ROBECOSAM
We are Sustainability Investing.

RobecoSAM Smart Mobility | 08/2018
Insight
For professional investors only

Rising currents are lifting EVs to new heights

By 2030 already 1/3 of all cars will be (plug-in) electric vehicles.

Technological advances in energy management and materials together with anti-pollution regulation are paving the way for low to no-emission vehicles. Further out, electrification, autonomous driving and shared mobility will revolutionize both the car and concepts of urban transport.

Bogged in smog

Air pollution is a distressing global topic that has unleashed outrage and action from not only environmentalists but also governments and corporations. Transportation is responsible for about a quarter of global greenhouse gas emissions, with passenger cars and other light vehicles accounting for 17% of the total.[1] In China, one-third of pollution comes from gas and diesel-burning engines and deaths due to air pollution in India and China have already reached a million per annum and continue to rise.[2] Developed and emerging economies face similar crises.[3] The European Environment Agency reported that dirty air resulted in the premature death of nearly half a million EU citizens.

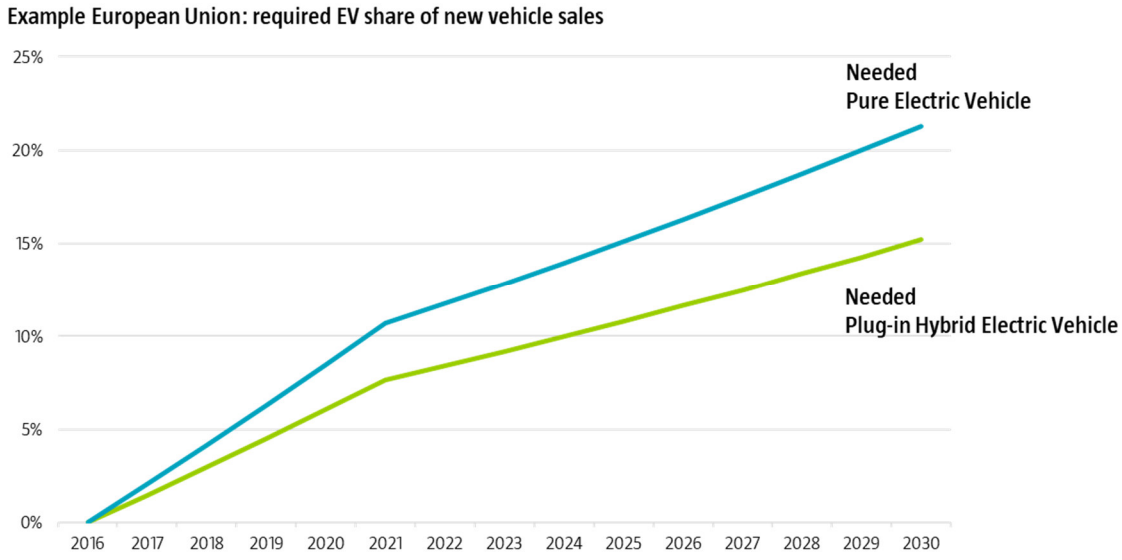
As air quality declines, total economic and welfare costs are rising.

[1] Credit Suisse Connection Series, "Drive Train to Supply Chain," April 14, 2016, p. 40
[2] Financial Times, "India air pollution deaths posed to exceed China's" February 14, 2017
[3] OECD Policy Highlights, Economic Consequences of Outdoor Air Pollution, 2018

As air quality declines, total economic and welfare costs are rising. Population growth and city density are also increasing, exacerbating a problem that is already out of control.

By 2060, the total cost of air pollution will account for 1% of global GDP (up from 0.3% in 2015).[4] Combatting air pollution by targeting automotive transport is gaining momentum among governments worldwide. China is aggressively supporting the Electric Vehicles (EV) market through subsidies and restrictions on petroleum-powered vehicles in smog-choked cities. Similar measures have been introduced in urban settings around the world and are hastening the demise of conventional cars (Figure 1).

Figure 1: Emissions standards—spurring EV uptake



Source: RobecoSAM, ICCT, 2018

Estimates assume fossil fuel car efficiency to improve 1% p.a. and 47g/CO2 per 100 km for Plug-in hybrid EVs

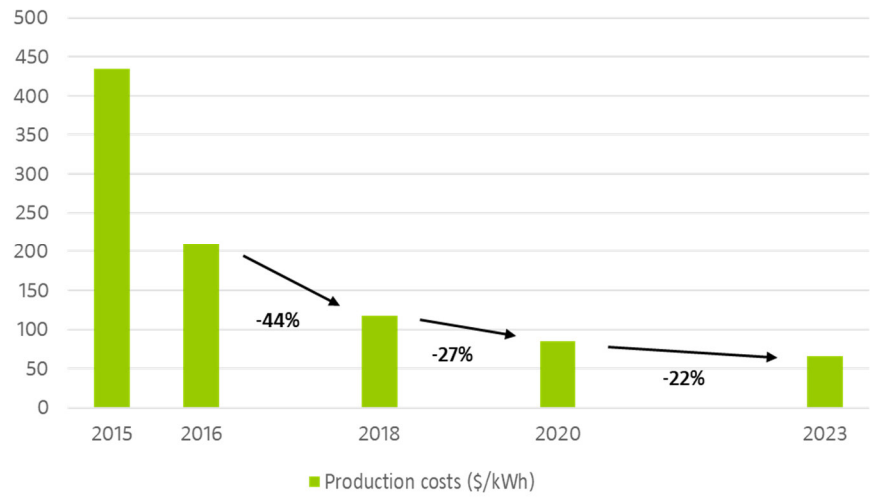
Although incremental improvements in fuel efficiency and exhaust technologies of traditional cars are advancing, the overall costs of carbon emission compliance are rising. As restrictions on ICEs (internal combustion engines) intensify and public awareness of climate change strengthens, EVs are in the crosshairs as a solution for pollution.

Lithium and lightweights

EV ascendency can't be achieved without battery power. Mass production of lower-cost, lighter-weight and energy-dense lithium-ion batteries are essential for charging the EV revolution. Driven by EV sales, RobecoSAM estimates the auto industry will consume 50% of total lithium output by 2020, up from around 18% in 2016. Batteries contribute, on average, to around a third of an EV's total cost and account for the EVs higher price tag.

[4] Ibid

Figure 2: Battery production costs continue to decline

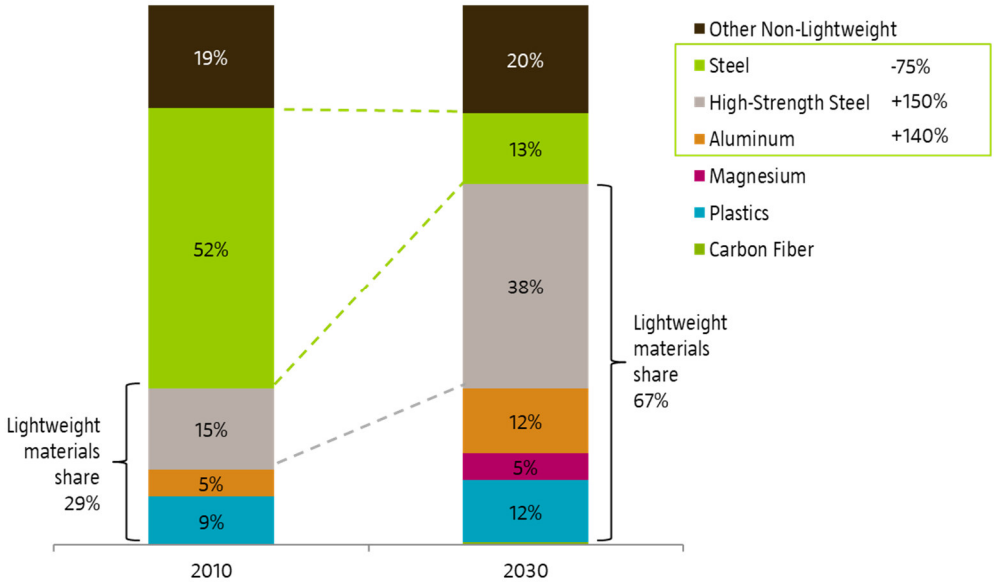


Source : Samsung SDI, BNP Paribas, 2016

Based on pure economics, prices need to fall for EVs to overtake sales volumes of traditional vehicles. Innovation and economies of scale have already driven down the average battery cost to a fifth of 2010 prices and analysts are optimistic that figures will continue to fall rapidly.[5] In fact, early movers, like Samsung and Tesla, are poised to half costs again (to $100 per kWh) by 2020 (Figure 2). Cost parity with traditional cars is expected when battery pack prices fall in the $125-150/kWh range, so a tipping point is fast approaching.[6]

Lithium isn't the only commodity needed to fuel the EV evolution. To maximize fuel efficiency, steel-heavy components of today's cars must be replaced with lighter weight materials like aluminum and polymer composites. Losing weight means gaining distance on less fuel and helps make room for the other essentials like bigger batteries, electronic motors, safety devices and onboard control systems which interface with external networks.

Figure 3: Shedding weight to gain distance — the share of lightweight materials in vehicles is rising



Source: McKinsey, RobecoSAM

[5] Bloomberg, "Electric cars may be cheaper than gas guzzlers in 7 years," 22 March 2018
[6] Howell D. et all, 2016, Overview of the US Dept of Energy VTO Advanced Battery R&D program. Online at https://www.energy.gov/sites/prod/files/2016/06/f32/es000_howell_2016_o_web.pdf

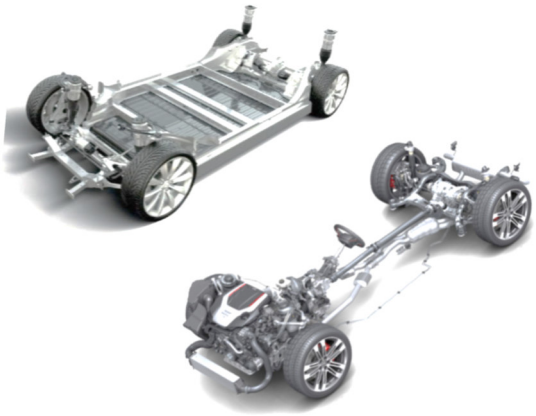
Vehicle Electrification Part 1— overhauling the powertrain

EVs are considerably cleaner and more energy-efficient compared to petrol-powered vehicles—compelling features that will continue to improve with time and technology. But the benefits to consumers extend beyond fuel costs and low emissions. Production and maintenance costs are also sinking thanks to a radically re-engineered powertrain system. The powertrain is the EV's life force that converts battery power into horsepower.

The EV powertrain is structurally simpler and lighter compared to traditional cars resulting in more efficient assembly and lower production costs (See Figure 4). And as production scales up, costs come down. Structural simplicity means fewer breakable parts to service and lower maintenance costs over the life of the car.

Figure 4: Simple & Sleek vs. Complex & Clunky

Electric Powertrain (Top) vs. Conventional Powertrain (Bottom)



Source: Tesla, Audi

Advantages like these are making EVs price-competitive and increasing their mass appeal. Unsurprisingly, automakers have announced ambitious targets for EV models across product line-ups. As these positive forces converge, an inflection point in EV sales is expected early in the next decade.[7]

[7] Bloomberg New Energy Finance, Electric Vehicle Outlook 2017

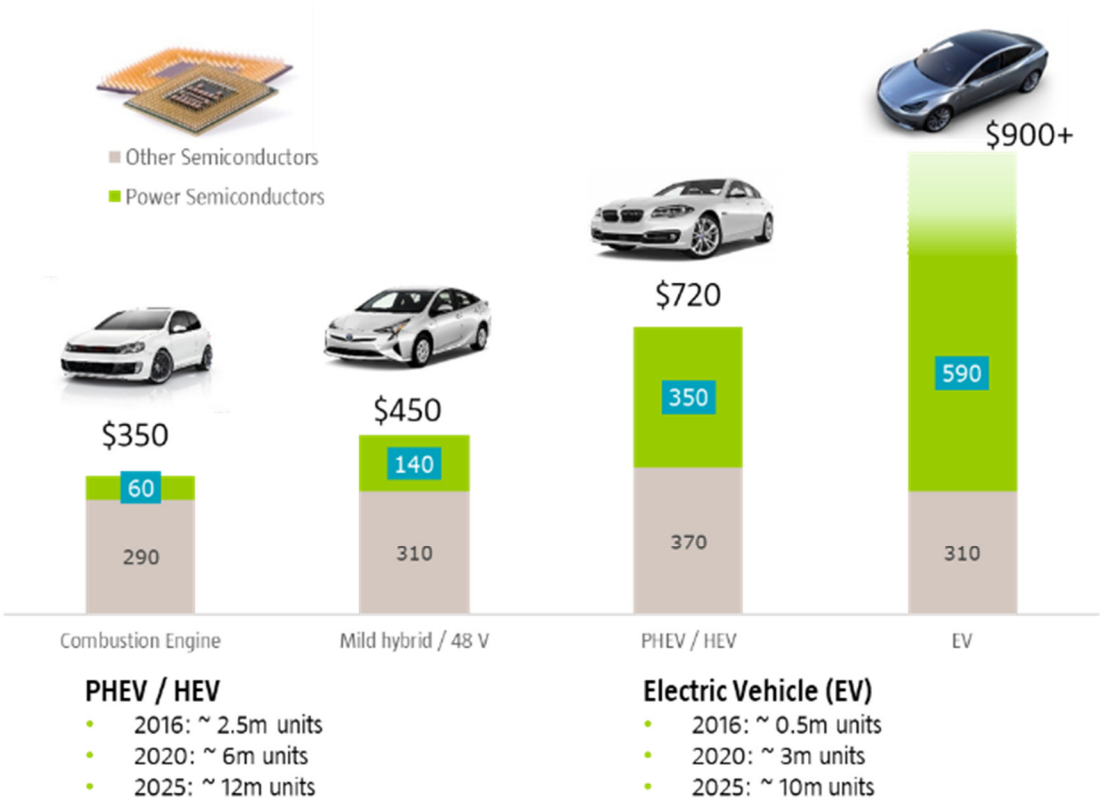
Vehicle Electrification Part 2—powering more than mobility

Electrification will revolutionize mobility quite literally from the inside out, starting with the car's internal design and then shifting to its external interactions within a larger transportation system.

Critical to this second stage of development are the IT technologies that enable cars to communicate information to centralized data hubs to prevent problems and optimize performance. In future, vehicle-to-vehicle (V2V) communication will improve passenger safety and reduce traffic congestion while vehicle-to-grid (V2G) applications will allow EV owners to optimize charging tariffs and help stabilize the energy grid.

Software, sensors and semiconductors are at the heart of this transition. Electric vehicles already have 10x more semiconductor content than traditional vehicles (Figure 5).

Figure 5: Circuits and semiconductors increasing in content



Source: RobecoSAM, company information (excludes ADAS semiconductors)

Conclusion

The demand and sophistication of vehicle electrification will intensify with the acceptance and expansion of autonomous driving. Ultimately, vehicle architecture, manufacturing, and engineering will undergo a complete overhaul. The car of the future will transform from one dominated by pure mechanics, hydraulics and hydrocarbons to one of circuits, silicon and software – a "computer on wheels" with the power to reduce pollution and improve urban life and infrastructure.

"The car of the future will be safe, green and connected. New business models will emerge and change our way of life. The electric revolution has just started. Join us on this electrifying journey!"

Thiemo Lang, PhD

Senior Portfolio Manager
RobecoSAM Smart Mobility

Pieter Busscher, CFA

Senior Portfolio Manager (deputy)
RobecoSAM Smart Mobility

References to specific securities are presented to illustrate our investment philosophy and are not to be considered recommendations. The specific securities identified and described do not represent all of the securities purchased, sold or recommended for advisory clients. It should not be assumed that these securities were or will be profitable.

No warranty This publication is derived from sources believed to be accurate and reliable, but neither its accuracy nor completeness is guaranteed. The material and information in this publication are provided "as is" and without warranties of any kind, either expressed or implied. RobecoSAM AG and its related, affiliated and subsidiary companies disclaim all warranties, expressed or implied, including, but not limited to, implied warranties of merchantability and fitness for a particular purpose. Any opinions and views in this publication reflect the current judgment of the authors and may change without notice. It is each reader's responsibility to evaluate the accuracy, completeness and usefulness of any opinions, advice, services or other information provided in this publication.

Limitation of liability All information contained in this publication is distributed with the understanding that the authors, publishers and distributors are not rendering legal, accounting or other professional advice or opinions on specific facts or matters and accordingly assume no liability whatsoever in connection with its use. In no event shall RobecoSAM AG and its related, affiliated and subsidiary companies be liable for any direct, indirect, special, incidental or consequential damages arising out of the use of any opinion or information expressly or implicitly contained in this publication.

No Offer The information and opinions contained in this publication constitutes neither a solicitation, nor a recommendation, nor an offer to buy or sell investment instruments or other services, or to engage in any other kind of transaction. The information described in this publication is not directed to persons in any jurisdiction where the provision of such information would run counter to local laws and regulation.

Additional information for investors in Italy:
This document is conceived for use solely by qualified investors and private professional clients (as defined in Article 26 (1) (d) of Consob Regulation No. 16190). If it is made available to Distributors and individuals authorised by Distributors to conduct promotion and marketing activity, it may only be used for the purpose for which it was conceived. Therefore, the information set forth herein is not addressed and must not be made available, in whole or in part, to other parties, such as retail clients. RobecoSAM is not licensed to offer investment services or financial instruments into Italy."

Important information

This document has been prepared on a confidential basis solely for the recipient and is for information purposes only. Any reproduction or distribution of this documentation, in whole or in part, or the disclosure of its contents, without the prior written consent of Robeco, is prohibited. By accepting this documentation, the recipient agrees to the foregoing. This document is intended to provide the reader with information on Robeco's specific capabilities, but does not constitute a recommendation to buy or sell certain securities or investment products. Investment decisions should only be based on the relevant prospectus and on thorough financial, fiscal and legal advice. The contents of this document are based upon sources of information believed to be reliable. This document is not intended for distribution to or use by any person or entity in any jurisdiction or country where such distribution or use would be contrary to local law or regulation. Neither the Robeco Capital Growth Funds or other Robeco Funds (the "Fund"), its investment manager nor any of their associates, nor any director, officer or employee accepts any liability whatsoever for any loss arising directly or indirectly from the use of this document. Investment Involves risks. Historical returns are provided for illustrative purposes only and do not necessarily reflect Robeco's expectations for the future. The value of your investments may fluctuate. Past performance is no indication of current or future performance.

Additional notes for Hong Kong investors
This document is for professional investors only. This document has been distributed by Robeco Hong Kong Limited. Robeco Hong Kong Limited is regulated by the Securities and Futures Commission ("SFC") in Hong Kong. The contents of this document have not been reviewed by the SFC in Hong Kong. If you are in any doubt about any of the contents of this document, you should obtain independent professional advice.

Additional notes for Singapore investors
This document has not been registered with the Monetary Authority of Singapore ("MAS"). Accordingly, this document may not be circulated or distributed directly or indirectly to persons in Singapore other than (i) to an institutional investor under Section 304 of the SFA, (ii) to a relevant person pursuant to Section 305(1), or any person pursuant to Section 305(2), and in accordance with the conditions specified in Section 305, of the SFA, or (iii) otherwise pursuant to, and in accordance with the conditions of, any other applicable provision of the SFA. The contents of this document have not been reviewed by the MAS.

This document has been distributed by Robeco Singapore Private Limited. Robeco Singapore Private Limited holds a capital markets services licence for fund management issued by the MAS and is subject to certain clientele restrictions under such licence. An investment will involve a high degree of risk, and you should consider carefully whether an investment is suitable for you. This document is not intended as a recommendation or for the purpose of soliciting any action in relation to the Fund and should not be construed as an offer to sell shares of the Fund (the "Shares") or solicitation by anyone in any.