

Power electronics  
for EV/HEV 2016:  
market, innovations  
and trends



# Report's presentation

---





- Provide updated market metrics and forecasts for electrified vehicles
- Analyze the differences between geographical areas, the incentives and the brakes for market growth
- Present main technological trends and ongoing developments for power electronics targeting automotive at each level (inverter, power module, power device)
- Provide updated market metrics and forecasts for power electronics (split by type of electrified vehicle)
- Present batteries evolution and its impact on power electronics
- Analyze business models evolution and supply-chain moves

# TABLE OF CONTENTS



• Glossary	4	• Innovations at module level: power packaging and integration	125
• Report objectives	5	• Power devices: silicon and WBG	149
• What we got right, what we got wrong	6	• Energy storage: a key challenge to face	165
• Companies cited in the report	7	Batteries in electrified vehicles	166
• Executive Summary	8	Fuel cell vehicles	178
• News wrap-up	25	• Business model, supply-chain and leaders	185
• Market evolution for electrified vehicles	30	• Innovations and evolution perspectives	195
Different types of vehicles and their market	31	• Conclusion	200
What made the market grow in the last years?	44	• Related report and events	203
What are the remaining brakes for electrified cars growth?	54	• Company presentation	205
Future and perspectives for electrified vehicles	60		
What about Chinese market?	65		
• Power electronics and EV/HEV	77		
• Technology evolutions	90		
Power density increase inside electrified vehicles	91		
Innovations at inverter level: topology and mechatronics	96		

# ABOUT THE AUTHORS

## Biography & contact



### **Coralie Le Bret**

Coralie Le Bret has been an analyst in power electronics and compound semiconductor technologies since 2014, at Yole Développement, the "More than Moore" market research and strategy consulting company. She graduated from INSA Lyon with an engineering degree in material sciences, specializing in semiconductors and microelectronics. At Yole Développement she is in charge of electro-mobility, and she uses her expertise on materials and semiconductors to follow power devices and power packaging evolution.

**lebret@yole.fr**

# COMPANIES CITED IN THE REPORT



AVL, BAIC, Beiqi, BMW, Bolloré, Bosch, BYD, Changan Automobile, Chery, Continental, CRRC/Dynex, Daimler, Delphi, Denso, Dongfeng, Elaphe, Faraday Future, DAW, Fiat, Ford, Fuji Electric, Geely, General Motors, Google, Great Wall Motors, Hitachi, Honda, Huanghai, Hyundai, Infineon/International Rectifier, JAC, Kandi, Kia, Macmic, Michelin, Mitsubishi Electric, Mitsubishi Motors, Nissan, Oak Ridge National Laboratory, Porsche, Protean, Renault, SAIC, Schaeffler, Semikron, Siemens, ST Microelectronics, Tesla Motors, Tianjin Qingyuan Electric Vehicles, Toshiba, Toyota, Uber, Valeo, Volkswagen, Volvo, Wanxiang Electric Vehicles, Zotye



# Report's extract

---



- Renault and Dongfeng announced partnership to produce electric Fluence-based car for China
- BYD announced partnership with ASMC to produce their own IGBTs
- Toyota revealed its plan for fuel-cell vehicles: target is 30,000 hydrogen fuel cell cars sales annually by 2020
- Honda unveiled the world premiere of its fuel-cell vehicle, with start of sale forecasted for March 2016
- California announced the target of 100% zero-emission vehicles sales by 2050
- Daimler presented its fuel-cell car at Tokyo Motor Show (prototype)
- Local Motors company (US) presented its 3D printed electric car, the LM3D Swim
- Audi, BMW, Daimler, Porsche, Volkswagen and others are part of 150kW charIN CCS fast charge initiative
- China's Government announced the target of 5,000,000 charging spots by 2020
- Volkswagen announced the increase of invest dedicated to electrification by €100M for 2016
- Cadillac CEO announced that most of new models will get PHEV version
- BMW announced an acceleration of efforts on plug-in electric cars in order to meet CO<sub>2</sub> emission limits
- Canada's Government granted a \$20 million help for public charging infrastructure development
- Fuel-cell technology got a \$35 million boost from US Energy Department



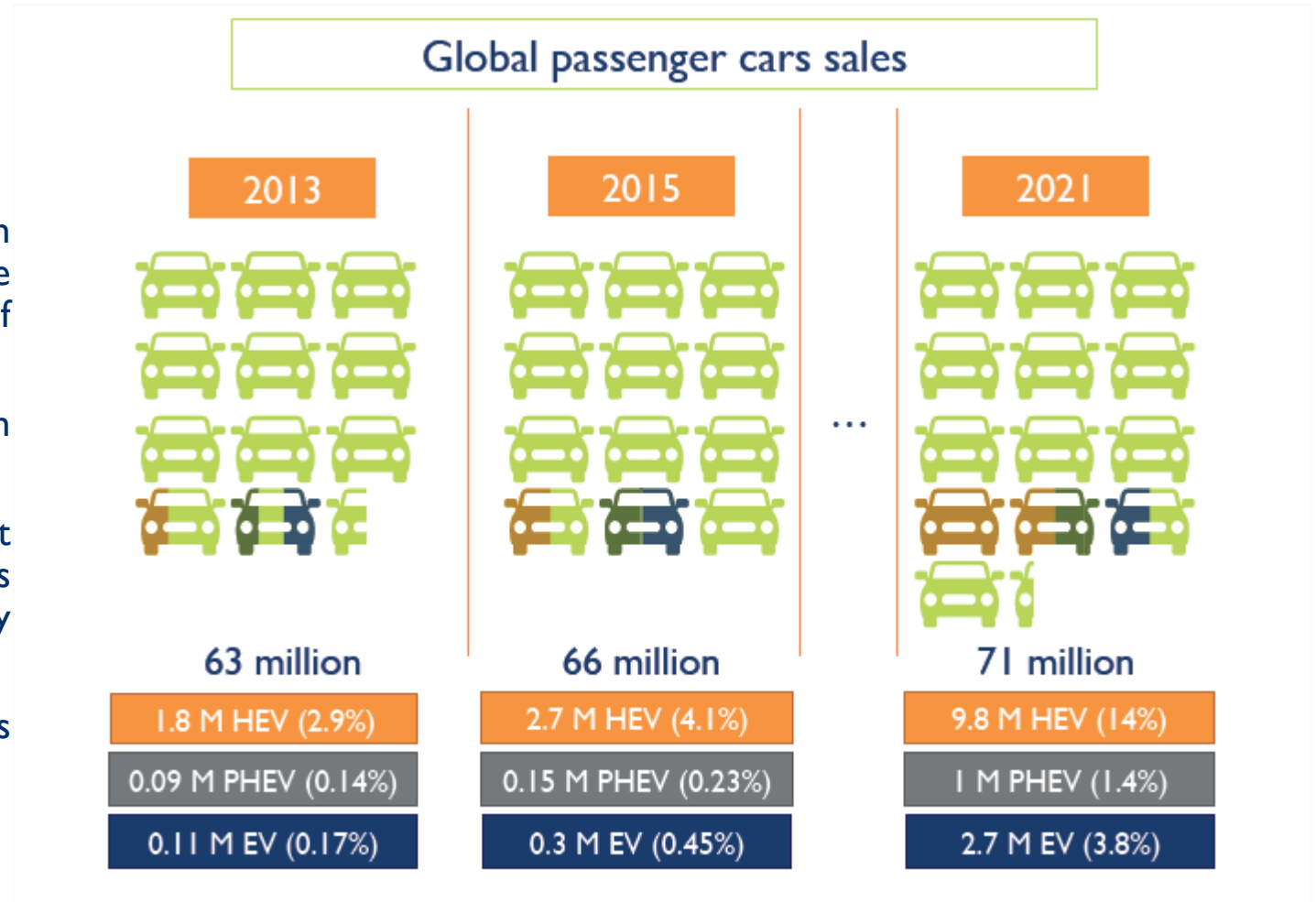


# DIFFERENT TYPES OF VEHICLES AND THEIR MARKET

## What about electrified cars?

According to Yole estimations, full electric cars should hit the 1% market shares by 2017-2018

- Even if the first electric car was born at the beginning of 20<sup>th</sup> century, the first representative sales of electrified cars started in 2013
- Since that year, vehicle electrification is growing
- Between 2014 and 2015, the amount of full electric cars sold was multiplied by 2, which is very encouraging for the future
- By 2021, we expect electrified cars to represent almost 20% of the sales

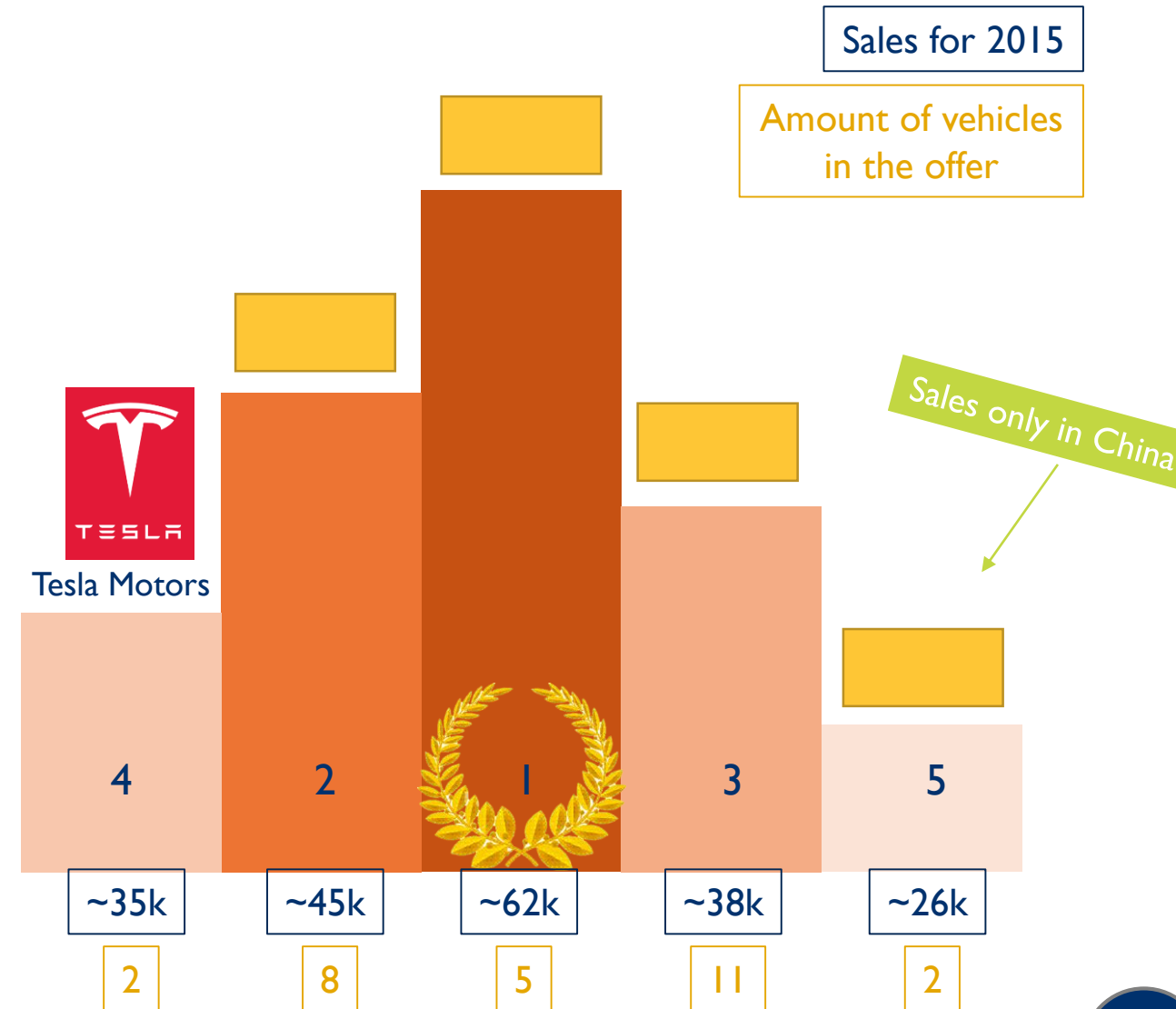


# DIFFERENT TYPES OF VEHICLES AND THEIR MARKET

## Top electric vehicles companies in 2015 (for EV+PHEV)

- Depending on the geographical area and on the type of electrification that is the most common (full EV or PHEV), different car makers are leading the market
- In China, almost all electrified cars sold are made by Chinese companies (otherwise there is no incentive from the state). Considering the huge weight of China in electrified cars market, 2 of the 5 leading companies are Chinese
- Toyota, pioneer of electrification, is not part of the top 5 mainly because of delay on launching of the new Prius
- Although the company provided only one vehicle for most of the year, Tesla Motors' success is confirmed by a 4<sup>th</sup> place in the 2015 ranking

China's weight is so big that 2 of the 5 leading companies for EV+PHEV are Chinese



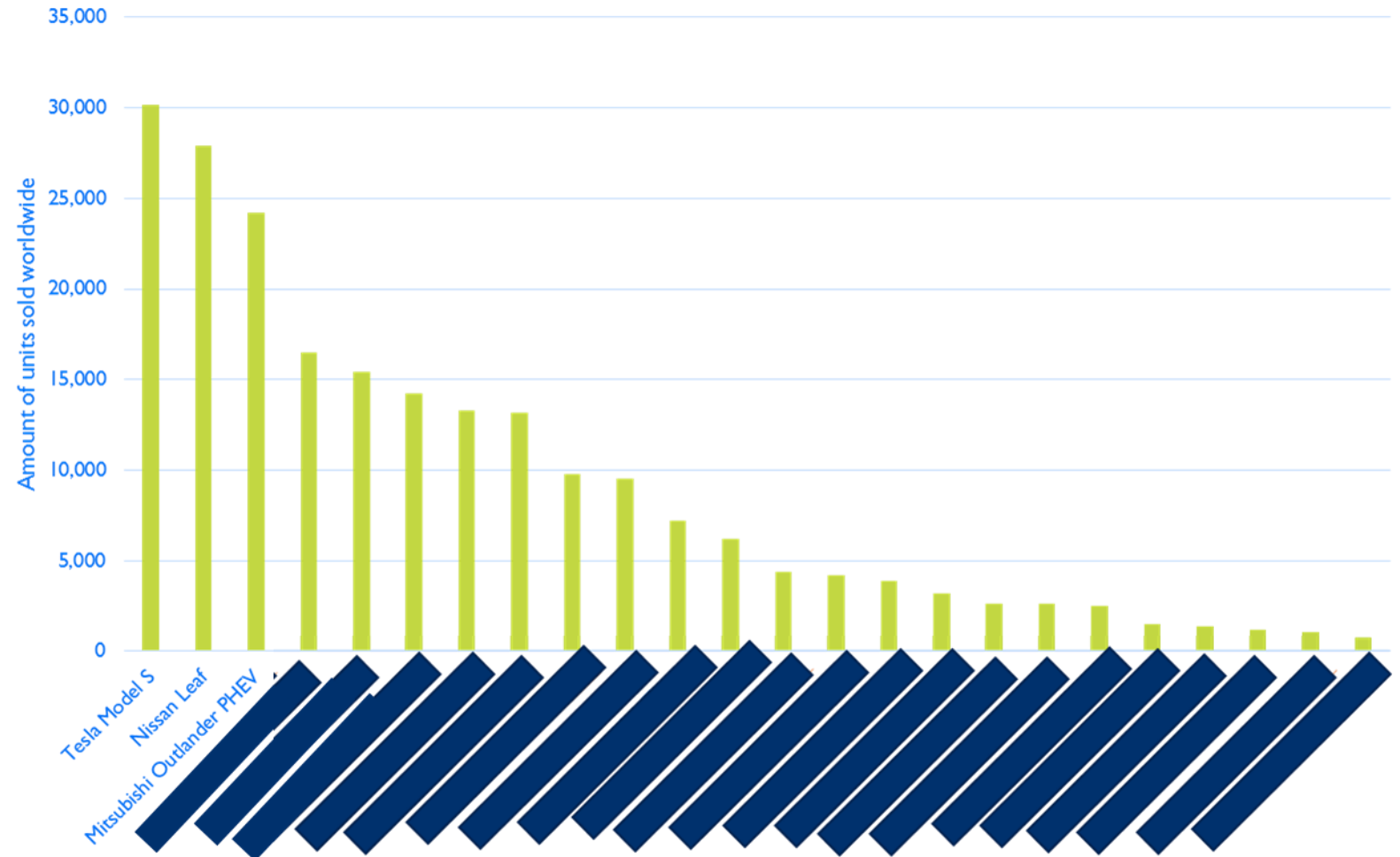
# DIFFERENT TYPES OF VEHICLES AND THEIR MARKET

## Ranking for EV and PHEV sold in 2015, China excluded

Despite the high selling price, Tesla Model S is leading the market

- **Xxx** was the most popular EV in 2015 despite being a “luxury car”
- **Xxx** is still a sure value with more than 25,000 units sold
- **Xxx** became the most sold PHEV in 2015, and its growth could be even higher as it was not sold in the US in 2015

Leading models of EV and PHEV in 2015, China excluded

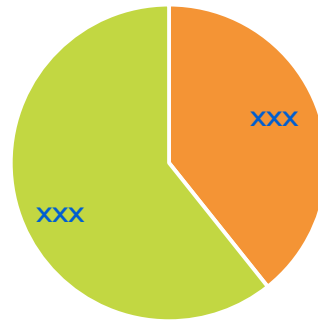


## Importance of China for electrified vehicles future

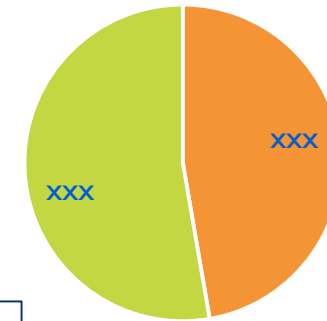
China market shares for electric vehicles will grow strongly in the future, especially for public transportation

- In 2015 China already represented **xxx%** of the market for electric vehicles (EV+PHEV, in Units). Chinese Government's helps and dynamism of this market will help it grow in the future, to reach almost the half of the market by 2020
- Public transportation in China is very common in China and especially buses. Aggressive targets in terms of CO<sub>2</sub> reduction makes China the leading country for electric buses. This trend should confirm in the coming years, and we expect China to have almost 90% of electric bus market by 2020

Passenger cars - 2015



Passenger cars - 2020

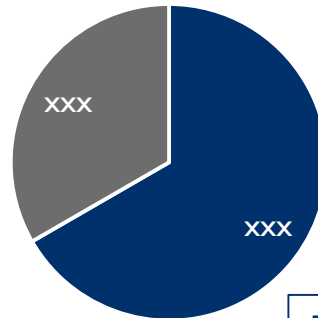


ROW

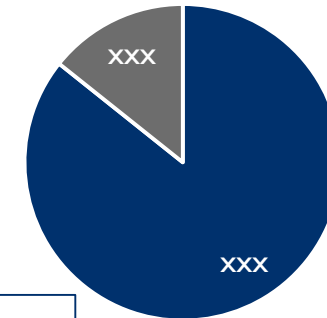
China

Figures given for EV+PHEV

Bus - 2015



Bus - 2020



ROW

China

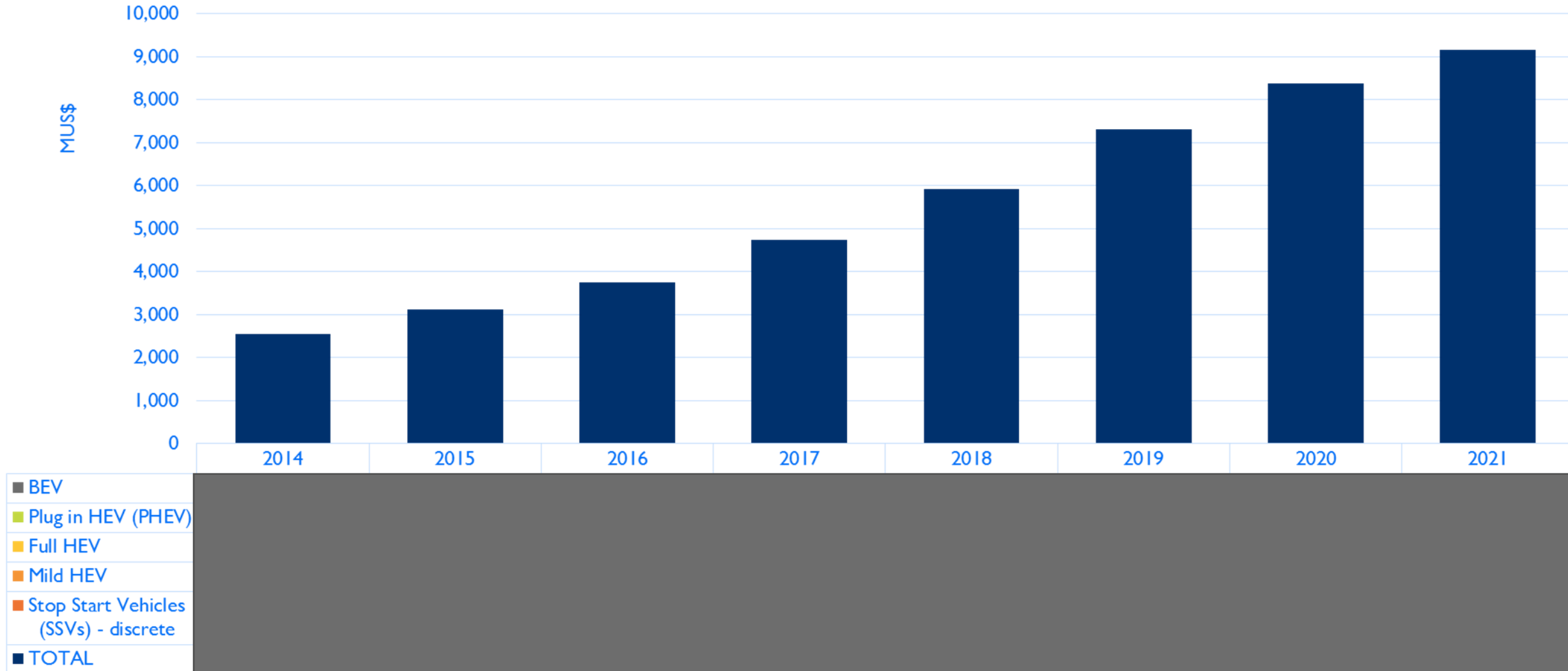
Figures given for full electric buses

Source for Chinese figures: Status of the Chinese Power Electronics Industry report, 2015



## Inverter market and forecasts for electrified vehicles (in M \$)

EV/HEV inverter market by type in MUS \$





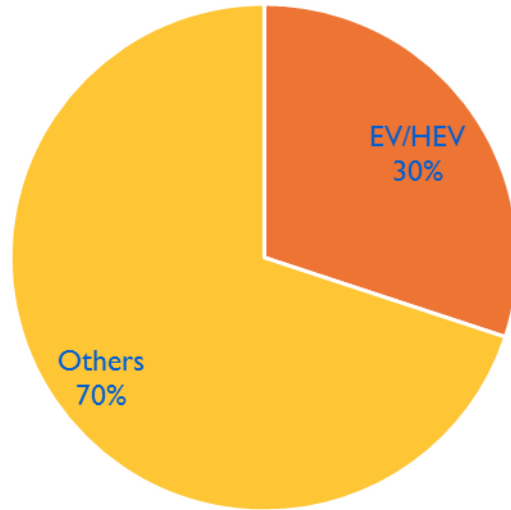
# POWER ELECTRONICS BUSINESS UPDATE



Part of EV/HEV in overall power module market – evolution between 2015 and 2021

EV/HEV will take important shares in power module market to finally represent half of the market by 2021

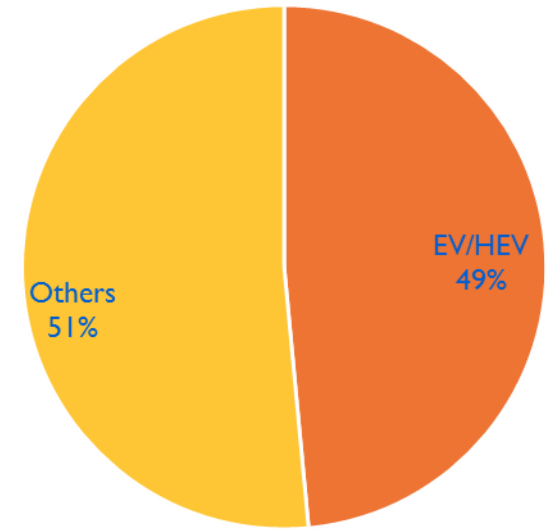
Shares represented by EV/HEV at power module level as of 2015 (in M\$)



Total: \$xxxB



Shares represented by EV/HEV at power module level as of 2021 (in M\$)



Total: \$xxxB

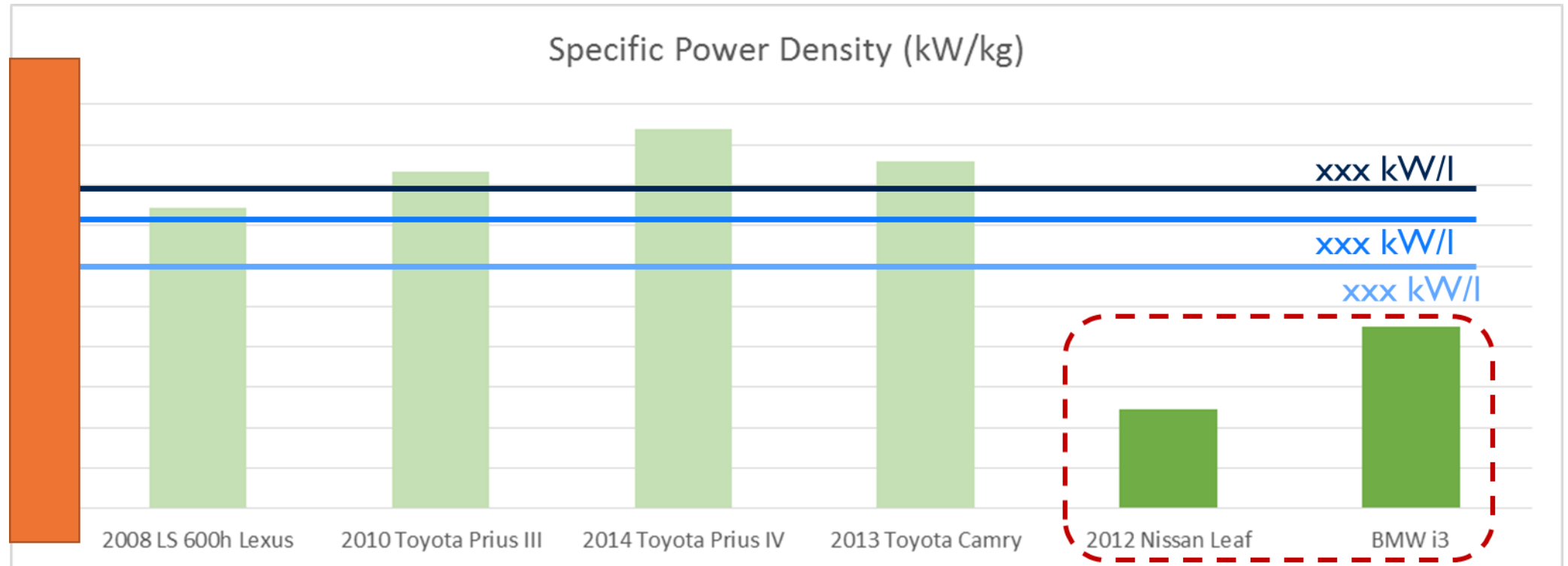
Power modules considered here are mostly IGBT modules, as it is the mainstream for EV/HEV. Some MOSFET modules are also used for lower powers, and by 2021 we expect that some SiC modules will enter the market.

# SPECIFIC POWER DENSITY

## EV/HEV examples - kW/kg

DOE Targets: — 2025  
— 2020  
— 2015

- Inverter's power density without taking into account the DC/DC boost:



■ Hybrid vehicles  
■ Full electric vehicles

More efforts need to be done on the **BEV segment** to attain the targets presented by the DOE

Concerning the specific power density, here again, hybrid vehicles show the highest values.

Presentation of different topologies and innovations at inverter level

### MECHATRONICS TRENDS Summary

- **Motor + inverter integration** is already a reality for mild hybrids, and in the future it could arrive to BEVs too.
- While PHEV and full HEV segments will focused on **reducing the size of their all-power electronics-in-one box** and maybe sharing the same cooling loop as the ICE motor.

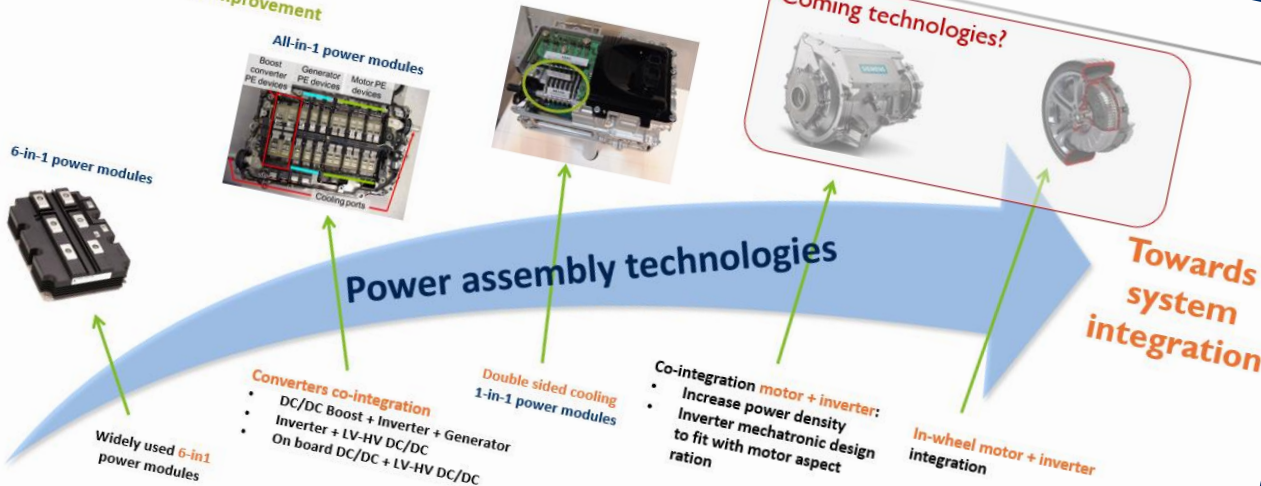
### TOPOLOGY AND INVERTERS AC/DC chargers (PHEV + EV)

- Function
  - Generates a DC current from the AC grid to charge the high power automotive battery (250 – 400V).

### TOWARDS SYSTEM INTEGRATION

Main evolutions in power electronics:

- Improved cooling
- Higher power density
- Mechatronic improvement



**In-wheel drive**  
for niche markets

Future trends?

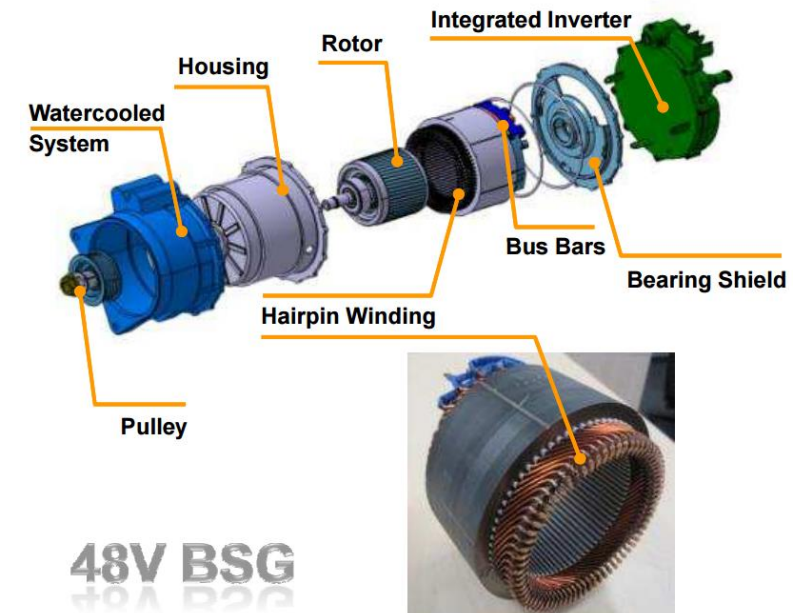
### High integration is achieved with motor-inverter mechatronics in mild hybrid vehicles.

- So far, the integration of power converters on the electric motor housing has just been seeing **in mild hybrid cars**, as low powers are involved (5-15kW).
  - This integration between the electric motor and the inverter **will be a strong trend for this category of electrified vehicles**.
- The electric motors are considered an auxiliary help for the ICE traction (belt-connection mainly).
- **Continental** provides a motor-inverter solution of permanently 5kW power (peak 13kW), for a 48V mild hybrid architecture.
  - The weight of the whole is 12kg.
- The mild hybrid **Volkswagen Golf TSI** is using this technology from **Continental**.

The 48V mild hybrid architecture is wide spreading among car OEMs and in several cases, they are using motor + inverter integrated solutions.



Continental's 5kW (max. 13kW) motor + inverter used by Volkswagen

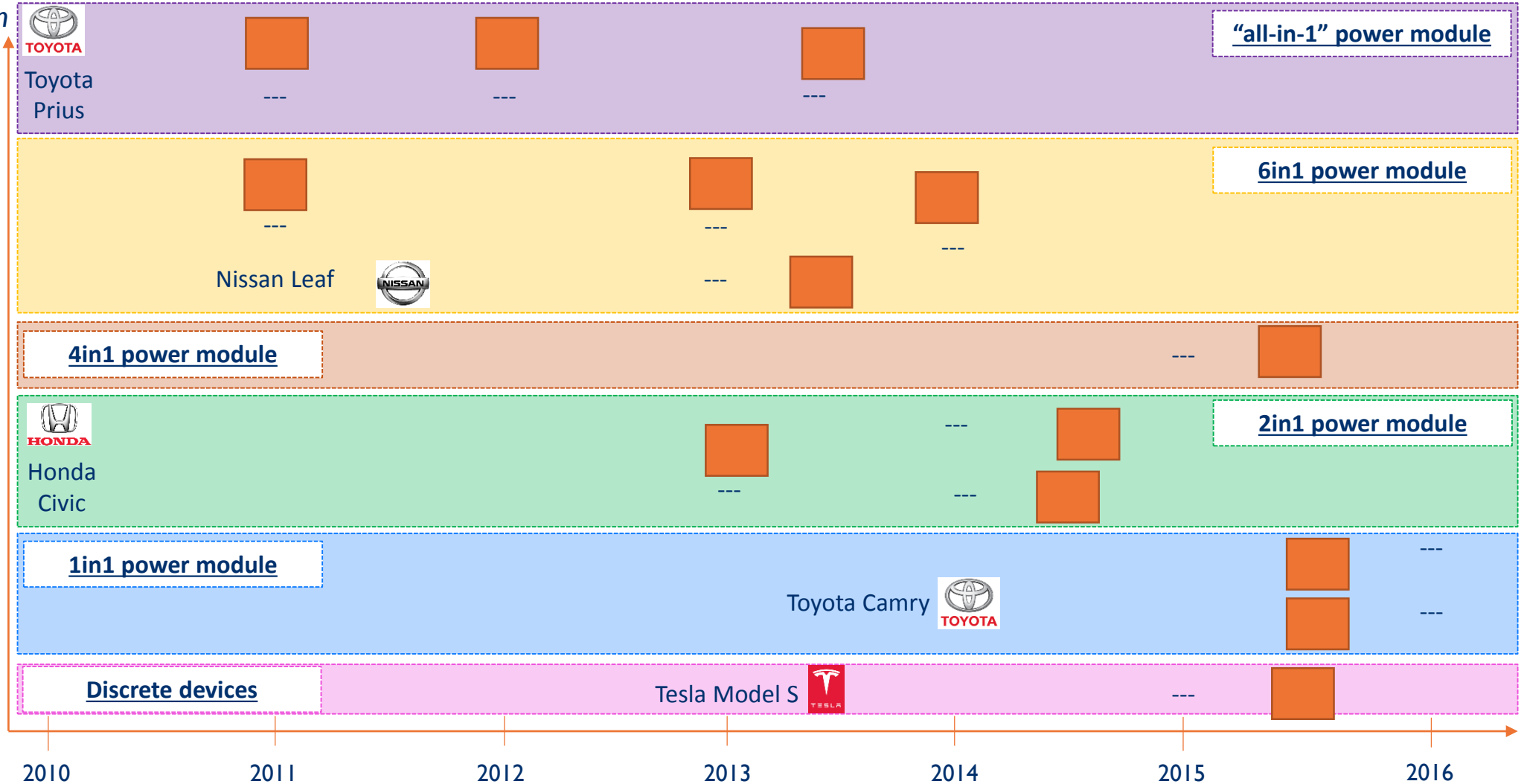


# POWER MODULE LEVEL

## Power module types and positioning of manufacturer

Amount of switches in  
1 module

Each car manufacturer has specific strategy, and power module chosen can depend on the car model. Generic trend seems to be reducing the amount of switches in the module



2008

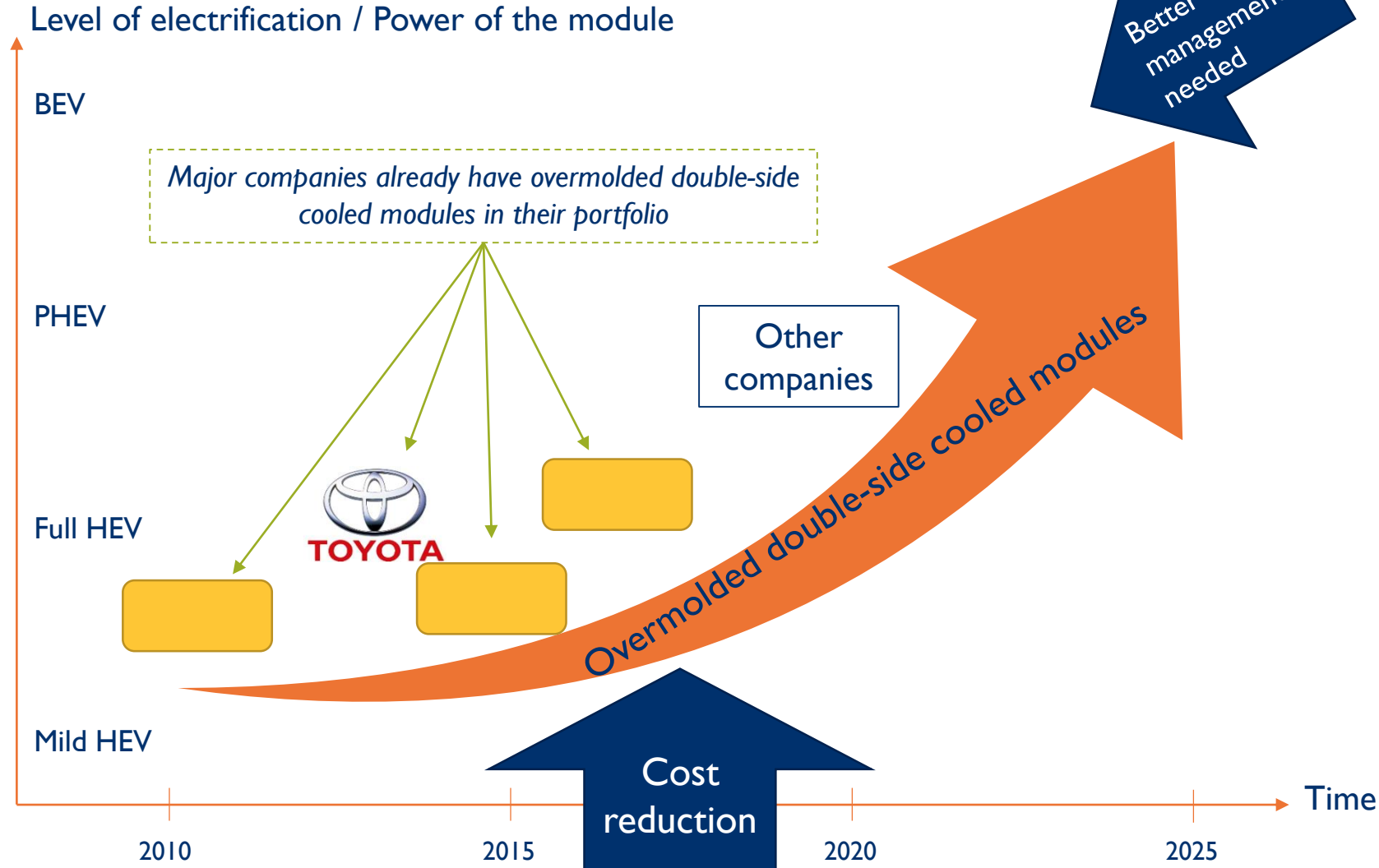


# POWER MODULE LEVEL

## Overmolded modules and double side cooling: a future generalization?

Double side cooling fits well with overmolded modules. Considering the context, we expect those modules to spread in the future

- Overmolding modules were first used thanks to their low cost, especially in hybrid vehicles
- Double-side cooling allows a better thermal management in a reduced volume, which is a key constrain in hybrid vehicles
- In the other hand, with increase of junction temperature, thermal management is also key for full electric vehicles. Cost pressure is also very strong on this segment
- We are confident in a strong development of overmolded double-side cooled modules in the future



# POWER DEVICES: SILICON AND WBG

## Device types and power levels: opportunities for WBG

Could be replaced by WBG

Converters	SSV	Mild HEV	Full HEV	PHEV (with EREV)	EV (BEV or FCV)
1. Start/stop module	MOSFET 1.5 to 10kW Av: 3.5kW				
2. DC/DC converter 14V (to		MOSFET – 1.5 / 3kW – Av: 2.25kW			
3. DC/AC inverter ( + DC/DC booster option )		MOSFET or IGBT 5 / 20kW Av: 15kW	IGBT – 20 / 150kW Av: 70kW		
4. Generator			IGBT – 20 / 40kW Av: 30kW		
5. Battery charger				MOSFET - 3/6kW – Av: 4.5kW and then IGBT - 10 / 20kW – Av: 15kW	
Total average power / car	3.5kW	17.25kW	52.25kW	56.75 to 102.5kW (for a single motor setup)	

WBG devices could replace Si-based IGBTs and MOSFETs in EV/HEV applications.

These applications are specific to EV/HEV. Standard ICE power device applications such as oil pump, steering, braking and HVAC are not considered. Auxiliary inverters have not been considered because they use few power devices.

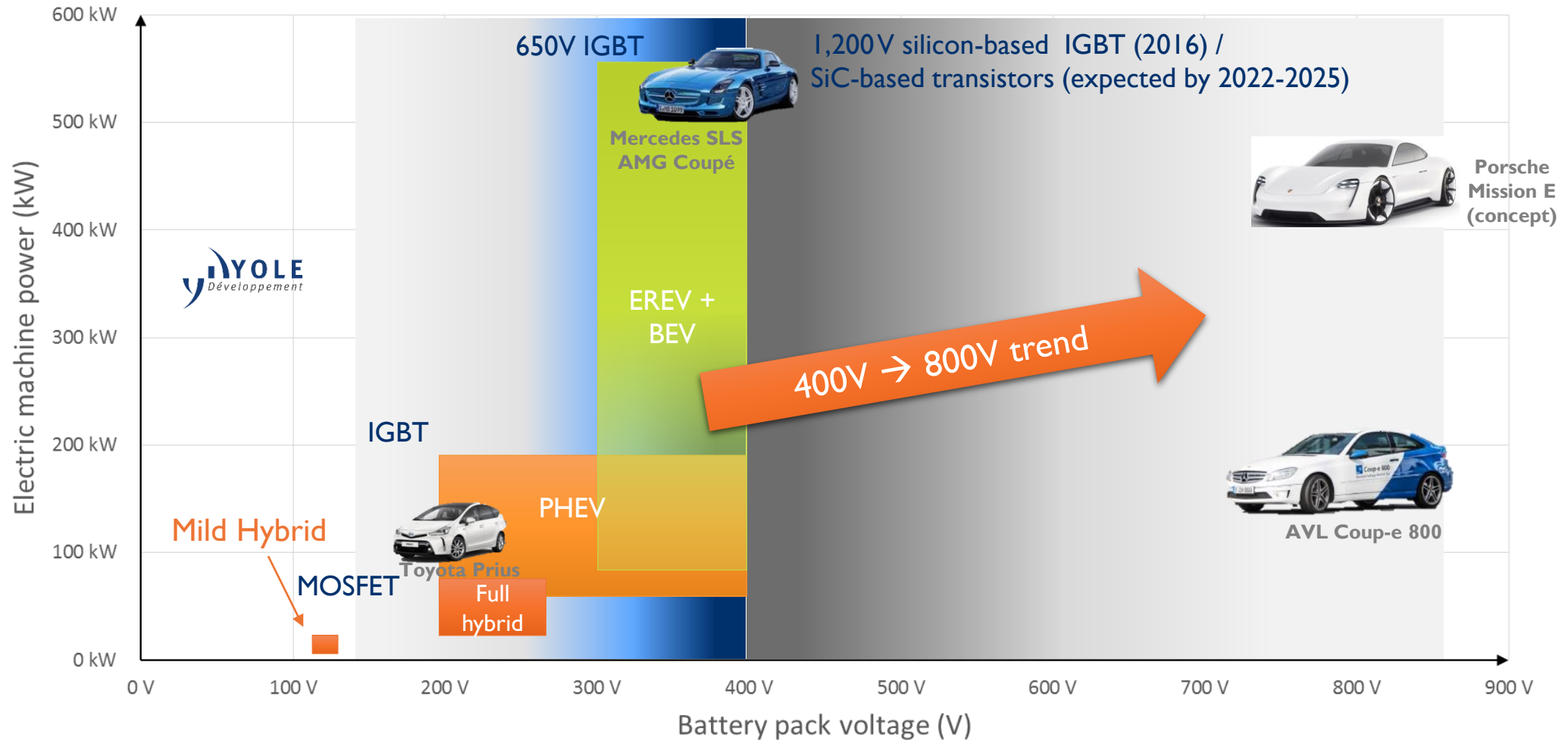
# BATTERIES IN ELECTRIFIED VEHICLES

## Different battery voltage levels in EV/HEV cars

Most EV/HEV cars batteries are based on the voltage level of about 350-400V

Only two 800V battery vehicles have been identified, of which one is at a concept stage only

HV battery can open the field to use of 1,200V IGBTs and increased use of SiC components



Overview of recent EV/HEV and the related power electronic components

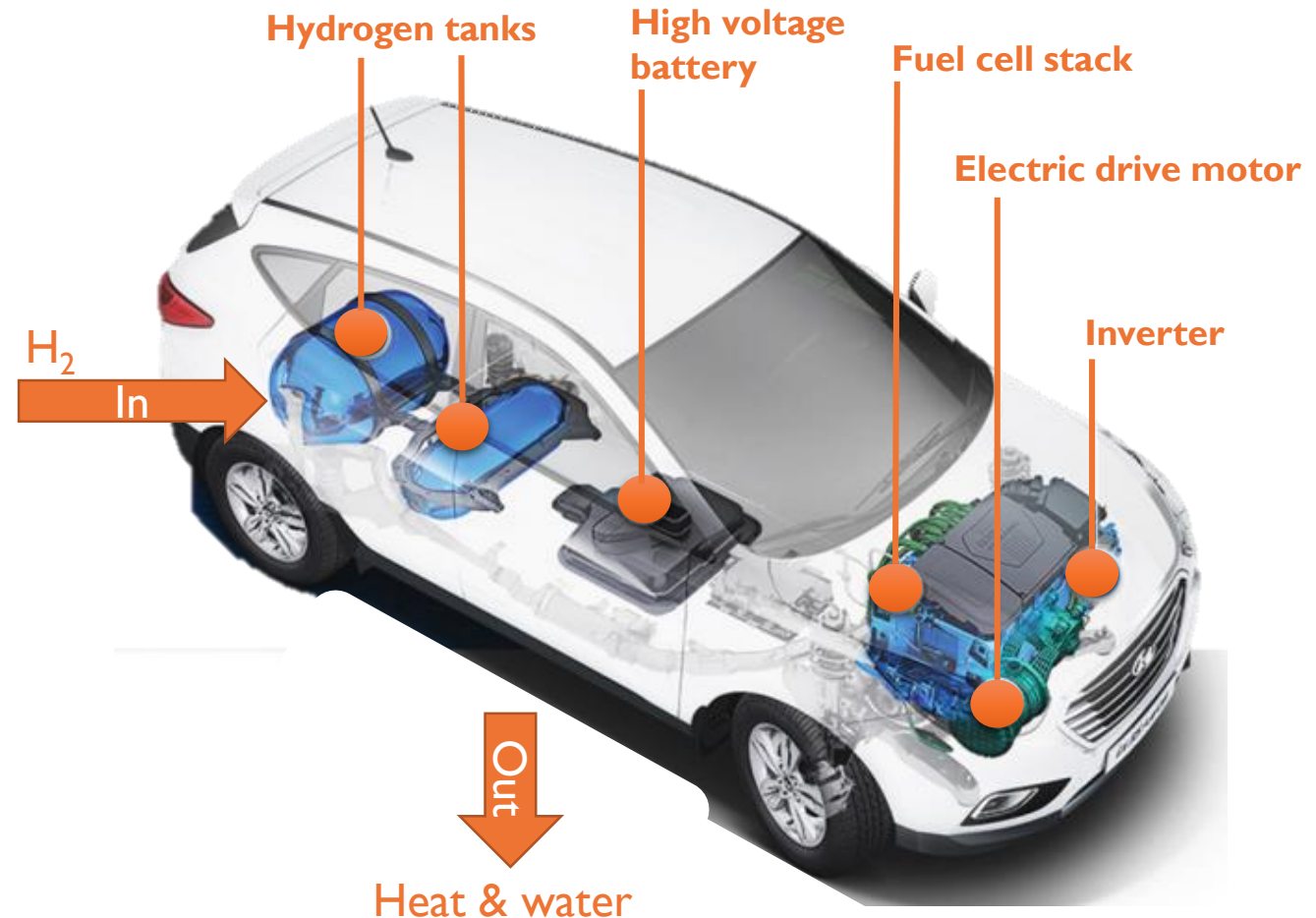
Yole Développement

## Fuel cell vehicle in a nutshell

- A fuel cell vehicle (FCV) is a vehicle that uses a fuel cell to power an electric drive system
- It is a Zero-Emission Vehicle, electrically powered, in which the electricity used to power electric engine is generated by converting hydrogen into electricity in fuel cell stack
- It is not just “a hydrogen vehicle”! The vehicles which burn hydrogen to power internal combustion engine (such as BMW Hydrogen 7) do not belong to the category of FCVs
- Fuel cells provide electricity by reacting hydrogen with heat and water as the products of the reaction
- Hydrogen is refilled into hydrogen tanks in vehicle at a hydrogen refilling stations similarly as petrol in a ICE car
- Fuel cell is not a new technology. Fuel cells provided spacecraft with power since 1960s

Fuel cell vehicle is an electric-powered vehicle

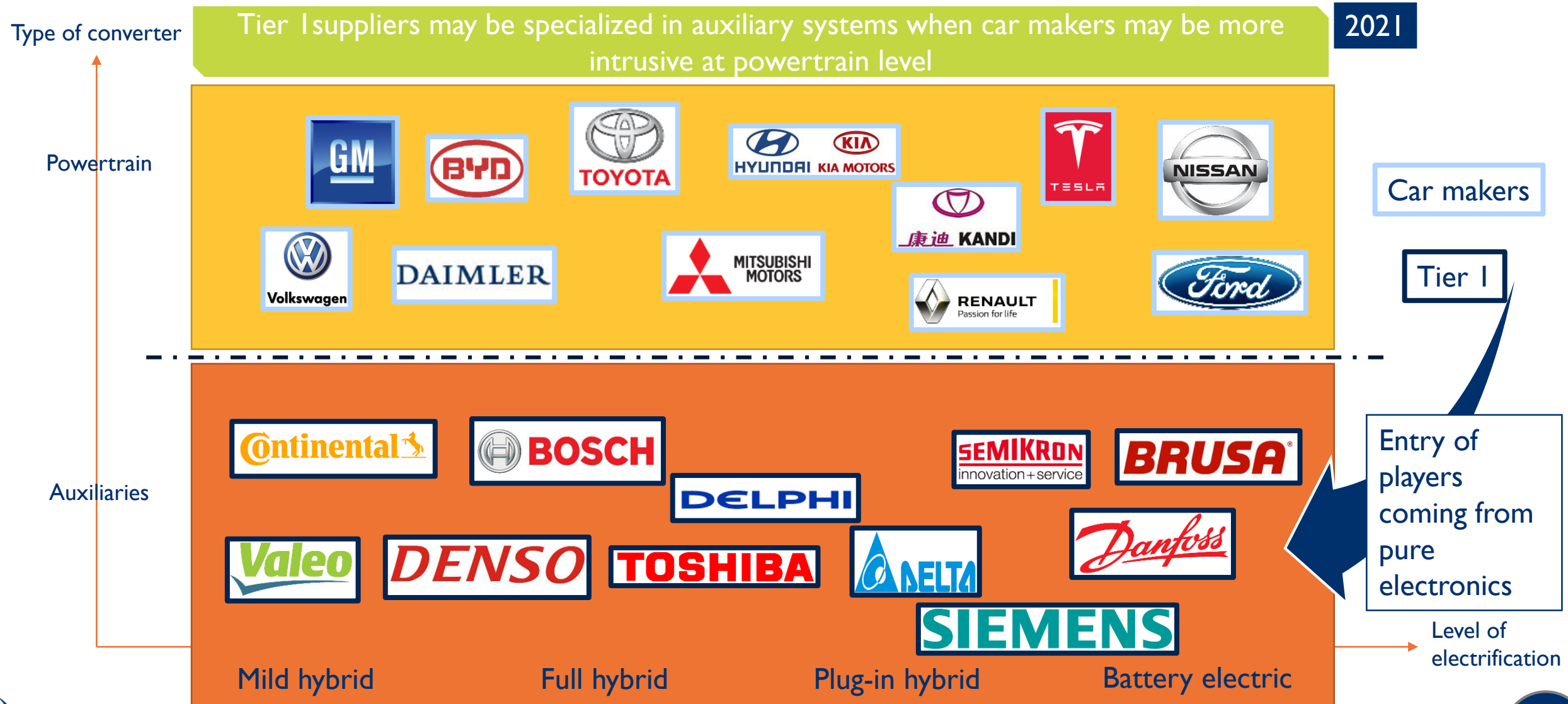
The electricity to power electrical engine is generated from hydrogen inside the car using fuel cells



Main parts of a fuel cell vehicle. Example of a Hyundai ix35 FCV

# BUSINESS MODELS, SUPPLY CHAIN AND LEADERS

## Business model evolution with market growth – 2021 expectations





# EVERY YEAR, YOLE DÉVELOPPEMENT ATTENDS MAIN EVENTS. MEET WITH US AT\*:

- **NEPCON Japan**  
January 13-15, 2016 – Tokyo, Japan
- **CS International**  
March 1-2, 2016 – Brussels, Belgium
- **Image Sensors**  
March 15-17, 2016 – London, UK
- **International Conference and Exhibition on Device Packaging**  
March 15-17, 2016 – Fountain Hills, USA
- **Lab-on-a-Chip European Congress**  
March 15-16, 2016 – Madrid, Spain
- **APEC**  
March 20-24, 2016 – Long Beach, USA
- **PCIM Europe**  
May 10-12, 2016 – Nuremberg, Germany
- **ECTC**  
May 31-June 3, 2016 – Las Vegas, USA
- **Sensors Expo & Conf**  
June 21-23, 2016 – San José, USA
- **SEMICON West**  
July 12-15, 2016 – San Francisco, USA
- **LED Professional Symposium – LpS**  
September 20-23, 2016 – Bregenz, Austria
- **SEMICON Europa**  
October 25-27, 2016 – Grenoble, France
- **SEMICON Japan**  
December 14-16, 2016 – Tokyo, Japan

*\*Non exhaustive list*

# ORDER FORM

## Power Electronics for EV/HEV 2016: Market, Innovations and Trends

### BILL TO

Name (Mr/Ms/Dr/Pr): .....

Job Title: .....

Company: .....

Address: .....

City: .....

State: .....

Postcode/Zip: .....

Country\*: .....

\*VAT ID Number for EU members: .....

Tel: .....

Email: .....

Date: .....

### PAYMENT

**BY CREDIT CARD**

Visa       Mastercard       Amex

Name of the Card Holder: .....

Credit Card Number: .....

Card Verification Value (3 digits except AMEX: 4 digits): .....

Expiration date: .....

### BY BANK TRANSFER

BANK INFO: HSBC, 1 place de la Bourse,  
F-69002 Lyon, France,  
Bank code: 30056, Branch code: 00170  
Account No: 0170 200 1565 87,  
SWIFT or BIC code: CCFRFRPP,  
IBAN: FR76 3005 6001 7001 7020 0156 587

### RETURN ORDER BY

- FAX: +33 (0)472 83 01 83
- MAIL: YOLE DÉVELOPPEMENT, Le Quartz,  
75 Cours Emile Zola, 69100 Villeurbanne/Lyon - France

### PRODUCT ORDER

Please enter my order for above named report:

One user license\*: Euro 5,490

Multi user license: Euro 6,490

- The report will be ready for delivery from April 12, 2016
- For price in dollars, please use the day's exchange rate. All reports are delivered electronically at payment reception. For French customers, add 20% for VAT

I hereby accept Yole Développement's Terms and Conditions of Sale<sup>(1)</sup>

Signature: .....

\*One user license means only one person at the company can use the report.

### SALES CONTACTS

- North America: Steve Laferriere - laferriere@yole.fr
- Japan & Asia: Takashi Onozawa - onozawa@yole.fr
- Taiwan: Mavis Wang - wang@yole.fr
- Europe & RoW: Fayçal Khamassi - khamassi@yole.fr
- Korea: Hailey Yang - yang@yole.fr
- General: info@yole.fr

<sup>(1)</sup> Our Terms and Conditions of Sale are available at [www.yole.fr/Terms\\_and\\_Conditions\\_of\\_Sale.aspx](http://www.yole.fr/Terms_and_Conditions_of_Sale.aspx)  
The present document is valid 24 months after its publishing date:  
April 12, 2016

### SHIPPING CONTACT

First Name: .....

Email: .....

Last Name: .....

Phone: .....

### ABOUT YOLE DÉVELOPPEMENT

Founded in 1998, Yole Développement has grown to become a group of companies providing marketing, technology and strategy consulting, media in addition to corporate finance services. With a strong focus on emerging applications using silicon and/or micro manufacturing (technology or process), Yole Développement group has expanded to include more than 50 associates worldwide covering MEMS, Compound Semiconductors, LED, Image Sensors, Optoelectronics, Microfluidics & Medical, Photovoltaics, Advanced Packaging, Manufacturing, Nanomaterials and Power Electronics. The group supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to develop their business.

#### CONSULTING

- Market data & research, marketing analysis
- Technology analysis
- Reverse engineering & costing services
- Strategy consulting
- Patent analysis

More information on [www.yole.fr](http://www.yole.fr)

#### FINANCIAL SERVICES

- Mergers & Acquisitions
  - Due diligence
  - Fundraising
- More information on Jean-Christophe Eloy  
([eloy@yole.fr](mailto:eloy@yole.fr))

#### REPORTS

- Collection of technology & market reports
  - Manufacturing cost simulation tools
  - Component reverse engineering & costing analysis
  - Patent investigation
- More information on [www.i-micronews.com/reports](http://www.i-micronews.com/reports)

#### MEDIA & EVENTS

- i-Micronews.com, online disruptive technologies website
  - @Micronews, weekly e-newsletter
  - Communication & webcasts services
  - Events: Yole Seminars, Market Briefings...
- More information on [www.i-micronews.com](http://www.i-micronews.com)

#### CONTACTS

- For more information about :
- Consulting Services: Jean-Christophe Eloy ([eloy@yole.fr](mailto:eloy@yole.fr))
  - Financial Services: Jean-Christophe Eloy ([eloy@yole.fr](mailto:eloy@yole.fr))
  - Report Business: Fayçal Khamassi ([khamassi@yole.fr](mailto:khamassi@yole.fr))
  - Press relations: Sandrine Leroy ([leroy@yole.fr](mailto:leroy@yole.fr))

**Definitions:** "Acceptance": Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions "I hereby accept Yole's Terms and Conditions of Sale".

**"Buyer":** Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

**"Contracting Parties" or "Parties":** The Seller on the one hand and the Buyer on the other hand.

**"Intellectual Property Rights" ("IPR")** means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

**"License":** For the reports and databases, 3 different licenses are proposed. The buyer has to choose one license:

- One user license: one person at the company can use the report.
- Multi-user license: the report can be used by unlimited users within the company. Subsidiaries and Joint-Ventures are not included.
- Corporate license: purchased under "Annual Subscription" program, the report can be used by unlimited users within the company. Joint-Ventures are not included.

**"Products":** Depending on the purchase order, reports or database on MEMS, CSC, Optics/MOEMS, Nano, bio... to be bought either on a unit basis or as an annual subscription. (i.e. subscription for a period of 12 calendar months). The annual subscription to a package (i.e. a global discount based on the number of reports that the Buyer orders or accesses via the service, a global search service on line on I-micronews and a consulting approach), is defined in the order. Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

**"Seller":** Based in Lyon (France headquarters), Yole Développement is a market research and business development consultancy company, facilitating market access for advanced technology industrial projects. With more than 20 market analysts, Yole works worldwide with the key industrial companies, R&D institutes and investors to help them understand the markets and technology trends.

## I. SCOPE

- 1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. ANY ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.
- 1.2 This agreement becomes valid and enforceable between the Contracting Parties after clear and non-equivocal consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions "I hereby accept Yole's Terms and Conditions of Sale". This results in acceptance by the Buyer.
- 1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer's address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

## 2. MAILING OF THE PRODUCTS

- 2.1 Products are sent by email to the Buyer:
  - within <sup>[1]</sup> month from the order for Products already released; or
  - within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.
- 2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer  
The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including incases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.
- 2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.
- 2.4 The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. If the Product's electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects. .

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer's risk.

## 3. PRICE, INVOICING AND PAYMENT

- 3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.
- 3.2 Yole may offer a pre release discount for the companies willing to acquire in the future the specific report and agreeing on the fact that the report may be release later than the anticipated release date. In exchange to this uncertainty, the company will get a discount that can vary from 15% to 10%.
- 3.3 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, credit card or by electronic transfer to the following account:  
HSBC, 1 place de la Bourse 69002 Lyon France  
Bank code: 30056  
Branch code: 00170  
Account n°: 0170 200 1565 87  
BIC or SWIFT code: CCFRFRPP  
IBAN: FR76 3005 6001 7001 7020 0156 587

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

- 3.4 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.
- 3.5 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

## 4. LIABILITIES

- 4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.
- 4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement
- 4.3 In no event shall the Seller be liable for:
  - a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller's website or the Products, or any information provided on the website, or in the Products;
  - b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.
- 4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.
- 4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.
- 4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.
- 4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of sale ability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

## 5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

## 6. PROTECTION OF THE SELLER'S IPR

- 6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.
- 6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:
  - Information storage and retrieval systems;
  - Recordings and re-transmittals over any network (including any local area network);
  - Use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
  - Posting any Product to any other online service (including bulletin boards or the Internet);
  - Licensing, leasing, selling, offering for sale or assigning the Product.
- 6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.
- 6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.
- 6.5 In the context of annual subscriptions, the person of contact shall decide who within the Buyer, shall be entitled to access on line the reports on I-micronews.com. In this respect, the Seller will give the Buyer a maximum of 10 password, unless the multiple sites organization of the Buyer requires more passwords. The Seller reserves the right to check from time to time the correct use of this password.
- 6.6 In the case of a multisite, multi license, only the employee of the buyer can access the report or the employee of the companies in which the buyer have 100% shares. As a matter of fact the investor of a company, the joint venture done with a third party etc...cannot access the report and should pay a full license price.

## 7. TERMINATION

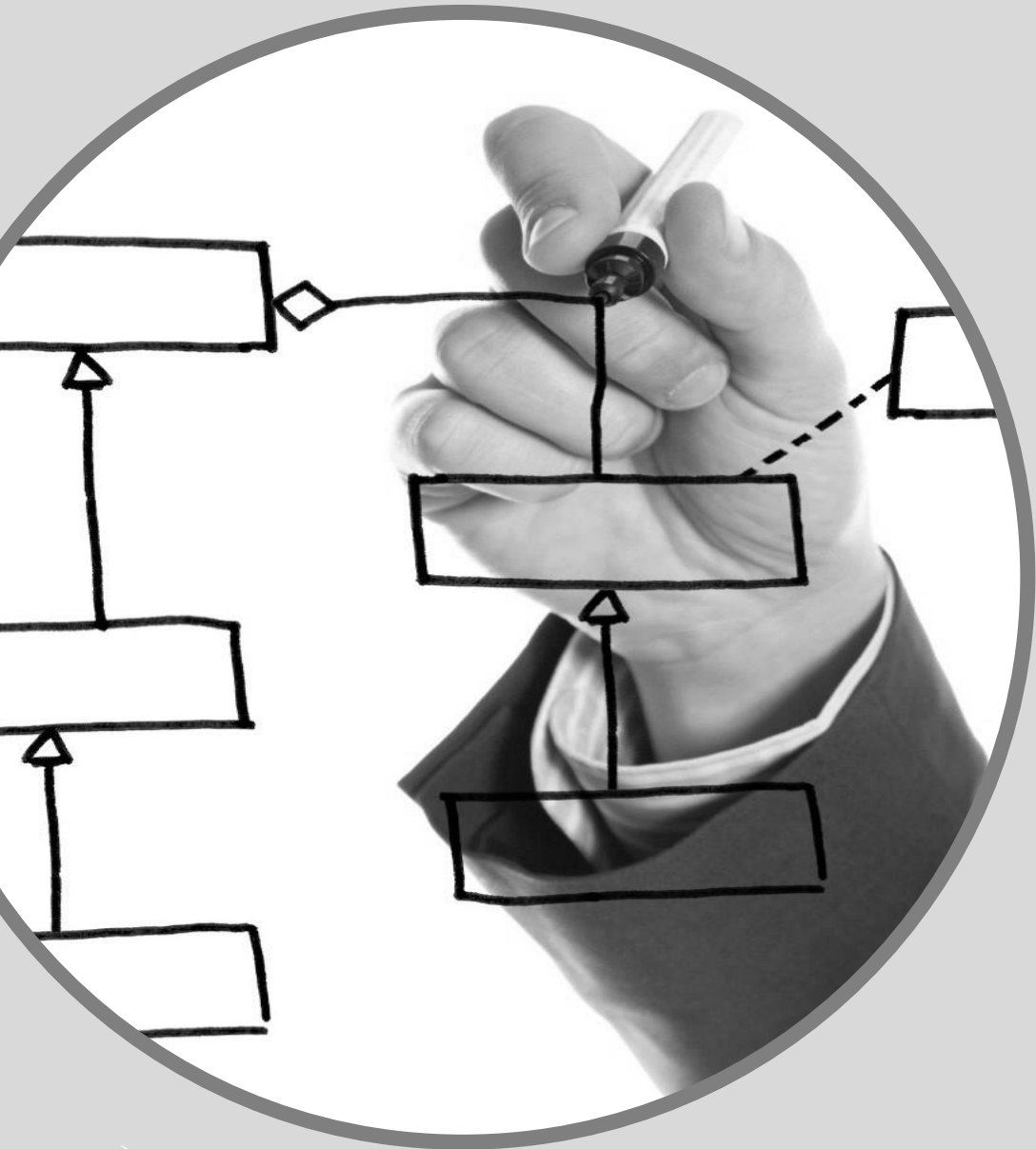
- 7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.
- 7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

## 8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.  
Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party. The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

## 9. GOVERNING LAW AND JURISDICTION

- 9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.
- 9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.



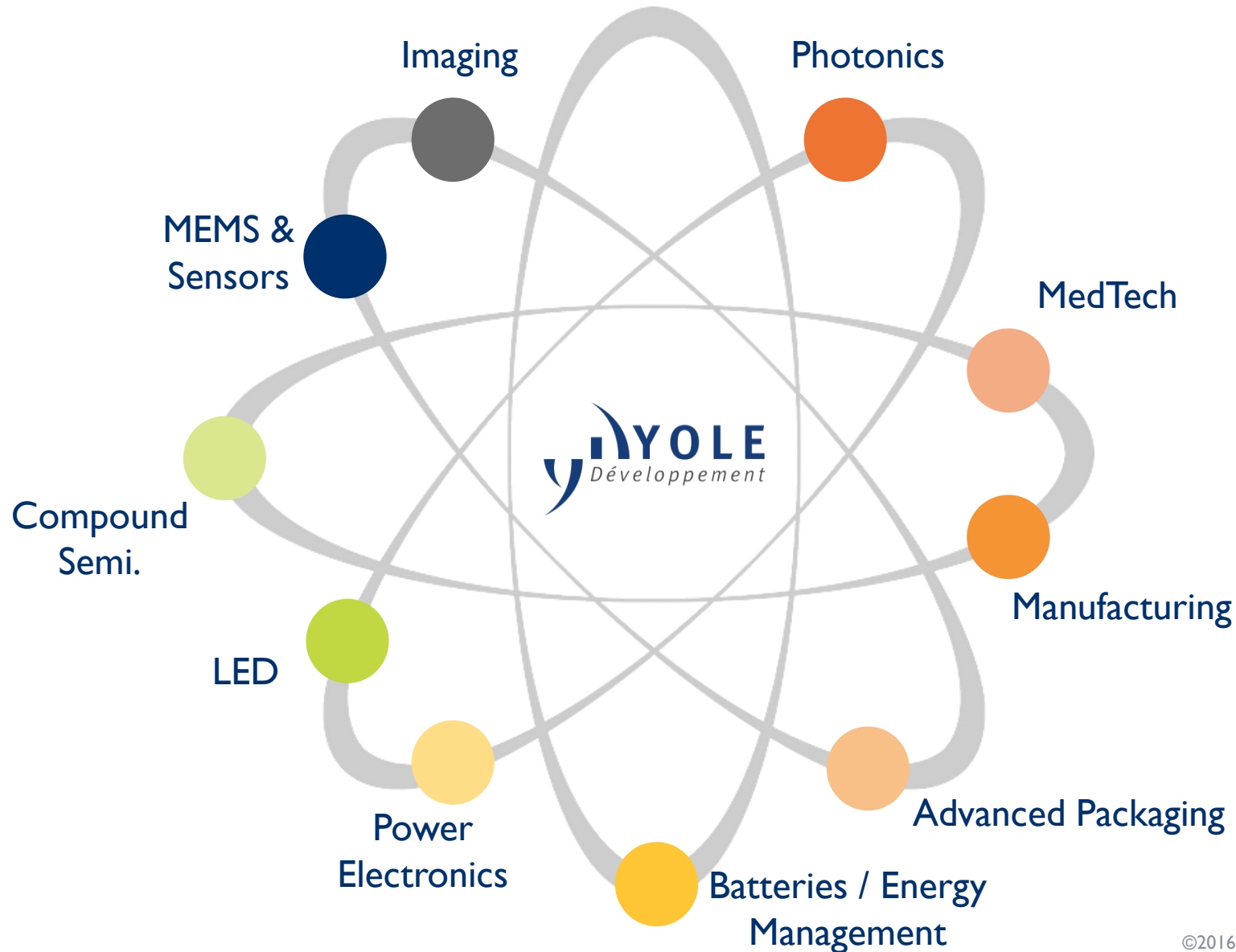
# Yole Développement

*From Technologies to Market*

---

# FIELDS OF EXPERTISE

Yole Développement's 30 analysts operate in the following areas





## ○ Consulting and Analysis

- Market data & research, marketing analysis
- Technology analysis
- Strategy consulting
- Reverse engineering & costing
- Patent analysis

[www.yole.fr](http://www.yole.fr)

## ○ Reports

- Market & Technology reports
- Patent Investigation and patent infringement risk analysis
- Teardowns & Reverse Costing Analysis
- Cost Simulation Tool

[www.i-Micronews.com/reports](http://www.i-Micronews.com/reports)

## ○ Financial services

- M&A (buying and selling)
- Due diligence
- Fundraising
- Maturation of companies
- IP portfolio management & optimization

[www.yolefinance.com](http://www.yolefinance.com)

[www.bmorpho.com](http://www.bmorpho.com)

## ○ Media

- i-Micronews.com website
- @Micronews e-newsletter
- Communication & webcast services
- Events

[www.i-Micronews.com](http://www.i-Micronews.com)





Market,  
technology and  
strategy  
consulting

[www.yole.fr](http://www.yole.fr)



- 

M&A operations  
Due diligences

[www.yolefinance.com](http://www.yolefinance.com)
- 

Innovation and business maker

[www.bmorpho.com](http://www.bmorpho.com)
- 

Manufacturing costs analysis  
Teardown and reverse engineering  
Cost simulation tools

[www.systemplus.fr](http://www.systemplus.fr)
- 

IP analysis  
Patent assessment

[www.knowmade.fr](http://www.knowmade.fr)

# OUR 2016 REPORTS PLANNING

## MEMS & SENSORS

- Gas Sensors and Combos 2016
- Status of the MEMS Industry 2016\*
- Sensors for Cellphones and Tablets 2016
- Market and Technology Trends of Inkjet Printheads: Towards New Printing Opportunities 2016...
- Sensors for Biometry and Recognition 2016
- Finger Print Sensors Market and Technologies 2016
- 3D Imaging & Sensing 2016\*\*
- Silicon Photonics 2016
- Emerging Non Volatile Memories 2016\*

## IMAGING & OPTOELECTRONICS

- Status of the CMOS Image Sensor Industry 2016\*
- Uncooled Infrared Imaging Technology & Market Trends 2016\*
- Imaging Technologies for Automotive 2016
- Sensors for Drones & Consumer Robots 2016
- 3D Imaging & Sensing 2016\*\*
- Silicon Photonics 2016

## MEDTECH

- BioMEMS 2016
- Point of Need Testing 2016: Application of Microfluidic Technologies

## ADVANCED PACKAGING

- FanOut WLP: Technology Trends and Business Update 2016\*
- Embedded Die Packaging: Technology and Markets Trends 2016\*
- 2.5D & 3D IC Business Update 2016
- Status of the Advanced Packaging Industry 2016\*
- Advanced Packaging for Wearables and Mobile Applications 2016
- Advanced Packaging in Emerging Markets: China 2016
- Supply Chain Readiness for Panel Manufacturing in Packaging 2016

## MANUFACTURING

- Inspection and Metrology Technology and Applications Trends in Advanced Packaging 2016\*\*
- Emerging Materials for Advanced Packaging 2016

- Deposition Technologies Equipment & Materials 2016
- Thinning & Dicing Equipment for Advanced Packaging, MEMS, Photovoltaics, LED, CMOS 2016

## COMPOUND SEMICONDUCTORS

- SiC Modules, Devices and Substrates for Power Electronics 2016\*
- GaN Modules, Devices and Substrates for Power Electronics 2016\*
- Sapphire Applications & Market 2016: from LED to Consumer Electronics\*
- RF GaN Technology and Market Analysis 2016

## LED

- Sapphire Applications and Market 2016: From LED to Consumer Electronics\*
- LED Packaging 2016
- Microdisplays and MicroLEDs
- UV LED Technology, Manufacturing and Applications Trends 2016\*
- OLED for Lighting 2016
- LED in Automotive Lighting 2016

## POWER ELECTRONICS

- Power Electronics in Electric and Hybrid Vehicles 2016
- Status of Power Electronics Industry 2016\*
- Passive Components Technologies and Market Trends for Power Electronics 2016
- SiC Modules, Devices and Substrates for Power Electronics 2016\*
- GaN Modules, Devices and Substrates for Power Electronics 2016\*
- Inverter Technologies Trends & Market Expectations 2016
- Power Electronics for Renewable Energy 2016
- Thermal Management for LED and Power 2016
- RF GaN Technology and Market Analysis 2016

## BATTERY

- Market Trends and Technologies in Battery Pack and Assembly 2016
- Innovative and Emerging Technologies in Energy Storage Market 2016

\*\*To be confirmed

Patent Analysis by Knowmade and Teardown & Reverse Costing by System Plus Consulting are available on [www.i-micronews.com](http://www.i-micronews.com)

# OUR 2015 PUBLISHED REPORTS LIST



## MEMS & SENSORS

- Sensors and Data Management for Autonomous Vehicles
- Sensors for Wearable Electronics And Mobile Healthcare
- Status of the MEMS Industry
- Uncooled Infrared Imaging Technology & Market Trends
- Infrared Detector Technology & Market Trends
- High-End Gyroscopes, Accelerometers and IMUs for Defense, Aerospace & Industrial
- Emerging Non Volatile Memory (NVM) Technology & Market Trends

## IMAGING & OPTOELECTRONICS

- Camera Module Industry
- Uncooled Infrared Imaging Technology & Market Trends
- Status of the CMOS Image Sensors
- Infrared Detector Technology & Market Trends

## MEDTECH

- Sample Preparation Automation Through Emerging Microfluidic Technologies
- 2015 Microfluidic Applications in the Pharmaceutical, Life Sciences, In-Vitro Diagnostic, and Medical Device Markets
- Sensors for Wearable Electronics And Mobile Healthcare

## COMPOUND SEMICONDUCTORS

- Sapphire Applications & Market 2015: from LED to Consumer Electronics
- SiC, GaN, and other Wide Band Gap (WBG) materials for power electronics applications
- GaN and SiC Devices for Power Electronics Applications

## LED

- LED Lighting Module Technology, Industry and Market Trends 2015
- UV LED - Technology, Manufacturing and Application Trends
- Phosphors & Quantum Dots 2015: LED Downconverters for Lighting & Displays
- Sapphire Applications & Market 2015: from LED to Consumer Electronics

## POWER ELECTRONICS

- Power Packaging Technology Trends and Market Expectations
- Energy Management for Smart Grid, Cities and Buildings: Opportunities for Battery Electricity Storage Solutions
- Status of Chinese Power Electronics Industry
- New Technologies and Architectures for Efficient Data Center
- IGBT Market and Technology Trends
- Status of Power Electronics Industry
- SiC, GaN, and other Wide Band Gap (WBG) materials for power electronics applications
- GaN and SiC Devices for Power Electronics Applications

## ADVANCED PACKAGING

- Status of the Advanced Packaging Industry
- Supply Chain Readiness for Panel Manufacturing in Packaging
- Fan-in Wafer Level Packaging: Market and Technology Trends
- Flip Chip: Technologies and Markets Trends
- Fan-Out and Embedded Die: Technologies & Market Trends

## MANUFACTURING

- Photolithography Equipment and Materials for Advanced Packaging, MEMS and LED Applications
- Emerging Non Volatile Memory (NVM) Technology & Market Trends

*Patent Analysis by Knowmade and Teardown & Reverse Costing by System Plus Consulting are available on [www.i-micronews.com](http://www.i-micronews.com)*



- **Consulting and Specific Analysis**

- North America: **Steve LaFerriere**, Director of Northern America Business Development  
Email: laferriere@yole.fr
- Japan & Asia: **Takashi Onozawa**, Representative Director, Yole KK  
Email: onozawa@yole.fr
- RoW: **Jean-Christophe Eloy**, CEO & President, Yole Développement  
Email: eloy@yole.fr

- **Report business**

- North America: **Steve LaFerriere**, Director of Northern America Business Development  
Email: laferriere@yole.fr
- Europe: **Fayçal El Khamassi**, Headquarter Sales Coordination & Customer Service  
Email: khamassi@yole.fr
- Japan & Asia: **Takashi Onozawa**, Representative Director, Yole KK.  
Email: onozawa@yole.fr
- Korea: **Hailey Yang**, Business Development Manager, Korean Office  
Email: yang@yole.fr
- Taiwan: **Mavis Wang**, Business Development Director  
Email: wang@yole.fr

- **Financial services**

- **Jean-Christophe Eloy**, CEO & President  
Email: eloy@yole.fr

- **General**

- Email: info@yole.fr



Follow us on

