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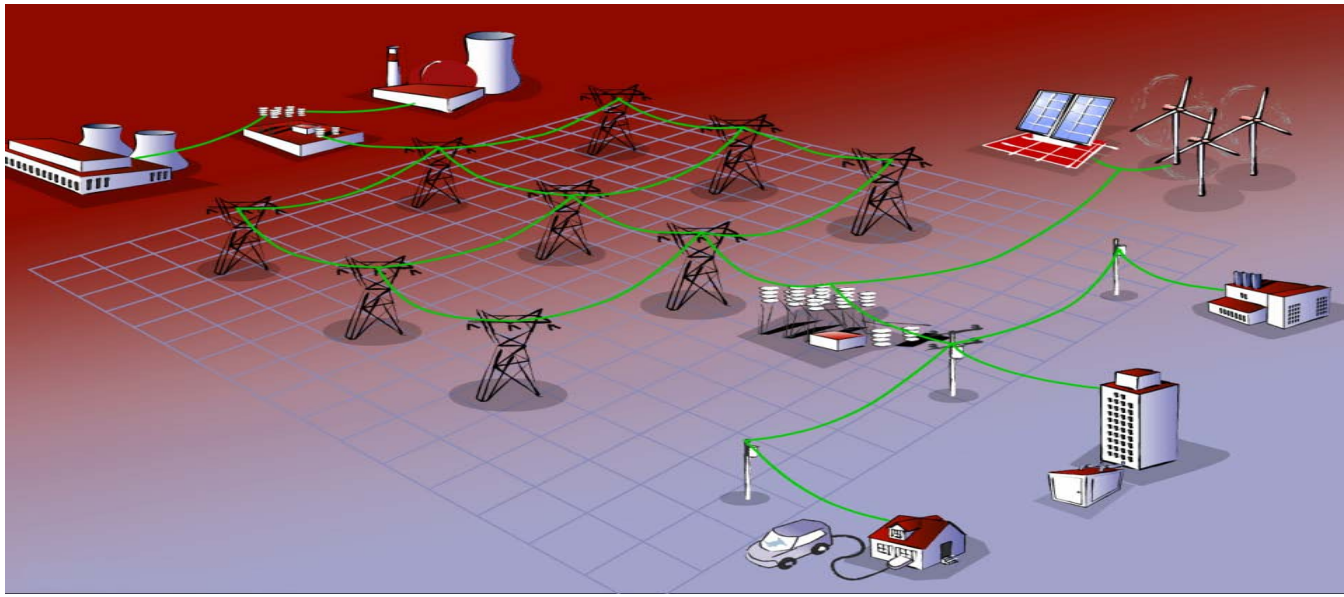


Assessment of Future Vehicle Transportation Options and Their Impact on the Electric Grid

January 10, 2010

New Analysis of Alternative Transportation Technologies

What's New?

- **Additional Alternative Transportation Vehicles**
  - Compressed Air Vehicles (CAVs)
    - Use electricity from the grid to power air compressor that stores compressed air
  - Natural Gas Vehicles (NGVs)
    - Connection to grid is in competing demand for fuel
    - Still an internal combustion engine (ICE)
  - Hydrogen Vehicles
    - Use fuel cell technology, no connection to electricity grid

General Takeaways

- **CAVs**
  - Unproven technology
  - Poor environmental performance
  - High cost
- **NGVs**
  - Poor environmental performance
  - Lack of refueling infrastructure
  - Cheaper fuel cost than ICEs
  - No direct impact on electric power grid
- **Hydrogen**
  - Unproven technology
  - High cost
  - Safety issues

Performance and Environmental Comparison

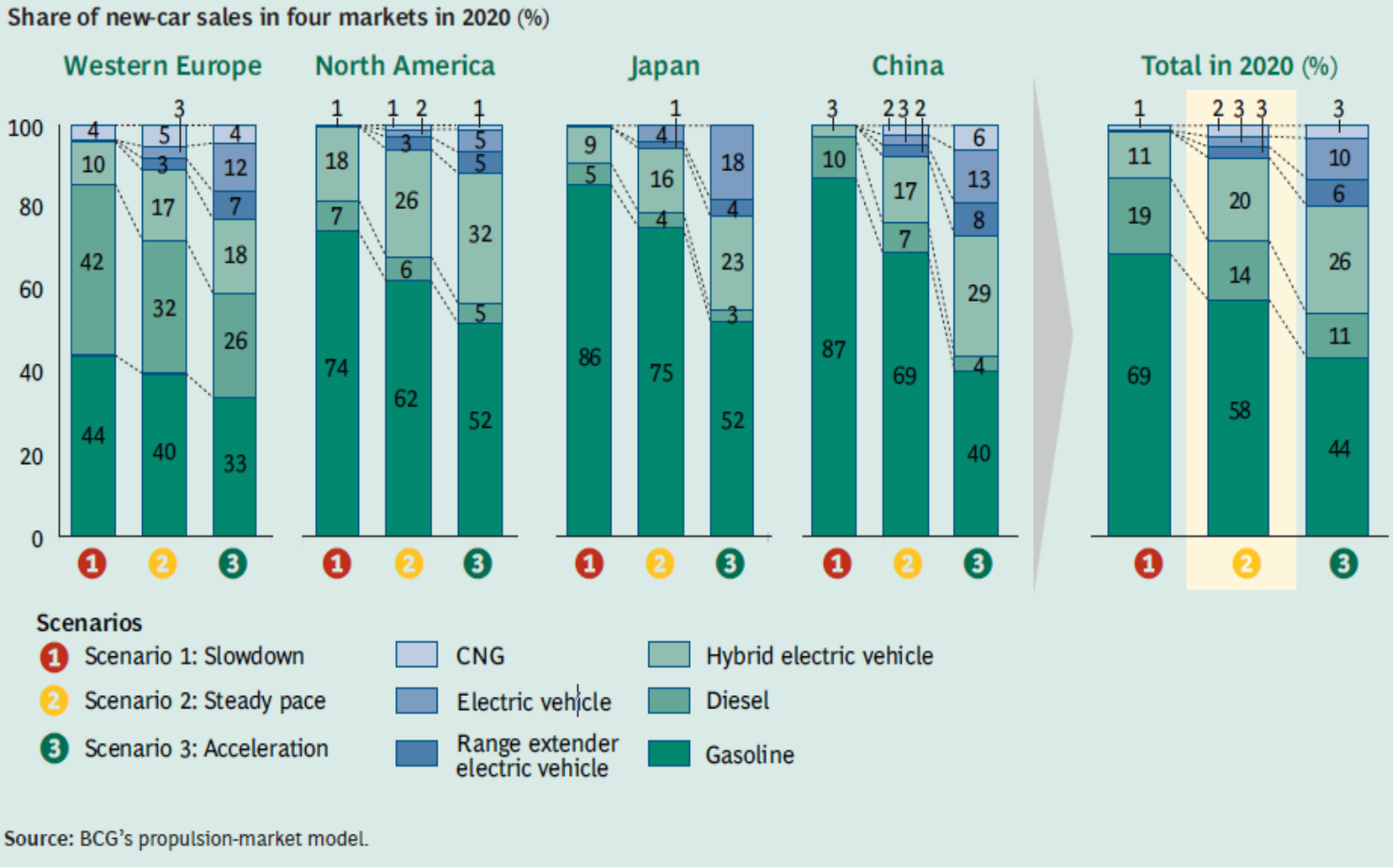
	Compressed Air Vehicle	Urban Gasoline Vehicle	Urban Electric Vehicle
Fuel Type	Compressed Air	Gasoline	Battery
Fuel Economy	38 MPG-e	32 MPG	163 MPG-e
Urban Range	29 mi	408 mi	127 mi
CO_2 Emissions (low-carbon)	361 g CO_2/mi	243 g CO_2/mi	184 g CO_2/mi
CO_2 Emissions (U.S. average)	626 g CO_2/mi	276 g CO_2/mi	147 g CO_2/mi
CO_2 Emissions (carbon-intensive)	721 g CO_2/mi	276 g CO_2/mi	169 g CO_2/mi
Fuel cost	$0.21/mi	$0.09/mi	$0.05/mi

Source: ICF International

Best In Class Vehicle Examples

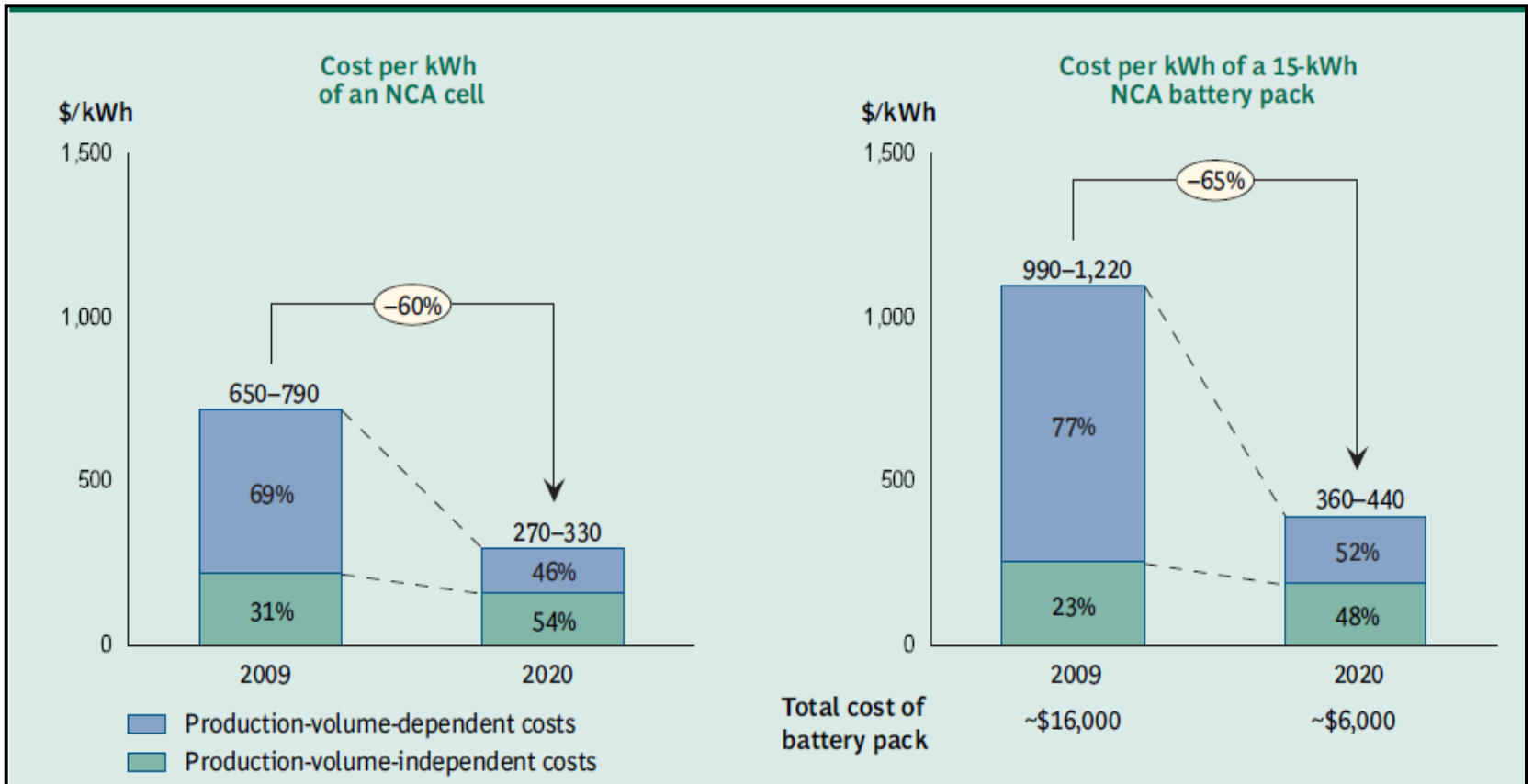
Best In Class Example	Typical Vehicle Cost	Typical Fuel Cost (gal gas equivalent energy)	Typical MPG	Average Highway Range	Top Vehicle Speed (MPH)	Safety Issues
ICE *Chevrolet Cruze*	$17k	$2.60	40	450	108	None
EV *Chevrolet Volt*	$40k	~$0.95	50 (charge sustaining mode)	450	108	Battery risk
Diesel / Kerosene *Volkswagen Jetta TDI*	$23k	$2.75	42	600	115	None
Natural Gas *Honda Civic GX*	$25k	$0.70-0.95	36	250	~105	Refill risk
Hydrogen *Honda FCX Clarity*	~$200K	~$3.50	68	240	100	Refill risk
Compressed Air	~$20k	$0.25-0.40	80-100	~120-140	68	None

Market Penetration Scenarios: 2020



Source: BCG's propulsion-market model.

Battery Cost Trends



Sources: Interviews with component manufacturers, cell producers, tier one suppliers, OEMs, and academic experts; Argonne National Laboratory; BCG analysis.

Note: Exhibit assumes annual production of 50,000 cells and 500 batteries in 2009 and 73 million cells and 1.1 million batteries in 2020. Numbers are rounded.

Conclusions

Key Takeaways

- **EVs** demonstrate clear advantage in terms of near term market penetration amongst competing alternative technologies
- **CAVs** could be included in follow-on analyses because of their direct impact on grid
  - Very similar analysis work would be done for both technologies.
  - However, perceived near term market penetration is minimal
- **NGVs** however present an interesting analysis opportunity from standpoint of Office of Fossil Energy

Discussion of Follow-on Analyses

Key Proposals

- **PHEV vs. all EV analysis**
  - Large difference in charging requirements and impact on grid
- **Assess the displaced peak energy generation and the additional potential penetration from wind power to fuel these distributed storage sources**
  - Changes to generation portfolio
- **Demand Dispatch and variable voltage charging**
  - Opportunities of Smart Grid technologies to regulate EV charging