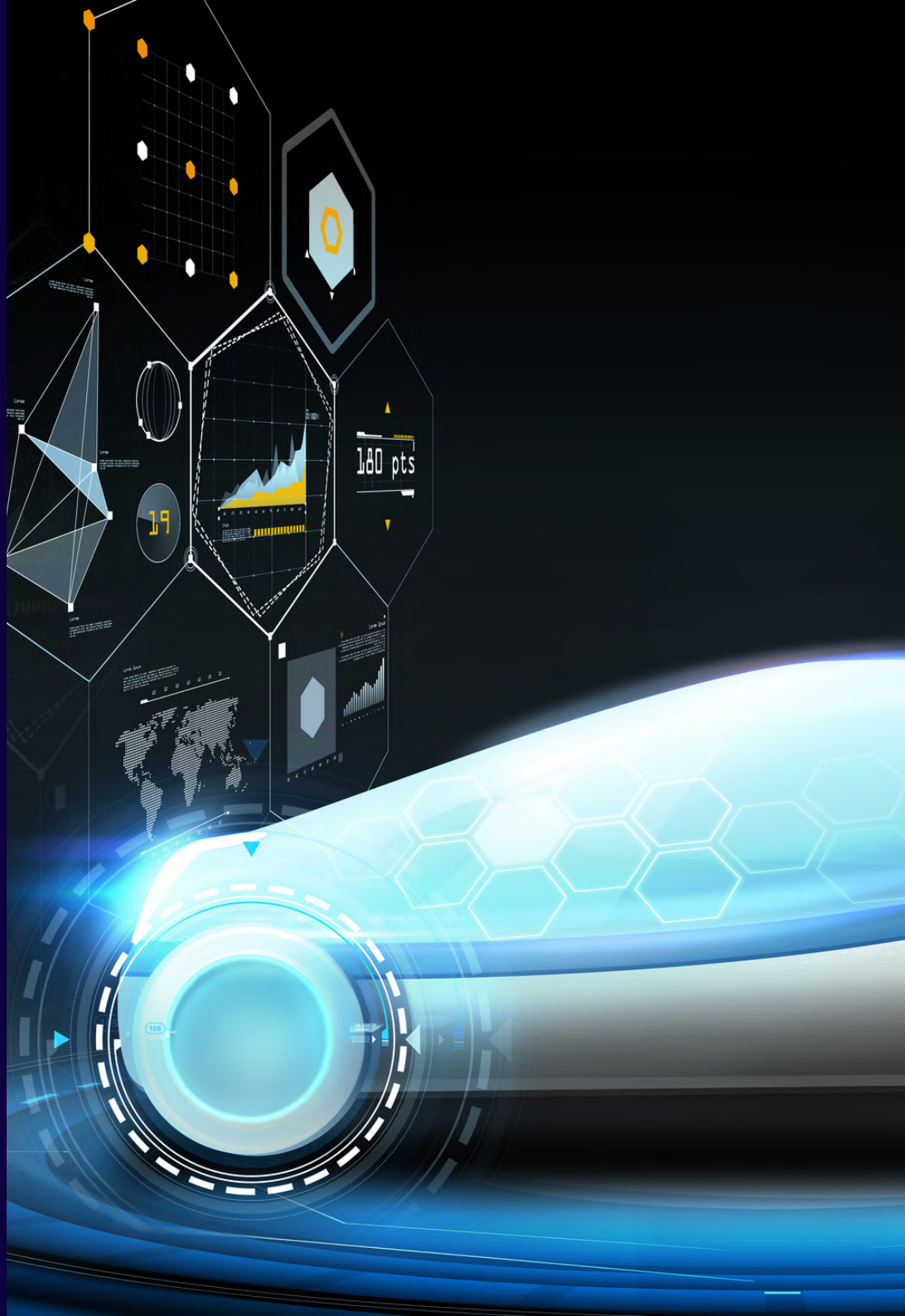
TRANSFORMING INDIA INTO A GLOBAL AUTOMOTIVE HUB

ROADMAP FOR AUTOMOTIVE ECOSYSTEM

OCTOBER 2023

ARTHUR D LITTLE




SELF-DRIVING
START
STOP

PREFACE

The Indian automotive industry is poised for rapid growth as a result of converging global and local factors. Favourable policies, growing presence of global OEMs, their need for alternative sourcing destination and growing software content have created a unique window of opportunity for Indian players to scale up revenues, capabilities and position India as a global automotive.

This report builds on Arthur D. Little's 2022 seminal report of *Unlocking India's Electric Mobility Potential* and explores key areas of automotive value creation in India, including becoming a destination for global platforms, achieving global scale in software and ER&D, striving for innovation and technology leadership, operations excellence at scale, being an early mover in building a sustainable value chain.

It highlights the increasing pace of innovation within the local automotive ecosystem and the shifting dynamics of disruption, which if harnessed effectively, can catapult India into a position of global automotive leadership. Finally, the report sets a bold vision for an export-led industry aspiration of USD 1 Trillion by 2035, enabled by manufacturing, innovation and technology leadership.

This report hopes to encourage relevant stakeholders across the value chain to tap into the plethora of opportunities and explore meaningful avenues of growth and collaboration, helping India become a global automotive hub. A robust dialogue on harnessing the true potential of the Indian automotive sector should catalyze the investments and concerted actions needed to achieve the USD 1 Trillion vision.

Barnik Chitran Maitra
Managing Partner
Arthur D. Little India & South Asia

Amit Dakshini
President & Sector Leader – Automotive & Manufacturing
Arthur D. Little India and South Asia

Prathamesh Chaudhari
Principal – Automotive & Manufacturing
Arthur D. Little India

AUTHORS

Barnik Chitran Maitra
Managing Partner
ADL India & South Asia
maitra.barnik@adlittle.com

Amit Dakshini
President & Sector Leader for Automotive & Manufacturing
ADL India & South Asia
dakshini.amit@adlittle.com

Prathamesh Chaudhari
Principal, Automotive
ADL India
chaudhari.prathamesh@adlittle.com

Dr. Andreas Schlosser
Partner & Global Automotive Lead
ADL Germany
schlosser.andreas@adlittle.com

Karl Markus Doerr
Senior Board Advisor
Automotive, Germany
doerr.karlmarkus@adlittle.com

Abhinav Chauhan
Manager, Automotive
ADL India
chauhan.abhinav@adlittle.com

Contributors

Shaishav Agrawal
Business Analyst, ADL India
agrawal.shaishav@adlittle.com

Ujjwal Tiwary
Business Analyst, ADL India
tiwary.ujjwal@adlittle.com

Manjari Ravuthan
Business Analyst, ADL India
ravuthan.manjari@adlittle.com

Ayush Anand
Business Analyst, ADL India
anand.ayush@adlittle.com

CONTENT

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

With USD 250 bn of revenues in FY23, the Indian automotive industry contributed a significant 7.3% to the national GDP. As per various industry projections, the automotive industry India is expected to grow at an annual rate of 7% to 8% to become the world's third-largest automotive cluster by 2030, with estimated annual revenues of USD 400 bn in FY30. While focused on catering to the growth in local demand, Indian players are striving to capture the export opportunity. However, on the global automotive landscape, India's presence still remains limited. Currently, India lags global automotive hubs such as Germany, Japan, South Korea, etc., in terms of development and production for global markets. Despite its factor cost advantage, in FY23, India's vehicle exports stood at USD 20 Bn and component exports another USD 20 bn, with cumulative contribution of less than 20% to the annual industry revenues.

The global megatrends of the automotive industry, including electrification and alternative powertrains, ADAS and autonomous driving, connected vehicles and new mobility concepts, have created a level playing field for automotive players around the world, as the leading global OEMs and suppliers are also in the process of re-inventing themselves to navigate the new realities of the industry.

Supportive policies under the Make-in-India initiative (Production Linked Incentives – PLI, Faster Adoption and Manufacturing of Electric vehicles – FAME), growing presence of global OEMs in India, their need for an alternative sourcing destination, consolidation of platforms, rise in electrification, push for green supply chains, the tightening of Indian safety and emission standards to bring it par with global standards, and growing software content in vehicles for which India is already seen as a hub, have created a conducive environment for Indian players to step up and be globally competitive for domestic and export markets. Export potential across vehicles, components, Engineering and Research and Development (ER&D) and software as well as other ancillary services needs to be realized to establish India's dominance in the automotive industry in the coming decade. This is certainly a critical window of opportunity for the Indian automotive players, given the convergence of favorable global factors and robust domestic growth.

EXECUTIVE SUMMARY

Industry players across the value chain need to act in a concerted fashion to make the most of this opportunity. Arthur D. Little has identified five pillars which must be strengthened to create a leadership position for India in the global automotive industry.

Destination for global platforms: India's automotive industry can become the destination for design, development, and production of global platforms, with universal appeal. With consolidation of platforms by OEMs and tightening local market safety and emission standards, Indian players have an opportunity to play an important part in the global supply chain. Indian players across the value chain need to upgrade their capabilities and position India as a reliable and competitive hub for the manufacturing of vehicles for global markets, including developed countries. As most of the new platforms are designed with electric powertrain, Indian players would need to build dominance in the EV value chain. Control over battery supply chain including scale in cell manufacturing is of paramount importance if India wants to become preferred destination for manufacturing and sourcing for global OEMs. Design and production of leading global platforms, new EV platforms and batteries will be crucial to build necessary scale in manufacturing as India aspires to become a global automotive hub. It will drive local OEMs to become global OEMs, creating global automotive champions out of India.

Automotive software & ER&D powerhouse: The global automotive ER&D and software market is expected to grow three-fold by 2030 to USD 400+ bn. Rapidly increasing value share of software in automotive industry creates a strong opportunity for Indian players. India can leverage its position as the software hub of the world and offshore destination of choice for ER&D. However, industry players must upgrade their offerings to include solutions relevant for emerging trends such as zonal architecture design, digital cockpit, ADAS, etc. By focusing on developing cost-effective software solutions with global applicability, India can secure a pivotal role in driving innovation for the industry's software-defined future.

New epicenter for technology, innovation & partnerships: India has the potential to be a leader in automotive innovation and technology.

EXECUTIVE SUMMARY

While there is evidence of innovation in India in auto-retail, e-commerce, shared mobility, India could strive to be a global leader in core engineering and deep technology across areas such as autonomous driving, Artificial Intelligence (AI). India already has several successful automotive start-ups, with an impressive US$ 19 Bn funding in the last 5 years. Indian startups and incumbents need to operate with 'Global-first' mindset and set a bold vision, aspiring for disruption. Investing in talent for AI, ML, cybersecurity, system engineering capabilities, etc., is crucial if India wants to position itself as a technology powerhouse for the global automotive industry. Indian players could embrace open innovation and invest in partnerships with start-ups, while also building organizational agility and adaptability. This will enable the industry to gain an early competitive advantage in the emerging technology areas such as autonomous driving, connected vehicles, battery technologies, alternative powertrains, etc. which will shape the future of the global automotive industry in the coming decade.

Operations excellence at scale: To achieve global competitiveness, India must build operational efficiencies at scale throughout the automotive value chain. Globally, OEMs are deploying technologies such as digital twins, AGVs (Autonomous Guided Vehicles), additive manufacturing, block chain, etc., to increase productivity, quality while reducing costs. India currently lags global automotive hubs such as US, Japan, Germany, South Korea in the use of industrial robots in production. India must invest in advanced manufacturing technologies at scale to become an attractive sourcing and production destination catering to global automotive market. Initiatives such as digital supply chain, digital business processes, Industry 4.0 use cases, will go a long way in building high quality and productivity standards and make India a competitive global automotive hub.

Leapfrog to sustainable materials & circular economy: Emission norms in India are rapidly closing the gap with global standards and regulations are likely to intensify towards global convergence on sustainability. Further strengthening of BS norms and CAFÉ norms and revisions in current super credit structure will require rethinking for new applications of advanced materials for both ICE and EV platforms. Europe's Carbon Border

EXECUTIVE SUMMARY

Adjustment Mechanism may impact Indian suppliers with exposure to Europe. Indian players across the value chain must adopt to such evolving regulations. Most of the global OEMs have committed for carbon neutrality between 2035-2050 and have undertaken multiple initiatives towards this journey. Indian players also need to invest in sustainable practices, such as use of lightweight materials, secondary aluminium, green steel, increasing composite content, recycling of Lithium batteries. Embracing sustainability and circularity and being an early mover in these areas is crucial as India aspires to become a global automotive hub.

Strengthening these five pillars will be instrumental in unlocking the growth potential for Indian automotive industry. The five pillars will lay the foundation for automotive industry to potentially reach annual revenues of USD 1 trillion by 2035, including an upside of USD 400 Bn from the business-as-usual trajectory. Importantly, the fundamental structure of the industry in India will transform to being innovation, technology and export led. In doing so, the automotive industry in India could indeed become a global leader, with dominant global multinationals emerging in manufacturing, components, and software/ER&D.

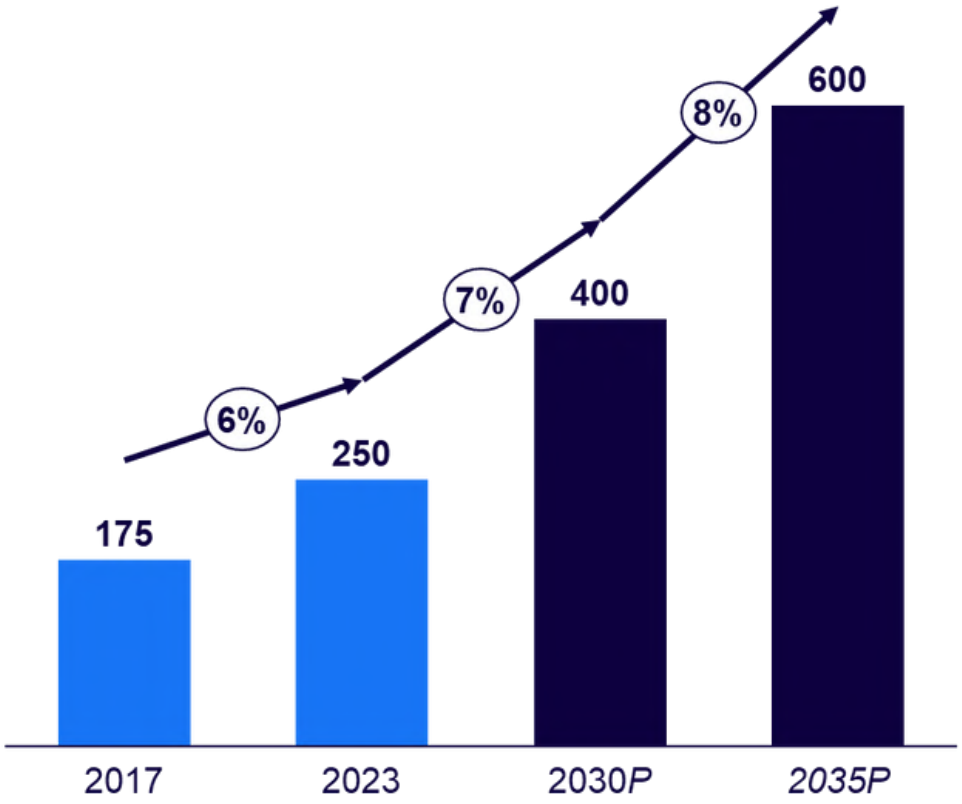
With this bold aspiration, the automotive industry can increase its share of India's GDP to 10% to 11%, accelerating GDP growth by at least 1%. This export driven growth will lead to nearly USD 500 bn of export revenues for Indian industry, a more than ten-fold increase from 2023. Moreover, the industry could add approximately 100 million in the next decade with positive ripple effects in adjacent industries, significantly benefitting the Indian economy as a whole.

The true potential of the Indian automotive industry can be capture only if all stakeholders (including the government) come together and in a concerted fashion shape the full ecosystem. With such much-needed impetus, India can truly become a global automotive hub with leadership in technology, innovation, and manufacturing by 2035.

WINDOW OF OPPORTUNITY FOR INDIA

Indian automotive industry, 4th largest globally, is expected to reach $600bn by 2035

Indian Automotive[1] Industry
(2017-2035, USD bn)



7.3%
of national GDP in FY23

37 Million
people employed in the industry

$40 Billion
exports in FY23 (5.2% of all exports)

Note: 1) – Includes vehicles, components, ER&D and other services
Source: Invest India, PIB, Arthur D. Little analysis

As per our analysis, India can unlock an additional $ 400+ bn value by transforming into a global automotive hub

	Import-based geography	Local assembly operations	Highly localized manufacturing	Auto manufacturing hub	Global Automotive Hub
Customer Segments and Markets	Local	Local	Local	Local + Exports	Global markets
Emerging Technologies & Product Planning	-	-	-	Collaborate with local tech holders for local platforms only. Control on new tech with HQ	Control on future tech roadmaps
Vehicle Engg. and Development	-	-	Local Engineering change support	Top hat design locally + Local Engineering Change support	Platform design locally, support for regional developments
Supply Chain	-	CKD / SKD	80%+ Local manufacturers	Local/regional supply chain decisions. Monitoring of circularity / responsible sourcing	Global supply chain decisions & driving circularity & responsible sourcing
Manufacturing & Quality	CBU imports	OEM controlled / Local partners	Locally competitive manufacturing	Cost efficiency at par quality	Global leadership in quality and operational efficiency
Distribution & Downstream	Local partners	OEM controlled / Local partners	OEM Controlled		
Example Countries	Bahrain, Nigeria, Nepal, Bangladesh, UAE	Kenya, Ethiopia, Morocco, Peru, Chile	Indonesia, Vietnam, Poland, South Africa, Philippines	Thailand, **India**, Mexico, Brazil, Italy, Spain	Germany, Japan, South Korea, China, France, USA
Size of Automotive Industry	**<$10B**	**$10B to $30B**	**$30B to $100B**	**$100B to $300B**	**$500B+**

Low Involvement — High Involvement

Source: Arthur D. Little analysis

Window of opportunities for India is now – we need to leverage ongoing industry disruptions and favorable policies & demographic environment

Key Industry Dynamics/Disruptions

- Rapid implementation of carbon neutrality initiatives
- Shift to electronic content: disintegration of hardware & software in vehicle architecture
- Pace of innovation across automotive ecosystem
- Global trade dynamics
- Search for new frontiers of productivity across value chain
- Race to secure natural/precious metal resources

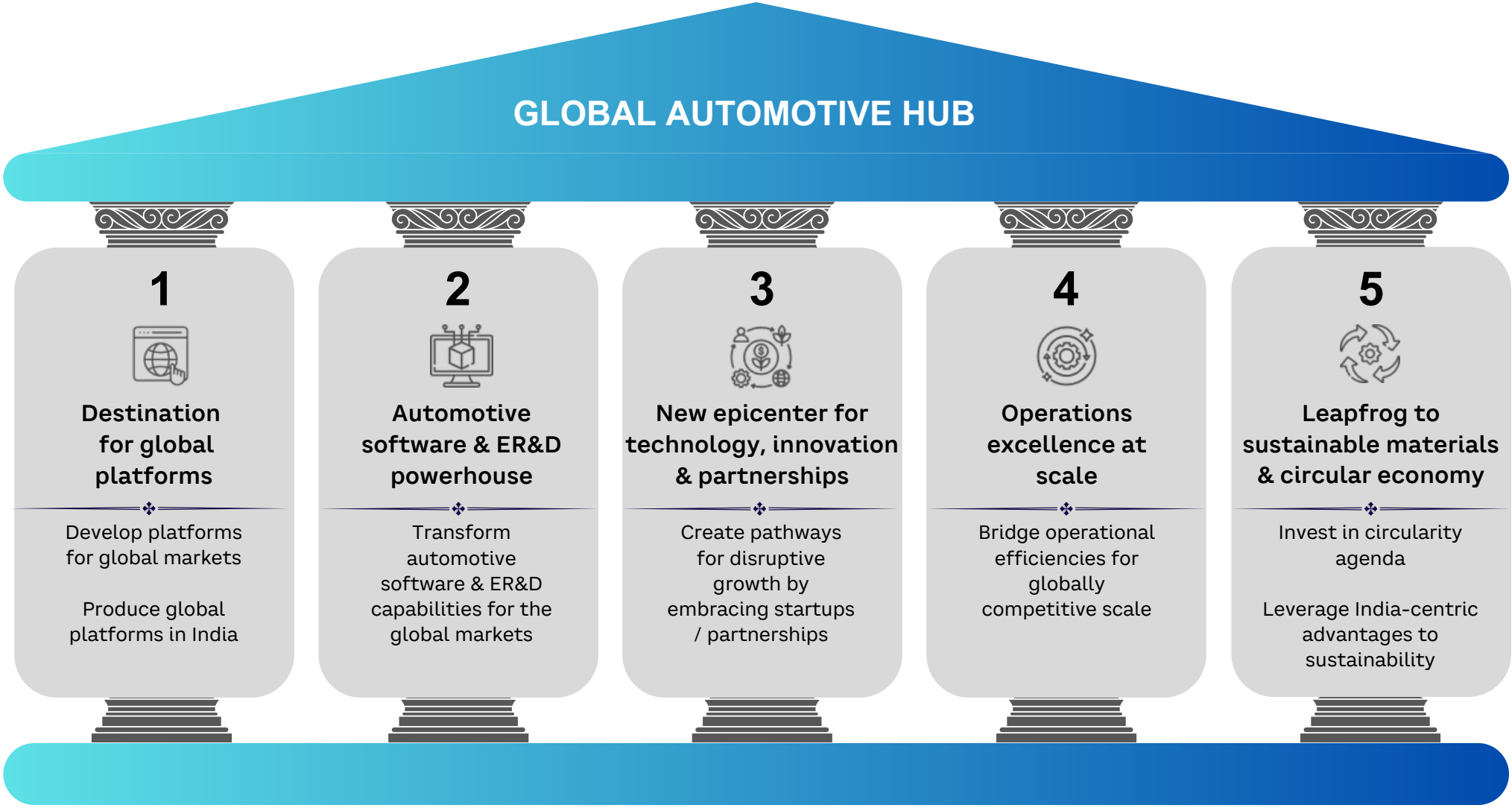
India's Favourable Environment

- Continuous push on Policies for "Make in India" / localization of content
- India closing gaps on global safety and emissions standards
- Favorable demographics for higher internal demand for automotives
- Growing number of OEMs and ER&D centers setting up in India
- Global players diversifying supply chains: India favorably considered as an option
- Availability of talent and evolution of manufacturing technologies

TRANSFORM INTO A GLOBAL AUTOMOTIVE HUB

Source: Arthur D. Little analysis

ADL's 5 pillar framework to transform India into a Global Automotive Hub



Source: Arthur D. Little analysis

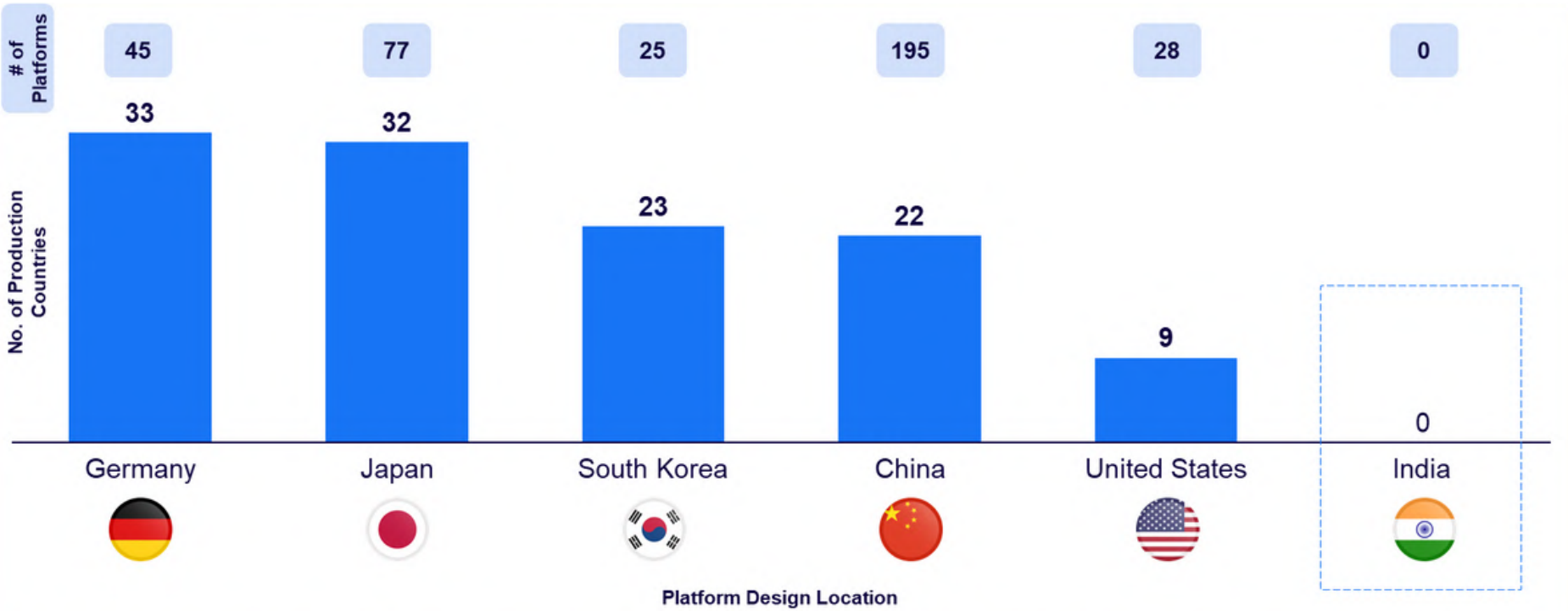
01

DESTINATION FOR GLOBAL PLATFORMS

Design & produce platforms for global markets in India

German and Japanese OEMs have designed multiple platforms that are being produced globally across several locations; Indian OEMs need to catch up

Global Production Footprint & Platform Design Location (# countries, 2022)



Note: Platform Design Location denotes location for the primary design center for the platform. No. of Production Countries excludes home country
Source: S&P Global Mobility, Arthur D. Little analysis

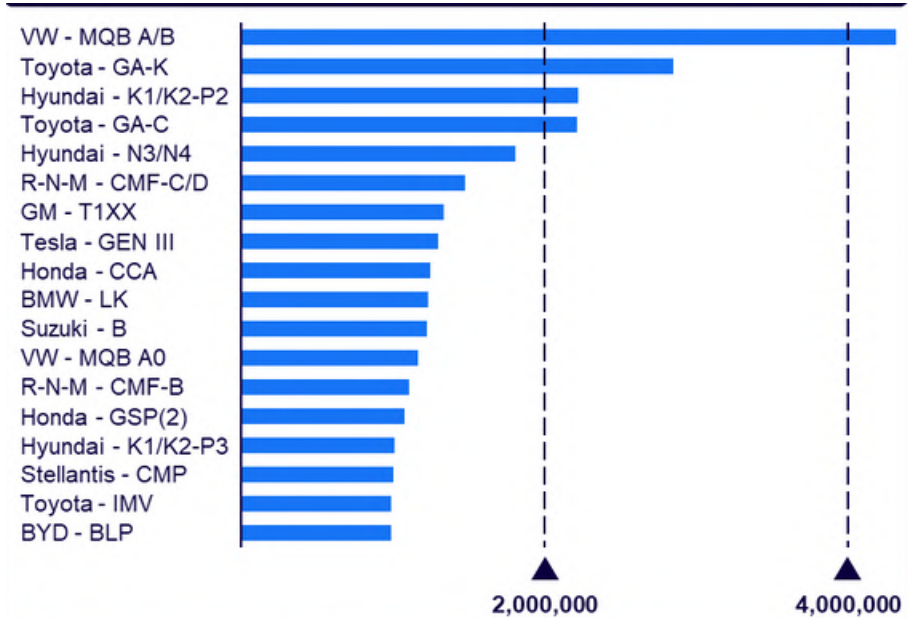
Leading global platforms are produced at scale across multiple locations, contributing a high share of overall sales; Indian OEMs are yet to build scale

Platform & Production Volume by OEM (2022)

Design OEM	# platforms in production	# platforms ~1m+ volume	% contribution	
			Top platform	Top 2 platforms
Toyota	24	3	27%	48%
VW	21	2	51%	68%
Hyundai	15	3	32%	58%
Stellantis	24	1	15%	29%
R-N-M	28	2	23%	40%
GM	20	1	28%	46%
Ford	11	0	24%	47%
Honda	11	2	32%	60%
Suzuki	9	1	37%	64%
MB	13	0	37%	63%
BMW	8	1	52%	81%
Geely	17	0	29%	52%
BYD	7	1	53%	78%

~80% of Global LV production in 2022 is based on platforms designed by 13 OEMs

Production Volume by Platform & OEM (2022)

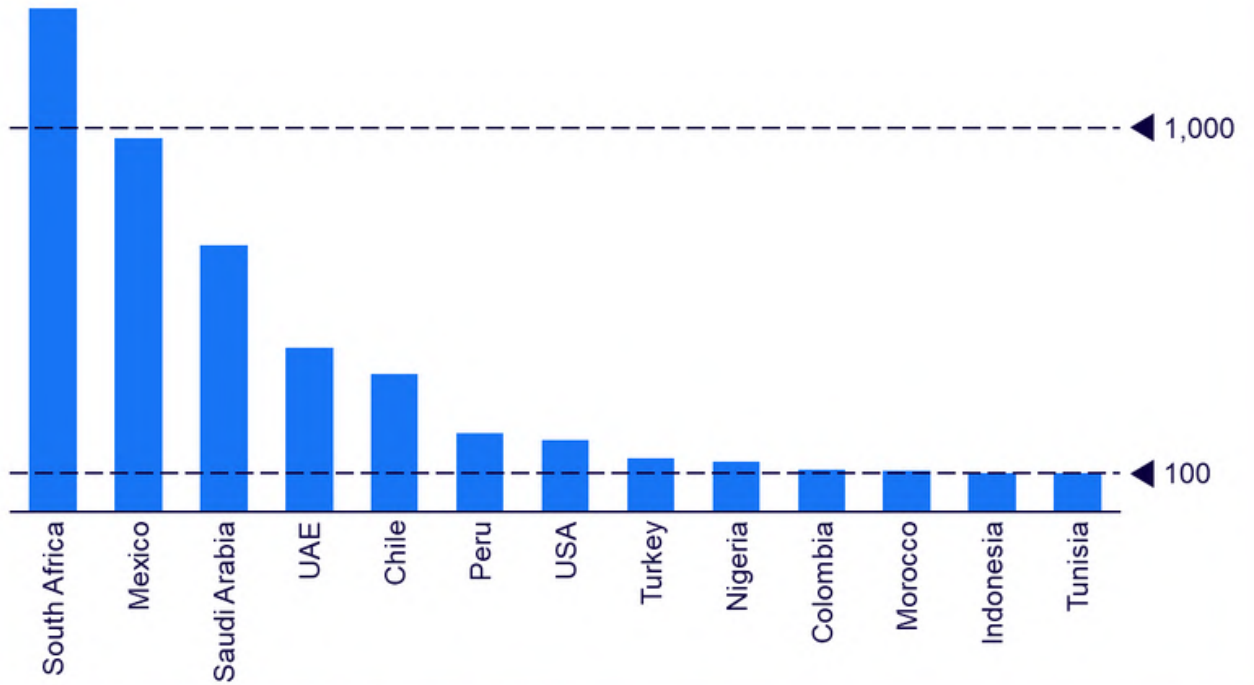


18 platforms had annual production of ~1 million units and above in 2022, accounting for ~35% of global production volume

Source: S&P Global Mobility, Arthur D. Little analysis

OEMs have started to leverage India's manufacturing capabilities to produce vehicles for emerging markets

Top destinations for Indian car exports
(USD Mn, FY2023)



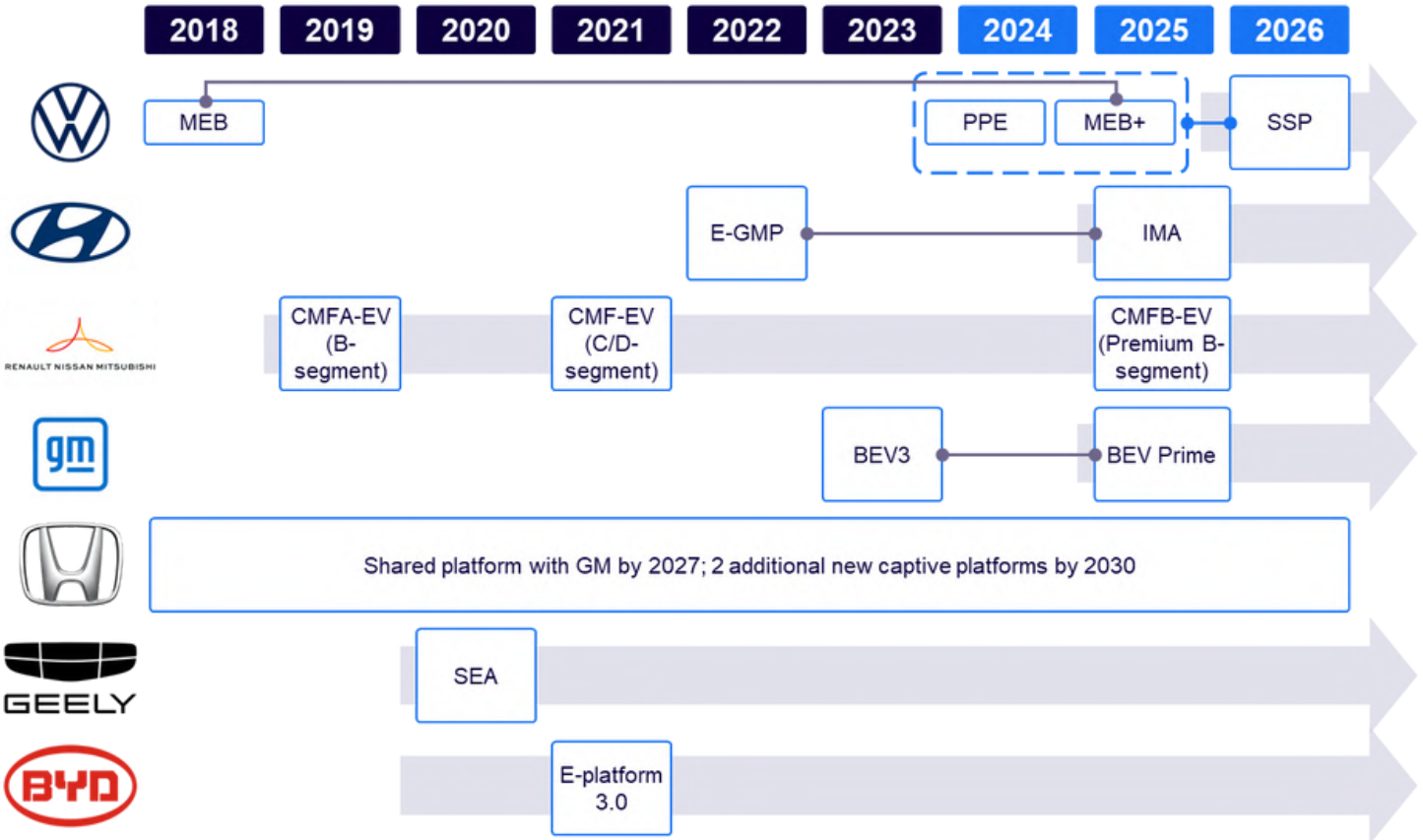
Top exporters

MARUTI SUZUKI
HYUNDAI
KIA
NISSAN
RENAULT
VW

Note: 1) – Global platforms are defined as platforms having more than 5,000 unit sales in at least 3 major regions globally. Country is counted as a manufacturing base for the platform if at least 25% of the platform production happens in the country
Source: S&P Global Mobility, Ministry of Commerce, Arthur D. Little analysis

EXAMPLE

Future platforms are going to be modular to achieve the benefit of scale and global reach;
This will present an opportunity for India to produce more vehicle platforms locally



Local Platforms

1. M&M will be leveraging VW's MEB platform in India
2. MSIL is jointly working with Toyota on a single PL40 platform

Global Platforms

1. Stellantis committed 20- 30Bn euro for global platform design
2. R-N-M creating 4 platforms with multiple body types: 30Bn euros planned investment
3. Geely making regional platform with 2-3Bn investment commitment

Source: Arthur D. Little analysis

EXAMPLE

A leading global OEM plans to move to Central Zone E/E Architecture from 2026, with its new generation Vehicle OS, across its entire portfolio

Platform Roadmap

	2012~	2020~		2026~(Plan)
Platform	Platform #1	Platform #2	Platform #3	Platform #4 (Platform 2+3)
Powertrain Type	ICE, HEV and PHEV	BEV	Premium BEV	All vehicle types
E/E Architecture	Traditional type with no Central Gateway (New MQB/w version is changed near to Domain Type)	**E³ 1.1** Planned to be Domain Type With one Central Gateway	**E³ 1.2** Planned to be Domain Type With one Central Gateway	**E³ 2.0** Planned to be Zone Type With one Central Computer※ and 2~4 Zone Controller
ECU Numbers	180	60	60	3~5 (Target)
Vehicle OS Version	No Vehicle OS	**OS 1.1** Divided in Domain	**OS 1.2** Divided in Domain	**OS 2.0** Vehicle OS across Domains
Main Vehicle Network Type	CAN	Ethernet, CAN (Multiple protocols)	Ethernet, CAN, CAN FD (Multiple protocols)	Ethernet, CAN, CAN FD, LIN (Multiple protocols)

Note: ※Will have one more central computer as a backup for L3~ Autonomous Driving car
Source: Secondary research, Arthur D. Little analysis

KEY IMPERATIVES

A

Go international with new platforms specially BEV platforms

- Invest upfront in E/E architectures and unified software
- Develop a global platform strategy, with a focus on modular architecture, 400 -1220 V, Motor topologies, body types, etc.
- Share platforms and contract manufacture vehicles for emerging start-ups and brands
- Secure partnerships on critical resources - Cell manufacturing resources, semi conductors, etc.
- Choose innovative routes to market - D2C, Agency models, digitized sales

B

Produce more global platforms in India

- Strengthen supply chain capabilities
- Invest in automation and flexible manufacturing capabilities
- Offer more platform choices to domestic market
- Invest in more testing and validation capabilities locally

C

Enhance design capabilities in terms of functionality, safety & sustainability

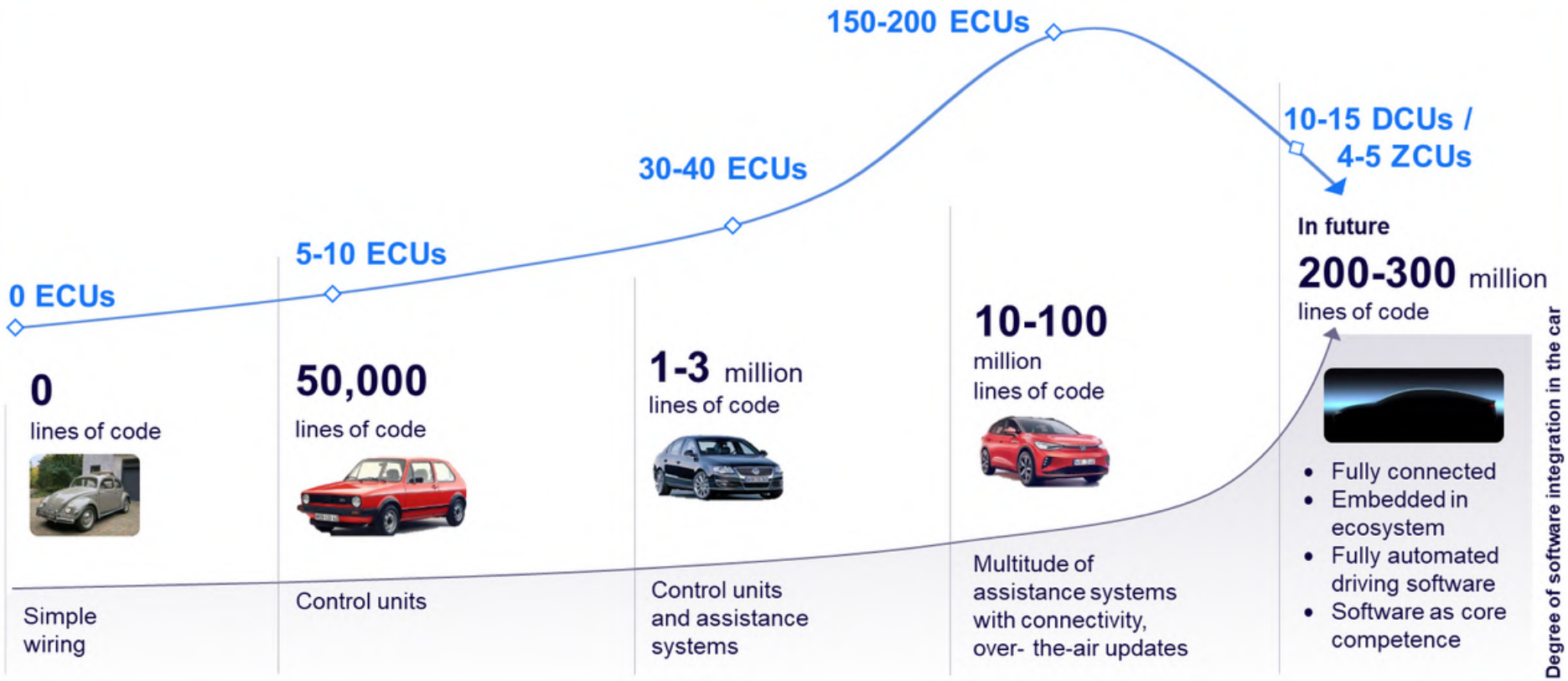
- Incubate design centers for excellence for HV architecture, automotive software, material innovation, SoC design, etc.
- Create clusters of tech innovation to support localization of supply chains in India for advanced technologies
- Collaborate and establish cross-sectoral partnerships on sustainable materials and circularity in India

02

Automotive software & ER&D powerhouse

Transform automotive software & ER&D capabilities
for the global markets

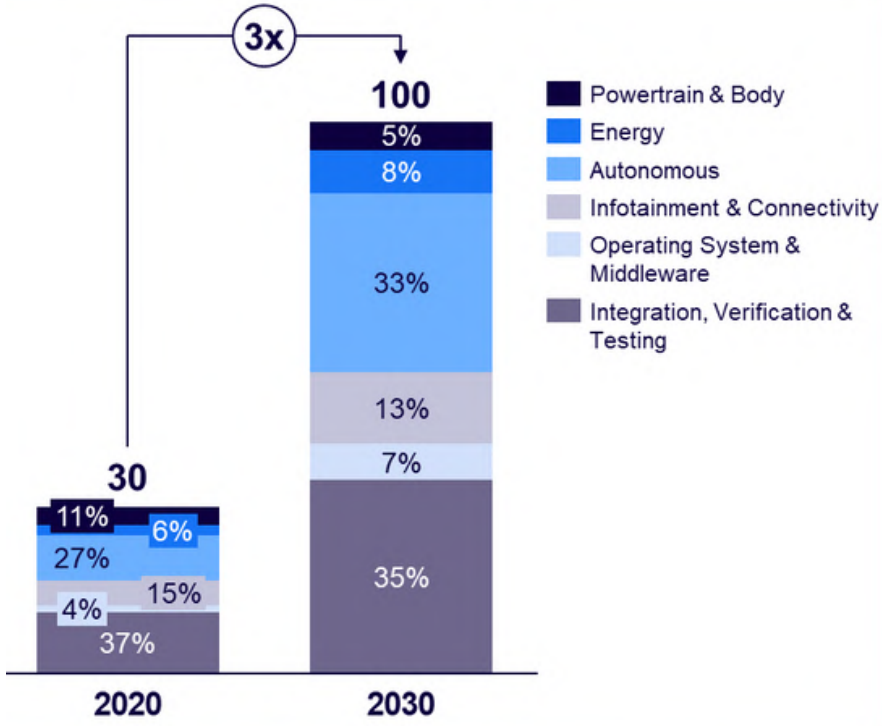
Transition from hardware first to software first vehicle will eventually evolve to neural networks and AI-based development



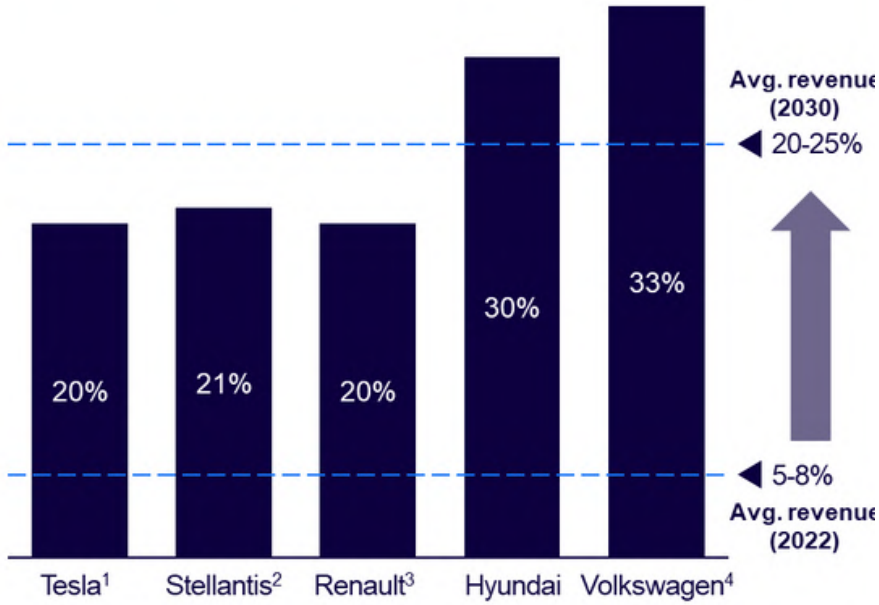
Source: Arthur D. Little analysis

Automotive software market will see a ~3x increase by 2030, creating an opportunity for Indian players to gain significant value

Global automotive software market
(2020, 2030; USD bn)



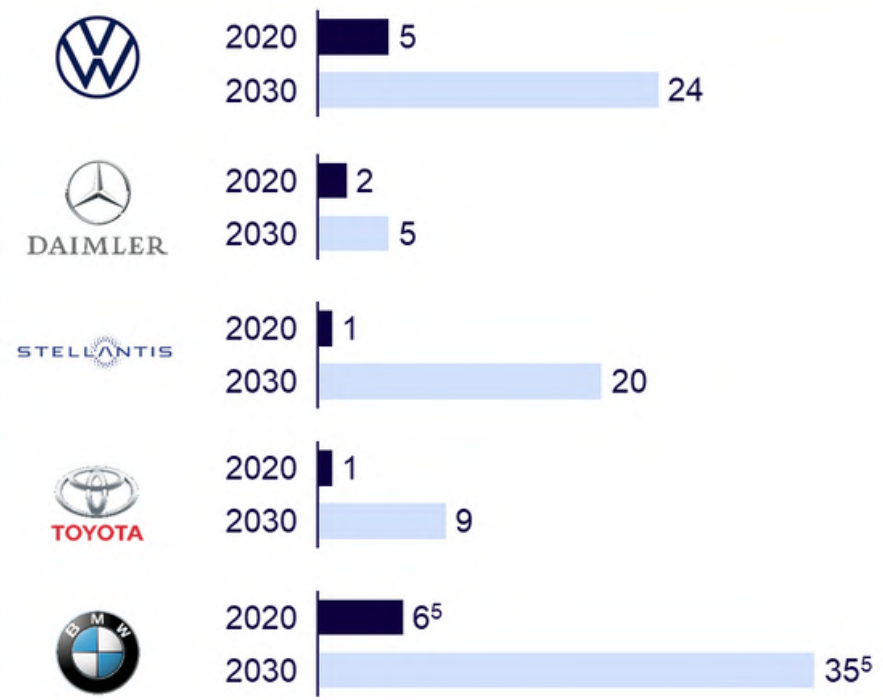
OEM announced objectives 2030
% of revenues from software related services



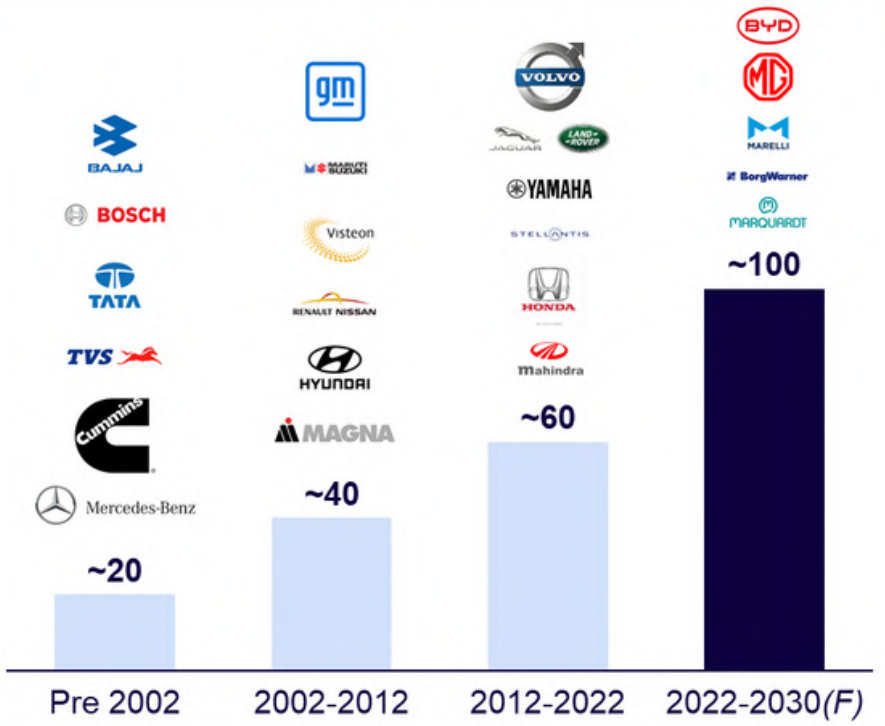
Notes: 1) Software as a service 2) Services include software-enabled product offerings and subscriptions 3) Services include data, mobility and energy-related services 4) Software-enabled sales expected to reach one-third on top of the expected BEV and ICE sales ADAS: Advanced Driver-Assistance Systems; E/E: Electrical/Electronic
Source: KBC Securities, IBM, Ericsson, Arthur D. Little analysis

Global OEMs are focusing on building software capabilities, and India has been one of the destinations of choice for building ER&D centers

Number of software engineers ('000)



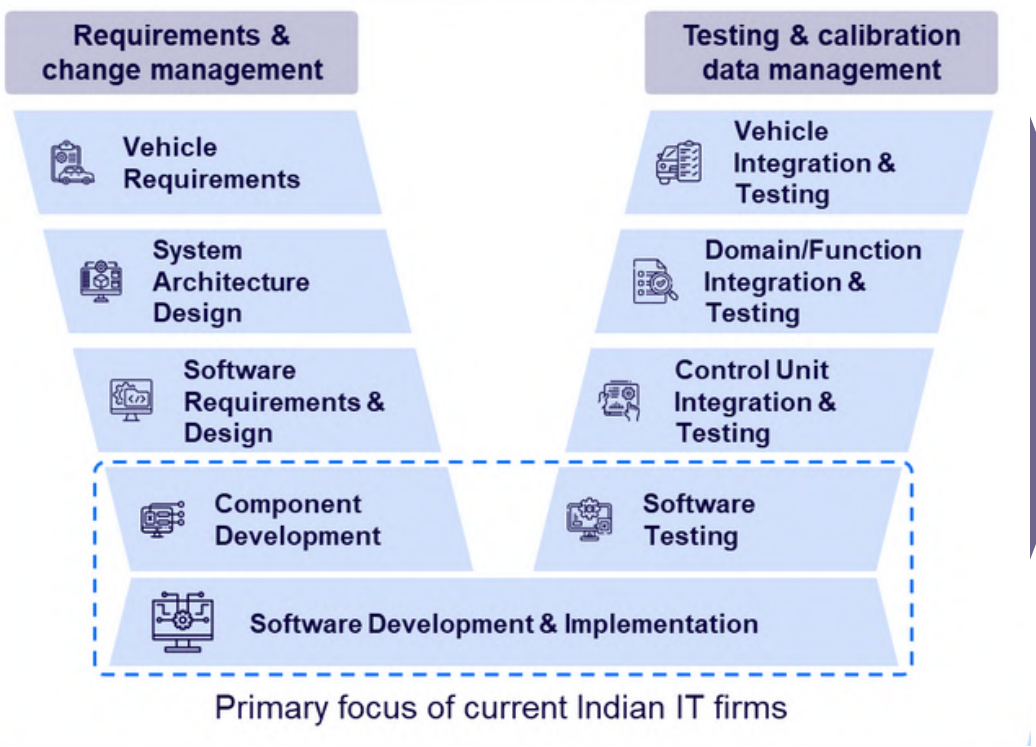
Number of automotive ER&D centers in India



Source: Companies' investor presentations, Ericsson, Arthur D. Little analysis

Era of software-defined vehicles is reshaping service requirements in automotive

Traditional software services



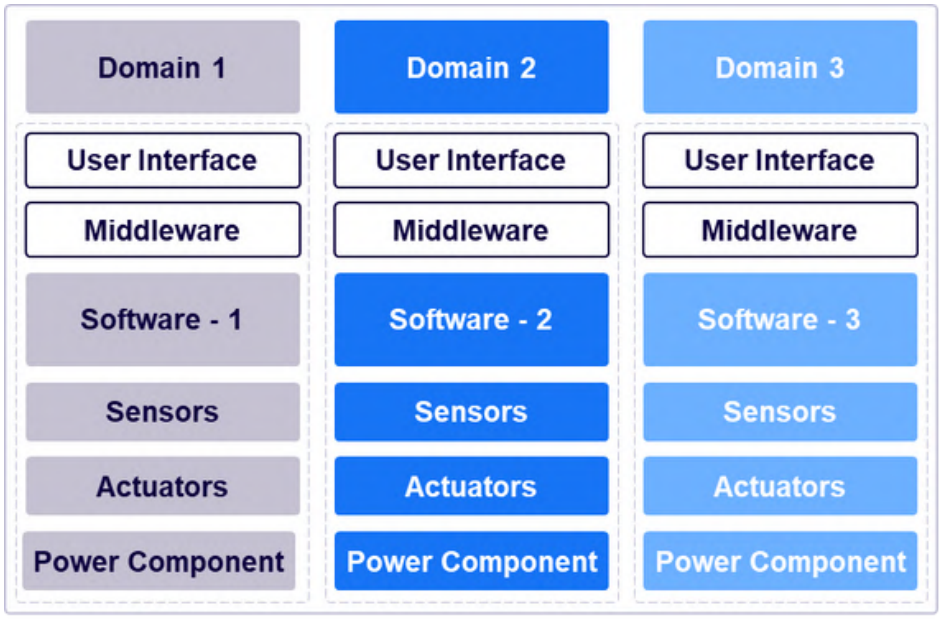
Emerging software services

- Over-the-Air updates
- Zonal architecture design
- AD/ADAS middleware development
- Car-2-X softwares
- Centralized software development
- Digital cockpit

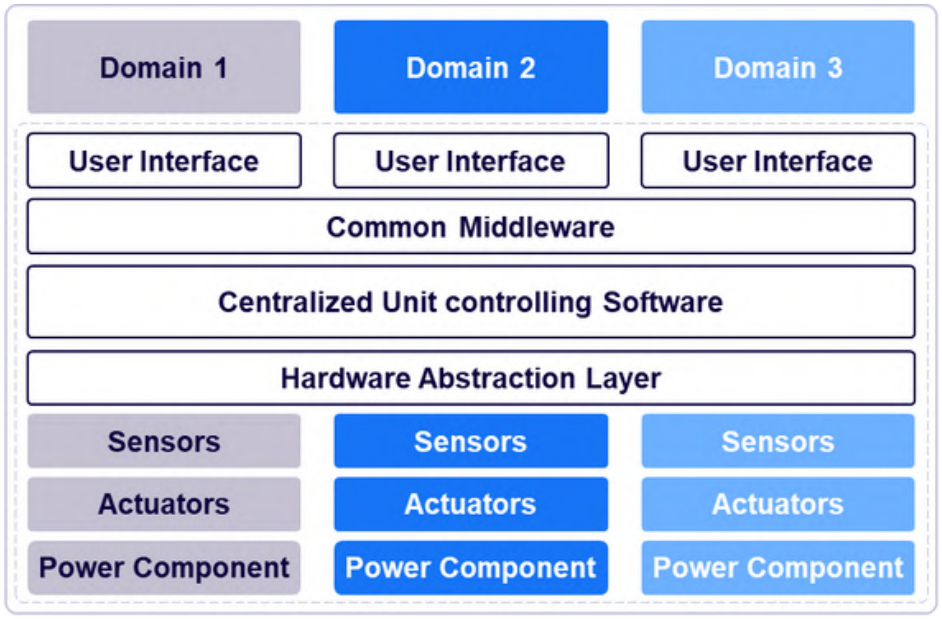
Source: Arthur D. Little analysis

Changes in vehicle E/E architecture will impact software capabilities and development cycles - Indian players will need to upgrade current capabilities to capture this opportunity

Traditional Embedded Software Stacks



Standardized Software Platform Approach



Increase in the adoption of **zonal and central E/E architecture** will impact **role of software** in all automotive vehicles

OEMs are shifting to developing **functional-oriented software** across brands and models to **improve development efficiency**

Horizontally **integrated abstraction layers** will ensure that high-level **software applications are made independent of the hardware**

Source: Arthur D. Little analysis

KEY IMPERATIVES

A

OEMs - Re-imagine R&D and Product Development organization

- Invest in Software talent and build capabilities on E/E design and Vehicle OS
- Focus on developing India specific use cases like ADAS and take it to emerging markets globally
- Fast-track design iterations, with the use of digital validations capabilities. E.g. NCAP crash test validations, etc.
- Re-imagine structure with new roles / new operating models for Engineering and new product development
- Invest software capabilities into agile and flexible production areas like modular production, AGVs, robotics, etc.

B

Automotive Software Companies: Move up the value chain of offerings

- Invest in vehicle engineering/ architecture design skills
- Collaborate early on with OEMs in vehicle architecture design
- Invest in improving productivity on development cycles to help OEMs launch platforms on time
- Aggressively innovate in areas of support integration of ECUs of cross-domain into zonal architecture

C

Support Ecosystem to innovate on offerings and cost-effective solutions

- Develop open APIs to support new application integration
- Develop solutions to improve compatibility with multiple vehicle OS and versions of AUTOSAR
- Develop cost-effective solutions to balance distributed and integrated architecture across platforms


> Part Selector
> Drivetrain
> Suspension
> Hydraulic System
v Batteries
Specifications:
> 48v System
> Regenerative Braking
START SIMULATION
AUTOMOTIVE DESIGN AND SIMULATIONS
Model 0.11010-G >Perspective View > Part Selector
Electric powertrain
Base Principle
Using electric motors in generator mode allows to use braking energy which usually disappears as heat, to charge battery which contributes up to 25% of total range.
One pedal Driving
One pedal driving is a way of driving when a driver uses only on pedal for acceleration and breaking. It works by switching electric motors in generator mode when accelerator pedal is not pressed.
Friction Brakes
Conventional friction brakes still are very important part of driving expirience as they needed for quick deceleration and in emergency situations
Regenrative Braking
rag Index 0.26
Range
Using Regerative Braking
Without Regerative Braking
395km
290km
CO2 Output
Efficiency Graph
Drag Index
Speed
TESTING
ENVIRONMENT
Presure Monitorng
START
PRINT
DIFF INDEX 1
DIFF INDEX 2
DIFF INDEX 3
Total Value:

03

New epicenter for technology, innovation & partnerships

Create pathways for disruptive growth by embracing startups/partnerships

Growing investments in new technologies across E/E architectures, connected and sustainability – USD 420-500 bn invested in 2022

E&E Architectures & Advanced Sensors

- VCUS/MCUs
- BMS
- ADAS L1-L2
- Generative AI
- ADAS L2-3
- Smart sensors
- High-speed processors
- Smart surfaces
- Zonal++ architecture
- Semiconductor 15nm & lower
- ADAS L4-5
- Quantum computing

Connected Technology

- Telematics
- Connected infotainment
- Cyber security
- Digital Twins
- Industry 4.0
- OTA updates
- Antennae advancements
- Co-bots in factories
- Edge computing
- V2G
- Additive manufacturing
- Robots/factory automation

Green Technology

- Fuel efficiency/Flex fuels
- Motor tech/topologies
- Battery chemistry
- Charging/swapping infra
- Magnet-less motors
- Advanced battery chemistries
- New lightweight materials
- Green Al/Steel
- H2-ICE
- Fuel cells
- Carbon fiber
- Giga press/cast
- Battery recycling

Emerging Technology: US$120-150Bn

- 50% R&D spent on **software development**
- 30% R&D spent on **EV development**

M&A: US$100-160Bn

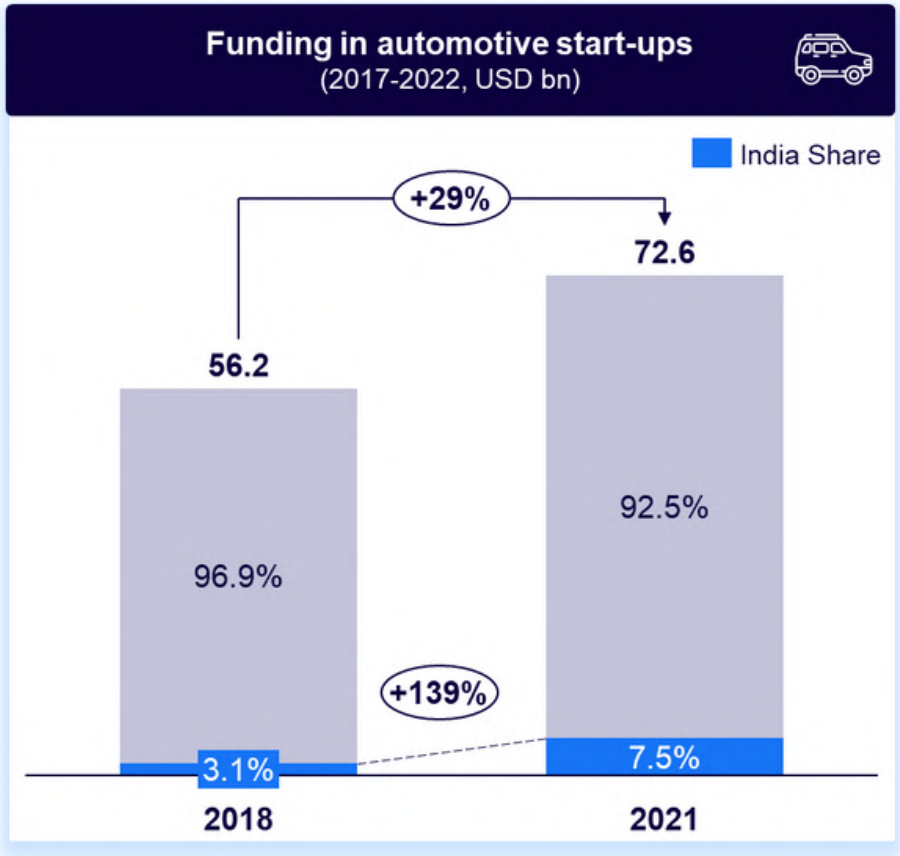
- 50% spent on **deep tech (AI, ML, etc.)**
- 35% spent on Start-ups for **EV related tech**

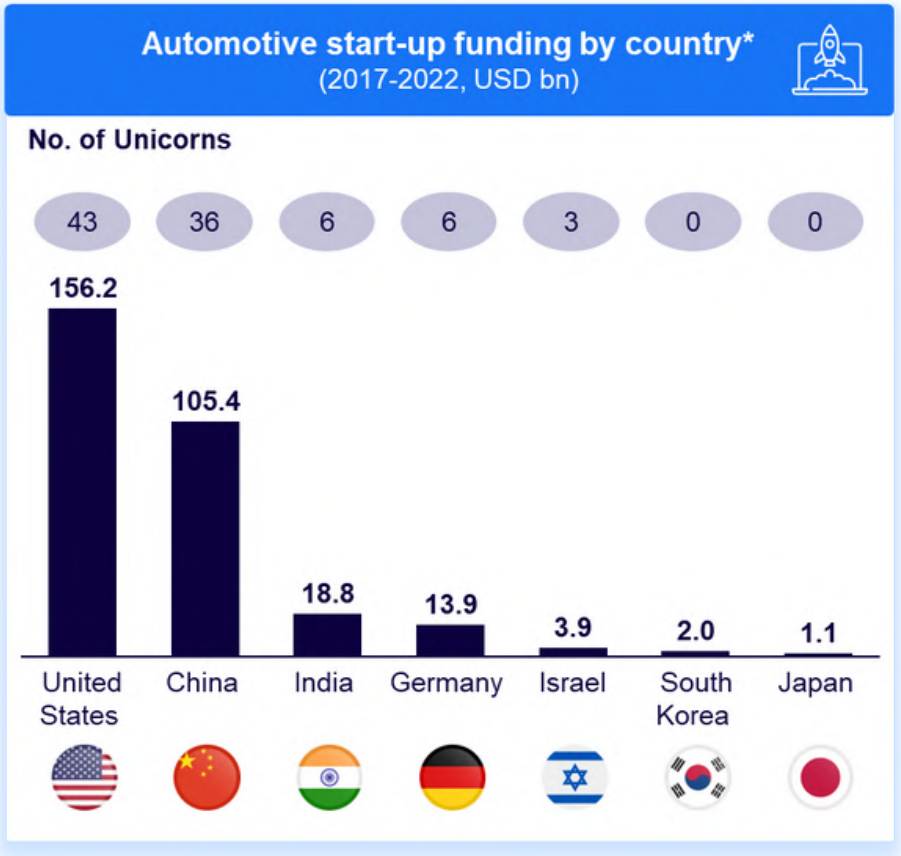
New Projects: US$200-250Bn

- 35% in **GCC development** globally

Source: Arthur D. Little analysis

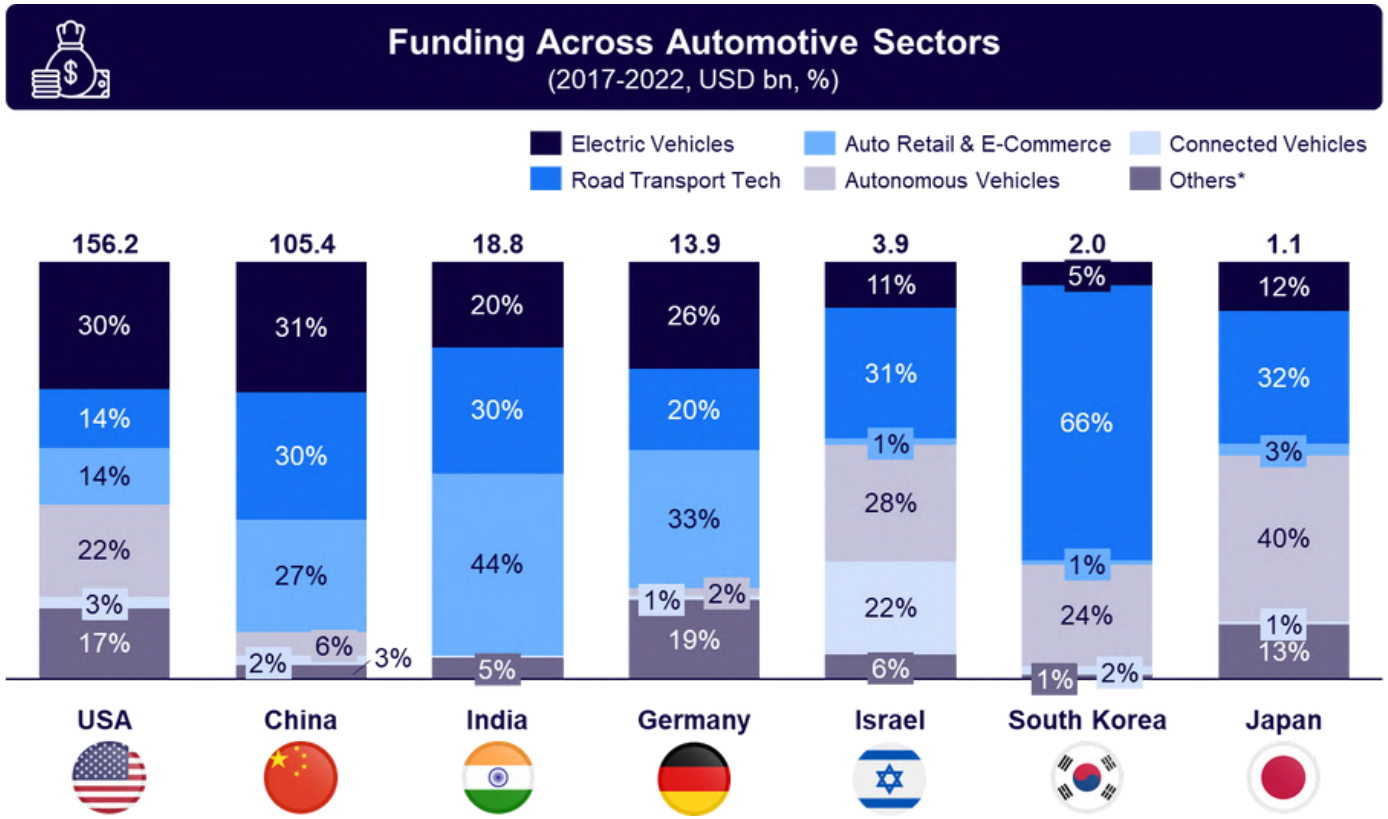
Indian automotive start-ups attracting a larger share of overall funding in the sector globally, however, USA and China-based start-ups still dominate





Note: * Funding amount excludes investment in Auto Brands & Auto Components
Source: Tracxn, Arthur D. Little analysis

USA and China lead the investments in emerging automotive sectors while ~50% of funding in India is for auto retail, e-commerce, fintech and other IT solutions



Indian start-ups need to focus on emerging trends such as ADAS/Autonomous solutions, connected vehicles, core EV engineering, which would capture high share of total value in future

Note: * Funding amount excludes investment in Auto Brands & Auto Components
Source: Tracxn, Arthur D. Little analysis

KEY IMPERATIVES

A

OEMs - Embrace open innovation

- Focus on Objective-driven tech scouting and not Opportunity-led
- Invest in technology absorption ahead of market
- Develop technology roadmap to ensure timely presence across multiple evolving technologies
- Invest in securing partnerships to have global competitive advantage

B

Start-ups – Operate with global first mindset – Set a bold vision

- Focus on solving scale up challenges ahead of the market
- Have disruptive mindset to address challenges of the market
- Invest in talent on AI/ML, Cybersecurity, systems engineering capabilities
- Become a serial entrepreneur

C

Ecosystem – Create conducive environment for start-ups

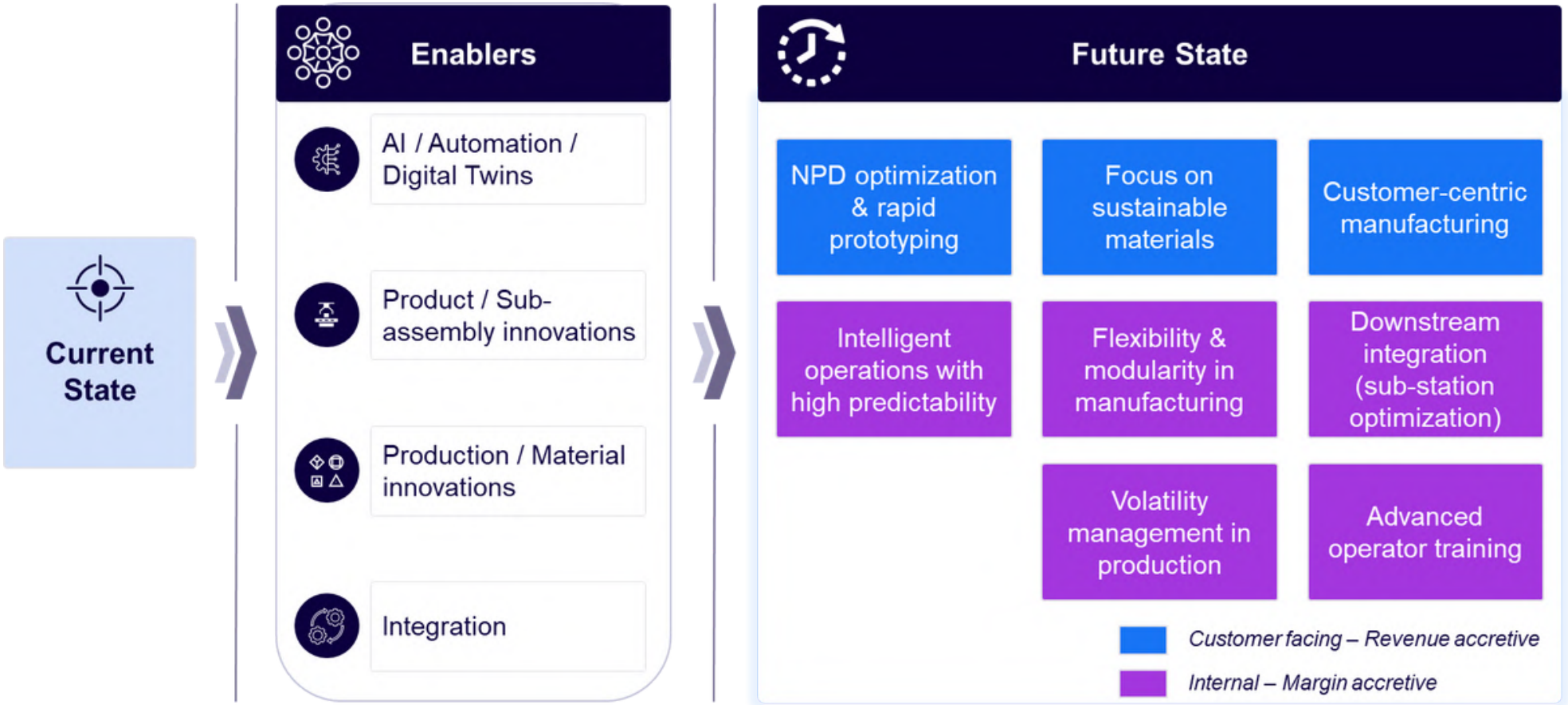
- Integrate business and start ups/ tech holders in academia vis TTOs
- Reorient and reskill organizations to embrace start-ups and new technologies
- Invest in setting up more testing and validation facilities
- Support start ups with global access of markets and talent

04

Operations excellence at scale

Bridge operational efficiencies at globally competitive scale

Manufacturing increasingly requires a strong balancing of customer-facing value propositions with internal efficiencies



Source: Tracxn, Arthur D. Little analysis

EXAMPLE

OEMs are taking advantage of innovative digital technologies to increase productivity and reduce costs across the value chain

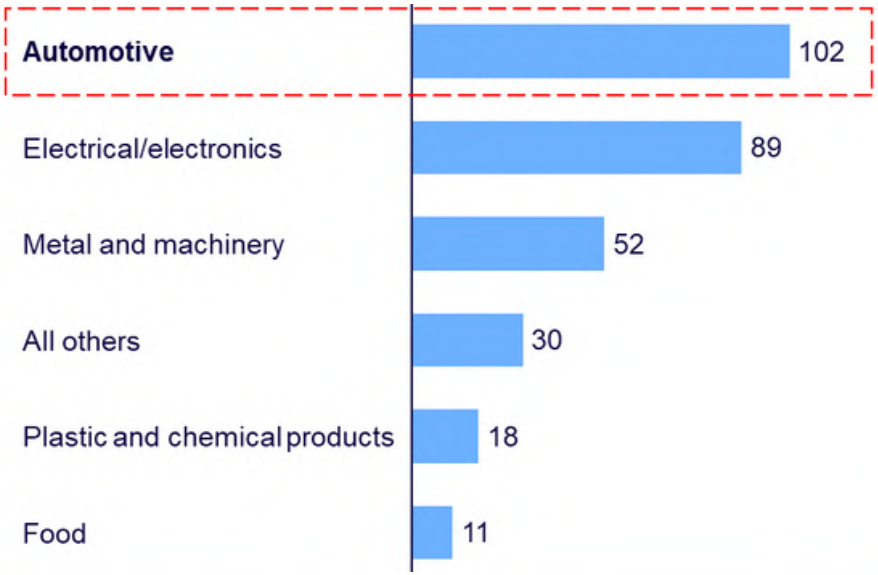
	Ford	Daimler	BMW	Volkswagen
Technologies Used	• Digital Twins • Blockchain • Artificial Intelligence & Machine Learning • Big Data Analytics • Cloud Computing	• Automated Guided Vehicles (AGVs) • Industrial Robotics • Advanced Materials • Digital Twins • Industrial Cybersecurity	• Blockchain • Artificial Intelligence & Machine Learning • Digital Thread • Additive Manufacturing • Augmented Reality	• Machine Vision • Hyper Automation • Cloud Computing • AR/VR in Manufacturing • Artificial Intelligence & Generative Design
Examples	**Ford uses digital twins to simulate and optimize the aerodynamics of their vehicles, reducing wind tunnel testing time and costs**	**Daimler reduced waiting time for parts by 22% and transportation time by 50% using AGVs in parts-to-line operations**	**BMW has partnered with VeChain to use blockchain for tracking and verifying the authenticity of auto parts in its supply chain**	**Volkswagen has integrated hyper automation into its quality control processes, using AI and machine vision to inspect vehicles & raise flags for defects**
Tesla leading industry in automation	**1,000+ robots** per Gigafactory	**Over 80%** vertically integrated supply chain	**90% automation** in production line using advanced robots	Elimination of **1,600 welds** & **30% size reduction** in body shop

Source: Tracxn, Arthur D. Little analysis

While the automotive sector ranks high for the use of industrial robots, India is currently far behind developed countries in terms of automation

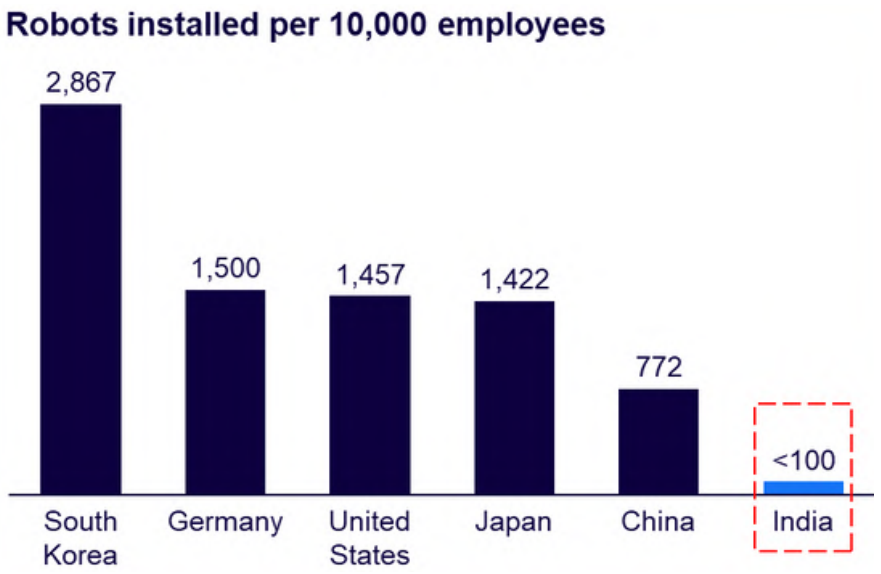
Installations of industrial robots by industry

('000 units, 2021)



Robot density in the automotive industry

(2021)



Relatively low cost of manual labor in India currently limits the large-scale adoption of industrial robots in the automotive sector

Source: International Federation of Robotics, World Robotics 2022, Arthur D. Little analysis

KEY IMPERATIVES

A

Technology driven operations excellence

- Deploy digital manufacturing and Industry 4.0 use cases, e.g., digital twins, AGVs
- Invest in capabilities to digitize supply chain and business processes
- Invest in process automation and robotics
- Reskill organization for upgraded capabilities

B

Scale up with global mindset

- Aim to become first source for global OEMs and IPOs for high value component categories
- Invest in building scale to support global OEM requirements
- Partner with technology players to building high quality and productivity standards
- Invest in enhancing R&D Capabilities and build roadmap for products as per global requirements

05

Leapfrog to sustainable materials & circular economy

Invest in circularity agenda & leverage India-centric advantages to sustainability

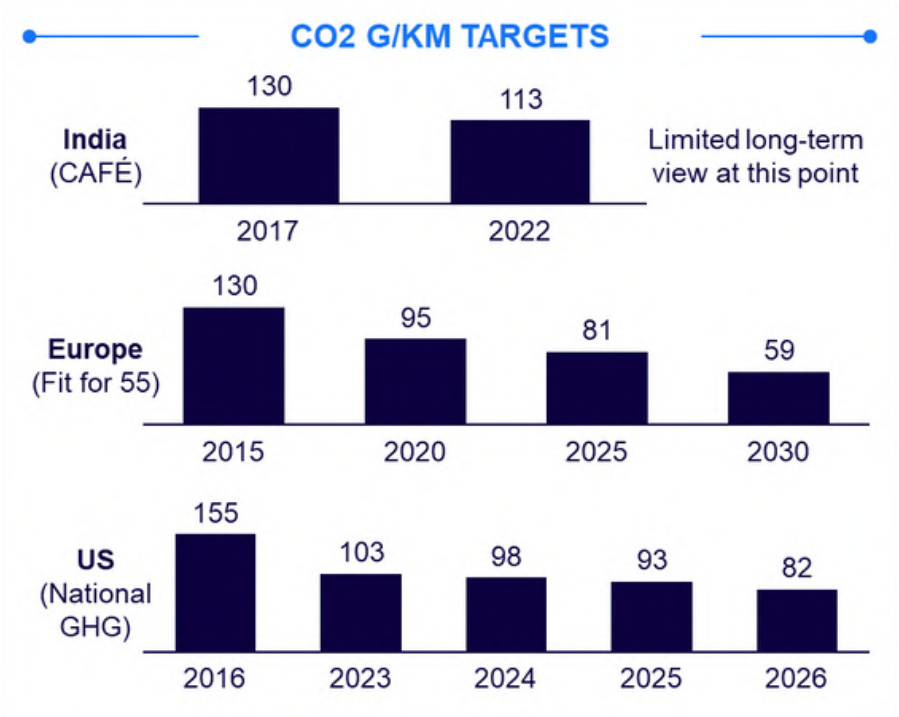
India's growing economy needs to significantly invest in climate change mitigation measures to ensure sustainable growth and to reach net-zero by 2070

CHALLENGES	SELECT MEASURES TAKEN
Third largest GHG emitter with emissions rising twice as fast as global average	**COP26 commitment:** • Cut carbon emission by 1 billion tonnes • Reduce the **carbon intensity by less than 45%** • **Net-zero carbon emissions by 2070**
Automotive industry ranks as the third-largest emitter of CO_2	• National / State level EV policies, CAFÉ norms, emission and circularity norms • BS VII norms likely to be in line with Euro 7
Lack of awareness and initiatives in environmental sustainability	• ESG disclosures under mandatory BRSR • Likely to be extended soon to more companies
Lack of sophisticated and formal end-of-life recycling system	• Scrappage policy implementation • GoI may mandate use of recycled materials in auto manufacturing by 2026-27

Source: Arthur D. Little analysis

Indian emission norms are following global standards and are likely to intensify towards global convergence on sustainability such as BS norms

European and US CO_2 targets are at 95-102 gm/km, ahead of CAFÉ II requirements of 113 gm/km



In the existing Indian norms, OEMs are likely to face penalties...

"Indian OEMs are likely to pay fines between INR 3,600-5,800 Cr in 2023, for exceeding the target emissions" –Economic times

...and further strengthening of norms, especially on revisions in current super credit structure (credits / BEV sold)...

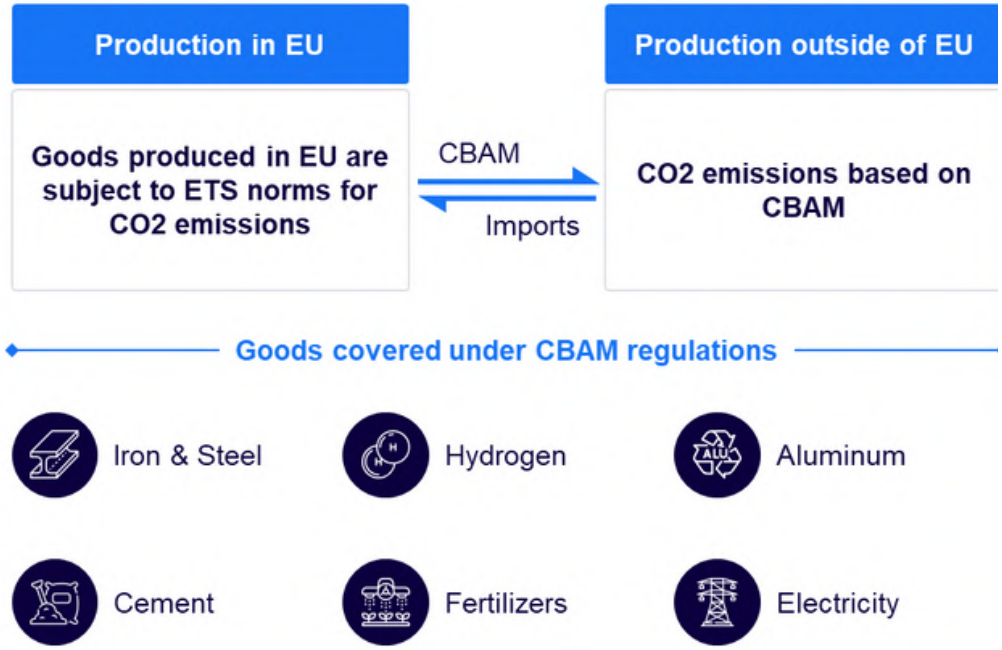
EU	China	US
Moved from 2 in 2020 to 0 credits in 2023	Moved from 5 in 2012 to 0 credits in 2025	Moved from 2 in 2017 to 0 credits in 2022

...will require re-thinking for new application of advance materials for traditional ICE & EV models

Source: Arthur D. Little analysis

In Europe, effective Oct 2023, CBAM[1] has been introduced under the "Fit for 55" regulation – which may impact Indian suppliers with exposure to Europe

CABM aims at bringing parity between imports and domestic goods based on carbon price adjustment and transparency of the supply chain



Impact on suppliers having significant business exposure to EU

1) Carbon Border Adjustment Mechanism
Source: Arthur D. Little analysis

EXAMPLE

Most of the global OEMs have committed for carbon neutrality between 2035-2050; multiple initiatives have been already taken towards this journey

Commitments from OEMs

- Carbon neutrality in global operations by 2040
- Joined the First Movers Coalition to utilize responsibly sourced materials in vehicles
- Invested in sourcing of Green Steel

- Carbon neutrality at all plants by 2035
- Eliminate CO_2 emissions from our value chain by 2050
- Established research center for sustainable materials

- Make manufacturing climate neutral by 2035
- Cut annual CO_2 emissions by 2.5M tons through circular materials
- To sell only all electric vehicles by 2030

- Committed to be carbon neutral by 2050
- Eliminating single use plastics from its operations by 2030
- Exploring circularity of raw materials with suppliers

- Commitment to net-zero facilities by 2045
- Completed a closed-loop plastic recycling pilot by producing new plastic parts from waste

- Aims to be carbon neutral by 2050
- Invest $14 bn in decarbonization projects across the supply chain by 2025
- Increasing use of composite components in their vehicles

- Commitment to reach net zero emissions by 2038 & reduce BEV parts' carbon footprint by 40% by 2030
- Aims at 100% fully-electric offerings in Europe by 2030

- Committed to be carbon neutral by 2040
- Focus on water-positive facility with 100% renewable energy

Source: Arthur D. Little analysis

Complying with new regulations requires automotive firms to actively circularize their supply chain with 4Rs – presenting new opportunities in the automotive value chain

Reduce
- OEMs to focus on vehicle lightweighting technologies
- Develop sustainable designs that utilise less resources
- Improve energy efficiency in vehicle and parts manufacturing processes

Reuse
- Design components suitable for easy replacement
- Promote remanufacturing of automotive parts

Recycle
- Establish closed-loop manufacturing process to recycle and reuse production waste
- Focus on battery and electronics end-of-life management

Recover
- Invest in resource recovery facilities
- Partner with recycling and recovery companies

- Improved resource efficiency
- Lowered production costs
- Reduced environmental impact
- Enhanced company reputation
- Alignment with upcoming regulations

Source: Arthur D. Little analysis

KEY IMPERATIVES

A

Focus on lightweight and alternative sustainable materials

- Develop light weighting targets aggressively based on CAFÉ norms
- Focus on using alternative sustainable materials like rice husk, FRP, Vegan materials, etc.
- Focus on ESG reporting and ESG compliances across tiers of suppliers
- Vision for carbon neutrality

B

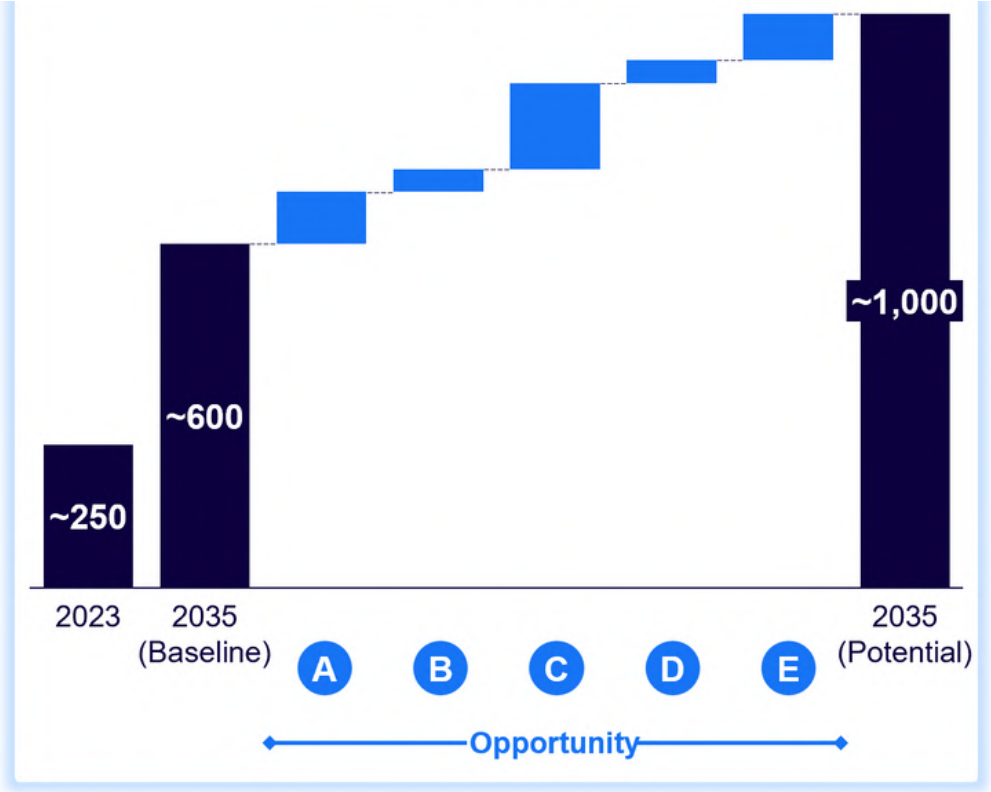
Invest in innovation & technologies for responsible sourcing

- Set up advance research on commercializing alternate sustainable materials
- Invest in securing green materials like green aluminum and green steel, etc.
- Establish ESG targets and visibility on supply chain for responsible sourcing
- Invest in new technologies like blockchain to monitor and establish responsible sourcing

UNLOCKING THE GROWTH POTENTIAL FOR INDIA'S AUTOMOTIVE INDUSTRY

ADL's 5 pillars working in cohesion can unlock the growth potential for India's automotive industry, leading it to nearly USD 1 trillion by 2035 (~4x growth)

Opportunity for automotive industry
(USD billion)



Potential value addition by 2035 from ADL's five pillars

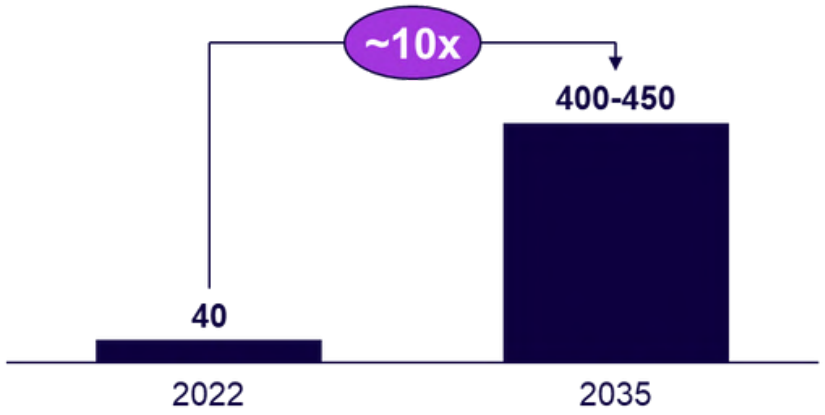
- Development and manufacturing of **global platforms** locally to achieve benefit of scale and capture larger market share — A
- Building **automotive software solutions and ER&D capabilities** to power the new age software-defined vehicles of the world — B
- Building **leadership in technology and innovation** by promoting start up ecosystems, partnerships and attracting investment capital — C
- Deploying advanced manufacturing techniques and productivity to ensure **operational excellence** — D
- Capturing opportunities arising from ongoing global shift towards **sustainability and circular economy** — E

Note: The proposed ADL's values also include additional value pools generated via EV charging infrastructure, recycling industry etc.
Source: Arthur D. Little analysis

With industry stakeholders working together, India's automotive exports can potentially grow seven-fold while employment in the industry can quadruple by 2035

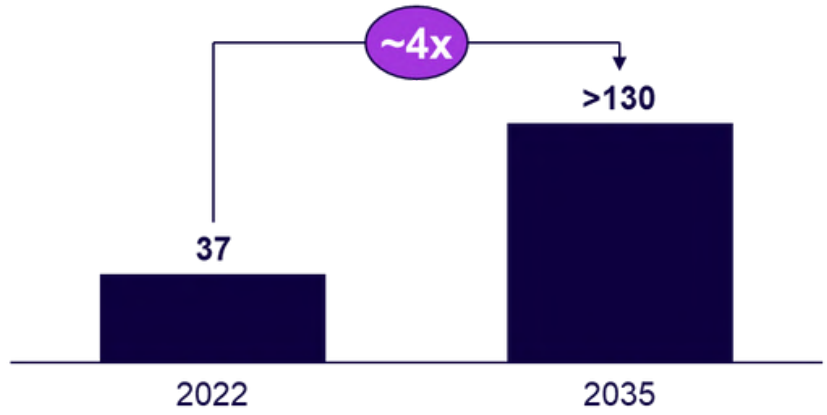
Automotive industry's contribution to India's GDP 7.3% (2023) ⟶ 10-12% (2035)

India's automotive export potential
(USD Bn)



Share of exports in the total automotive industry has the potential to increase from **~18% in 2023 to ~40% in 2035**

India's automotive sector employment
(mn #)



The automotive industry has the potential to **add ~100 million new jobs** by 2035

Source: Arthur D. Little analysis

CONCLUSION

ROADMAP TO GLOBAL AUTOMOTIVE HUB

Strengthening the 5 pillars will lay the foundation for India to become a global automotive hub

ADL PILLARS	KEY IMPERATIVES
Destination for global platforms	• Go international with new platforms specially BEV platforms with focus on modular architecture platforms • Enhance platform design capabilities that comply with global functionality, safety, sustainability & emission norms • Produce more global platforms in India by investing in & strengthening local supply chain capabilities
Automotive software & ER&D powerhouse	• Invest in software engineering and R&D to maintain India's position as a software hub of the world • Upgrade capabilities to develop solutions for emerging trends such as zonal E/E architecture, digital cockpit, ADAS etc. • Support software ecosystem and focus on developing cost-effective software solutions with global applicability
New epicenter for technology, innovation & partnerships	• Embrace open innovation and invest in partnerships with start-ups, while also building organizational agility & adaptability • Operate with a global first mindset & focus on solving challenges in engineering & deep tech areas within the value chain • Invest in talent development for crucial areas such AI, ML, cybersecurity, system engineering capabilities, etc.
Operations excellence at scale	• Invest in advanced manufacturing technologies such as digital twins, robotics etc. at scale to increase productivity • Invest in education and training programs to develop a pool of skilled technicians • Leverage latest technologies to produce at scale at global quality standards to become an attractive sourcing destination
Leapfrog to sustainable materials & circular economy	• Invest in de-carbonizing operations and supply chains to meet varying ESG and regulations set by different countries • Develop production capabilities for sustainable & lightweight materials such as green steel etc. to serve global markets • Embrace circularity to ensure long term value creation and sustainable growth of the whole industry

Source: Arthur D. Little analysis

Arthur D. Little has been at the forefront of innovation since 1886. We are an acknowledged thought leader in linking strategy, innovation, and transformation in technology-intensive and converging industries. We navigate our clients through changing business ecosystems to uncover new growth opportunities. We enable our clients to build innovation capabilities and transform their organizations.

Our consultants have strong practical industry experience combined with excellent knowledge of key trends and dynamics. ADL is present in the most important business centers around the world. We are proud to serve most of the Fortune 1000 companies, in addition to other leading firms and public sector organizations.

For further information,
please visit **www.adlittle.com** or **www.adl.com**.

ARTHUR D LITTLE

THE DIFFERENCE