ACMA
Automotive Component Manufacturers Association of India

Grant Thornton

Automotive Electronics Ecosystem In India - Roadmap 2032

May 2023

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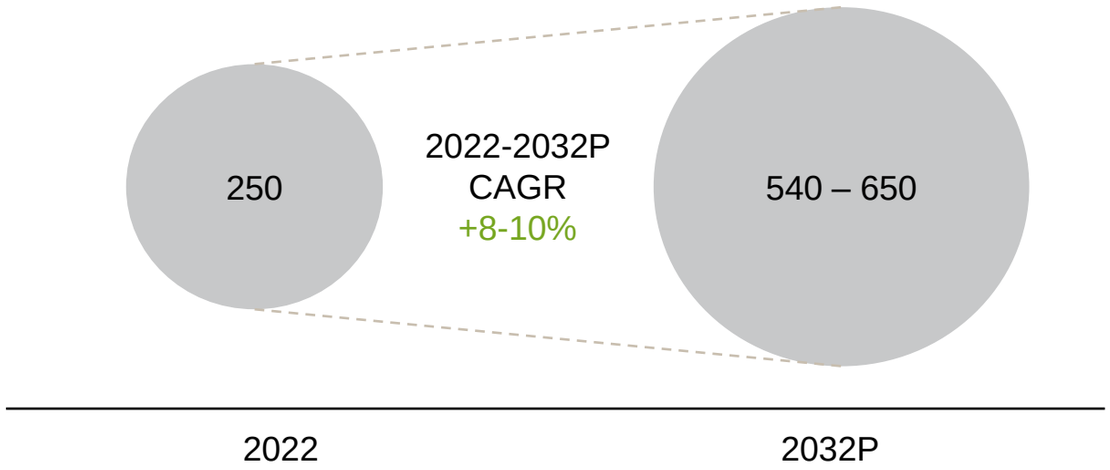
Executive Summary

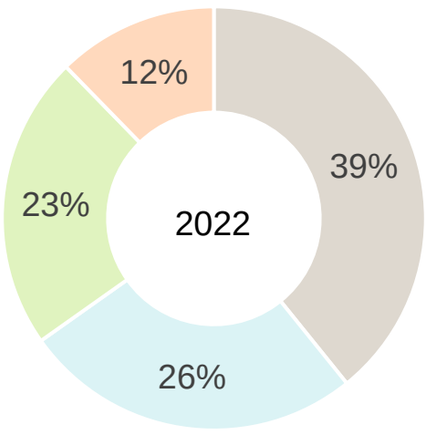
Global consumption of automotive electronics will double in the next decade

Global automotive electronics market size *(in $ bn)*[(a)]



- OEMs share (70-75%) will continue to grow as more electronic products will be factory fitted
- Passenger vehicles are expected to maintain share (80-90%), given their dominance in the global automotive market
- China accounts for 30% share in the global automotive electronics market

Market share by product category *(% of value)*



Power electronics

Safety controls

Communication & entertainment

Body electronics

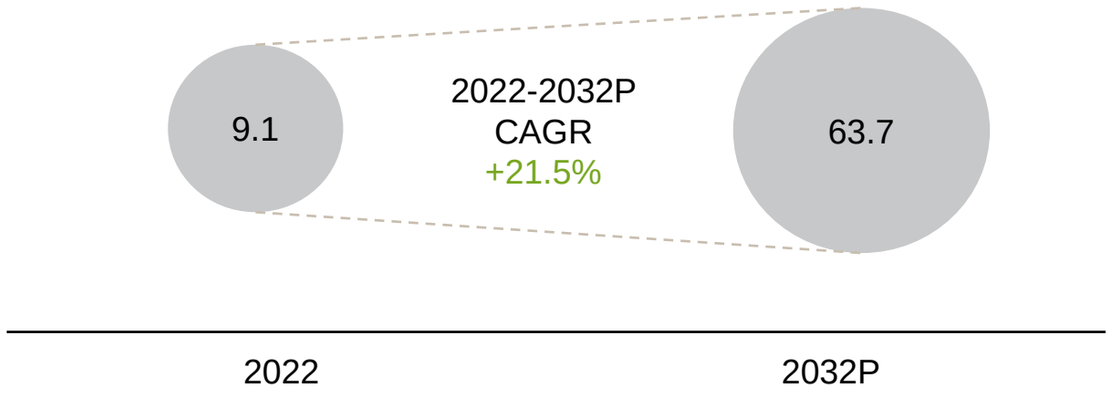
- The above market share by product category is likely to remain consistent over the next decade
- Power electronics growth will be driven by EV related products
- Within safety controls, level 1 and 2 ADAS solutions are driving growth
- Regulations are also giving additional push to safety and communication electronics

Note: (a) Basis passenger vehicles and commercial vehicles

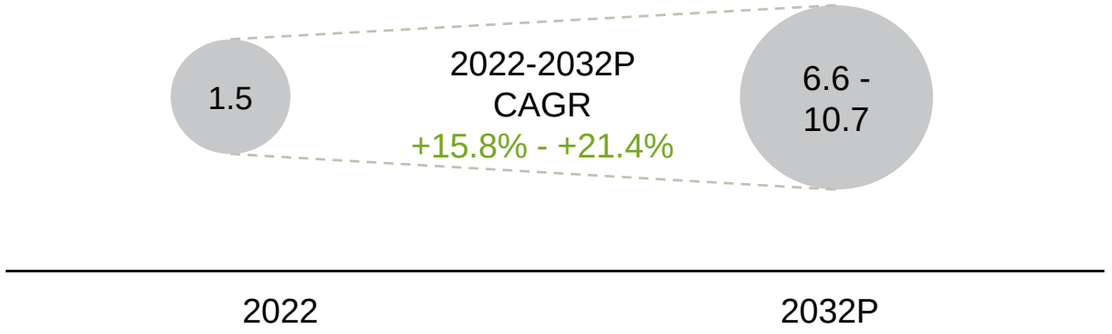
Source: (1) Automotive electronics market, Global Market Insights, 2023 (2) Automotive electronics – Master plan development for auto components industry, ACMA, 2016 (3) Automotive electronics market, Prescient & Strategic Intelligence, 2020 (4) Automotive electronics market, Grand View Research, 2020 (5) Automotive body electronics Market 2021, Market Stats, 2021 (6) Automotive safety system market, Markets & Markets, 2018 (7) Automotive infotainment market, Grand View Research 2022 (8) GT Analysis

Total India demand of automotive electronics will become >7X in the next decade

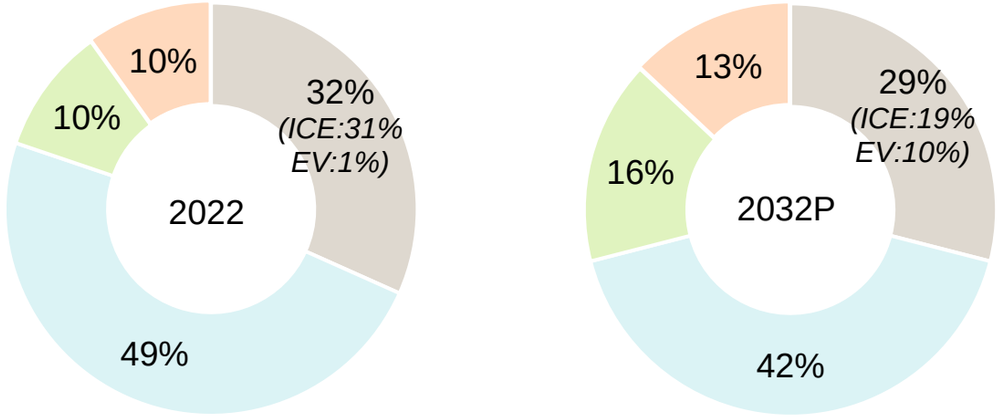
Domestic demand of automotive electronics *(in $ bn)*[(a)]



Demand of automotive electronics from vehicle exports *(in $ bn)*[(a)]



Domestic demand share by product category *(% of value)*



	CAGR 2022-32P
Power electronics	ICE: +16% EV: +54%
Safety controls	+20%
Communication & entertainment	+28%
Body electronics	+25%

Note: (a) $ 1 = Rs. 74

Source: (1) Automotive electronics, ACMA,2016 (2) CE Info Systems, Centrum, 2022 (3) Global automotive exhaust gas recirculation market, MarketResearch.com, 2022 (4) Indian automotive wiring harness market, GlobeNewswire, 2022 (5) India automotive software market, Businesswire, 2022 (6) Electrifying India mobility, IVC Association, 2022 (7) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (8) GT Analysis

64.3% of the total demand of auto electronics is being imported, the silver lining is that the balance is being manufactured in India

- We estimate that **64.3% of total demand** (i.e. $ 10.6 bn = $ 9.1 bn of domestic demand + $ 1.5 bn from vehicle exports) in 2022 was fulfilled via imports[a]
- Some of the auto electronic products which are being manufactured in India include:

Power electronics (ICE)	Power electronics (EV)	Safety controls	Communication & entertainment	Body electronics
Fuel injector	Power distribution module	Electronic power steering	Telematics unit	Reverse parking guide
Selective catalytic reduction	DC-DC converter	Tire pressure monitoring system	Driver information system	Fully automatic temperature control
Exhaust gas recirculation	Thermal management system	Airbag electronics	In-car entertainment system	Remote keyless entry & immobilizer
Automatic transmission system	Charger system	Electronic stability control	Navigation system	Body control module
Engine control system	Controller	Anti-lock braking system		

Imports[a] as % of total demand:	*Less than 40%*	*Between 40% and 80%*	*Greater than 80%*

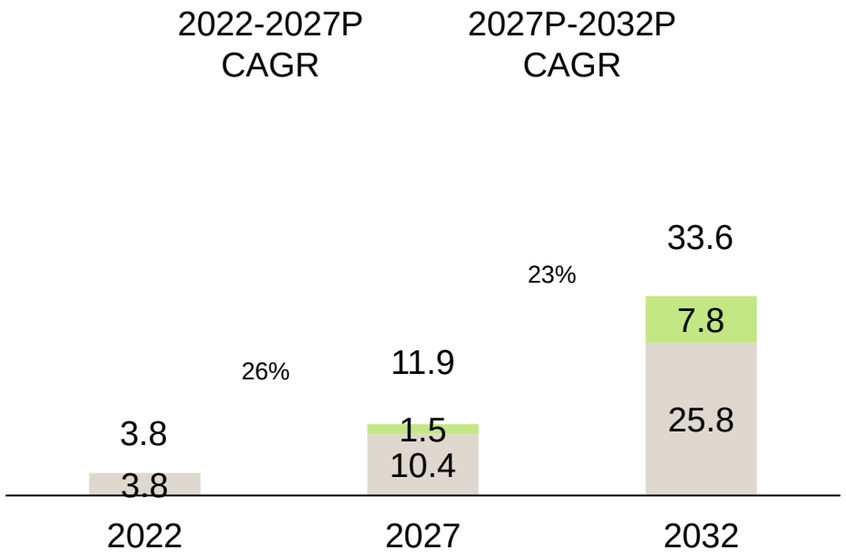
Note: (a) Includes both direct imports by OEMs as well as indirect imports (i.e., import via tier 1/2 supplier)
Source: (1) GT Analysis based on > 200,000 import transactions of CY2022 port data for a select OEM and its primary tier 1 supplier. The transactions included both complete products as well as sub-parts. The result observed for this OEM was taken average case for the Industry and extrapolated at category and product level for the total India demand (2) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers

Industry can target to manufacture automotive electronics of $ 34 - 59 bn by 2032

Manufacturing targets for 2032

- Automotive sector in India is poised to grow and through concentrated efforts of all stakeholders (e.g., Central Government, State Governments, Industry, and trade bodies), Industry can target to manufacture $ 33.6 – 58.8 bn by 2032

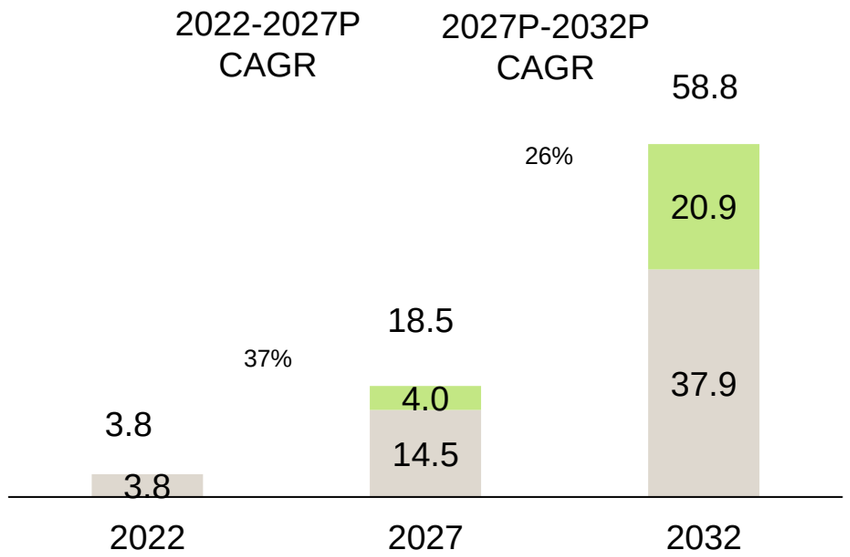
Base case: *Manufacturing (in $ bn) to grow as per the growth expected in total demand with moderate focus on exports[(b)]*



For exports as discrete components to OEMs in other countries

For India's demand (i.e., domestic demand + demand from vehicle exports)

Optimistic case: *Manufacturing (in $ bn) to grow faster than the growth expected in total demand with significant focus on exports[(b)]*



India faces impediments when it comes to auto-electronics sector

Cost disability differential of 7.5%-9.8% - Vietnam and 17.3%-19.0% - China in electronics manufacturing

Software solutions and auto-electronics design are critical elements, despite India's software development might, its use in auto is in early stages of maturity

Limited research & development and export opportunities

Not leveraging the otherwise thriving non-auto electronics manufacturing segment for the auto-segment

Imports are preferred for auto electronics even for products which are being manufactured in India

Multiple HSN codes are being used to import auto-electronics, seemingly making it difficult to assess the overall imports

We noticed some good practices globally which gives an impetus to auto electronics sector

- Research and development spend given importance: German automotive suppliers have invested an average of 5.7% of their turnover in research and development in recent years
- Cluster approach enabling Industry evolution: Bavaria cluster in Germany is a key center for global partnerships. Together with international experts from FCA, Intel and Mobileye, BMW is working on implementation of fully automated vehicles

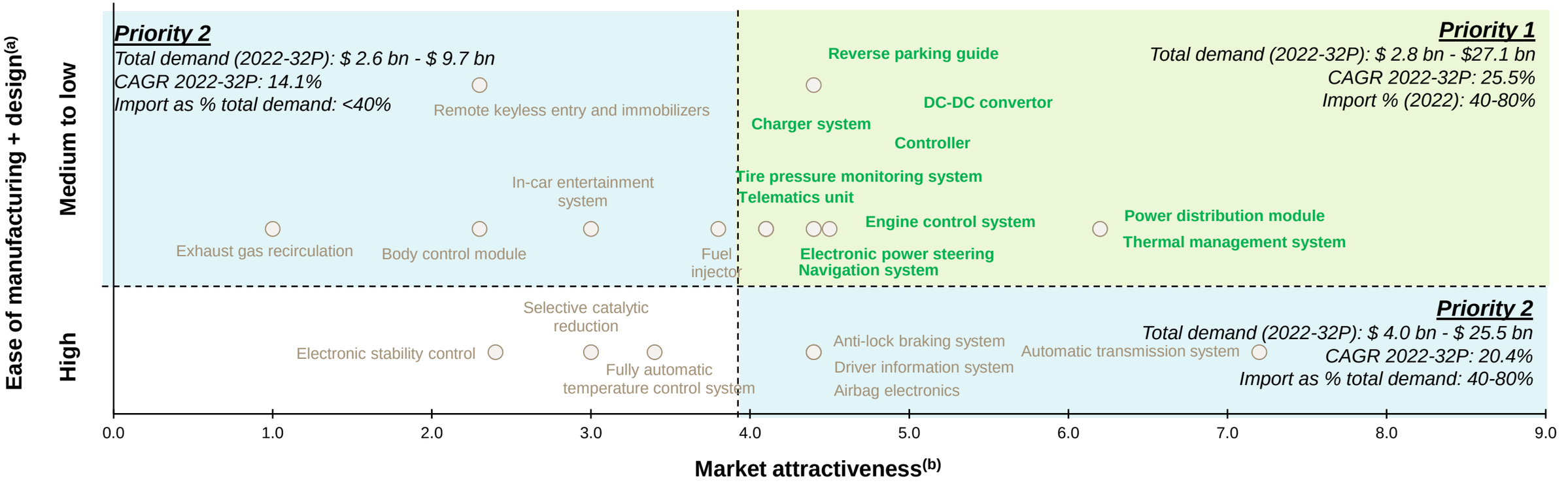
- Use of efficient products in vehicles: Japanese OEMs are required to meet the target of average fuel efficiency of 25.4 km/L (32.4% increase over actual value in 2016) by 2030 for new PVs

- Regulations enabled the use of safety products: In the past 2 decades, US NHTSA has mandated the use multiple safety technologies across vehicle segments - electronic stability control, occupant crash protection, and rear visibility systems

Recommendation 1: Certain auto-electronics products can be manufactured in India

Our research suggests that there are 23 automotive electronics products that have established demand in the Indian automotive market. Hence, these can be further evaluated for new manufacturing units or capacity expansion

High level product prioritization – market attractiveness vs. manufacturing + design complexity



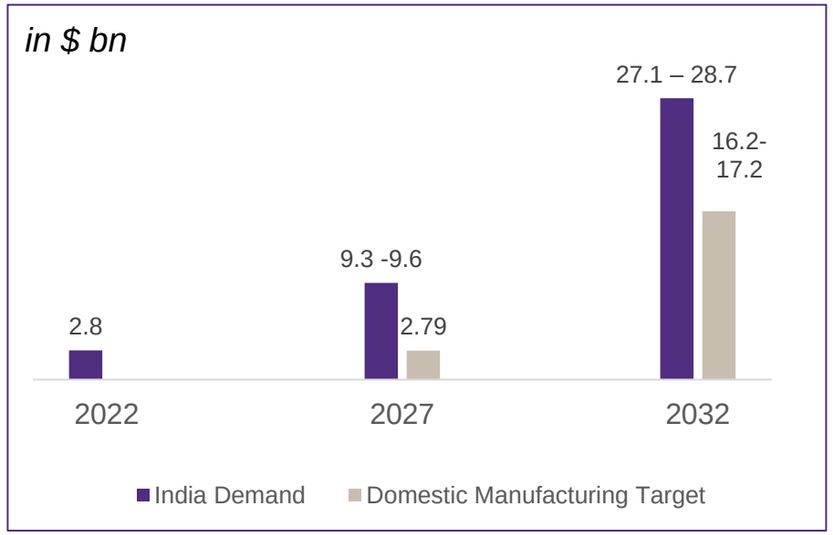
Automotive components suppliers can further evaluate these products in-depth basis investment requirements, synergies with existing product portfolio, capability transferability (i.e. IP, design, etc.), testing and lead time for OEM approval

Notes: (a) Ease of manufacturing + design refers to hardware design integration with software, PCB design, Electromagnetic Interface / Compatibility, need for graphical user interface, etc. (b) Based on weighted average score 2022 demand (35%), demand growth for 2022-32P (30%), Localization need (basis imports in 2022) (35%). Assessed on the scale of 1, 3, and 9. For detailed criteria and ratings, refer appendix
Source: (1) GT Analysis

Recommendation 1: Certain auto-electronics products can be manufactured in India

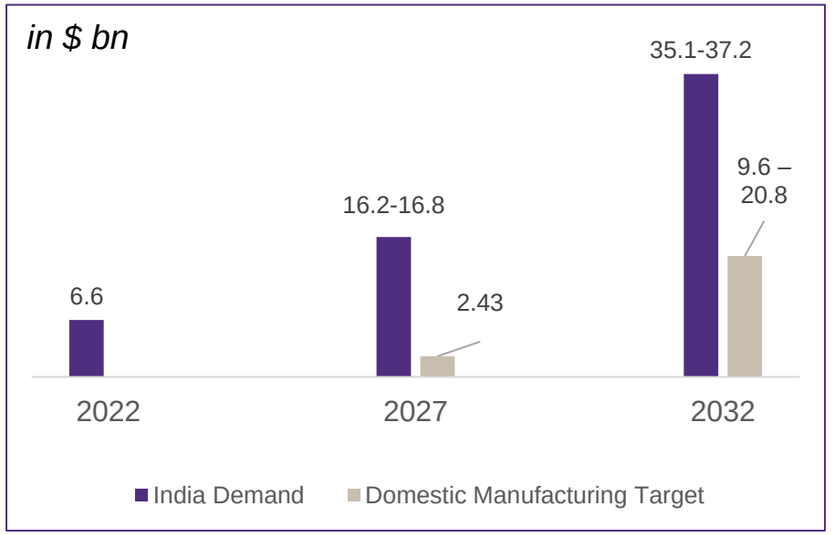
The manufacturing target implies reaching a 60% share of domestic manufacturing for the priority 1 and a 27-56% share in priority 2 products by 2032.

Priority 1 - 11 products which have a favorable market potential and manufacturing ease is also medium to low



Products include reverse parking guide, power distribution module, thermal management system, engine control system, electronic power steering, navigation system, telematics unit, tire pressure monitoring system, controller, charger system, and dc-dc converter

Priority 2 - 9 products are where either one of the market potential or manufacturing ease is medium to low



Products include exhaust gas recirculation, body control module, in-car entertainment system, fuel injector, anti-lock braking system, driver information system, airbag electronics, automatic transmission system, remote keyless entry and immobilizers

Keeping in view the above targets, if India is able to achieve 30% localization of priority 1 products and 15% in case of priority 2 products by 2027, it can expect to reduce imports by USD 5.22 bn by then

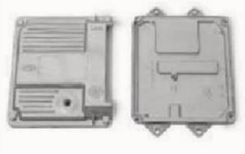
Source: (1) GT Analysis

Recommendation 2: Encourage manufactures of child parts (electronic and non-electronic) that can be used across different auto-electronic parts to expand scale in India

Encouraging domestic sourcing of child parts such as aluminum casings can save the import bill by $ 1.75 bn - $2.2 bn

Examples of common non-electronic components

- Strengths of existing automotive components suppliers can be leveraged to localize non-electronics related assembly parts such as:
  - **Electric Control Unit (ECU) thin wall casing** - accounts for 20-25% value share in the engine control unit

  - **Heat exchangers** - accounts for 20% value share in the thermal management system



- Currently, most OEMs are importing assemblies including heat exchangers and electronic control unit thin wall casings
- Indian auto-components suppliers have already created capability in aluminum castings and hence focusing on the localization of aluminum castings used in auto-electronics will help in increasing the local value add
  - It is expected that approximately $ 275 mn of import bill can be reduced by 2032 from localization of just two products or encouraging OEMs to procure aluminum locally – ECU thin wall casing and heat exchangers
  - In addition, localization of aluminum castings will also help target auto-electrical products such as casings for battery pack and electric motor. It is expected that $ 1.5 - 2 bn of import bill can be reduced by 2032

[Details of imports by different products]

[Details of imports bill savings]

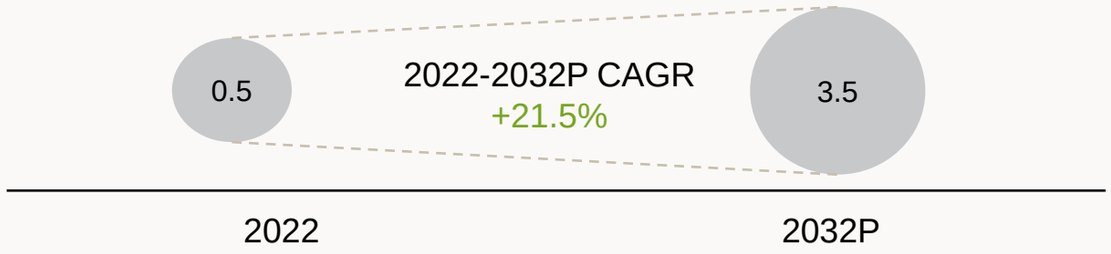
Source: (1) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (2) GT Analysis

Recommendation 2: Encourage manufactures of child parts (electronic and non-electronic) that can be used across different auto-electronic parts to expand scale in India

Encouraging domestic sourcing of child parts such as PCBs can save the import bill by $ 3bn - $3.5 bn

Examples of common electronic components

- PCBs account for approx. 5-6% value share in the automotive electronic products. PCBs consumption is expected to grow significantly, following total automotive electronic demand trend



- Other example include switches which account for 1-2% value share in the automotive electronic products

[Details of relevant PCB manufacturers]

- Some Indian companies have launched fabless chips and OEMs have also tested the same
- Indian companies have also started chip designing and finishing operations (Navigation and radar chips for auto sector have been designed by Indian companies)
- PCB companies catering to the non-auto electronic sector can be encouraged to supply to auto sector, some OEMs have successfully used industrial PCBs in their respective platforms
- Foxconn has already started supplying information display units to some OEMs

Recommendation 3: Adopt cluster approach to address manufacturing cost disability

Automotive Electronics Clusters

- Dedicated clusters to address cost disability via lower land and building costs along with support services such as testing / certification, hostels for labor and staff, back-up power, and logistics support should be evaluated
- These dedicated clusters can be established around automotive hubs such as Delhi-NCR, Pune, and Chennai
- An example of such a cluster is '**ELCINA Electronics Manufacturing Cluster'** located in Bhiwadi, Rajasthan
    - *Preliminary discussions indicate that setting-up electronics manufacturing facility in ELCINA cluster helps reduce cost of manufacturing by 5-8%*
    - *Further, for investments above Rs. 100 Cr. the officials are willing to extend customised benefits. These would be arrived on case to case basis – taking the cost advantage further*

Recommendation 4: Incentives and dis-incentivization specific to auto electronics

Incentives

- Exports of auto-electronics and allied components may be subject to reduced export duties (can be specific products linked to specific HSN codes)
- Additional benefits in the form of income-tax deductions, infra-support and grants for R&D taken up in the field of auto-electronics (can be controlled to provide benefits to products with IP etc.)
- Additional benefits (financial and non-financial (EODB related) in case an Indian company acquires significant stake in an overseas company in the field of auto-electronics
- Support non-auto electronic product manufacturers to supply to auto companies by providing linkage support with tier 1 and OEMs

Disincentives

- In a gradual manner, levy additional duties on auto-electronic components being imported. A list of components with high manufacturing volumes can be included (can be tracked through HSN codes)

Recommendation 5: Strengthen policy guidelines for safety products uptake + testing

Long term policy guidelines for the uptake of safety related electronic products

- Currently, OEMs have observed the uptake of safety related automotive electronics has been driven by sudden product specific notifications by MoRTH
- One such example is MoRTH notification on making 6 airbags mandatory in passenger vehicles from October 2023. As per latest news articles, MoRTH is currently in consultation with OEMs on whether October 2023 is feasible or not
- Therefore, it is recommended that a long-term plan on the uptake of safety related products will help OEMs to plan the sourcing of these products in advance.
  - Further, the complexity of products can be increased with growth of automotive electronics manufacturing in India
  - An example regulation that can be considered for the same is EU Regulation 2019/2144
- Some of these rules can be evaluated by MoRTH

Testing norms for electronic components crucial from the cybersecurity standpoint

- Currently, detailed testing at component level for telematics unit is not required
- Components - crucial from cybersecurity standpoint - such as security modules GNSS unit, engine interface, external interface, etc. are not vetted during telematics unit testing
- Formulation of component standards for the same should be considered to ensure functional safety and security of the complete telematics unit
- Key global standards that can be considered for the same are:
  - ISO 26262
  - IEC 61508
  - SAE J2980
- Some of these rules can be evaluated by MeitY

Source: (1) Draft car norms on mandatory 6 airbags, seat belts lapse, Times of India, 2023 (2) MoRTH approves draft notification for making 6 airbags mandatory, ET Auto, 2022 (3) GT Analysis

Recommendation 6: Establish technical and academic linkages for capability and skill building

Technical linkages

- Technical linkages with globally recognized CoEs will help in establishing dedicated R&D centers focusing on automotive electronics manufacturing
- Further, leading Indian component suppliers which have recently or are in process of acquiring foreign companies to gain access to relevant IPs / product design have indicated that mandatory processes related to forex regulations could be eased to fast-track such acquisitions

[Details of relevant CoEs]

- There are many start-ups in automotive electronics
- Such start-ups can be mentored on technology and product development aspects with the help of new R&D centers
- Select examples of start-ups include:
  - Flux Auto, Bangalore
  - Cyrrup, Hyderabad
  - Cell Propulsion, Bangalore
  - Swaayatt Robots, Bhopal

[Details of relevant start-ups]

Academic linkages

- Academic linkages between Indian and foreign universities will help in offering automotive electronics specific degree as well as certificate programs, leading to human capital development for R&D and manufacturing teams of future
  - Currently, some aspects of automotive electronics (e.g. power electronics) are covered as part of select degree programs in leading engineering institutions, indicating the presence of base which can be leveraged for launching automotive electronics dedicated degree programs
- Select examples of foreign universities offering such programs include:
  - Riverside College, USA
  - University of Michigan, USA
  - OTH Regensburg, Germany
  - Clemson University, USA
  - Coventry University, UK
  - University of Warwick, UK

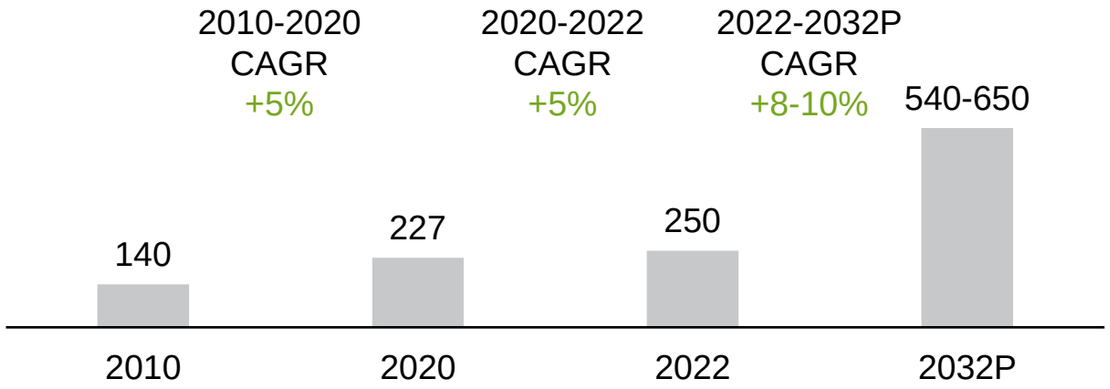
[Details of relevant foreign universities]

Global automotive electronics market

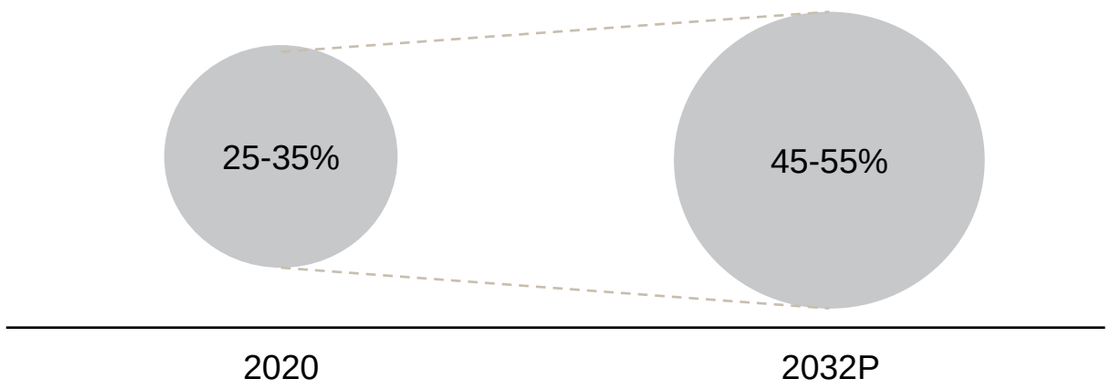
- Global consumption
- Trends shaping global consumption

Global consumption of automotive electronics will become double in next decade

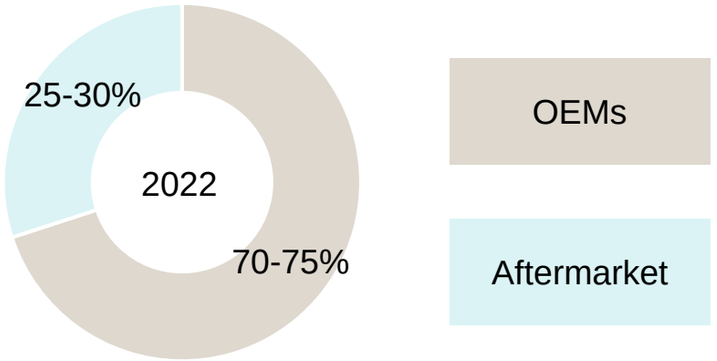
Automotive electronics market size by value *(in $ bn)*[(a)]



Electronics share in total car cost *(in %)*

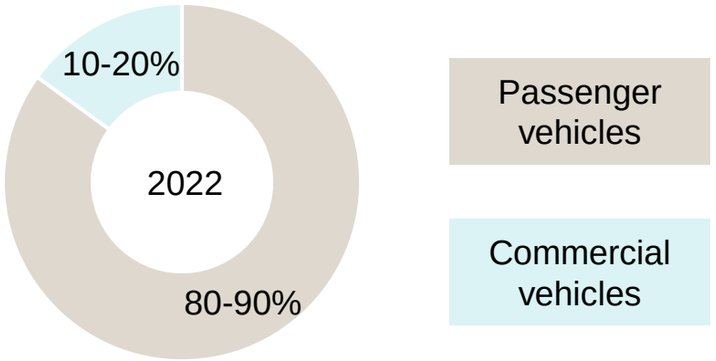


Market share by channel *(% of value)*



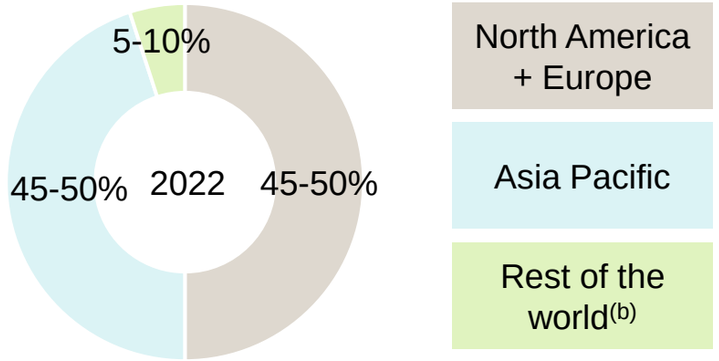
OEMs share will continue to grow as more electronic products will be factory fitted

Market share by vehicle type *(% of value)*



Passenger vehicles are expected to maintain share, given their dominance in the global automotive market

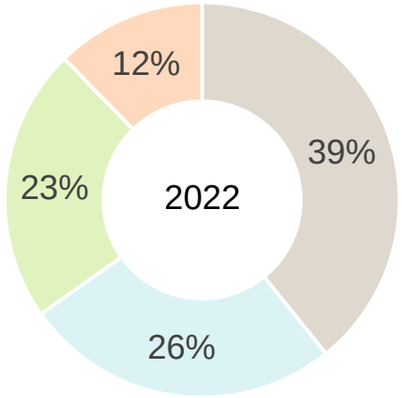
Market share by region *(% of value)*



China accounts 30% share in the global automotive electronics market

Note: (a) Basis passenger vehicles and commercial vehicles (b) Rest of the world includes Middle East, Africa, and Latin America
Source: (1) Automotive electronics market, Global Market Insights, 2023 (2) Automotive electronics – Master plan development for auto components industry, ACMA, 2016 (3) Automotive electronics market, Prescient & Strategic Intelligence, 2020 (4) Automotive electronics market, Grand View Research, 2020 (5) GT Analysis

Currently, products related to power electronics have the highest value share



Market share by product category *(% of value)*	2022 size *(in $ bn)*	2032P size *(in $ bn)*	2022-32P CAGR	Definition	Select product examples
Power electronics	98	210-250	+8-10%	Components that control and process the flow of electrical energy required in both ICE and EV vehicles	ICE: Automatic transmission system, fuel injector, engine control unit, etc. EV: DC-DC converter, charger, etc.
Safety controls	65	150-185	+9-11%	Components that are responsible for the active and passive safety related features in the vehicle[(a)]	Airbag electronics, advanced driver assistance system, active suspension system, etc.
Communication & entertainment	56	120-146	+8-10%	Components that deliver entertainment and information to driver, passengers, and externally (information if required)	Telematics unit, in-car entertainment system, navigation system, etc.
Body electronics	31	60-70	+7-9%	Components that provide the control function to implement the diagnostics, safety features and manage power	Body control module, adaptive front lighting, reverse parking, temperature control, remote keyless entry, etc.
Total	***250***	***540-650***	***8-10%***		

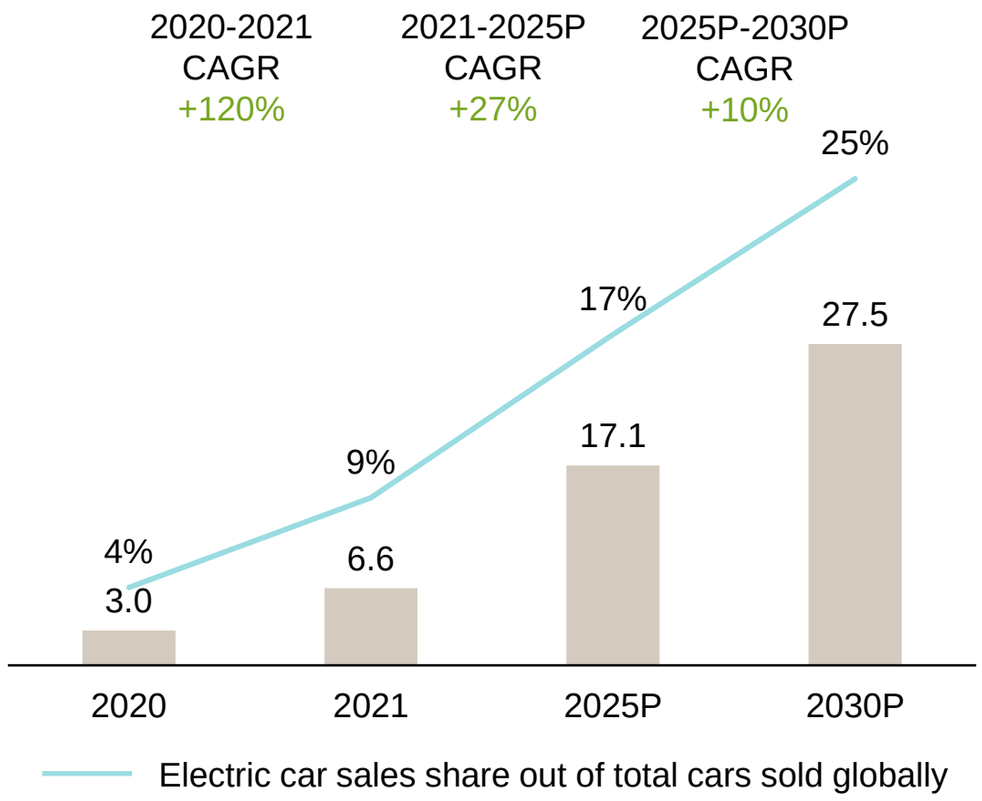
Note: (a) Passive safety feature is any safety system that reacts to a collision and attempts to keep occupants safe, but only after a collision occurs. Active safety features are those that attempt to avoid collisions altogether
Source: (1) Automotive electronics market, Global Market Insights, 2023 (2) Automotive body electronics market 2021, Market Stats, 2021 (3) Automotive safety system Market, Markets & Markets, 2018 (3) Automotive infotainment market, Grand View Research 2022 (4) GT Analysis

Global automotive electronics market

- Global consumption
- Trends shaping global consumption

1. Power electronics growth will be driven by electric vehicle related products

Global electric car sales *(in mn units)*[(a)(b)(c)]



Announcements on electrification by select OEMs in 2021

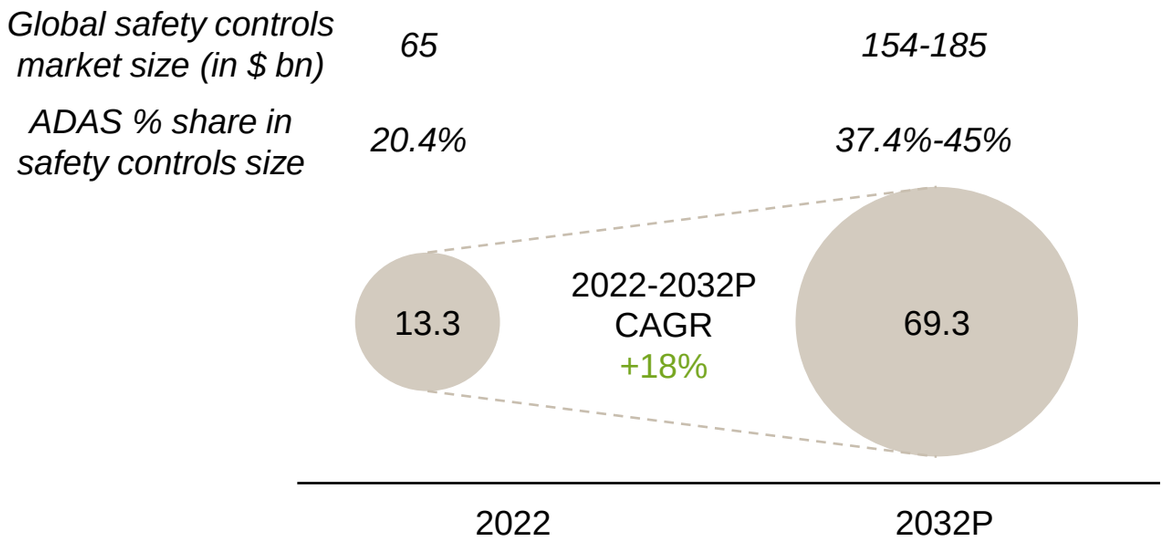
#	Select OEMs	OEM ambition with respect to electric cars
1	TOYOTA	3.5 mn annual electric car sales by 2030
2	gm	30 electric car models + production capacity of 1 mn units in North America by 2025
3	HYUNDAI	1.9 mn annual electric car sales by 2030
4	KIA	Increase sales of electric cars to 1.2 mn by 2030
5	Mercedes-Benz	From 2025, all newly launched vehicles will be fully electric

Key takeaway: Acceptance of electric vehicles globally among customers combined with supply side push from multiple OEMs will result in strong demand for electric vehicle related power electronic products

Note: (a) Includes sale of both battery electric vehicles and plug-in hybrid vehicles (b) Refers to STEPS Scenario (i.e., Stated Policies Scenario), (c) ICE passenger cars expected CAGR for 2021-30 is 0.7%
Source: (1) Electric car registrations, International Energy Agency, 2022 (b) Global electric vehicles outlook 2022, 2030, International Energy Agency (3) EV A to Z Encyclopedia: Understanding EV Components, Hyundai Motor Group, 2020 (4) 2021 and 2030 passenger vehicle sales statistics – OICA & Statista (6) GT Analysis

2. Within safety controls, level 1 and 2 ADAS solutions are driving growth

Global ADAS[(a)] market size by value *(in $ bn)*



- The above market sizing is basis level 1 and 2 solutions such as adaptive cruise control, blind spot detection, automated emergency braking, parking assistance, night vision, and lane departure warning
- OEMs are increasingly adopting these solutions because of multiple benefits to industry as well as customers – including accident mitigation, increased driving comfort and fuel efficiency gains

Penetration and attainment of ADAS levels by OEM

ADAS level	Key function	Penetration	Global OEM example
1	Driver assistance		Widely present across OEM cars *(in North America + Europe)*
2	Partial driving automation[(b)(c)]		Tesla's Autopilot
3	Conditional driving automation[(d)]		Mercedes Benz Drive Pilot[(e)]
4	High driving automation[(f)]		Waymo Robotaxi
5	Full driving automation		Not yet achieved by any OEM

Key takeaway: Higher penetration of level 1 and 2 solutions and attainment of higher automation levels by more OEMs will continue to make ADAS increasingly relevant in the global automotive electronics market

Note: (a) In terms of BOM, Sensors such as Radar, Ultransonic, Lidar, etc. account for more than 30% share. Other sub-components include Processors, Software, etc. Lidar refers to Laser imaging, detection, and ranging (b) Automation refers to control of steering, braking and acceleration (c) Requires driver to be attentive and be in seat all the times (d) Driver will have to take car controls when system asks for the same (e) Received approval from German Federal Motor Transport Authority in 2021 (f) Geofencing based self-driving
Source: (1) Automotive electronics market, Global Market Insights, 2023 (2) Advanced driver assistance market, Grand View Research, 2021 (3) ADAS levels, TopGear, 2023 (4) Waymo launches autonomous rides to Phoenix airport, TechCrunch, 2022 (5) GT Analysis

3. Regulations are giving additional push to safety and communication electronics

Select examples of regulatory initiatives positively impacting the demand of safety and communication electronics

Regulation 2015/758

- It mandated that from March 2018, all passenger cars and light commercial vehicles are to be equipped with a permanently installed eCall in-vehicle system[(a)]
- This system ensures that if there is a severe accident detected by the vehicle sensors, an eCall to the 112-emergency number is triggered automatically for appropriate response from emergency alert services

Regulation 2019/2144

- It mandates that from July 2022, all new vehicles must have a range of new safety features
- The key examples of these features include[(b)]:
  - Event data recorder
  - Tire pressure monitoring system
  - Driver drowsiness and attention warning system
  - Intelligent speed assistance

FMVSS 138/2005[(c)]

- It was introduced in April 2005 and specified performance requirements for tire pressure monitoring system to warn drivers of significant under-inflation of tires
- It applied to all passenger cars, multipurpose passenger vehicles, trucks, and buses that have a gross vehicle weight rating of 4,536 kgs or less

C-ITS Plan 2012-13

- C-ITS (Cooperative-Intelligent Transport Systems) provides traffic conditions to the driver in real time using V2I and V2V communication
- The deployment target of C-ITS by 2025 is:
  - Expressway: Complete
  - National highway: 4075 kms
  - 4 lane above local roads: 12995 kms

<u>Key takeaway:</u> This trend is expected to be witnessed in other markets as Governments begin to focus on promoting safer and faster road transportation, while reducing the overall road fatalities

Note: (a) Applies to passenger cars with not more than eight seats in addition to the driver's seat and light commercial vehicles used to transport goods with a maximum mass not exceeding 3.5 tones (b) Select features (c) Federal Motor Vehicle Safety Standards
Source: (1) Regulation 2015/758 - Type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service, EU Monitor (2) New vehicle safety systems, Federal Ministry for Digital and Transportation, Germany (3) Regulation (EU) 2019/2144, EUR-Lex (4) FMVSS - Standard No. 138, Cornell Law School (5) C-ITS Project, Ministry of Land, Infrastructure, and Transport, South Korea (6) Korean New Deal Policies 2020, Smart Road Team, Road Bureau, South Korea

Regulation related to: ***Safety controls*** ***Communication & entertainment***

4. OEMs are using electronics related features to differentiate from competition

Select examples of unique electronics related features witnessed across different OEMs

Honda Sensing

- Honda Sensing is a suite of safety + driver-assistive technologies to alert drivers
- Key technologies are:
  - Collision mitigation braking system(a)
  - Road departure mitigation system(b)
  - Traffic sign recognition(c)

Safety Sense

- Safety Sense is a suite of safety features for the vehicle riders:
  - Pre-collision system with pedestrian detection
  - Lane departure alert
  - Automatic high beam
  - Lane tracing assist
  - Road sign assist

OnStar

- OnStar is a telematics-based subscription service for GM vehicle owners
- Key services offered:
  - Automatic crash response
  - Roadside assistance for flat tire
  - Unlimited in-vehicle data (via Wi-Fi)

BlueLink

- Bluelink is a connected car system
- Key services offered:
  - Connected Care: service reminders, diagnostic alerts, and vehicle health report
  - Remote: lock / un-lock, start / stop, and climate control using an app

FordPass

- FordPass App allows vehicle owners to:
  - Access vehicle details such as fuel level, maintenance intervals, etc.
  - Remotely lock / unlock and start / stop the vehicle
  - Order services such as flat tire repair

Key takeaway: OEMs are primarily using electronics related features to bring down the total cost of car ownership, make their vehicles safer for occupants + road users, and improve customer in-car + off-car engagement

Note: (a) Applies brake pressure when an unavoidable collision is determined (b) Adjusts steering if you cross detected lanes without signaling (c) Can notify drivers of posted speed limits with the use of a small camera

Source: (1) What is Honda Sensing?, Honda US website accessed 22nd Feb, 2023 (2) Safety Sense, Toyota US website accessed 22nd Feb, 2023 (3) FordPass Connect, Ford US (4) OnStar website accessed 21st Feb, 2023 (5) Hyundai Bluelink overview, Hyundai website accessed 22nd Feb, 2023

Feature related to: Safety controls | Communication & entertainment

5. Industry stakeholders are building alliances to capture electronics opportunity

Select examples of strategic partnerships among industry stakeholders in the recent past

#	Companies involved in the partnership	Year	Partnership objective
1	CARIAD (A VOLKSWAGEN GROUP COMPANY) & BOSCH	2022	• Develop partially automated (i.e., allowing drivers to temporarily take hands off the steering wheel) and highly automated (i.e., taking control of all driving functions on the freeway) driving functions
2	HONDA & SONY	2022	• Develop and commercialize an electric car with subscription-based technology and entertainment choices. Honda to contribute automated driver-assist technology and Sony to provide metaverse-related entertainment
3	Qualcomm & Independently with multiple OEMs	2022	• GM started using Qualcomm's Snapdragon Ride platform to power the advanced driver assist systems in its Cadilla Lyriq models • BMW & Volkswagen to also start using Snapdragon Ride platform from 2025
4	STELLANTIS & Mercedes-Benz & TotalEnergies	2021	• Develop and produce battery packs for electric vehicles via a jointly and equally owned company – Automotive Cells Company. All 3 partners have committed to increasing ACC's capacity to 120 GWh by 2030
5	RENAULT NISSAN MITSUBISHI & Google	2018	• Embed android operating system in vehicle sold by the alliance members, providing navigation with Google Maps, ability to answer calls, and manage vehicle functions with voice using the built in Google Assistant

Key takeaway: The underlying objective of these partnerships is to shorten the innovation cycle and share investment costs, ultimately decreasing the time to market

Source: (1) Automated driving: Bosch and CARIAD agree on extensive partnership, CARIAD, 2022 (2) Renault-Nissan-Mitsubishi and Google join forces on Next-Generation infotainment, Nissan Motor Corporation, 2018 (3) Stellantis and TotalEnergies welcome Mercedes-Benz as a new partner of Automotive Cells Company (ACC), Total Energies, 2021 (4) Honda and Sony's Joint EV Is Coming in 2025, Will Be Made in Ohio for U.S., Car & Driver, 2022 (5) Qualcomm partners with Mercedes-Benz and Red Hat to accelerate its automotive chip ambitions, Silicon Angle, 2022

Indian automotive electronics market

- Difference between India and global peers
- India demand size
- Trends shaping India’s domestic demand

India has lower labor costs and improved significantly in ease of doing business

Comparison of India and its global peers on macro-levers

Key macro-levers	India	China	USA	Germany	Japan
Manufacturing labor cost (in $ per hour)	2.1	6.5	27.2	49.6	26.5
2021 labor productivity (in $ GDP per hour worked)[a]	8.5	13.5	70.7	58.3	39.6
2020 ease of doing business ranking *(change w.r.t. 2016)*[b]	63 *(improved by 63 ranks)*	31 *(improved by 53 ranks)*	6 *(improved by 1 rank)*	22 *(declined by 7 ranks)*	29 *(improved by 5 ranks)*
2022 economic competitiveness ranking *(change w.r.t. 2016)*[c]	37 *(improved by 4 ranks)*	17 *(improved by 5 ranks)*	10 *(declined by 7 ranks)*	15 *(declined by 3 ranks)*	34 *(declined by 8 ranks)*
Current vehicles penetration (in per 1000 population)[d]	59	221	890	628	624

Key takeaway: Despite recent improvements, global peers outperform India in – productivity, EODB, economic competitiveness, and vehicles penetration; however, labor cost advantage and future potential basis expected penetration are strong drivers

Note: (a) GDP constant 2017 international $ at PPP (b) Measures regulatory quality and efficiency (c) Ranks countries according to how they manage their competencies to achieve long-term value creation (d) Includes cars, vans, etc. and excludes two wheelers
Source: (1) LPI, World Bank (2) Doing Business 2020 and 2016, World Bank (3) World Competitiveness Center, IMD (4) Motorization rate per 1000 population, Statista (5) Comparisons of hourly compensation costs in manufacturing, The Conference Board, 2018 (6) Shaping the new normal for India's auto component Industry, ACMA, 2020 (7) Statistics on labor productivity, International Labor Organization, 2023 (8) GT Analysis

In 2022, India became the third largest automotive market in terms of sales volume

Comparison of India and its global peers on automotive market construct

Key market factors	Year	India	China	USA	Germany	Japan
Total vehicles sold (in mn units)[a]	2022	4.7	26.9	14.2	2.9	4.2
CAGR of total vehicles sold (in %)	2019-22	+7%	+1%	-7%	-10%	-7%
Share of passenger vehicles sold (in %)	2021	82%	82%	21%	87%	82%
Share of commercial vehicles sold (in %)	2021	18%	18%	79%	13%	18%
Electric vehicles share in passenger vehicle sales (in %)[b]	2021	0.4%	16%	5%	26%	1%

Key takeaway: India has registered highest automotive sales growth compared to its global peers. As vehicle penetration increases further combined with rise in EV share, automotive electronics market will witness both volume and value growth

Note: (a) Includes both passenger vehicles and commercial vehicles (b) Includes both BEV and PHEV. BEV stands for Battery Electric Vehicles. PHEV stands for Plug-in Hybrid Vehicles
Source: (1) World motor vehicle production data 2019-22, International Organization of Motor Vehicle Manufacturers (2) Global EV data explorer, International Energy Agency, 2022 (3) GT Analysis

Indian automotive electronics market

- Difference between India and global peers
- India demand size
- Trends shaping India’s domestic demand

India demand size = Domestic demand (i.e., demand from vehicles that are sold in India) + demand from vehicles that are manufactured in India but exported to other countries

India demand size is estimated using the below mentioned electronic products

Detailed list of products considered relevant for the Indian automotive market[(a)(b)]

Automotive electronics

Power electronics (ICE)	Power electronics (EV)	Safety controls	Communication & entertainment	Body electronics	Electricals
Fuel injector	Power distribution module	Electronic power steering	Telematics unit	Reverse parking guide	Wiring harness
Selective catalytic reduction	DC-DC converter	Tire pressure monitoring system	Driver information system	Fully automatic temperature control	Printed circuit boards
Exhaust gas recirculation	Thermal management system	Airbag electronics	In-car entertainment system	Remote keyless entry & immobilizer	Switches
Automatic transmission system	Charger system	Electronic stability control	Navigation system	Body control module	Actuators
Engine control system	Controller	Anti-lock braking system			Sensors

Automotive software

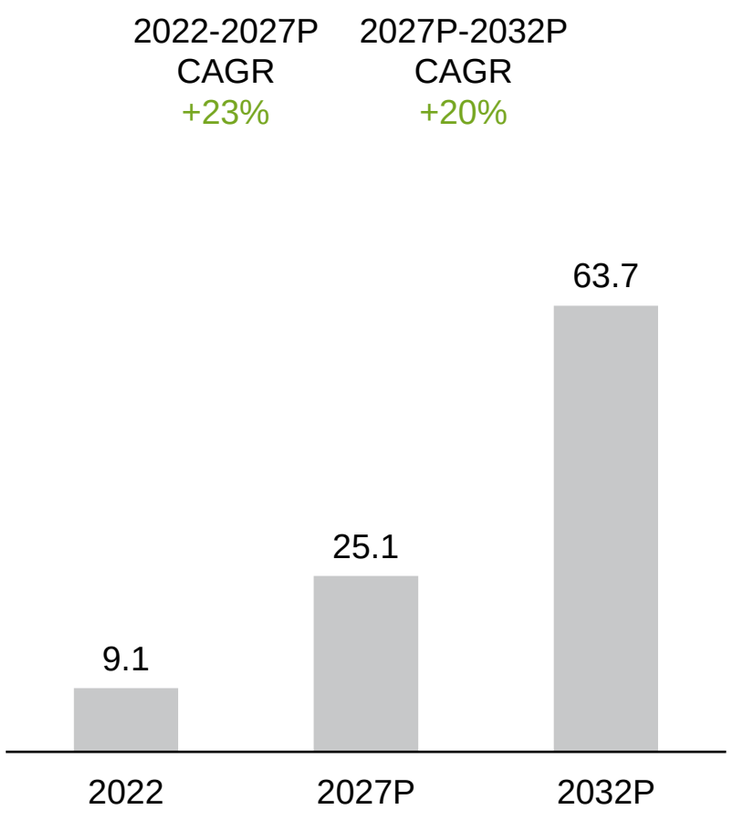
Adjacent products

Note: (a) The vehicle segments applicable for each product have been in the appendix (b) The detailed list of sub-parts has been highlighted in the appendix
Source: (1) 4-5 primary interactions with 2 market research firms (2) List of electronic products, MarkLines Database (3) Automotive Electronics: Master plan development for auto component industry in India, ACMA, 2016 (4) Study on xEV market and opportunities for xEV component suppliers, ACMA, 2018 (4) GT Analysis

Domestic demand is expected to become 7X in the next decade, reaching $ 63.7 bn

Domestic demand size *(in bn $)* basis product universe considered[(a)]

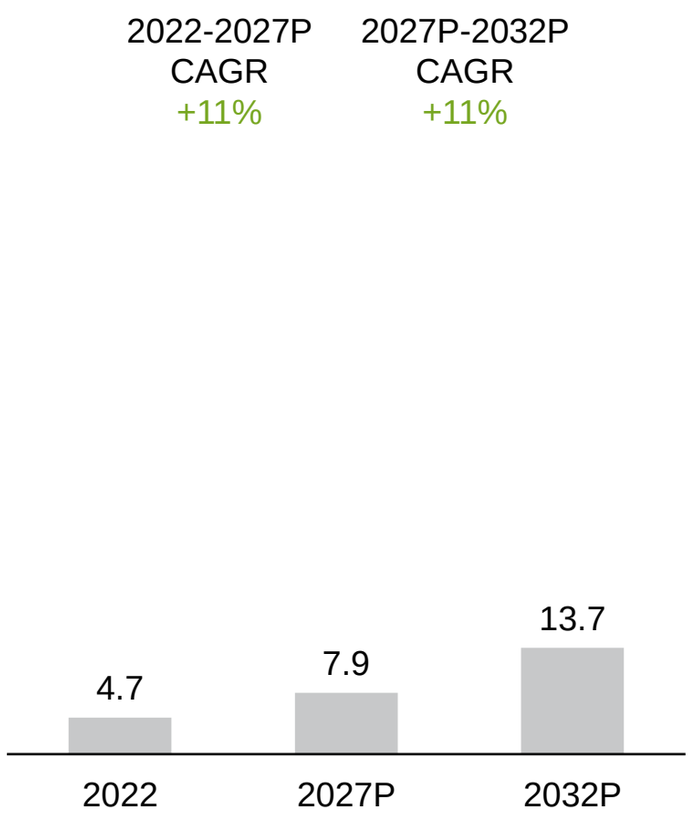
Automotive electronics



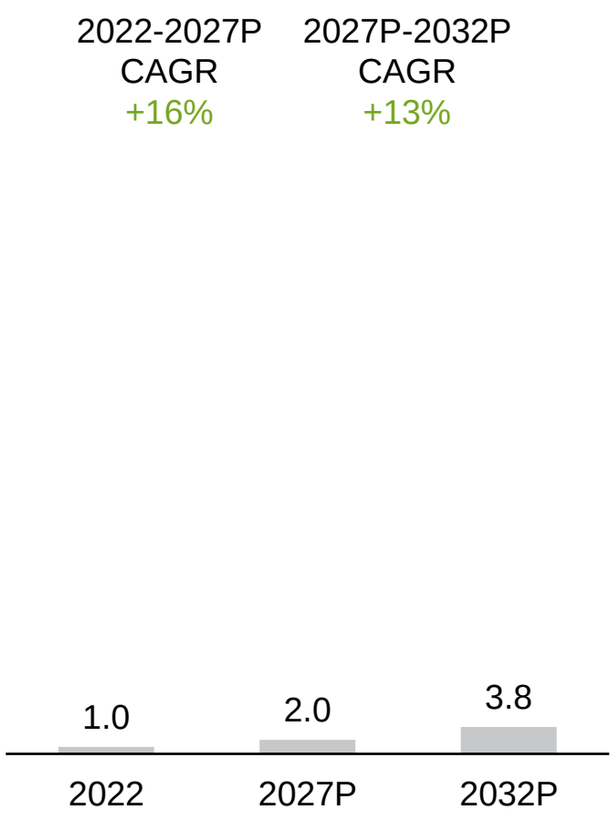
India's share in the total global consumption is expected to increase from 3.6% in 2022 to 9.8%-11.8% in 2032

The key reason for the same is India will witness higher CAGR in the next decade – 20+% in comparison 8-10% globally

Electricals



Automotive software

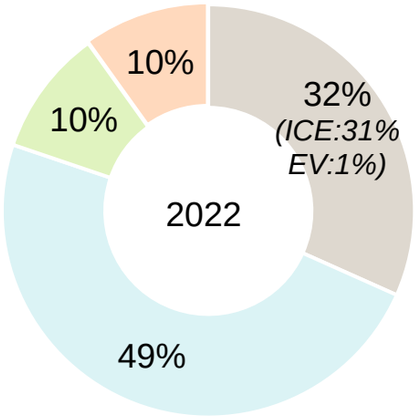


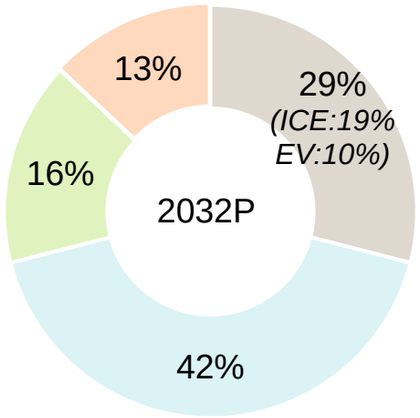
Note: (a) $ 1 = Rs. 74

Source: (1) Automotive electronics, ACMA,2016 (2) CE Info Systems, Centrum, 2022 (3) Global automotive exhaust gas recirculation market, MarketResearch.com, 2022 (4) Indian automotive wiring harness market, GlobeNewswire, 2022 (5) India automotive software market, Businesswire, 2022 (6) Electrifying India mobility, IVC Association, 2022 (7) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (8) GT Analysis

Power electronic (EV) is expected to witness fastest domestic demand growth

Domestic demand share by different product categories[a]





Product categories	2022 size *(in $ bn)*	2032P size *(in $ bn)*	2022-32P CAGR
Power electronics	ICE: 2.8 EV: 0.1	ICE: 12.3 EV: 6.3	ICE: +16% EV: +54%
Safety controls	4.4	26.5	+20%
Communication & entertainment	0.9	10.3	+28%
Body electronics	0.9	8.2	+25%
Total	***9.1***	***63.7***	***21.5%***

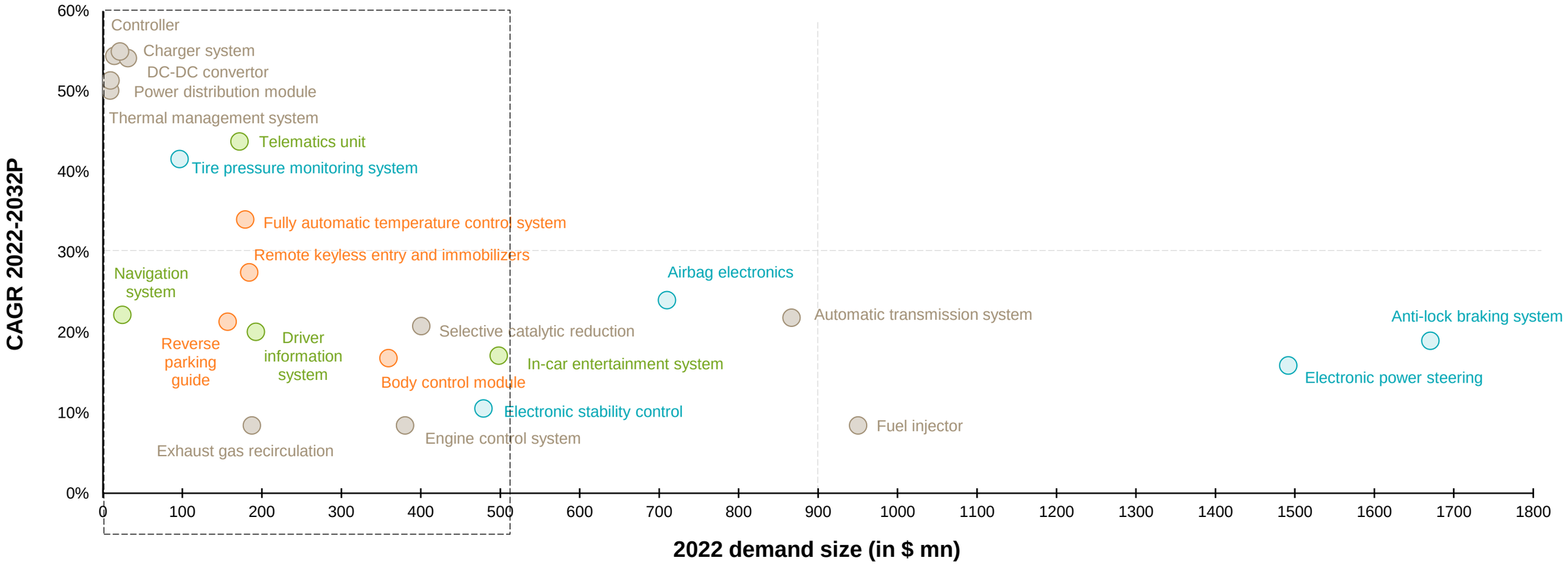
Note: (a) $ 1 = Rs. 74

Source: (1) Automotive electronics, ACMA,2016 (2) CE Info Systems, Centrum, 2022 (3) Global automotive exhaust gas recirculation market, MarketResearch.com, 2022 (4) Indian automotive wiring harness market, GlobeNewswire, 2022 (5) India automotive software market, Businesswire, 2022 (6) Electrifying India mobility, IVC Association, 2022 (7) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (8) GT Analysis

In 2022, domestic demand for majority products was within $ 500 mn range

2022 domestic demand size by different products and their growth in the next decade[a][b]

Product categories: Power electronics | Safety controls | Communication & entertainment | Body electronics



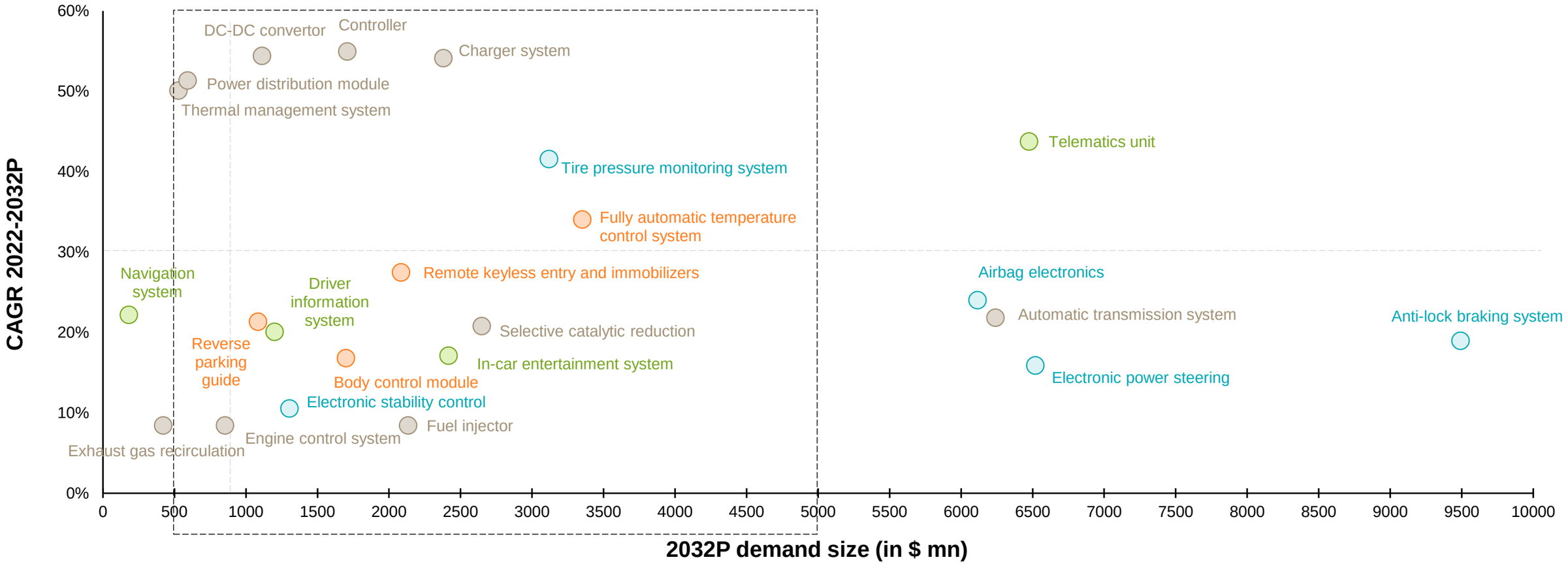
Note: (a) $ 1 = Rs. 74

Source: (1) Automotive electronics – Master plan development for auto components industry, ACMA, 2016 (2) CE Info Systems, Centrum, 2022 (3) Global automotive exhaust gas recirculation market, MarketResearch.com, 2022 (4) Electrifying India mobility, IVC Association, 2022 (5) Estimating e2W costs in India to 2030, ICCT, 2021 (6) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (7) GT Analysis

In 2032, domestic demand for majority products will be greater than $ 500 mn

2032 domestic demand size by different products[a][b]

Product categories: Power electronics | Safety controls | Communication & entertainment | Body electronics



Note: (a) $ 1 = Rs. 74

Source: (1) Automotive electronics – Master plan development for auto components industry, ACMA, 2016 (2) CE Info Systems, Centrum, 2022 (3) Global automotive exhaust gas recirculation market, MarketResearch.com, 2022 (4) Electrifying India mobility, IVC Association, 2022 (5) Estimating e2W costs in India to 2030, ICCT, 2021 (6) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (7) GT Analysis

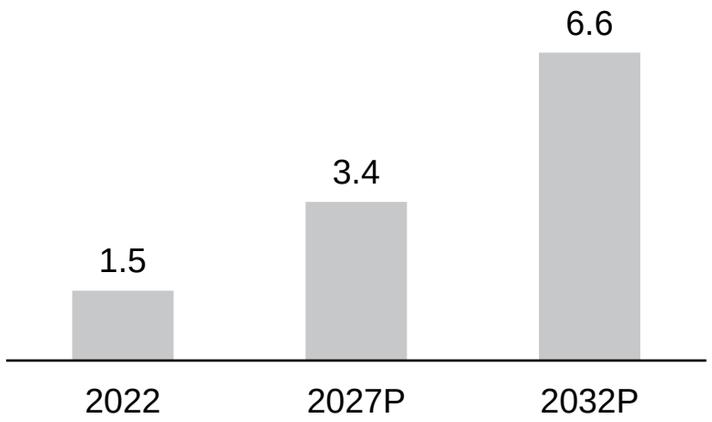
Demand from vehicle exports is expected to become at least 4X in the next decade

Automotive electronics demand (in $ bn) from vehicle exports[(a)(b)]

Base case

2022-2027P CAGR +18%

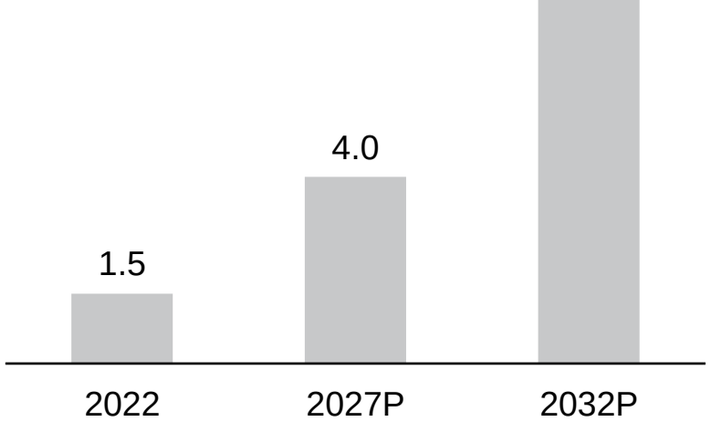
2027P-2032P CAGR +14%



Optimistic case

2022-2027P CAGR +21%

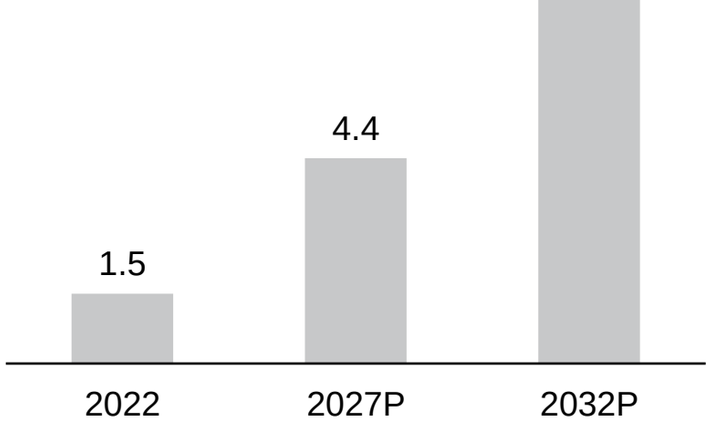
2027P-2032P CAGR +17%



Best case

2022-2027P CAGR +23%

2027P-2032P CAGR +20%



Note: (a) $ 1 = Rs. 74 (b) Estimated using current vehicle exports x net price of vehicle x share of electronics in vehicle cost. Further, rolling 5-year CAGR of FY12-22 is analyzed for volume growth across vehicle segments and different cases, FY12-22 inflation growth is taken into consideration for net price increase, current share of electronics in vehicle cost taken as 15% in PV, 10% in 2W, and 10% in CV and it is expected to reach 27.5% in PV, 15% in 2W, and 15% in CV by 2032

Source: (1) Vehicle exports data, Society of Indian Automobile Manufacturers (SIAM) website accessed 17/03/23 (2) GT's primary interactions with select members of Automotive Component Manufacturers Association and SIAM (3) GT Analysis

Hence, the total demand size is expected to become >7X in the next decade

Total demand size for automotive electronics				
#	**Opportunity type**	**2022 size *(in $ bn)***	**2032P size *(in $ bn)***	**CAGR 2022-32P**
1	Domestic demand (i.e., demand from vehicles that are sold in India) [A]	9.1	63.7	21.5%
2	Demand from vehicles that are manufactured in India but exported to other countries [B]	1.5	6.6 - 10.7	15.8% - 21.4%
3	**Total India demand [A] + [B]**	**10.6**	**70.3 - 74.4**	**20.8% - 21.5%**

Indian automotive electronics market

- Difference between India and global peers
- India demand size
- Trends shaping India’s domestic demand

1. Regulatory initiatives are acting as enablers for automotive electronics demand

Select examples of regulatory decisions positively impacting the domestic demand of automotive electronics

Bharat Stage (BS) VI Norms 2020

- These norms set permissible levels for pollutants emitting from motor vehicles (e.g., 60mg NOx for petrol PVs and 80mg NOx for diesel PVs)(a)
- With this, OEMs have to add these electronics to vehicles:
  - Selective Catalytic Reduction (SCR) to assess emission
  - Sensors for various throttle and crankshaft position
  - On-board diagnostics to monitor SCR

Corporate Average Fuel Efficiency II (CAFE II)

- It limits the total emission of CO_2 by an OEM's entire fleet, not an individual model
- From 2023, OEMs have to comply with a base of 113gm of CO_2 /km, basis average industry kerb weight of 1,145kg(b)
- This will push OEMs towards more fuel-efficient vehicles
  - Higher credits are awarded on sales of EVs
  - Use of electronics (e.g., tire pressure monitoring system)

Faster Adoption & Manufacturing of EVs 2 (FAME 2)

- Under this scheme, incentives are provided to buyers in the form of an upfront reduction in the purchase price of EVs
- The incentive is linked to battery capacity (e.g., Rs. 15,000/KWh for e2Ws with a cap of 40% of the cost of vehicle)
- Thus far, e2W buyers have been key beneficiaries of this scheme
- By 2022 end, 7.1 Lac e2W buyers had availed the subsidy

Mandatory Airbags Notification 2022

- In 2022, Ministry of Road & Transport & Highways made it mandatory for PVs to have 6 airbags from October 2023
- This will result in significant addition to the demand for airbag electronics
- The approx. variable cost for 4 airbags (i.e., 2 side air bags and 2 curtain airbags) varies from Rs 5600 to Rs 7000

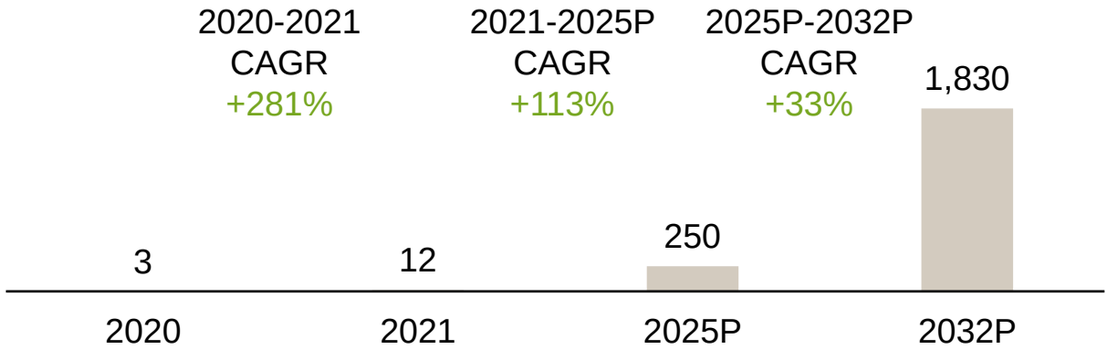
<u>Key takeaway:</u> These initiatives are resulting in demand push across product categories (e.g., power electronics and safety controls) and intends to fulfil the objective of manufacturing localization and shift towards safer and cleaner transportation

Note: (a) Nitrogen Oxide (b) This is computed by taking into account the weight of individual models and the number sold. Each model then gets a CO2 number. The final CAFE group target is calculated when all the models + individual CO_2 numbers are put together
Source: (1) Difference between BSIV & BSVI Engine: BS4, BS6 Performance, ACKO, 2022 (2) Auto industry prepared for BS6 Phase 2, but vehicle costs to go up, Autocar Professional, 2021 (3) CAFE regulations and why they are important, Autocar Professional, 2022 (4) Electric Vehicles Manufactures registered under FAME-India Scheme phase-II, MHI, 2022 (4) India's FAME-II Scheme for Electric Vehicles Gets 80% Bump in Budget Allocation, India Briefing, 2023 (5) Mandatory Airbags in Vehicles, MoRTH, 2022

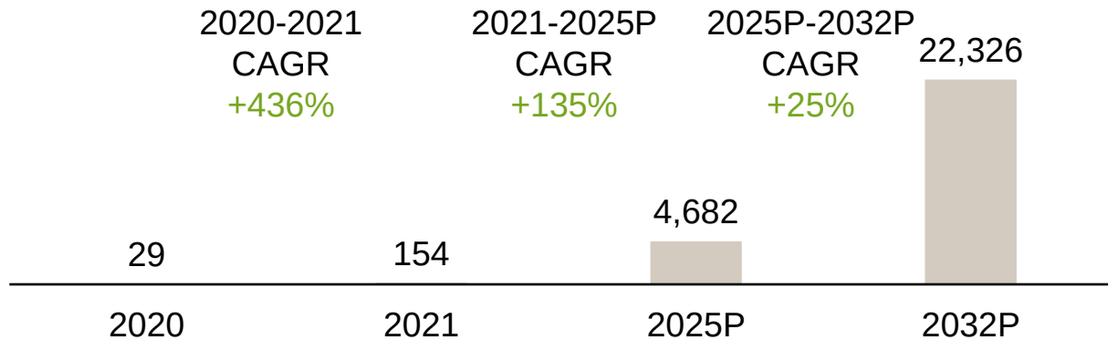
Regulation related to: ***Power electronics*** ***Safety controls***

2. EV traction to result in promising demand for EV related power electronics

India electric car sales *(in 000 units)*[(a)]



India electric 2W sales *(in 000 units)*[(b)]



Blu Smart: *On demand e-cab service provider*

Scale of operations in Jan 2023

- 130+ mn km distance covered
- 3.7+ mn trips done
- 3000+ e-cabs (5000+ target by March 2023)

Zypp: *EV service platform for e-comm players & gig workers*

Scale of operations in Feb 2023

- 86+ mn km distance covered
- 15+ mn deliveries done
- 10,000+ e-2Ws (50,000 by December 2023)

Key takeaway: Acceptance of EVs among end-customers for daily use, e-commerce companies for deliveries, and gig workers as a tool to earn money has resulted in demand for new product category - EV related power electronics, non-existent in 2020

Note: (a) The pentation %s are – 0.4% in 2021, 5.1% in 2025P, and 21% in 2032P (b) The pentation %s are – 1% in 2021, 26% in 2025P, and 74% in 2032P

Source: (1) Electrifying India mobility, IVC Association, 2022 (2) Electric is the Trick: Why BluSmart is on a high-voltage ride, Forbes, 2023 (3) EV startup Zypp Electric nabs $25M to hit 30 Indian cities by 2025, TechCrunch, 2023 (4) Passenger car sales statistics, International organization of motor vehicle manufacturers, 2021 (5) Passenger cars – India sales in 2027, Statista (6) GT Analysis

3. Commoditization of select electronics related features

Select examples of electronics related features that were once available only in premium segment vehicles

Passenger vehicles

1. Keyless entry
2. Reverse parking sensors
3. Anti-lock braking system (ABS)
4. Engine immobilizer
5. Infotainment system
6. Digital instrument cluster

Commercial vehicles

1. Telematics *(fleet management feature)*[(a)]
2. Digital instrument cluster

"Telematics based features[(b)]*, tire pressure monitoring system, electronic stability control, etc. will be part of next wave of features that will become common in Indian market in next 5-10 years"*

- Vice President (Commercial), German automotive electronics company in India

2Ws

1. Anti-lock braking system
2. Engine immobilizer
3. Digital instrument cluster

"Electronic features such as keyless entry, ABS, reverse parking sensors, digital driver information system, etc. are a norm in Indian market. They are not a differentiator anymore"

- Director of Purchase, Chinese OEM in India

<u>Key takeaway:</u> The appearance of such features in mass segment vehicles exemplifies the strength of famed Indian frugal innovation, helping to cut the cost of such offerings and ultimately prompting more adoption

Note: (a) Refers to vehicle / asset tracking (b) Select examples include emergency alerts, auto-call feature, stolen vehicle assistance, in-vehicle wi-fi service, etc.
Source: (1) GT Analysis of entry level vehicles of different OEMs present in India (2) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers

Feature related to: ***Safety controls*** | ***Communication & entertainment*** | ***Body electronics***

4. Component suppliers are expanding their portfolio to electronics

Select examples of recent electronics related product launches by automotive suppliers

#	Discrete name	Launch year	Product category	New electronics related products launched
1	Component Supplier 1	2023	Power electronics (EV)	• Battery management system, dc-dc converter, connectors and harnesses, off-board charger, etc.
2	Component Supplier 2	2023	Communication & entertainment	• End-to-end telematics solution, driver information system (i.e., instrument cluster + displays) for electric vehicles
3	Component Supplier 3	2023	Body electronics	• Entry level autonomous tech (i.e., rearview camera display instead side rearview mirrors, driver drowsiness detection, etc.) aimed at premium vehicles
4	Component Supplier 4	2022	Power electronics (ICE)	• Automated manual transmission for commercial vehicles, supporting applications such as passenger transport, mining, long haul and fuel carriers, etc.
5	Component Supplier 5	-	Safety controls	• Actively exploring the local manufacturing of electronic stability control system, given interest from select OEM accounts

Key takeaway: OEMs are launching safer, smarter, and more efficient vehicles. This in turn is translating into new demand for electronic products, which were either earlier not relevant for Indian market or limited to select vehicle models only

Source: (1) ZF launches EcoTronic Mid AMT for CVs to enhance operational efficiency, The Economic Times, 2022 (2) Tata AutoComp Displays Latest Technologies at Auto Expo, TimesTech, 2023 (3) Pricol displays EV-ready solutions at Auto Expo 2023 –Components Show, Autocar Professional, 2023 (4) Uno Minda gears up for connected mobility, Times of India, 2023 (5) ZF bullish on ESC market in India, explores technology localization, Autocar Professional, 2023 (6) GT's primary interactions with select members of Automotive Component Manufacturers Association

5. Indian automotive space is beginning to witness electronics related acquisitions

Select and recent examples of acquisitions made by automotive suppliers

#	Company acquired	HQ country	Year	Acquisition details	Acquisition objective
1	NOVELIC		2023	54% stake acquired for Rs. 350+ Cr.	• Develop capabilities related to ADAS sensors and software, since Novelic is supplier of mmWave radar sensors to electric vehicle manufacturers
2	Tsuyo		2022	Up to 51% with investment of Rs. 100+ Cr. over 5 years	• Enhance product portfolio and expand facilities for manufacturing motors, controllers, etc. related to electric vehicles
3	technica engineering		2022	100% stake for Rs. 700+ Cr. and variable of Rs. 250+ Cr. for 2.5 years	• Become full stack service provider for automotive industry w.r.t. capabilities required for prototyping, software, etc. for software defined vehicles
4	EVQ Point		2021	26% stake for an undisclosed amount	• Strengthen electric vehicle equipment portfolio and offer battery chargers in both on-board and off-board configurations
5	CarIQ		2019	74% stake for an undisclosed amount	• Complement connected vehicle product offerings such as instrument clusters, telematics devices, etc. with data based analytical product offerings

Key takeaway: Automotive suppliers are making these acquisitions for new capabilities - particularly electronic products with high manufacturing and design complexity or high software driven functionality

Source: (1) Sona Comstar to acquire 54% stake in Serbian firm NOVELIC; stock jumps 9%, Business Standard, 2023 (2) Ramkrishna Forgings to acquire majority stake in Tsuyo Manufacturing, to strengthen EV portfolio, Express Mobility, 2022 (3) KPIT and Technica Engineering join forces to accelerate the transformation towards Software-Defined Vehicle (SDV), KPIT, 2022 (4) Varroc Engineering to acquire Pune-based start-up CarIQ, Autocar Professional, 2019 (5) Spark Minda Group enters into a strategic partnership with EVQPOINT Solutions to grow EV footprint, Spark Minda Pres Release, 2021

Manufacturing targets for 2032

- Current imports scenario
- Key factors impacting domestic manufacturing
- Target for the Industry

We estimate that 64.3% of total demand ($ 10.6 bn) in 2022 was fulfilled via imports

Current imports scenario at category and product level[(a)]

Power electronics (ICE)	Power electronics (EV)	Safety controls	Communication & entertainment	Body electronics
Fuel injector	Power distribution module	Electronic power steering	Telematics unit	Reverse parking guide
Selective catalytic reduction	DC-DC converter	Tire pressure monitoring system	Driver information system	Fully automatic temperature control
Exhaust gas recirculation	Thermal management system	Airbag electronics	In-car entertainment system	Remote keyless entry & immobilizer
Automatic transmission system	Charger system	Electronic stability control	Navigation system	Body control module
Engine control system	Controller	Anti-lock braking system		

Imports[(a)] as % of total demand: ***Less than 40%*** ***Between 40% and 80%*** ***Greater than 80%***

Note: (a) Includes both direct imports by OEMs as well as indirect imports (i.e., import via tier 1/2 supplier)
Source: (1) GT Analysis based on > 200,000 import transactions of CY2022 port data for a select OEM and its primary tier 1 supplier. The transactions included both complete products as well as sub-parts. The result observed for this OEM was taken average case for the Industry and extrapolated at category and product level for the total India demand (2) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers

All ecosystem stakeholders need to make concerted efforts to reverse the current imports scenario and save on the growing import bill w.r.t. automotive electronics.

Therefore, in order to meet the future demand of automotive electronics via domestically manufactured products, GT has:

(i) Identified key factors impacting domestic manufacturing

(ii) Highlighted manufacturing targets for the Industry.

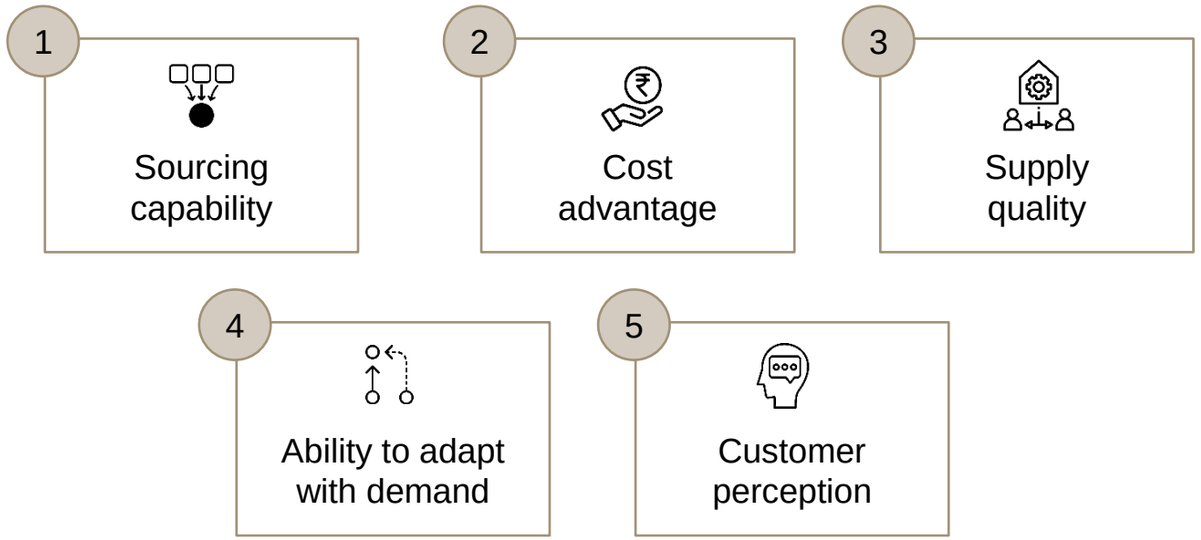
Manufacturing targets for 2032

- Current imports scenario
- Key factors impacting domestic manufacturing
- Target for the Industry

The market competitiveness of MSMEs, partnerships with start-ups…

1. MSMEs form the backbone of any local manufacturing ecosystem or industry

- In order to meet any demand via import substitution or even for exporting globally, the market competitiveness of MSMEs plays the key role. Their competitiveness is primarily determined by 5 key levers:



- Ecosystem stakeholders play key role in building this competitiveness. This role is largely in the form of knowledge and training in the areas of design, manufacturing, selling, and logistics to help MSMEs make products that are in sync with technological and consumer trends while meeting all the aspects of quality, cost and delivery

2. Start-ups help traditional players in capturing emerging market opportunities

- In general, start-ups in any industry are centered around white spaces and unmet customer demand. Similarly, there are many such start-ups in Indian automotive space. Select examples include:

Name	Year started	HQ city	Business offering or plan
AVIN Systems	2014	Nagpur	Automotive software products with focus on functional safety, driver assistance, etc.
INTANGLES A DIGITAL TWIN COMPANY	2014	Pune	Solutions for monitoring vehicle health, driver behavior, fuel theft, etc.
SWAAYATT	2015	Bhopal	Develop level-5 autonomous driving technology for the Indian roads
locoNav	2016	Gurgaon	Solutions related to fleet management, vehicle tracking, driver safety, etc.
Cell Propulsion	2016	Bangalore	Develop fully electric commercial vehicles with proprietary powertrain component

- Partnerships with such start-ups can offer traditional players – early insights into emerging product categories as well as access to talent or skill sets required to build new business verticals

Source: (1) Why corporate-startup partnerships are the route to resilience, Crunchbase News, 2021 (2) AVIN Systems, Company website accessed 13/03/23 (3) Intangles Lab, Company website accessed 13/03/23 (4) Swaayatt Robots, Company website accessed 13/03/23 (5) LocoNav, Company website accessed 13/03/23 (6) Cell Propulsion website accessed 13/03/23 (7) GT Analysis

…wider product applications, and market linkages enable local manufacturing

3. Wide ranging scope of products supports financial viability for setting up manufacturing units

- Automotive electronic products considered relevant for the traditional vehicle segments (i.e., PV, CV and 2W) have applications in multiple industries. Select examples include:

Other vehicle types	Agricultural	Construction & mining	Material handling
Driver information system	✓	✓	✓
Entertainment system	✓	✓	✗
Telematics devices	✓	✓	✓
Immobilizer	✓	✓	✓
Sensors[a]	✓	✓	✓

- Such wider applications could help existing and new electronic manufacturers target new customers, ultimately expanding their total addressable market beyond PV, CV, and 2W OEMs

4. Market linkages help in getting product designs, related technology, and some customer base

- Traditionally, Indian automotive component industry has been dependent on joint ventures and technical alliances for access to new technologies, given Industry spends <1% of revenue on research and development[b]

Discrete names[c]	FY 22 Revenue (in $ mn)[d]	# of joint ventures	# of technical alliances
Component supplier 1	1120	17	1
Component supplier 2	315	10	1
Component supplier 3	280	4	-
Component supplier 4	203	7	-
Component supplier 5	220	1	-

- Currently, similar approach is being adopted for venturing into automotive electronics. However, this approach has its own disadvantages - 2-5% of revenue as royalty payout, restricted access to global markets, etc.

Note: (a) Refers to inertial sensors for vehicles – measures vehicle directions in x, y, and z axis, angular rate, acceleration, etc. (b) Globally, the R&D spend ranges between 3 – 5% of revenues (c) Only select listed players showcased (d) $ 1 = Rs. 74
Source: (1) Company websites of global automotive electronics players accessed 14/03/23 (2) Who owns the Indian automotive component industry, Auto Originals by The Economic Times, 2021 (3) GT Analysis

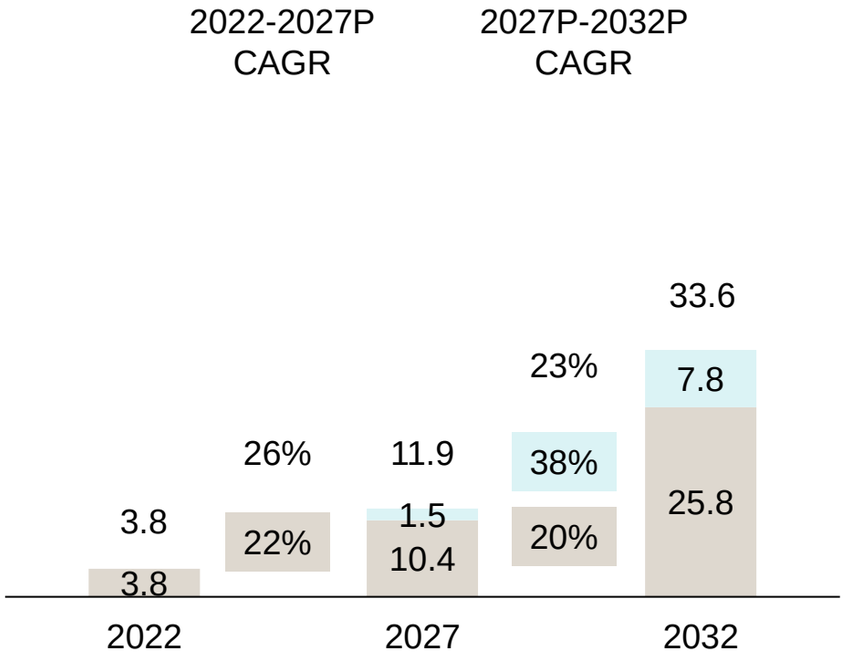
Manufacturing targets for 2032

- Current imports scenario
- Key factors impacting domestic manufacturing
- Target for the Industry

Industry can target to manufacture electronics of $ 33.6 - 58.8 bn by 2032

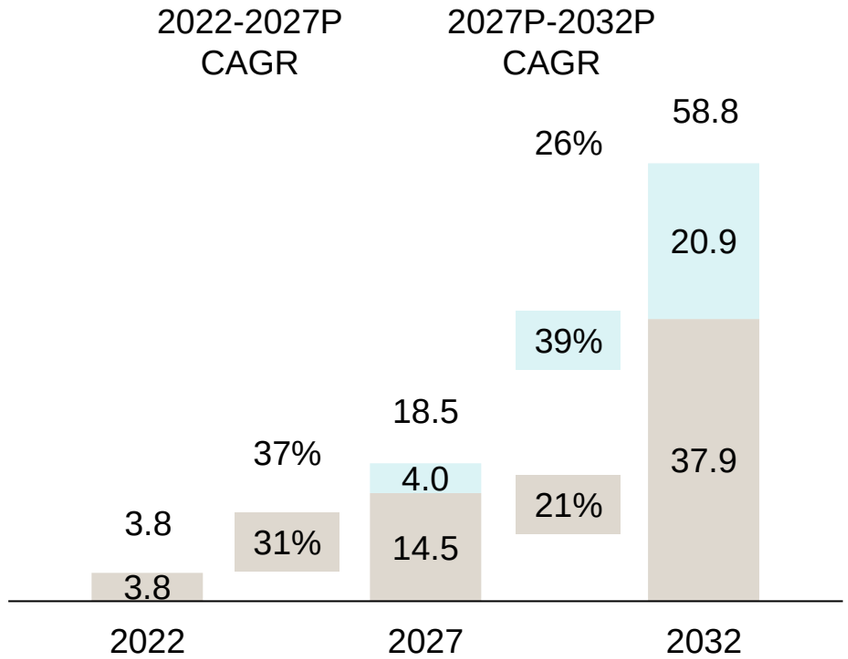
These targets have been considered basis multiple consultations with ACMA, SIAM, and SCALE Committee

Base case: *Current manufacturing (in $ bn) to grow as per the growth expected in total demand with moderate focus on exports[(a)(b)]*



For India's demand (i.e., domestic demand + demand from vehicle exports)

Optimistic case: *Current manufacturing (in $ bn) to grow faster than the growth expected in total demand with significant focus on exports[(a)(b)]*



For exports as discrete components to OEMs in other countries

Note: (a) For exports, GT has analyzed sales breakup of domestically produced automotive components – in particular - % of exports to domestic sales of the Industry in India, Japan, and South Korea (b) Based on total value addition and applicable for components + sub-assemblies
Source: (1) GT's primary interactions with the leadership of Automotive Component Manufacturers Association, Society of Indian Automobile Manufacturers, and SCALE Committee

Hence, total opportunity size for Industry is expected to be ~8X in the next decade

Total opportunity size for automotive electronics in India				
#	**Opportunity type**	**2022 size *(in $ bn)***	**2032P size *(in $ bn)***	**CAGR 2022-32P**
1	Domestic demand (i.e., demand from vehicles that are sold in India) [A]	9.1	63.7	21.5%
2	Demand from vehicles that are manufactured in India but exported to other countries [B]	1.5	6.6 - 10.7	15.8% - 21.4%
3	Exports as discrete components [C]	-	7.8 - 20.9	-
4	**Total India demand [A] + [B]**	**10.6**	**70.3 - 74.4**	**20.8% - 21.5%**
5	**Total opportunity size [A] + [B] + [C]**	**10.6**	**78.1 - 95.3**	**22.1% - 24.6%**

Industry challenges

- **Bottlenecks faced by the Industry**
- **Case study of 3 global peers**

India has cost disability differential of >7.5% w.r.t. established manufacturing hubs

Summary of the cost disabilities in India vs. Vietnam and China for manufacturing of mobile phones. Such disabilities are common across electronic products accommodating for minor variations

#	Factors resulting in cost reduction[(a)]	India	Vietnam	China
1	Corporate income tax exemption / reductions	0.73-0.95%	1.5-2%	2%
2	Subsidy for machinery and equipment	Nil	0.20%	3%
2A	State subsidies in India for capital investments	0.6-1.2%	NA	NA
3	Cost of power	0%	1%	1%
4	Interest subvention on working capital	0%	1.5-2%	3-3.5%
5	R&D subsidy	0.15%	0.4-1%	2%
6	Incentive for supporting industry	0%	0.5%-1%	0%
7	Manufacturing incentives	-	0%	1-2%
8	Exemption/reduction of land rental	0%	0.5%	0.6%
9	Industrial land development support	0.4%	0.5%	0.6%
10	Building (or plug and play)	Negligible	0.3%	1%
11	Labor subsidy	Negligible	0.5%	2%
12	Logistics	0%	0.5%	1%
13	Factors affecting “Ease of doing business”	-	1.5-2.5%	2-3%
14	Duty free imports for creating fixed assets, and of inputs not available domestically	0%	0.5%	-
Total		**1.88 - 2.7%**	**9.4% - 12.5%**	**19.2% - 21.7%**
Cost disability differential for India vs. Vietnam and China		**-**	**7.5% - 9.8%**	**17.3% - 19.0%**

Source: (1) $ 300 bn sustainable electronics manufacturing and exports by 2026: Roadmap and Strategies, Indian Cellular and Electronics Association, 2022

India has limited research & development, export opportunities, and productivity

Key bottlenecks identified basis primary interactions[(a)]

Limited research & development

"Globally, in automotive supplier industry the spend on R&D is about 3-5 % in normal technology, while in some technology it goes up to 8-10% of revenue. Are Indian suppliers capable of this kind of investment? Do they have that kind of margins?"

"Low investment in R&D by the Industry. We are always late in technology adoption. Partnerships or JVs can be explored for this to share the required costs."

Limited export opportunities

"Many South-east Asian economies having joined mega-regional trade deals such as the Regional Comprehensive Economic Partnership and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, India's position means that it will have fewer export-oriented opportunities"

"Malaysia and Thailand already have strong electronics and automotive manufacturing clusters and Indonesia is implementing significant business environment reforms to woo international investors. Vietnam has mopped up a lot of the low value-added manufacturing to have already left China. The efficiency of China's supply chain will also retain considerable appeal"

Limited manufacturing productivity

"India has lower productivity when compared to many Southeast Asian countries. For example, Thailand is better in India by 5-10%. I think that upskilling is lagging in the Industry"

"Low manufacturing productivity is also due to the challenges faced the MSMEs / tier 2 suppliers. Some of these challenges include financial stability, manpower quality, quality of machines, low perception of end-product, etc."

Note: (a) The details of primary interactions completed have been highlighted in the appendix
Source: (1) GT's primary interactions with select members of Automotive Component Manufacturers Association, Society of Indian Automobile Manufacturers and other Industry stakeholders (2) ETAuto Originals, Who owns the Indian component Industry, 2021 (3) India's Manufacturing Moment, Economist Intelligence Unit, 2023

Industry challenges

- **Bottlenecks faced by the Industry**
- **Case study of 3 global peers**

There are 5 key learnings from India's global peers

1

Research and development spend given importance

2

Use of efficient products in vehicles

3

Regulations enabled the use of safety products

4

Declining cost of vehicle ownership

5

Cluster approach enabling Industry evolution

In the subsequent slides, each point is supported by a quantitative fact as well as an example from respective market's Industry

Key learnings from Germany automotive market are:

1. Research and development spend given importance

- German automotive suppliers have invested an average of 5.7% of their turnover in research and development in recent years
- In 2021, ZF invested $ 3.6 bn (8% of revenue) for research and development w.r.t. automated drive, integrated safety equipment, automotive software, etc. ZF made 2624 invention disclosures and 1862 new patents applications in that particular year

2. Use of efficient products in vehicles

- The average CO_2 emissions for cars reduced by 12% from 128g to 113 g CO_2/km during 2017- 20, with a 55% reduction target till 2030
- In 2017, Bosch developed iDisc, a brake disc rotor generating 90% less brake dust in comparison to conventional variant. Nearly a third of particulate matter emissions in road traffic comes from brakes and tires – half of that is brake dust

3. Regulations enabled the use of safety products

- Road traffic fatalities reduced from 3206 to 2719 during 2016-20, despite rise in motorization rate from 555 to 580 vehicles per 1000 inhabitants
- The road fatalities are expected to decline further since EU regulation[(a)] have made it mandatory for OEMs to introduce safety technologies such as driver drowsiness and attention warning system, advanced emergency braking system, tire pressure monitoring system, etc.

4. Declining cost of vehicle ownership

- While total number of passenger cars registered increased from 45 mn to 48 mn, the market for automotive maintenance services declined from $ 38 bn to $ 31 bn during 2016-21. This decline can be attributed to penetration of EVs (26% in 2021) – which have 20% to 35% lower maintenance costs compared to an equivalent combustion powered vehicle

5. Cluster approach enabling Industry evolution

- Bavaria cluster is home to the headquarters of multiple OEMs such as Audi, BMW and MAN, and branches of ~1100 businesses from across the automotive value chain. It is a key center for global industrial partnerships: the BMW Group opened its Autonomous Driving Campus in 2018. Together with international experts from FCA, Intel and Mobileye, BMW is working on the implementation of fully automated vehicles

Note: (a) EU Regulation, 2019/2144 adopted in 2020 was made compulsory for EU members in 2022, intended for general safety and protection of vehicle occupants and vulnerable road users
Source: (1) VDA Annual Report 2022 (2) ZF website accessed 27/04/23 (3) Press Releases by Federal Ministry for Environment, Nature Conservation, Nuclear Safety, and Consumer Protection (4) iDisc – a key contribution toward improving our air quality, Bosch website accessed 27/04/23 (5) Statista website accessed 27/04/23 (6) Invest in Bavaria website accessed 27/04/23

Key learnings from US automotive market are:

1. Research and development spend given importance

- In 2020, the US automotive industry spend on research and development was $ 48.7 bn. This has been on the rise since 2016, with a CAGR of 23%, due to government policy initiatives such as research and development tax credit, advanced technology vehicles manufacturing loan program, etc.
- In 2020, the 3 largest OEMs - Tesla ($ 1.5 bn), GM ($ 6.2 bn), and Ford ($ 7.1 bn), ranked among top 10 research and development spenders in the US

2. Use of efficient products in vehicles

- In 2021, average CO_2 emission rate for all new vehicles was 347 g/mi, lowest ever measured. However, fuel economy remained at a record high 25.4 mpg
- Engine technologies such as turbocharged engines, gasoline direct injection, cylinder deactivation, etc. allow for more efficient engine design and operation. These technologies are widely adopted among US OEMs

3. Regulations enabled the use of safety products

- In the past 2 decades, National Highway Traffic Safety Administration has mandated the use multiple safety technologies across different vehicle segments - electronic stability control, occupant crash protection (i.e., airbags, seatbelt sensors, etc.), and rear visibility systems
- According to Insurance Institute for Highway Safety – Virginia, electronic stability control reduces the risk of fatal crash by 33%

4. Declining cost of vehicle ownership

- The average age of passenger cars and light commercial vehicles reached a record high of 12.1 years in 2021, up from 11.9 years in 2020
- In 2019, Delphi Technologies developed Dynamic Skip Fire (DSF) technology which increases engine efficiency by up to 15%, and extend the life of engine components by reducing wear and tear

5. Cluster approach enabling Industry evolution

- Detroit, termed as the Motor City, is the key location in North America for vehicle production, manufacturing more than 1.6 million vehicles in 2020. It is home to more than 200,000 assemblers and production talent with lowest turnover rate. From 2009-2019, the region received a steady stream of automotive investments of $ 41.6 bn

Source: (1) National Science Foundation, Business Research and Development Survey (BRDS) 2016-2021 (2) Nasdaq - Automobile Companies and R&D: Top 5 Spenders, 2021(3) US Environment Protection Agency (EPA) - The 2022 EPA Automotive Trends Report (4) Insurance Institute for Highway Safety website accessed 04/04/23 (5) IHS Markit – vehicle registration data in US, website accessed 04/04/23 (6) Delphi-Tula Dynamic Skip Fire Cylinder Deactivation System, Delhi Technologies website accessed 04/04/23 (7) Detroit regional partnership website accessed 04/04/23

Key learnings from Japan automotive market are:

1. Research and development spend given importance

- In FY20, research and development spend in Japanese automotive sector amounted to $ 28 bn, contributing to ~30% of total research and development spend across all major manufacturing sectors in Japan
- In FY20, Toyota spent approx. $ 8 bn on research and development, increase of $ ~3 bn from FY10

2. Use of efficient products in vehicles

- Japanese OEMs are required to meet the target of average fuel efficiency of 25.4 km/L (32.4% increase over actual value in 2016) by 2030 for new PVs
- To achieve the same, Japanese OEMs are focusing on low rolling-resistance tires, Idling prevention (stop-start), expanded number of transmission gears, reduction of piston and piston ring friction loss, etc.

3. Regulations enabled the use of safety products

- In 2021, road fatalities dropped to 2636, lowest since 1948. Road accidents and road injuries also declined to 305,196 and 362,131 respectively
- Japan's Ministry of Land, Infrastructure, Transport and Tourism, National Police Agency, and automobile-related organizations have been working together to promote the use of "safety support cars" equipped with advanced safety features such as collision-mitigation braking systems (97.2% installation rate)

4. Declining cost of vehicle ownership

- The average monthly maintenance cost of a passenger vehicle has come down from $ 144 in 2013 to $ 115 in 2022
- In 2021, Hitachi Astemo developed direct-drive system that integrates an in-wheel motor, inverter and brake. This simpler drive mechanism slashes energy loss by 30% compared with conventional electric vehicles

5. Cluster approach enabling Industry evolution

- Aichi is one of the key automotive cluster in Japan. It is home to Toyota and its major tier 1 suppliers such as Denso, Aisin, etc. located in proximity, positively impacting cost of delivery, quality management, new product development, etc.
- In 2020, Toyota and Denso announced a new JV for research and development on 3 fields - power electronics, sensing, and SoC (System-on-a-Chip)

Source: (1) Japan Automobile Manufacturers Association Industry Report 2022 (2) Automotive market related articles published in The Japan Times (3) Average passenger vehicle lifecycle, Japan, Statista website accessed 31/03/23 (3) Passenger vehicle maintenance cost Japan, Statista website accessed 31/03/23 (3) PVs in use, Japan, Statista website 31/03/23 (4) Denso Website website 31/03/23 (5) Hitachi puts more EV drive tech in wheels to extend range, Nikkei Asia, 2021

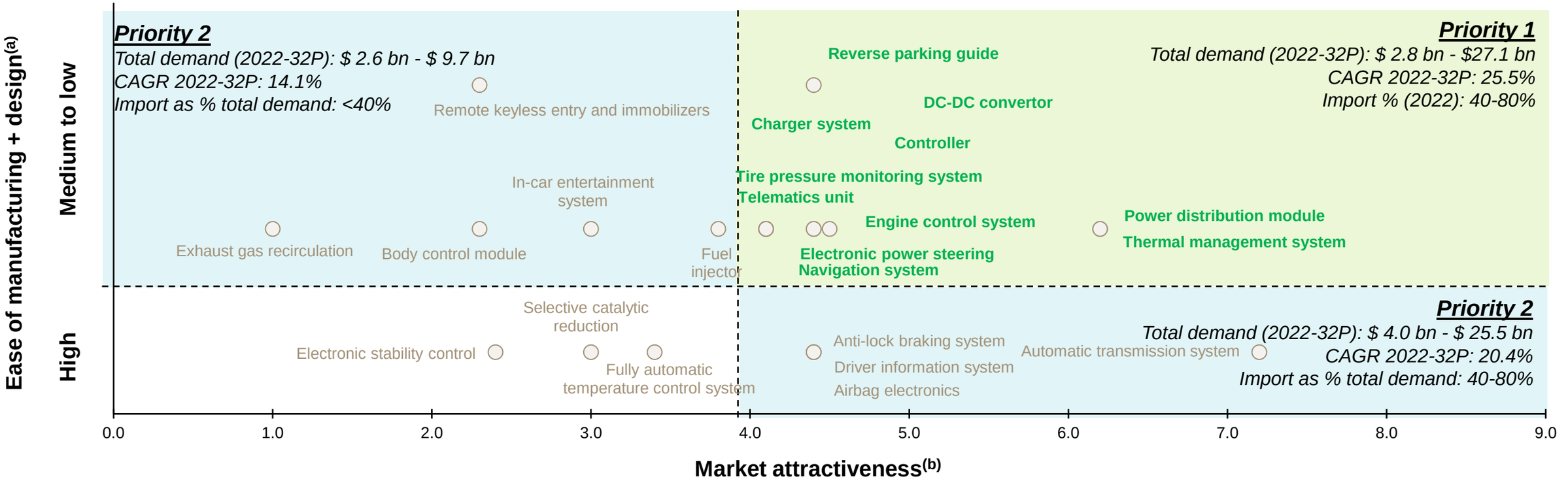
Recommendations to make India a hub of automotive electronics manufacturing

Our recommendations address India's challenges and include learnings from peers

Recommendation 1: Certain auto-electronics products can be manufactured in India

Our research suggests that there are 23 automotive electronics products that have established demand in the Indian automotive market. Hence, these can be further evaluated for new manufacturing units or capacity expansion

High level product prioritization – market attractiveness vs. manufacturing + design complexity



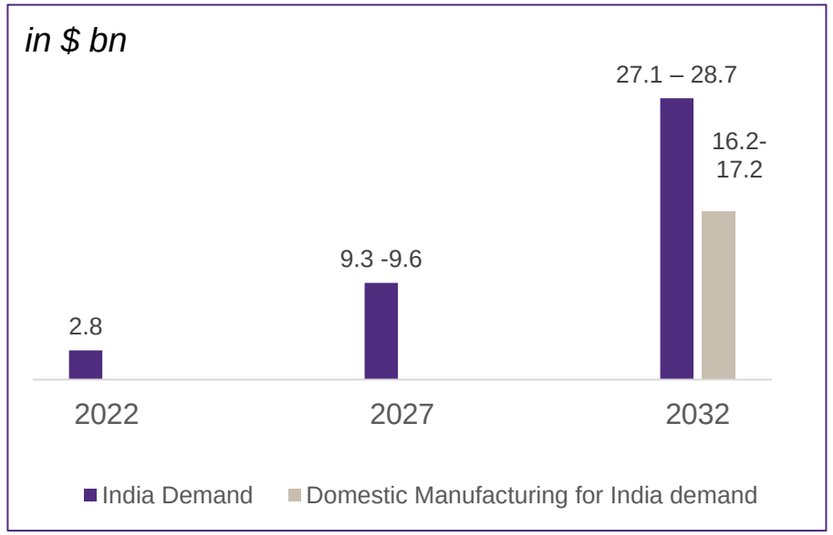
Automotive components suppliers can further evaluate these products in-depth basis investment requirements, synergies with existing product portfolio, capability transferability (i.e. IP, design, etc.), testing and lead time for OEM approval

Notes: (a) Ease of manufacturing + design refers to hardware design integration with software, PCB design, Electromagnetic Interface / Compatibility, need for graphical user interface, etc. (b) Based on weighted average score 2022 demand (35%), demand growth for 2022-32P (30%), Localization need (basis imports in 2022) (35%). Assessed on the scale of 1, 3, and 9. For detailed criteria and ratings, refer appendix
Source: (1) GT Analysis

Recommendation 1: Certain auto-electronics products can be manufactured in India

The manufacturing target implies reaching a 60% share of domestic manufacturing for the priority 1 and a 27-56% share in priority 2 products

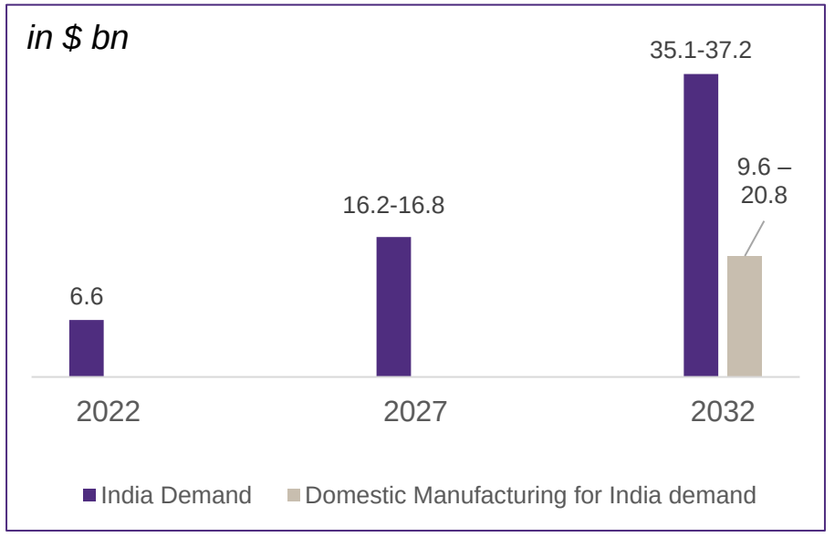
Priority 1 - 11 products which have a favorable market potential and manufacturing ease is also medium to low



Domestic manufacturing could target to account for ~60% of the India demand by 2032 in both base & optimistic cases

Products include reverse parking guide, power distribution module, thermal management system, engine control system, electronic power steering, navigation system, telematics unit, tire pressure monitoring system, controller, charger system, and dc-dc converter

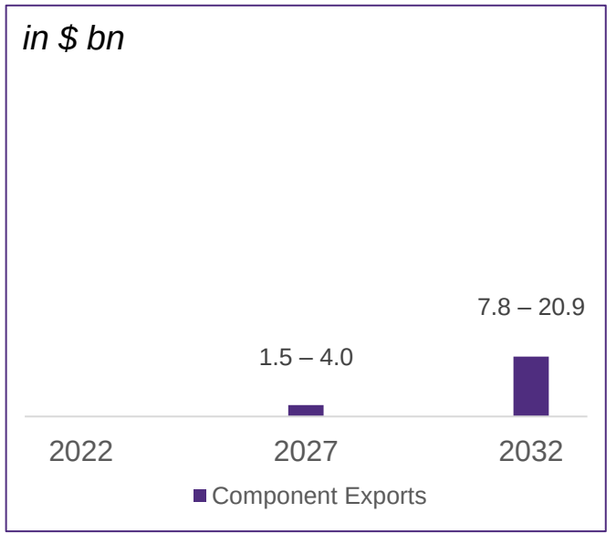
Priority 2 - 9 products are where either one of the market potential or manufacturing ease is medium to low



Domestic manufacturing could target to account for ~27% and 56% of the India demand by 2032 in base & optimistic cases

Products include exhaust gas recirculation, body control module, in-car entertainment system, fuel injector, anti-lock braking system, driver information system, airbag electronics, automatic transmission system, remote keyless entry and immobilizers

Export of Discrete Components



Domestic manufacturing could target to account for ~27% and 56% of the India demand by 2032 in base & optimistic cases

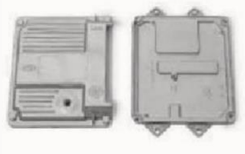
Key import dependent market by different products have been highlighted in the annexure

Source: (1) GT Analysis

Recommendation 2: Encourage manufactures of child parts (electronic and non-electronic) that can be used across different auto-electronic parts to expand scale in India

Examples of common non-electronic components

- Strengths of existing automotive components suppliers can be leveraged to localize non-electronics related assembly parts such as:
  - **Electric Control Unit (ECU) thin wall casing** - accounts for 20-25% value share in the engine control unit

  - **Heat exchangers** - accounts for 20% value share in the thermal management system



[Details of imports by different products]

- Currently, most OEMs are importing assemblies including heat exchangers and electronic control unit thin wall casings
- Indian auto-components suppliers have already created capability in aluminum castings and hence focusing on the localization of aluminum castings used in auto-electronics is feasible
- If dis-incentivized to import these products, it is expected that approximately $ 275 mn of import bill can be reduced by 2032
- In addition, localization of aluminum castings will also help target auto-electrical products such as casings for battery pack and electric motor. It is expected that $ 1.5 - 2 bn of import bill can be reduced by 2032

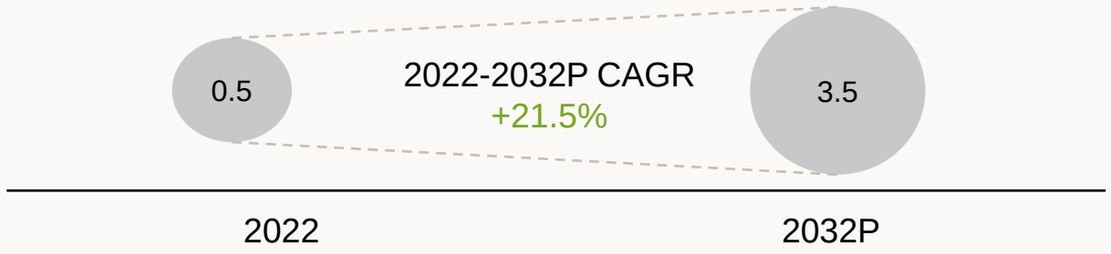
[Details of imports bill savings]

Source: (1) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (2) GT Analysis

Recommendation 2: Encourage manufactures of child parts (electronic and non-electronic) that can be used across different auto-electronic parts to expand scale in India

Examples of common electronic components

- PCBs account for approx. 5-6% value share in the automotive electronic products. PCBs consumption is expected to grow significantly, following total automotive electronic demand trend



- Other example include switches which account for 1-2% value share in the automotive electronic products

[Details of relevant PCB manufacturers]

- Some Indian companies have launched fabless chips and OEMs have also tested the same
- Indian companies have also started chip designing and finishing operations (Navigation and radar chips for auto sector have been designed by Indian companies)
- PCB companies catering to the non-auto electronic sector can be encouraged to supply to auto sector
- Foxconn has already started supplying information display units to some OEMs

Recommendation 3: Adopt cluster approach to address manufacturing cost disability

Automotive Electronics Clusters

- These dedicated clusters to address cost disability via lower land and building costs along with support services such as testing / certification, hostels for labor and staff, back-up power, and logistics support
- These dedicated clusters can be established around automotive hubs such as Delhi-NCR, Pune, and Chennai
- An example of such a cluster is '**ELCINA Electronics Manufacturing Cluster'** located in Bhiwadi, Rajasthan

"Focused cluster can play a key role in improving the ecosystem. Cost gap will further decline with GoI initiatives on infrastructure improvement and economies of scale" – EMS Provider

Recommendation 3: Adopt cluster approach to address manufacturing cost disability

Case Study: ELCINA Electronics Manufacturing Cluster

1. Cluster background

- ELCINA Electronics Manufacturing Cluster is a greenfield cluster
- It was conceived in 2019 by ELCINA members with an objective to overcome cost disabilities and provide an eco-system to enable electronics manufacturing

2. Cluster location and infrastructure

- It is located in Industrial Area Salarpur, Bhiwadi, Rajasthan
- It spans across 100 acres (Phase I - 50 acres + Phase II - 50 acres)
- Proposed railway freight corridor and power supply + water distribution system

3. Benefits and facilities provided

- Central Government Incentives: (MSIPS) capital subsidy up to 25% or capital expenditure of the project and refund of indirect taxes paid on capital equipment
- Rajasthan state govt industrial policy benefits (RIPS 2019)
- Hostel facility for employees, testing facility, Electronics CoE, etc.

4. Progress made

- 19 companies have already been allotted land in the Cluster
- Environment clearance obtained from Rajasthan State Pollution Control Board for full 100 acres
- Basic development work of Phase I is nearing completion

Preliminary discussions indicate that setting-up electronics manufacturing facility in ELCINA cluster helps reduce cost of manufacturing by 5-8%

Further, for investments above Rs. 100 Cr. the benefits could be arrived on case to case basis – taking the cost advantage further

Source: (1) ELCINA Electronics Manufacturing Cluster, ELCINA website accessed 16/05/23 (2) GT's primary interactions with select members of Automotive Component Manufacturers Association and Society of Indian Automobile Manufacturers (3) GT Analysis

Recommendation 4: HSN code mismatch needs to be addressed

As an illustration, we noticed that despite having significant demand for certain product category, the actual imports were much lower. This demonstrates that some of these categories are also being imported under other HS codes.

#	Product	HSN code	Description alignment	2021 import value ($ mn)*	Estimated Import ($Mn) (2021)	Basis of Calculation
1	In car entertainment system	85272100	High	102	196.1	Imports estimated based on India Demand x Share of import in the respective product category Ideally since the HSN code will have other (non auto products), the value of HSN based imports should be higher than the estimated import
2	Navigation system	90148090	Low	16	18.5	

A detailed review of HS codes for a category of auto electronics needs to be undertaken to unearth the real position. This will enable us to mark products which need to be given additional emphasis in the Indian context

* As per trade map data

Recommendation 5: Incentives and dis-incentivization specific to auto electronics

Incentives

- Exports of auto-electronics and allied components may be subject to reduced export duties (can be specific products linked to specific HSN codes)
- Additional benefits in the form of income-tax deductions, infra-support and grants for R&D taken up in the field of auto-electronics (can be controlled to provide benefits to products with IP etc.)
- Additional benefits (financial and non-financial (EODB related) in case an Indian company acquires significant stake in an overseas company in the field of auto-electronics
- Support non-auto electronic product manufacturers to supply to auto companies by providing linkage support with tier 1 and OEMs

Disincentives

- In a gradual manner, levy additional duties on auto-electronic components being imported. A list of components with high manufacturing volumes can be included (can be tracked through HSN codes)

Recommendation 6: Strengthen policy guidelines for safety products uptake + testing

Long term policy guidelines for the uptake of safety related electronic products

- Currently, OEMs have observed the uptake of safety related automotive electronics has been driven by sudden product specific notifications by MoRTH
- One such example is MoRTH notification on making 6 airbags mandatory in passenger vehicles from October 2023. As per latest news articles, MoRTH is currently in consultation with OEMs on whether October 2023 is feasible or not
- Therefore, it is recommended that a long-term plan on the uptake of safety related products will help OEMs to plan the sourcing of these products in advance.
  - Further, the complexity of products can be increased with growth of automotive electronics manufacturing in India
  - An example regulation that can be considered for the same is EU Regulation 2019/2144
- Some of these rules can be evaluated by MoRTH

Testing norms for electronic components crucial from the cybersecurity standpoint

- Currently, detailed testing at component level for telematics unit is not required
- Components - crucial from cybersecurity standpoint - such as security modules GNSS unit, engine interface, external interface, etc. are not vetted during telematics unit testing
- Formulation of component standards for the same should be considered to ensure functional safety and security of the complete telematics unit
- Key global standards that can be considered for the same are:
  - ISO 26262
  - IEC 61508
  - SAE J2980
- Some of these rules can be evaluated by MeitY

Source: (1) Draft car norms on mandatory 6 airbags, seat belts lapse, Times of India, 2023 (2) MoRTH approves draft notification for making 6 airbags mandatory, ET Auto, 2022 (3) GT Analysis

Recommendation 7: Establish technical and academic linkages for capability and skill building

Technical linkages

- Technical linkages with globally recognized CoEs will help in establishing dedicated R&D centers focusing on automotive electronics manufacturing
- Further, leading Indian component suppliers which have recently or are in process of acquiring foreign companies to gain access to relevant IPs / product design have indicated that mandatory processes related to forex regulations could be eased to fast-track such acquisitions

[Details of relevant CoEs]

- There are many start-ups in automotive electronics
- Such start-ups can be mentored on technology and product development aspects with the help of new R&D centers
- Select examples of start-ups include:
  - Flux Auto, Bangalore
  - Cyrrup, Hyderabad
  - Cell Propulsion, Bangalore
  - Swaayatt Robots, Bhopal

[Details of relevant start-ups]

Academic linkages

- Academic linkages between Indian and foreign universities will help in offering automotive electronics specific degree as well as certificate programs, leading to human capital development for R&D and manufacturing teams of future
  - Currently, some aspects of automotive electronics (e.g. power electronics) are covered as part of select degree programs in leading engineering institutions, indicating the presence of base which can be leveraged for launching automotive electronics dedicated degree programs
- Select examples of foreign universities offering such programs include:
  - Riverside College, USA
  - University of Michigan, USA
  - OTH Regensburg, Germany
  - Clemson University, USA
  - Coventry University, UK
  - University of Warwick, UK

[Details of relevant foreign universities]

Appendix

- **India demand size**
- **Current imports scenario**
- **Target for the Industry**
- **Recommendations**
- **Primary interactions list**

Details of sub-parts applicable for this study (1/10)

#	Category	Products	Key sub-parts
1	Power electronics (ICE)	Fuel injector	
2		Selective catalytic reduction	
3		Exhaust gas recirculation	
4		Automatic transmission system *(including automated manual transmission Continuously variable transmission, and Dual clutch transmission)*	
5		Engine control system	Engine ECU OBD Engine Control Parts

Details of sub-parts applicable for this study (2/10)

#	Category	Products	Key sub-parts
6	Power electronics (EV)	Power distribution module	Switches / MOSFETs Printed circuit board Fuses
7		DC-DC converter	
8		Thermal management	Pumps Valves Pipes Heat exchanger

Details of sub-parts applicable for this study (3/10)

#	Category	Products	Key sub-parts
9	Power electronics (EV)	Charger system	Electric vehicle communication controller On board charger Charging cord
10	Safety controls	Electronic power steering	
11		Tire pressure monitoring system	Tire Pressure Sensor Display unit Controller
12		Airbag electronics	Airbag module Airbag control unit Crash sensors

Details of sub-parts applicable for this study (4/10)

#	Category	Products	Key sub-parts
13	Safety controls	Electronic stability control	
14		Anti-lock braking system	ECU Wheel speed sensors Modulator unit (Hydraulic/Pneumatic)
15	Communication and entertainment	Telematics Unit	Telematics box Service package
16		Driver information system	Instrument clusters Displays

Details of sub-parts applicable for this study (5/10)

#	Category	Products	Key sub-parts
17	Communication and entertainment	In-car entertainment system	Car radio / Head unit Speakers
18		Navigation system	
19	Body electronics	Reverse parking guide	Ultrasonic sensors Controllers Displays Cameras
20		Fully automatic temperature control system	Controllers Sensors

Details of sub-parts applicable for this study (6/10)

#	Category	Products	Key product types
21	Body electronics	Remote keyless entry and immobilizer	
22		Body control module	

Details of sub-parts applicable for this study (7/10)

#	Category	Products	Key product types
1	Electricals	Wiring harness	
2		Printed circuit boards	
3		Switches and connecters	
4		Actuators	Starter solenoid switch Automated manual transmission (AMT) solenoid Wastegate actuators Idle air control valve Canister purge solenoid

Details of sub-parts applicable for this study (8/10)

#	Category	Products	Key product types
4	Electricals	Actuators	Exhaust gas recirculation (EGR) valve Power steering motors Power sunroof Light-emitting diode (LED) headlamps cooling fans Engine cooling fan Electrical fuel pump Windshield wipers and washers Power door locks Heating, ventilation, and air conditioning (HVAC) blower Power windows

Details of sub-parts applicable for this study (9/10)

#	Category	Products	Key product types
4	Electricals	Actuators	Variable valve timing actuation Electronic throttle control Idle speed controller Self-adjusting mirrors
5		Sensors	Crank position sensor Cam sensor Coolant temp sensor Accelerator / throttle pedal position sensor Temperature manifold absolute pressure sensor

Details of sub-parts applicable for this study (10/10)

#	Category	Products	Key product types
5	Electricals	Sensors	Air mass flow (HFM) Vehicle speed sensor Oxygen sensors Parking sensors Tire pressure monitoring system sensors Fuel level sensors Ambient temperature sensors

Vehicle segments covered for products considered in this study (1/3)

#	Category	Product	Coverage as per vehicle segment		
			2Ws	PV	CV
1	Power electronics (ICE)	Fuel injector			
2		Selective catalytic reduction			
3		Exhaust gas recirculation			
4		Automatic transmission system			
5		Engine control system			
6	Power electronics (EV)	Power distribution module			
7		DC-DC converter			
8		Thermal management system			
9		Charger system			

Key: ***Yes*** ***No***

Vehicle segments covered for products considered in this study (2/3)

#	Category	Product	Coverage as per vehicle segment		
			2Ws	PV	CV
10	Safety controls	Electronic power steering			
11		Tire pressure monitoring system			
12		Airbag electronics			
13		Electronic stability control			
14		Anti-lock braking system			
15	Communication & entertainment	Telematics unit			
16		Driver information system			
17		In-car entertainment system			
18		Navigation system			

Key: ***Yes*** ***No***

Vehicle segments covered for products considered in this study (3/3)

#	Category	Product	Coverage as per vehicle segment		
			2Ws	PV	CV
19	Body electronics	Reverse parking guide			
20		Fully automatic temperature control			
21		Remote keyless entry & immobilizer			
22		Body control module			

Key: ***Yes*** ***No***

Approach for India demand estimation:

We have used 2 approaches for demand estimation

Top-down approach

Domestic demand

=

Vehicle sales by segment

×

Average net cost of vehicle in a segment

×

% share of electronics in cost

Demand from vehicle exports

=

Vehicle exported by segment

×

Average net cost of vehicle in a segment

×

% share of electronics in cost

Bottom-up approach

Domestic demand

Products where unit cost is known:

- *Vehicles sales by segment x product volume used in 1 vehicle x per unit cost*

Products where unit cost is unknown:

- *Basis credible secondary research sources available in public domain*

Demand from vehicle exports

The demand from top-down approach has been divided in the value share observed for each product in domestic demand (bottom-up)

This is done basis the assumption that exported vehicles largely resemble domestic vehicles

Current and projected domestic demand by different products:

Product	Domestic demand in 2022 *(in $ mn)*	Domestic demand in 2032P *(in $ mn)*	CAGR 2022-32P
Anti-lock Braking System	1670.4	9490.8	19%
Electronic Power Steering	1491.7	6518.2	16%
Fuel Injector	950.2	2134.0	8%
Automatic Transmission System	866.5	6239.3	22%
Airbag Electronics	709.8	6114.0	24%
In-car Entertainment System	498.1	2415.7	17%
Electronic Stability Control	478.9	1304.4	11%
Selective Catalytic Reduction	400.6	2648.4	21%
Engine Control System	380.1	853.6	8%
Body control module	359.3	1698.5	17%
Driver Information System	192.5	1199.7	20%
Exhaust Gas Recirculation	187.5	421.5	8%
Remote keyless entry and immobilizers	184.0	2084.0	27%
Fully automatic temperature control system	178.9	3350.5	34%
Telematics Unit	171.7	6474.6	44%
Reverse parking guide	156.8	1083.6	21%
Tire Pressure Monitoring System	96.3	3118.3	42%
Charger system	31.5	2380.6	54%
Navigation System	24.3	180.5	22%
Controller	21.4	1708.5	55%
DC-DC converter	14.4	1112.1	54%
Thermal management system	9.4	592.3	51%
Power distribution module	9.1	527.1	50%
Total domestic demand	**9083**	**63650**	**21.5%**

Appendix

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Approach for total imports estimation:

This estimation involves 7 key steps:

1. We have analyzed direct import transactions through port data (> 200,000) for CY22 for a select OEM
2. To this data, a % of import transactions of its primary tier 1 supplier were added
3. Each transaction was classified as for auto-electronic product or not
4. If the transaction is for auto-electronics, category and product was decided basis the universe finalized
5. Using pivots function, the value of auto-electronics imports by this OEM were identified at the aggregate level
6. This total value was divided by total PVs manufactured by this OEM in India (in CY22) to arrive at imported electronic content per PV
7. This value was then extrapolated for all the PVs manufactured in India to arrive at total electronics import for PV segment in India

Basis primary interactions, we already knew the value of electronics content that goes into a PV, CV, and 2W – 15%, 10%, and 10% - respectively for current state. The above analysis gives imported electronics content in 1 PV. The % share of imported electronic content comes out to 64% of total electronics content in 1 PV. The same % has been assumed for CV and 2W segment to arrive at total auto-electronics import value.

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Approach for manufacturing target setting:

Total auto-electronics demand (in $ bn) - domestic demand + demand from vehicle exports

Case 1

2022	2027	2032
10.6	28.6	70.3
	21.9%	*19.7%*

Case 2

2022	2027	2032
10.6	29.1	72.4
	22.3%	*20.0%*

Domestic manufacturing for domestic demand + demand from vehicle exports (in $ bn)

Manufacturing CAGR

Base case

	2022-27	2027-32
	22.3%	20.0%

assumed to grow as per total demand

Optimistic case

	2022-27	2027-32
	30.8%	21.1%

as per AE specific ICEA growth rate

Base case

2022	2027	2032
3.8	10.4	25.8

Optimistic case

2022	2027	2032
3.8	14.5	37.9

Approach for manufacturing target setting:

Top up for discrete exports ($ Bn)

Base Case: To achieve target of 30% exports [as-is industry status achieved in automotive electronics]

Export %	15.0%	30%

2022	2027	2032
	1.6	7.8

Optimistic Case: To achieve the target of 55% exports [average industry exports % of Japan & Korea] [second best among India's global peers]

Export %	27.5%	55%

2022	2027	2032
	4.0	20.9

Total manufacturing target (in $ bn)

Base case

2022	2027	2032
3.8	11.9	33.6

Optimistic case

2022	2027	2032
3.8	18.5	58.8

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Criteria used high level product prioritization :

Criteria		UOM	1	3	9
Market attractiveness	Total demand in 2022	in $ Mn	<350	351-700	>700
	Total demand growth (2022-32)	%	<15	16-30	>30
	Localization need (Import in 2022)	%	<40	41-80	>80
Ease of manufacturing + design			High	Medium	Low

Localization need - Helps to account for SCALE Committee's objective of the import reduction
Ease of manufacturing + design refers to hardware design integration with software, PCB design, Electromagnetic Interface / Compatibility, need for graphical user interface, etc.

Source: (1) GT Analysis

Ratings for high level product prioritization:

	35%	30%	35%	100%	
Product names	**Total demand in 2022**	**Total demand growth (2022-32)**	**Localization need (Import in 2022)**	**Weighted average**	**Manufacturing + design complexity**
Fuel Injector	9	1	1	3.8	Medium
Selective Catalytic Reduction	3	3	3	3	High
Exhaust Gas Recirculation	1	1	1	1	Medium
Automatic Transmission System	9	3	9	7.2	High
Engine Control System	3	1	9	4.5	Medium
Power distribution module	1	9	9	6.2	Medium
DC-DC convertor	1	9	3	4.1	Medium
Thermal management system	1	9	9	6.2	Medium
Charger system	1	9	3	4.1	Medium
Controller	1	9	3	4.1	Medium
Electronic Power Steering	9	3	1	4.4	Medium
Tire Pressure Monitoring System	1	9	3	4.1	Medium
Airbag Electronics	9	3	1	4.4	High
Electronic Stability Control	3	1	3	2.4	High
Anti-lock Braking System	9	3	1	4.4	High
Telematics Unit	1	9	3	4.1	Medium
Driver Information System	1	3	9	4.4	High
In-car Entertainment System	3	3	3	3	Medium
Navigation System	1	3	9	4.4	Medium
Reverse parking guide	1	3	9	4.4	Low
Fully automatic temperature control system	1	9	1	3.4	High
Remote keyless entry and immobilizers	1	3	3	2.3	Low
Body control module	3	3	1	2.3	Medium

Source: (1) GT Analysis

Estimation for import bill savings (1/2)

Import bill savings on aluminum castings for auto-electronics – Engine Control Unit and thermal management system	
Particulars	**Value**
India demand of Engine Control Unit (in $ bn)	0.94
Assuming current import % will be aplicable in 2032	80%
India demand fulfileed via imports (in $ bn)	0.75
Value % share of ECU casing	22.50%
Import bill that could be saved via ECU casing localization (in $ bn)	0.170
India demand of Thermal management system (in $ bn)	0.65
Assuming current import % will be aplicable in 2032	80%
India demand fulfileed via imports (in $ bn)	0.52
Value % share of Heat exchangers	0.20
Import bill that could be saved via heat exchangers localization (in $ bn)	0.105

Source: (1) GT Analysis

Estimation for import bill savings:

Import bill savings on aluminum castings for auto-electricals – battery back and electric motor	
Particulars	**Value**
PV EVs Sold in 2032 (in mn)	1.83
PV EVs Sold in 2032 (#)	1,830,000
Weight of battery pack + electric motor (in kgs)	482
Total weight of battery pack + electric motor (in kgs)	882,060,000
Taking % share of aluminium casting as 20%	176,412,000
Per kg cost of aluminium casting (in $)	6.8
Total value of alumimnium casting used in battery and electric motors (in $ bn)	1.2
2W EVs Sold in 2032 (in mn)	22.326
2W EVs Sold in 2032 (#)	22,326,000
Weight of battery pack + electric motor (in kgs)	25
Total weight of battery pack + electric motor (in kgs)	558,150,000
Taking % share of aluminium casting as 20%	111,630,000
Per kg cost of aluminium casting (in $)	6.8
Total value of aluminum casting used in battery and electric motors (in $ bn)	0.8

Source: (1) GT Analysis

Bottom-up check with manufacturing targets (2/2)

			Key Importers				
#	Category	Product Name	Country 1	Country 2	Country 3	Country 4	Country 5
1	Power Electronics (ICE)	Fuel injector	South Korea	Colombia	Zimbabwe	Vietnam	
2		Selective catalytic reduction	Vietnam	Turkey	Philippines	Pakistan	
3		Exhaust gas recirculation	Vietnam	South Korea	Netherlands	Japan	
4		Automatic transmission system	Japan	Vietnam	South Korea	Philippines	
5		Engine control system	Spain	Germany	France	Hungary	Portugal
6	Power Electronics (EV)	Power distribution module	Hong Kong	Germany	Zimbabwe	Vietnam	China
7		DC-DC converter	Vietnam	South Korea	Brazil	Hong Kong	
8		Thermal management system	Vietnam	Japan	Turkey	Brazil	
9		Charger system	Vietnam	USA	Paraguay	Pakistan	
10	Safety Controls	Electronic power steering	Vietnam	Japan	Liberia	China	
11		Tire pressure monitoring system	USA	Vietnam	Germany	Turkey	
12		Airbag electronics	Turkey	USA	South Korea	Vietnam	
13		Electronic stability control	Vietnam	Turkey	Singapore	Pakistan	
14		Anti-lock braking system	Japan	Brazil	South Korea	Vietnam	Hungary
15	Communication & Entertainment	Telematics unit	Hungary	South Korea	Turkey	Germany	
16		Driver information system	Thailand	Malaysia	Indonesia	Taiwan	
17		In-car entertainment system	Vietnam	South Korea	Uzbekistan	Hong Kong	
18		Navigation system	Germany	France	USA	Italy	UK
19	Body electronics	Reverse parking guide	US	Japan	Thailand	Vietnam	
20		Fully automatic temperature control system	Phillipines	Vietnam	Kenya	Nepal	
21		Remote keyless entry and immobilizers	Zimbabwe	USA	Turkey	Vietnam	
22		Body control module	Vietnam	Phillipines	USA	Zimbabwe	

Source: (1) GT Analysis

Select domestic PCB manufacturers:

PCB Manufacturers in India
Genus Electrotech Ltd.
AT&S India Pvt. Ltd.
Epitome Components Ltd.
Anand Electronics & Industries Ltd
India Circuits Ltd.
Ascent Circuits Pvt. Ltd.
Shogini Technoarts Pvt. Ltd.
Mohite Electronics Pvt. Ltd
CIPSA-TEC India Pvt. Ltd.
Meena Circuits Pvt. Ltd

Source: (1) GT Analysis

Select domestic PCB manufacturers:

Source: (1) GT Analysis

List of relevant COEs:

#	Country	CoE name	COEs details
1	Germany	KPIT Technology's center of excellence	Located in Munich, it focuses on the development and implementation of solutions for autonomous driving, electric powertrains, and vehicle diagnostics
2	Germany	Bosch Research and Technology Center,	Located in Renningen, it focuses on the development of advanced electronic systems for automobiles, including driver assistance systems, sensors, and connectivity solution
3	Japan	Japan Automobile Research Institute	It focuses on research and development on solutions such as autonomous driving, vehicle safety, vehicle security, etc.
4	Japan	Toyota Research Institute	It focuses on developing active vehicle safety products, automated driving technology, and robotics
5	USA	Center for Automotive Research	It is an independent, non-profit research organization that conducts research in various areas related to auto-electronics such as - autonomous driving, vehicle safety, electric vehicles, etc.
6	USA	Clemson University International Center for Automotive Research	It is a research and educational institution that focuses on automotive engineering including autonomous driving, power electronics, battery management, integration of systems, etc.

Source: (1) GT Analysis

List of relevant foreign universities:

#	Country	University / College name	Course details
1	USA	Riverside College	Associate of Science Degree in Automotive Technology - Electrical: Automotive Electrical and Electronics Specialist
2	USA	University of Michigan	Certificate - Vehicle Electronics and Control
3	USA	Clemson University	Bachelor's and Master's - Clemson University and its International Center for Automotive Research
4	Germany	West Saxon University of Applied Sciences	Bachelor of engineering (Automotive electronics)
5	Germany	OTH Regensburg	Master degree in automotive electronics (Part time for working professionals)
6	Germany	University of Europe	Masters in Science -Software Engineering
7	Japan	Nakanihon automotive college	Certificate - Auto Mechanic course
8	Japan	Uplatz Training	Training Course - Automotive Electric and Automotive electronics
9	UK	Cranfield University	MSc - Automotive Mechatronics
12	UK	University of Warwick	MSc - Sustainable Automotive Electrification MSc
13	UK	University of East London	MSc - Electrical automotive engineering
14	UK	University of Bath	MSc - Automotive engineering with Electric Propulsion

Source: (1) GT Analysis

List of relevant start-ups:

#	Name	Founding Year	HQ City	Business details
1	AVIN Systems	2014	Bangalore	Automotive software products with focus on functional safety, driver assistance, etc.
2	Intangles Lab	2014	Pune	Solutions for monitoring vehicle health, driver behavior, fuel theft, etc.
3	Swaayatt Robots	2015	Bhopal	Developing level-5 autonomous driving technology for the Indian roads
4	LocoNav	2016	Gurgaon	Solutions related to fleet management, vehicle tracking, driver safety, etc.
5	Cell Propulsion	2016	Bangalore	Developing fully electric commercial vehicles with proprietary powertrain component
6	Ather Energy	2013	Bangalore	Designs and manufactures electric scooters
7	Flux Auto	2017	Bangalore	Developing autonomous driving technology for commercial vehicles
8	Cariq Technologies	2013	Pune	Provides connected car technology solutions such as access to status, vehicle data, location and advanced analytics, alerts for Rash Driving, Geofence, Engine Errors, Continuous Idling, etc.
9	Tork Motors	2010	Pune	Startup that designs and manufactures electric motorcycles
10	Cyrrup	2017	Hyderabad	Offers a cloud-based telematics platform for fleet management, vehicle tracking, and driver analytics

Source: (1) GT Analysis

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The details of primary interactions completed during the course of this study

Together with ACMA and SIAM, Grant Thornton reached out to approx. 40 potential interviewees for primary interactions. The details of interviewees with whom primary interaction was successfully completed are as follows:

#	Interviewee Name	Organization Name	Organization Type
1	Mr. Kapil Gupta	ICEA	Industry association
2	Mr. KV Suresh	ZF	Automotive components / electronics manufacturer
3	Mr. Prashanth Doreswamy	Continental Corporation	Automotive components / electronics manufacturer
4	Mr. S Kumar	Bosch	Automotive components / electronics manufacturer
5	Mr. Aman Rathee	ASK Automotive	Automotive components / electronics manufacturer
6	Mr. Vishwas Deshpande	MG Motor	OEM
7	Mr. Muthu C	Daimler Trucks	OEM
8	Mr. Veeraraghavan R	Mahindra	OEM
9	Mr. Gaurav Gupta	MSIL	OEM
10	Mr. S K Marwaha	Ministry of Electronics & IT	Government of India
11	Mr. Vijay Aditya	Flex Engineering	EMS Provider

In addition, Grant Thornton also presented the key quantitative outcomes of this study to the SIAM Sourcing Group as well as SIAM Executive Council with an objective to gather directional inputs

Thank You!