Center for Advanced Automotive Technology

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Fuel Cell Electric Vehicles: The Other Electric Vehicle

CAAT Webinar

August 23, 2016

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Presenters

Part 1

Nelson Kelly, Assistant Director for Energy and Automotive Technology, CAAT, Macomb Community College

Part 2

John Frala, Advanced Transportation Technology, Rio Hondo Community College

Webinar Outline

Nelson Kelly, Part 1

- Who we are: Center for Advanced Automotive Technology (CAAT)
- The road to electric vehicles, xEV
- Making electricity using electrochemistry
- Proton Exchange Membrane fuel cells (PEM)
- Using hydrogen to store energy on fuel cell electric vehicles
- ZEVs, Greenhouse Gas Emissions, and protecting the planet
- Hydrogen and renewable energy for fuel cell electric vehicles

John Frala, Part 2

- Who we are: Automotive Technology, Rio Hondo Community College
- The state of transportation and fuel cell technology
- Public Transit
- California and the new fuel investment
- The California Energy commission and ZERO Emission
- Focus on ZERO Emission training
- Fuel infrastructure in California

Presenter #1

Nelson Kelly, Assistant Director for Energy and Automotive Technology (CAAT), Macomb Community College

B. S. Chemistry	Miami University (Ohio)
Ph.D. Physical Chemistry	Pennsylvania State University
Research Scientist	General Motors R&D Center
Macomb Community College	Adjunct Instructor
CAAT	Assistant Director, Energy and Automotive Technology

My background includes conducting research on the chemistry of photochemical smog formation, vehicle emissions, foundry emissions, airbag emissions, hydrogen production and storage, renewable hydrogen production, and battery charging using solar energy. I have published approximately 60 technical papers, have 15 patents, and recently wrote a book chapter on electrolytic hydrogen.

About the Center for Advanced Automotive Technology (CAAT)

- Located at Macomb Community College South Campus
- Became an Advanced Technological Education (ATE) Center in 2010 funded by the National Science Foundation in partnership with Wayne State University
- Grant renewed in 2014 for three more years
- Mission
  - Develop and disseminate advanced automotive technology curricula
    - Connected/automated vehicles
    - Light-weight materials for vehicles
    - Electric and hybrid vehicles and alternative fuels
  - Provide outreach activities to middle and high school students

Where Does the Energy to Drive a Typical Vehicle Come From?

- An internal combustion engine (ICE) burns a gasoline to make heat that expands the gases in a cylinder to create mechanical energy to propel the vehicle

- $C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O + \text{heat}$

octane + oxygen in the air forms carbon dioxide and water and produces heat

- Some of the heat is converted to work (mechanical energy)

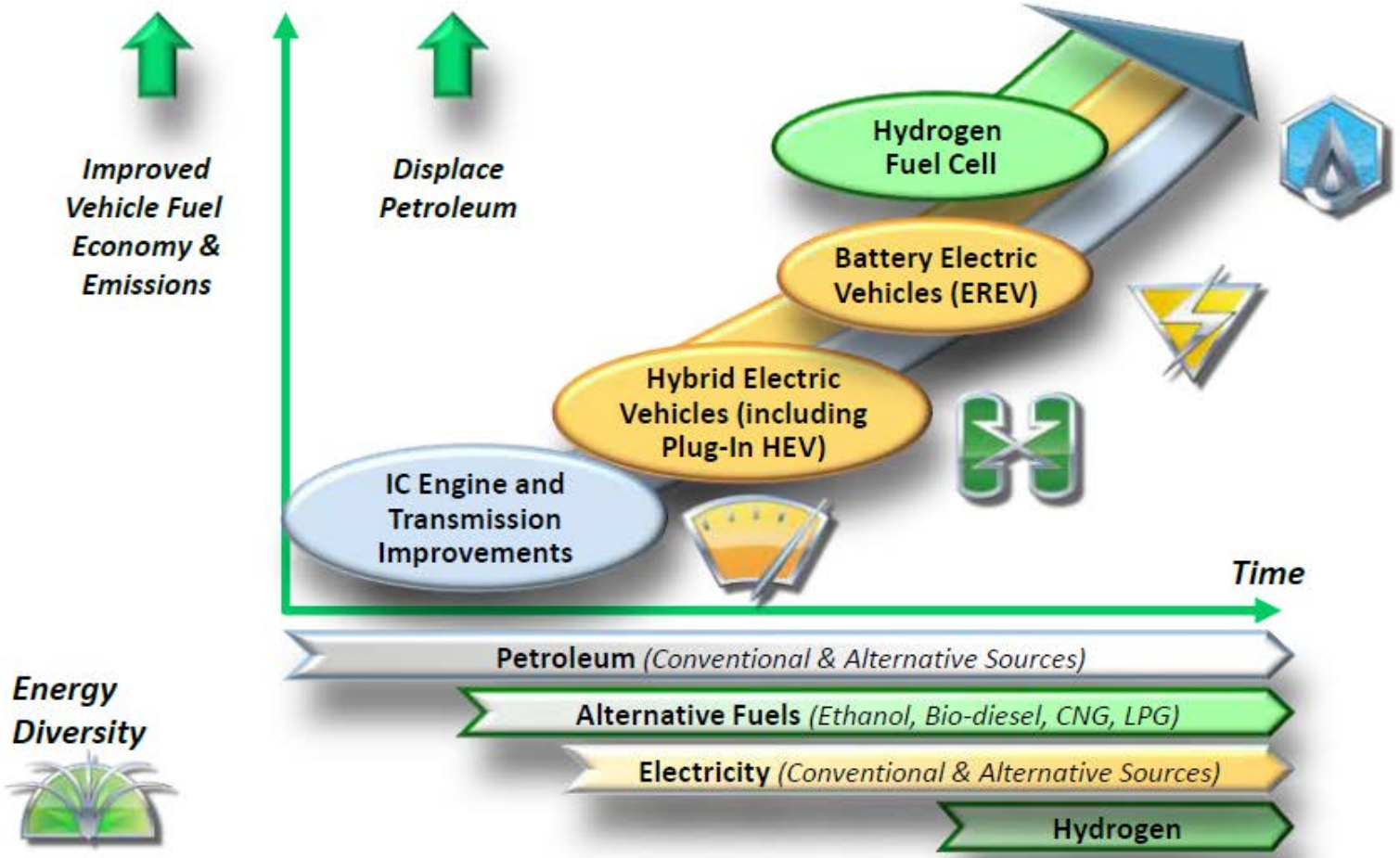
Internal Combustion Engines (ICE)

- They are reliable and relatively inexpensive
- The use a liquid fuel that has a very high energy density permits fast refueling and a long range
- They have a long history and will be around for a long time, but ….
  - they emit pollutants, GHG, and are slowly using up petroleum – this is not sustainable
  - they are not energy efficient (Carnot limitation on heat to work conversion)
- They finally have competition from several types of electric vehicles, xEV
  - energy conversion devices that use electrochemistry to produce electricity
  - very efficient electric motors and power electronics

Why Must Automakers Build Electric Vehicles?

- EPA and CARB can set pollutant emission standards to protect public health (hydrocarbons, CO, NOx, SO_2, lead, particulate matter)
  - NHTSA can set mpg standards (CAFE)
  - CO_2 can also be regulated – a greenhouse gas (GHG)
- Increasingly difficult for internal combustion engines (ICE) to meet fuel economy standards (mpg and CO_2 emission) standards
  - 54.5 mpg by 2025 (163 g CO_2/mile)
- Impossible for ICE to meet California zero-emission vehicle (ZEV) standards

Advanced Propulsion Technology Strategy
No single silver bullet exists



Source: Charles Freese, GM Executive Director, Global Fuel Cell Activities

Some Nomenclature for xEV

- x = H is a Hybrid Electric Vehicle, HEV
- X= PH is a Plug-in Hybrid Electric Vehicle (PHEV), sometimes also called an Extended Range Electric Vehicle (EREV)
- x = B is a Battery Electric Vehicle, BEV
- x = FC is a Fuel Cell Electric Vehicle, FCEV

Each of these systems can help reduce the environmental impact of vehicles relative to internal combustion engine (ICE) systems and can also improve the sustainability of the transportation system

Examples of Each Type of xEV

- HEV

Toyota Prius

- PHEV

Chevy Volt

(EREV)

Very common

- BEV

Nissan Leaf

Tesla Model S

Becoming common

- FCEV

Honda FCX Clarity

Toyota Mirai

Genesis mode

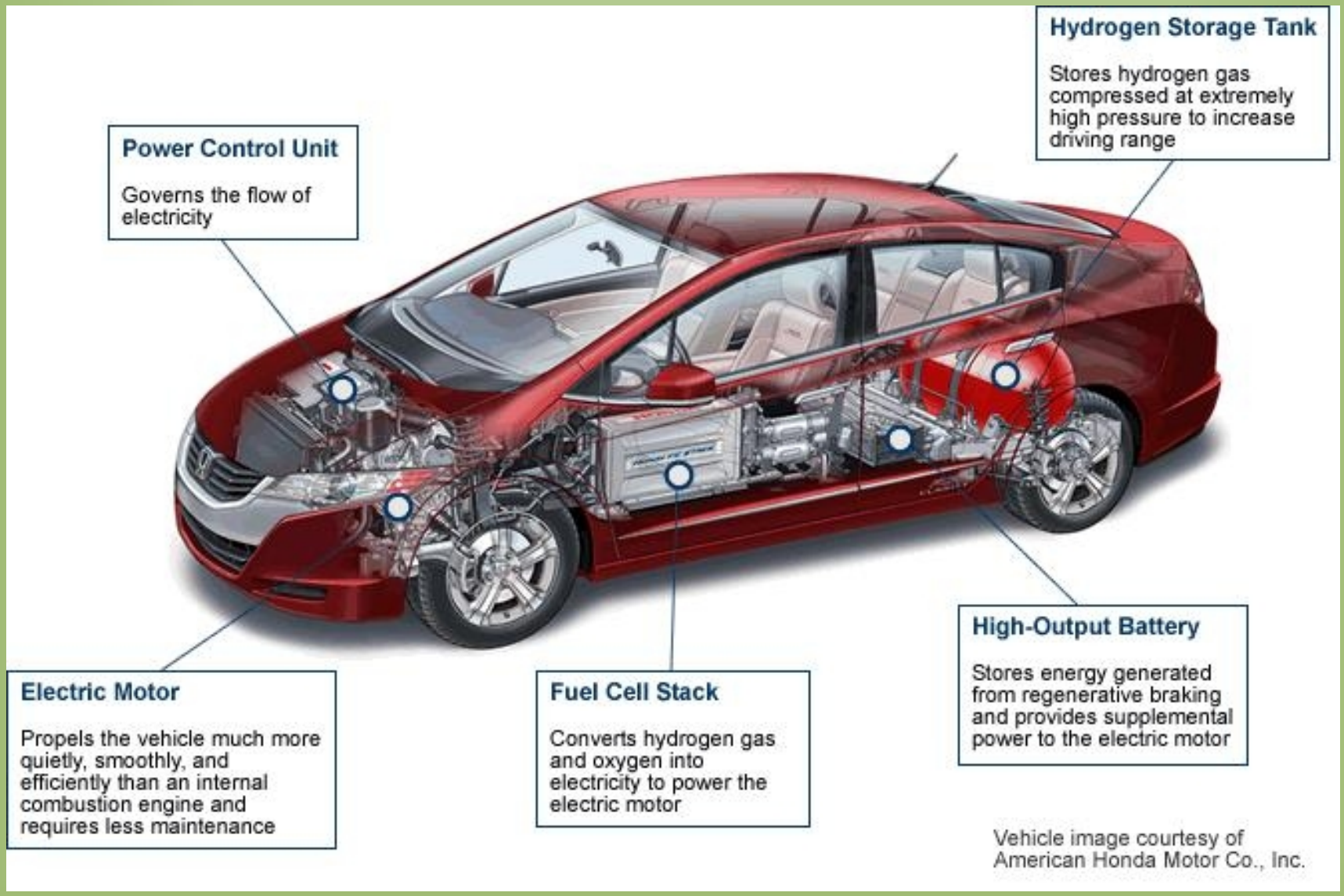
“the Other”

EV: BEV versus HEV versus FCEV

- When people think of EV they think of HEV (either plug-in or not) and BEV
- FCEV have consistently missed expected introduction dates due to the lack of a hydrogen fueling infrastructure
- But, things are changing, especially in California, Japan, and Germany and automotive technicians of the future will need to be able to maintain and repair FCEV

Main Components in a FCEV

Honda FCX Clarity



How do Fuel Cells (and Batteries) Work?

Nomenclature

Electrochemistry

Oxidation/Reduction Reactions

Anode/Cathode/Electrolyte

Ion and Electron Flow

The Electromotive Series, Half-Reactions

Standard Potential, E^0

Overvoltage

Oxidation-Reduction reactions are important in electrochemistry, batteries, and fuel cells

Oxidation: The loss of one or more electrons by a substance, whether element, compound, or ion.
Half reaction example: $Cu(s) \longrightarrow Cu^{2+}(aq) + 2\ e^-$

Reduction: The gain of one or more electrons by a substance, whether element, compound, or ion.
Half reaction example: $Cu^{2+}(aq) + 2\ e^- \longrightarrow Cu(s)$

Notice that one process is the reverse of the other

Some "Half-Reactions" in the Electromotive Series written as Reduction Reactions

Reduction Half-Reaction		E° (V)
$F_2(g) + 2\,e^-$	$\longrightarrow 2\,F^-(aq)$	2.87
$H_2O_2(aq) + 2\,H^+(aq) + 2\,e^-$	$\longrightarrow 2\,H_2O(l)$	1.78
$MnO_4^-(aq) + 8\,H^+(aq) + 5\,e^-$	$\longrightarrow Mn^{2+}(aq) + 4\,H_2O(l)$	1.51
$Cl_2(g) + 2\,e^-$	$\longrightarrow 2\,Cl^-(aq)$	1.36
$Cr_2O_7^{2-}(aq) + 14\,H^+(aq) + 6\,e^-$	$\longrightarrow 2\,Cr^{3+}(aq) + 7\,H_2O(l)$	1.36
$O_2(g) + 4\,H^+(aq) + 4\,e^-$	$\longrightarrow 2\,H_2O(l)$	1.23
$Br_2(aq) + 2\,e^-$	$\longrightarrow 2\,Br^-(aq)$	1.09
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	0.80
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	0.77
$O_2(g) + 2\,H^+(aq) + 2\,e^-$	$\longrightarrow H_2O_2(aq)$	0.70
$I_2(s) + 2\,e^-$	$\longrightarrow 2\,I^-(aq)$	0.54
$O_2(g) + 2\,H_2O(l) + 4\,e^-$	$\longrightarrow 4\,OH^-(aq)$	0.40
$Cu^{2+}(aq) + 2\,e^-$	$\longrightarrow Cu(s)$	0.34
$Sn^{4+}(aq) + 2\,e^-$	$\longrightarrow Sn^{2+}(aq)$	0.15
$2\,H^+(aq) + 2\,e^-$	$\longrightarrow H_2(g)$	0
$Pb^{2+}(aq) + 2e^-$	$\longrightarrow Pb(s)$	−0.13
$Ni^{2+}(aq) + 2\,e^-$	$\longrightarrow Ni(s)$	−0.26
$Cd^{2+}(aq) + 2\,e^-$	$\longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2\,e^-$	$\longrightarrow Fe(s)$	−0.45
$Zn^{2+}(aq) + 2\,e^-$	$\longrightarrow Zn(s)$	−0.76
$2\,H_2O(l) + 2\,e^-$	$\longrightarrow H_2(g) + 2\,OH^-(aq)$	−0.83
$Al^{3+}(aq) + 3\,e^-$	$\longrightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2\,e^-$	$\longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.71
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.04

The voltage, E^0, describes the relative tendency of the reaction to occur

It is called the standard half-cell potential

A Battery Cell Works by Combining Oxidation and Reduction Reactions with a Special Arrangement so Electrons Flow in an External Circuit

Oxidation half-reaction:

$$Zn(s) \longrightarrow Zn^{2+}(aq) + 2\ e^- \qquad E^0 = 0.76\ V$$

Reduction half-reaction:

$$Cu^{2+}(aq) + 2\ e^- \longrightarrow Cu(s) \qquad E^0 = 0.34\ V$$

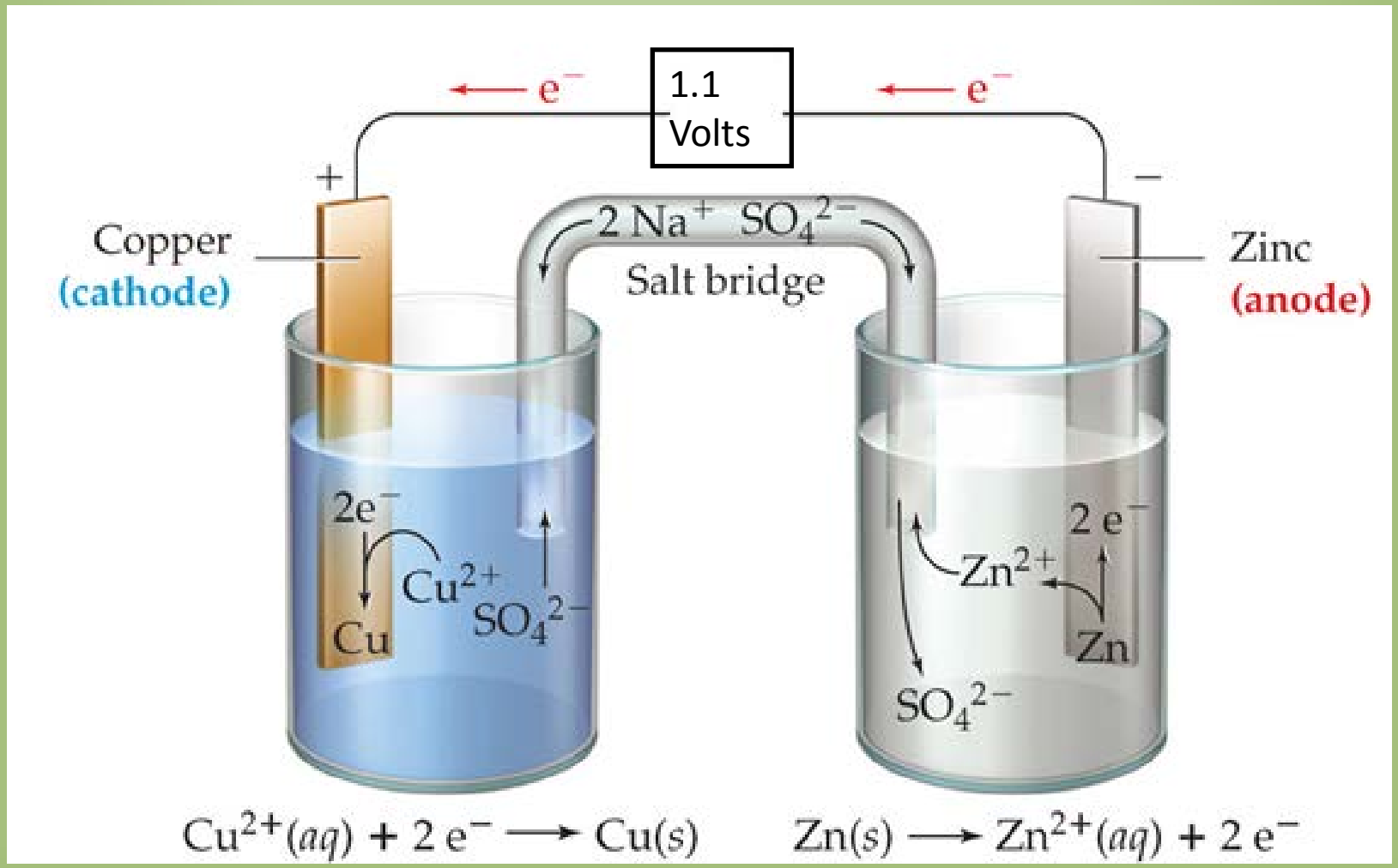
Overall Reaction:

$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s) + \text{electrical energy}$$

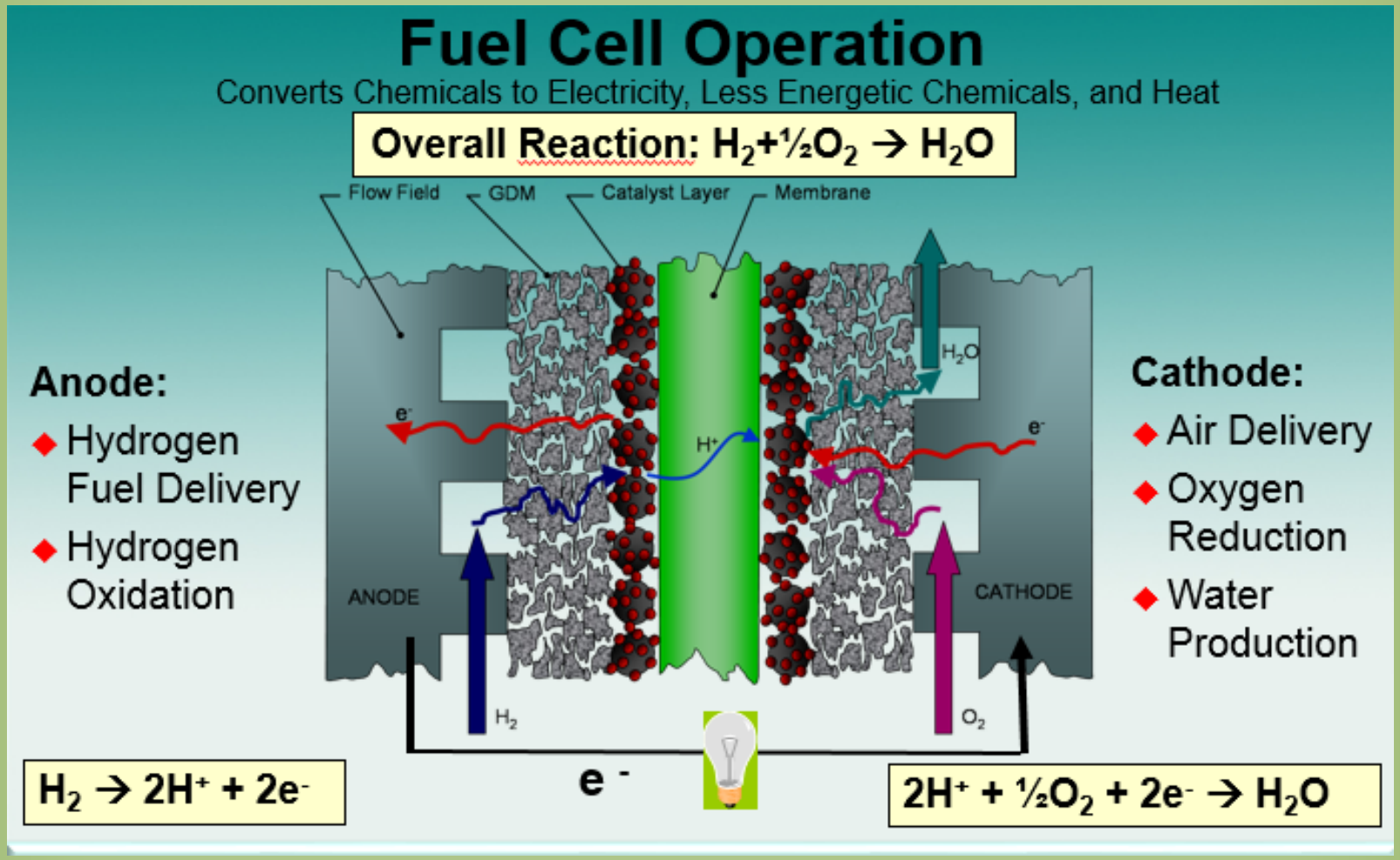
$$E^0 = 1.1\ V$$

Electrochemistry in the Daniell cell (an early battery cell)

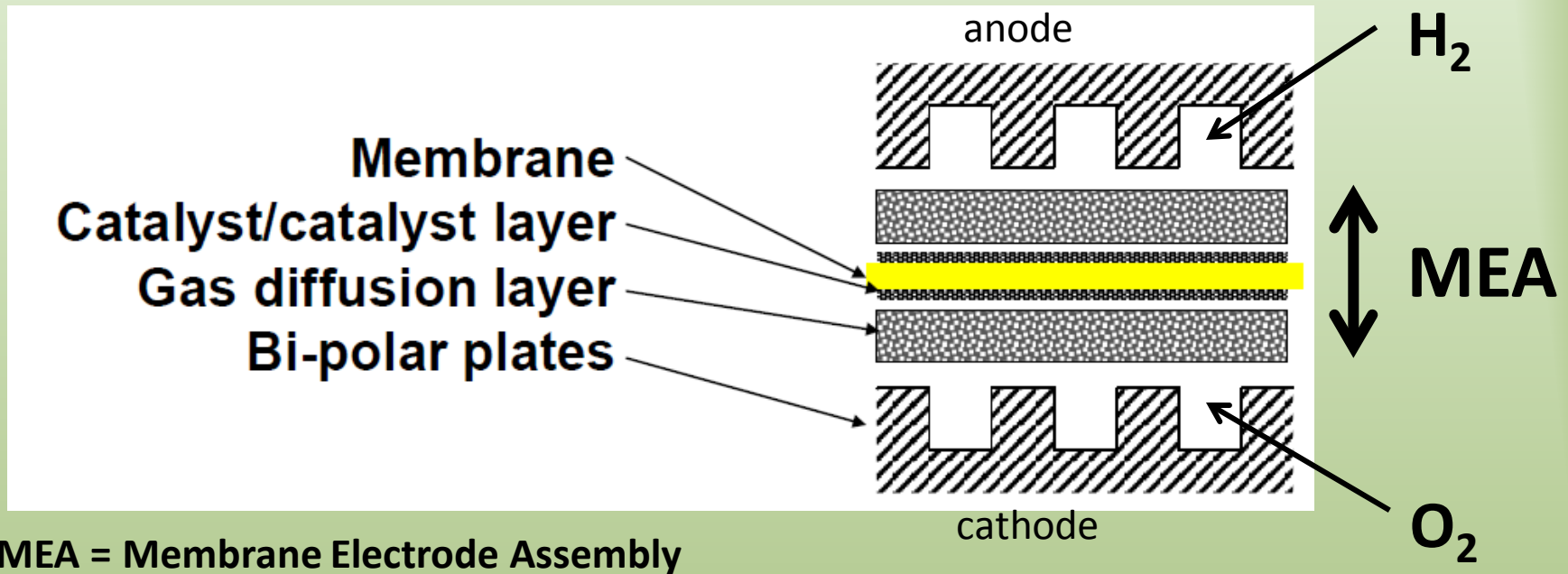
$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$ $E^0 = 1.1$ V



A Proton Exchange Membrane (PEM) Fuel Cell



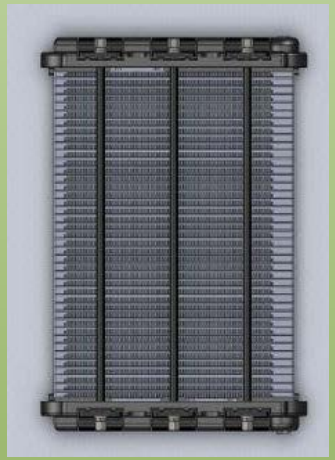
Components of a PEM Fuel Cell



MEA = Membrane Electrode Assembly

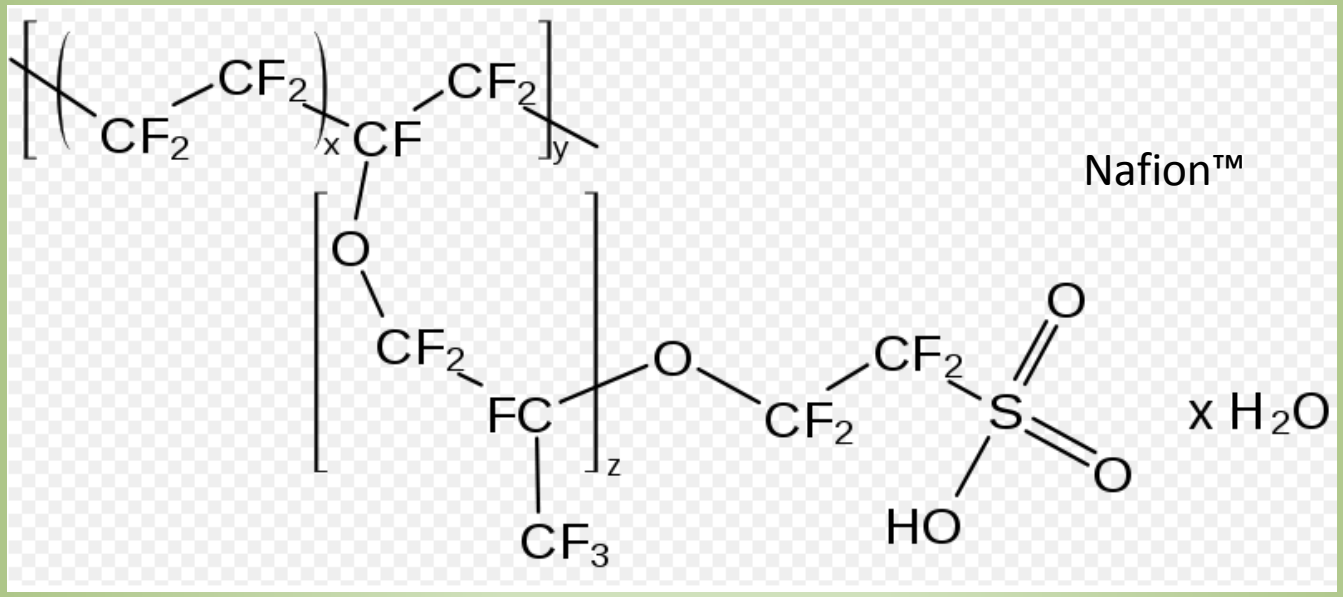
Catalyst is finely divided platinum (Pt) on high surface-area carbon

Gas Diffusion Layer (GDL) is a sheet of carbon fibers coated with Teflon™. Pores in the GDL transport the gaseous reactants into the catalyst layer.



Many cells combined into a Fuel Cell Stack

A Key Component of a PEM Fuel Cell is the Solid Polymer Electrolyte Membrane



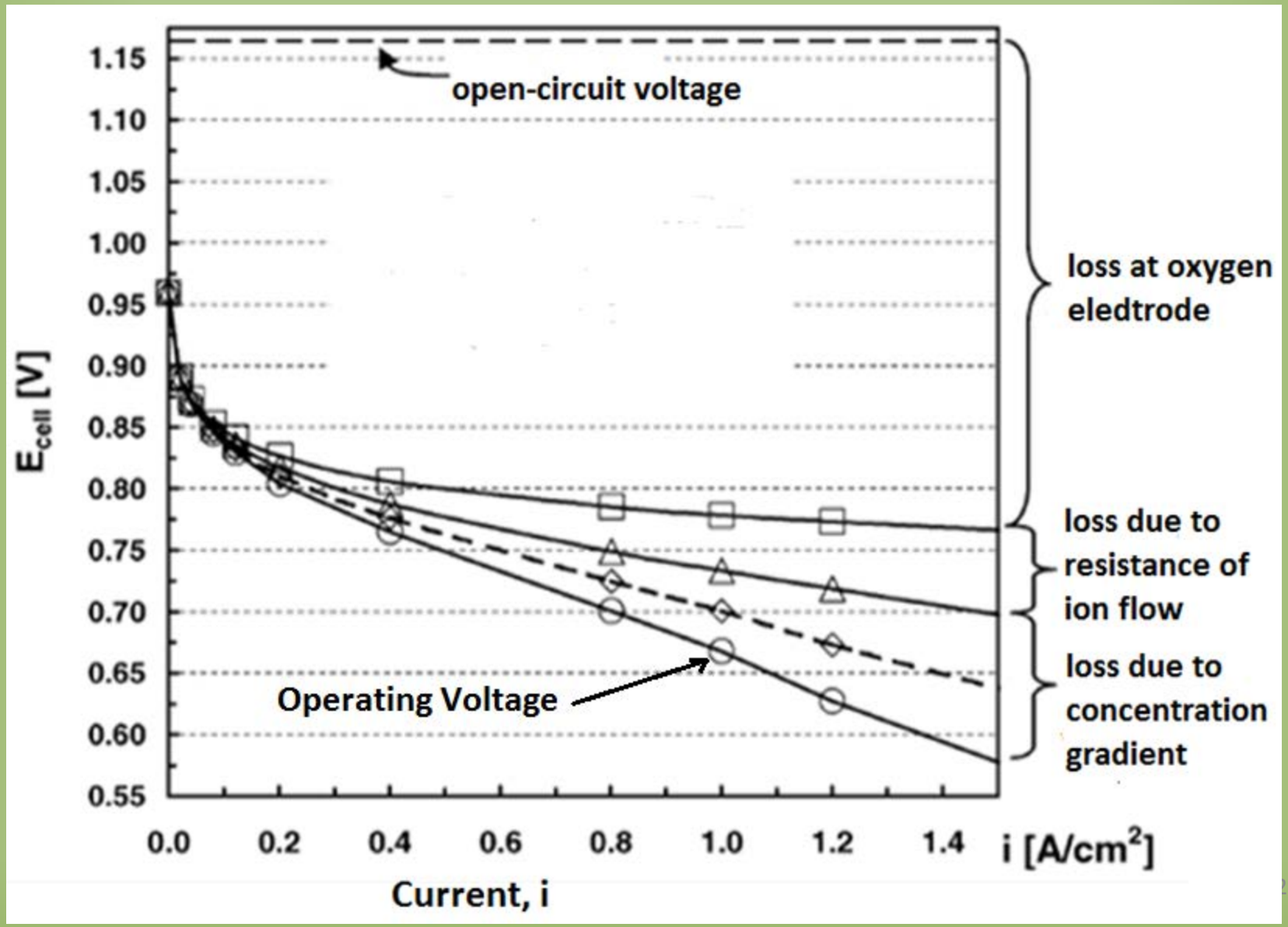
- This is a very acidic perfluorinated sulfonic acid that is permeable to hydrogen ions (protons) but not anions
- It absorbs water and must be hydrated to effectively conduct protons (H^+ ions)

PEM Fuel Cell Chemistry

Oxidation	$2\ H_2 \rightarrow 4\ H^+ + 4\ e^-$	0.0 V
Reduction	$O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$	1.23 V
Overall reaction	$2\ H_2 + O_2 \rightarrow 2\ H_2O$	1.23 V

- Real world voltage under load is 0.6 to 0.7 V
  - Due to sluggish reaction for oxygen reduction
  - So efficiency is about 50%
- For comparison, Li-ion batteries have efficiencies of 80 to 90% (energy out/energy in)
  - depends on charging and discharging rate

Under a Typical Load (about 1 A/cm^2) a Fuel Cell Produces about Half of the Open Circuit Voltage (1.23 V)



PEM Fuel Cell Power and Hydrogen Energy Storage for Vehicles

- Hydrogen is stored in high-pressure tanks (up to 10,000 psi = 700 bar) and delivered to the fuel cell at low pressure, i.e., ~3 bar
  - The hydrogen must be very pure, >99.99%
  - Limits on specific substances such as carbon monoxide - poisons the platinum catalyst

- Air is used as a source of oxygen – also delivered to the fuel cell at low pressure, i.e., ~3 bar

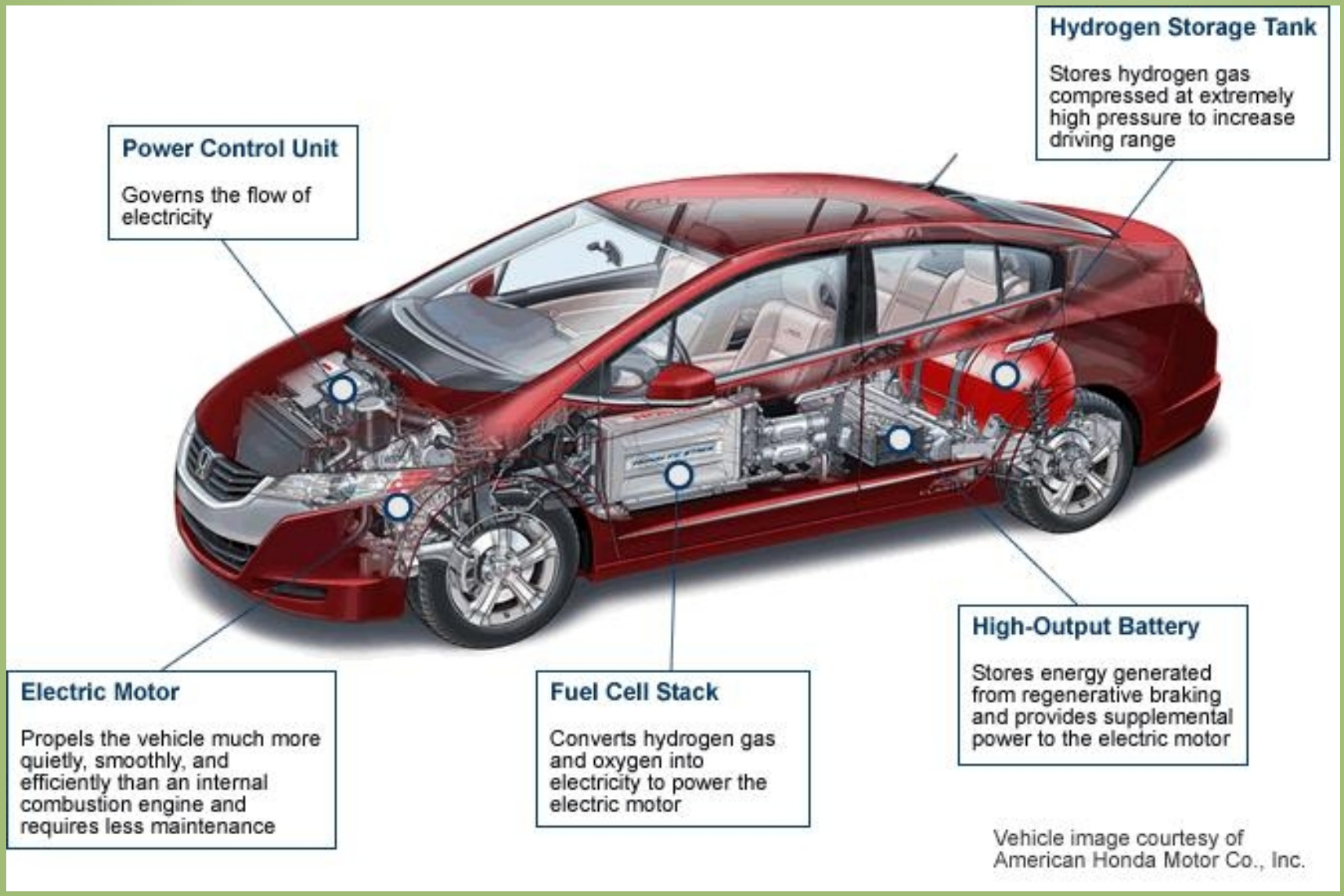
- The water vapor produced is conducted away to an exhaust pipe at the rear of the vehicle (some recycled to PEM for humidification)

Components of a FCEV

- Fuel Cell Stack, hundreds of PEM cells in series to get high voltage, about as high as a BEV
- Hydrogen Storage Tank to store high-pressure hydrogen gas (700 bar)
- Electric Motor and Power Inverter Module, basically the same as a BEV
- Power battery or ultra capacitor
  - a FCEV needs this for high instantaneous power and to recover mechanical energy during braking (regenerative braking) – so it is a hybrid!

Main Components in a FCEV

Honda FCX Clarity



Storing Hydrogen Aboard the FCEV

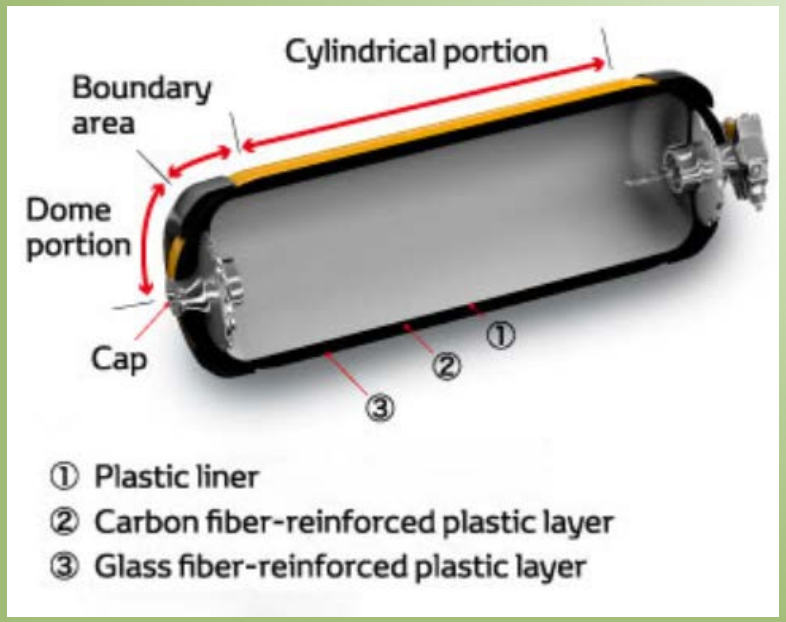
High-pressure hydrogen tanks

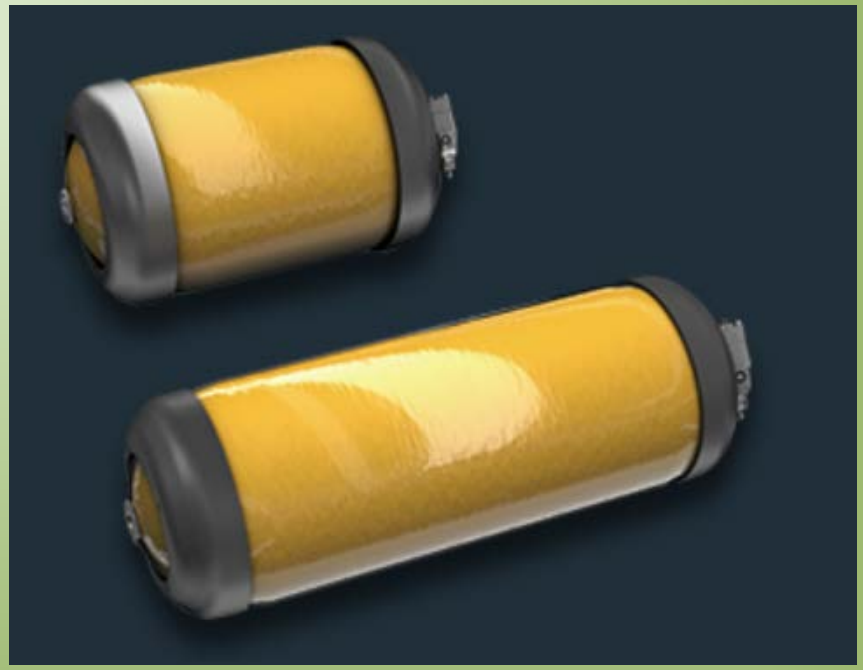
The Mirai is equipped with in-house developed 70 MPa high-pressure hydrogen tanks. The new 70 MPa tanks have three layers; a plastic liner a plastic liner to retain pressurized hydrogen (the innermost layer of the tank), a carbon fiber reinforced plastic layer, and a glass fiber reinforced plastic layer to protect the surface. The structure of the carbon fiber reinforced plastic layer has been innovatively lightened, giving it world-leading* tank storage performance.

High-pressure hydrogen tanks

Nominal working pressure	70 Mpa (approx. 700 bar)
Storage density	5.7 wt% (World-leading*)
Internal volume	122.4 L (front tank: 60.0 L, rear tank: 62.4 L)
Hydrogen storage mass	Approx. 5.0 kg

*As of November 2014, Toyota data





Source: http://www.toyota-global.com/innovation/environmental_technology/technology_file/fuel_cell_hybrid.html

Hydrogen Fuel Cell Technology

Zero Emissions, Zero Petroleum, 2X Efficiency

Fuel Cell Benefits:

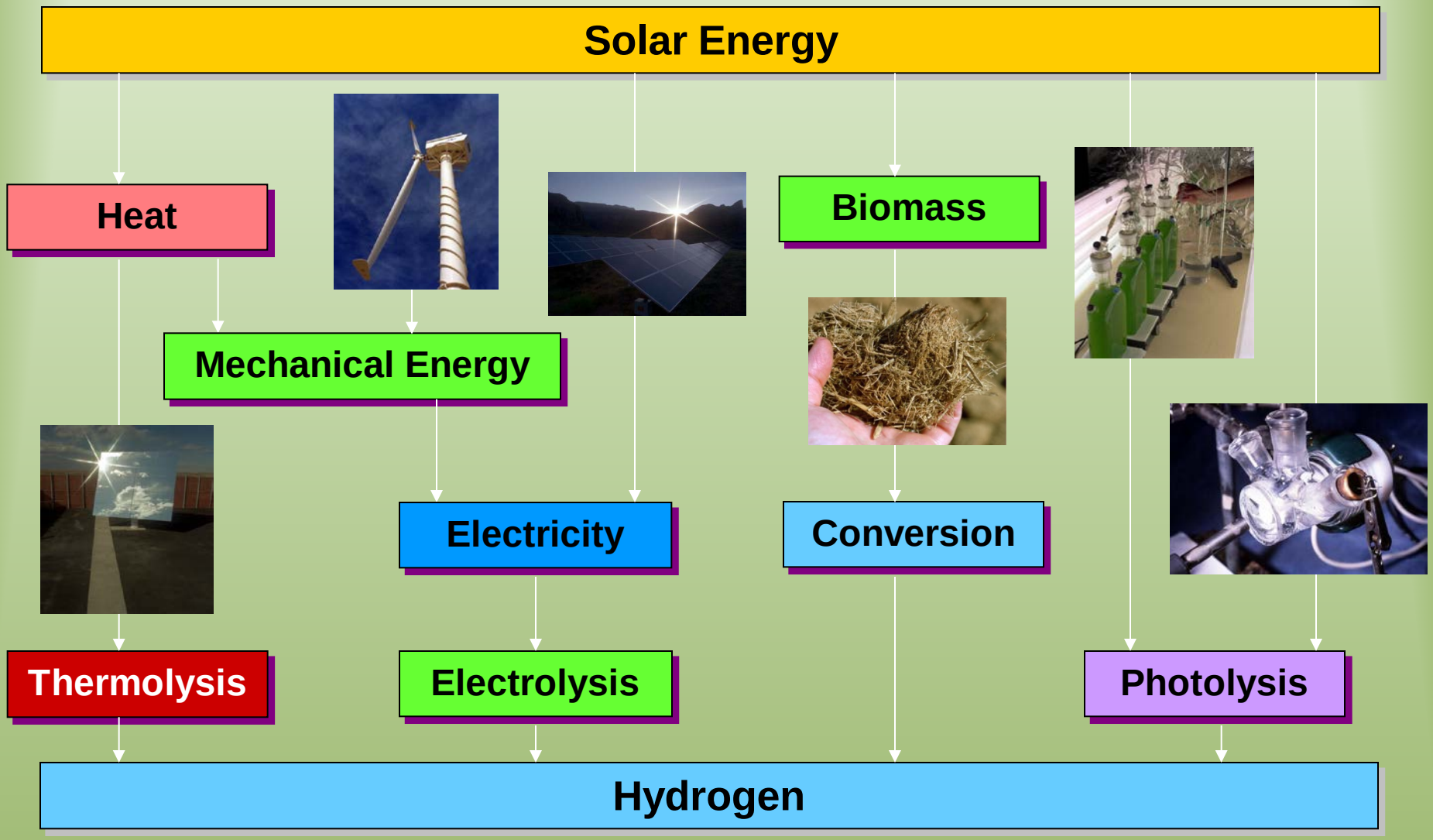
- Zero emissions & Zero petroleum
- Compared to internal combustion engine:
  - More than twice as efficient
  - Comparable precious metal content
  - Comparable durability, range (300 miles) and performance
  - Fast refueling – within 3 minutes
  - 60% fewer part numbers
  - 90% fewer moving parts
- Cold and hot operation capability
- Family-sized vehicles
- Synergy with renewable energy sources

Source: Charles Freese, GM Global Fuel Cell Activities, June 3, 2010 presentation to the DOE Hydrogen Technical Advisory Committee

Let's Talk About Hydrogen

- Hydrogen is an energy carrier
  - Technically not a fuel, hydrogen must be produced
- Currently 95% of hydrogen, H_2, is produced from steam-reforming of methane, CH_4 – natural gas
- Possibility of diverse sources (unlike ICE + petroleum)
  - Natural gas, coal, electrolysis of water, biological
- Possibility of sustainable pathways to hydrogen

Sustainable Paths to Hydrogen



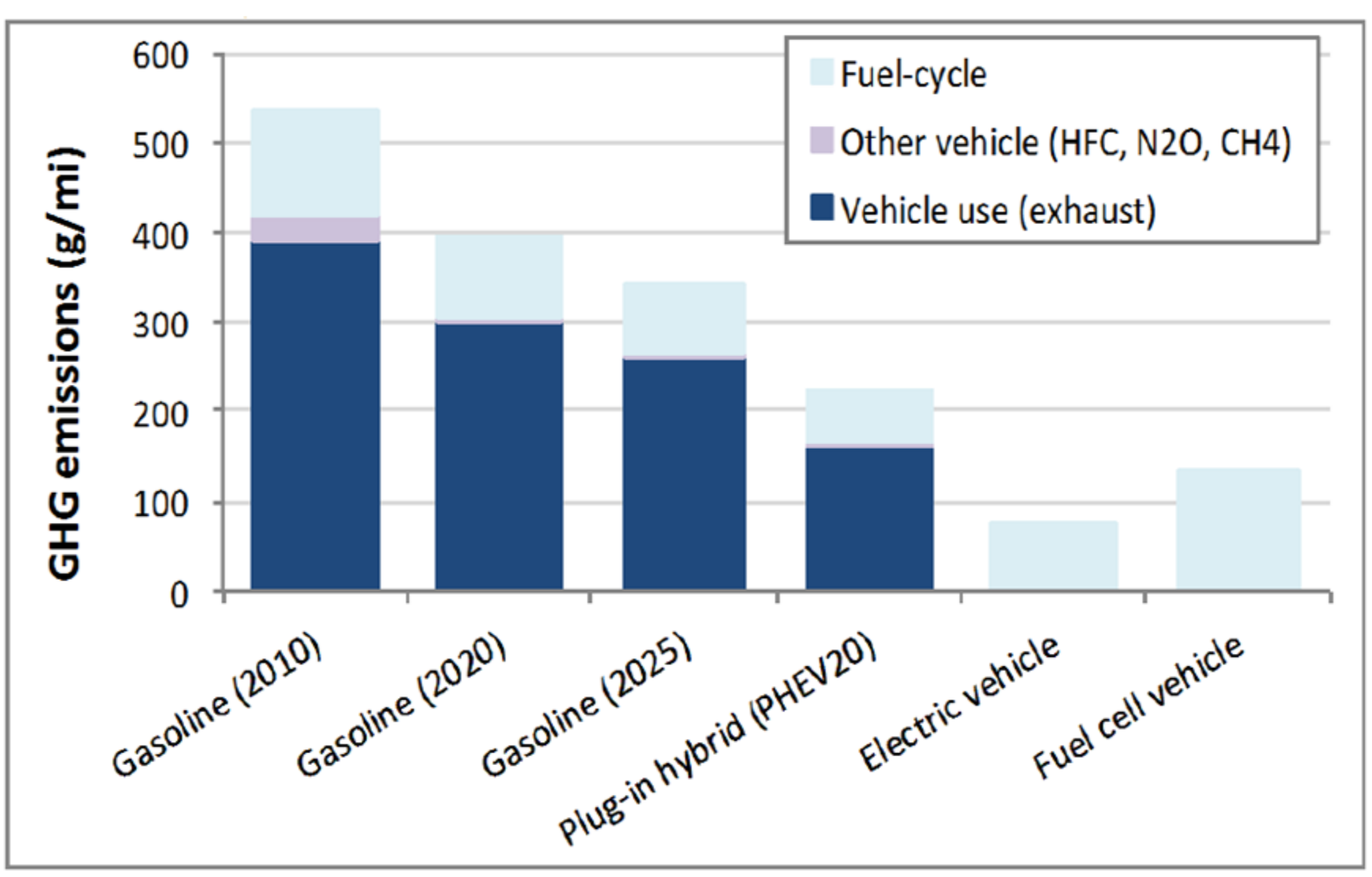
Source: John Turner, NREL, 2008

Example: GM Solar-Powered Hydrogen Fueling System and Project Driveway Fuel Cell Equinox

Other Countries are Also Into Hydrogen and Renewable Energy

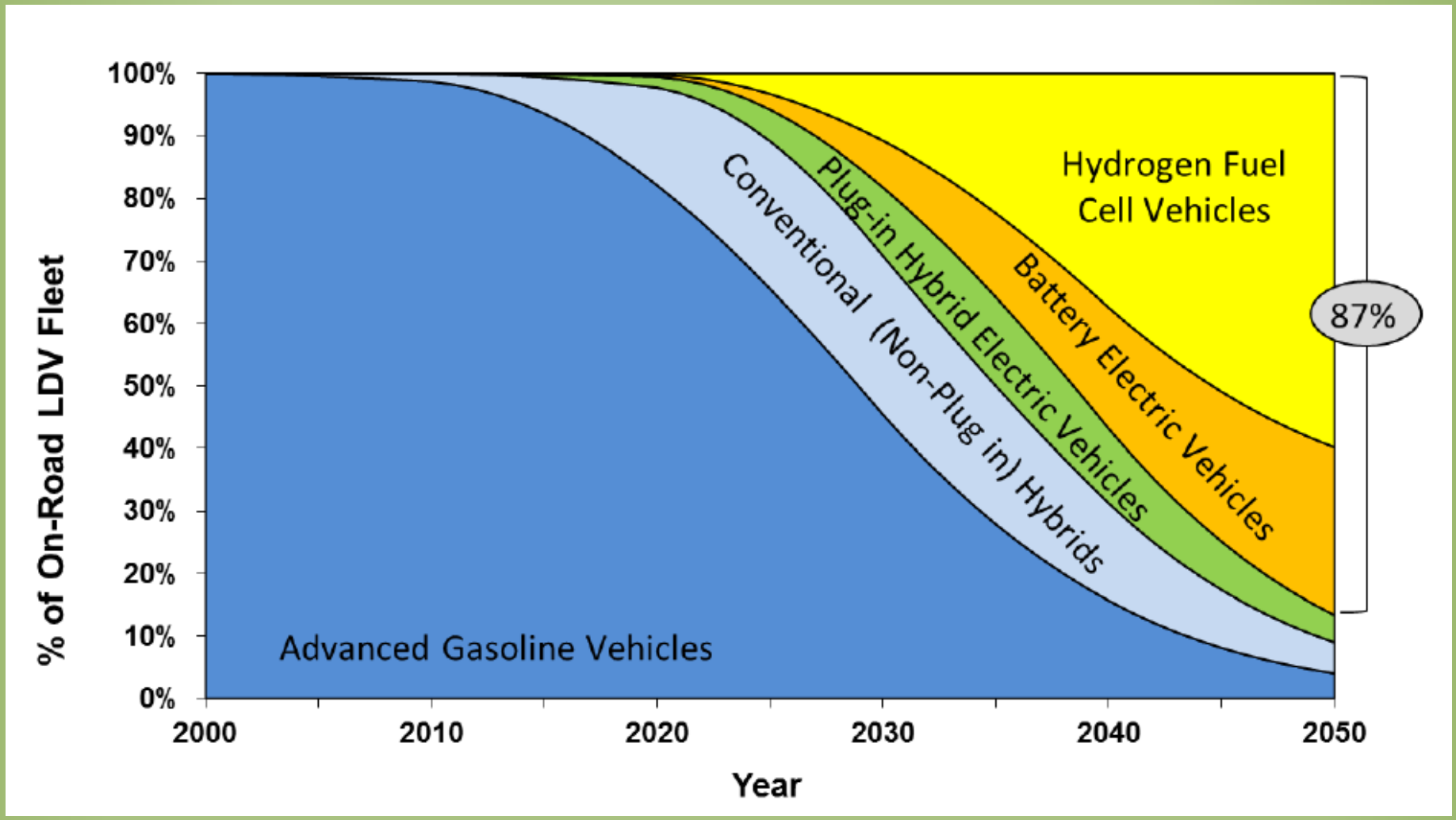
- On June 6, 2014, 50 Percent of the Energy Produced in Germany Is Solar: New Record
- German wind-to Hydrogen plant constructed
  - ENTERTRAG Hybridkraftwerk in Brandenburg
- Wind power to produce hydrogen in Fukushima (Japan)- for Tokyo 2020 Olympics
- World's Largest Fuel Cell Plant Opens in South Korea, February, 2014

Well to Wheels (WTW) GHG Emissions



Source: www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf

On Road Light-Duty Vehicle Scenario to Reach California 2050 GHG Reduction Goal Relies Heavily on FCEV



Source: www.arb.ca.gov/regact/2012/zev2012/zevisor.pdf

Why are Some so Critical of FCEV?

- BEV have more than twice the efficiency for a given amount of electricity
  - Making H_2 using electrolysis is ~60% efficient
  - Making electricity from H_2 is about ~60% efficient
- FCEV need a fueling infrastructure
- These criticisms are not show stoppers!
  - H_2 can be made in more efficient ways and can use diverse and renewable pathways
  - California, Japan, and Germany are committed to a hydrogen fueling infrastructure

Batteries versus Fuel Cells for the xEV of the Future

FCEV

- New infrastructure needed (for dispensing H_2)
- Fast fill and long range comparable to ICE; could replace present vehicles, even heavy vehicles
- High pressure tank may be replaced with better storage method

BEV

- Home charging, convenient; expanded fast charge coming
- Fast charge is still relatively slow
- Batteries may become somewhat lighter

The power of “and” – they both have a place

Summary

- They're here -- xEV are an important component of an advanced vehicle portfolio
  - BEV, HEV, PHEV or EREV, FCEV
- Batteries and fuel cells use electrochemistry rather that combustion to release chemical energy
  - Higher efficiency that ICE
- Government regulations and perhaps fuel cost will drive EV growth
  - GHG reduction, petroleum reduction, ZEV mandate

Summary, continued

- Both BEV and FCEV have advantages and limitations at present
  - Both can reduce the environmental impact of vehicles on the planet and contribute to sustainable transportation
- Each type of vehicle can serve a different set of customers and be successful in the marketplace
  - the power of “and”
- Renewable energy will make BEV, PHEV, and FCEV sustainable technologies from an energy and environmental viewpoint

Where to go for More Information on Part 1 Topics

- Department of Energy, Fuel Cells
  - http://energy.gov/eere/fuelcells/fuel-cell-technologies-office
  - https://www.hydrogen.energy.gov/
- Alternative Fuels
  - http://www.afdc.energy.gov/
- California ARB
  - http://www.arb.ca.gov/homepage.htm
- CAFCP
  - http://cafcp.org/
- Northeast Electrochemical Energy Storage
  - http://neesc.org/
- CAAT Technologies web site
  - http://autocaat.org/Technologies/

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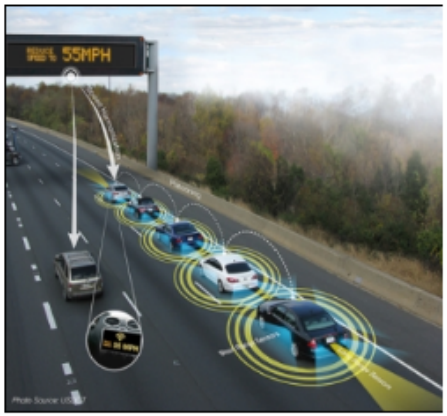
Automated and Connected Vehicles

Automated and connected vehicle technologies are becoming some of the most heavily researched automotive technologies. Currently, some automated and connected vehicle technologies are available, but are only a fraction of what will be available in the future. Although this page contains separate sections for connected and automated vehicle technologies, be aware that many of the technologies overlap. For instance, to have a fully automated vehicle, the vehicle must also be a connected vehicle.



Click the image above to view a larger version

Connected Vehicles

Source:Center for Automotive Research (CAR) Publications

Connected vehicles are vehicles that use any of a number of different communication technologies to communicate with the driver, other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and the "Cloud." This technology can be used to not only improve vehicle safety, but also to improve vehicle efficiency and commute times. Listed below are some of the benefits of connected vehicles:

Crash Elimination: Crash-free driving and improved vehicle safety could change the concept of a vehicle as we know it

Reduced Need for New Infrastructure: Self-driving can reduce the need for building new infrastructure and reduce maintenance costs

Travel Time Dependability: Convergence can substantially reduce uncertainty in travel times via real-time, predictive assessment of travel times on all routes

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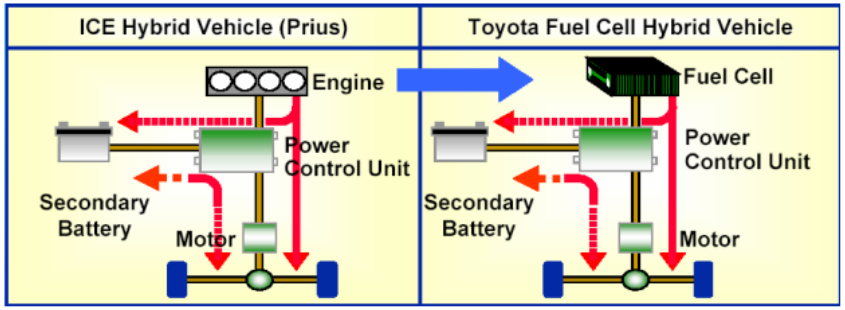
Fuel Cells

Source: U.S. Department of Energy Fuel Cell Technologies Office

A fuel cell uses the chemical energy of hydrogen to cleanly and efficiently produce electricity with water and heat as byproducts. Fuel cells are unique in terms of the variety of their potential applications; they can provide energy for systems as large as a utility power station and as small as a laptop computer. Fuel cells have several benefits over conventional combustion-based technologies currently used in passenger vehicles. They emit no emissions, including greenhouse gases and air pollutants that create smog and cause health problems. On a life-cycle basis, if pure hydrogen is used as a fuel, fuel cells emit only heat and water as byproducts.

Universities with Fuel Cell Programs



CAAT web site, Technologies, http://autocaat.org/Technologies/Fuel_Cells/

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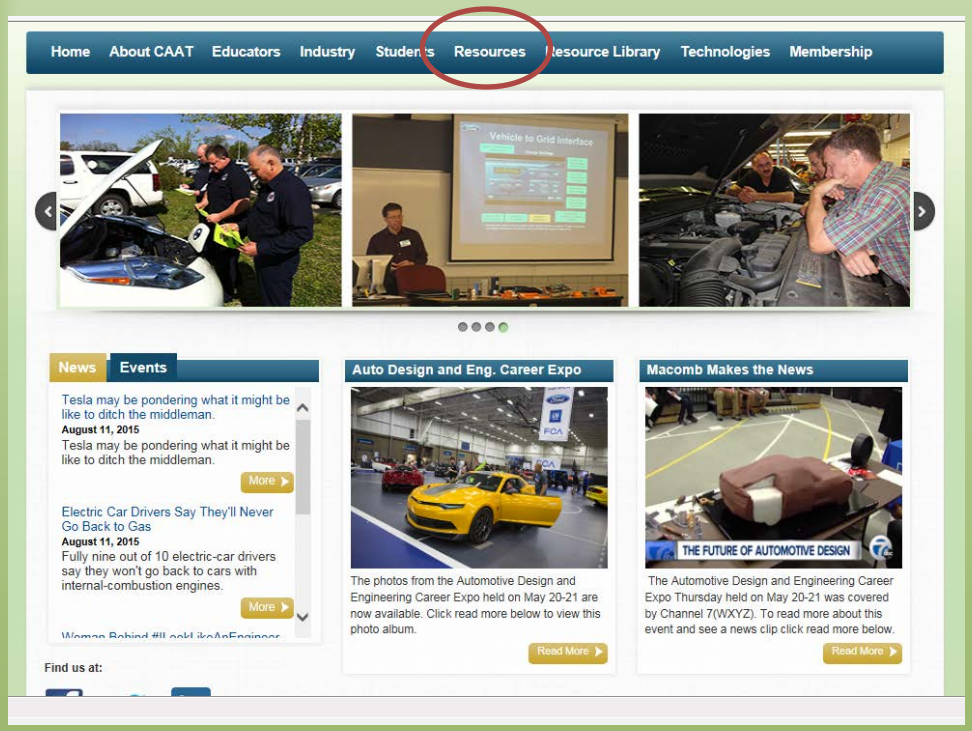

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Alternative Fuels and Lubricants (16)
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Electric Machines and Power Electronics (23)
Energy Policy (22)
Energy Storage and Battery Technology (30)
Grid Interface (Power and Communications) (11)
Fuel Cells/Hydrogen (15)
HEV/EV System Technologies (HEV, EV, and Plug-in HEV) (55)
Integration, Networking, and Communications (8)
Materials Lightweighting (33)
Other (29)

Education Level

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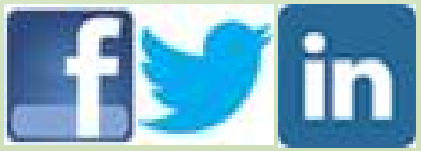
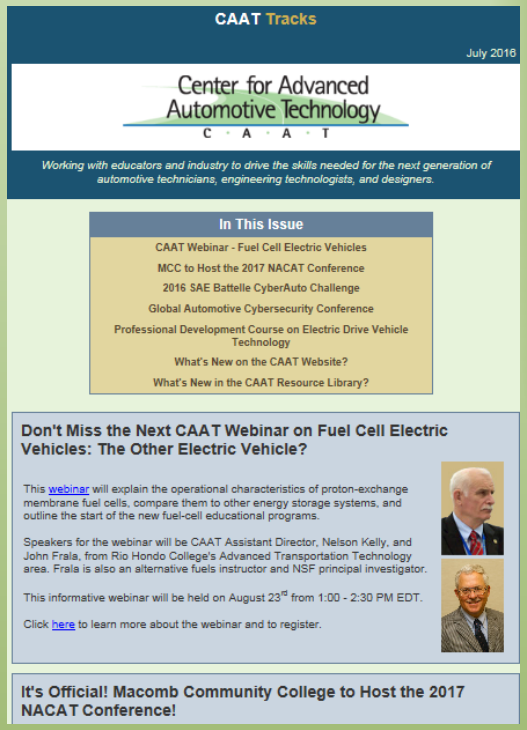
- Join us at NACAT, July 2017
  - http://autocaat.org/Educators/NACAT_2017/

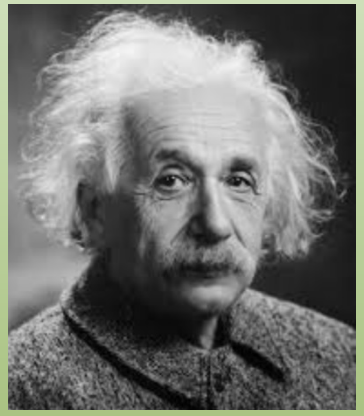




Thank You!

Questions?

The important thing is not to stop questioning.
Curiosity has its own reason for existing.



Presenter #2

Professor John Frala
Rio Hondo Community College
Coordinator Alternative Fuels
jfrala@riohondo.edu
http://faculty.riohondo.edu/jfrala/

Masters, Adult Education Learning
Masters, On-line Education
Research Alternative Fuels Technology
Research Hydrogen Fuel Cell Technology
Coordinator Associates of Science Degree Program
California Community Colleges Green Community College Leadership Award

36 Years General Motors
18 Years American Honda
18 Years Electric Vehicle Research
18 Years Hydrogen Research

Webinar Outline

Nelson Kelly, Part 1

- Who we are: Center for Advanced Automotive Technology (CAAT)
- The road to electric vehicles, xEV
- Making electricity using electrochemistry
- Proton Exchange Membrane fuel cells (PEM)
- Using hydrogen to store energy on fuel cell electric vehicles
- ZEVs, Greenhouse Gas Emissions, and protecting the planet
- Hydrogen and renewable energy for fuel cell electric vehicles

John Frala, Part 2

- Who we are: Automotive Technology, Rio Hondo Community College
- The state of transportation and fuel cell technology
- Public Transit
- California and the new fuel investment
- The California Energy commission and ZERO Emission
- Focus on ZERO Emission training
- Fuel infrastructure in California

What is the state of transportation and fuel cell technology?

- Vehicles currently available
  - Mercedes-Benz B-Class F-CELL
  - Audi A7 Sportback h-tron quattro
  - Chevy Fuel Cell EV
  - Honda Clarity Fuel Cell
  - Hyundai Tucson Fuel Cell
  - Nissan X-Trail
  - Toyota Mirai (FCV)

Public Transit

A very large Federal Transit Administration (FTA) grant has just been funded to support the ZERO emission purchase in the United States.

19 Transit Agencies across the US received various amounts totaling $55, Million dollars to purchase and install fueling infrastructure to support these Fuel Cell bus purchases.

- AC Transit
- OCTA Transit
- SunLine Transit

Currently have this in place and have been using the technology.

Logistics

- Class 8 fuel cell drayage trucks are funded for development and operation between the Ports of Los Angeles and Long Beach, near dock rail yards and warehouses. U.S. DOE and South Coast Air Quality Management District will provide cost share to industry partners BAE Systems, CTE, US Hybrid, and Trans Power to develop and operate these trucks.
- UPS is also working on a fleet of fuel cell vans

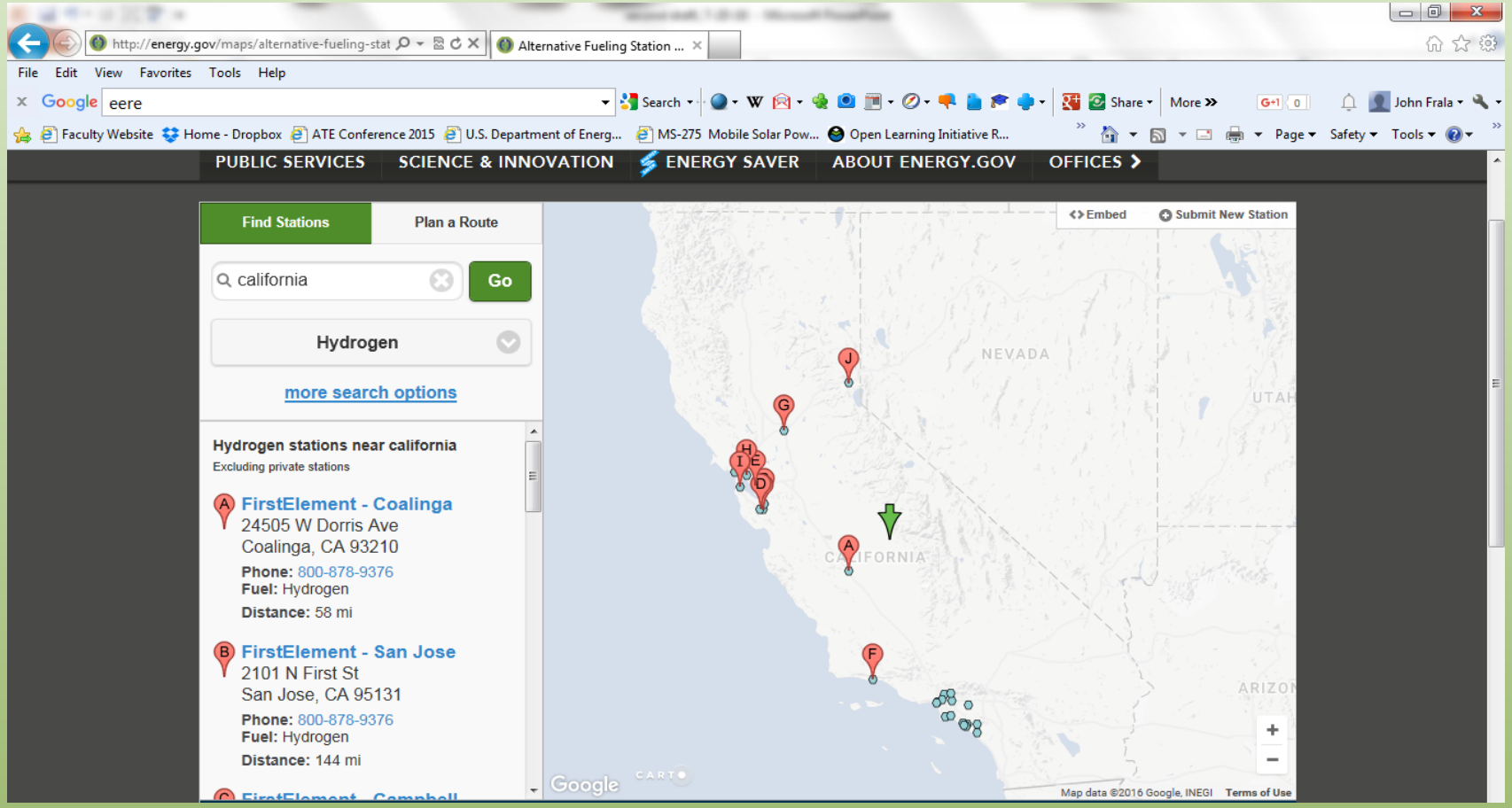
The new fuel investment in California

California AB 8 .

The bill requires the state board to aggregate and make available to the public, no later than June 30, 2014, and *every year thereafter*, the number of hydrogen-fueled vehicles that motor vehicle manufacturers project to be sold or leased over the next 3 years, as reported to the state board, and the number of hydrogen-fueled vehicles registered with the Department of Motor Vehicles through April 30. The bill would require the commission to ***allocate $20 million annually***, as specified, until there are at least 100 publicly available hydrogen-fueling stations in California. The bill, on or before December 31, 2015, and annually thereafter, would require the commission and the state board to jointly review and report on the progress toward establishing a hydrogen-fueling network that provides the coverage and capacity to fuel vehicles requiring hydrogen fuel that are being placed into operation in the state, as specified.

The new fuel investment in California

25 stations currently, 80 stations private and public are planned by 2018



Discussion of Worker Skills Required in the Field of Fuel Cell Vehicles

- STEM
  - Physics
  - Chemistry
  - Math
- Mechanical skills
- Electronic skills
  - High voltage
  - Power conversion
- Software skills

Typical Technician Skills Required in the Field of Fuel Cell Vehicles

- STEM, the basics
  - Physics, chemistry, mathematics
- Basic automotive and prototype shop knowledge (teardown vehicles, build harnesses, basic fabrication skills, troubleshoot auto systems with and without manuals)
- High-voltage, high-pressure gas, and flammable-gas safety
- Power electronics, electronics skills (embedded controllers, sensors, CAN and cable protocols, scan tools, soldering, shielding, troubleshooting)
- Software Skills (embedded systems, basic programming, networks)
- Lab testing, data acquisition and analysis

Are there JOBS?

- **Summary Report for:**
  17-3029.10 - Fuel Cell Technicians
- Install, operate, or maintain integrated fuel cell systems in transportation, stationary, or portable applications.
- This title represents an occupation for which data collection is currently underway.
- View report: Summary
- **Tasks**
- Assemble fuel cells or fuel cell stacks according to mechanical or electrical assembly documents or schematics.
- Build fuel cell prototypes, following engineering specifications.
- Calibrate equipment used for fuel cell testing.
- Collect or maintain fuel cell test data.
- **Technology** used in this occupation:
- **Analytical or scientific software** — Data acquisition software; Load simulators
- **Computer aided design CAD software** — Autodesk AutoCAD software
- **Data base user interface and query software** — Oracle software
- **Presentation software** — Microsoft PowerPoint
- **Spreadsheet software** — Microsoft Excel
- **Word processing software** — Microsoft Word
- Hot Technology — a technology requirement frequently included in employer job postings.

Source O NET: http://www.onetonline.org/link/summary/17-3029.10

What is safe to touch?

- According to this vehicles manufacture;
  - “ONLY” a certified and skilled technician may service this vehicles charging system.

How about this vehicle?

How many propulsion systems are in this vehicle?

The “car of the future, will need the technician of the future”

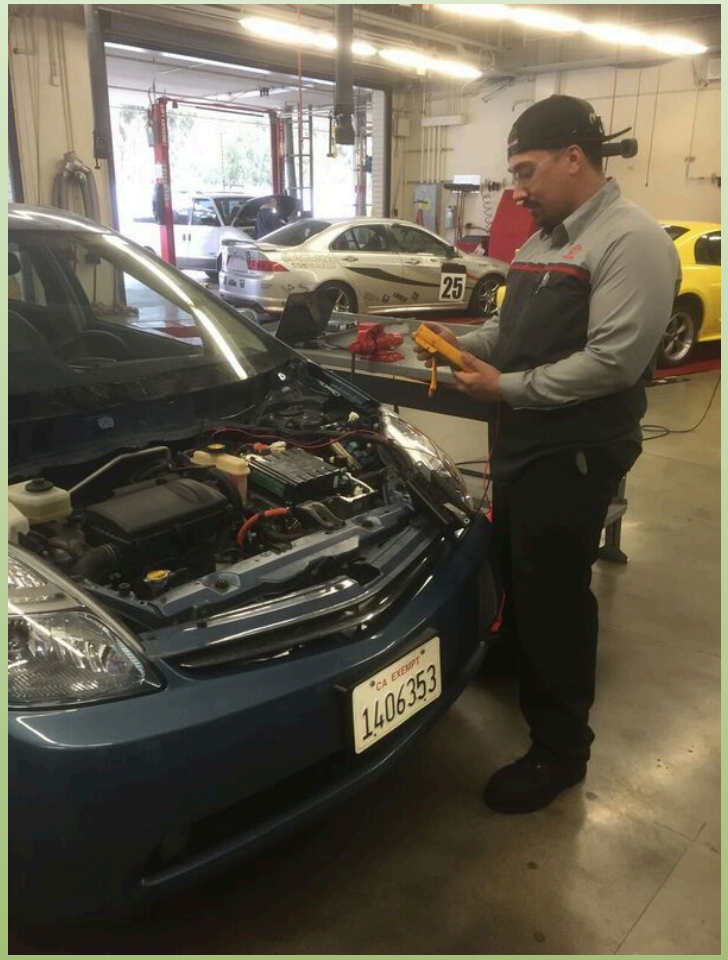
Associates of Science Degree in Electric Vehicle/Fuel Cell Vehicle Technology

Rio hondo community College currently has the only Fuel cell technician program in the State of California.

23 students currently enrolled and most will be graduating next year with this degree.

Hands on training in live laboratory with live vehicles

Rio Hondo college lead under the supervision of the P.I. Professor John Frala have an award from the NSF/ATE Foundation for “Preparing Students for Advances in Transportation that Utilize Alternative Energy Sources
“We are currently developing curriculum to be shared with our NS/ATE network of colleges on this training.



Students learning components of the high-Voltage compressor

Something simple as Air Conditioning systems are now powered by 201vDC to 248vDC.
Electric Power Steering Assist systems are 45vDC to 85vDC
This could kill or injure a technician without proper training.

STRATOS Fuels, INC. showing students Hyundai Tucson Fuel Cell

California has taken this industry very seriously. Governor Brown's office has added $200 Million to the GO-BIZ program installing the states first 59 Hydrogen fuel stations.

Many of these students are going to graduate with the first Associates of Science degree in Electric Vehicle/Fuel Cell Vehicle Technology May 2017. The program has been well supported by industry and fuel companies already.

Certifying Automotive Technicians for Fuel Cells and Other New Technologies

- High voltage, high-pressure flammable gases
- John Frala and Ken Mays (Central Oregon CC)
- ASE, NATEF, NFPA, first responder

Contact for Training Information

If you are interested in the training material or to enroll in this emerging field of technology you may contact:

- Professor John Frala
- Rio Hondo College
- Alternative Fuels Technology
- Office (562) 463-7473
- jfrala@riohondo.edu
- cleanfuel@gmail.com
- h2professorjohnfrala@gmail.com
- Our blog page: http://h2professional.wordpress.com

QUESTIONS?

Please type in the chat room any questions that you may still have.

Not all cars are created equal.

Center for Advanced Automotive Technology

C · A · A · T

Please take a moment to help us become better by completing our survey:

INSERT LINK TO EVALUATION SURVEY:

Macomb Community College

Education • Enrichment • Economic Development

Discover. Connect. *Advance.*

RIO HONDO COLLEGE

NSF

WAYNE STATE

Thank You!