use, the potential of hydrogen. It would also instantly involve the private sector as refueling stations and trial devices could be implemented far beyond a single government locale or centralized refueling area.

Few other programs could as quickly or as fully maximize taxpayer dollars while supporting a innovative, clean and technologically advanced industry. The number and kind of hydrogen fuel cell powered devices could touch multiple government departments, regions, schools and users. Consider a one-year budget that currently has earmarked funds for the purchase of three hydrogen fuel cell buses and a single refueling station:

**Estimated Government Budget: Hydrogen Fuel Cell Programs**

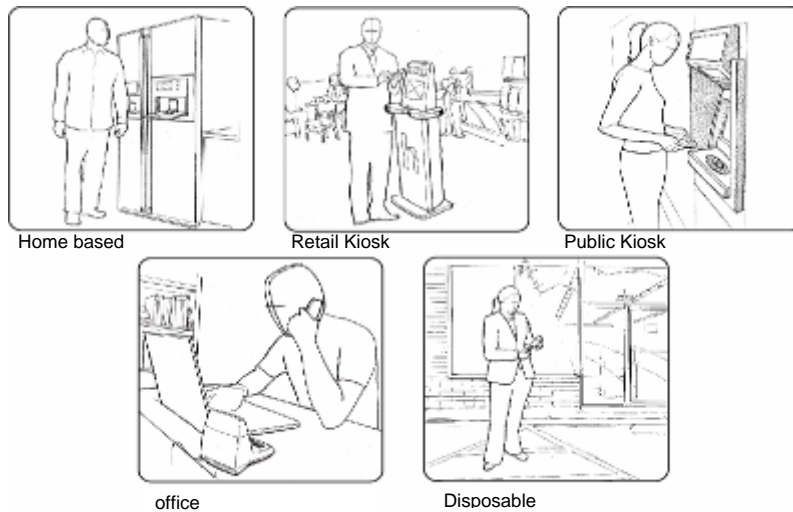
<b>BUDGET YEAR 1</b>	
<i>Estimated Micro Hydrogen™ fuel cell budget of \$10 million could include:</i>	<i>Estimated hydrogen fuel cell bus budget of \$10 million could include:</i>
3,000 Portable/desktop refueling stations (About 2 in every Starbucks™ in California)	3 buses**
3,000 Power packs (on-the-go micro hydrogen™ power for portable devices such as Blackberrys or searchlights)	1 refueling station
5,000 LED Flashlights	
4,000 Bikelights	

**Refueling: Would you like Hydrogen with your Latte?**

With micro hydrogen™ the single, costly, centralized hydrogen refueling station is no longer a 'chicken or egg' burden. In fact, micro hydrogen™ presents government and industry multiple opportunities to build legitimate, near-term private enterprises around hydrogen refueling. Micro hydrogen™ devices can be 'topped up' in a couple minutes. They can be popped into a small (and portable) refueling station or cartridge. It is conceivable that the opportunity to create a hydrogen infrastructure, dramatically spur visibility and ease the pathway to mass market use of hydrogen could be as simple, for example, as deploying a small co-branded refueling stand in every Starbucks™ – that's about 10,000+ stores all around the world.

Each micro hydrogen™ user, invariably near a Starbucks, could refuel their device in the time it takes their barista to pour them a cappuccino. Thousands, maybe millions of people would be exposed to your hydrogen fuel cell program.

### Fueling Vision



**Potential refueling options include cartridges, desktop stations, and kiosks in high-traffic areas**

Other refueling options include small desktop appliances in offices. Post offices and motor vehicle offices, for example, could encompass both government employee and private citizen use. Users devices could be topped up in the time it takes to write an email, send a letter or fill a water bottle. Larger 'kiosk' units could be made available for public usage in public spaces or retail outlets. It is not too difficult to conceive of free hydrogen refueling stations for customers to encourage them to linger in a shop or visit a office.

### Hit the Road Today with Micro Hydrogen™ Devices

Micro hydrogen™ fuel cells, powering a range of portable devices, available today, able to be refueled in multiple locations, offer governments, hospitals, universities and private organizations an opportunity to seize upon an environmentally sustainable technology while generating mass market usage. Micro hydrogen™

enables organizations and governments to support environmental initiatives, spur technological innovation and showcase their commitment in a manner that is visual, appealing and intuitively understood. The fastest road to a clean, safe hydrogen economy is there in the palm of your hand.



Anyone can use micro hydrogen™ powered devices, which can power flashlights, bike lights, 2-way radios and soon, cell phones.

### **About Angstrom Power Inc.**

Based in North Vancouver, British Columbia, Angstrom develops and commercializes micro hydrogen™ technology which enables high energy density power sources in small form factors suitable for portable devices, handheld electronics, lighting and battery replacement applications. Angstrom presently offers micro hydrogen™ technologies and products for demonstration, evaluation and OEM integration. Founded in 2001, Angstrom has over forty patents and patents pending. To learn more visit [www.angstrompower.com](http://www.angstrompower.com).

### **About the Author**

Brian Prior to joining Angstrom Power, Brian led the marketing and communications for several high-tech start-ups. He received his Bachelor's degree from the University of Michigan and his MA in Telecommunications Management from Michigan State University.