Industrial Internet of Things (IIoT) and the Future of Electric Vehicle Manufacturing - Overcoming Challenges to Achieve Profitability

Prepared for:

Lightweight Materials Joining, Forming, & Manufacturing Innovation 2019 Summit

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FROST & SULLIVAN

Presentation Agenda

Digital Transformation of the Automotive Industry

IIoT and Future of Electric Vehicles

Focus on Electric Vehicles Profitability

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Digital Transformation of the Automotive Industry

Focal Points

Automotive digitalization focuses on five key pillars

- Connected Supply Chain

*(*Value chain disruption*

**Intelligent fulfilment*

**Responsive supply networks*

**Smart logistics)*

- IIoT
- A.C.E. vehicles
- Digital Retailing
- Mobility as a Service (MaaS)

Automotive IIoT spend is bound to increase at a CAGR of 11.5% (2015-2025)

- $12.30 billion in 2015 to
- $36.70 billion in 2025.
- Over 1700 new digital startups

*(*Simulation modelling*

**Cloud-based IoT platform*

**Cognitive manufacturing*

**Contextual intelligence)*

Manufacturing (including EVs) impacted by ongoing Digital Transformation

- Highly configurable and flexible production operated by robots
- Real-time production optimization through integration with simulation techniques
- Predictive analytics through pattern recognition methods
- Data packets enhanced encryption
- Automatic capturing, modelling, and optimizing of production systems

Industrial Internet of Things—The 4 Functional Facets

Industry Convergence: IT-OT

The cross-pollination of ideas, technologies, and processes between the worlds of information technology and operations technology will form the crux of the fourth industrial revolution.

Services 2.0

Exploring newer avenues for service innovations, such as cloud-based service platforms, and evaluating potential for new profit centers; opportunity analysis for ICT technology in services

Supply Chain Evolution

The dawn of the future factory is set to disrupt existing supply chain networks. Digitalization and increased connectivity are set to disrupt and realign existing value-chain networks in the future.

The Industry 4.0 Business Ecosystem

The advent of advanced ICT technologies will promote new inter-relationships and interdependencies giving way to unexpected business collaborations and partnerships in the future.

IT-OT = Information Technology-operational Technology; ICT = Information and communication Technology

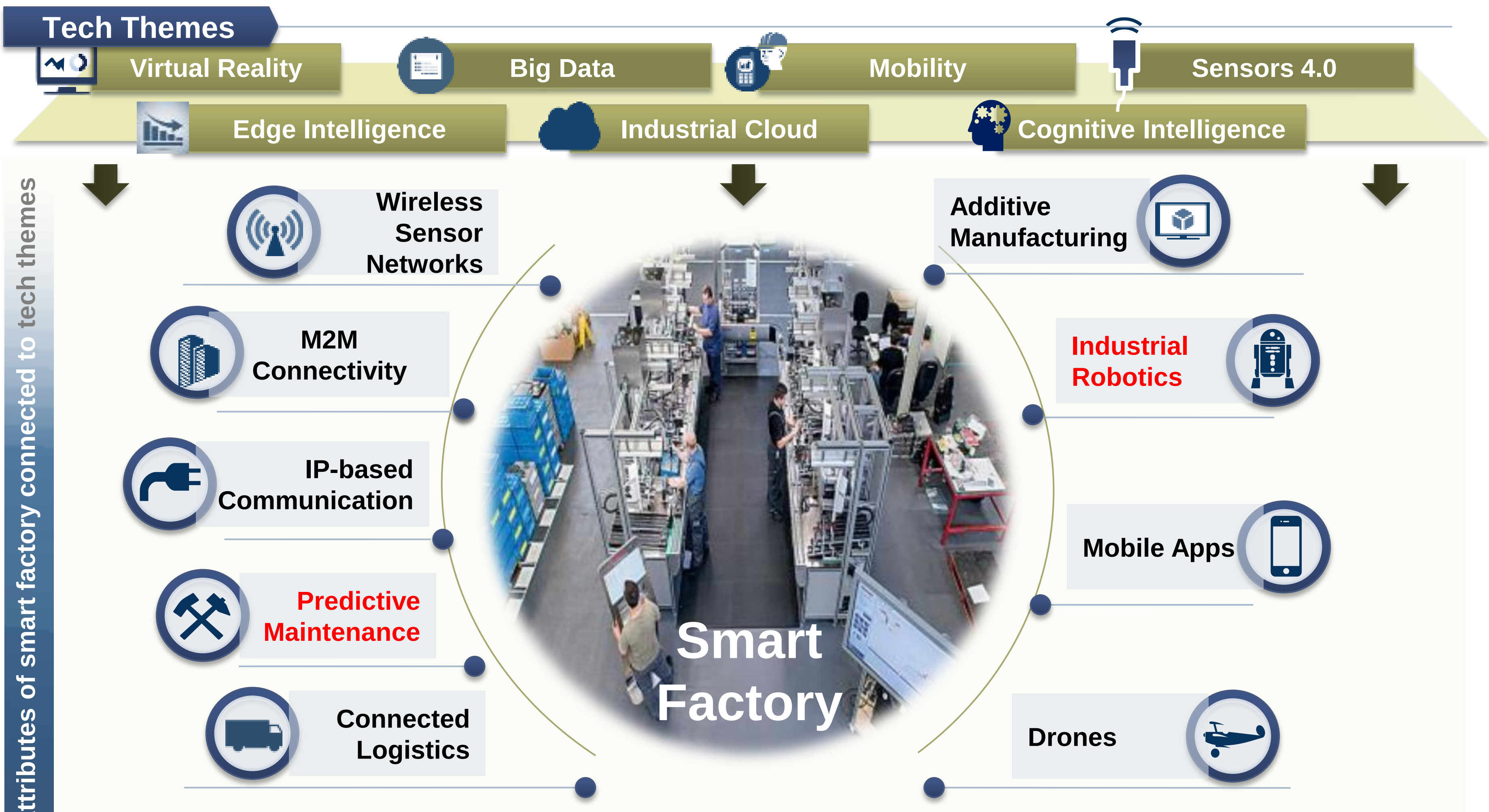
Images Source: Thinkstock

Source: Frost & Sullivan

IIoT—Key Attributes of a Smart Factory

The broader technology themes will give rise to new attributes in the shop floor.

IIoT—Key Attributes of a Smart Factory, Global



Source: Frost & Sullivan

Example: Jeep Transforms its US Factory Realizing IIoT

Kuka and Microsoft Supports Jeep help realize IIoT driven plant efficiency benefits at its Toledo factory.

Jeep Toledo (Ohio) Factory

Business Challenge	Solution	Impact

Internet of Things transforms a Jeep factory

Business Challenge

- KUKA needed an automated manufacturing solution that could produce multiple car models on the same assembly line while meeting a rigorous production schedule.

Solution

- KUKA implemented an intelligent system anchored by Windows Embedded and Microsoft SQL Server that connects 259 assembly-line robots, a controller, more than 60,000 device points, and backend systems.

Impact

- It produces a car body every 77 seconds.
- It provides 24 hours of production per day for more than 8 years.
- It improves efficiency and reduces training time with a familiar interface.

KUKA Microsoft Jeep

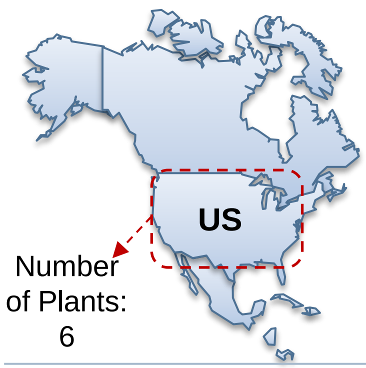
Image sources are for reference only. Source: Frost & Sullivan

Example: Toyota Operations Technology (OT) for Efficiency

Predictive maintenance tool has enabled Toyota's paint engineers to identify a problem within two hours, which typically would take eight weeks to spot.

Case Study: Toyota Operations Technology for Efficiency, Global

Total Number of Assembly Plants in North America	14



Number of Plants: 6

Operations in United States	
Direct CAPEX	$22 B
Number of jobs created	365,000
Investment in parts and materials	$35 B

Operational Challenges

- Very high production lead time.
- No real-time data capture facility.
- Low level of flexibility, wherein multiple product types cannot move on a single line.

Toyota Operations Availability System (TOAD)

—In-house Data Visualization and Predictive Analytics Platform

32
Smart manufacturing systems implemented

$6 million
Savings in OPEX

$187 million/ year
Downtime avoidance through IIoT in supply chain

40,000 minutes
Saved production time in single plant

TOYOTA

Existing & Future Strategy

- It currently augments the existing capacity by improving operational efficiency and working alternative shifts.
- It temporarily reduces the production cycle time by making small strategic investments.
- In future, implement a new business strategy called the Advanced IT for Manufacturing across all the plants.

Source: Toyota Motor Sales, U.S.A.; Frost & Sullivan

Example: Connected Supply Chain as a Means to Achieve Profitability

Performance Attribute	Metric	Estimated Reference Value	Improvement potential (%) with CSC
Supply Chain Reliability	Perfect order fulfillment	75-85%	10-30% Improvement
Supply Chain Responsiveness	Order fulfillment cycle time	30- 45 days	30 - 50% Reduction
Supply Chain Flexibility	Upside supply chain flexibility	45-60 days	30-50% Reduction
	Upside supply chain adaptability	…	…
	Downside supply chain adaptability	…	
Supply Chain Costs	Supply chain management cost	10-12% of Revenues	25% - 50% Reduction
	Cost of goods sold	70-80% of revenues	5-10% improvement
Supply Chain Assets Management	Cash-to-Cash cycle time	30-95 days	25-50% improvement
	Return on supply chain fixed assets	….	10 - 20% Improvement (based on capacity realization/ revenues)
	Return on working capital	…	25 - 50% Increase (based on C2C cycle time)

Connected Supply Chain has the potential to reduce vehicle cost by up to **6%** through reduction in supply chain management cost and additional up to **10%** reduction through savings in Cost of Goods Sold using IIoT

Source: Several and Frost & Sullivan

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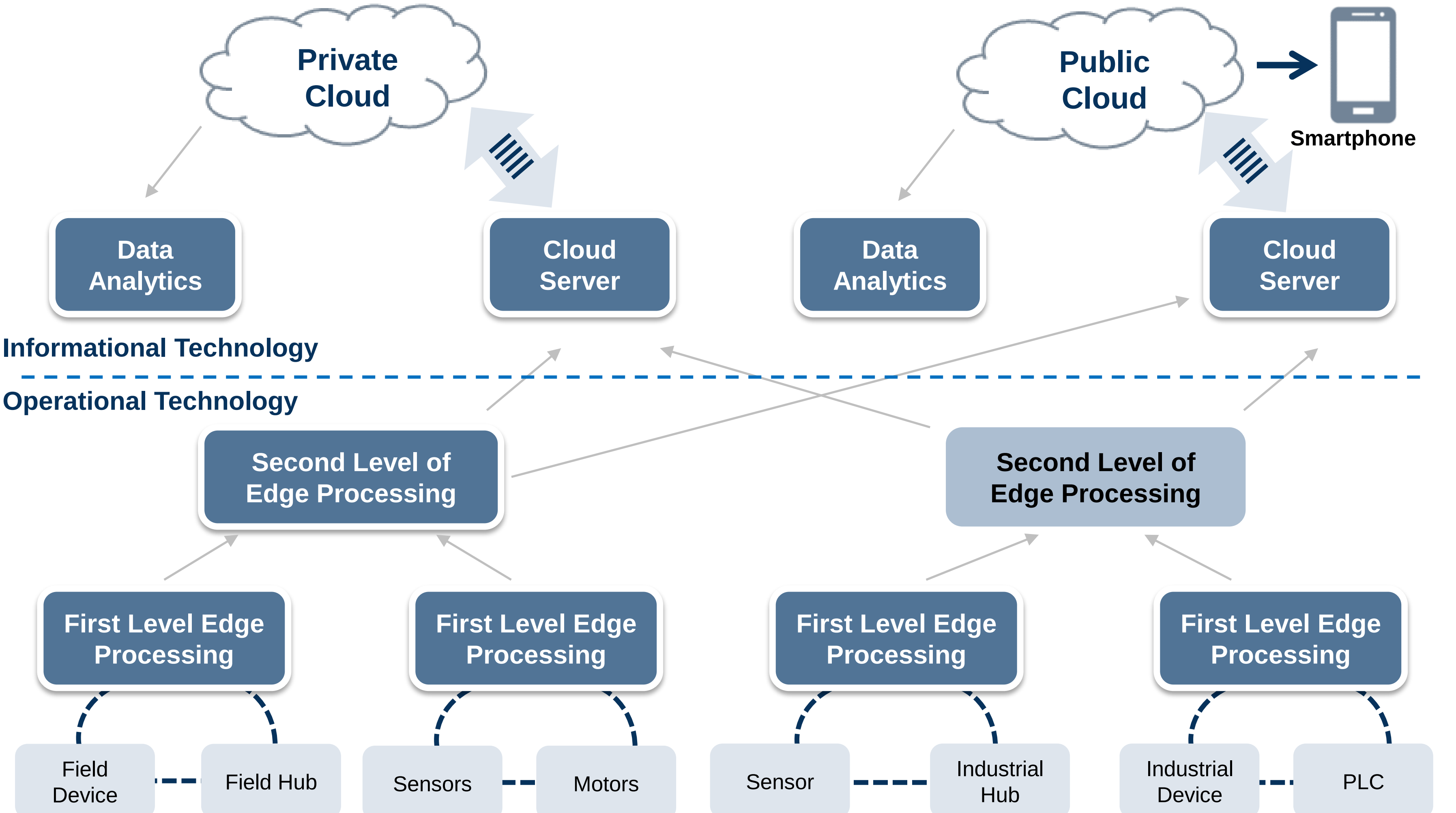
IIoT and Future of Electric Vehicles

Focus on Electric Vehicles Profitability

IIoT System Architecture

IIoT and Future of Manufacturing: IIoT System Architecture, Global

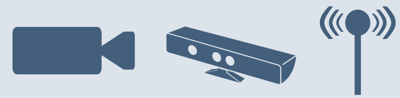
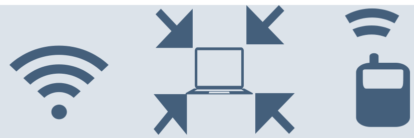
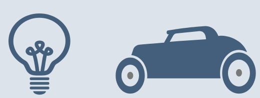
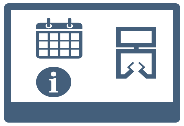
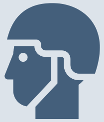


Key: PLC—Programmable Logic Controller

Source: Frost & Sullivan

IIoT Different Layers

7 different layers

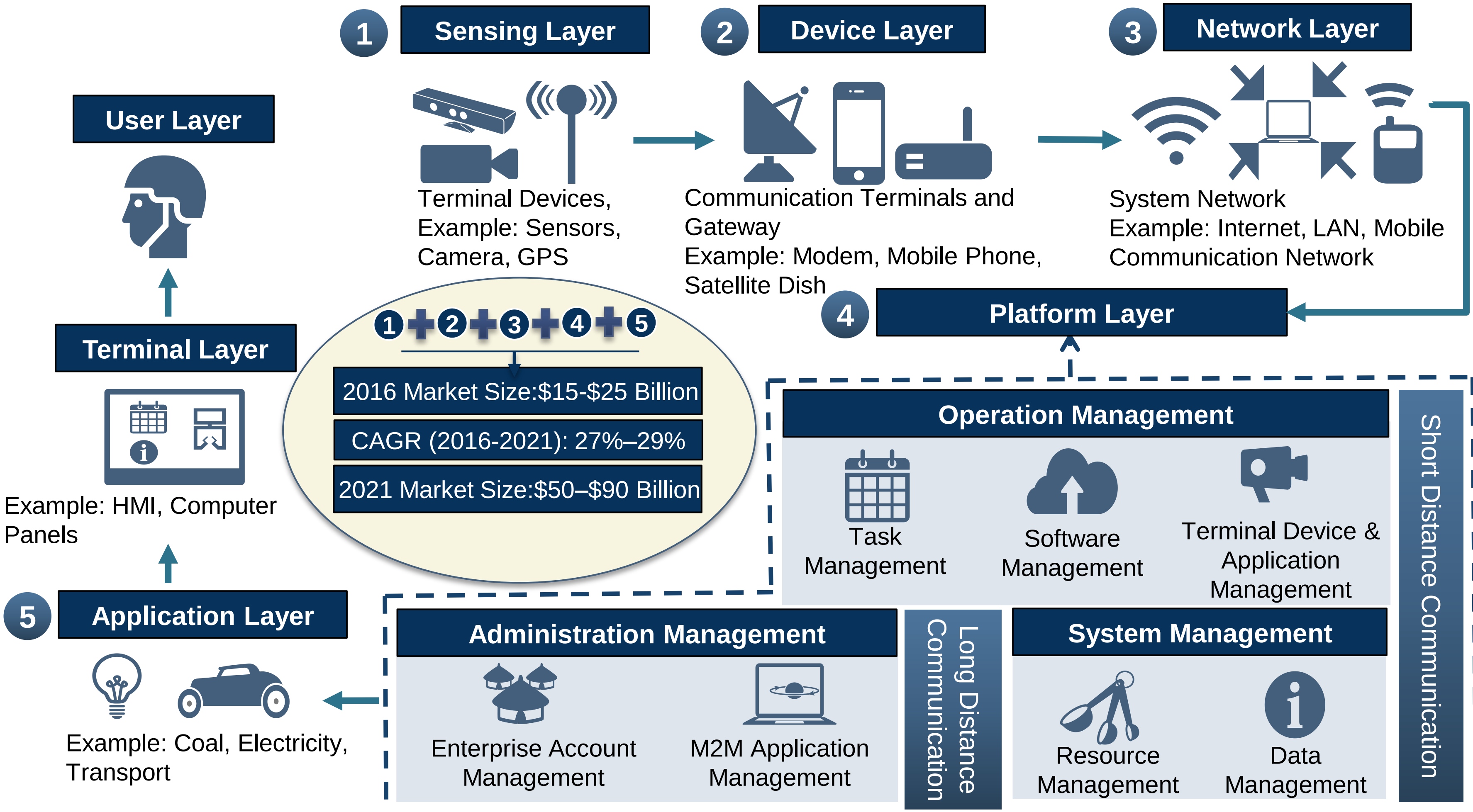
Layers Segmentation	Representation	Devices and Examples
Sensing Layer		Terminal Devices E.g., Sensors, camera, global positioning system (GPS)
Device Layer		Communication Terminals and Gateways E.g., Modem, Mobile Phone, Satellite Dish
Network Layer		System Networks E.g., Internet, local area network (LAN), multi-channel network (MCN)
Platform Layer		Database, File Storage E.g., Operation management, administration management, system management
Application Layer		Gateways, Firewalls, All End Devices like PCs, Phones, Servers E.g., Coal, electricity, transport
Terminal Layer		OpenCard Framework E.g., Human machine interface (HMI), computer panels
User Layer		Simple Mail Transfer Protocol (SMTP) E.g. Directory services

Source: Frost & Sullivan

Exploring IIoT's End-to-End Industrial Architecture

The standardization of architecture will create a $90 billion opportunity by 2021.

Exploring IIoT's End-to-End Industrial Architecture, Global, 2016–2021

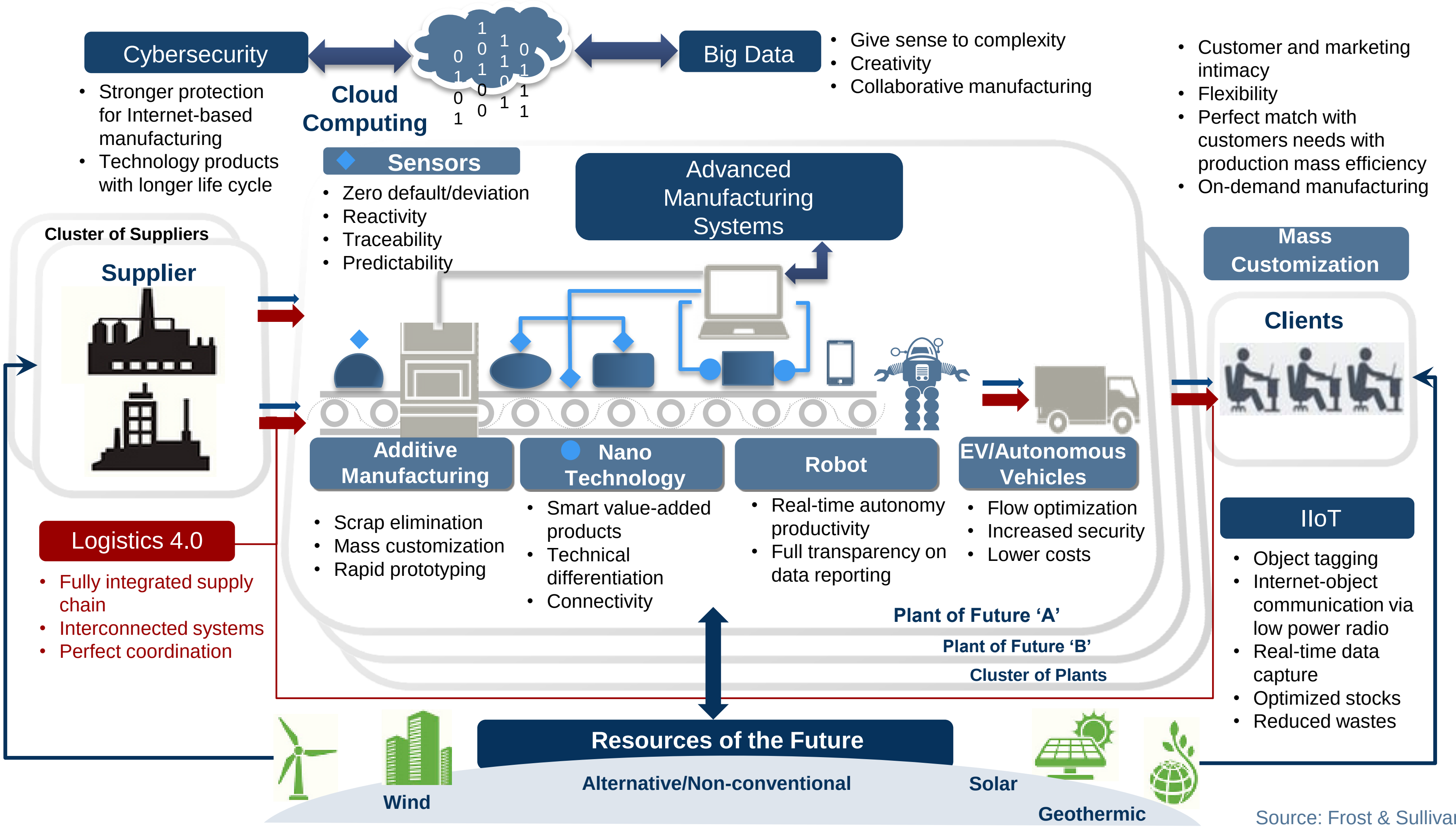


Source: Frost & Sullivan

Example: Plant of the Future—Industry 4.0 Ecosystem

Industry 4.0 connects embedded system production technologies and manufacturing processes to drastically transform industry and production value chains and business models.

Plant of the Future—Industry 4.0 Ecosystem, Global



Source: Frost & Sullivan

Example: Bosch Analogy—A Smart Watch Solution

A Bosch plant, based in South Carolina, has successfully integrated iPhones and Pebble Watches into assembly lines.

Bosch Analogy—A Smart Watch Solution, Global

How it used to be

Production line → Machine stops → Red Lights & Buzzers go off

A Typical Production Floor

- Machine stoppages occur due to feeder jams and other specific faults, triggering the Buzzers
- Operator response time increases thereby resulting in increased wastage of time and money.

Key Convergence of Technology

PLC

Apple iPhone

Pebble Smart Watch

Robert Bosch's Anderson Plant

- The PLC communicates to server when a problem or jam is about to occur.
- The server interprets the signal and sends a SMS to iPhone.
- The iPhone relays message to all Pebbles (worn by line operators) via Bluetooth.

- **For every 3 production days, 1 hour of downtime eliminated.**
- **This is 122 hours of additional production per year.**

Inferred Strategy

- Engineering a strategy to integrate minimal technology with extended possibilities will reap huge benefits.
- Open firmware, like that of Pebble Smart watch, can help in customized implementation of its features in real-time production floor.
- Need for next-generation technology platform that spurs convergence concepts and simulations.

Source: Bosch Software Innovations; Frost & Sullivan

Automotive Industry Key Future Trends Overview

New opportunities in technologies and businesses have expanded the ecosystem of car manufactures to enhance their products and manufacturing process

IIoT and its Impact On Manufacturing: KEY IMPACTS ON MANUFACTURING, GLOBAL

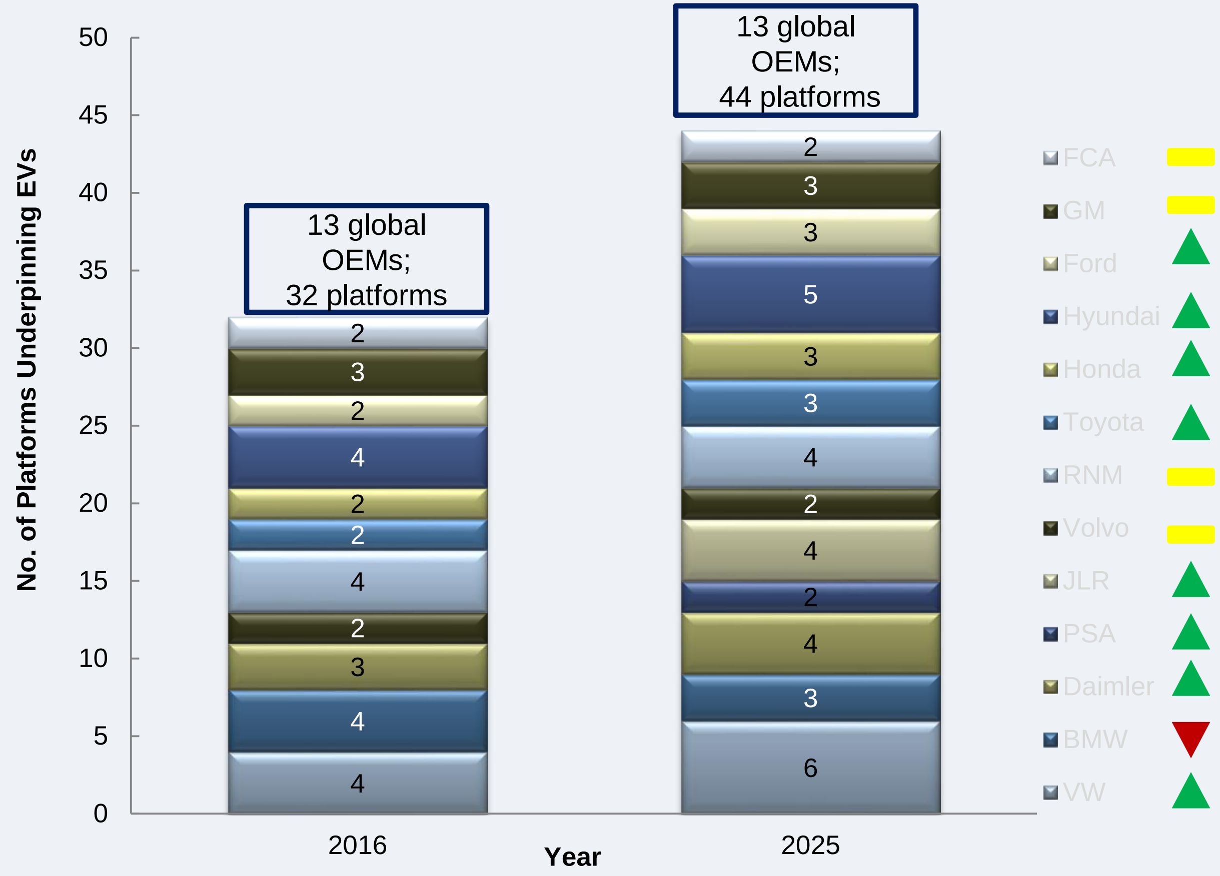
PRODUCT TRENDS	BUSINESS TRENDS	SUPPLY CHAIN TRENDS
Electrification	Modularization	Value Chain Expansion
Connected Vehicles	New Mobility	Connected Supply Chain
Autonomous Driving	e-Retailing	EOL disposal
Multi Material Structures	Environmental Compliance	

Source: Frost & Sullivan

Electrification—Key to Meeting Future Emission Regulations

Electrifying ICE models is no longer an optimal solution to meet emission regulations because of the limitations in extending range and battery capacity; OEMs are expected to utilize their platforms for EVs.

EV Platform Strategy: OEM EV Platform Forecast, Global, 2016 and 2025



Key Takeaways

- A 37.5% increase in platforms that underpin EVs (including PHEVs, BEVs, and FCEVs) is expected between 2016 and 2025.
- OEMs will add a dedicated platform by 2025 that can house vehicles across multiple segments.
- The challenges with electrifying existing platforms include extending battery capacity and range, which are crucial to meeting emission regulations.

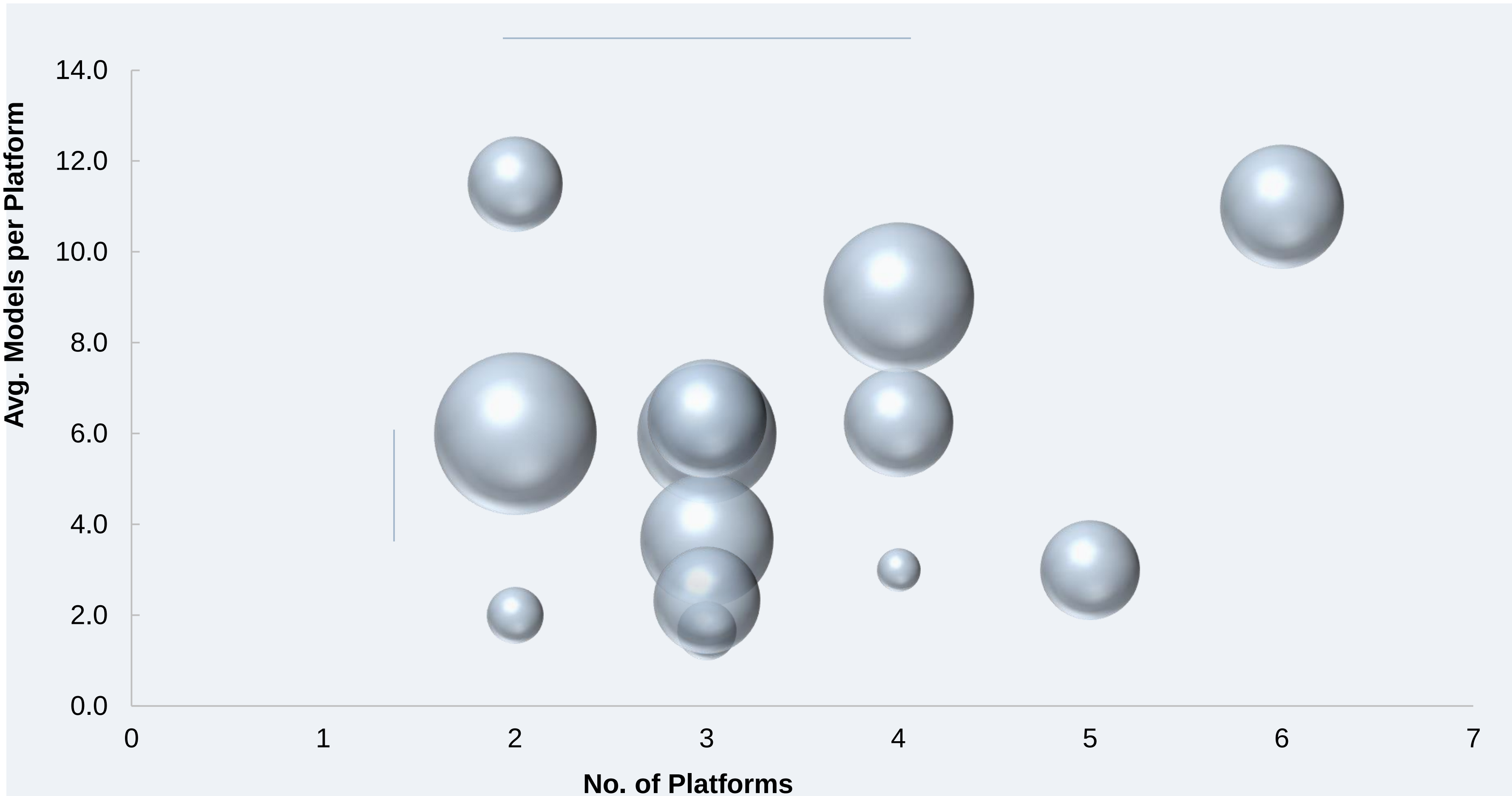
BMW's CLAR will underpin its future PHEVs, replacing its LG/LK and ULK-2 platforms

Note: All figures are rounded. The base year is 2016. Source: Frost & Sullivan

Number of Platforms and Average Models per Platform

OEMs are expected to utilize 2 to 4 platforms to underpin future EVs, with an industry average of 5 to 6 models per platform by 2025.

EV Platform Strategy: Number of Platforms and Average Models per Platform, Global, 2025



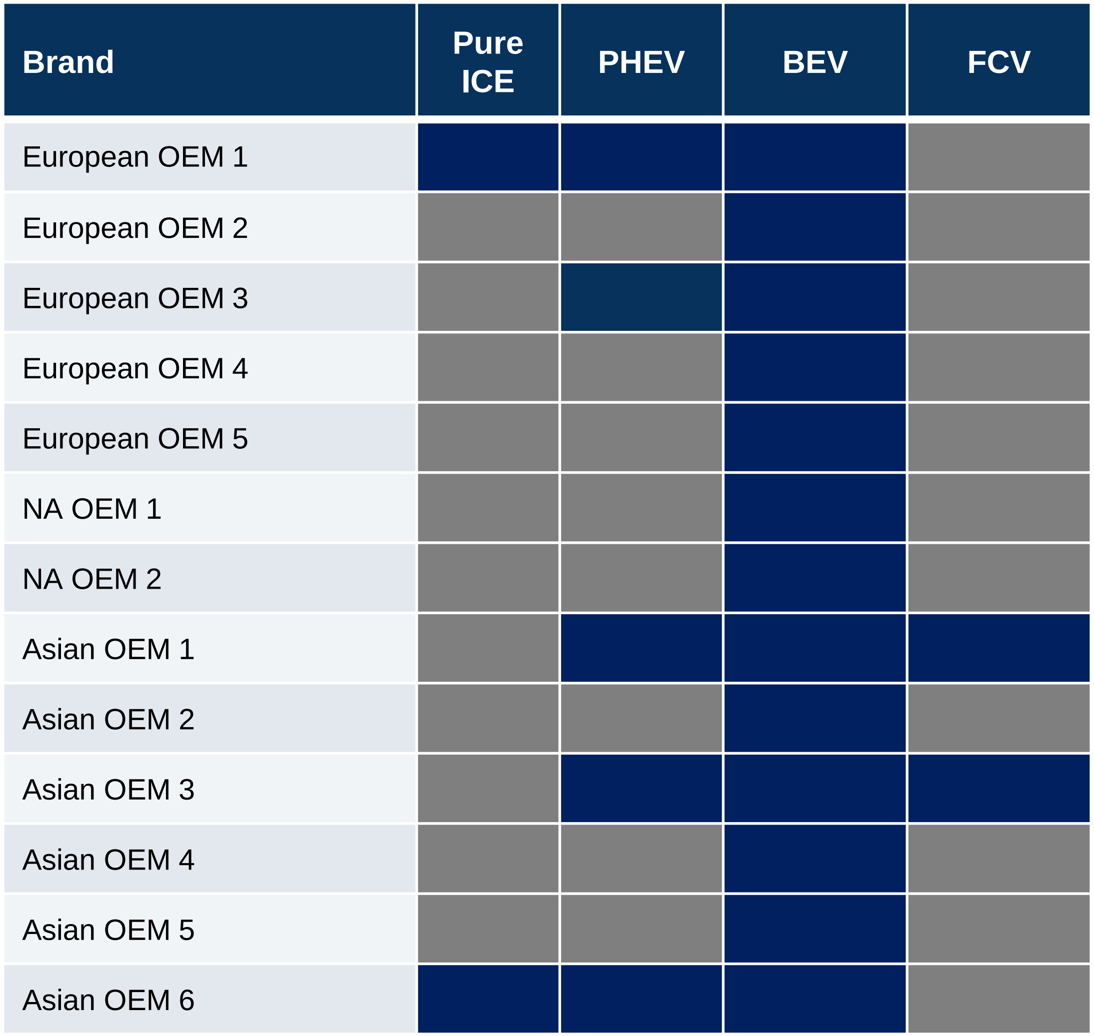
Size of Bubble = Average Production per Platform

Note: All figures are rounded. The base year is 2016. Source: Frost & Sullivan

New Dedicated Platforms—Powertrain Flexibility Comparison

With the exception of a few OEMs, many automakers are expected to build only BEVs on their dedicated platforms.

New Dedicated Platforms' Powertrain Flexibility Comparison, Global, 2016–2025



Key Takeaways

- More than 75% of major global OEMs are expected have a BEV-only platform by 2025.

Powertrains expected

Powertrains not expected

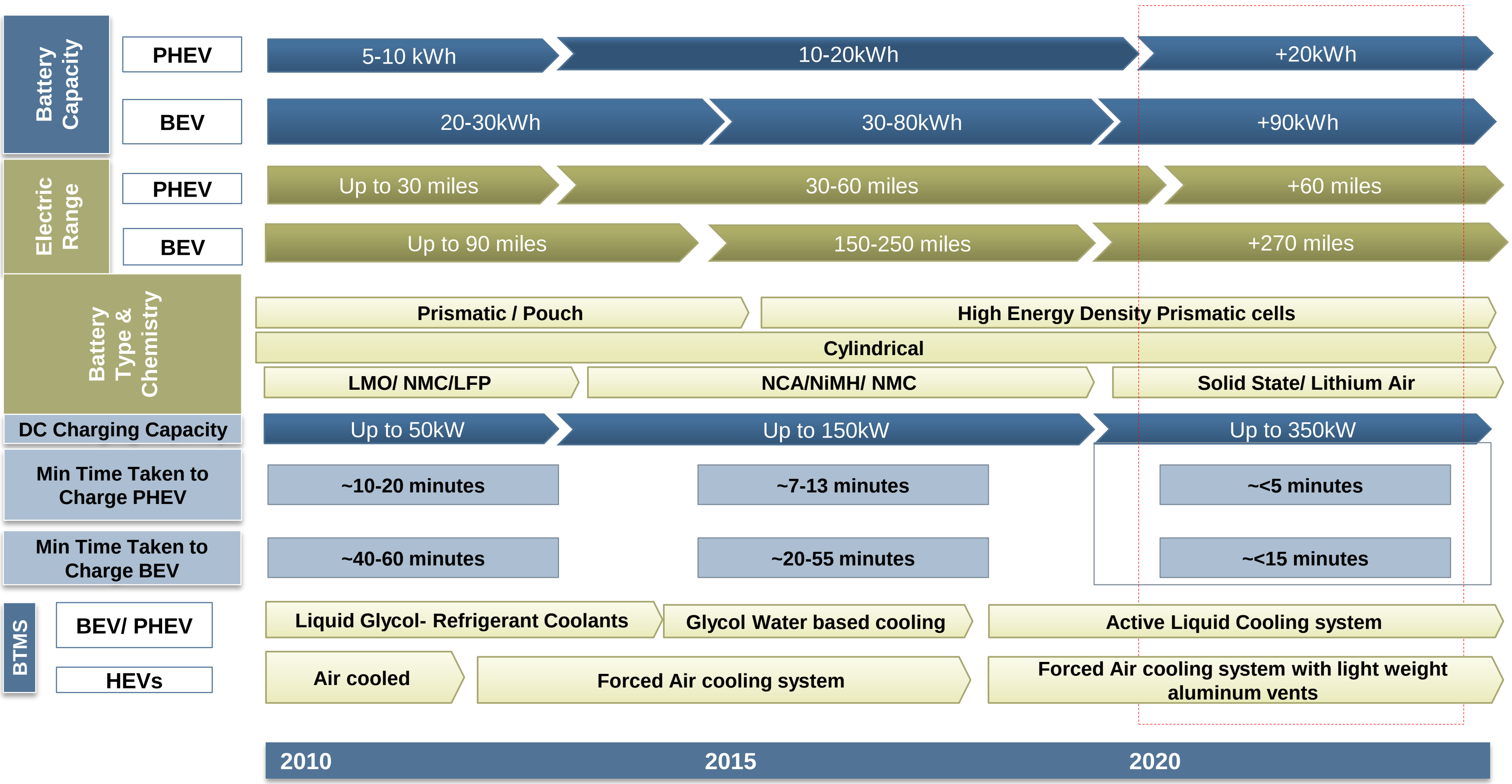
Note: List is not exhaustive

Source: Frost & Sullivan

Battery Specification Roadmap

The trend is moving towards higher battery capacities over 60kWh to increase the range of an electric vehicle up to 200 miles on a single charge.

Electric Vehicle Market : Battery Capacity and Range Roadmap, Global, 2010–2020



Source: Frost & Sullivan

Technology Roadmap by P – BTMS Solution

Flame barriers with epoxy and PCM materials will be the key trend in the future to adhere to the stringent battery thermal safety regulations such as GB/T regulations.

Electric Vehicle Outlook: Passive BTMS Technology Roadmap, Global, 2017-2025

2010 | 2015 | 2020 | 2025

Heat Sink
- Copper based foam-thermal fins → Aluminum fins-die casted graphite foam interface → Aluminum fins-die casted base fins, liquid coolant tube and plate
- Liquid glycol cooled aluminum heat sink liquid cold plate → Al alloy base with phase change material

Heat Spreader
- copper-molybdenum (Cu-Mo) → AlSiC , MgSiC- Adhesives & Plates
- Aluminum Foil, Copper Foil, Polyester, Synthetic Graphite → Cold plates with liquid coolant and polyester coating
- → Cold plate lined with PCM

Flame Barrier
- Composites/Ceramic insulation plates
- Barrier insulator
- → Glass epoxy, reinforced glass polymer, Polyamide films, thermo foams & sheets → Glass polyamide, glass epoxy and PCM Materials.

Thermal Conduction
- Plastic polymers, foam, copper graphite alloy → Copper foil coated with a mixture of carbon-based material

Thermal Insulation
- Polyvinyl Chloride (PVC) or Polyethylene Terephthalate → Metal alloy and inorganic sodium acetate
- Calcium Silicate, pyrotechnic materials, fiberglass battery separator, foam, ceramic foam, synthetic graphite

Source: Frost & Sullivan

Key Question Remains - How to achieve Profitability

Managing Manufacturing Complexity becomes Key

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Example: BMW Smart Factory Technologies—Implementation

Collaborative robots (cobots), wearables, augmented realty applications, smart glasses, exoskeletons, and innovative work gloves are the key technologies that are being integrated at BMW's global plants.

BMW workers using exoskeleton devices

BMW factory (Leipzig,Germany)—robot applies adhesive to window

~ 60 lightweight robots in BMW group plants

230 innovative work gloves at the BMW Group

~ 68 exoskeleton vests in use in the series production at **Spartanburg BMW plant**

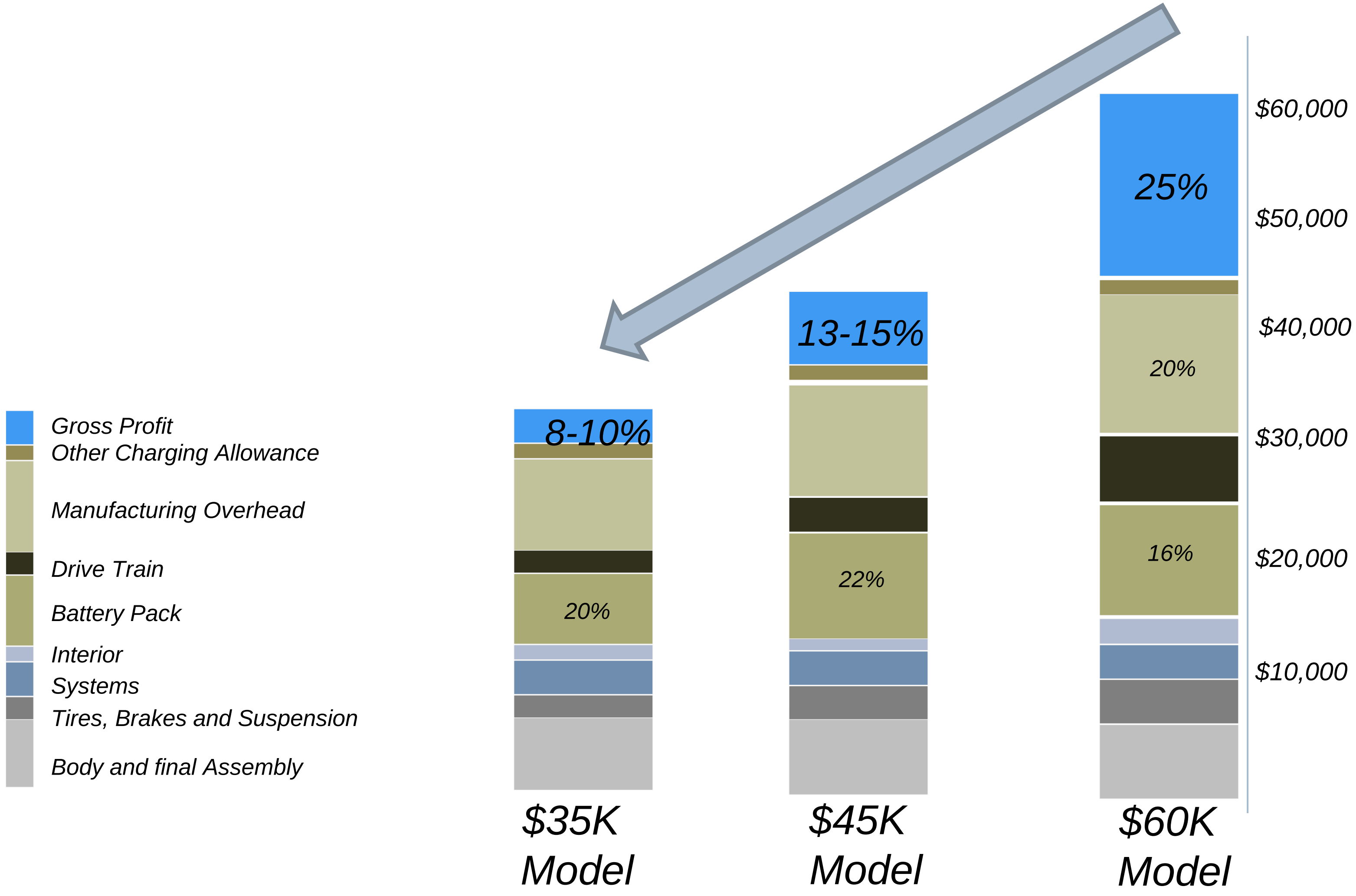
BMW worker uses smart gloves to scan items in warehouse

Augmented realty applications on smart devices such as tablet computers

Image Source: BMW

Source: Frost & Sullivan

Example: Popular EV Model Cost Breakdown Profitability Analysis



Source: Frost & Sullivan

Thank you

Q&A

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