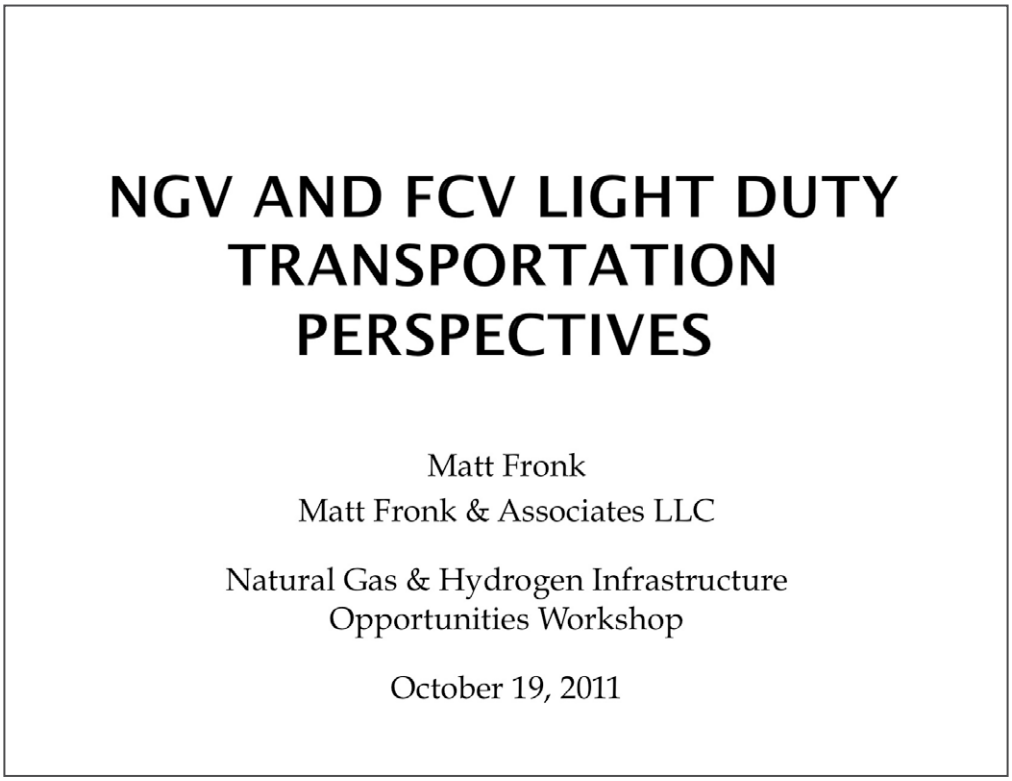
Presentation Slides: Natural Gas and Fuel Cell Vehicle Light-Duty Transportation Perspectives

Matt Fronk, Matt Fronk & Associates, LLC



NGV AND FCV LIGHT DUTY TRANSPORTATION PERSPECTIVES

Matt Fronk
Matt Fronk & Associates LLC

Natural Gas & Hydrogen Infrastructure Opportunities Workshop

October 19, 2011

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CAFE standards set to rise to 54.5 mpg for 2025

President Barack Obama on (7/29/2011) revealed ambitious plans to raise the corporate average fuel economy standard for cars and light trucks to 54.5 mpg by the 2025 model year, a landmark move that will dramatically remake carmakers' product portfolios and consumers' buying habits.

"**GM** plans to pursue the technical challenge ahead and to lead in delivering **new fuel-saving technologies** in cars and trucks customers want to buy and can afford," the company said in a statement. "Reducing fuel consumption and lessening the automobile's impact on the environment is important to our business because it's important to our country and our customers."

Toyota concurred:
"Toyota has embarked on the most aggressive expansion of hybrid, electric and **hydrogen-fuel-cell cars** of any automaker, and we are committed to continuing our demonstrated environmental leadership," Toyota Motor Sales COO Jim Lentz said in a statement. "We share the administration's goal of achieving major advances in clean, fuel-efficient vehicles. Obviously, there is still a great deal of uncertainty as to how the market will respond and what vehicle technologies consumers will embrace, which is why we are rolling out and testing a range of alternative fuel options."

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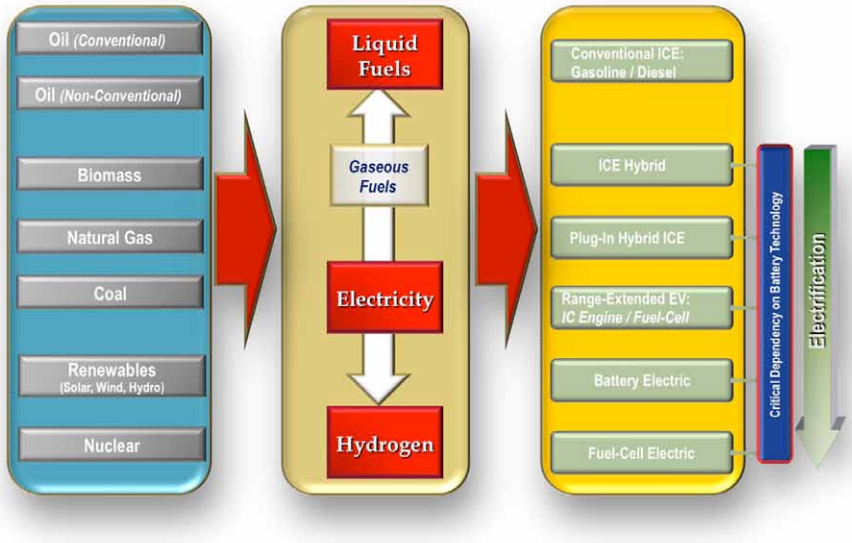
"Cleaner" Options – No Silver Bullet Portfolio Approach

- Gasoline/diesel
- Corn Ethanol
- Current US Electric Grid for Electric Vehicle Charging
- Compressed Natural Gas
- Cleaner Electric Grid for Electric Vehicle Charging
- Natural gas to Hydrogen for FCVs
- Cellulosic biomass to liquid fuel/vehicle charging/Hydrogen
- Nuclear electricity for electric vehicle charging/Hydrogen
- Renewable Electricity for electric Vehicle charging/Hydrogen

Energy & Technology Options

Despite Variety of Resources, 3 Predominant Energy Carriers



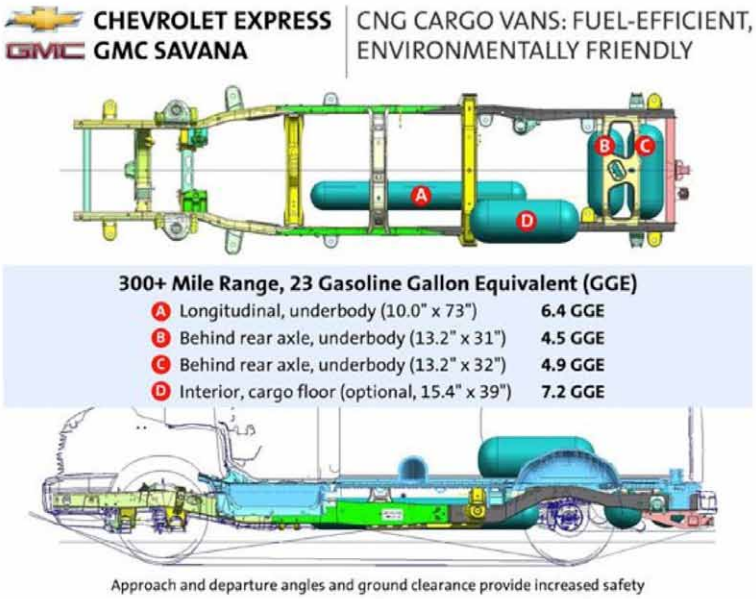
Goodbye gasoline? GM gives natural gas cars a boost

Edward McAllister Automotive News - July 2, 2011

Natural gas is used mainly in electricity generation and for industry, but with just 120,000 natural gas vehicles on the road and only 900 filling stations, transport remains a tiny fraction of total demand.

However, assuming production forecasts are correct, natural gas will likely remain cheap for years and could help cut U.S. reliance on oil. While crude prices soared above $110 a barrel this year due to unrest in the Middle East, U.S. natural gas prices, impervious to international influence, remained low as there was no shortage of natural gas at home.

Drivers who fill up with natural gas at the pump saved up to $2 per gallon when gasoline prices hit $4 a gallon.

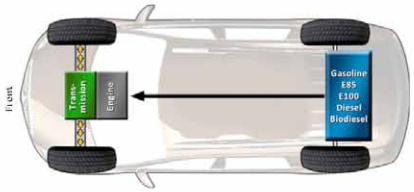


Telecommunications giant AT&T has taken interest in The General's offering of full-sized compressed natural gas (CNG) vans and has ordered exactly 101 Chevy Express 2500 cargo vans for its service fleet.

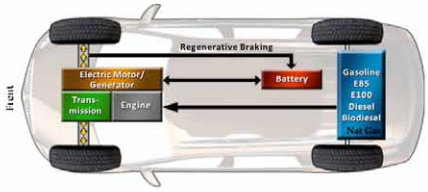
The only downside is that the package itself costs $15,910 upwards, plus the cost of whatever Express van it's to be fitted in.

Transitioning From Mechanical to Electrical

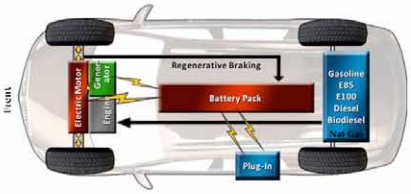
Conventional Liquid-Fueled Vehicle



Hybrid Vehicle (HV)

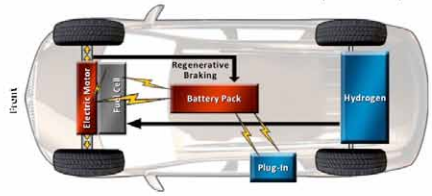


Extended-Range Electric Vehicle (EREV)

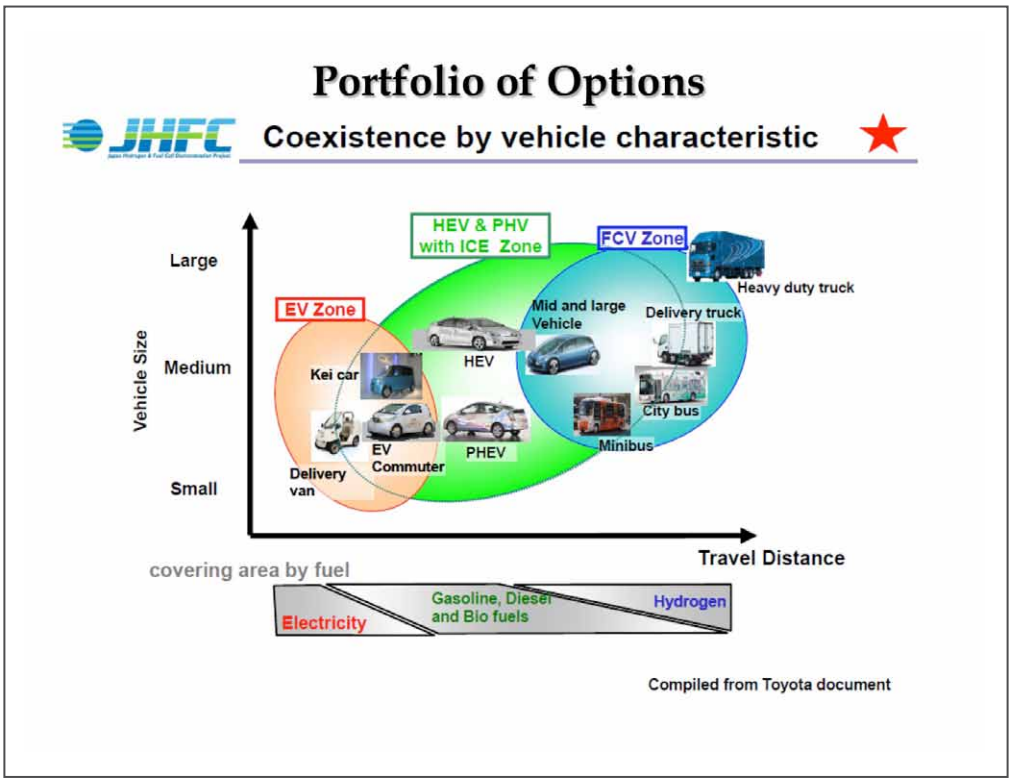


Battery Electric Vehicle (BEV) + EREV – Engine - Generator

Fuel Cell Electric Vehicle (FCEV)



Three electric vehicle options: BEV, EREV, FCEV



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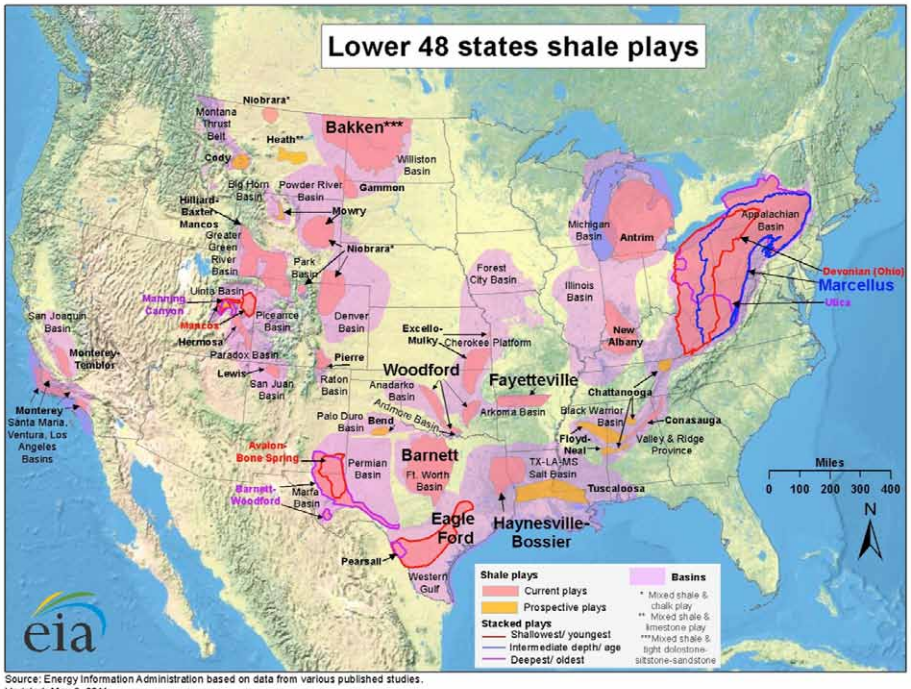
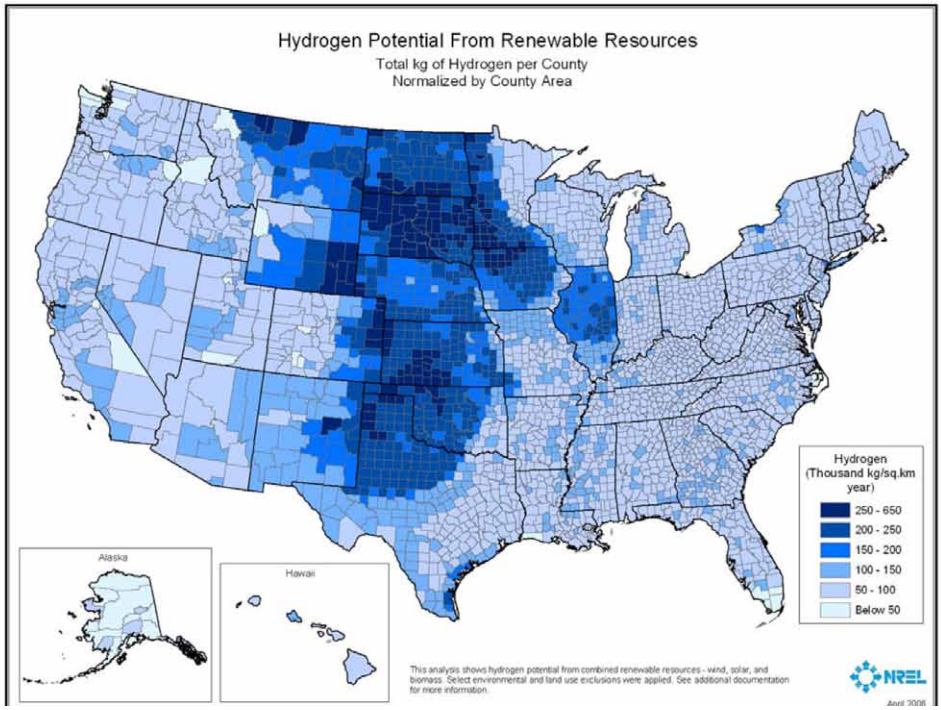
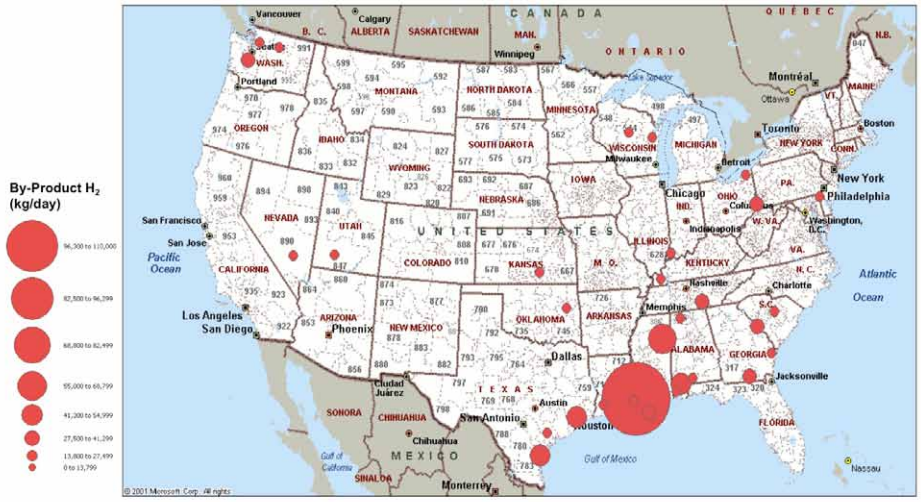


Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011



NREL NATIONAL RENEWABLE ENERGY LABORATORY http://maps.nrel.gov/transatlas

By-Product Hydrogen Production by Plant Location



Source: *Chemical Economics Handbook: Hydrogen, SRI Consulting, 2001*

Excess H2 concentrated along East Coast

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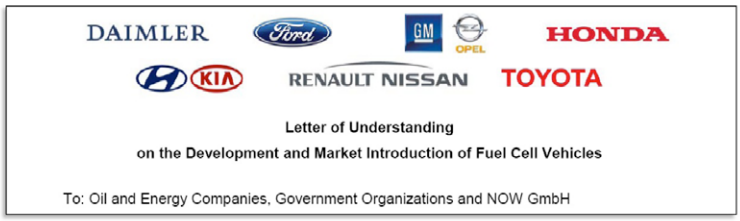
Infrastructure Developments

- Technology for both NG and hydrogen refueling is available
- Commercial stations in play around the world
- On board storage still requires more development
- To implement a national plan requires a team effort between Fed/State Gov't, Auto OEMs, Gas suppliers, and other interested parties - a team sport:
  - ✓ Energy Independence & Security
  - ✓ Industrial Competitiveness – NGVs and FCVs
- There are some state infrastructure initiatives already in play – CA, Hawaii, and NY as examples

Letter of Understanding Signed in Germany – Sept 8, 2009
Automotive Industry Support for Battery & Fuel Cell Technology



- Battery and fuel cell vehicles complement each other
- Fuel Cell Electric Vehicle commercialization from 2015 onwards anticipated
- Hydrogen infrastructure network with sufficient density required by 2015
- Germany is starting point for Europe

Japan 2015 Announcement (Jan '11)

Japanese gas suppliers and oil companies will seek to build some **100** hydrogen supply stations at **four major city** areas to prepare for the launch of mass-produced hydrogen-powered fuel cell vehicles in 2015.

A total of 10 energy companies made the announcement in a statement jointly issued with Toyota Motor Corp, Nissan Motor Co and Honda Motor Co, signaling their **coordinated efforts** to expand the next-generation eco-friendly vehicle in Japan.

"Automakers and hydrogen fuel suppliers will work together to expand the introduction of FCVs and develop the hydrogen supply network throughout Japan," the statement said, while also calling on the government to support their efforts.

The four areas where the companies would seek to build hydrogen fueling stations center on Tokyo, Aichi, Osaka and Fukuoka.

Case Study - NY State

NY is in a position to:

- ✓ **Support the US H2 infrastructure and Commercial FCV Vehicle deployment in 2015 for the Northeast/East Coast sector**
- ✓ **Participate in the jobs creation that the introduction of a new, game changing technology would provide (Infrastructure & System Mfg)**
- ✓ **Demonstrate National leadership**
  - ✓ **Walk the talk on 80 by 2050 CO2 reduction**
  - ✓ **Energy Independence – utilize NY State resources of NG, Hydro, Nuclear, Wind & Solar to make Hydrogen**
  - ✓ **Energy Security**
  - ✓ **Industrial Competiveness**
- ✓ **Position the US to compete globally with Germany and Japan**
- ✓ **The time is now to do this as both Ca and Hawaii have funded plans in place**

East Coast/National Hydrogen Infrastructure

Boston-Miami=1500mi
6 major cities
>100m people

Massachusetts - Billerica, Boston
Nuvera forklifts
Transit buses

Connecticut - Wallingford, Hartford, East Hartford
Sun Hydro, Proton,
UTC, U.Conn,
Transit Authority buses/station

New York - NY City, Rochester, Buffalo, Albany
NYHY2 Initiative, JFK, White Plains, Hempstead
Praxair green H2, ATK, GM stations, RIT, Plug Power station

New Jersey - Jersey City
Hess, Daimler

Pennsylvania – Allentown, Susquehanna
Air Products station, Defense Logistics station

Ohio - Engelwood
Millennium Reign Energy

WDC / Virginia **Fairfax County station**
Fort Belvoir, additional station

Tennessee
United Hydrogen

Georgia – Atlanta
United Hydrogen stations

Florida – Miami, Orlando, Cape Canaveral
NASA - station
Proton, Lumber Liquidators, home refueler

NY Job Creation

In February, 2011, the US Department of Energy released a comprehensive study concluding that the fuel cell and hydrogen industries could generate substantial revenues and job growth. Over the next two decades, assuming hydrogen does indeed play a central role in our energy future (an assumption which is still very likely, despite the US falling behind other nations), it would create **between 360,000 and 675,000 jobs**.

Should New York State see but 10 percent of the benefit from this economic growth, it would still translate to the creation of between 36,000 and 67,500 jobs over two decades. When looking at the public expenditure this proposal calls for, the return on investment would be substantial.

Why NY?

Vision

- ✓ Executive Order sets a goal for 80% reduction of greenhouse gas (GHG) emissions by 2050
- ✓ State Planning Legislation in place that requires developing an inventory of GHG emissions and identification of GHG reduction strategies
- ✓ NY Climate Action Plan Nationally recognized for approach and thoroughness http://www.nyclimatechange.us/index.cfm

Early Strategy in Place

- ✓ NY BEST (NY Battery & Energy Storage Technology Consortium) – http://www.ny-best.org/ - Batteries, Fuel Cells, Ultracapacitors, & Electrolysis technologies
  - NY, US, and International Members

Will

- ✓ World Class Public/Private team in place to **Lead/Execute** a Hydrogen Infrastructure and Fuel Cell vehicle deployment program in parallel with Germany and Japan
- ✓ We need government to take a leadership role – set a vision - **The US is falling behind Germany & Japan**

Public/Private Partnership

Automotive OEMs
- GM
- Toyota
- Daimler
- Honda
- Hyundai
- Ford

Hydrogen Suppliers
- HESS
- Linde
- Praxair
- Air Products
- Proton
- H2 Pump LLC
- Hydrogenics

Government
- NY State Legislature
- NYSERDA
- Brookhaven National lab

Additions Since June

Hydrogen Suppliers
- United Hydrogen (JFK)

Industry
- ATK – Station Installer
- Parsons – Station Installer
- Nuvera – Fuel Cell and Refueling

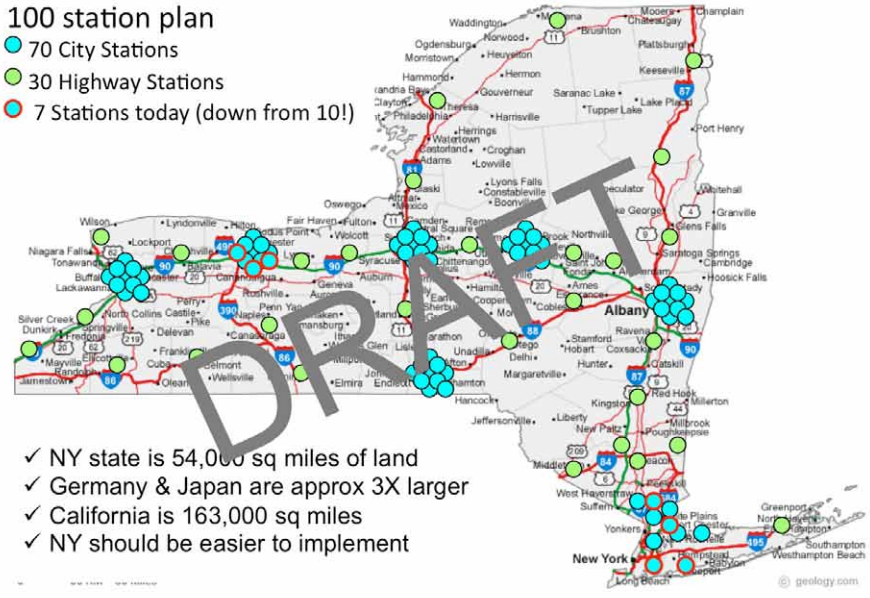
Vehicle/Station Users
- Port Authority
- White Plains
- Town of Hempstead
- Monroe County
- CAT – CT Transit

Academia
- R.I.T.
- UConn

What is Needed?

Plan for New York State Hydrogen Highway and Connecting City Plan in Support of early FCEV Deployment – 2015-2020

100 station plan
- 70 City Stations
- 30 Highway Stations
- 7 Stations today (down from 10!)



- ✓ NY state is 54,000 sq miles of land
- ✓ Germany & Japan are approx 3X larger
- ✓ California is 163,000 sq miles
- ✓ NY should be easier to implement

Proposed Infrastructure Rollout

Calendar Year	Min # Cars Required	Total Cars in NY	Fed Gov't Incentive per car ($k)	Total Gov't Incentive ($k)	Number of Cities in Program	City cluster station total	Total Highway station #	Yearly new station #	Estimate Station cost	Total Station Cost ($M)	Station funding % cost share	NYS Investment	*Total NY/ Fed Cost ($M)
2015	1500	1500	7.5	11250	2	20	0	20	2.2	44	0.5	22	33.25
2016	3000	4500	7.5	22500	3	30	5	15	2.2	33	0.4	13.2	35.7
2017	5000	9500	5	25000	4	40	10	15	1.8	27	0.3	8.1	33.1
2018	8000	17500	3.5	28000	5	50	15	15	1.4	21	0.2	4.2	32.2
2019	12500	30000	3	37500	6	60	20	15	1.1	16.5	0.1	1.65	39.15
2020	20000	50000	2	40000	7	70	30	20	0.8	16	0.1	1.6	41.6
Total		**50000**		**164250**	**7**	**70**	**30**	**100**		**157.5**		**50.75**	**215**

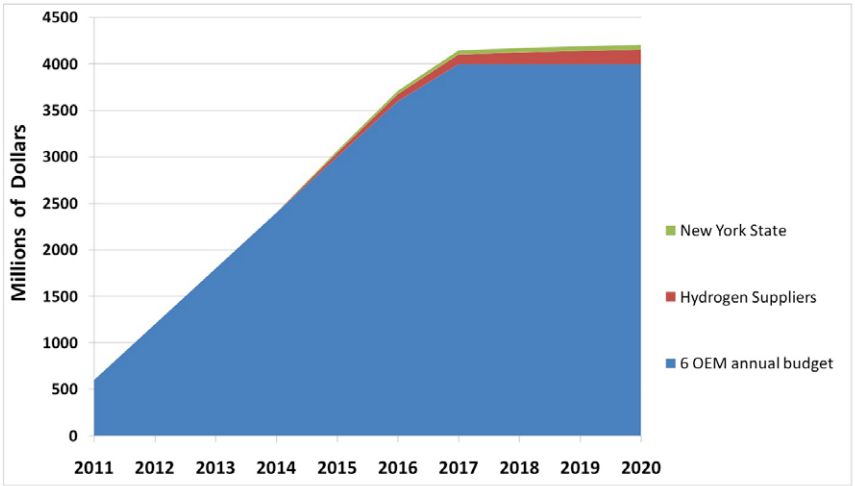
Goals: Lead in Industry Vehicle Deployment, H2 Filling Stations, etc.
7 cities by 2020 - Albany, Rochester, NY City, Buffalo, Syracuse, Binghamton, Utica, H
100 stations by 2020 (10 per city) = 70 + 5 per year on connecting "Highway" hwy Total)
50,000 total cars by 2020
*** Includes anticipated $164,250,000 Federal Custo Vehicle ve currently in lace for Adv Technology vehicles**

2015 – Initial NYC (10) and Upstate City #1 (10) for initial launch
2016 – Add Upstate City #2 (10) and add 5 highway station along Thruway
2017 – Add Upstate City #3 (10) and add 5 highway stations
2018 – Add Upstate City #4 (10) and add 5 highway stations
2019 – Add Upstate City #5 (10) and add 5 highway stations
2020 – Add Upstate City #6 (10) and add last 10 highway stations

**** Station location selection based on input from Greet/Street Model***

Public-Private Investments in 2011-2020 timeframe

Cumulative Program Spending by Sector



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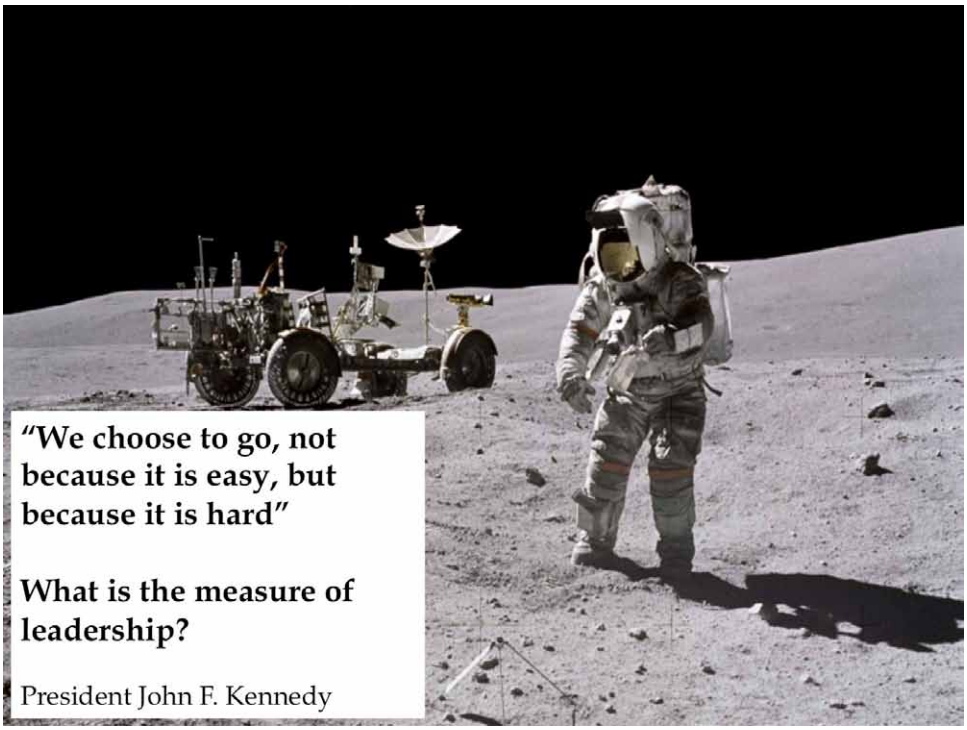
It really is about leadership and connecting all of the appropriate organizations to support a vision to make these initiatives happen

It will also take all of us as a team and as individuals to make this happen


"We choose to go, not because it is easy, but because it is hard"
What is the measure of leadership?
President John F. Kennedy

Thank You