

Future Propulsion & Energy

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GM Research & Development

UNLOCKING
THE VALUE OF
INNOVATION



ZERO CRASHES
ZERO EMISSIONS
ZERO CONGESTION



GENERAL MOTORS

ENVIRONMENTAL COMMITMENT

WE CONTINUALLY ASSESS OUR ENVIRONMENTAL IMPACT AND TAKE STEPS TO REDUCE IT

GM has a commitment to the environment and sustainability that applies to every part of our business – from our *supply chain*, to *product manufacturing*, to the *vehicles* we put on the road

GENERAL MOTORS



Zero Crashes.



2017
Sustainability
Report

Zero Emissions.



Zero Congestion.



GM TO BUILD MORE VEHICLES WITH WIND ENERGY

400 MW

by end of 2018

20%

of GM's global electrical use



200 MW

for 7 facilities in Indiana and Ohio, including assembly plants for Chevrolet Silverado, GMC Sierra and Chevrolet Cruze



BY 2050

100%
RENEWABLE ENERGY



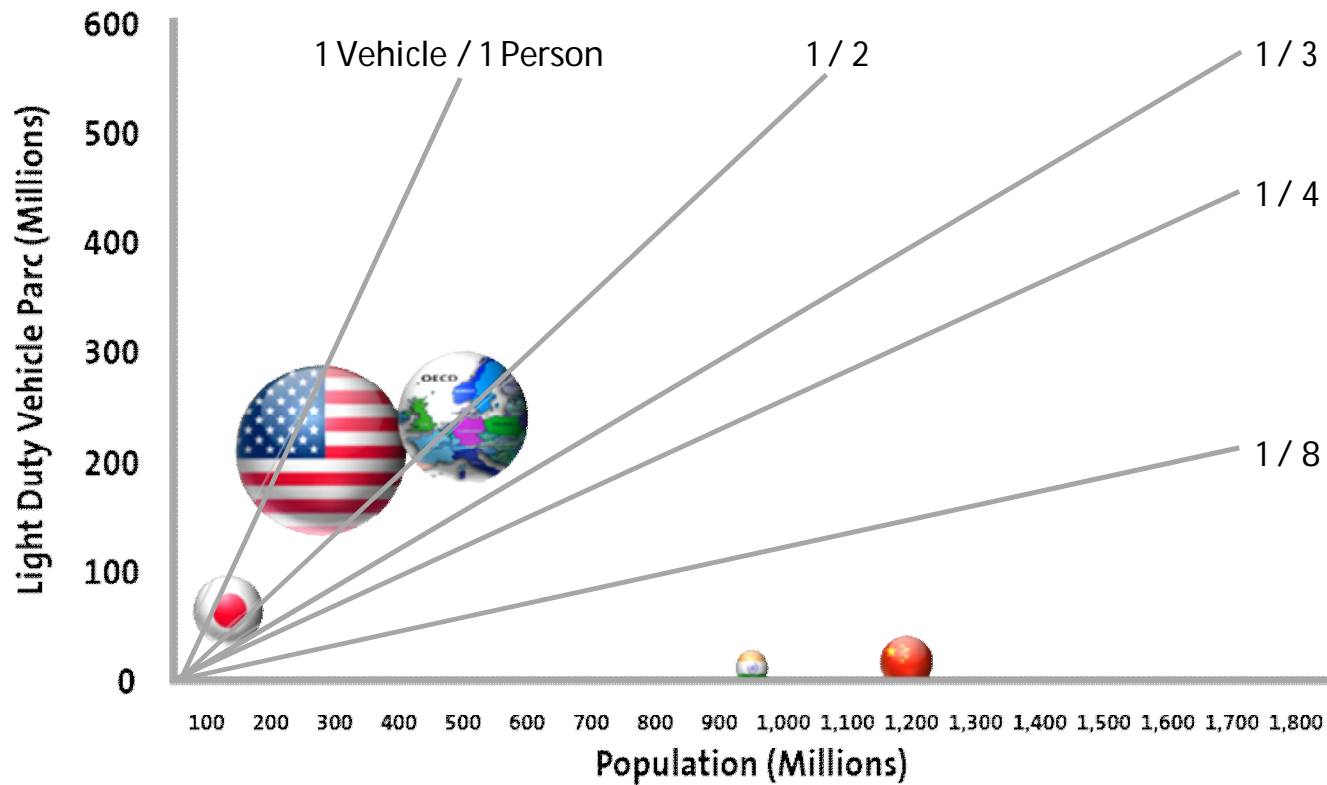
300 FACILITIES ACROSS 5 CONTINENTS



GLOBAL GROWTH

PERSONAL TRANSPORTATION – 2000

Light Duty Vehicle Parc vs. Population for Selected Countries/Regions

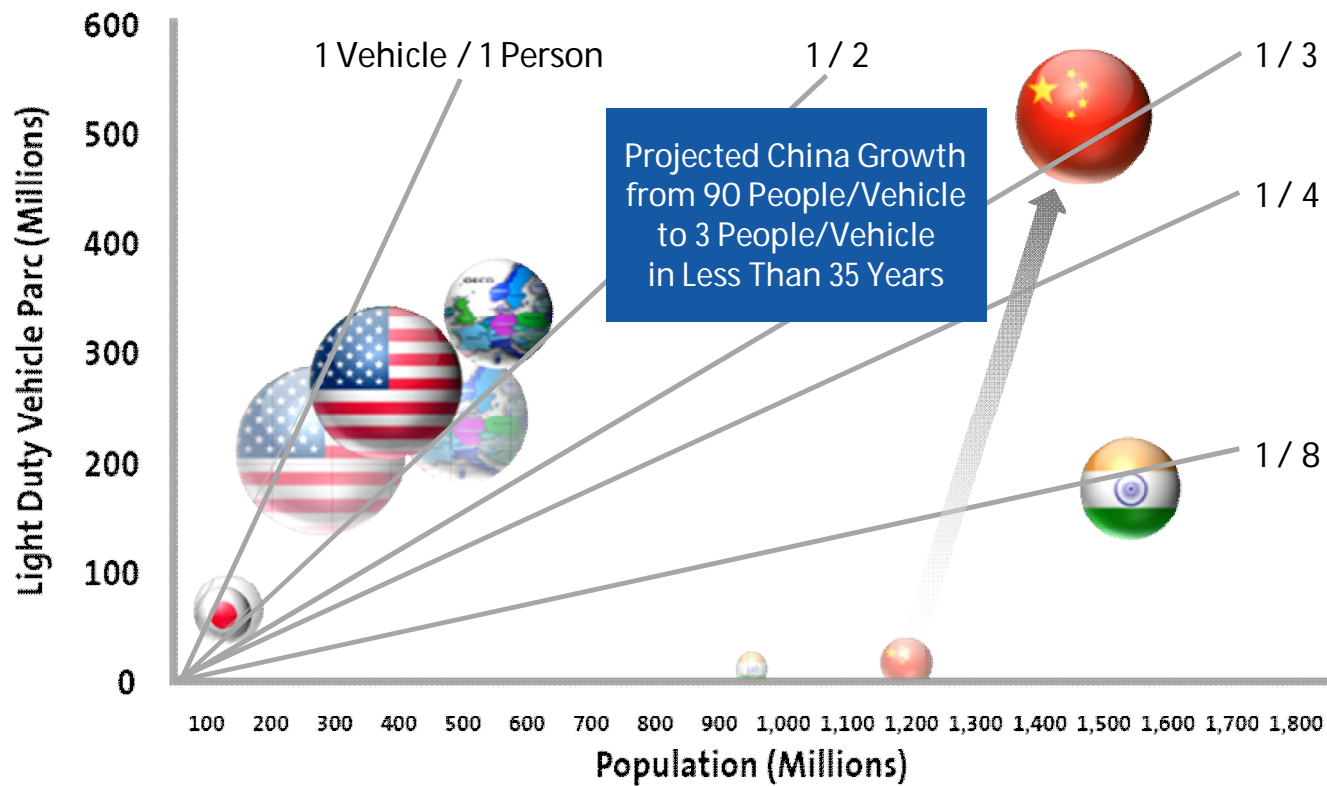


Size of icon is proportional to light duty parc fuel consumption

GLOBAL GROWTH

PERSONAL TRANSPORTATION – 2035

Light Duty Vehicle Parc vs. Population for Selected Countries/Regions



Size of icon is proportional to light duty parc fuel consumption



ELECTRIC



CONNECTED



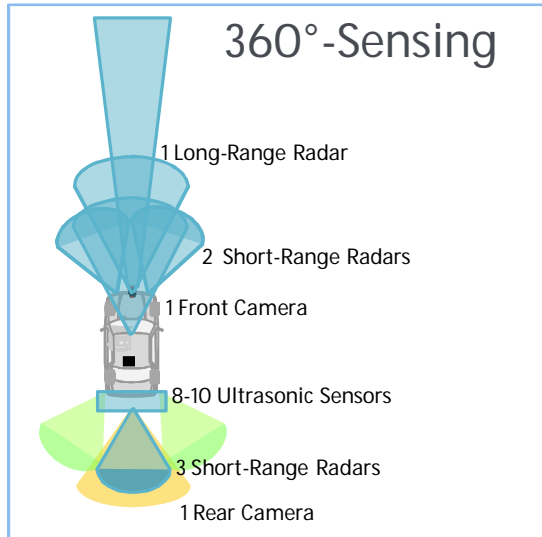
SHARED



AUTONOMOUS



TECHNOLOGY INNOVATION



Electrification



Robotic Mfg



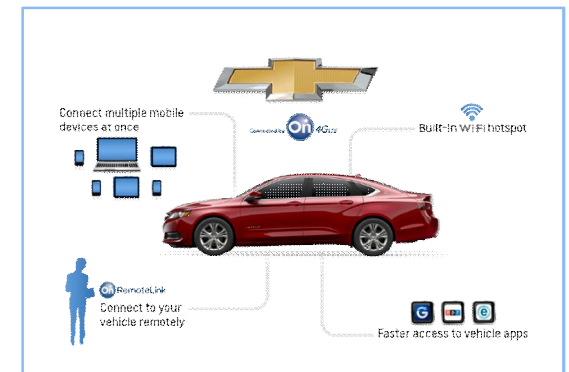
Fuel Cell Vehicles



Automated Driving

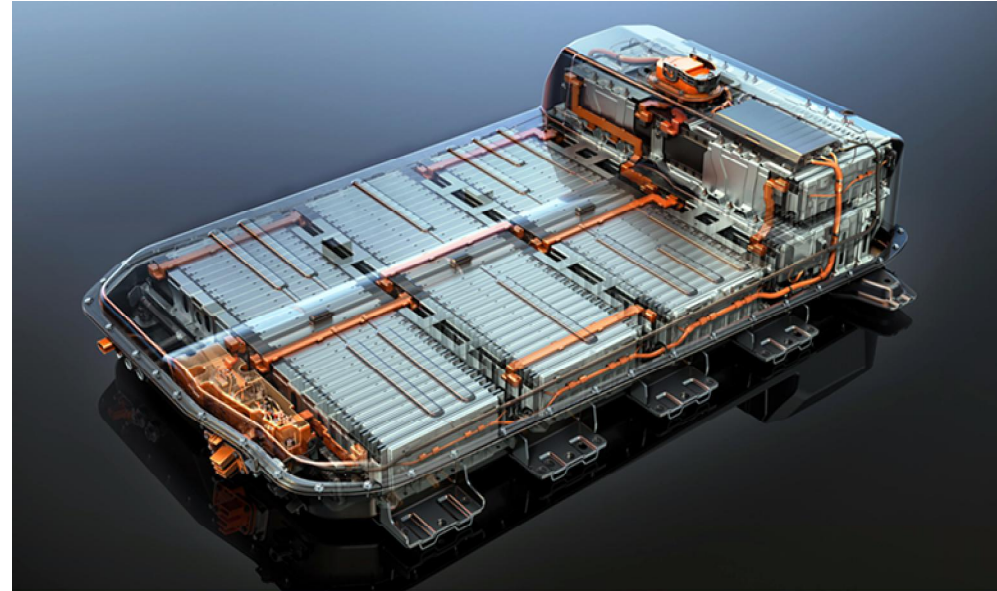


OnStar 4G LTE



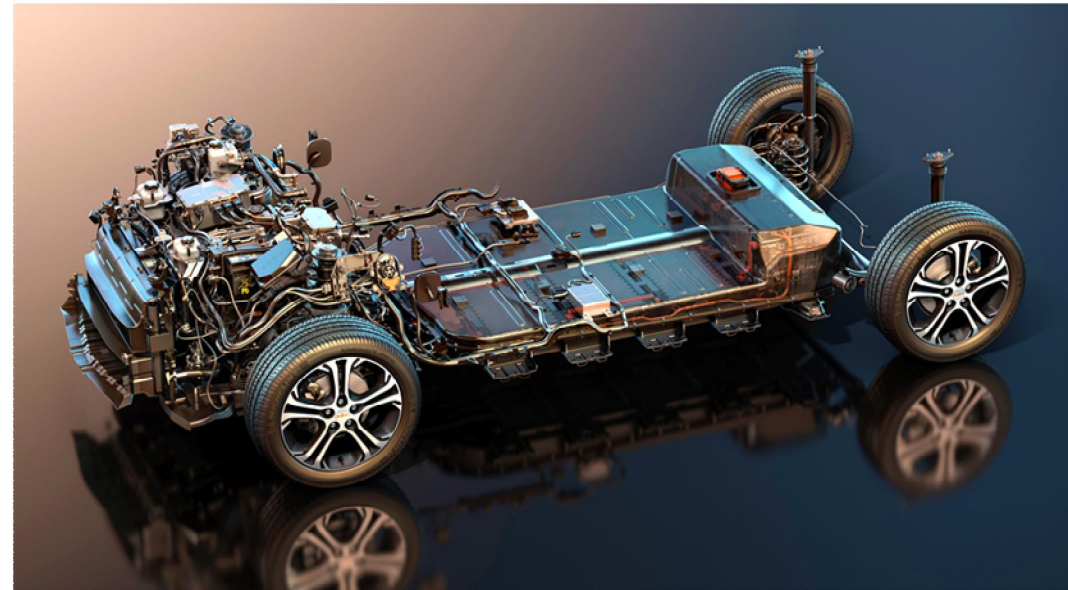
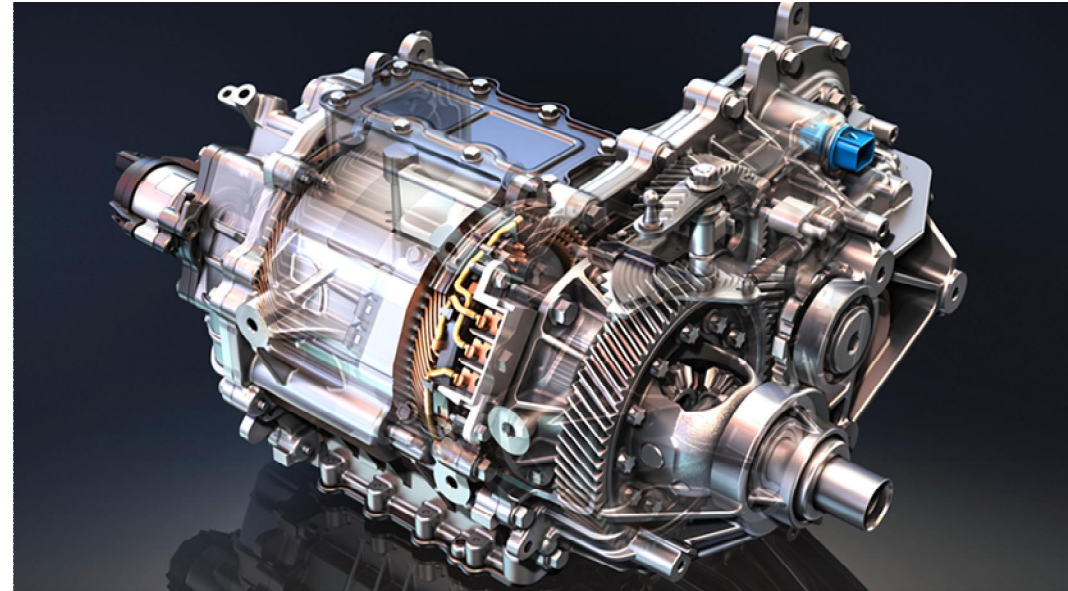
Disruptive Technology for Battery & Power Electronics

- ▶ 60 kWh lithium-ion battery pack
- ▶ 288 lithium ion cells in 96 cell groups
- ▶ 960 lbs. (435 kg) total weight
- ▶ 160 kilowatts of peak power
- ▶ 60 kilowatts hours of energy



Disruptive Technology for Electric Drives

- ▶ Single high-capacity electric motor
- ▶ 266 lb.-ft. (360 Nm) torque
- ▶ 200 hp (150 kW) motoring power
- ▶ 0-60 mph in < seven seconds
- ▶ Chevrolet's first Electronic Precision Shift system



Chevrolet Volt & Bolt EV Usage Study

Over 100,000 Vehicles in Study

- Chevrolet Volt & Bolt EV North America usage examined via OnStar®*



Bolt EV 18,569



Gen2 Volt 46,520



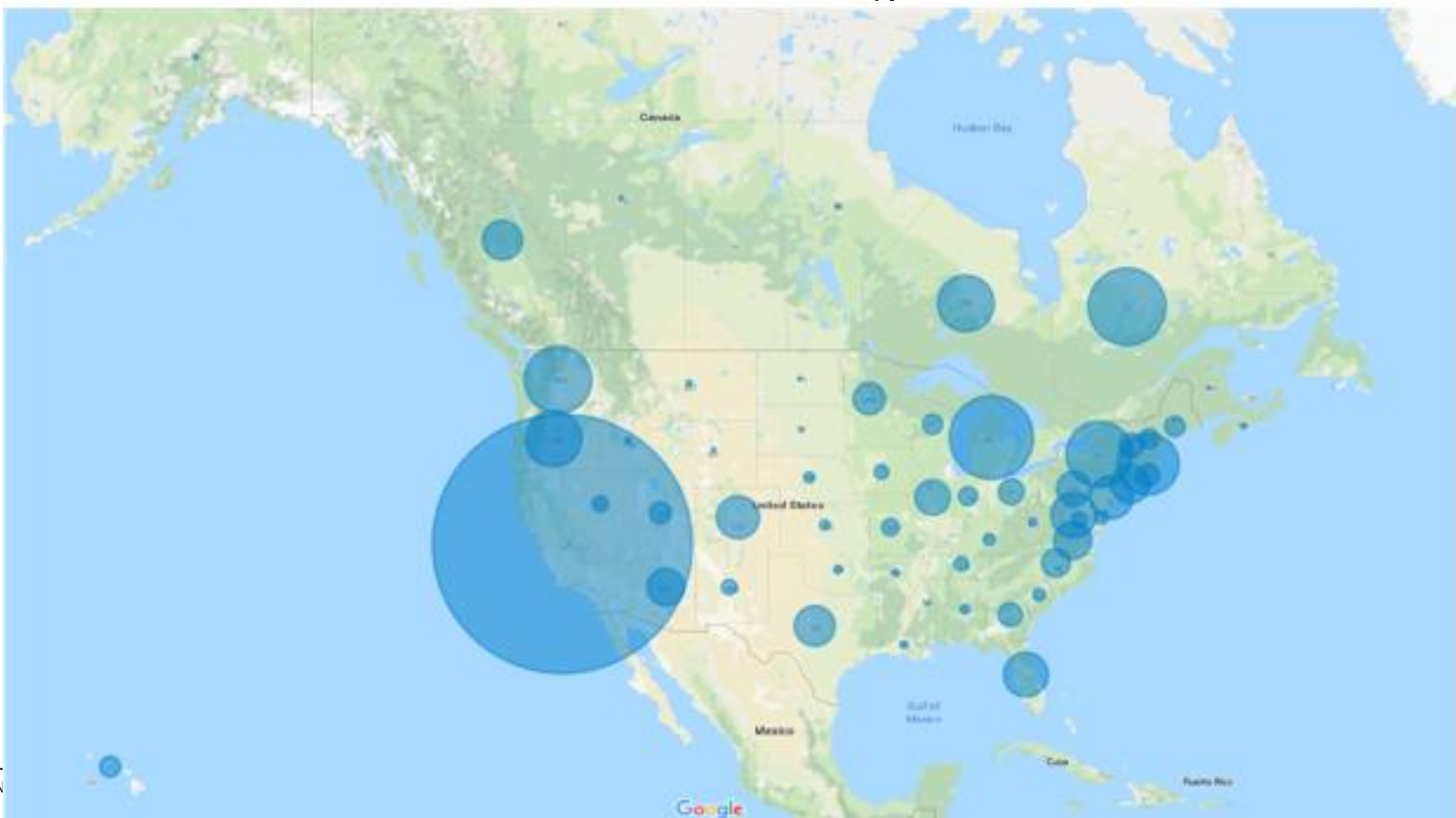
Gen1 Volt 37,671



Chevrolet Volt & Bolt EV Usage Study

Over 100,000 Vehicles in Study

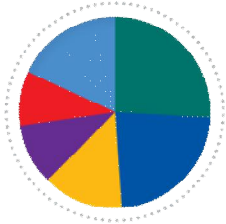
- Chevrolet Volt & Bolt EV North America usage examined via OnStar®*



EV PORTFOLIO

GM IS FOCUSED ON DRIVING WIDESPREAD CONSUMER ADOPTION OF EVs IN PURSUIT OF ZERO EMISSIONS

2017 GLOBAL SALES OF ELECTRIFIED VEHICLES



Chevrolet Bolt EV
Chevrolet Volt
Cadillac XT5 with eAssist
Baoyun E100
Chevrolet Malibu Hybrid

OTHER:

Buick Velite 5
GMC Sierra with eAssist
Buick LaCrosse with eAssist
Buick LaCrosse HEV
Chevrolet Silverado
Cadillac CT6 Plug-In
Buick Regal HEV
Chevrolet Spark EV

TOTAL: 109,666

13 GLOBAL MODELS WITH SOME FORM OF ELECTRIFICATION



EV PORTFOLIO

NSU

MOD

S

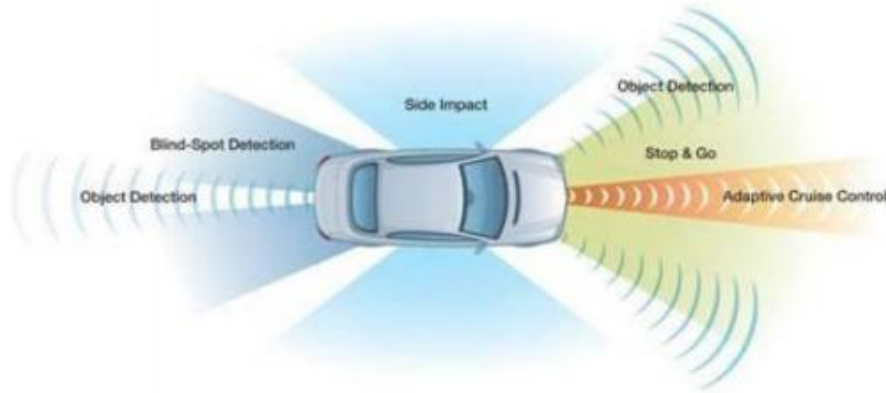


- Chevrolet Bolt EV
- Chevrolet Volt
- Cadillac XT5 with eAssist
- Baojun E100
- Chevrolet Malibu Hybrid



TOTAL: 109,666

Advanced Sensing and Connectivity..... "System Integration"



Advanced sensing systems enabling Active Safety features are hitting the roads. (e.g., GM SuperCruise)

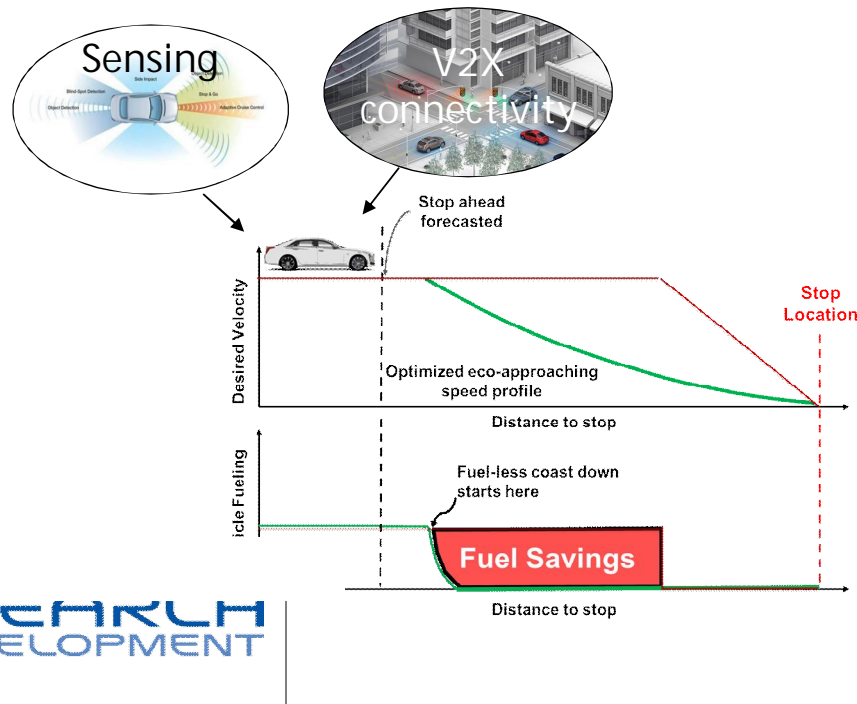
Vehicle connectivity is rapidly proliferating.



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Information Rich Controls Systems

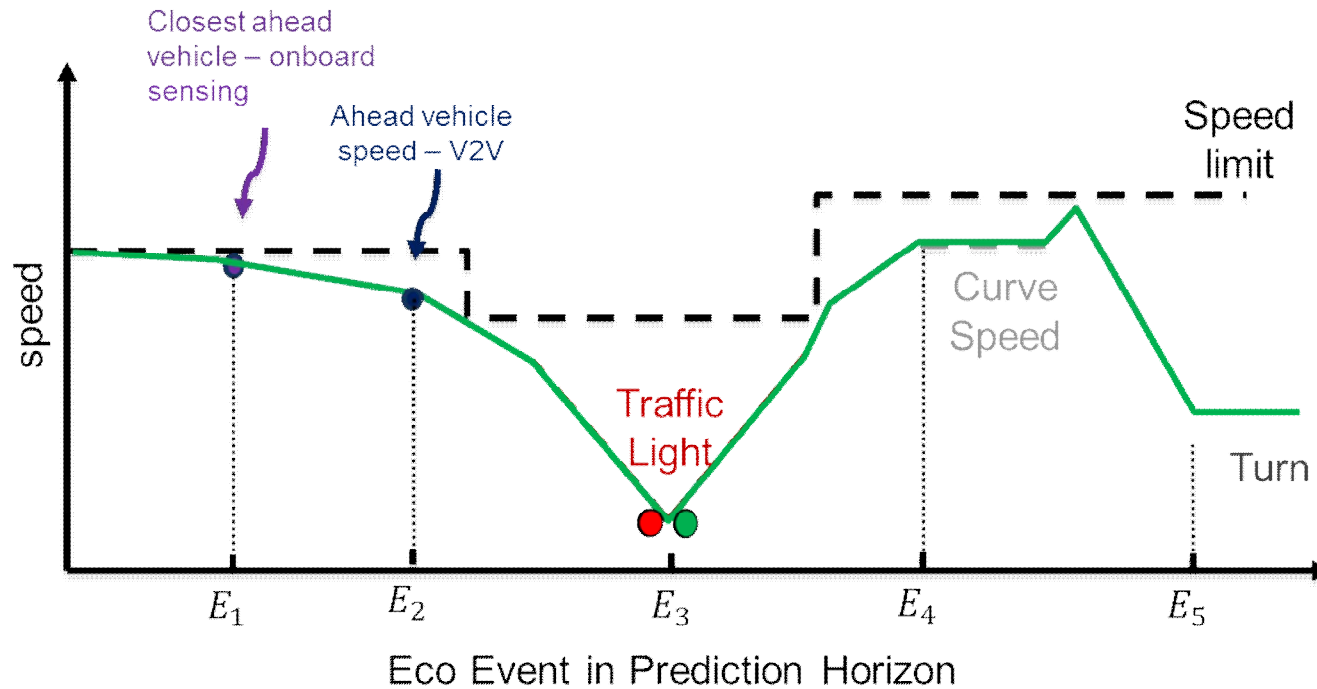
Preview information can be generated from on-onboard sensors and connectivity to optimize mobility (i.e., safety, comfort, efficiency, etc.) through the use of predictive vehicle and propulsion controls



Preview Information
+
Advanced Control Strategies
=
InfoRich Controls

~~Reactive~~
Predictive

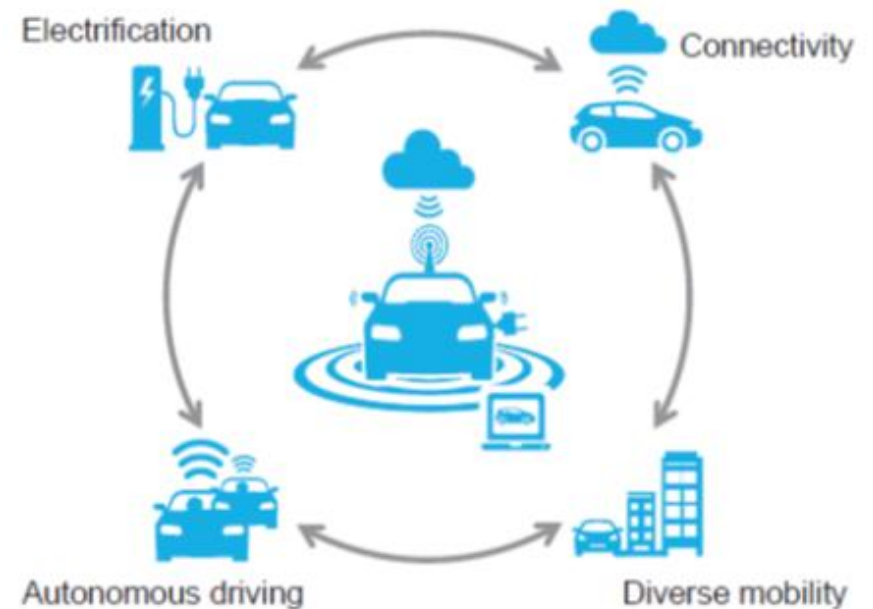
Information Rich Controls Systems



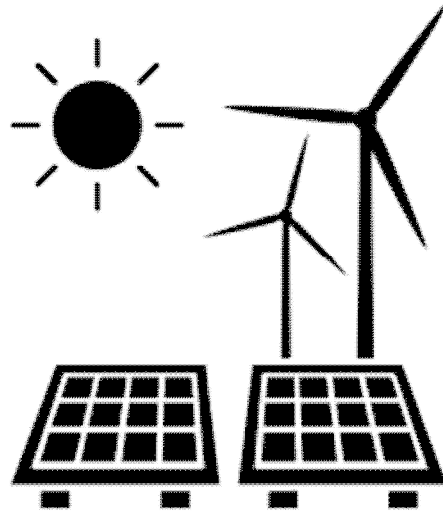
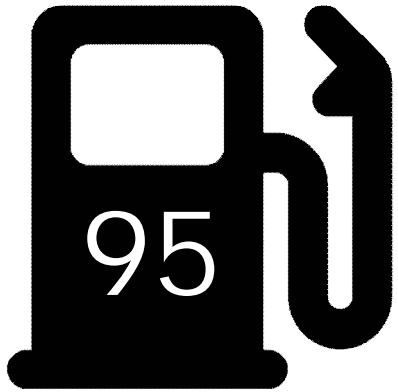
Est. fuel savings of ~7 %

Propulsion Controls Systems

- Multi-core Algorithm Parallelization
 - To accommodate sophisticated control and diagnostic algorithms (AI, MPC, etc.) needed for future propulsion systems
 - Deep Learning
 - Driver prediction / environment / Machine Learning
- AI / Big Data
 - New customer features
 - FE / Faster routes
 - \$ generation
- Low Cost Sensors and Actuators
- AI enhanced controls and diagnostics (VHM)



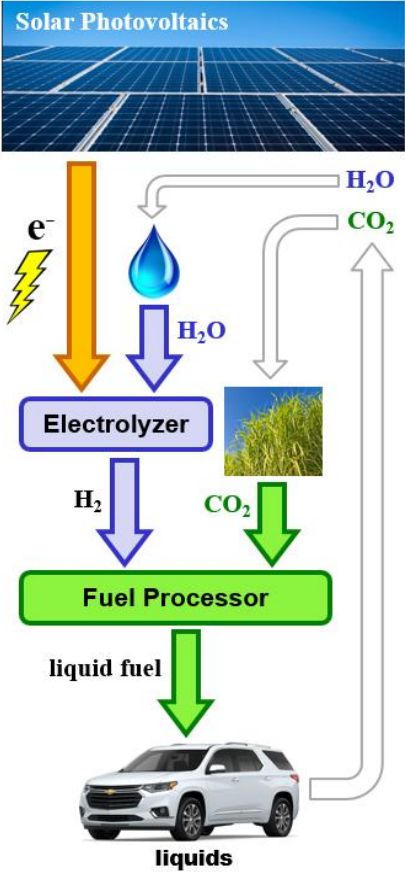
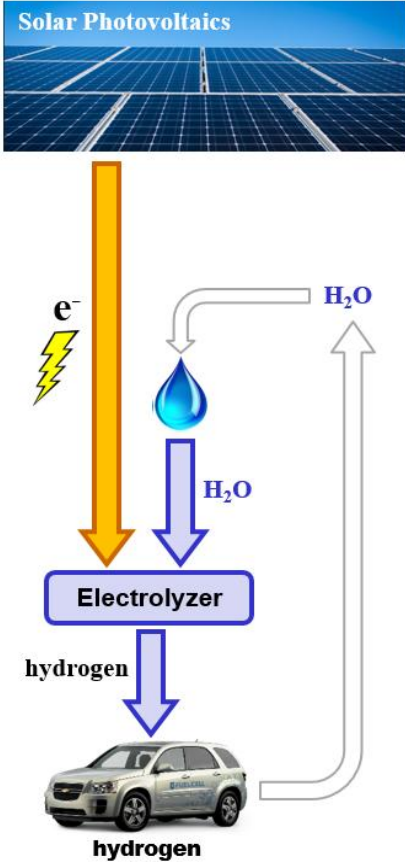
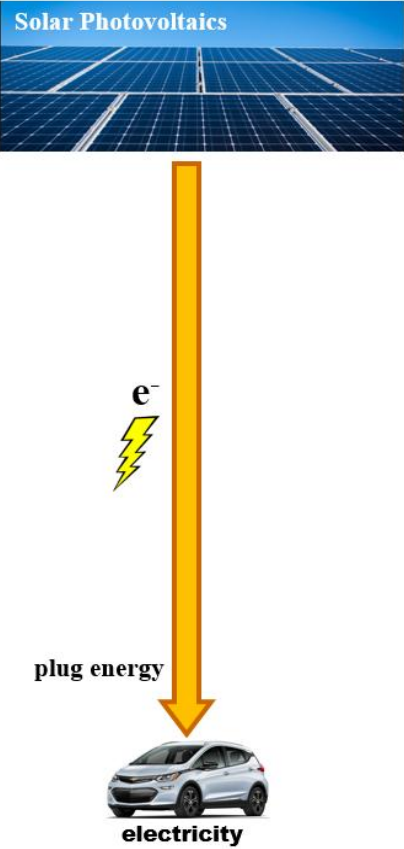
Disruptive Fuels (Disrupting the Disrupter)



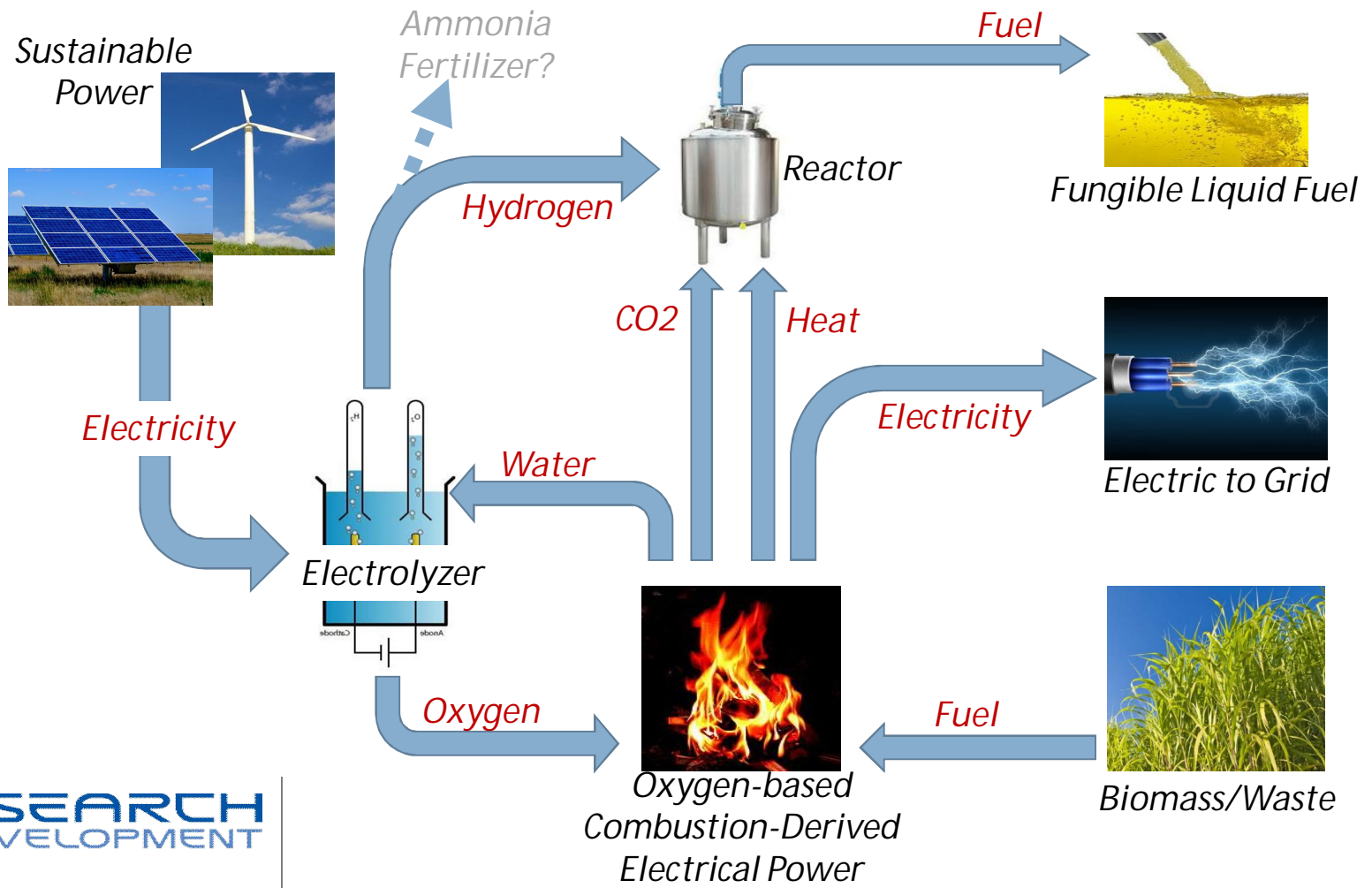
- ▶ High Octane 95 RON / High Sensitivity Gasoline
- ▶ Zero-Net-Carbon Liquid Fuels



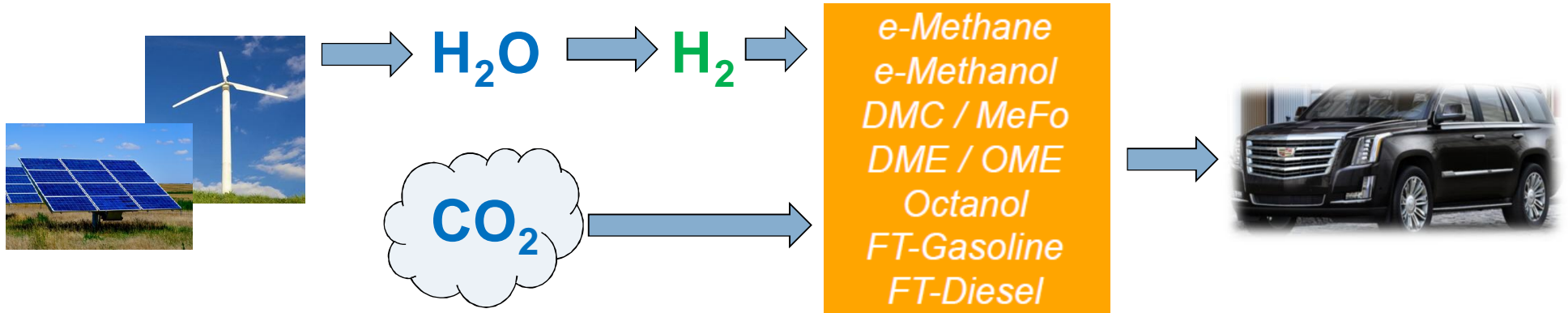
Net-Zero Carbon Fuels



Net-Zero Carbon Liquid Fuel Production Scenario



Net-Zero Carbon Liquid Fuel



DMC = DiMethylCarbonate; MeFo = Methylformiate; DME = Dimethylether; OME = Oxymethylenether; FT = Fischer-Tropsch Synthese

THANK YOU



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