Melexis Playground for the next 5 Years
Automotive Trends

- Zero Emissions
  - (xHEV & xEV)
- User Experience
  - (Customization)
- Zero Traffic Fatalities
  - (Assisted & Autonomous Drive)
- Communication
  - (V2V - V2I - V2X)
Melexis vs Automotive Trends

Melexis enables edge sensing & edge driving
Melexis vs Automotive Trends

Melexis engineers small, smart Sensing and Driving nodes supporting in-vehicle edge computing systems
Melexis vs Automotive Trends

Powertrain Systems

- Electrification (xHEV & xEV)
- Zero Emissions
- ADAS (Assisted & Autonomous Drive)
- User Experience (Customization)

Chassis, Body & Safety Systems
Powertrain Systems
Powertrain Systems

Growth Driver: Regulations – Emission Norms

Source: ICCT – International Council on Clean Transportation
## Powertrain Systems

**Growth Driver: Regulations – Emission Norms**

<table>
<thead>
<tr>
<th>Euro Norm</th>
<th>5b</th>
<th>6b</th>
<th>6d-temp</th>
<th>6c</th>
<th>6d</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>1 Sep. 11</td>
<td>1 Sep. 14</td>
<td>1 Sep. 17</td>
<td>1 Sep. 18</td>
<td>1 Jan. 20</td>
</tr>
<tr>
<td>Cycle</td>
<td>NEDC</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Conformity factor NOx RDE</td>
<td>2.1</td>
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<td>1.5</td>
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</table>

### Gasoline Engine

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>HC (mg/km)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOx (mg/km)</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO (mg/km)</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM (mg/km)</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM (/km)</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 x 10¹²</td>
<td></td>
<td></td>
<td></td>
<td>6 x 10¹¹</td>
</tr>
</tbody>
</table>

### Diesel Engine

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx (mg/km)</td>
<td>180</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HC + NOx (mg/km)</td>
<td>230</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO (mg/km)</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM (mg/km)</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM (/km)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 x 10¹¹</td>
</tr>
</tbody>
</table>


Source: ACEA – European Automobile Manufacturers Association
Electrification

Recent Press Clippings

EU Parliament proposes tougher CO2 limits on cars and vans
October 4th 2018; Multiple countries | Fuel sources

Parliament voted to raise the targets set by the EU Commission and set new goals for electric vehicle adoption.

Members of the European Parliament approved a draft law on October 3rd that would require vehicle-makers to cut carbon dioxide (CO2) emissions from across their new car and van fleets by 20% by 2025 and 40% by 2030, compared with 2021 levels. The Parliament also wants 35% of new cars sold from 2030 to be low-emission electric or hybrid models, up from just 1.5% in 2017. The interim target for 2025 is 20%.

Chinese electric vehicle market is poised for explosive growth, says expert

- For the next couple of years, the market share of China’s electric vehicles will grow by 40 percent, said Jacob George, vice president and general manager of Asia Pacific at U.S.-based global marketing information services company J.D. Power.
- China has said it aims to see total annual sales of 2 million electric and gasoline-electric hybrid vehicles by 2020 and for manufacturers to at least have one electronic vehicle produced by 2019.

Source: ICCT – International Council on Clean Transportation

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Powertrain Systems

Levels of Electrification

- Internal Combustion Engine (ICE & uHEV)
- 48 Volt Mild Hybrid (mHEV)
- Full Hybrid (fHEV)
- Plug-In Hybrid (pHEV)
- Electrical Vehicle (BEV - FCEV)

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Powertrain Systems

Electrification – Segmentation – Market Split

Source: Strategy Analytics
# Powertrain Systems

## Electrification – Segmentation – TAM

### Market CAGR

<table>
<thead>
<tr>
<th>CAGR</th>
<th>Market (Millions Cars)</th>
<th>Powertrain Systems</th>
<th>TAM for Melexis (Total Available Market - # ICs/car)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2%</td>
<td>90</td>
<td>Internal Combustion Engine (ICE &amp; uHEV)</td>
<td>#24 #31</td>
</tr>
<tr>
<td>+42%</td>
<td>81.5</td>
<td>48 Volt Mild Hybrid (mHEV)</td>
<td>#37 #45</td>
</tr>
<tr>
<td>+16%</td>
<td>11.5</td>
<td>Full Hybrid (fHEV) Plug-In Hybrid (pHEV)</td>
<td>#50 #58</td>
</tr>
<tr>
<td>+25%</td>
<td>4</td>
<td>Electrical Vehicle (BEV - FCEV)</td>
<td>#41 #44</td>
</tr>
</tbody>
</table>

### Market

<table>
<thead>
<tr>
<th>Year</th>
<th>CAGR</th>
<th>Total</th>
<th>Weighted TAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>+2%</td>
<td>97.5</td>
<td>#26</td>
</tr>
<tr>
<td>2023</td>
<td></td>
<td>106</td>
<td>#35</td>
</tr>
</tbody>
</table>

Source: Strategy Analytics and Melexis estimates
ICE + uHEV

- Down-sized Engine (GDI, Turbo)
- Thermal Management
- Start-Stop Unit
ICE + uHEV
mHEV

- Down-sized Engine (GDI, Turbo)
- Thermal Management
- 48 V Starter-Generator Unit
- e-Turbo
- Battery Monitoring
- DC/DC Converter (48-to-12)

mHEV

https://www.continentalautomotive.com/en-gb/Passenger-Cars/Powertrains/Electrification
48-Volt-Mild-Hybrid/48-Volt-Auxiliaries/48V-e-Compressor
fHEV + pHEV

- Down-sized Engine (GDI, Turbo)
- Thermal Management
- High-Voltage Inverter
- Battery Monitoring
- DC/DC Converters
- On-Board Charger (OBC)
fHEV + pHEV

ACDC inverter (onboard charger)

DCAC inverter (eAxle)

12v battery

HV battery

DCDC converter
• Thermal Management
• High-Voltage Inverter(s)
• Battery Monitoring
• DC/DC Converters
• On-Board Charger (OBC)
Chassis, Body & Safety Systems
# Chassis – Body – Safety Systems

## SAE Automation Levels (SAE J-3016)

<table>
<thead>
<tr>
<th>Level</th>
<th>Automation Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>Zero autonomy; the driver performs all driving tasks.</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.</td>
</tr>
</tbody>
</table>

Source: Society of Automotive Engineers (SAE)
Chassis – Body – Safety Systems

Segmentation - TAM

<table>
<thead>
<tr>
<th>Market CAGR</th>
<th>Market (Millions Cars)</th>
<th>Car Segments</th>
<th>Chassis - Body - Safety Systems</th>
<th>Weighted TAM for Melexis (Total Available Market - # ICs/car)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+3%</td>
<td></td>
<td></td>
<td>Chassis - Steering</td>
<td>#9</td>
</tr>
<tr>
<td>+1%</td>
<td></td>
<td></td>
<td>Chassis - Braking</td>
<td>#12</td>
</tr>
<tr>
<td>+3%</td>
<td></td>
<td></td>
<td>Chassis - Suspension</td>
<td>#11</td>
</tr>
<tr>
<td></td>
<td>Low-End</td>
<td></td>
<td>Chassis - (Passive) Safety</td>
<td>#42</td>
</tr>
<tr>
<td></td>
<td>Mid-End</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High-End/Premium</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>#6</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>#9</td>
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<td>#6</td>
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<td>#9</td>
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<td>#9</td>
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<td>#14</td>
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<tr>
<td></td>
<td>2018</td>
<td>Total</td>
<td></td>
<td>#68</td>
</tr>
<tr>
<td></td>
<td>97.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2023</td>
<td></td>
<td></td>
<td>#115</td>
</tr>
</tbody>
</table>

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• Market Trend = ADAS
• Market Trends = ADAS, Electrification
Body - Lighting

• Market Trends = Personalization, ADAS & Electrification

Body - HVAC

- Market Trends = Electrification & ADAS
• Market Trends = ADAS & Personalization
Body – Others ➔ Power Tailgate

• Trend = Personalization

Source visual: Youtube: X5 Rear Hatch | BMW Genius How-To
Body – Others ➔ Time-of-Flight/3D

- Market Trends = ADAS & Personalization

Source visuals: BMW - Melexis
(Passive) Safety

- Market Trends = ADAS
Melexis inside...
Tesla Model 3

* Chassis - Body - Safety (19)
* Powertrain (9-10)

- HVAC airco flap (x1)
- Rain light sensor (x1)
- Seat belt buckle (x5)
- Seat positioning sensor for airbags (x1)
- EV inverter (up to x5 - x6)
- Child seat belt position module (x3)
- Battery monitoring (x2)
- Door handle wake-up switch (x4)
- Cooling actuator - Water valve (x1)
- Water pump (x1)
- Height sensor (x4)
BMW 530e

* Chassis - Body - Safety (>30)
* Powertrain (11)

- Time-of-flight for gesture control
- Multimedia GPU cooling fan
- Fragrance fan
- RainLight for automatic wipers
- Interior ambient lighting
- LIN switches
- Anti-theft protection
- EV inverter
- Seat motor
- Seat belt buckle
- Window lifter

Variable geometry turbo
Electric waste gate actuator
Water valve
Oil pressure sensor
Lambda sensor
Grille shutter
Engine cooling fan
Water pump (BLDC)

Headlight LED matrix mirror adjustment
SensorEye for laser headlight
LED headlamp fan

Brake booster
High pressure brake sensor interface

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Conclusion
## Conclusion

<table>
<thead>
<tr>
<th></th>
<th>Market CAGR</th>
<th>Market (Millions Cars)</th>
<th>Chassis - Body - Safety Systems</th>
<th>Weighted TAM for Melexis (Total Available Market - # ICS/car)</th>
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<tbody>
<tr>
<td><strong>Powertrain</strong></td>
<td>+2%</td>
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<td>#26</td>
<td>#115</td>
</tr>
<tr>
<td><strong>Chassis - Body - Safety</strong></td>
<td></td>
<td>Total</td>
<td>Weighted TAM</td>
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</tr>
<tr>
<td></td>
<td>106</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2023</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Take-Away

Melexis enables 
edge sensing & edge driving

We are all geared up, on our way to 20 ICs/car