

Unplugging the Hype around Electric Vehicles

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Lux Research profile

- We help clients capitalize on **science-driven innovation**
- We focus on **emerging technologies** in the chemicals and materials sector and the energy and environment sector (cleantech)
- We have practices in **Nanomaterials, Solar, Alternative Power and Energy Storage, Water and Biosciences**
- We have clients on **five continents** – blue-chip corporations, government agencies and laboratories, universities, investors, and small/mid-cap companies
- We **source** our intelligence from the Lux Research Network: CEOs, CTOs, CSOs, and R&D execs at cutting-edge technology firms in our sectors of focus
- We draw on **our network** to:
 - Continuously monitor emerging technologies
 - Assist with company and technology evaluation
 - Identify discontinuities in technology commercialization
- We have **global research reach**, with offices in New York, Boston, San Francisco, and Amsterdam with 50+ employees: 67% scientists, 33% business analysts

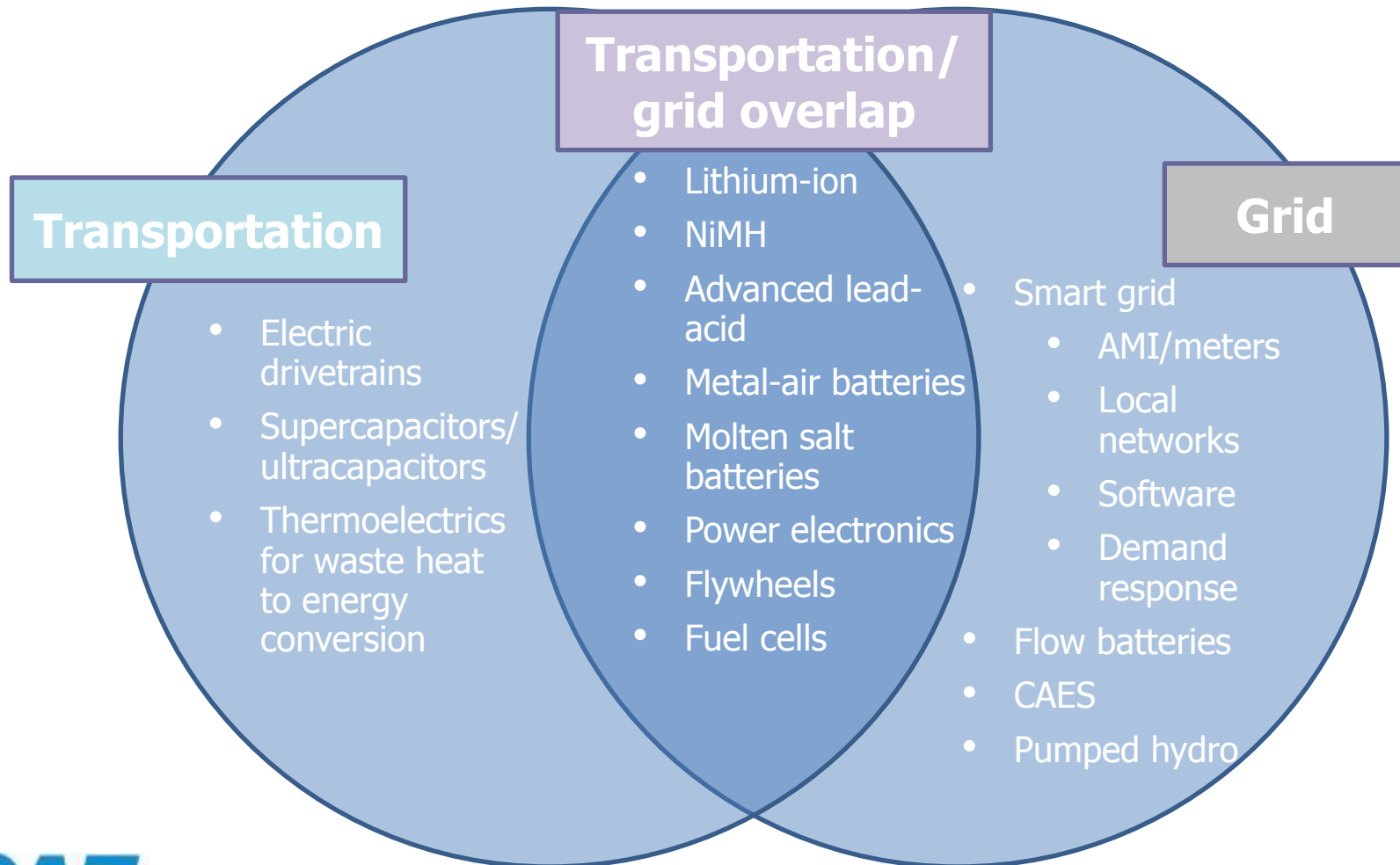


LR Director Josh Wolfe present in the Oval Office during the signing of the 21st Century R&D Act



LR President Matthew Nordan testifying before U.S. Congress

Lux Alternative Power and Energy Storage Intelligence Service



Key question

With virtually every major automaker launching a PHEV or EV within the next three years, will these cars see the same success as their HEV cousins?

Agenda

- Electric vehicle landscape
 - Electric vehicle overview and auto/battery partnerships
 - Li-ion costs
- Analysis
 - Demand-driven market model
 - Electric vehicle sales projections by region
 - Global battery market forecast
- Outlook
 - Winning players
 - Technical issues
 - Market implications
 - Other considerations (ores, governments, and greens)

Agenda

- Landscape
- Analysis
- Outlook

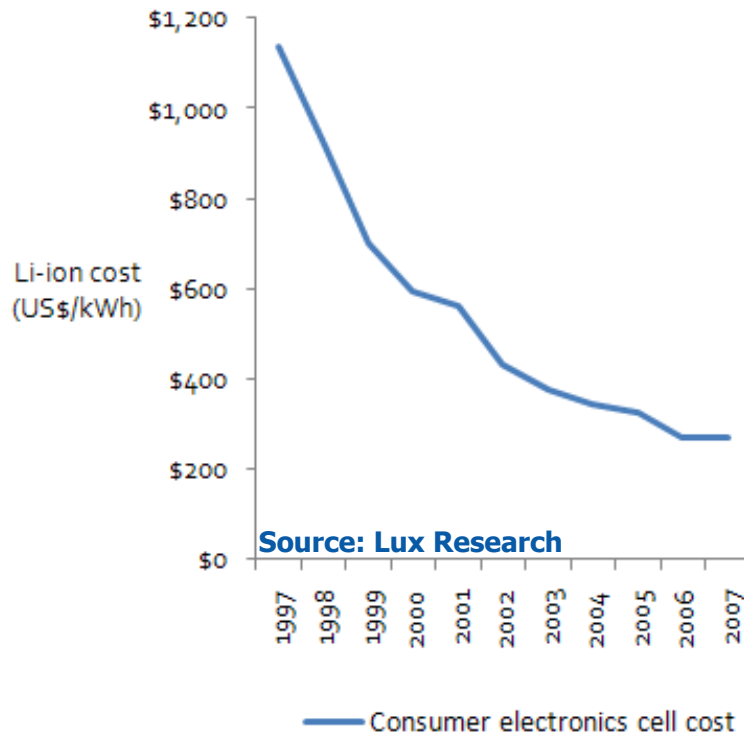
Types of electric vehicles

| Vehicle type | Subtypes | Relevant battery chemistries | Typical fuel savings |
|--------------------------------------|---------------------|-------------------------------------|----------------------|
| Hybrid electric vehicle (HEV) | Micro | Lead-acid, advanced lead-acid, NiMH | 5% to 15% |
| | Mild | NiMH | 15% to 30% |
| | Full | NiMH, Li-ion | 40% to 50% |
| Plug-in hybrid vehicle (PHEV) | Series/ parallel | Li-ion | 55% to 85% |
| | Series | Li-ion | 55% to 85% |
| All-electric vehicle (EV) | N/A | Li-ion | 100% |

Selected Li-ion partnerships for PH/EVs

| Automaker/ model | Battery partner | Vehicle type | Expected commercial availability | Expected price (unsubsidized) |
|--|------------------------|--------------|----------------------------------|---|
| Toyota | Panasonic | PHEV | 2012 | Unannounced |
| GM/Chevy Volt | LG Chem/ Compact Power | PHEV | 11/2010 | \$40,000 |
| Volkswagen/ Golf Twin Drive; E-Up | Sanyo; unannounced | PHEV; EV | 2011; 2013 | Unannounced |
| Ford | JCI-Saft | PHEV | 2012 | Unannounced |
| Nissan/Leaf | NEC | EV | 2010 | \$30,000 (likely does not include battery pack) |
| BYD Auto/F3DM; e6 | BYD | PHEV; EV | December 2008; late 2009 | \$20,000; unannounced |
| Tesla Motors/ Roadster; Model S | Multiple | EV; EV | 2008; 2011 | \$109,000; \$57,400 |

Historical Li-ion costs for consumer electronics and future costs for automotive



Landscape conclusion

- Partnerships between automakers and battery manufacturers are already in place, and PHEV/EV and battery production is ramping up with major support from national governments.
- Lithium-ion battery prices for electric vehicles will come down, but not to the extent they did for consumer electronics applications in the 1990s.
- Despite all the money invested, governmental support offered, and hype generated, PHEVs' and EVs' high prices mean that widespread adoption remains a question mark.

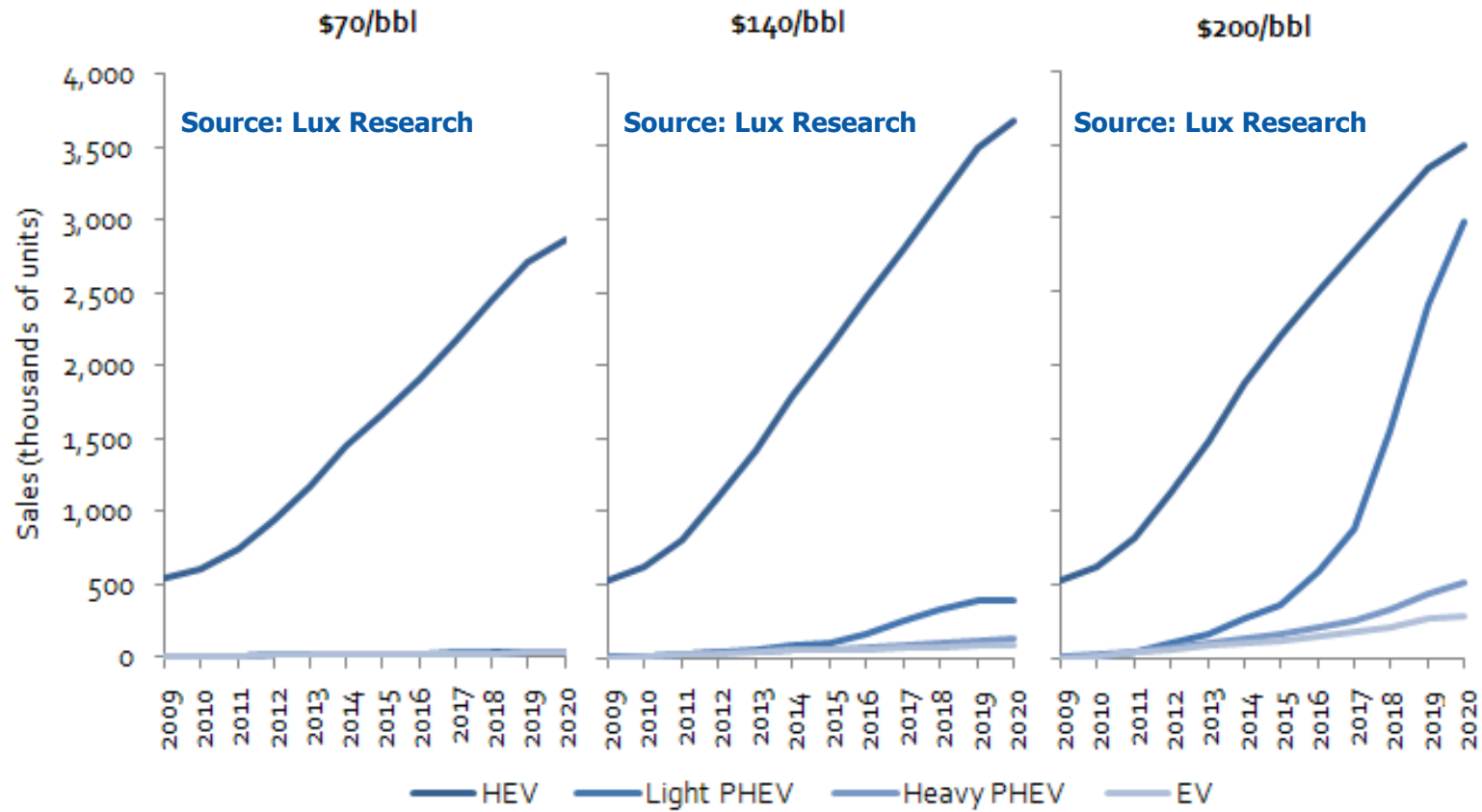
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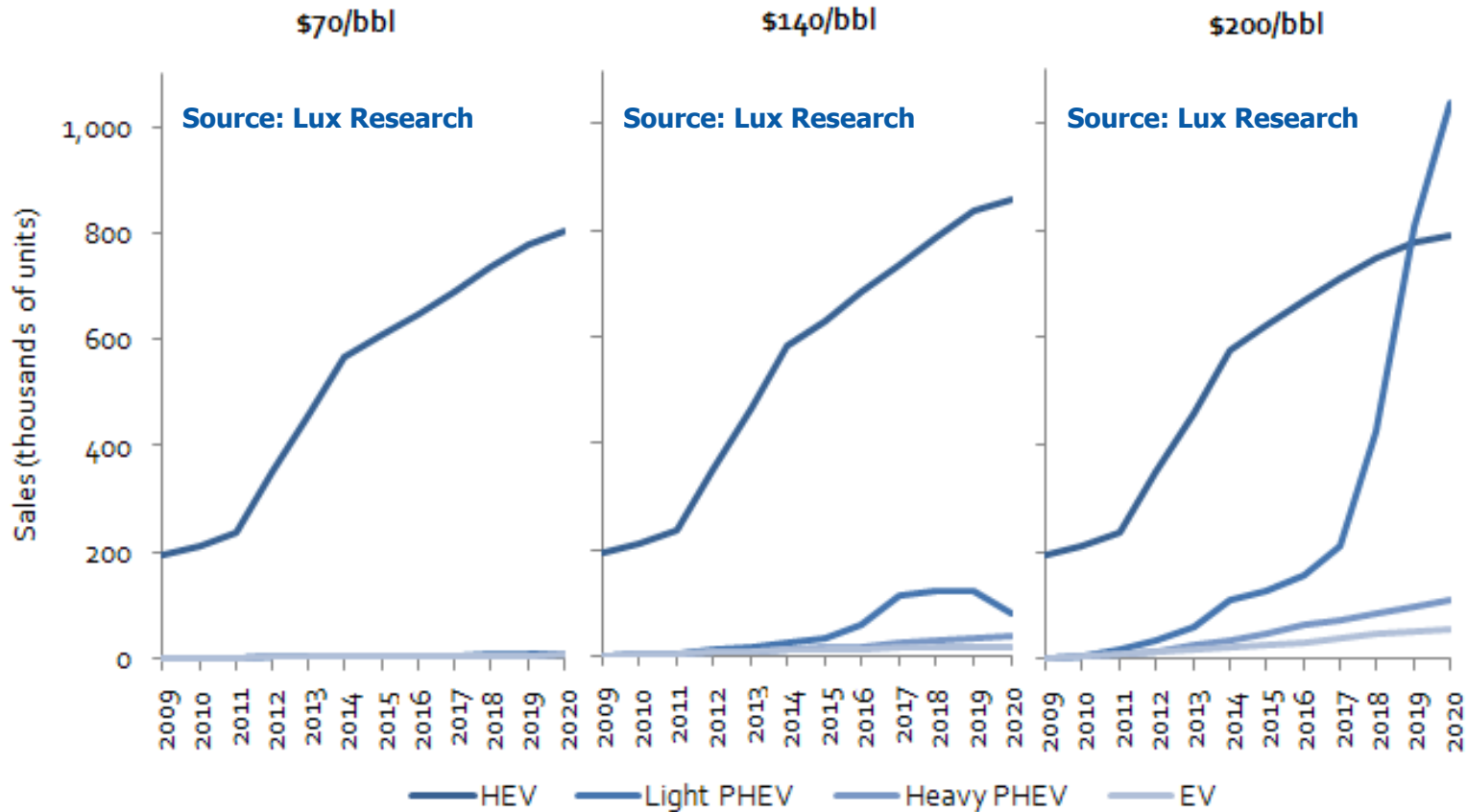
Demand-driven market model

- Analysis accounts for:
 - Technology improvements (including ICE technologies)
 - Component cost reductions
 - Gas/electricity prices
 - Driving habits
 - Governmental subsidies
- Model is based on relative **payback periods** of electric vehicles vs. ICE vehicles and has two phases:
 - A “hippie phase” (logarithmic growth)
 - A “growth phase” (logistic growth)
- Types of vehicles modeled:
 - HEV: contains a NiMH battery pack (like the Toyota Prius)
 - Light PHEV: a PHEV-12 with a Li-ion battery pack (like Toyota’s planned PHEV)
 - Heavy PHEV: a PHEV-40 with a Li-ion battery pack (like the Chevy Volt)
 - EV: contains a Li-ion battery pack (like the Nissan Leaf)

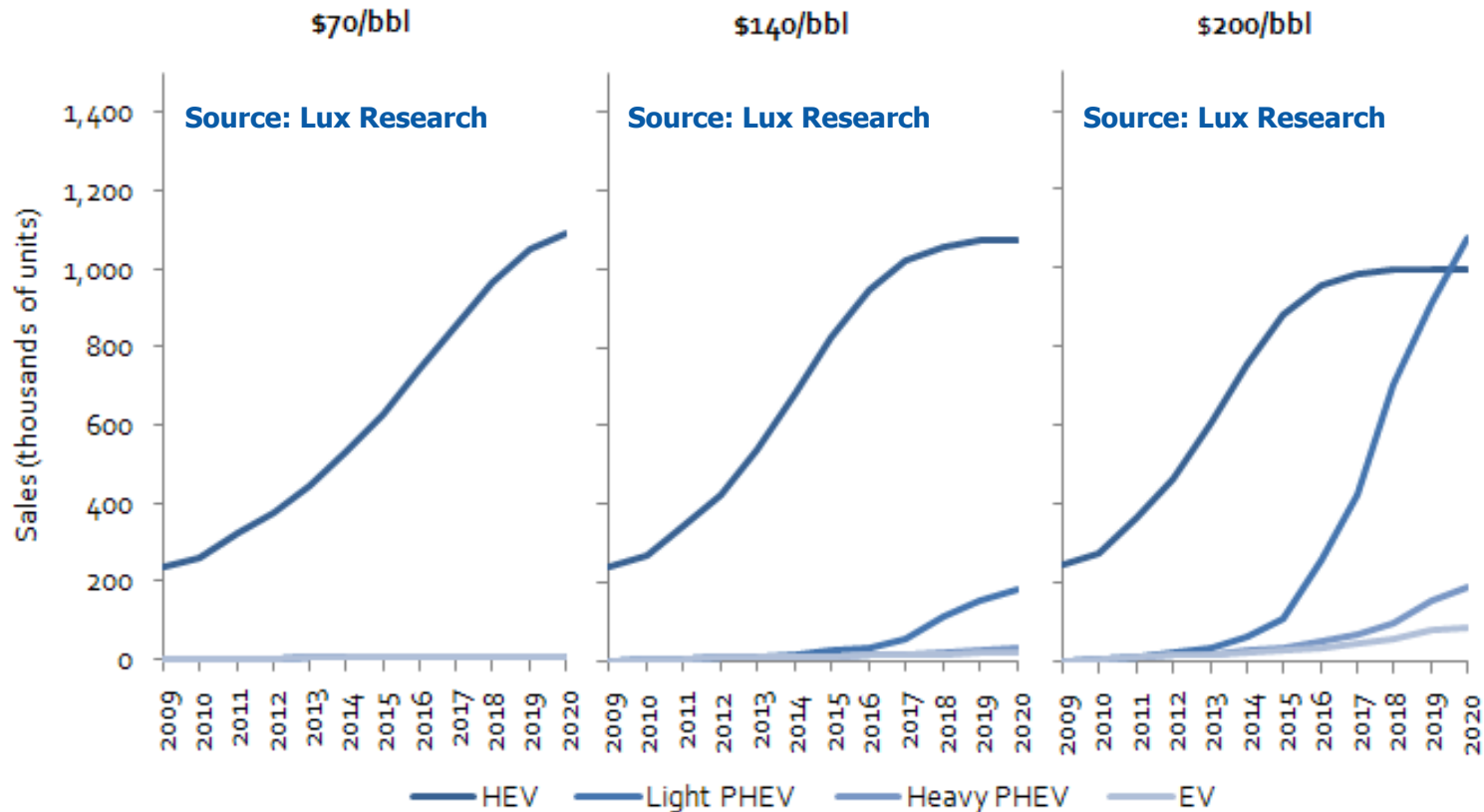
Global automotive sales by vehicle type: three scenarios



The U.S. market is primed for light PHEVs, if oil prices play along



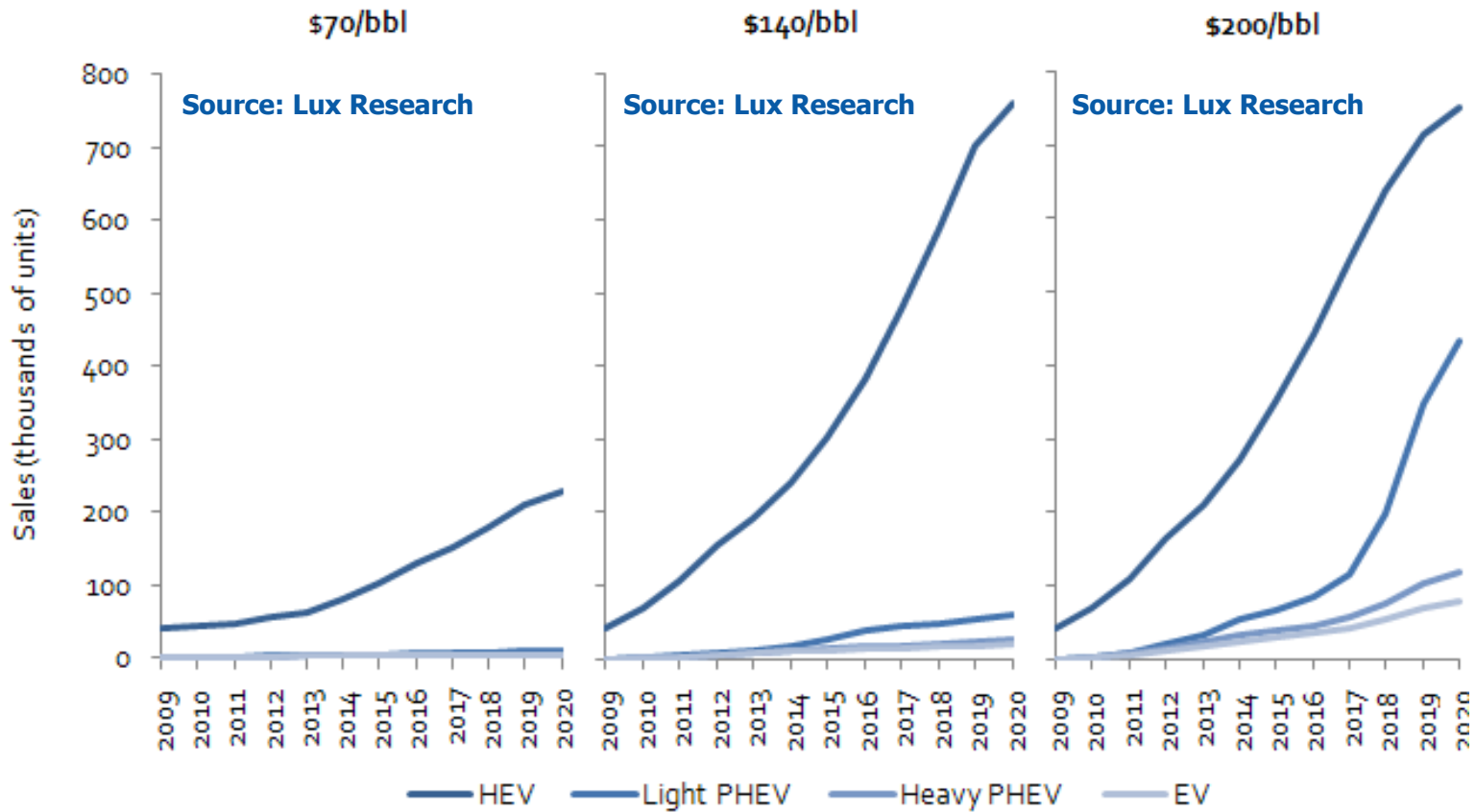
Japan represents the perfect breeding ground for electric vehicles



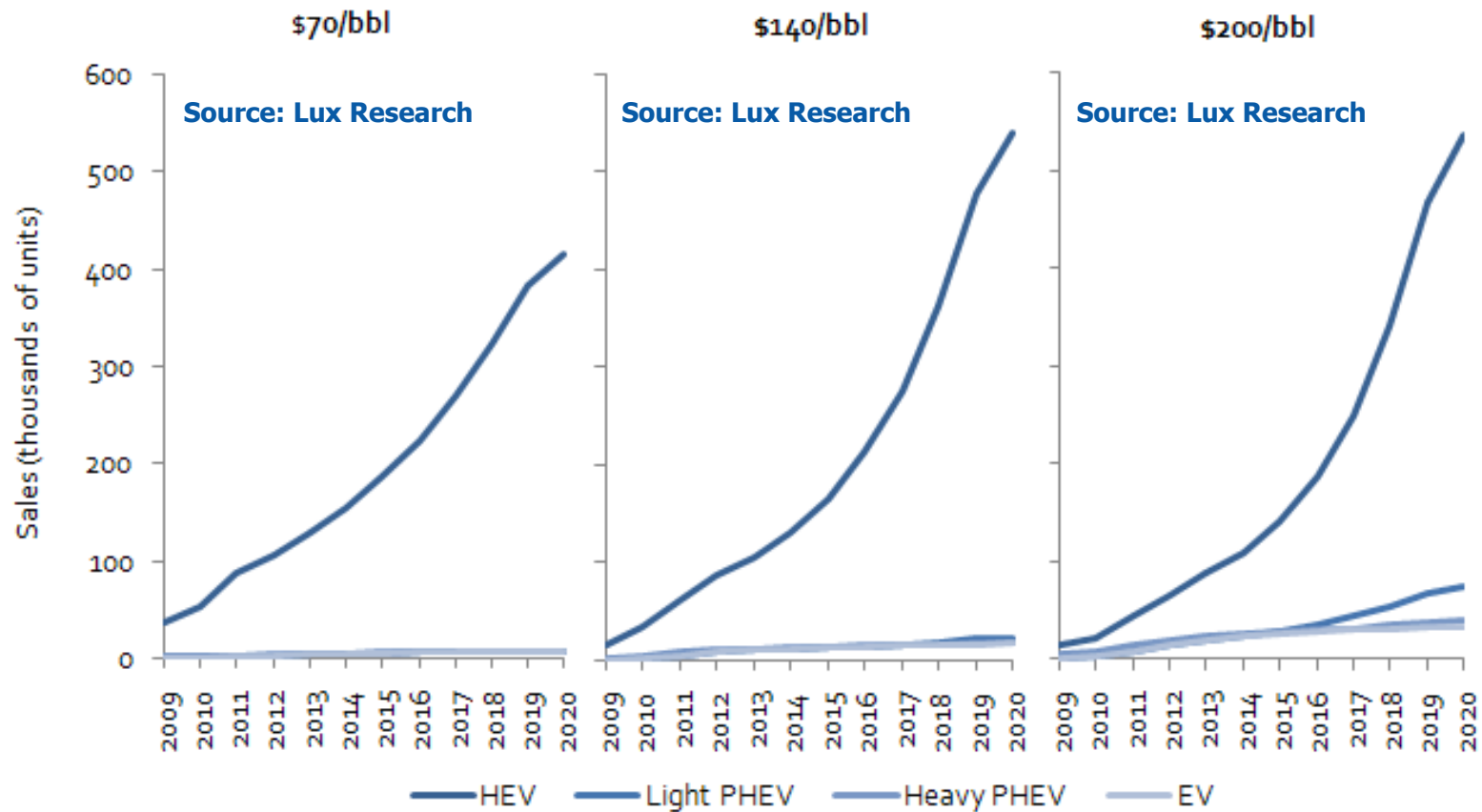
Similarities between Japan and Europe



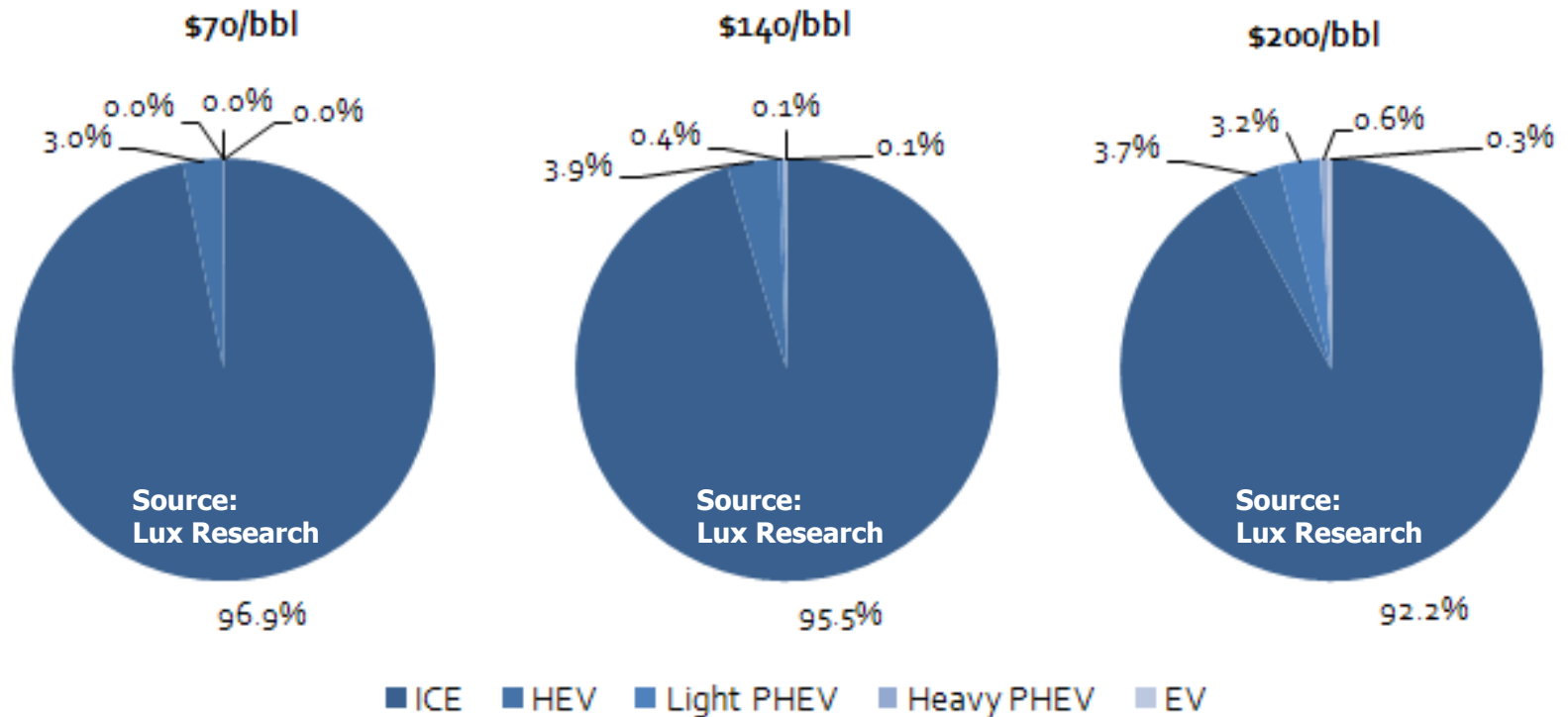
Western European governments move away from PHEV/EVs, leading to high HEV sales



China's conflicting governmental subsidies hurt electric vehicle sales

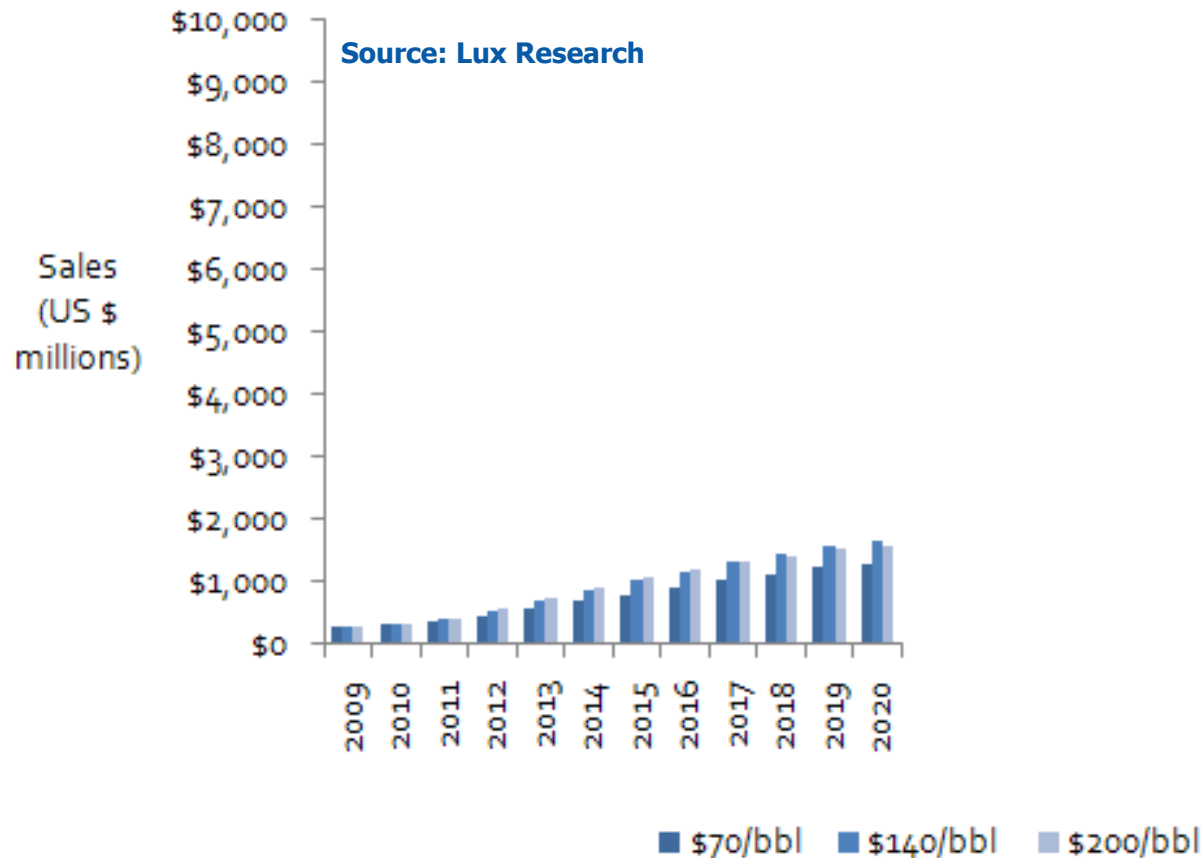


No electric vehicle will threaten ICE vehicles by 2020



Relatively small numbers of PHEV/EVs have large effects on global battery sales

NiMH market



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Outlook

➤ Winning players

- Electric vehicles further separate the automotive haves from the have-nots
- The winning Li-ion battery makers are the ones paired with the winning automakers

➤ Technical issues

- Charging, lifetime, and safety issues surrounding Li-ion are the wildcards
- New technologies could be a game-changer in the long term

➤ Market implications

- A Li-ion battery glut may be looming, creating a boon to Asian e-bike and scooter makers
- Cheaper ICE microcars will arrive in the U.S. poised to profit if electric vehicles stumble
- Micro-hybrids and diesel-powered cars will dominate Europe

➤ Other considerations

- While lithium supply should not be an issue, rare earth metals are another story
- Supporters of electric vehicles will reconsider their investments

Thank you

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