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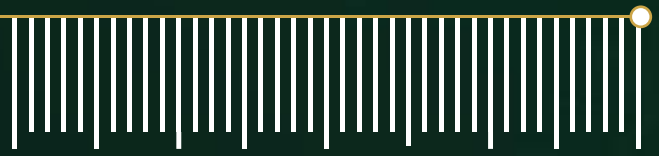
OCTOBER 2023

SEIZING THE ER&D ADVANTAGE

FRONTIERS FOR 2030



Global Landscape of Engineering Research & Development

BOSTON CONSULTING GROUP

Boston Consulting Group partners with leaders in business and society to tackle their most important challenges and capture their greatest opportunities. BCG was the pioneer in business strategy when it was founded in 1963. Today, we work closely with clients to embrace a transformational approach aimed at benefiting all stakeholders—empowering organizations to grow, build sustainable competitive advantage, and drive positive societal impact.

Our diverse, global teams bring deep industry and functional expertise and a range of perspectives that question the status quo and spark change. BCG delivers solutions through leading-edge management consulting, technology and design, and corporate and digital ventures. We work in a uniquely collaborative model across the firm and throughout all levels of the client organization, fuelled by the goal of helping our clients thrive and enabling them to make the world a better place.

nasscom

The National Association of Software and Services Companies (NASSCOM) is the premier trade body and chamber of commerce of the Tech industry in India and comprises over 3000-member companies. Our membership spans across the entire spectrum of the industry from startups to multinationals and from products to services, Global Capability Centres to Engineering firms. Guided by India's vision to become a leading digital economy globally, NASSCOM focuses on accelerating the pace of transformation of the industry to emerge as the preferred enablers for global digital transformation. Our strategic imperatives are to reskill and upskill India's IT workforce to ensure that talent is future-ready in terms of new-age skills, strengthen the innovation quotient across industry verticals, create new market opportunities - both international and domestic, drive policy advocacy to advance innovation and ease of doing business, and build the industry narrative with focus on Talent, Trust and Innovation. And, in everything we do, we will continue to champion the need for diversity and equal opportunity.

Foreword

DEBJANI GHOSH
PRESIDENT
NASSCOM

RAJIV GUPTA
MANAGING DIRECTOR
AND SENIOR PARTNER
BCG

When we first conceptualized the idea of this report, one question was top of mind: How will India's Business ER&D sourcing market share shape up in 2030? While India is currently doing well in this space, will it continue to grow? Or will a known (or yet unknown) competitor leapfrog India to become a preferred sourcing destination?

After weeks of industry discussions, a global survey spanning 280+ industry executives and endless late-night brainstorming sessions, we can sum up the answer in one statement: India's future looks bright. For 2 precise reasons – No other country can compete with the scale of India's Engineering talent, and the possibility to leverage existing relationships Indian firms have been able to put in place with work done in the past.

India is expected to increase share of Global ER&D sourcing market to 22% (2030) v/s 17% in 2023. There are several factors at play here, some in India's favor (e.g. – decline in working age populations across several developed countries) and others that will need attention of all stakeholders, like building a global branding story for Indian ER&D. Ultimately, the country that is able to collectively pivot their service offerings (For e.g. – upskill in Digital engineering, or acquire/develop niche skills in specialized areas like Electric Vehicles platform development) will be able to garner disproportionate share of future spends.

In this report, we address each factor at play, and chart out the road ahead for India, including future ER&D opportunities in specific sectors and geographies that Indian firms can target. We have also identified the specific skillsets that will be in demand from each sector.

There were some great learnings on the road to writing this report, and we hope you enjoy the ride reading this report as much as we did!

EXECUTIVE SUMMARY (I/II)

1. OVERALL ER&D INTENSITY IS INCREASING ACROSS SECTORS; WE EXPECT TO SEE A SUSTAINED UPTICK LEADING TO ER&D SPEND OF $3T BY 2030 (CURRENTLY ~$1.8T)
   - Resurgence of AI, digital imperative across sectors will drive industry at ~9% CAGR in ER&D spend till 2027
   - Beyond 2027, growth is expected to accelerate marginally (~10% CAGR), driven by increasing digital spend and sophistication of digital needs (AI@scale, 6G rollout, etc.)
   - As digital engineering drives the accelerated spend, few sectors will see a disproportionate rise in share of digital engineering spend – Automotive, Industrials, Energy, Utilities and Oil & Gas

2. WHILE TRADITIONAL SECTORS (AUTOMOTIVE, SOFTWARE AND HEALTHCARE) WILL DRIVE 50% OF ER&D SPEND, HIGH-GROWTH SECTORS LIKE TELECOM, SEMICONDUCTORS AND INDUSTRIALS WILL BE IMPORTANT FOCUS AREAS
   - Traditional sectors will spend on fresh sector-specific themes (EVs, telemedicine etc.) to drive $1.5T of ER&D spend
   - New high-growth sectors like telecom (11% CAGR), Semiconductors (10% CAGR) and Industrials (9% CAGR) will mandate a relook at India's strategic areas of focus, reassess talent needs and refresh policies & regulations landscape

3. US IS THE LARGEST ER&D SPENDER ($550B+), BUT SIX NEW MARKETS ACROSS EU & APAC HAVE EMERGED
   - In EU, Germany, UK, France and Nordics spend $250B+, while Japan and S.Korea spend ~$275B on ER&D
   - But ESPs and GCCs haven't enjoyed same level of success in these markets, as they have in the US

EXECUTIVE SUMMARY (II/II)

4. A LARGE SHARE OF ER&D WILL BE HQ-LED BUT NEARLY 25% ER&D SPEND IS EXPECTED TO BE SOURCED (VIA GCCS OR ESPS) LEADING TO SHARP RISE IN THE ER&D SOURCING MARKET FROM ~$280B TO ~$775B IN 2030
   - Emerging from the aftermath of the pandemic and war, as companies focus on resilience and agility, ER&D sourcing outside of HQ locations will gain momentum
   - Cost dynamics and access to new-age, digital-ready talent will continue to drive sourcing decisions

5. THOUGH INDIA DOES FACE COMPETITION FROM OTHER COUNTRIES, IT WILL CONTINUE TO REMAIN A KEY SOURCING DESTINATION AS THESE COUNTRIES WILL NOT BE ABLE TO SERVICE ALL THE DEMAND
   - Vietnam is well positioned to capture share in large, traditional sectors (Software, Automotive) while other locations like Thailand (Automotive, Energy & Utilities, Oil & Gas), Bulgaria (Industrials), Turkey (Consumer electronics) and Philippines will compete in targeted sectors
   - Nearshore ER&D centers have gained prominence, with locations like Poland, Mexico and Malaysia being some of the preferred locations

6. TO REMAIN COMPETITIVE, INDIA MUST FOCUS ON THREE KEY IMPERATIVES - GREATER POLICY SUPPORT AND INFRASTRUCTURE IMPROVEMENT, BRANDING & PROMOTION AND SKILL DEVELOPMENT
   - Incentivizing sectoral leaders to shift larger share of design and R&D work to India (e.g. Design linked incentives) and infrastructure support to setup digital engineering innovation hubs and ER&D industry labs
   - Organizing ER&D capability roadshows, digital expo and participating in marquee sectoral events (MWC, CES) to promote India as a competitive destination
   - Inculcate ER&D related skills in colleges through curated curriculum and incorporate industry inputs into national R&D initiatives (like National Research Foundation)

Glossary of key terminology

Terminology	Definition
ER&D Intensity	Percentage of company's revenue spent on ER&D
Business ER&D Spend	Absolute $ spend on ER&D activities of the company; ER&D Intensity X Revenue of the Company. This excludes Govt. R&D spends
ER&D Sourcing	Business ER&D spend through GCCs and ESPs
Sourcing %	Share of ER&D Sourcing as part of Business ER&D Spend
GCC	Global Capability Centres
ESP	Engineering Service Provider companies
Digital Engineering	Refers to work involved in building smart, connected, and intelligent products by using digital technology as the backbone (Software, Data & analytics and Embedded systems)
% Digital Engineering	Spend on digital engineering as a % of Business ER&D spend
Aerospace & Defence	Includes Aerospace & Defence R&D, Aerospace and Defence Maintenance and Services (MRO), Aero Transportation systems, Aircraft systems, Passenger and Cargo Aircraft and Airplanes, Components & equipment, Rockets and subsystems, Space structure and components, Comms. Satellite
Automotive	Includes Automobile manufacturers, auto components, and auto ancillary industries
Consumer Electronics	Includes Consumer electronics, Technology, Hardware, Storage and Peripherals, Household appliances
Energy, Utilities and Oil & Gas	Includes Integrated O&G, O&G refining and marketing, O&G exploration and production, O&G storage and transport, O&G drilling, Electric utilities, Gas utilities, Power producers and traders, Renewable Electricity
Healthcare & Medical Devices	Includes Pharmaceuticals, Biotechnology, Healthcare Technology, Medical devices; excludes Payers & Providers, Healthcare supplies & services
Industrials including Construction	Includes Construction and Engineering, Construction Machinery and Heavy Transportation Equipment, Industrial Machinery and Supplies and Components; excludes on-highway
Semiconductors	Includes Semiconductor, Semiconductor design and manufacturers
Software	Includes Software and System Software and excludes e-commerce
Telecommunication	Includes Integrated Telecommunication Services, Wireless Telecommunication Services, Communications Equipment, Alternative Carriers, Networking equipment

Note: 1. All market sizes in US$ 2. Years indicate CY unless specified otherwise

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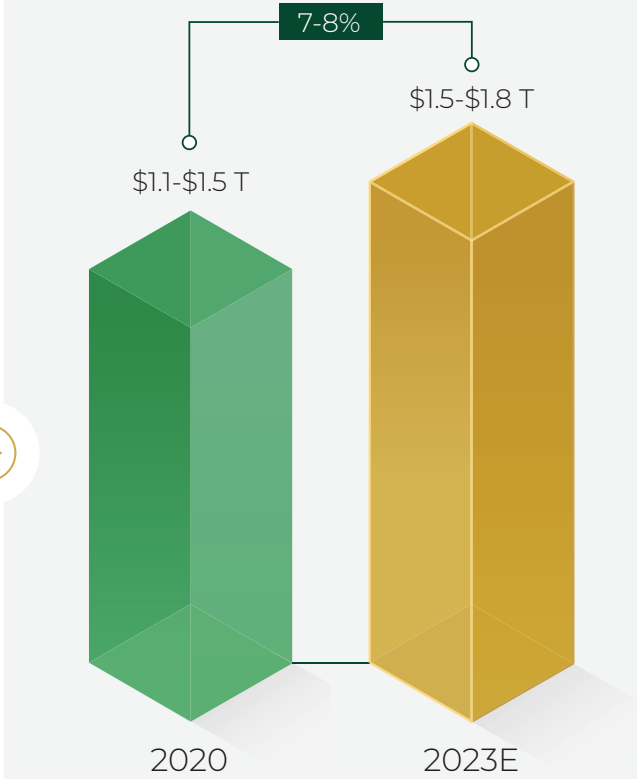
01

Accelerating Global ER&D Intensity

Globally, ER&D spending has accelerated post-pandemic and has witnessed a Business ER&D spend CAGR of 7-8% (2020 to 2023)

THE GROWTH OF GLOBAL ER&D UNTIL 2023 CAN BE ATTRIBUTED TO...

Renewed interest in ER&D post pandemic (including Capex growth)	Recovering from the pandemic shock which saw reduction in ER&D spends, companies improved ER&D investments to bridge gap between evolving market demand and offerings
Inflection point for technologies like AI/ Metaverse/Social Media	New technologies drove heightened demand for innovative engineering solutions as companies sought to adapt offerings to consumers who increasingly engaged from home
Increased demand for digital products and services	The beginning of digital products and services adoption across various sectors served as a catalyst for ER&D growth



Global Business ER&D Spend[1] ($T)

1.Refer glossary for definition

Source: CapitalIQ, BCG ER&D Survey 2023 n=281, Press Search; BCG Analysis

As the world looks forward, five key mega trends are expected to shape the future of global business ER&D spend (I/II)

MEGA TRENDS BEYOND 2023

1
DIGITAL ENGINEERING: INCREASING PROMINENCE

2
CLIMATE & SUSTAINABILITY AMBITIONS KEY DRIVER FOR ER&D SPENDS

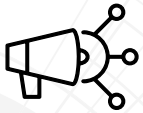
3
AI AUGMENTATION: GENERATIVE ENGINEERING

4
SERVICE-ORIENTATION: SHIFT IN ENGINEERING MODEL

5
POPULATION & SKILL INVERSION: SHIFTING SKILLS AND TALENT POOLS

Source: BCG Analysis

As the world looks forward, five key mega trends are expected to shape the future of global business ER&D spend (II/II)



MEGA TRENDS BEYOND 2023

1 DIGITAL ENGINEERING: INCREASING PROMINENCE

Integration of digital layers with traditional products or their supplementation is fueling a growing impetus in ER&D. Companies are recognizing the improved outcomes both for themselves and their consumers through this approach

2 CLIMATE & SUSTAINABILITY AMBITIONS KEY DRIVER FOR ER&D SPENDS

Global climate targets and evolving regulations driving the agenda for reduction of carbon footprint, building sustainable products and adoption of green energy thus increasing the ER&D intensity

3 AI AUGMENTATION: GENERATIVE ENGINEERING

Generative engineering, powered by AI, automates and optimizes design across industries like automotive, aerospace, and manufacturing – increasing efficiency, and reducing costs

4 SERVICE-ORIENTATION: SHIFT IN ENGINEERING MODEL

Innovative trend of product combined with services gaining traction across industries including heavy equipment, automotive and energy sectors resulting in a new ER&D approach focused on building a whole product

5 POPULATION & SKILL INVERSION: SHIFTING SKILLS AND TALENT POOLS

Ageing population and skills gap in several developed economies are reshaping the ER&D spend patterns and intensity

Source: BCG Analysis

Further, specific sectoral developments are expected to drive significant increase in the global business ER&D[1] intensity[2], taking the spending to $3.3T+ by 2030, from current levels of $1.8T

Sectoral developments driving increase in Business ER&D spend

Aerospace & Defence

- Shifting to more fuel-efficient aircrafts
- Tackling concerns of cybersecurity & increased use of automation
- Leveraging additive manufacturing (e.g., 3D printing)
- Urban air mobility

Automotive

- Adopting electric powertrains
- Transforming automotive value chains with increasing role of software
- Connected cars, in-car technologies and Autonomous driving

Consumer Electronics

- Quantum Computing leading to faster market launch
- Foldable & Flexible Display tech
- Connectivity: Smarter Devices & Homes
- Sustainable Electronics

Energy, Utilities and Oil & Gas

- The net-zero transition with low-emission technology
- Enhancing efficiency through digitization

Healthcare & Medical Devices

- Real-world data & AI-enabled treatment and discovery
- Rise of precision medicine and robotic aid
- Consumer-driven digital health (wearables etc.)

Industrials including Construction

- Automation & Robotics
- Platformization
- Data in Industrials

Semiconductors

- Innovation in Advanced Packaging & Chip stacking
- AI in semiconductor value chain
- Design customization to meet specific needs of growth frontiers(including AI, xEV, Crypto)

Software

- Platform to super platforms
- Integration of advanced AI/ ML into enterprise software suite
- Integration of advanced AI/ ML into enterprise software suite
- Continued focus on cybersecurity

Telecommunication

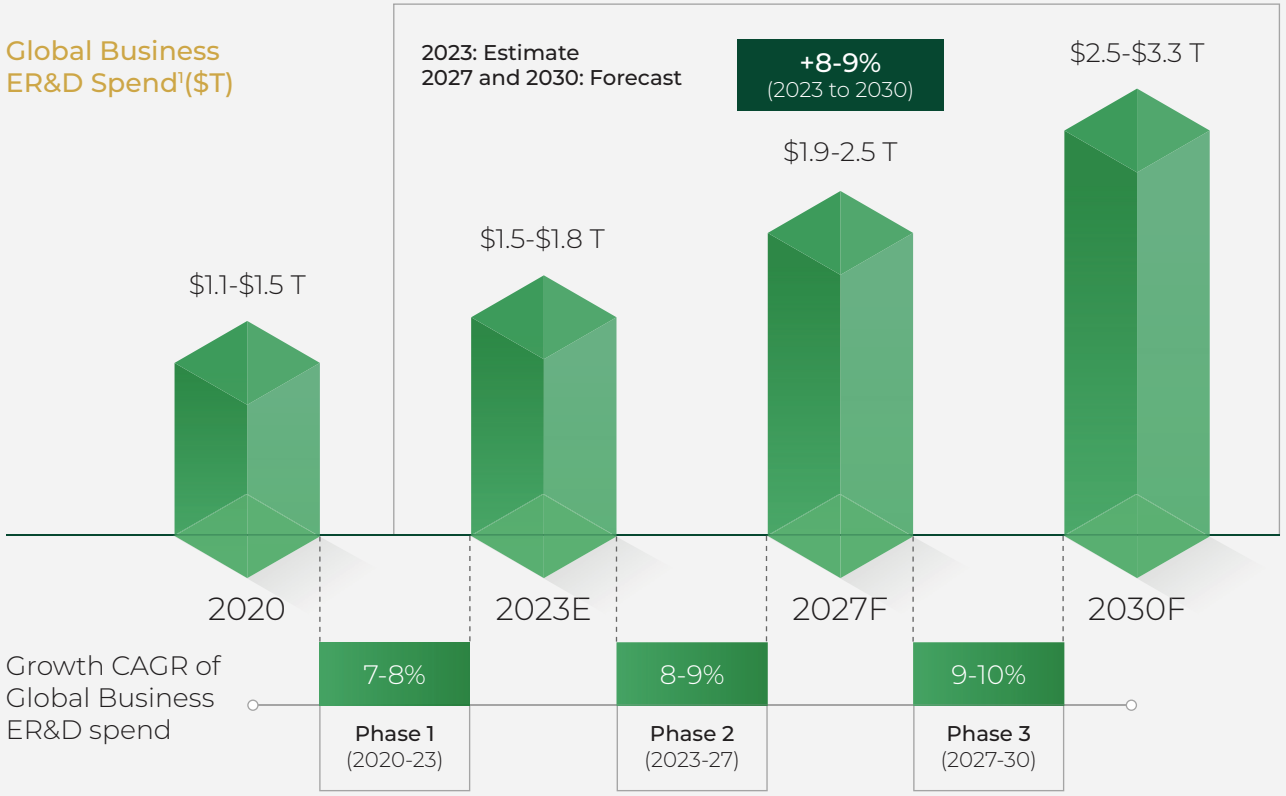
- Achieving Hyperconnectivity
- Implementing Open Digital Architecture (ODA) & Virtualization
- Evolving into a “Telco to Techco” Operating Model
- Pervasive 5G & 6G development

1. Refer Glossary for the description of Global Business ER&D 2. ER&D intensity refers to % of revenue spend on ER&D by firms

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; BCG Analysis

Global Business ER&D spend is expected to grow at an 8-9% CAGR from 2023-2030, up from 7-8% between 2020-2023; thus, signaling increasing ER&D Intensity across sectors

Global Business ER&D spend growth to further accelerate from 2027 to 2030 owing to stable economic environment & adoption at scale of the current disruptive technologies



PHASE 1 (2020-23)

Emerging from Uncertainty

Driven by slower economy in 2020, followed by uncertainty and large push on digitization triggered due to COVID-19

PHASE 2 (2023-27)

Stabilization and Transformation

Managing current economic uncertainties, expected to be followed by continued focus on innovation in digital & AI across sectors (e.g., AI adoption, xEV growth in automotive, digitization across sectors, etc.)

PHASE 3 (2027-30)

Sustained Growth at Scale

Driven by strong outlook of global economy and improving digital & electronics technologies ER&D spend across sectors (e.g., roll-out of 6G, AI @ Scale etc.)

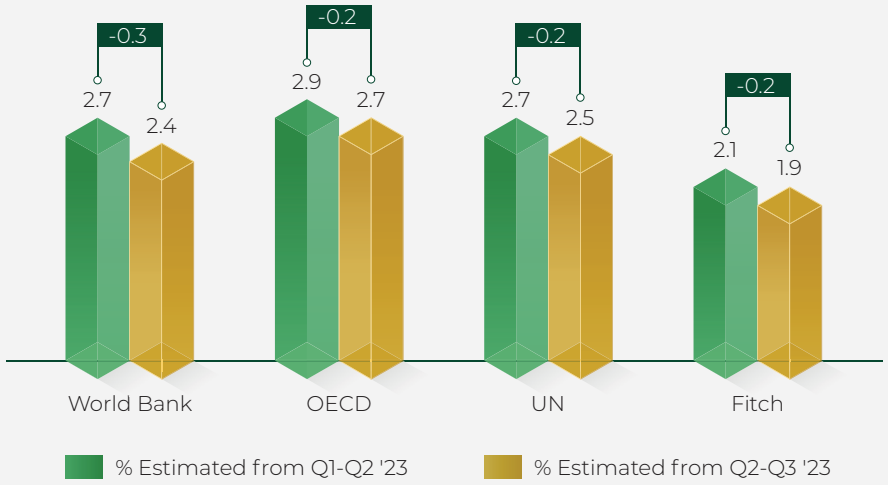
1. Refer glossary for definition

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Even in 2024, amid the dynamic macroeconomic environment, ER&D spending is anticipated to demonstrate resilience across sectors

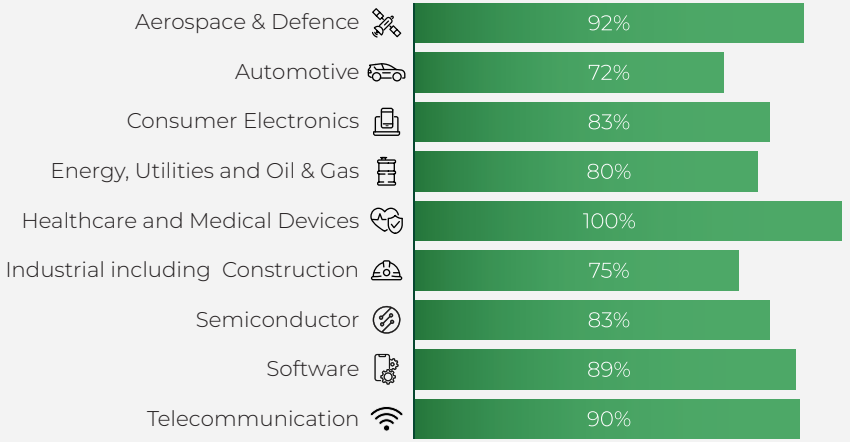
Analysts are indicating uncertainties in 2024 global economy as they downgrade Global GDP growth forecasts...

Global GDP Forecasts



- Amid uncertainties, 2024 Global GDP growth projections have experienced downward revisions in analyst forecasts
- However, the impact is expected to be short lived, and World Bank predicts a recovery in 2025, with global GDP growth rate pegged at 3.2%

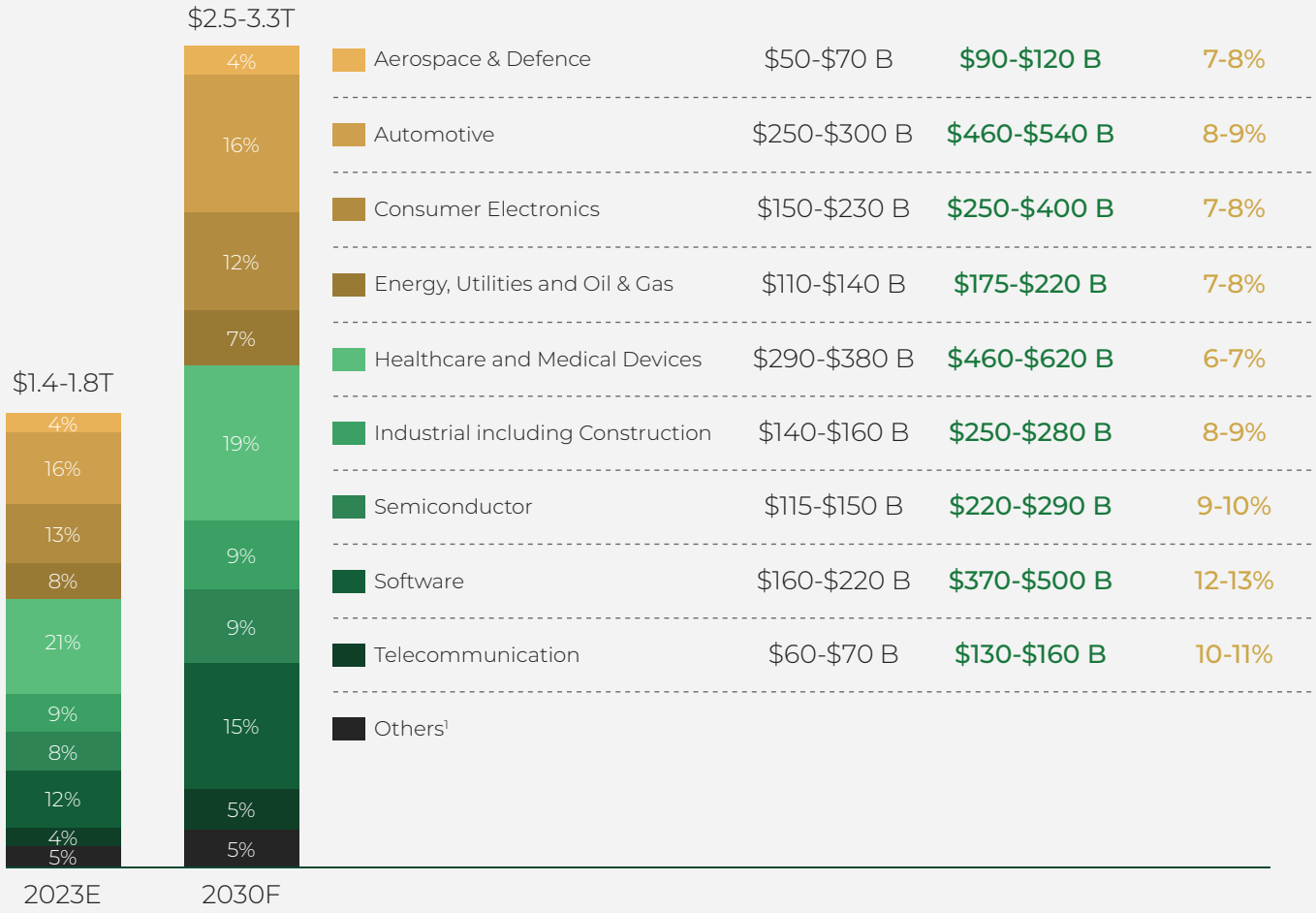
Despite uncertainties, at least %70+ industry leaders across sectors want to either increase or maintain their ER&D spend in 2024



- Fastest growing sectors of Software & Telecommunications are resilient to economic downturn & have ~90% of industry leaders surveyed want to maintain or increase ER&D spends
- COVID-19 pandemic has increased focus on Healthcare & Medical Devices ER&D,with ~100% industry leaders in Healthcare and Medical Devices wanting to increase or maintain their ER&D spend (as a % of revenue)

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG analysis

Automotive, Software and Healthcare & Medical Devices are expected to be top three ER&D spend contributors in 2030



Global Business ER&D Spend by Sector ($T)	2023E ($B)	2030F ($B)	CAGR% (2023-2030)
Aerospace & Defence	$50-$70 B	$90-$120 B	7-8%
Automotive	$250-$300 B	$460-$540 B	8-9%
Consumer Electronics	$150-$230 B	$250-$400 B	7-8%
Energy, Utilities and Oil & Gas	$110-$140 B	$175-$220 B	7-8%
Healthcare and Medical Devices	$290-$380 B	$460-$620 B	6-7%
Industrial including Construction	$140-$160 B	$250-$280 B	8-9%
Semiconductor	$115-$150 B	$220-$290 B	9-10%
Software	$160-$220 B	$370-$500 B	12-13%
Telecommunication	$60-$70 B	$130-$160 B	10-11%
Others[1]			

THREE SECTORS EXPECTED TO CONTRIBUTE TO ~50% OF TOTAL GLOBAL BUSINESS ER&D SPEND IN 2030

Automotive

Focus on innovation in xEV, ADAS, in-car entertainment experience, etc.

Software

Driving digitization across sectors and large tech innovations through Generative AI, etc.

Healthcare & Medical Devices

Large R&D investments in pharmaceutical and MedTech innovations

1. Refer glossary for description, share of Others considered as 5% of total ; % here indicates sector's share of global business ER&D spend

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; BCG Analysis

Software, telecom, semiconductors and auto[1] sectors are expected to see high growth rates due to increasing demand & investments to maintain competitive R&D momentum

12–13%

SOFTWARE

- Driven by enterprise demands, companies adapting faster product and update releases cycles driving ER&D. Achieving rapid iteration of large-scale complex software has become a necessity in this context
- Detailed engineering work required for integration and end-to-end testing of distributed services driving the demand for development and testing services

10–11%

TELECOMMUNICATION

- Growth prospects of the Telecom sector can be attributed to a blend of factors, including a lower base spend2 and rollout of 5G and associated applications
- Sector set for expansion as it serves as the fundamental digital infrastructure supporting future applications such as IIoT, Connected Vehicles etc. requiring innovation and investment in network coverage, load management, security, edge computing and resilient connectivity

9–10%

SEMICONDUCTOR

- Growth in Semiconductor demand from sectors including Auto, Telecom and Technology giving rise to application specific innovations and SoC3 developments
- Govt. incentives driving larger private sector investments into R&D (Example: In the US for every $1 federal government investment, private sector adds $20+ investment)

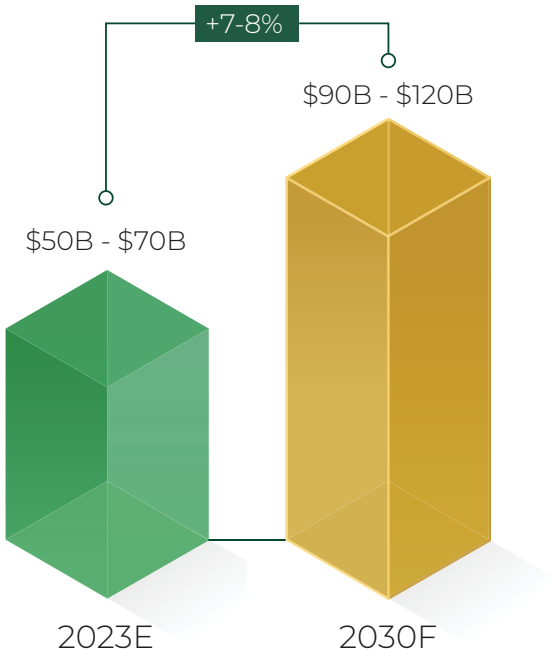
CAGR %(2023-2030)

1.Primarily driven by new breakthroughs, competition from new entrants and incumbents 2. Influenced by TSPs; 3. System on Chip;
Source: Source: Press search, Alibaba Group, Semiconductor Industry Association; BCG Analysis

Sector wise ER&D Spend Priorities | Deep dive

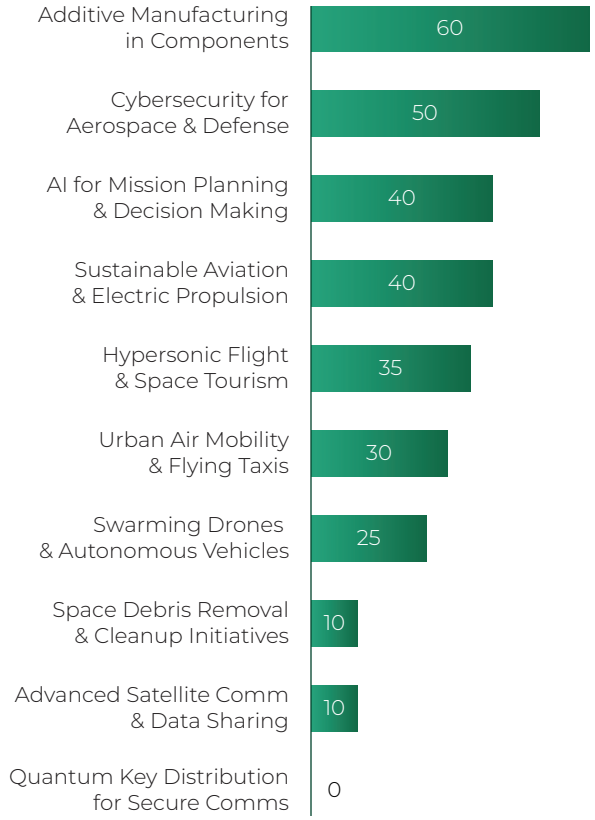
Aerospace & Defence: ER&D spend expected to reach $90-120B by 2030 growing at ~7-8% CAGR with high focus on additive manufacturing & tech in defence

SECTOR'S ER&D SPEND EXPECTED TO REACH $90-120B BY 2030...



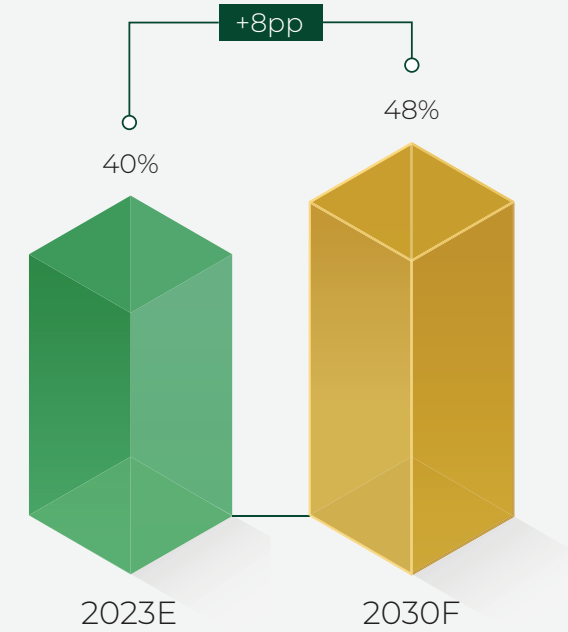
Sector's Business ER&D Spend ($B)

...WITH ADDITIVE MANUFACTURING & CYBER SECURITY AS KEY FOCUS AREAS IN THE SECTOR...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY SHARE OF DIGITAL ENGINEERING REACHING ~50%

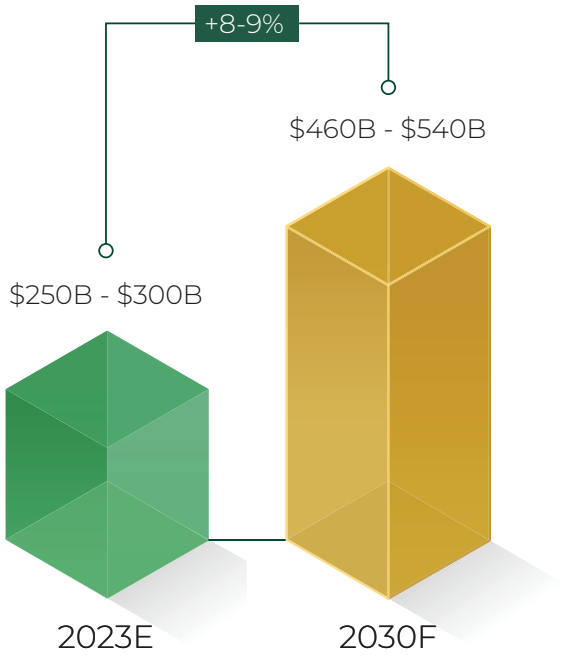


% of sector's ER&D spend on digital engineering

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

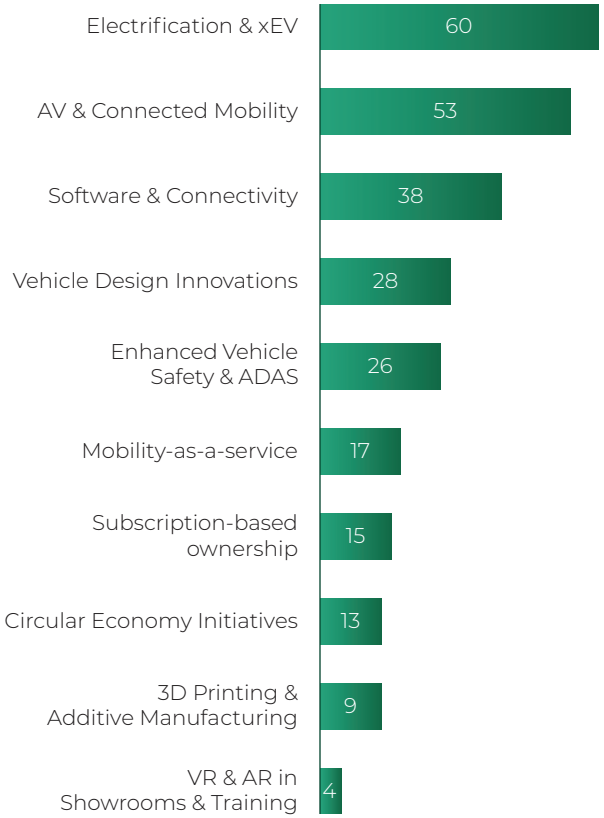
Automotive: ER&D spend expected to reach $460-540B by 2030 driven by xEV, connected mobility and vehicle software priorities

AUTOMOTIVE BUSINESS ER&D SPEND EXPECTED TO INCH TOWARDS ~$460-540B BY 2030 GROWING AT 8-9% CAGR...



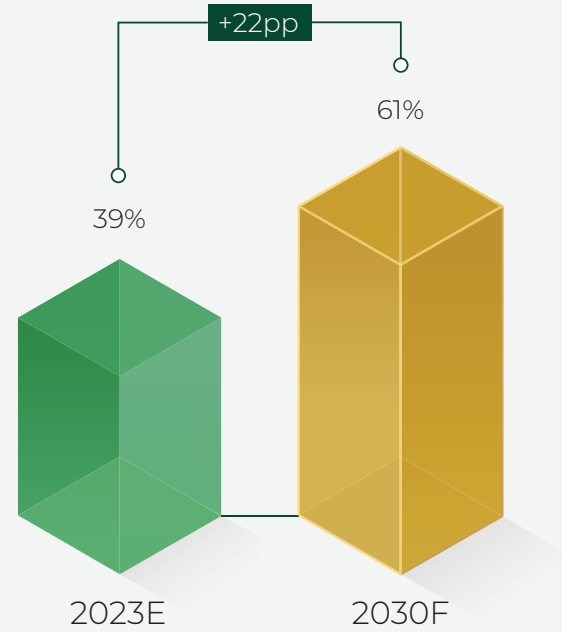
Sector's Business ER&D Spend ($B)

...WITH ELECTRIFICATION, CONNECTED VEHICLES & SOFTWARE AS TOP 3 ER&D PRIORITIES FOR THE SECTOR...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY SHARE OF DIGITAL ENGINEERING INCREASING BY 22PP

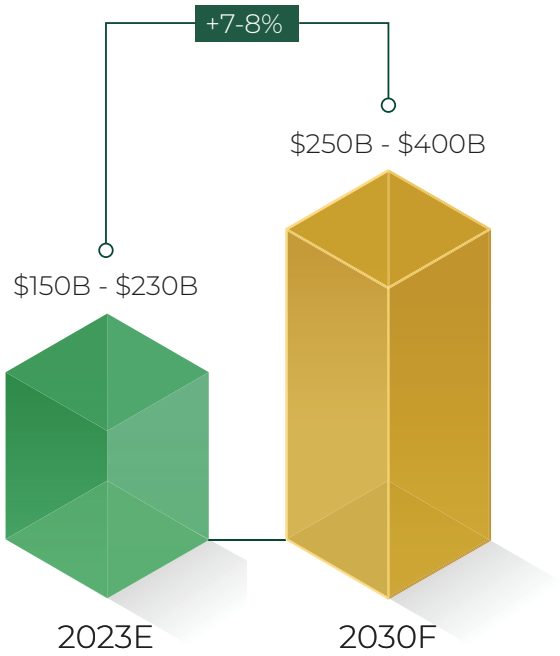


% of sector's ER&D spend on digital engineering

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

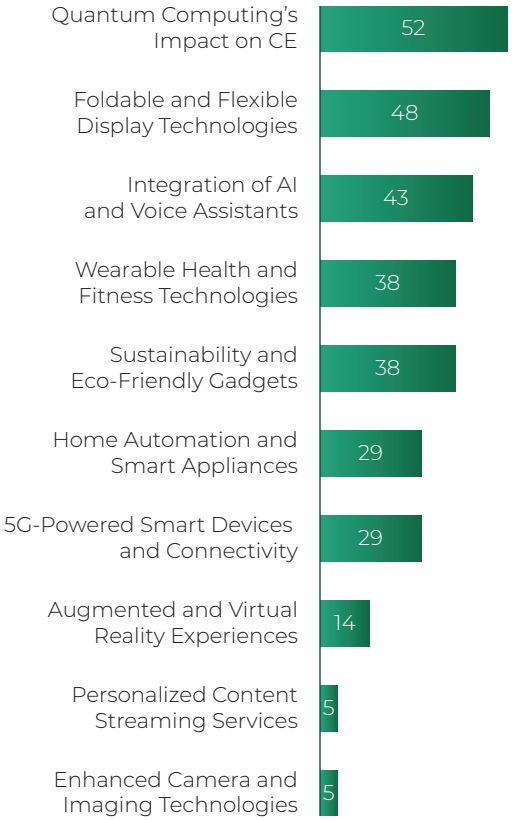
Consumer Electronics: ER&D spend expected to reach $250-400B by 2030 owing to impact of innovations in computing, display technologies and AI

CONSUMER ELECTRONICS ER&D SPEND EXPECTED TO REACH ~$250-400B BY 2030 GROWING AT ~7-8% CAGR...



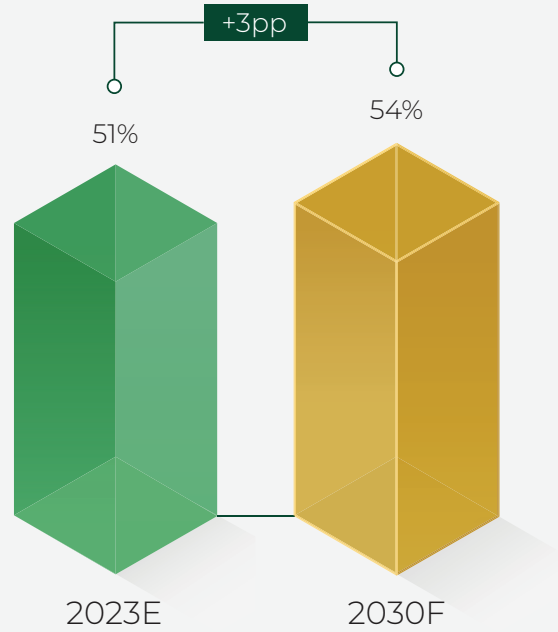
Sector's Business ER&D Spend ($B)

... WITH QUANTUM, FLEXIBLE DISPLAY & AI AS TOP 3 ER&D PRIORITIES OF THE SECTOR...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY SECTOR'S DIGITAL ENGINEERING AS A % OF ER&D SPEND REMAINING HIGH

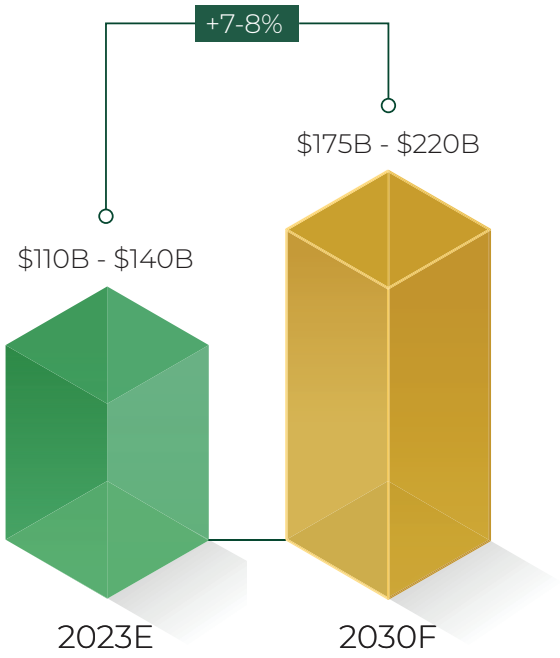


% of sector's ER&D spend on digital engineering

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

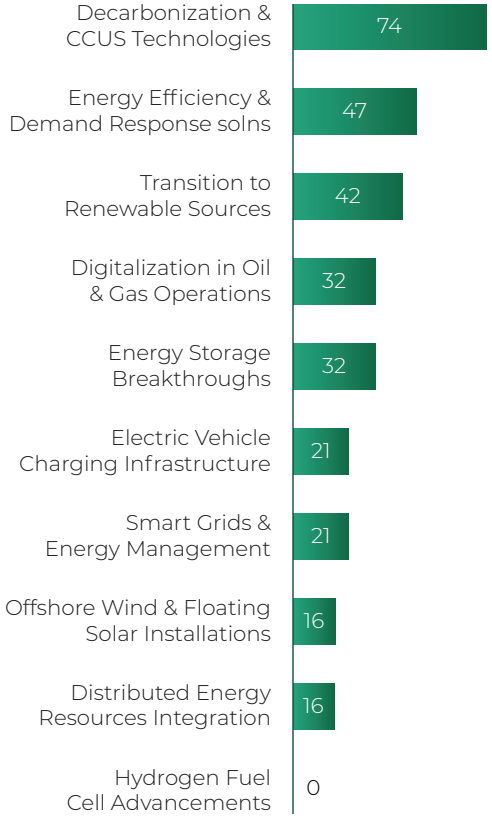
Energy, Utilities and Oil & Gas: Increased focus on green technologies & digital expected to take sector's business ER&D spend towards $175-220B by 2030

ENERGY, UTILITIES AND O&G ER&D SPENDS EXPECTED TO REACH $175-220B+ BY 2030...



Sector's Business ER&D Spend ($B)

...WITH DECARBONIZATION, ENERGY-EFFICIENCY & RENEWABLE ENERGY AND DIGITIZATION AS TOP ER&D PRIORITIES...



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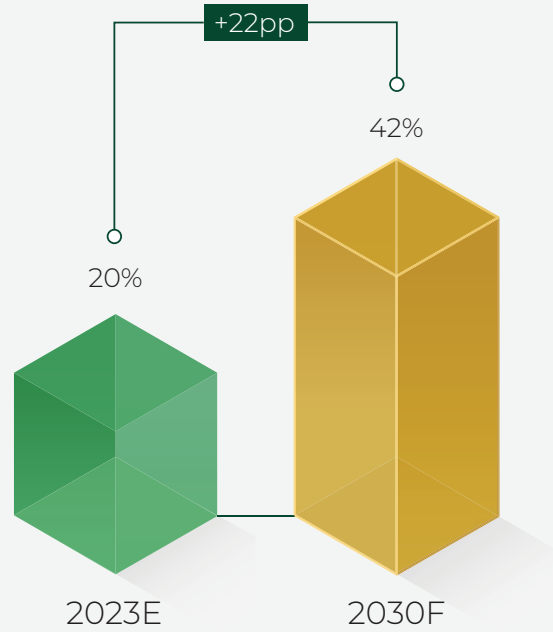
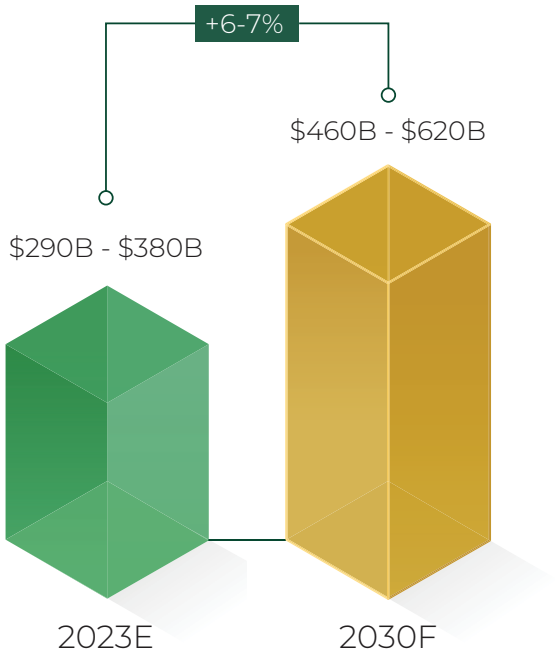


% of sector's ER&D spend on digital engineering

Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge
Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

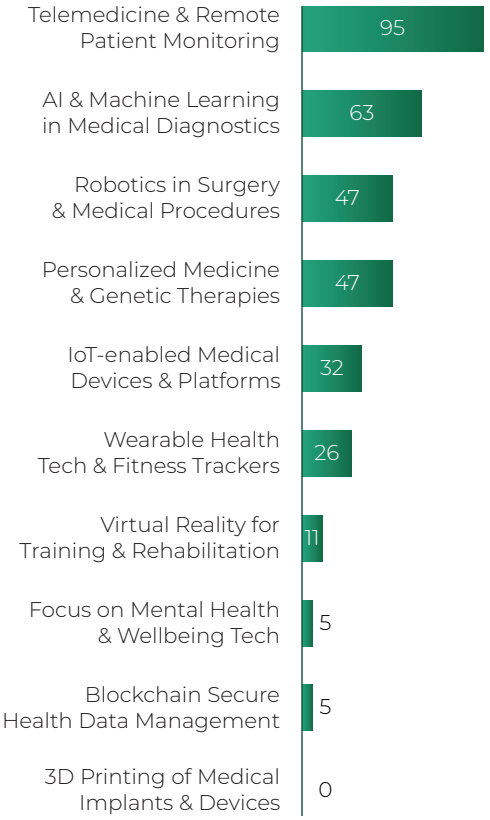
Healthcare & Medical Devices: ER&D spends expected to remain high in healthcare & medical devices making it the highest ER&D spender across sectors

BY 2030, SECTOR EXPECTED TO LEAD ER&D SPENDING, INCHING TOWARDS $460-620B...



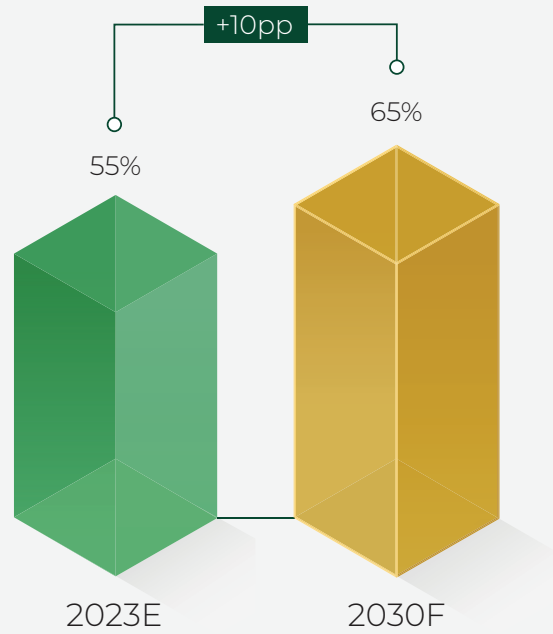
Sector's Business ER&D Spend ($B)

...WITH TELEMEDICINE, AI/ML IN DIAGNOSTICS, ROBOTICS & PERSONALIZED THERAPIES AS KEY FOCUS AREAS...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY DIGITAL ENGINEERING SHARE OF ER&D SPEND REACHING 65% BY 2030

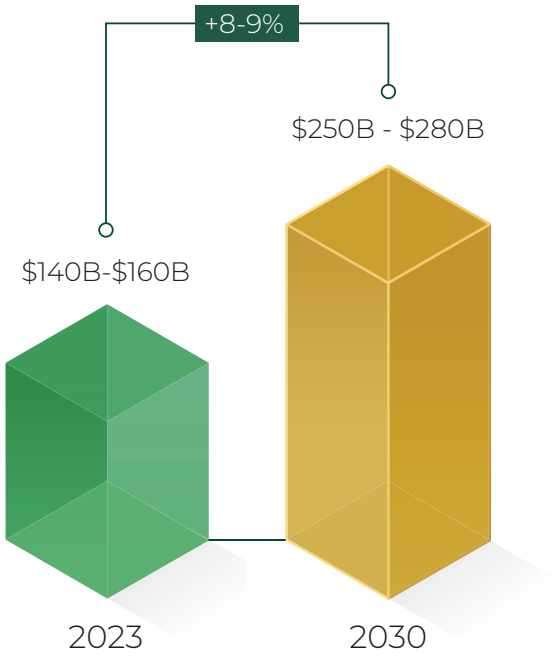


% of sector's ER&D spend on digital engineering

Includes prevention & tracking, diagnostics, therapies, surgeries, etc.., 2. Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge **Source:** BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

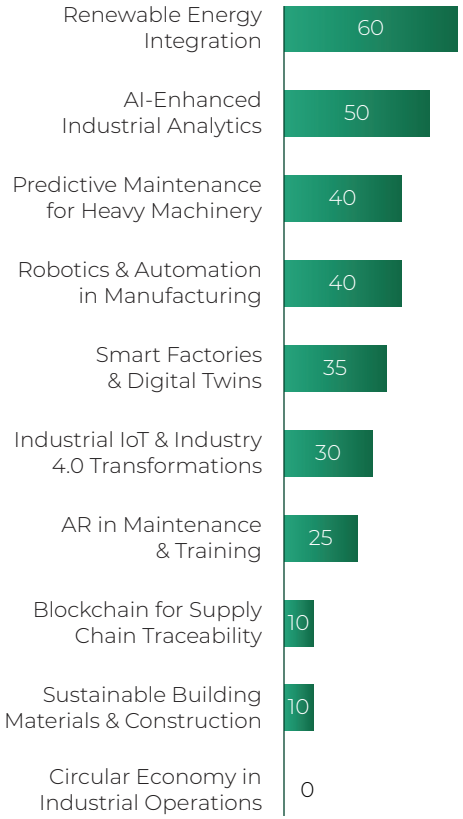
Industrials including Construction: ER&D spend driven by focus on advances in data backed ops, improving efficiency and quality of output through digital

INDUSTRIAL ER&D SPEND EXPECTED TO REACH $250B-280B BY 2030 GROWING AT ~8-9% CAGR[1]...



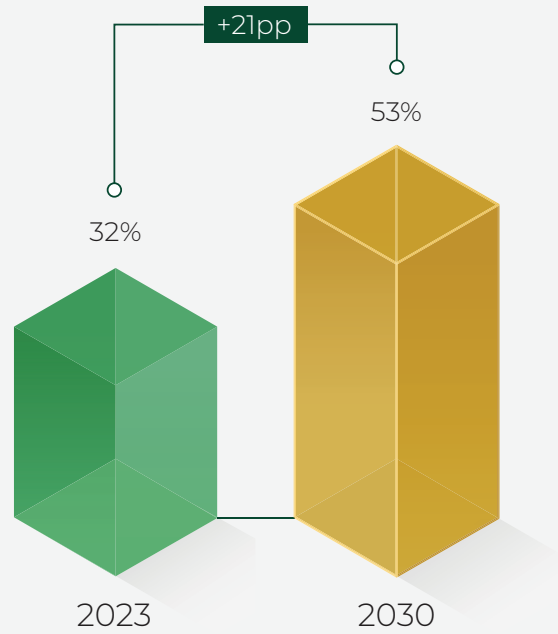
Sector's Business ER&D Spend ($B)

...WITH SUSTAINABILITY, AI-ENHANCED ANALYTICS & AUTOMATION AS TOP 3 ER&D SPENDS...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY INCREASING SPEND ON DIGITAL ENGINEERING BY 21PP

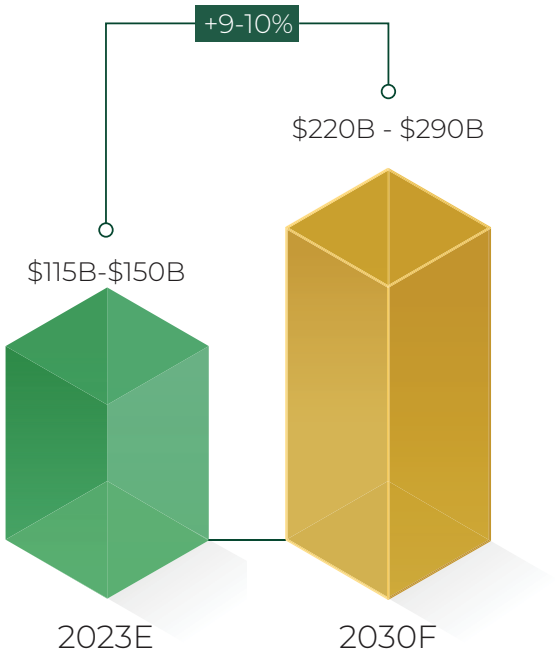


% of sector's ER&D spend on digital engineering

1. Does not include major Chinese companies.Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge **Source:** BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

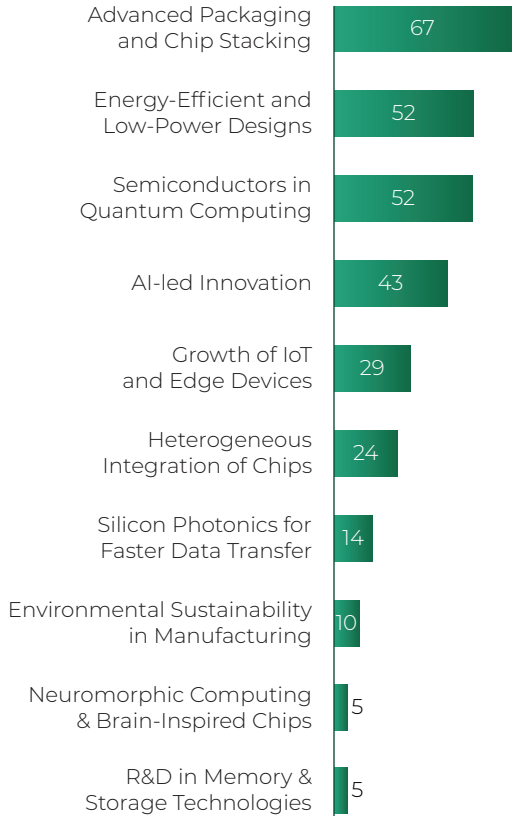
Semiconductors: ER&D spend expected to reach $220-290B with focus on areas of packaging and new application specific developments

SEMICONDUCTORS ER&D SPEND EXPECTED TO REACH $220-290B BY 2030 GROWING AT 9-10% CAGR...



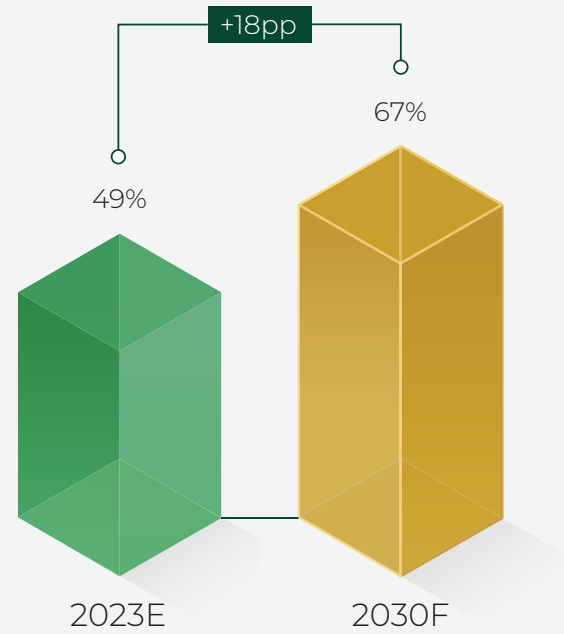
Sector's Business ER&D Spend ($B)

...WITH PACKAGING, ENERGY-EFFICIENCY & QUANTUM COMPUTING AS TOP 3 ER&D PRIORITIES...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY AN INCREASE IN SHARE OF DIGITAL ENGINEERING AS PART OF ER&D SPEND BY 18PP

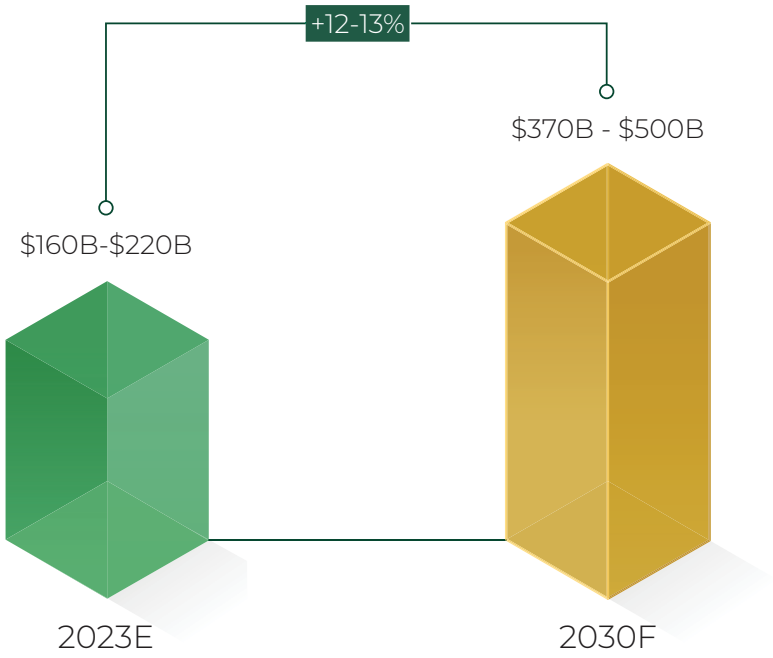


% of sector's ER&D spend on digital engineering

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG Analysis

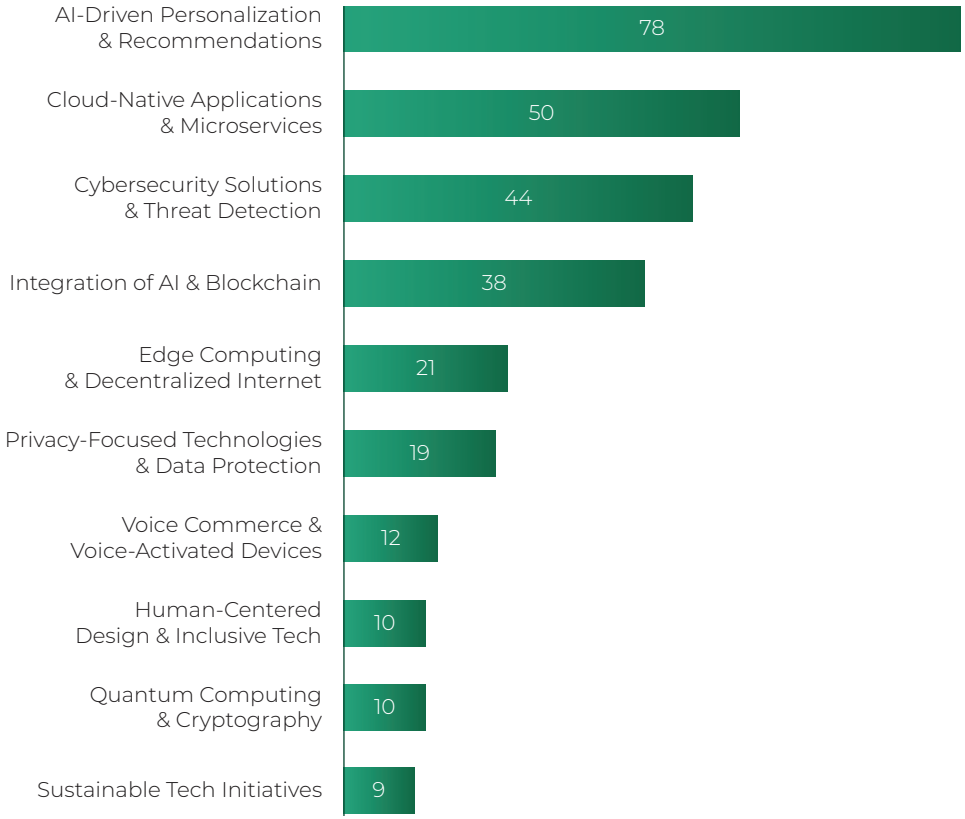
Software: Continuous innovation in software space will leverage new AI breakthroughs; Focus on cloud and cyber security expected to take ER&D spends to $370-500B by 2030

SOFTWARE ER&D SPEND EXPECTED TO REACH $370-500B+ BY 2030 GROWING AT ~12-13% CAGR...



Sector's Business ER&D Spend ($B)

...WITH AI-DRIVEN PERSONALIZATION & CLOUD APPLICATIONS AS TOP TWO PRIORITY AREAS

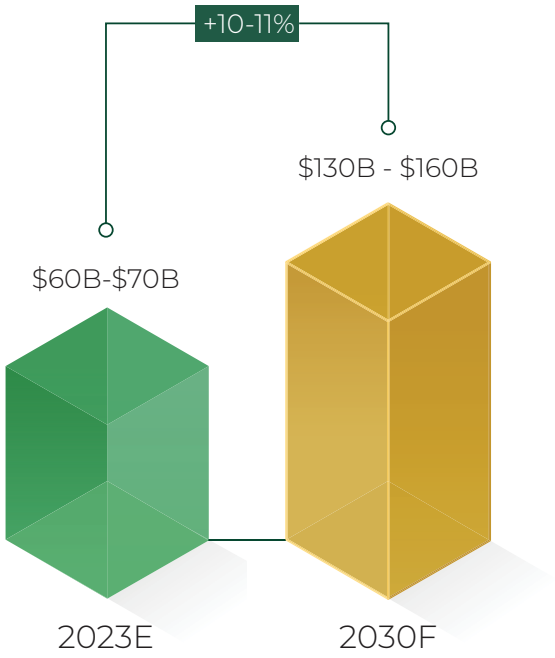


% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG Analysis

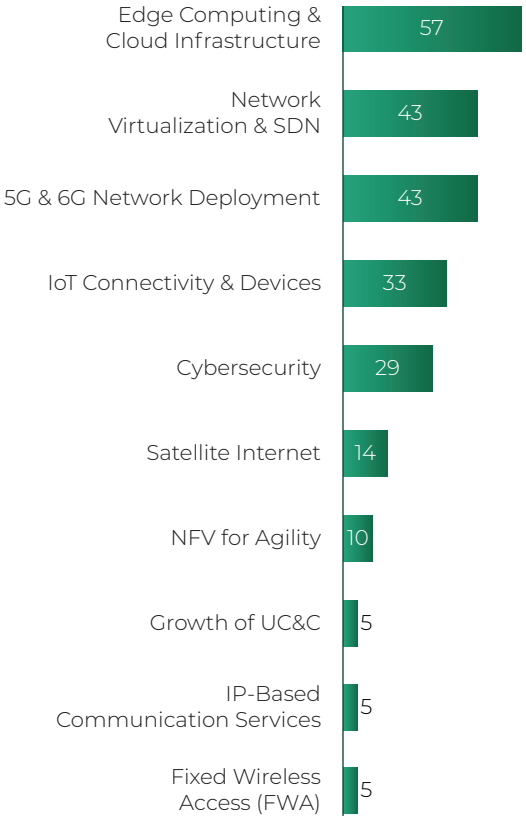
Telecommunication: ER&D spend expected to grow at 10-11% CAGR to reach $130-160B by 2030, maintaining the high share of digital engineering in spends

SEMICONDUCTORS ER&D SPEND EXPECTED TO REACH $220-290B BY 2030 GROWING AT ~10-11% CAGR...



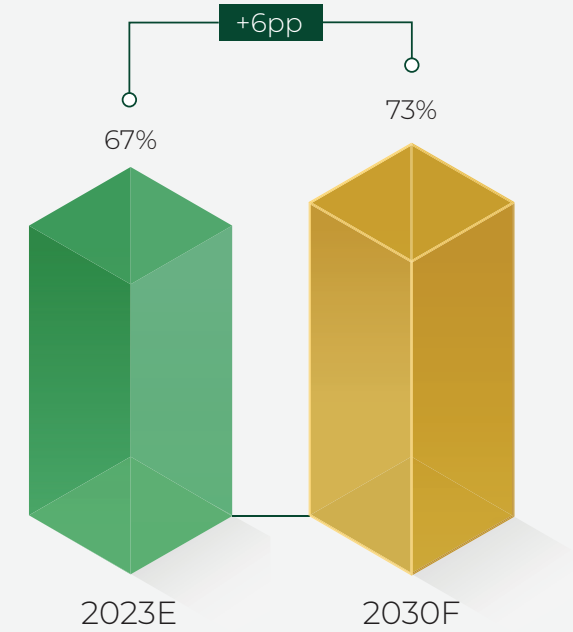
Sector's Business ER&D Spend ($B)

...WITH EDGE, CLOUD, SDN, 5G & 6G AS TOP ER&D PRIORITIES...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY AN INCREASE IN SECTOR'S DIGITAL ENGINEERING SPEND AS SHARE OF ER&D SPEND

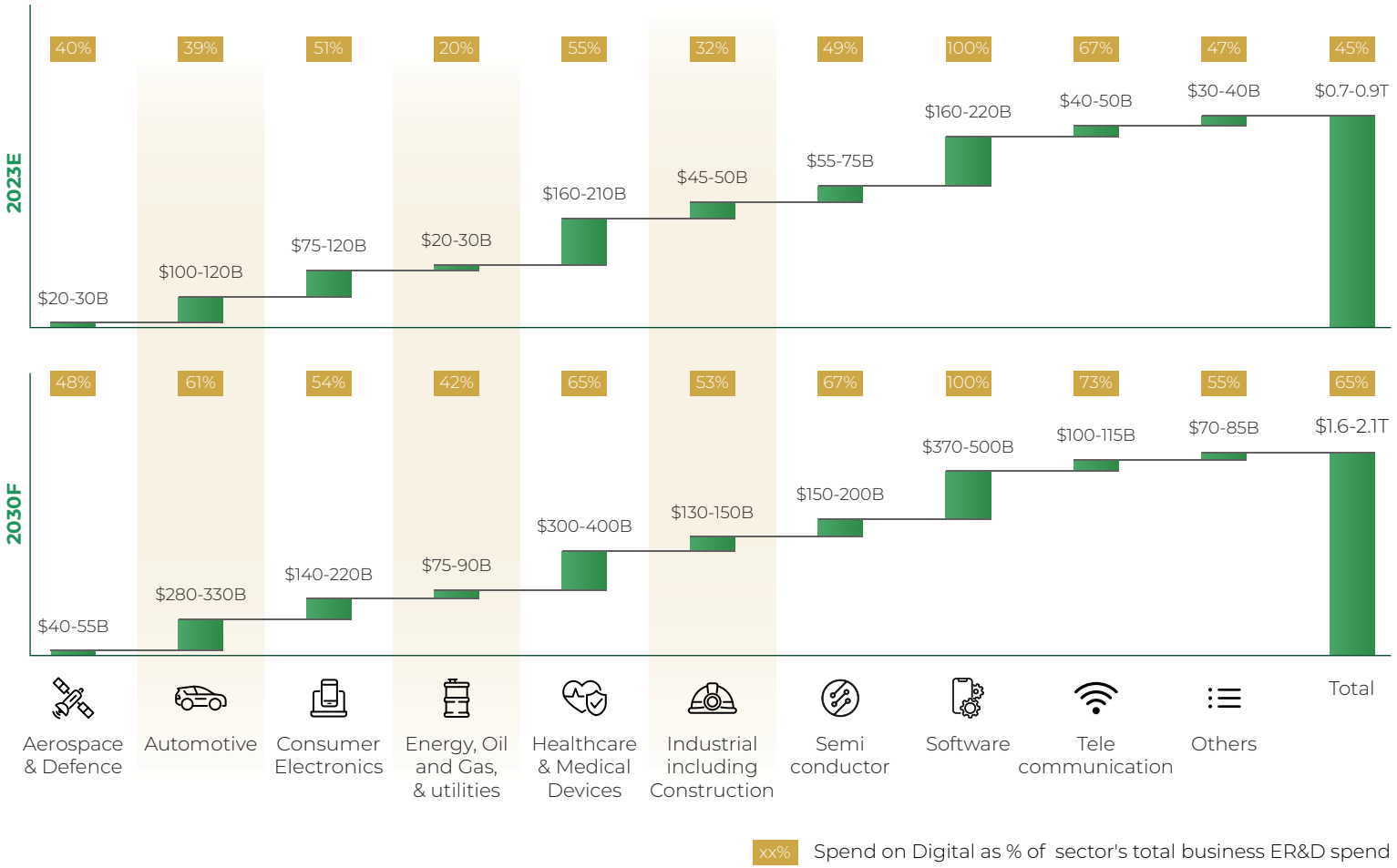


% of sector's ER&D spend on digital engineering

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG Analysis

Not surprisingly, digital engineering is the driving force behind this spend acceleration; expected to contribute 65% of spend[1] in 2030 vs ~45% in 2023

Spend On Digital Engineering and R&D Across Sectors[1] ($Bn)



xx% Spend on Digital as % of sector's total business ER&D spend

AUTOMOTIVE, ENERGY, UTILITIES, OIL & GAS AND INDUSTRIALS EXPECTED TO SEE LARGEST JUMP IN DIGITAL ENGINEERING AS A % OF GLOBAL BUSINESS ER&D SPEND BETWEEN 2023 & 2030:

Automotive: Most innovations are in software; xEV, ADAS, infotainment systems, connected cars, etc. are driving sector's spend on digital engineering

Energy, Utilities, Oil & Gas: Smart grid technology, predictive maintenance of O&G plants, digital simulations, etc.

Industrials: Optimized processes with higher output is driving sector's spend on digital; e.g., AI-driven analytics, digital twin technology for simulations, predictive maintenance, etc.

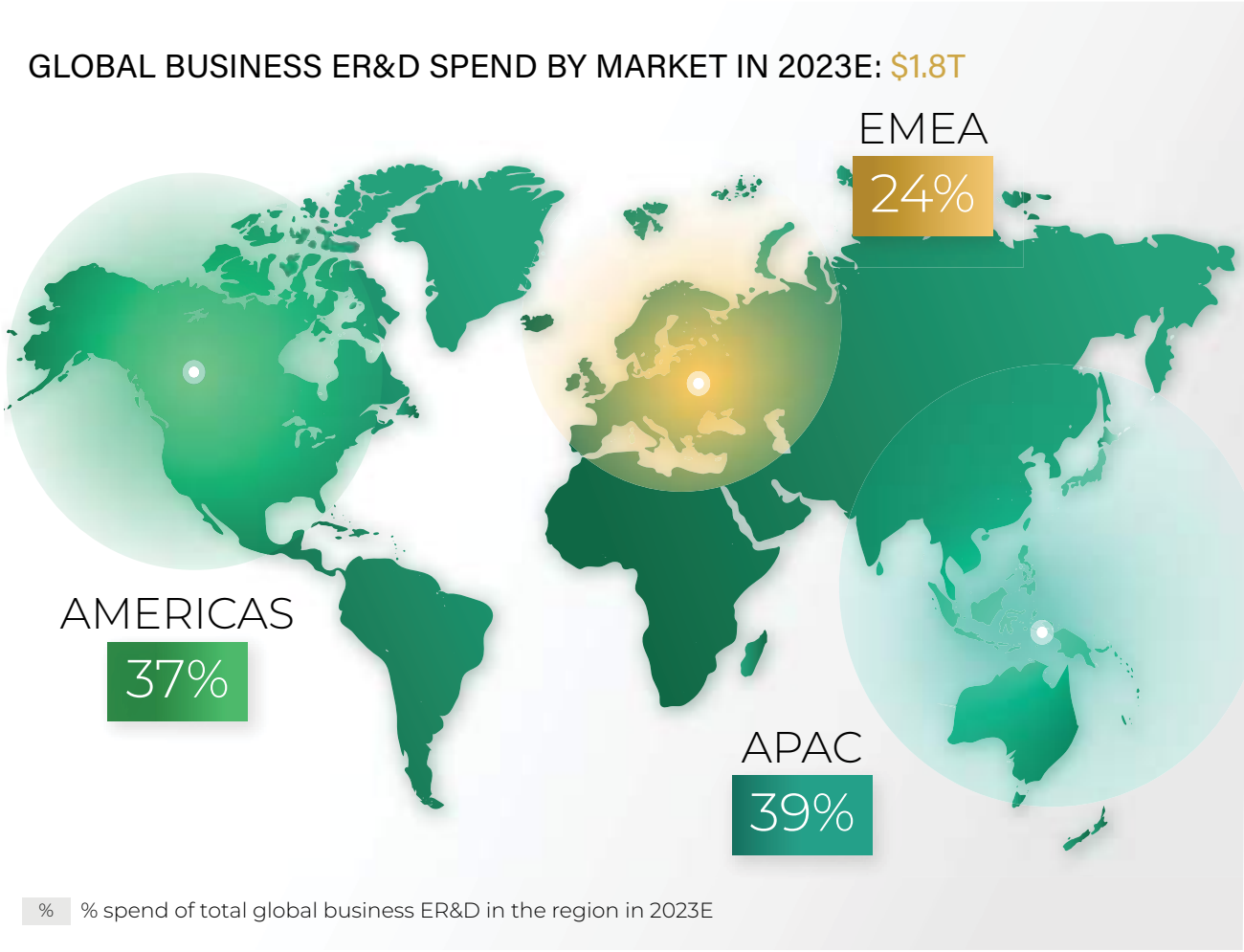
Healthcare & Medical Devices has one of the highest contribution to the total spend on digital engineering due to increasing focus on telemedicine, digital in research, wearable devices, remote monitoring, etc.

1.spend on digital engineering as a % of Global Business ER&D spend
Source: CapitalIQ, BCG ER&D Survey 2023 n=281; BCG Analysis

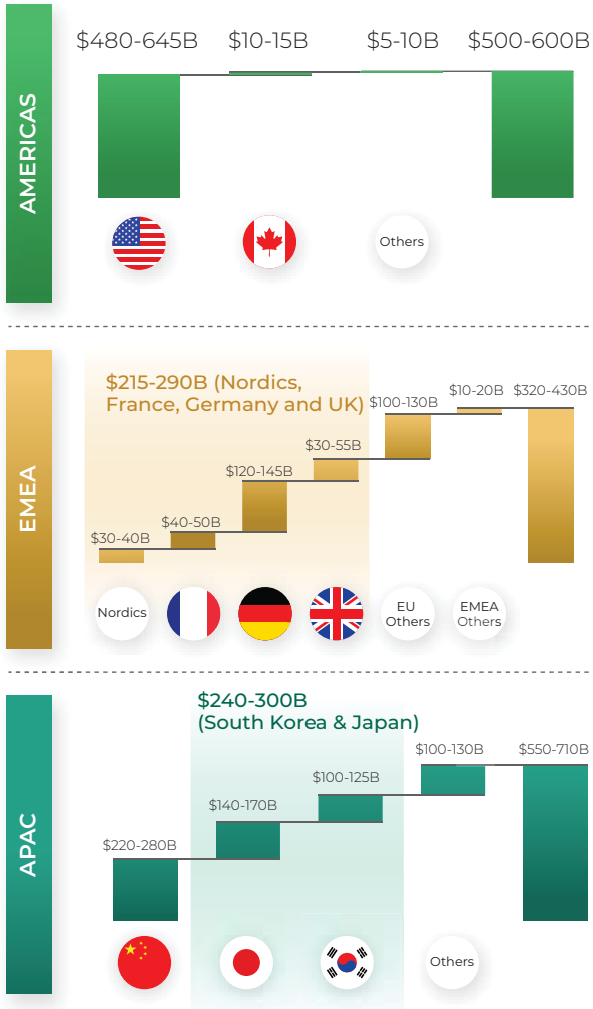
02

Sourcing Opportunity for ER&D Services

Increasing Business ER&D spend is witnessed across regions, and highlights six non-US, non-China countries/sub-regions which are collectively spending $450-600B in 2023



ER&D spend by firms headquartered in the region in 2023E ($B)



Source: CapitalIQ, BCG ER&D Survey 2023 n=281; BCG Analysis

Sourcing[1] decisions across sectors are expected to be shaped by 3 factors:
Evolving Nature of ER&D, the Chase for Talent and Cost Dynamics

EVOLVING NATURE OF ER&D

ER&D has undergone a transformative journey in recent years, with a continued shift from asset-intensive practices to asset-light models. This shift is breaking down traditional boundaries in ER&D teaming models and allowing organizations to Source specific capabilities from non-HQ teams

Sectors most likely to benefit:

- Aerospace & Defence
- Automotive
- Energy, Utilities and Oil & Gas
- Industrial including Construction

CHASING THE TALENT

The demand for multi-disciplinary expertise is driving organization to look for new talent sources

Also, the talent well-versed with Digital in ER&D is being sought after across sectors (e.g. Software developers for Automotive sector)

- Software
- Automotive
- Tele-communication
- Semiconductor

COST DYNAMICS

Cost dynamics will maintain their role in shaping the sourcing decisions

The ongoing pursuit of cost-efficiency will continue to guide organizations to invest more in scaling up their global ER&D teams (through GCCs) and also drive deeper partnerships with ESPs

- Healthcare & Medical Devices
- Consumer Electronics

1. Sourcing % : % of ER&D Spend that is spend on non-HQ teams. This includes spend with GCCs as well as ESPs

Source: BCG ER&D Survey 2023 n=281; BCG Analysis

Besides cost & talent access, agility & scalability, market expansion, evolving manufacturing footprint, and partnerships...

TABLE[2]: % OF RESPONDENTS FROM THE CORRESPONDING SECTOR WHO HAVE RANKED THE REASONS IN TOP 3 SELECTION CRITERIA FOR ER&D SPEND SOURCING

	#1 Cost Optimization	#1 Access To Talent	Time Zone Coverage	#2 Market Expansion	#3 Technological Ecosystem
Aerospace & Defence	78%	44%	0%	44%	0%
Automotive	62%	52%	10%	29%	19%
Consumer Electronics	75%	50%	50%	0%	50%
Energy, Utilities and Oil & Gas	70%	30%	20%	10%	40%
Healthcare & Medical Devices	64%	55%	18%	27%	27%
Industrial including Construction	79%	79%	14%	29%	7%
Semiconductors	80%	50%	10%	10%	60%
Software	84%	64%	20%	20%	24%
Telecommunication	63%	38%	0%	13%	38%

Note: Commentary in next page 1. Sourcing refers to ER&D spend on Global Capability Centers (GCC) and Outsourced Engineering Services (ESP) 2. Each cell refers to % of respondents from the corresponding sector who have ranked the reasons in top 3 selection criteria who said that they will either maintain or increase their ER&D Sourcing (Business ER&D spend on GCCs or ESPs)
Source: BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

...are vital factors for sourcing[1] across industries

#4 Agility & Scalability	#5 Strategic Partnerships
33%	56%
33%	19%
50%	0%
70%	30%
55%	36%
50%	29%
50%	10%
44%	8%
38%	25%

High — Low

Relative importance of the criteria for sourcing decisions

Key considerations for sourcing

Trend #1: Cost Optimization & Access to Talent

Cost optimization & access to talent are key reasons for sourcing across sectors as skillset requirements are rapidly changing resulting in demand for talent@scale

Trend #2: Market Expansion

Companies in sectors like Aerospace & Defence, industrial, automotive, and healthcare & medical devices are exploring opportunities to establish local presence in specific regions, aiming to design and manufacture products tailored to the needs of those markets basis regulatory standards and consumer preferences

Trend#3: Technological Ecosystem

Semiconductor & Consumer Electronics industry's sourcing is also being influenced changing manufacturing footprint of these industries and the desire of these two sectors to keep design and manufacturing together

Trend #4: Agility & Scalability

Agility and Scalability is a key priority for all organizations, i.e., ability to scale up easily (easy talent availability, plug-&-play infrastructure set-ups, less paperwork, etc.)

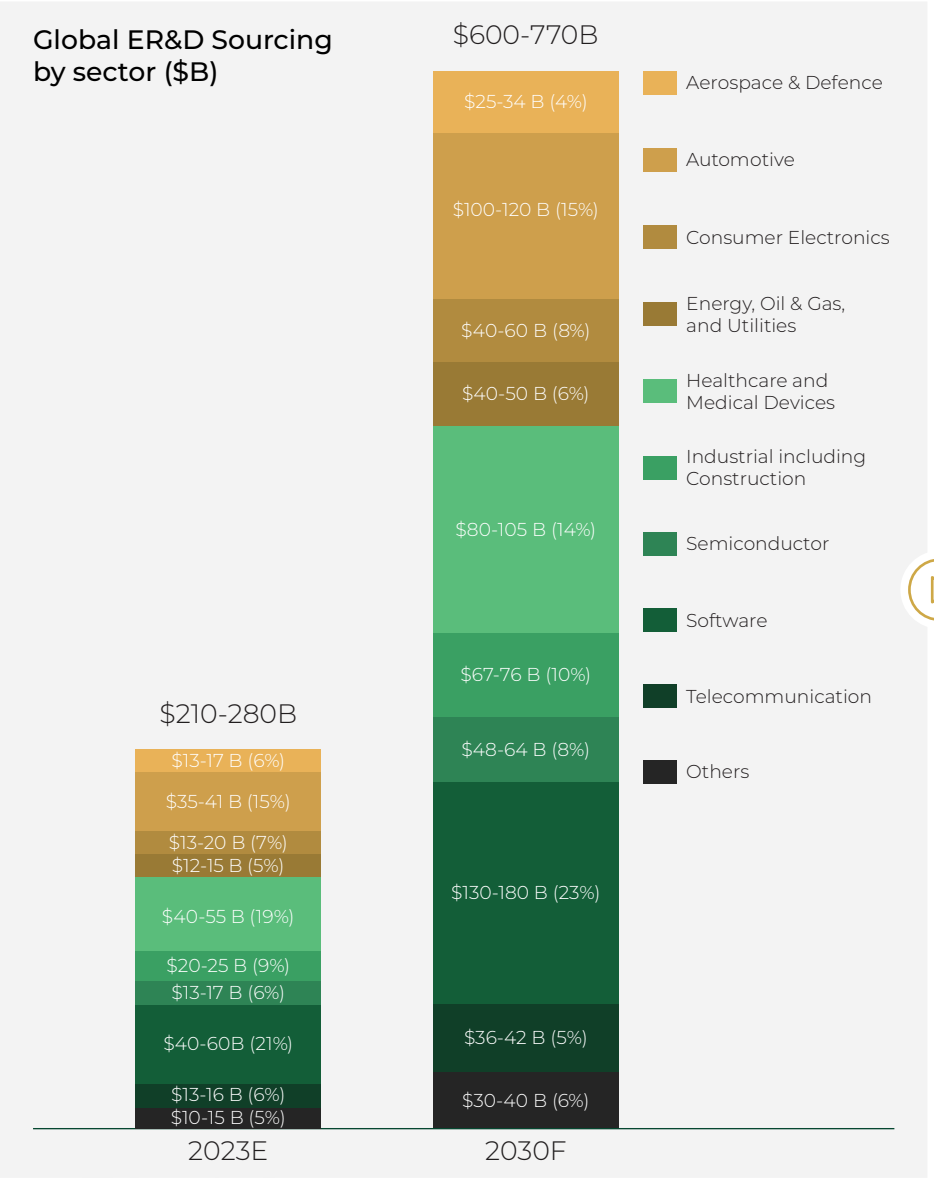
Trend #5: Strategic Partnerships

Aerospace & Defence places key emphasis on strategic partnerships for collaboration opportunities & access to key stakeholders (with govt., defence contractors, etc.), technological expertise or capabilities of the sourcing country

Source: BCG Analysis

It is estimated that global ER&D Sourcing will increase from ~$280B in 2023 to ~$775B in 2030

	ER&D Sourcing ($B)	As share of Global ER&D Spends (%)
2023E	$210B -280B	15%
2030F	$600B -770B	24%
CAGR% (2023-2030)	~16%	



Software sector to retain the highest share in the sourcing spends in 2030, while share of total sourcing from Energy, Utilities and Oil & Gas and Industrial sector is set to increase by 200bps by 2030

Above sectors' gain in share of sourcing stems from the high 2-digit growth (~20% CAGR) in their respective ER&D Spend Sourcing

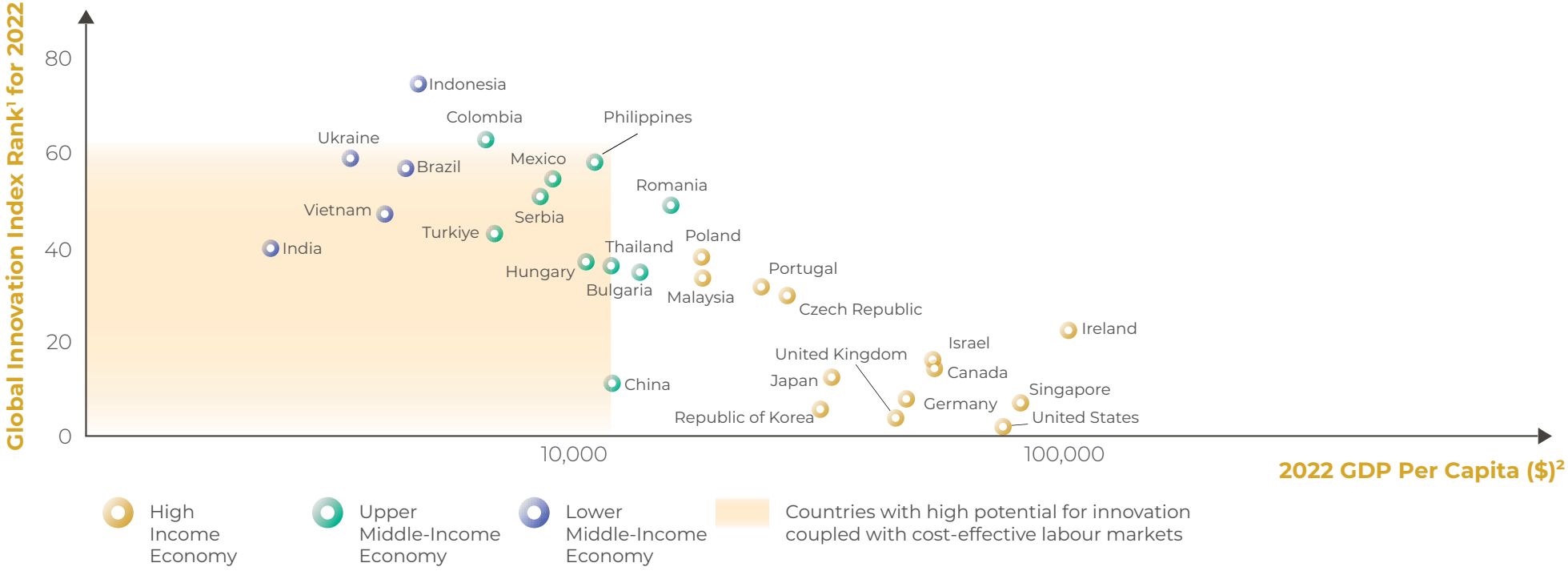
1.Refer glossary for description

Source: BCG ER&D Survey 2023 n=281; BCG Analysis

India continues to be well positioned to grab significant share of the Global ER&D Sourcing; India's advantage is unique combination of ER&D prowess as a top 5 innovative middle-income powerhouse & ability to provide talent @ scale

INDIA'S INNOVATION AND ECONOMIC VALUE PROPOSITION FOR ER&D

Innovation ranking vs GDP per capita for select countries



1. WIPO Global Innovation Index Rank for countries; 2. Directional indicator for labour market wages

Source: WIPO Global Innovation Index 2022, World Bank; BCG Analysis

Few non-India destinations offer engineering talent at India's scale

Non-exhaustive

India

- World's largest population, 1.4B+ population
- 8M people tagged to next-gen skills1
- ~39M total students enrolled in tertiary education
- ~34% of Graduates in science and engineering
- ~20% of work in Knowledge-intensive employment sectors

Vietnam

- 98M population
- ~2.7M total students enrolled in tertiary education
- ~22% of Graduates in Science and engineering
- ~11% of work in knowledge-intensive employment sectors
- **Promoting Industry-Academia tie-ups** to promote ER&D; e.g., large telecom equipment provider has partnered with university to set-up AI lab to include work integrated learning in 5G, AI/ML, AR/VR, etc.

Philippines

- 111M population
- ~3.6M total students enrolled in tertiary education
- ~23% of Graduates in Science and engineering
- ~19% of work in knowledge-intensive employment sectors
- List of ~**25 engineering courses** feature in the list of priority courses for **CHED (Commission for Higher Education) scholarships for promoting STEM uptake**

Thailand

- 70M population
- ~2M total students enrolled in tertiary education
- ~28% of Graduates in Science and engineering
- ~15% of work in knowledge-intensive employment sectors
- Thai gov has made **attracting** tertiary students to **STEM and STI disciplines** a priority in its HRD strategy through **curriculum enhancement, scholarships**

Bulgaria

- 6.9M population
- ~0.2M total students enrolled in tertiary education
- ~20% of Graduates in Science and engineering
- ~33.4% of work in knowledge-intensive employment sectors
- Private sector support: awards **annual scholarships to engineering students** who need financial support to continue their studies

Türkiye

- 85M population
- ~8.3M total students enrolled in tertiary education
- ~23% of Graduates in Science and engineering
- ~15.2% of work in knowledge-intensive employment sectors

1. AI/ML, Big Data, Digital services, IoT

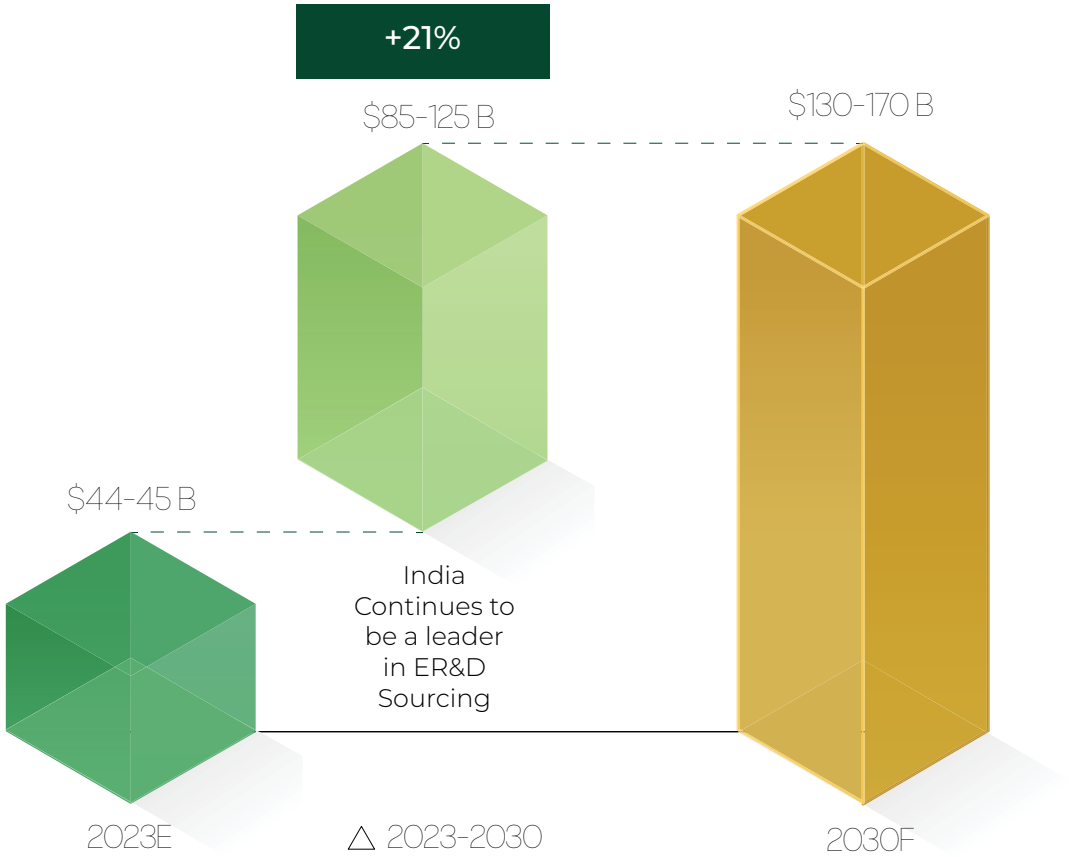
Source: WIPO Global Innovation Index 2022, UNESCO Institute for Statistics, World Bank; BCG Analysis

03

The India Advantage

India share in ER&D Sourcing expected to increase from $46B in 2023 to $170B in 2030

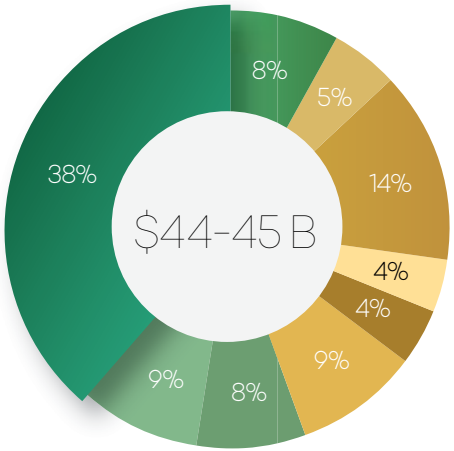
INDIA'S SHARE IN THE GLOBAL BUSINESS ER&D SOURCING ($B)



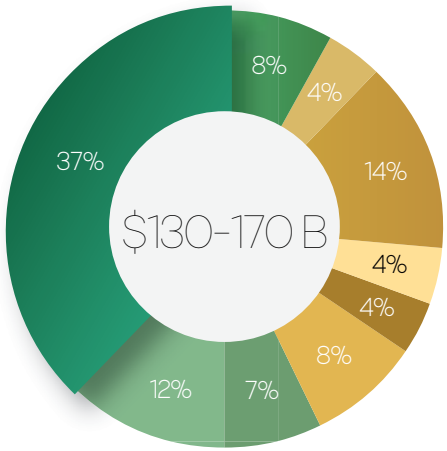
22% India's share of global ER&D sourcing market in 2030 **VS** 17% In 2023

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; BCG Analysis

Software, Automotive and Semiconductor sectors are expected to contribute 60%+ of India's share of ER&D sourcing by 2030



2023E Share



2030F Share

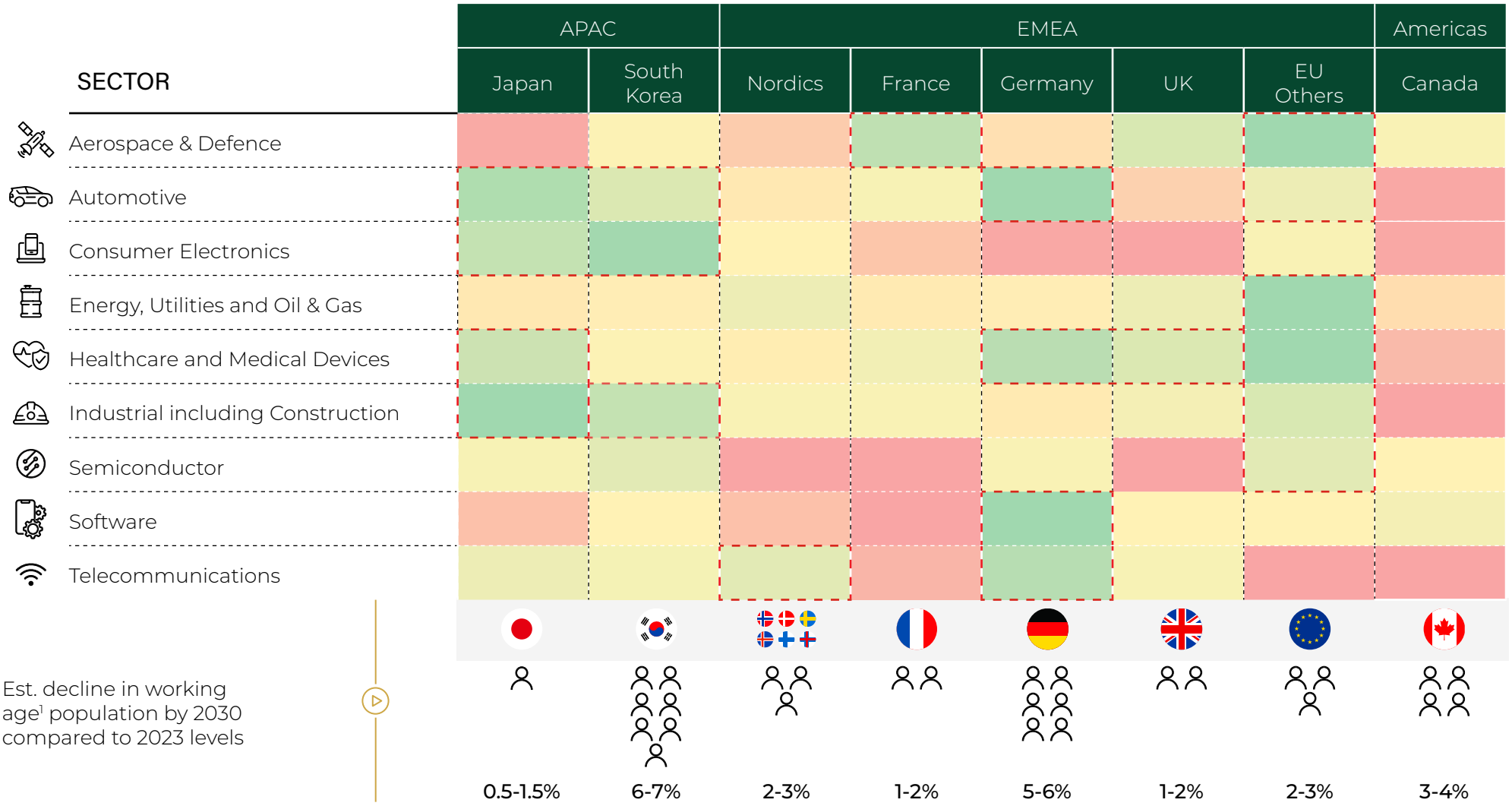
- Aerospace & Defence
- Automotive
- Consumer Electronics
- Energy, Utilities and Oil & Gas
- Healthcare and Medical Devices
- Industrial including Construction
- Semiconductor
- Software
- Telecommunication

- Software to retain the highest share, followed by Automotive inline with the global sourcing trend
- Semiconductor ER&D sourcing share to see the highest jump (9% to 12%) to become the third highest contributing sector by 2030 driven by the global push to use India as a base for Semiconductor manufacturing and which is further accelerating a consolidated design + manufacturing ecosystem in India

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; BCG Analysis

India expected to see additional opportunities to grow its penetration...

RELATIVE SOURCING OPPORTUNITY SIZE FOR INDIA FOR NON-US GEOGRAPHIES (2023E)



Est. decline in working age[1] population by 2030 compared to 2023 levels

Note: Digital ER&D offerings recommended for the intersections highlighted; 1. Population in the age group of 15-64 years

Source: BCG ER&D Survey 2023 n=281, UNDP zero migration scenario; BCG Analysis

Sector X Region intersection : Opportunity for India

… at the intersection of specific sectors & developed economic regions (excluding US)

% Digital Engineering in sector (2023)	% Digital Engineering in sector (2030)
40%	48%
39%	61%
51%	54%
20%	42%
55%	65%
32%	53%
49%	67%
100%	100%
67%	73%

- Automotive: Largest Digital engineering spender, esp. Germany, Japan & South Korea
- Consumer electronics: Japan and South Korea provide an opportunity due to their demographic shift
- Energy, Utilities and Oil & Gas: Digital transformation across Europe (Switzerland, Netherlands, Italy etc.)
- Industrial: Companies in South Korea and Japan similarly offer digitization opportunity
- Software: Germany's thriving software industry offers opportunity for collaboration and innovation
- Telecom: Germany provides upcoming opportunity owing to sectoral trends
- Healthcare & Medical Devices, Aerospace & Defence and Semiconductor: Europe as a key region for innovation and Engineering partnerships

Low High

Region's ER&D spend share within the sector

However, to achieve the expected growth, India needs to focus on two key growth challenges

01 Skill Synchronicity

Focus on identifying ER&D skillsets required for industries, and developing an ecosystem to train people for these skills at scale

02 Emerging Geo Contenders

Countries emerging as contenders, with demographic advantages and skill expertise

Source: BCG Analysis

01 Skill Synchronicity

Laser-sharp focus on identifying skill-sets required for industries, and developing an ecosystem to train people for these skills

02 Emerging Geo Contenders

Countries emerging as contenders, with demographic advantages and skill expertise

Source: BCG Analysis

India has an inherent advantage – Skillset @ Scale…

LARGE TALENT POOL

66%
Current working age population

80-85K digitally skilled graduates

~2M
STEM talent pool

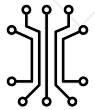
1 in 10 analytics professionals worldwide from India

~7M
Total fresh talent in India(UG+PG)

32% growth YoY indigital talent

PRESENCE OF A RICH AND VIBRANT ECOSYSTEM

~50K
active startups in India



~25-27K active tech start-ups
3000+ in deep tech (such as AI, IoT, and AR/VR)

1100+
Universities

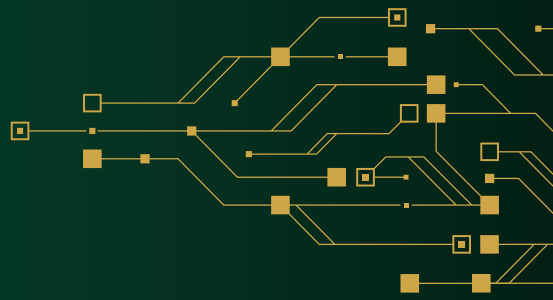
135+ global organization investors collaborating with start-ups

>US$8M
funding to startups through accelerator programs by GCCs

US$39.5BN PE/VC investments to start-ups in 2020

Source: Nasscom "GCC value proposition" report, Nasscom "GCC India landscape: 2021 & beyond" report, BCG analysis; Rise of deep-tech: India home to 3,000+ AI, Big Data and blockchain start-ups, says Nasscom – BusinessToday; How PE Investing in India Has Evolved | Portfolio for the Future | CAIA; India: number of universities | Statista; India: undergraduate degree completion number | Statista; Nearly 2/3rds of Indians are of working age, between 15 and 59 | India News - Times of India (indiatimes.com); Digital India | IBEF

Across sectors survey respondents have mentioned digital skills as key while also needing specific industry skills exposure



SECTOR	DIGITAL SKILLS	INDUSTRY SKILLS
Aerospace	**Data Analytics:** • AI/ML and digital technologies • Big data and analysis • Data analysis using tools like Python, R, or SQL **Software skills:** • At least one programming language (Java, C++, Python, etc.) • Software development methodologies	• **Mechanical Engineering:** Mechanics, Materials, Testing & Prototyping • **Embedded/Electrical Engineering:** Embedded Systems, Verification and Validation
Automotive		• **Mechanical Engineering:** Mechanics, CAD software for 2D/3D modeling, Testing & Prototyping • **Electrical:** Electrical circuit design, Microcontroller-based systems
Consumer Electronics		• **Embedded & Electrical Engineering:** Microcontrollers and their programming & applications, Electrical circuit theory and basic component
Energy, Oil & Gas, and Utilities		• **Mechanical Engineering:** Mechanics, Geophysics
Healthcare and Medical Devices		• **Biomedical skills:** Biotechnology/Biochemistry, Electric System of the human body
Industrial incl Construction		• **Mechanical Engineering:** Mechanics, CAD software for basic 2D/3D modeling, Materials
Semiconductor		• **Embedded Engineering:** Microcontrollers and their applications; Analog, Digital, and mixed-signal circuit design & VLSI, Electronic Design Automation (EDA) tools
Software		• **Project Lifecycle Management:** Product documentation and data management • **Software engineering:** Protocols (OAuth etc.), and security testing
Telecommunication		• **Embedded & Electrical Engineering:** Microcontrollers and their applications, Technologies such as DWDM, CWDM, SONET, OTN, Ethernet, IP, GMPLS,5G (incl. ORAN)

Source: BCG ER&D Survey 2023 n=281; BCG Analysis

The future ER&D skills that India needs will differ from the current ones...

Meet Nitin!

Nitin is a Senior Engineer with a leading Automotive ER&D player in Bangalore, working with them since 2015.

He is a B.Tech. in Mechanical Engineering from NIT. As the automotive industry went through the digitization wave with his firm focusing on ADAS, etc., he upskilled himself with a certification course in "Introduction to Internet of Things (IoT) and Connected Cars" from NASSCOM's futureskills platform. As he was also promoted to Team Manager, he took-up internal trainings in data analytics, and AI to hone his functional skills.

He is looking to hire Automotive ER&D engineering with focus on AI applications in his team to Level 4 ADAS for his company.

Source: BCG ER&D Survey 2023 n=281; BCG Analysis

...even in traditionally conservative sectors like Oil & Gas

Meet Maria!

Maria, a Software Engineer employed by an ESP, has been collaborating with an Oil & Gas company based in Mumbai since 2021.

She is a B.Tech. in Computer Engineering from a leading private engineering college in India. She had a month-long onboarding process to help learn about O&G value chain, plant operations, analytics & coding for digital twin, etc. Her job includes developing, updating and maintaining digital twin of the plant along with her team to simulate development, operations, etc.

As the digital wave permeates traditional industries like Oil & Gas, companies like hers are increasingly seeking computer science and data science graduates with domain expertise for recruitment.

Source: BCG ER&D Survey 2023 n=281; BCG Analysis

However, it is important to ensure that talent supply meets the demand from the industry

INDIAN ACADEMIA SHOULD SEEK BROADER COLLABORATIONS WITH THE PRIVATE SECTOR TO BETTER UNDERSTAND MARKET DEMANDS, DEVELOP CURRICULA TAILORED TO THE NEEDS OF ER&D

Organizations have established alliances with academic institutions on specific initiatives, including faculty upskilling, student internships, curriculum revision workshops, and research incubation

Example

- Emphasis on internships to foster practical skill development within academic programs, resulting in a robust talent pipeline for the industry. Additionally, harnessing events like hackathons for rapid solution development to achieve similar outcomes as internships
- Conducting curriculum design workshops from industry for subjects requiring continuous updates and enhancements
- Promoting shared investment and collaboration in research and development infrastructure between industry and academia

These sample collaborative initiatives aim to deliver sustainable benefits for skill enhancement among India's ER&D workforce, amplifying the collective potential of academic and industrial partnerships.

INDIA'S SKILLSET IN SECTORS WHERE IT REMAINS DOMINANT SUCH AS SOFTWARE SHOULD REMAIN COMPETITIVE

- Skillsets of ER&D talent should remain competitive and adaptable to the changing requirements for sectors where it holds dominance (Software) and those expected to experience a surge in digitalization (Automotive, Industrial etc.)

Source: Press Search; BCG Analysis

01 Skill Synchronicity

Focus on identifying ER&D skillsets required for industries, and developing an ecosystem to train people for these skills at scale

02 Emerging Geo Contenders

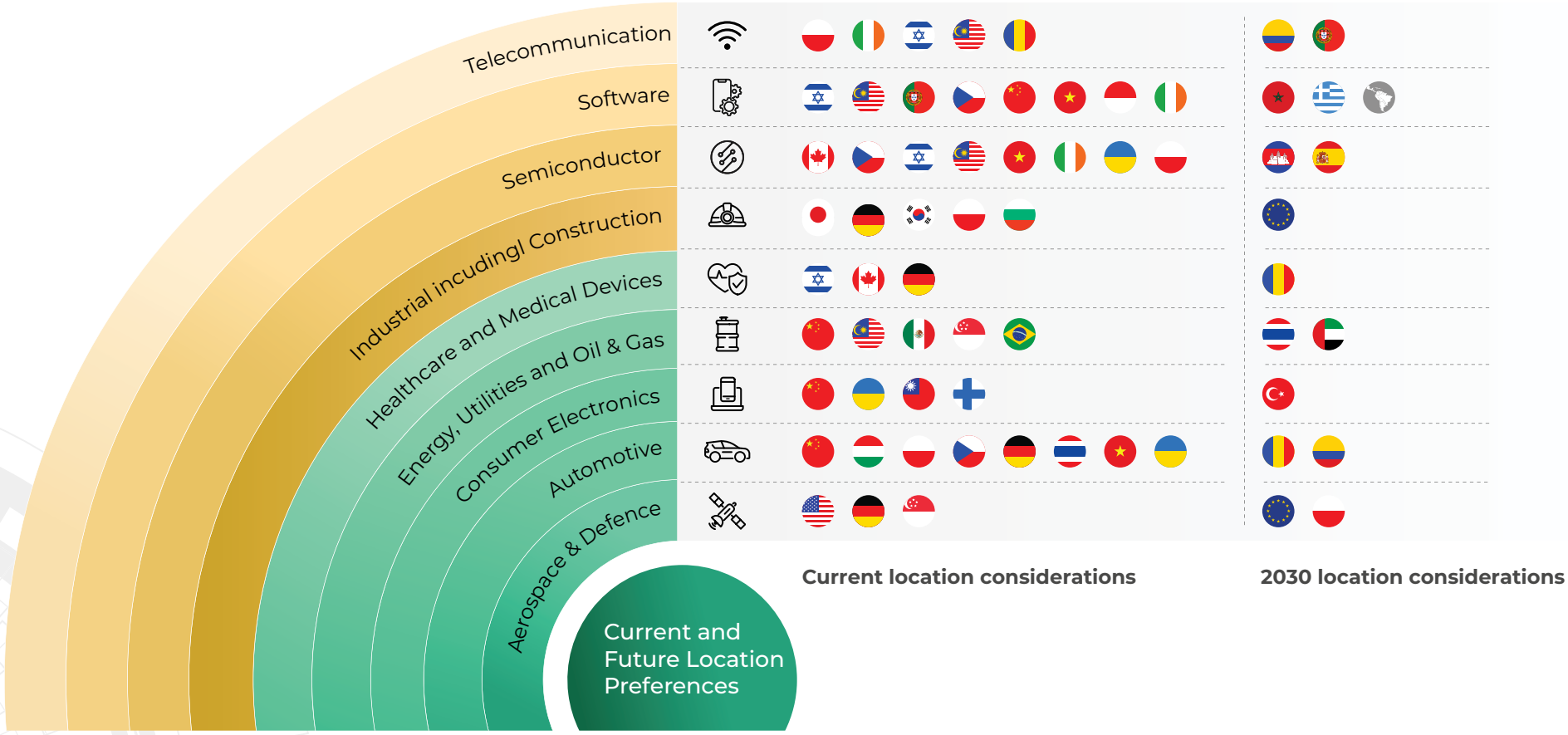
Countries emerging as contenders, with demographic advantages and skill expertise

Source: BCG Analysis

Organizations are actively considering additional sector-specific sourcing locations

CHART: PREFERRED ALTERNATIVE LOCATIONS TO INDIA FOR CURRENT AND FUTURE ER&D CENTERS BY SECTOR

Non-Exhaustive



Source: : BCG ER&D Survey 2023 n=281; BCG Analysis

India's share of sourcing market faces competition from nearshoring preference and presence of attractive alternatives backed by their respective investment policies

Nearshoring
Poland, Bulgaria & Mexico identified as preferred future locations acrossmost sectors

POLAND

- Poland boasts a significant proportion of individuals aged 25–34 holding masters and advanced degrees, with a rate of 43%, surpassing both the EU average and several notable countries, including Germany (35%), Italy (29%), Hungary (31%), Bulgaria, and the Czech Republic (33%)
- Poland's student population exceeds 14 million, surpassing the combined total of students in all other Central and Eastern European countries
- However, average salary in Poland remains at 30% of Germany's and 35% of France's average salaries

BULGARIA

- Country evolving from a cost-effective near-shoring location, to a well-recognized European digital hub

MEXICO

- In addition to manufacturing capability, many US companies are considering Mexico or Central America as future ER&D Centres

Source: BCG ER&D Survey 2023 n=281, Press Search; BCG Analysis

ER&D location strategy influenced by government policies; Sectoral policies attracting investments through ecosystem development and financial incentives push

National R&D policies & initiatives, in addition to spillover effect of manufacturing policies attracting investments to new destinations

THAILAND

- Thailand Science Park (TSP) was set up with a mission to promote innovation development and R&D activities in private sector
- TSP builds ecosystem to promote and support R&D linkage between government & private sector and stimulate creation of new technology businesses
- National Science and Technology Development Agency (NSTDA) and corporates are closely located in the park, giving corporates access to highly-skilled personnel

MALAYSIA

- Malaysian leaders, including PM, have reinforced Malaysia as a regional hub for aerospace & maritime industries in an international exhibition[1] held in the country
- National Energy Policy 2022-2040 launched; focus on developing and supporting private sector contribution in this space, esp. towards renewable energy, green tech, etc.

COUNTRY PREFERENCES BASED ON IP AND SECURITY CONSIDERATIONS

- Sectors such as Aerospace (with close ties to Defence ER&D), Consumer Electronics and Semiconductor which are of significant national security interest are expected to show bias towards few destinations over others

1. Langkawi International Maritime and Aerospace (Lima'23) exhibition; **Source:** BCG ER&D Survey 2023 n=281, Press Search; BCG Analysis

Select examples of sectoral ER&D location preferences (I/III)

AEROSPACE & DEFENCE

- USA: R&D centers present in regions with robust Aerospace & Defence industry, driven by talent and local market demand; e.g. A Non-US player established an ER&D center in the US to deliver innovative and cost-effective aerospace components to US and global market
- Niche talent requirement & partnerships – in fact, firms in our study strongly agree that "Technical industry expertise" is an important factor in choosing the ER&D location; e.g. Companies from large aerospace & defence markets from Europe considering setting up centers in USA
- South Korea: Large US-based aerospace & defence player set up R&D center in South Korea to collaborate on tech development on advanced production systems, urban air mobility, aerospace semiconductors

AUTOMOTIVE

- Thailand: Present across similar cost-effective R&D geographies
- Colombia: Presence of Automotive manufacturing in the country or in vicinity highly correlates with ER&D location preference
- Germany: Green-tech (EV) agenda encouraging innovation, resulting in ER&D centers evolving in developed economies where broader consumer uptake (consumer adoption of xEV) is also driving innovation and availability of talent
- Hungary: European cost effective centres are also evolving, focusing on AV and EV; examples of firms especially focusing on sensor tech; provides incentives to attract R&D investments

CONSUMER ELECTRONICS

- Asia: Asia continues to be a key ER&D location for CE firms with few regional shifts in recent times:
  - » Regulations set forth by Government: Japanese Govt. export restrictions on critical semiconductor equipment has caused CE industry to be wary of ripple effect on adjacent industries
  - » IP concerns: Challenges with IP protection as some countries mandate disclosure of technical details
- Finland: Talent with advanced skills related to sensor and measurement technology, microelectronics, integrated systems and printed electronics

Source: BCG ER&D Survey 2023 n=281, Press Search; BCG Analysis

Select examples of sectoral ER&D location preferences (II/III)

ENERGY, UTILITIES AND OIL & GAS

- Germany: As the world moves towards renewables, North American companies are looking at European counterparts for renewable tech. Example: Germany has achieved close to 55% RE contribution in its Electricity mix
- Brazil and Malaysia: Traditional O&G ER&D centres see diversification into green tech and renewables ER&D
- Other Asian hubs: Technology seen as key driver for safety in O&G operations, benefiting Asian tech hubs
- Others: R&D leaders such as Singapore offer new solutions in offshore O&G tech(e.g. - Submersible Crane)

HEALTHCARE AND MEDICAL DEVICES

- Hungary: Leading hub for healthcare R&D given biotechnology is one of the top 5 priority sectors with start-ups and subsidies, and tax credits from govt which encourages R&D investment
  - » In the past 10 years, # of people working in pharma sector has increased by 1.5x in Hungary
  - » The Hungarian Government provides cash subsidies for R&D activities based on individual government decisions throughout Hungary
  - » A new R&D Facility in Hungary will Double Annual Testing Capability for pharma

INDUSTRIAL INCLUDING CONSTRUCTION

- Bulgaria: Apart from Hungary & Poland, Bulgaria is emerging as a popular sourcing destination; country evolves from a cost-effective near-shoring location, to a well-recognized European digital hub
  - » Operations of Bulgarian tech companies have moved higher up the value chain from support and services to product creation, innovation, research and development

Source: BCG ER&D Survey 2023 n=281, Press Search; BCG Analysis

Select examples of sectoral ER&D location preferences (III/III)

SEMICONDUCTOR

- While India is the leading integrated design ER&D hub for the global Semiconductor sector (esp. US) companies, other alternatives are emerging
- Israel: Availability of Talent driving ER&D sourcing
- Ireland: Major firms have announced investments into ER&D centres, with country driving innovation in the sector

SOFTWARE

- SEA and Eastern Europe: Due to its asset light nature, companies in the sector are leveraging wide number of geographies for their ER&D centres including regions where market expansion is expected
- LatAm: Multiple global geographies with stable internet infrastructure and engineering talent are turning into software hubs

Increased commodization seen in the sector as Engineering development is possible from low cost centres while R&D is concentrated in advanced centres such as US, Germany, India and China.

TELECOMMUNICATION

- Europe: Multiple ER&D centres in mainland Europe playing a significant role in the supporting ER&D in the sector
- Asia: While Hardware innovation takes places close to HQ or through ESPs, software driving the underlying Telecom hardware being developed and maintained by ER&D centres
- Israel: New innovations such as 6G to be focus area for R&D centres and talent availability to drive ER&D center expansions

Source: BCG ER&D Survey 2023 n=281, Press Search; BCG Analysis

04

Growth Imperatives for India

India should focus on growth imperatives in 3 key areas

1

INFRASTRUCTURE & POLICY SUPPORT

Improving the policy and infrastructure required for ER&D to attract new collaboration opportunities and drive innovation

2

BRANDING & PROMOTION

Support branding and marketing for ER&D across sourcing markets while promoting a common collaborative agenda from the Indian industry

3

SKILLING & RESEARCH FOCUS

Industry, Academia and Government to work together to improve talent employability and research quality

1 Infrastructure Development & Policy Support to drive innovation and improve competitiveness

	INFRASTRUCTURE-RELATED		POLICY-RELATED	
INITIATIVES	Establish Digital Engineering Innovation Hubs	Formation of 'ER&D Industry Labs'	ER&D related start-up ecosystem support to drive coordination between Start-ups, GCCs, ESPs and Academia	Incentives for large-scale manufacturing players to move part of ER&D to India
DESCRIPTION	• Establish **Digital Engineering Innovation hubs** responsible for collaboration between Academia and Industry to provide innovative digital engineering solutions **E.g. –** NASA's Digital Engineering Design Centre operated by the UTEP (University of Texas at El Paso)	• Establish **Industry-specific Lab facilities** to solve industry-level problems at scale E.g. – Labs within entities like ARAI (Automotive Research Authority of India) help standardize testing for vehicles	Facilitate Funding & partnership opportunities for start-ups: • Encourage **collaboration between ER&D focused start-ups and GCCs, ESPs** through structured investment policy and programs • **Milestone-based ER&D funding program** for startups • Replicate success of models like **IIT-Madras Research Park** which includes **sector-specific incubators (e.g., Robotics, EV Powertrain, Battery Tech)** for deep-tech start-ups (detailed case study on next page)	• Encourage manufacturing heavy players to **also scale-up ER&D** activities in India • Encourage sectoral market leaders (across Auto, Telecom, Consumer Electronic, Aerospace) to **shift larger share of their global design work** to India **E.g. –** IT Hardware Manufacturing PLI Scheme 2.0 (of 2023) provides for 1% additional incentive if both design and manufacturing are done in India. These are covered under Design Linked Incentives (DLIs)

Source: Expert Inputs, Press Search; BCG Analysis

IIT-Madras Research Park (IITMRP)| R&D focused innovation and research program

BACKGROUND

IIT-Madras has successfully built a knowledge and innovation ecosystem where ideas can not only be generated, but also incubated and scaled

PROBLEM STATEMENT

- Companies looking set up R&D facilities in India often faced several challenges – lack of supporting ecosystem, lack of skilled resources, poor lab and test facilities, etc.
- IIT-Madras also wanted to set up a platform for incubating innovative ideas coming from students

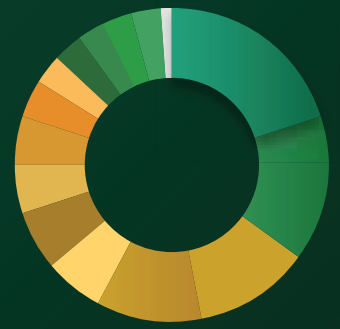
DESCRIPTION OF SOLUTION

- IITMRP was started in 2010
- Today it has 16 Departments, over 600 Faculty, 3,500 Research Scholars, Hitech Laboratories, testing facilities and Innovation Centres
- Centres of Excellence at IITMRP partner with companies/startups for specific research and also share their lab resources with partners and startups

IMPACT

- 70+ R&D partners across 17 sectors
- 200+ start-ups incubated across 13 sectors
- 1300+ patents filled

FOCUSED RESEARCH AREAS FOR IITMRP CLIENTS



- 20% ITES & Consulting
- 15% Mech Eng & Design
- 12% Automotive & Energy
- 11% Telecom
- 6% Power
- 6% Big Data & Analytics
- 5% Social Enterprises
- 5% Financial Services
- 4% Incubators
- 3% Product Eng & Design
- 3% IP Services
- 3% Bio-Medical Devices
- 3% Professional Bodies
- 3% Technology & Policy
- 1% Bio Process

TCS TITAN BHEL CATERPILLAR

Source: IIT-Madras website; BCG Analysis

2 Branding & Promotion - India's ER&D achievements and potential need to be promoted and amplified across the globe

INITIATIVES	DESCRIPTION
Establish Digital expo to showcase India ER&D	• Launch **digital expo to showcase India's ER&D strengths,** credentials and investment opportunities to connect international audience with the Indian ER&D community • Facilitate direct **contact** with international ER&D players, government bodies and Industry leaders for **networking and investment opportunities**
Capability Roadshows in key ER&D sourcing markets	• Showcase Indian ER&D story by **organizing Capability Roadshows** in key ER&D sourcing markets • Roadshows to include demos, industry sessions, panel discussions, etc. by **Indian startups, GCCs and ESPs**
Showcase Brand 'ER&D India' at global marquee events	• Identify critical **sector-specific marquee events** to showcase Brand "ER&D India' before high-profile industry leaders and government representatives **E.g. -** Mobile World Congress (Telecom-specific) or CES in Las Vegas (Technology-specific)
Delegation management for international tradeshows	• **Actively manage the selection and composition of delegations** (comprising of relevant ER&D experts) from various sectors to participate in prominent international ER&D events, such as Trade Expos and ER&D summits to promote India as an ER&D destination
Amplification through ad agencies/digital marketing firms in key sourcing markets	• **Promote brand "ER&D India' through specialized B2B ad agencies**/ digital marketing agencies in priority markets for ER&D sourcing

Source: Expert Inputs, Press Search, Govt. of India, Invest India; BCG Analysis

Israel Innovation Authority + CERN| Israel's focus on promoting ER&D expertise in Bio-tech leads to collaboration with CERN

BACKGROUND

CERN has partnered with Israel's Innovation Authority (IIA) – Partnering with several Israeli companies to develop real-world applications for cutting-edge research being done at CERN

PROBLEM STATEMENT

- The Knowledge Transfer group at CERN has initiated a pilot programme in collaboration with the Israel Innovation Authority
- The purpose of the programme is to explore how cutting-edge Israeli companies and institutes can embrace specific CERN technology and know-how to fuel their innovation and help drive positive impacts for society

DESCRIPTION OF SOLUTION

- The Israel Innovation Authority funded 4 companies to collaborate with CERN:
  - » CEVA (neural networks)
  - » All-In-Image (Machine Learning in Medicine)
  - » ImmunoBrain Checkpoint (Cell simulation)
  - » HIL Applied Medical (Proton Therapy solutions)
- These companies have partnered with CERN to develop practical use-cases for CERN technologies

IMPACT

- Israel's focus on promoting ER&D expertise in certain sectors led to recognition and collaboration with CERN
- Scientific advances in accelerators, detectors and computing have led to positive impacts on medical and biomedical technologies
- 3 out of the 4 programs are related to medical and biomedical applications

Source: CERN website; BCG Analysis

3 Graduate skill deficit and quality of research output requires immediate attention

INITIATIVES

DESCRIPTION

Pilot to launch ER&D curriculum in Top 100 engineering colleges	Industry-Academia collaboration to be extended to Tier-2 colleges	Incorporate industry inputs with research priorities of National Research Foundation (NRF)
• Initiate a pilot program introducing an ER&D certification curriculum in addition to degree programs across India's top 100 engineering colleges • Program to lead to specialized training and qualification for ER&D skillset; Curriculum for pilot program to be reviewed periodically with industry experts	• Need to identify research areas, refine curriculum and act as conduit between Industry and Academia to identify next set of ER&D-ready engineers • Collaboration between Industry and Academia required to move beyond top-tier institutes to improve quality of graduate pool • This initiative will also aid improvement in research quality and intensity	• Align industry ER&D inputs with research priorities of national R&D initiatives (like NRF) **E.g.** – Israel's Research & Development fund offers the largest financial incentive for Israeli corporations' R&D activity

Source: Expert Inputs, Press Search, Govt. of India, Invest India, Union Budget – Saptarishi Priorities; BCG Analysis

Taiwan: STEM to STEAM model| Curriculum redesign to increase enrollment in STEM disciplines at secondary school level

BACKGROUND

Taiwan introduced STEAM (science, technology, engineering, arts, and mathematic) to attract more students to STEM at the secondary level education and placed great emphasis on arts and design-related disciplines

PROBLEM STATEMENT

- Gender disparities in the interest towards STEM disciplines are substantial
- Research from United Nation's Educational, Scientific, and Cultural Organization (UNESCO) shows that female students represent only 35% of all students enrolled in STEM-related degrees worldwide
- Lack of women participating in STEM would hinder Taiwan's economic development and reduce the diversity of perspectives and the ability to offer different answers and breadth to new problems

DESCRIPTION OF SOLUTION

- STEAM can be understood as the integration of STEM with arts, such as design, creative thinking, and any interdisciplinary education approach, and emphasizes the synergy of creativity and problem-solving skills
- In order to attract more students to STEM careers, Taiwan changes its curriculum to incorporate STEAM into primary school education

IMPACT

- Eventually, the country's secondary education system moved to a more gender-equal, dynamic, and interdisciplinary STEAM approach
- As a result of this program, Women's enrollment and interest in STEM-related disciplines increased

Source: MDPI database; BCG Analysis

05

Appendix
Mega Trends Deep dive

5 Mega trends that will affect ER&D

1
DIGITAL ENGINEERING: INCREASING PROMINENCE

2
CLIMATE & SUSTAINABILITY AMBITIONS KEY DRIVER FOR ER&D SPENDS

3
AI AUGMENTATION: GENERATIVE ENGINEERING

4
SERVICE-ORIENTATION: SHIFT IN ENGINEERING MODEL

5
POPULATION& SKILL INVERSION: SHIFTING SKILLS AND TALENT POOLS

Source: BCG Analysis

1

DIGITAL ENGINEERING: INCREASING PROMINENCE

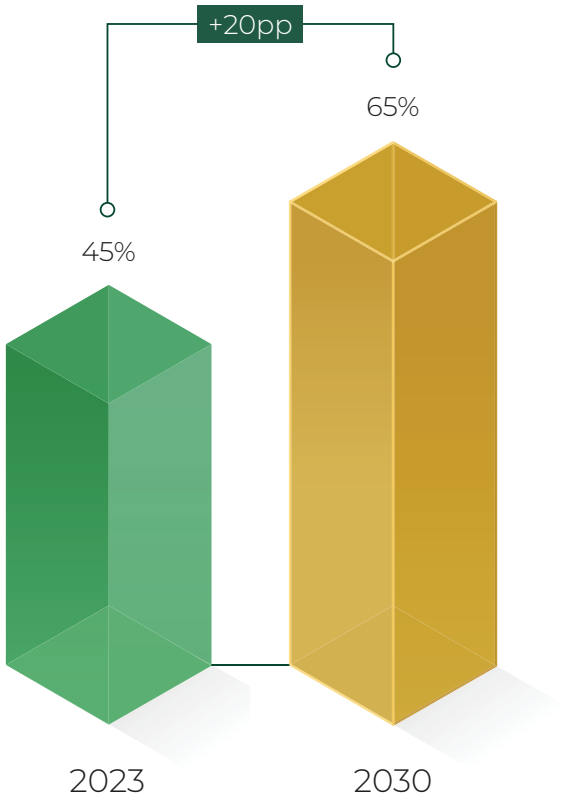
2

3

4

5

ER&D firms are moving from traditional pillars of mechanical, electrical, etc. to now focus on digital engineering (software, data analytics & embedded)



% of Global Business ER&D spend on digital engineering

DEVELOPMENTS IN DIGITAL ENGINEERING…	…LEADING COMPANIES TO PIVOT TO NEW CAPABILITIES
Constant innovation leading to more demanding customer expectations	New product categories to be developed within existing portfolio (e.g., – Connected cars, Smart factories) Data analytics capabilities to constantly reinvent product categories and launch more personalized products
Increasing reliance on Software and coding - Large quantum of data creation, capture, reporting and dissemination	Data protection measures to be put in place to ensure data security and compliance
Virtual testing (Digital Twin)	Reduced costs and lead-time for R&D

Source: BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Digital engineering is transforming ER&D, enhancing efficiency, cost-effectiveness, and the ability to deliver groundbreaking solutions across sectors

Illustrative not exhaustive

Sector	Use cases for Digital Engineering	Implications
Aerospace & Defence	• Unmanned aerial systems • Development supported by AR/VR simulation	• Knowledge of aerodynamics supported with knowledge of ML for inducing autonomy in UAS • High proficiency in AR/VR development platforms like Unity
Automotive	• Autonomous vehicles • Vehicle connectivity/ infotainment features • Digital Twin for testing purposes	• Enhanced coding skillsets required for writing code for autonomous vehicles and advanced S/W features
Consumer Electronics	• AV/VR enabled entertainment • Connected devices	• Expertise in designing and developing circuitry for AV/ VR devices and connected electronics along with dev platforms
Industrial including Construction	• Additive manufacturing (3D printing) • Industrial IoT • Digital Twin	• Familiarity with different 3D printing technologies like FDM, SLA, SLS, etc. • Familiarity with cloud platforms & understanding of IoT security protocols
Semiconductor	• Automated customer experience (with AI enablement) • Virtualization	• Knowledge of software-defined networking (SDN) and network function virtualization (NFV) along with rich coding skillset
Energy	• Smart grid in power & utilities segment • Digital (AI/ML, etc.) in O&G value chain	• Higher sourcing in sector given Energy is a traditional sector and internal talent is limited

Source: Press Search; BCG Analysis

Maruti Suzuki | Energy Management IoT solutions

ABOUT THE COMPANY

Company: **Maruti Suzuki**
Megatrend: **Digital Engineering**

INNOVATION BRIEF

Equipment-level energy analytics solution that combines non-invasive & maintenance-free sensors and data-driven energy analytics to enable deeper visibility into production efficiency using site's energy consumption on real time basis. Urja.io is the co-creator

NEED OF ER&D

- Unavailability of equipment level real time energy consumption
- Difficulty in wastage identification
- Manual Process tedious and time taking

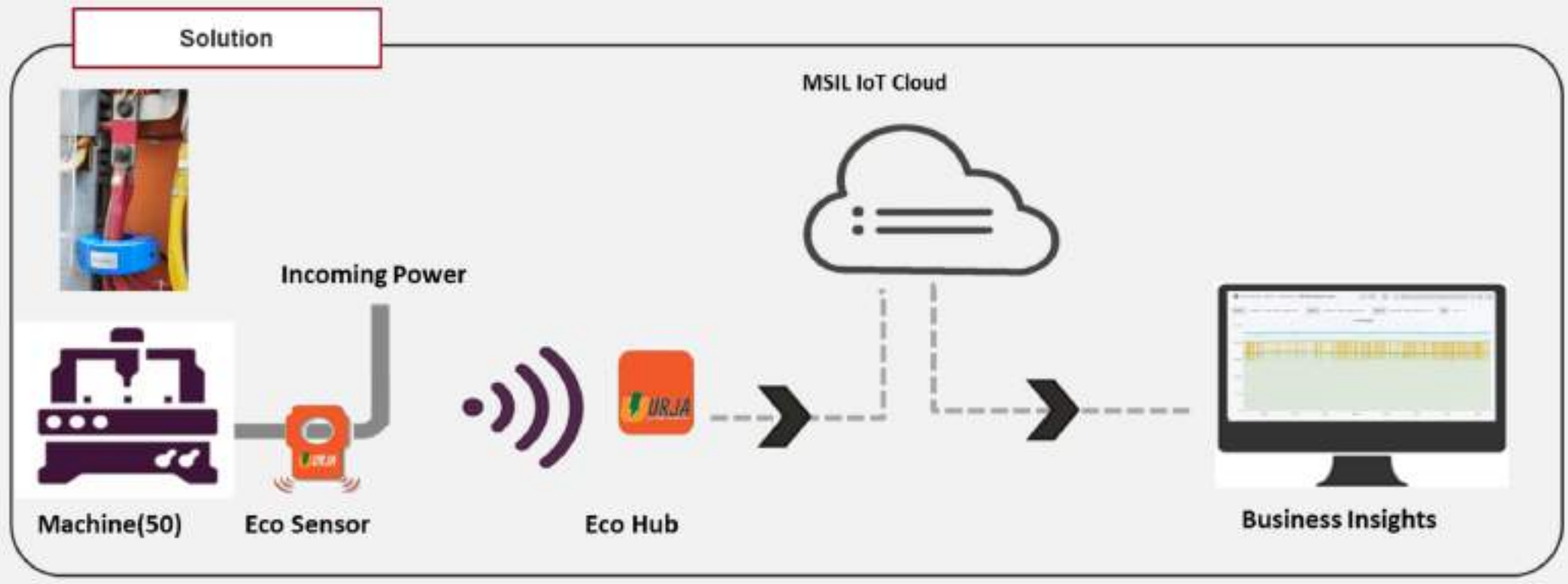
DESCRIPTION OF SOLUTION

- **IoT Energy sensors** to capture equipment level data
- Non-Intrusive, **Plug and Play**
- **24x7 Real time data**

IMPACT

- Yearly Cost Savings – Energy savings of **INR 2 Crores** and Productivity savings of **INR 2.5 Crores**
- **Reduced Downtime** of the machine by predictive analytics

Maruti Suzuki | Energy Management IoT solutions



HCLTech | Twinalytics

ABOUT THE COMPANY

Company: **HCLTech**
Megatrend: **Digital Engineering**

INNOVATION BRIEF

Twinalytics converts physical assets to digital, integrates ecosystems, provides a single-source-of-truth, and delivers a data-driven, human-centric experience

NEED OF ER&D

- A building's entire lifecycle is estimated to be responsible—both directly and indirectly—for around 40% of global CO2 emissions
- In addition to the process-related emissions, the carbon generated throughout the building lifecycle is also a large contributor
- Inefficiencies and poorly managed buildings are leading to wasted energy and higher CO2 emissions, leading to increased financial costs and reduced building occupant satisfaction

DESCRIPTION OF SOLUTION

- Twinalytics **enables customers to assess business value and sustainability, providing a roadmap to a sustainable future.** It includes data and analysis for energy, thermal comfort, solar, daylight, and wind loads
- Twinalytics **combines IoT and BIM for a smart, real-time digital twin** that enhances decision-making and evolves dynamically

IMPACT

- **Digital Factory:** Real-time insights, enhanced efficiency
- **Carbon Footprint:** Energy analysis, AI/ML predictions
- **Green Building:** Productivity strategies for environmental impact reduction
- **Human-Centric:** Boost workforce productivity, safety, and well-being through thoughtful environmental planning
- **Building LCA:** Enables our customers to get certifications like LEED & BREEAM

SUSTAINABILITY KPIS TRACKED BY TWINALYTICS

HIGH LEVEL ARCHITECTURE OF TWINALYTICS

REALTIME PERSONA BASED INSIGHTS

DEVELOPED PHYSICS BASED MODELS IN BIM - REVIT

SENSOR INTEGRATION & DATA ENABLEMENT IN 3D SPACE

5 Mega trends that will affect ER&D

1

2

CLIMATE & SUSTAINABILITY AMBITIONS KEY DRIVER FOR ER&D SPENDS

3

4

5

Source: BCG Analysis

Climate & Sustainability ambitions key driver for ER&D spends

COMPANIES HAVE A SIGNIFICANT CLIMATE IMPACT…

Fortune 500 companies are estimated to be responsible for around **27% of global emissions**[1]

…AND STAKEHOLDERS ARE APPLYING PRESSURE TO ACT…

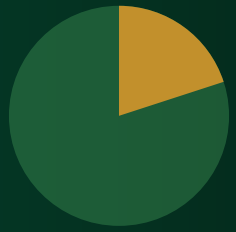
127 countries nowhave restrictions on single-use plastic

62% take sustainability into account in their portfolios[2]

2/3 applicants are more willing to apply for and accept jobs from a sustainable company[3]

…CREATING NEED FOR BOLD TARGETS AND SUPPLY CHAIN TRANSFORMATIONS

A Fifth Of World's Largest Companies Committed To Net Zero Target



1. Recapture Carbon, as of 2019 2. References personal investors (IBM); 3. IBM; 4. Forbes
Source: BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Several areas of global industry under transition to minimize impact of climate change on economic activity

CLIMATE CHANGE MITIGATION

Decarbonisation, abatement of GHG emissions and removal of GHG from the atmosphere

1. Power generation	2. Electrified solutions	3. Fuel and material switch	4. Efficiency	5. Demand mgmt. and circularity	6. Carbon capture, utilization, or storage
1.1 Renewables tech and services	2.1 Electrified private transport	3.1 Hydrogen	4.1 Building energy efficiency	5.1 Power & heat co-generation	6.1 Carbon capture, utilization or storage (CCUS and DAC)
1.2 Nuclear power	2.2 Electrified public transport	3.2 Sustainable fuels	4.2 Industrial heat optimization	5.2 Waste-to-energy solutions	6.2 Methane and flare gas capture
1.3 Utility scale storage	2.3 Electric charging infrastructure	3.3 Biomass as heating fuel	4.3 Motor & machinery efficiency	5.3 Recycling & resource recovery	
1.4 Power networks & transmission	2.4 Heat pumps	3.4 Low-carbon building materials			
1.5 Distributed energy	2.5 Electric arc furnaces (iron & steel)	3.5 Sustainable packaging			
	2.6 Marine electrification	3.6 Climate-focused materials mining			

Source: BCG Analysis

CLIMATE CHANGE ADAPTATION & RESILIENCE

Resilience of key systems and infrastructure against extreme weather scenarios caused by climate change

7. Offsetting and compensation

- 71 Nature base solutions
- 7.2 Negative emission technologies
- 7.3 Carbon markets & services

8. Enablement solutions

- 8.1 Carbon measurement & accounting
- 8.2 Leak detection and repair

9. Food & agriculture

- 9.1 Agriculture Technology
- 9.2 Alternative proteins

10. Coastal resilience

- 10.1 Infra-structure resilience
- 10.2 Flood & water mgmt.
- 10.3 Early warning systems

11. Nature preservation

- 11.1 Catas-trophe risk management
- 11.2 Eco-system conservation & restoration

12. Water

- 12.1 Industrial water treatment and technologies
- 12.2 Municipal water treatment and technologies
- 12.3 Water equipment enhancement technology
- 12.4 Water harvesting and drip irrigation
- 12.5 Other efficient water infrastructure

Three archetypes emerges to address climate & sustainability challenges which will collectively drive ER&D spends aimed at C&S

Types of approach	GREEN TRANSITION ENABLER	GREEN TECH PRACTITIONER	TRANSITIONING CARBON EMITTER
	Industries with inherent low carbon footprint and can reduce global emission indirectly (e.g., new teleconferencing software)	Industries with some carbon footprint yet can reduce global emission directly, esp. as part of a green infrastructure (e.g., solar PV manufacturers)	Industries from emission-intensive sectors with high carbon footprint (e.g., Green innovations in Oil & Gas companies)
Areas of impact	• Impact mainly a result of emissions reduced associated with the use of its products	• Impact a mixture of the industry's GHG emission reduction efforts and the result of emissions reduced associated with the use of its products	• Climate impact results predominantly from its own green transition
Impact on ER&D players	• Developing products, technologies, and software that directly reduces emissions • Cross-industry ER&D collaboration	• ER&D for more efficient, durable, and cost-effective RE technologies • ER&D efforts for seamlessly integrating RE technologies into larger energy systems (grid etc.)	• ER&D activities to meet evolving regulations and environmental standards • Green innovations to address new markets and customer segments
	Software, Telecommunication	**Automotive**	**Energy, Oil & Gas** **Industrial incl Construction** **Aerospace & Defence**

Source: BCG Analysis

Baker Hughes | NOx estimator for a gas turbine

ABOUT THE COMPANY

Company: Baker Hughes
Megatrend: Sustainability

INNOVATION BRIEF

A surrogate model for NOx emissions has been built, taking as input sensor measurements describing 100% hydrogen-fueled burners operating conditions

NEED OF ER&D

- **NOx emission estimation is crucial** to develop combustion system control logic or hardware, to achieve a green, regulatory-compliant gas turbine
- **Emission measurement is often challenging** because sensor purchase, installation and maintenance is costly or unfeasible due to harsh conditions

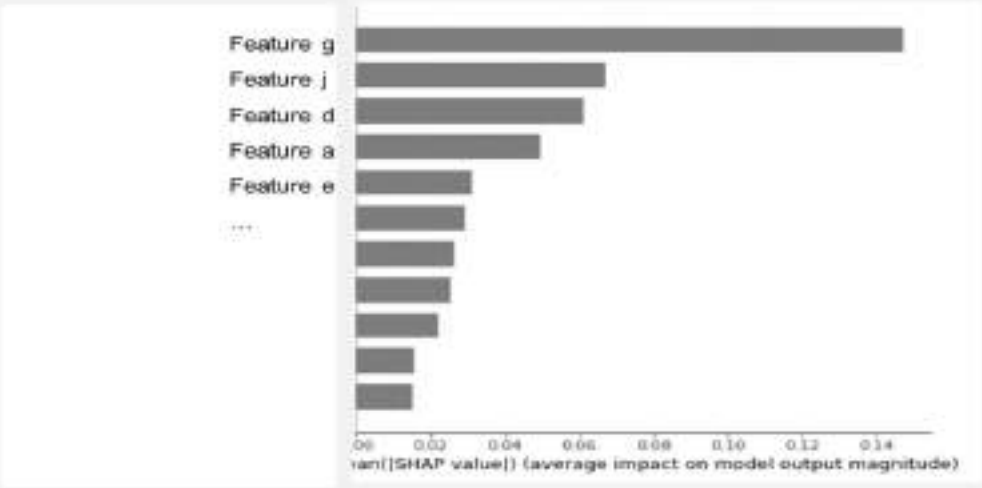
DESCRIPTION OF SOLUTION

- Our solution leverages **AI techniques,** in particular a deep learning approach
- A **neural network has been trained** to regress NOx values and some advanced technique has been used to **assess regression feature** importance. This enables design and control engineers to better understand factors affecting NOx emission levels
- This approach **combines deep learning's high accuracy and improved reconstruction error,** resulting in over a 5% improvement in estimation accuracy

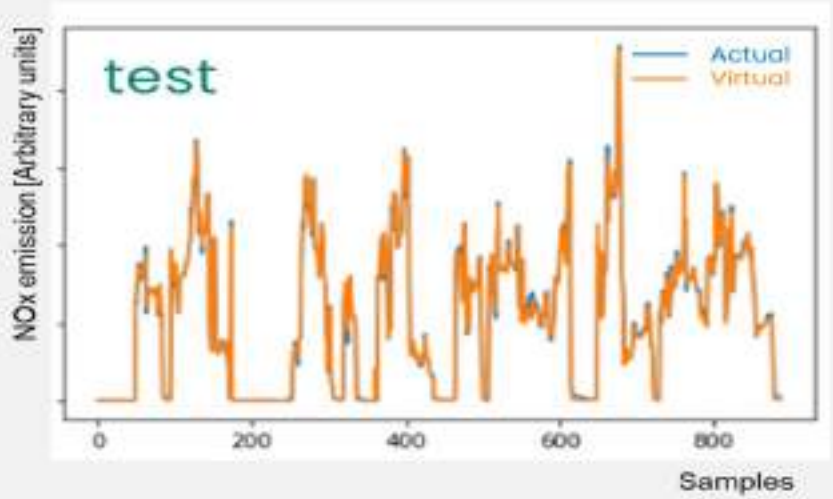
IMPACT

- An **early pollutants estimation,** starting from combustion chamber operation design, allows to get to a low-emission final product
- Moreover, it **reduces design reworking and testing activity,** thus also reducing the total environmental impact of the product development

Baker Hughes | NOx estimator for a gas turbine



Feature importance ranking



Reconstruction accuracy fulfills customer acceptance criteria

Infosys | Smart Solution for Water

ABOUT THE COMPANY

Company: Infosys
Megatrend: Sustainability

INNOVATION BRIEF

This enterprise solution provides a unified view of water usage efficiency across all levels and locations, reducing wastage and aligning with sustainability goals.

NEED OF ER&D

- Features like **loss analysis, demand forecasting, economic analysis and auto maintenance scheduler** are essential features in water management
- To develop a **best-in-class solution for enhanced real time monitoring and analysis of water usage** we developed a software concept with advanced analytical capabilities

DESCRIPTION OF SOLUTION

- Solution **interfaces with diverse hardware, collects real-time data,** and provides industry-standard KPI dashboards
- **Water loss analysis** quantifies campus losses, including leaks, non-revenue water, and etc
- Water demand forecast with **statistical models and alerts, aiding staff with issue resolution and troubleshooting guidance**
- **Auto maintenance scheduler tracks and assigns maintenance activities until completion**

IMPACT

- Smart Water Solution **monitors continuously, detects** and plugs leaks promptly
- At Infosys, it **reduced freshwater consumption by 64%, achieving 100% water recyclability,** winning IoT projects and driving sustainability initiatives

Infosys | Smart Solution for Water

KPIT | Sustainability – Solar Car Park

ABOUT THE COMPANY

Company: KPIT
Megatrend: Automotive

INNOVATION BRIEF

This project not only addresses the pressing challenges of harnessing and energy consumption, also sets new standards in environmental responsibility and urban design

NEED OF ER&D

- The **increased demand for energy, coupled with the pressing need to transition to cleaner alternatives,** presented an urgent opportunity for us to revolutionize the way energy is generated and utilized within urban spaces

DESCRIPTION OF SOLUTION

- We have taken a proactive approach to harnessing renewable energy by **transforming our open parking lots into covered parking areas using solar panels.** These solar panels generate clean and sustainable energy, **provide shelter to 600+ vehicles**
- The Solar Car Park represents a milestone in sustainable innovation, demonstrating our unwavering commitment to **environmental stewardship, technological advancement, and societal betterment**

IMPACT

- Total plant capacity: 661.65 Kwp
- Total solar modules: 2005 (330 WP each)
- Annual power generation: **960,000 units**
- Annual carbon emission reduction: **800 tonnes**
- Annual cost savings : **~INR 3+ Millions**

KPIT | Sustainability – Solar Car Park

FULFILLING THE PROMISE OF SUSTAINABILITY

Our commitment to environmental sustainability has enabled us to develop solutions that help Mobility leaders reduce their carbon footprint and lay the foundation for a cleaner, smarter, and safer future. we are consist antly enhancing efforts to minimize our impact on the natural environment, increase contributions for community development projects and improve our corporate governance framework.

11975 Kl
water conserved

Water Conservation

At KPIT, we focus on water conservation and recycling efforts, which include the installation of sewage treatment plants in our facilities.

2105 GJ
Energy consumption reduced

33.74 GJ
Energy consumed from Renewable sources

Energy Consumption

At KPIT, we made efforts in reducing energy consumption, generating clean and sustainable energy, contributing to our commitment to encourage environment-friendly practices.

4.5
tonnes E-waste collected

Waste Management

Recognizing the environmental consequences associated with e-waste, we at KPIT take precise steps to promote its use within underserved communities.

5 Mega trends that will affect ER&D

1

2

3

AI AUGMENTATION:
GENERATIVE
ENGINEERING

4

5

Source: BCG Analysis

Gen AI will augment, not replace, traditional AI capabilities and make them more accessible

TRADITIONAL AI STRENGTHS	GEN AI STRENGTHS
Sense patterns and trends	Doc/meeting summaries
Target government investments	Review and draft contracts
Service segmentation and design	Customer engagement
Target 'risk treatment'	Messaging content generation
Optimise public assets and operations	Code generation
Anomaly/Fraud detection	Social media monitoring

Source: Press Search; BCG Analysis

With vast and growing number of use cases with many expected to become table-stakes; driving companies to invest in topic's ER&D

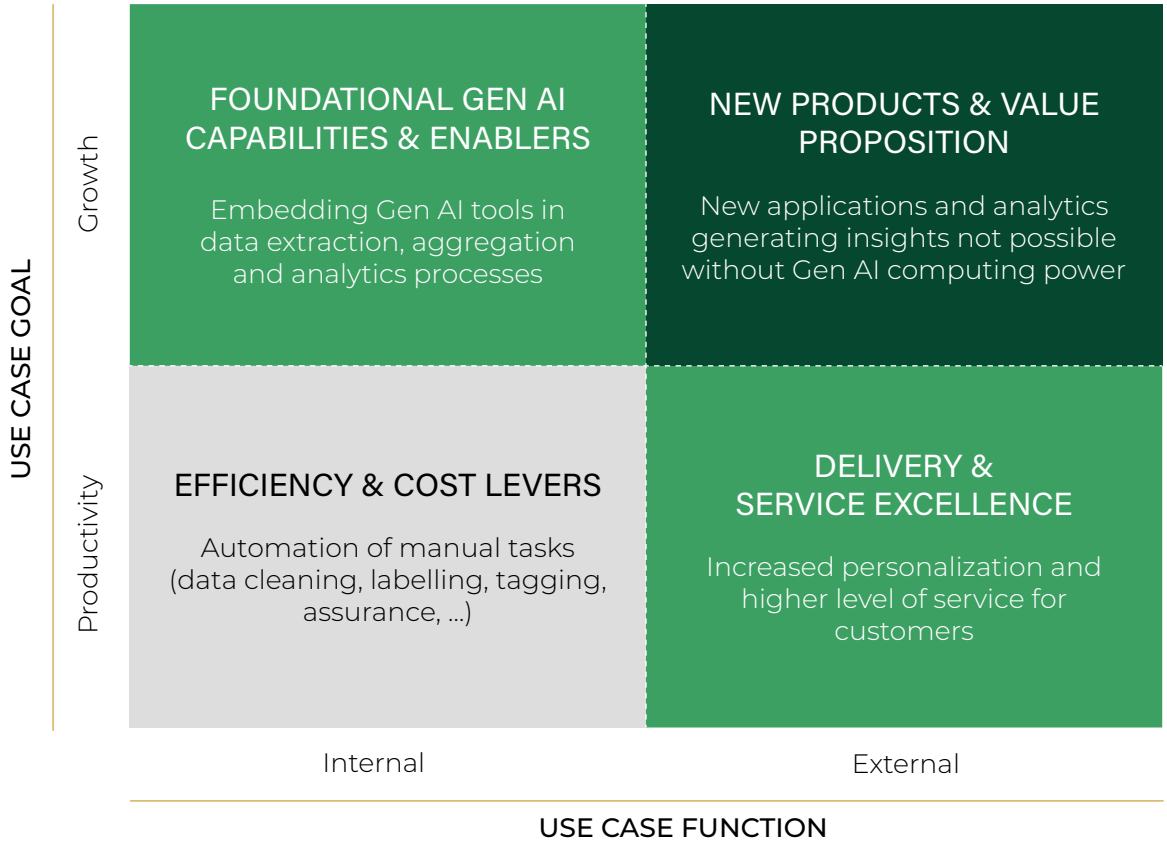


TABLE-STAKES USE CASES

- Lower barrier to adoption
- Essential to keep pace with peers; competitive disadvantage, if not adopted

ENABLING USE CASES

- Offer differentiation in current market while technology is still maturing
- Barrier to adoption reduces over time

GOLDEN USE CASES

- Unique applications that drive value
- Challenging to develop and adopt
- Users will incorporate into workflows creating barriers to change

Source: Press Search; BCG Analysis

Internal processes across all industries can benefit from generative AI horizontal use cases








FUNCTIONS	Marketing	Sales	Logistics and distribution	Customer support	Customer success	Legal	Finance	Human resources
GENAI USE CASES	Hyper-personalized campaigns	Personalized sale pitch generation	Conversational assistant for logi- stics coordination	Conversational assistant responding to customer queries	Dashboard and report generation to track key metrics	Legal document review and synthesis to extract key points	Business case draft	Conversational assistant for employee knowledge mgmt.
	White papers, blogs commercial, and ad writing	Demos tailored to customer environment	Supply chain optimization from demand forecast	Auto-generated user guides & tutorials	Account profile generation to find upsell opportunities	Convert Legalese into plain English	Financial statement and budget draft	Virtual recruiter for sourcing, interviewing, and screening
	Visual marketing material generation	Client outreach email writing	Robot route planning in warehouse	Support swarming w/ recommended resolutions	Customer sentiment and experience mgmt.	Contract draft creation	Sale forecasting using full body of data (e.g., AE sentiment)	Workforce training and job simulation
POTENTIAL IMPACT	5–10X Faster content gen[1]	4X Reply rates[2]	99% Accuracy in order execution[3]	42% Outbound calls eliminated[4]	12% Net rev. retention increase[5]	70% Increase in productivity[6]	5X Faster deployment[7]	$1M In savings[8]

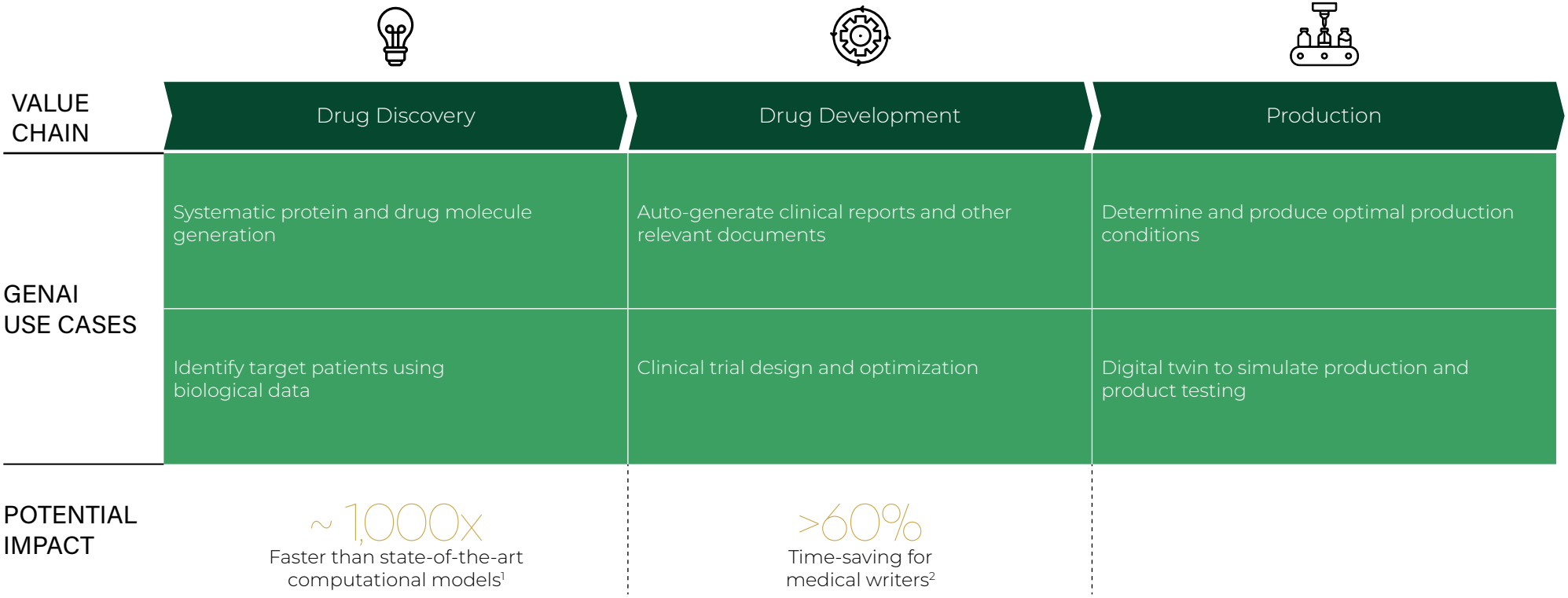
1. Jasper website 2. Lavender website 3. Avaamo website 4. Ushur website 5. ChurnZero website
6. BlackBoiler website 7. Boltzbit website 8. Moveworks website;
Source: Press search; BCG analysis

Example 1: Sector specific use cases | Semiconductor chip design

VALUE CHAIN	RTL generation	Verification	Physical Design	Customer tuned models
GENAI USE CASES	Generate RTL code based on descriptive prompt	Shortlist error causes, conduct root cause analysis, and recommend solutions	Generate first pass physical design with specific optimizations	Enable customers to personalize established models via Gen AI integrations
	(E.g., write an AND gate using IEEE package)	Estimate issue probability Generate synthetic data for simulation & testing	Incorporate historic characterization data into recipe steps	Customers can reuse and modify existing designs more easily
POTENTIAL IMPACT	Increase R&D engineer productivity and satisfaction	Reduce debugging time and risk of errors	Increase process efficiency and speed to market;	Unlock new design possibilities & increase customer share-of-wallet

Source: Press search; BCG analysis

Example 2: Sector specific use cases | Biopharma



1. MIT research 2. ZYLiQ website
Source: Press search; BCG analysis

Samsung | Unlocking secure and fair code generation

ABOUT THE COMPANY

Company: **Samsung**
Megatrend: **GenAI**

INNOVATION BRIEF

An AI based Code generation system that can write code alongside human developers. This In-house system helps to improve development efficiency, reduce errors, and increase the speed of our software development

NEED OF ER&D

- An Organization with major focus on Research and Development, It is required to secure our code
- This restricts us from utilizing tools available in the market. Also, they lack domain-specific knowledge, resulting in less relevant suggestions for organization specific needs. And they will not be 100% aligned with our organization's coding guidelines

DESCRIPTION OF SOLUTION

- Our idea is to train the best open source LLM with a domain specific dataset and develop extensions/ plugin to connect with Trained Model from developer IDEs
- Thus, developers working on the specific Domain can get code completion suggestions from the model, from the comfort of their IDE without worrying about the privacy and security
- Trained model will be familiar with the coding guidelines of the organization since its trained on in-house datasets

IMPACT

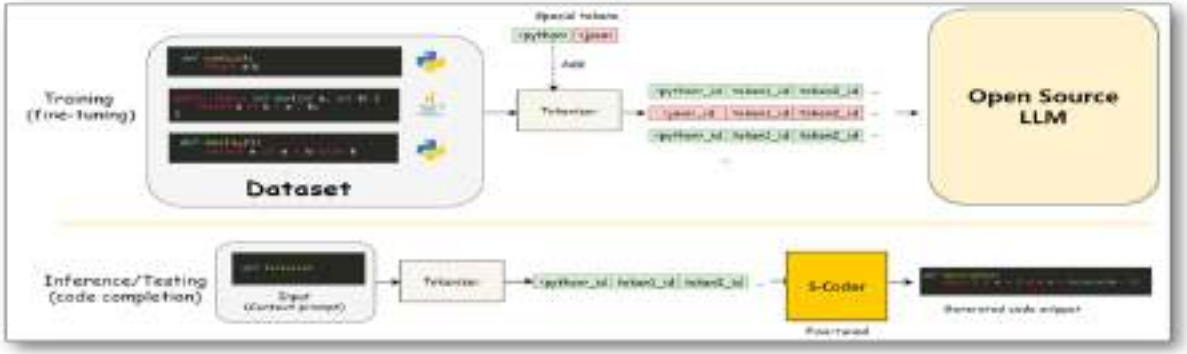
- Our solution **accuracy is 80%** compared to that of Market tools which is only 20%.
- **100% Data Privacy and Security.**
- **100% adherence to Organization Coding Guidelines.**
- Average **25%~30% increase** in **Developer productivity**

Samsung | Unlocking secure and fair code generation

S-Coder, an AI based Tool, can be used in the Development Environment by every developers in our organization to improve their productivity in a safe and secure way thereby protecting our company data.

Key Features :

- ❑ Natural language comment to code
- ❑ Function header to function body completion
- ❑ Partial code completion based on previously written lines



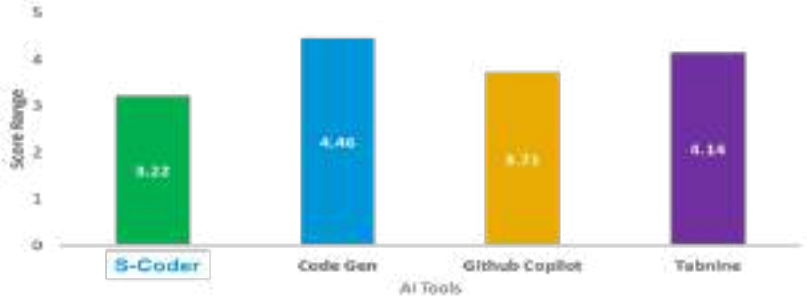
Training Methods :

We have used the below Training methods for Model Training

- ❑ Unsupervised learning
- ❑ Supervised fine-tuning (SFT)
- ❑ Reinforcement learning with Human feedback (RLHF)

Evaluation Results :

100 Prompts (Android) were taken for evaluating its performance. This is a Human Feedback based evaluation and **Lower Score indicates good recommendation**. (Score goes up, quality of recommendation reduces)



5 Mega trends that will affect ER&D

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3

4

SERVICE-ORIENTATION: SHIFT IN ENGINEERING MODEL

5

Source: BCG Analysis

Ecosystems are forming across industries, creating innovative products and services…

1

EVOLVING CUSTOMER DEMANDS …

- Personalized experience
- Continuous innovation
- Seamlessly integrated customer journey

2

…ARE DRIVING NEW BUSINESS MODELS…

- Network of partnersand contributors
- Data-intensive
- Flexible and resilient

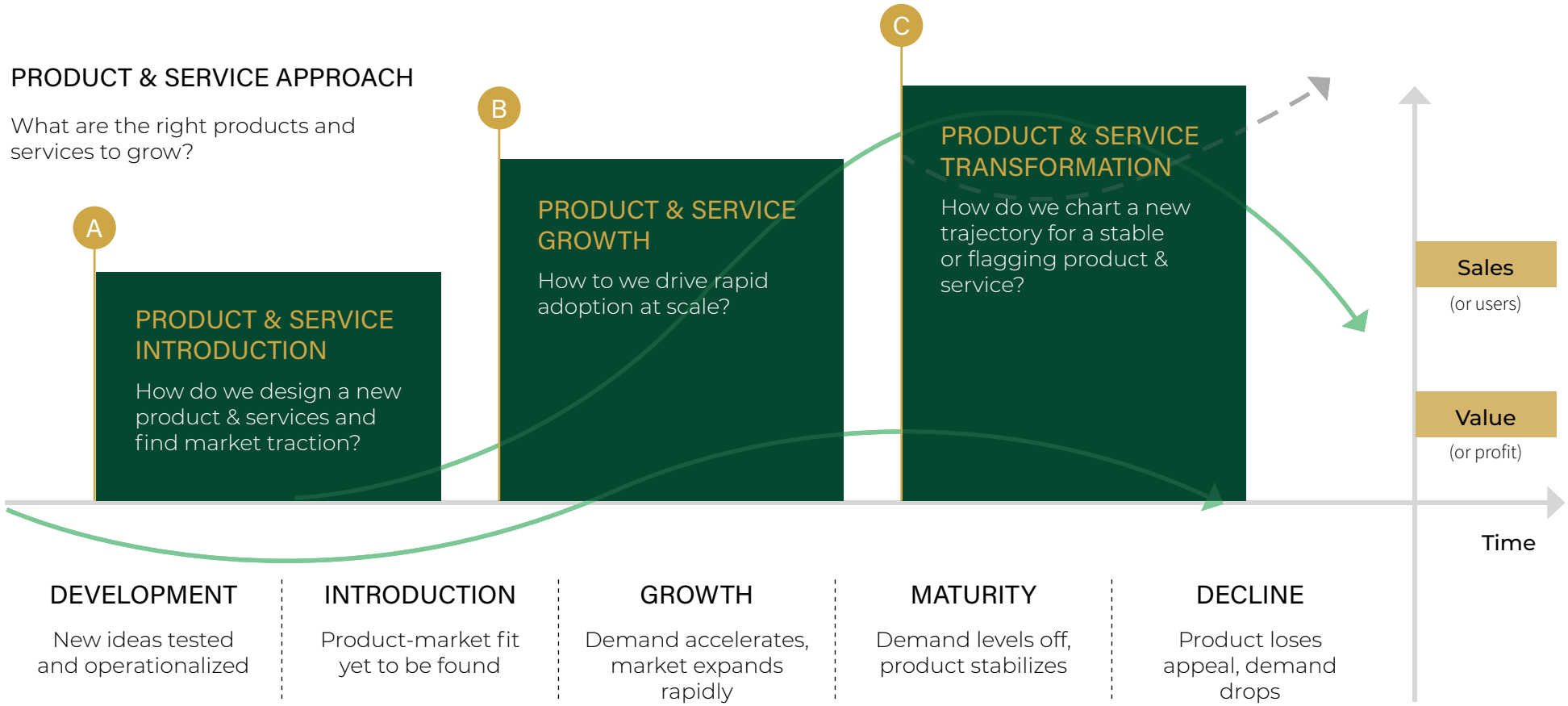
3

…TO DEVELOP NEW OFFERINGS

- Connected cars
- Industrial service bundling
- Smart factories
- Collaborative supply chains

Source: BCG Analysis

Trend towards pivoting at Product-Service transformation business model picking up in recent times



1. Based on Theodore Levitt "Exploit the Product Life Cycle." Harvard Business Review, November 1965;
Source: Press Search; BCG Analysis

Pivot towards an integrated (Product-Service) approach becoming a key growth driver…

1

PRODUCT & SERVICE SUITE INTRODUCTION

How do we design a new product and services suite?

Introducing a service alongside the product during the product development and introduction phase creates a comprehensive solution for customers and market pull

2

PRODUCT & SERVICE SUITE GROWTH

How to we drive rapid adoption at scale?

Subscription-based services, maintenance contracts, and extended warranties provide opportunities for recurring income during product growth phase

3

PRODUCT & SERVICE TRANSFORMATION

How do we chart a new trajectory for a stable or flagging product?

Integrated solution provider approach that leverages new technologies and heightens the customer experience, adding to shadow P&L and create competitive edge

INTEGRATED SOLUTIONS

- Business model moving from a pure product focus to integrated solutions that drive further value for the customers
- Integrated solutions consider the customer journey in its entirety – developing new product, services and incentives and refining the revenue model

Source: BCG Analysis

. . . resulting in a new ER&D strategy focused on using data, cross-engineering and hybridization of product

1

DATA

Engineering to leverage the wealth of data generated by the product to drive service offerings

- Industries are prioritizing data driven digital transformation, making it a central tenet of their ER&D strategies as they pivot to the service paradigm
- ER&D teams are focusing on developing smart products, predictive maintenance solutions, and data-driven optimization techniques to enhance operational efficiency and customer experiences

2

CROSS-ENGINEERING

Ecosystem collaboration and open innovation beyond own organization

- Traditional industries looking for fresh perspectives and complementary technologies from startups, research institutions, and service partners to accelerate innovation
- ER&D will involve a more diverse range of stakeholders, leading to cross-industry solutions, faster time-to-market, and shared expertise

3

PRODUCT-SERVICE HYBRIDIZATION

Companies to bundle their products with complementary services to create additional value

- ER&D teams are designing products that are not only functional but also support seamless integration with value-added services, enhancing customer experiences and loyalty

Source: BCG Analysis

Expleo | Smart Mobility using IoT platform - ThingWorx

ABOUT THE COMPANY

Company: Expleo
Megatrend: Service Orientation

INNOVATION BRIEF

The solution will intelligently change the personalization of the new car subscription by continuously monitoring the past subscription of the vehicles by the same customer

NEED OF ER&D

- Millennials want to **use the services for transporting from Point A to Point B(uberization) than owning a car** due to either liking to drive different models or aligning with self driving cars
- The **challenge with uberization is customer dissatisfaction over continuously changing the settings on each new car subscribed**

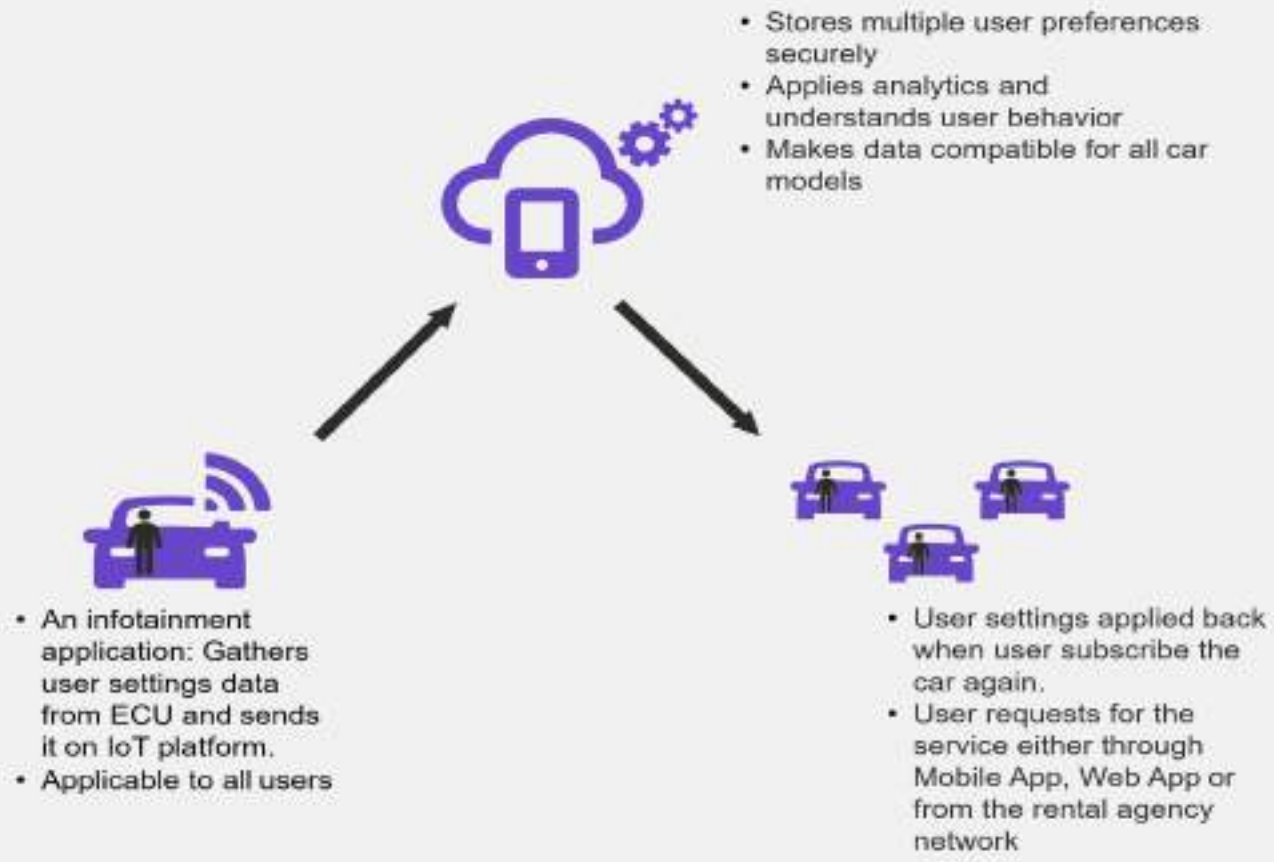
DESCRIPTION OF SOLUTION

- The solution **customizes car settings (climate, seating, infotainment) based on customer preferences** learned through **data sharing with the IoT platform and analytics**
- It uses the **IT Gateway to apply these preferences and adjust ECUs for intelligent personalization**

IMPACT

- **Personalization** is the benefit of this solution
- It gives a feeling to the customer that **they are using their own car,** if the car model is same
- If the car model is different, then based on **data analytics best preferred personalization** is provided

Expleo | Smart Mobility using IoT platform - ThingWorx



TCS | IoT enabled - Predictive Maintenance

ABOUT THE COMPANY

Company: TCS
Megatrend: Product to Service

INNOVATION BRIEF

It Is a Smart Industrial IoT product that optimizes MRO, sustainability, performance, predictive maintenance, OEE, and reliability to create actionable insights

NEED OF ER&D

- Supplier : **Lack of Inhouse integration capabilities, Spares and Supply chain issues and Longer Problem Resolution time**
- Distributor: **Value Chain Optimization and Limited ecoSystem Play**
- End Customers: **Asset Downtime, Efficiency and Reliability, Stranded data and Silo Operations, Cost Pressure, Multi Standard and Multi Interfaces**

DESCRIPTION OF SOLUTION

- TCS developed "RS INDSTRIA," an industry-first IIoT platform based on **AWS IoT,** serving multiple industries
- They provided **contextual IoT knowledge, digital manufacturing expertise, remote diagnostics, and predictive services to build this scalable product**
- Key TCS solutions include **OTDO, iHAL, AWS Greengrass, CDD, aADF frameworks, and insights** for predictive maintenance and operational efficiency

IMPACT

- **14% energy optimization, high asset availability** through predictive maintenance, and **significant OEE improvement**
- **Interoperable, scalable, cloud-centric IoT** for versatile device and OT component integrity
- **Ensured Data-To-Decision (D2D) and Bringing-Life-To-Components (BLTC)** to bring resilient to industry needs and auto scale on capacity

5 Mega trends that will affect ER&D

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POPULATION& SKILL INVERSION: SHIFTING SKILLS AND TALENT POOLS

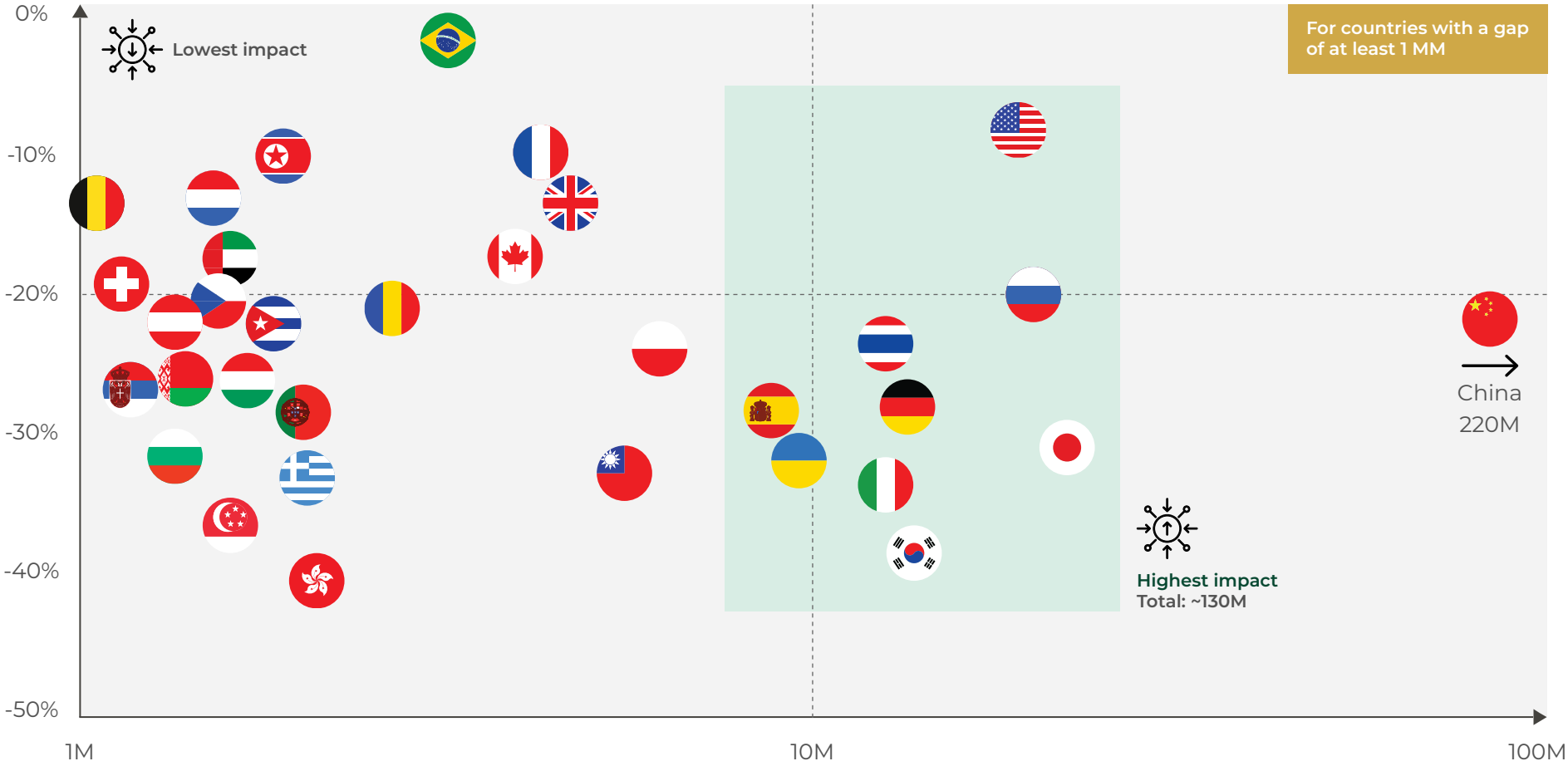
Source: BCG Analysis

Demographic Impact: all feel it, but some (significantly) more than others

TOTAL LOSS IN WORKING AGE POPULATION IN AFFECTED COUNTRIES: ~400 MILLION BY 2050

Comparison of population decline and working age population gap

Decrease in working age population 2050 - 2020

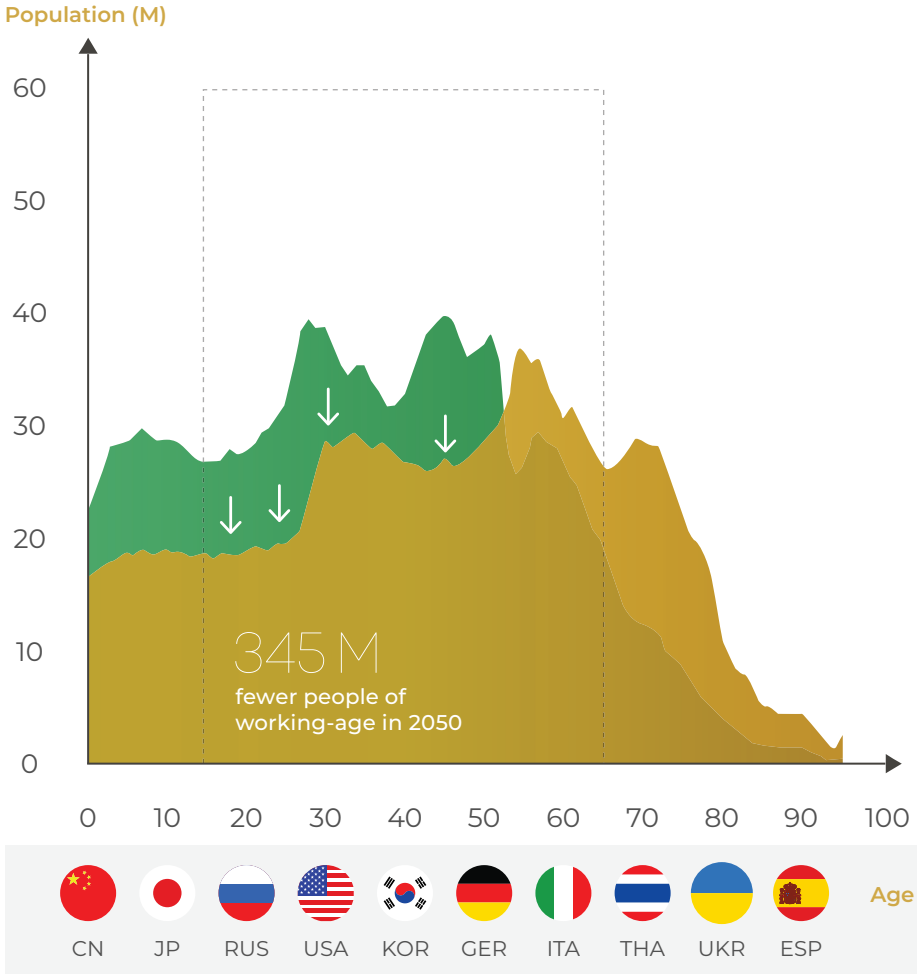


Source: UNDP zero migration scenario, World Bank, BCG analysis

Gains and losses: Significant shifts in working age population

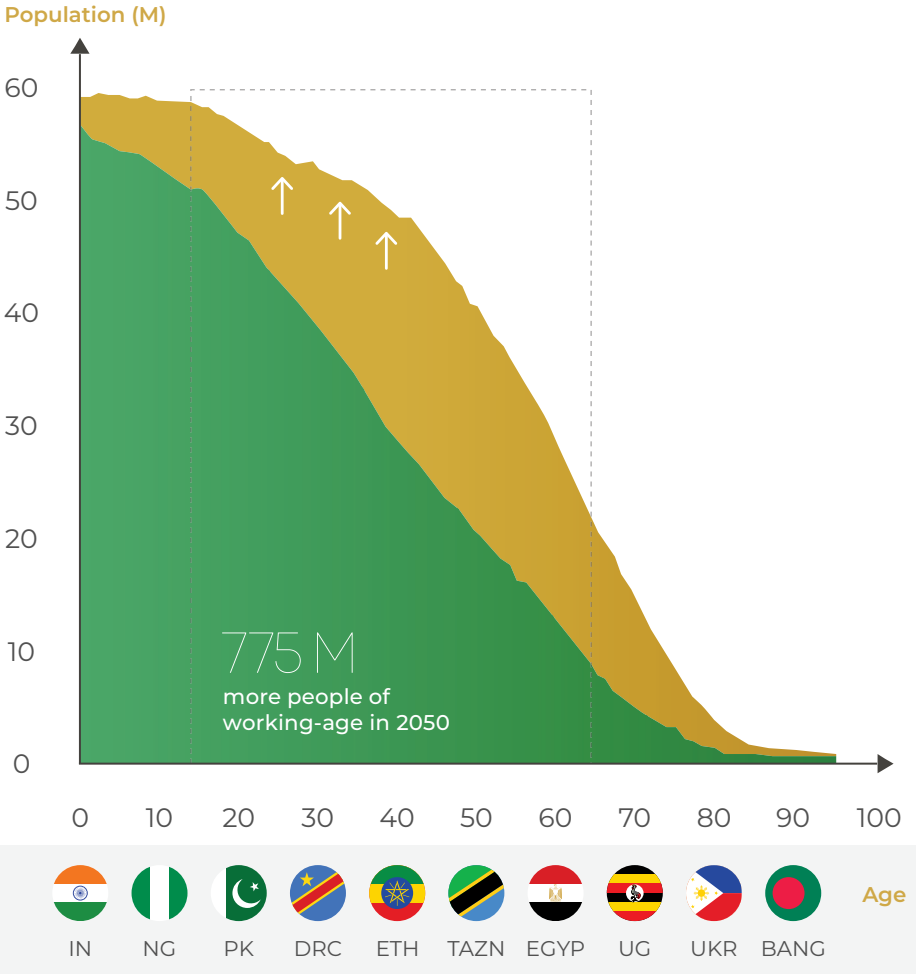
OVERALL: 345M NET LOSS OF WORKING AGE POPULATION

Top 10 countries[1] - 2020 vs. 2050



775M NET GAIN OF WORKING AGE POPULATION

Top 10 countries[2] - 2020 vs. 2050



2020 Population 2050 Population

1. 10 countries with greatest absolute decreases in population age 15-64, in order: China, Japan, Russia, USA, Korea, Germany, Italy, Thailand, Spain, Ukraine
2. 10 countries with greatest absolute increases in population age 15-64, in order: India, Nigeria, Pakistan, Dem. Repub. Of Congo, Ethiopia, Tanzania, Egypt, Uganda, Philippines, Bangladesh

Source: BCG ER&D Survey 2023; BCG Analysis

Aging population affecting ER&D talent availability in hotspots like Japan, Germany and the UK

Japan (Ministry of Economy): Japan will face a deficit of

789,000

software engineers by

2030

Demand for non-Japanese engineersis growing

Germany: In 2020, there were three workers for every person over 65, while in

2035

the ratio will drop to

1:1

Unavoidable demographic change represents major challenges to the German economy, correcting economic growth forecasts from 1.8% down to 1.5%

UK: There is an estimated shortfall of over

173,000

workers in STEM sectors in U.K

Over 150 engineering leaders have urged the government to tackle the UK's skills shortage by embedding engineering into the national curriculum.

Source: Handelsblatt, Bertelsmann Stiftung, Bundesfinanzministerium, S&P Global, Guardian, The Local, Japan Times, IET

Which will affect ER&D sourcing patterns and operating models under a new ‘Global’ ER&D strategy

GLOBAL ENGINEERING STRATEGY

1

“One person, many teams”
Switch key teams (and if needed full department)to operate in a matrix structure and overcomeskill shortages

2

Broaden the reach
Build a globally recognizable employer brand and value proposition to attract talent

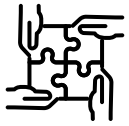
3

Create new depth
Build dedicated bridges for global geo-diverse junior talent hiring pools

GLOBAL R&D STRATEGY

Minimum viable process
Run a pragmatic decision-making process to ensure best projects survive with given talent

Remain mission-first
Create new hubs where talent is available and growing or outsource to competent partners



Mix and match diverse teams
Developing diverse teams with localand migrant talents

Source: BCG Analysis

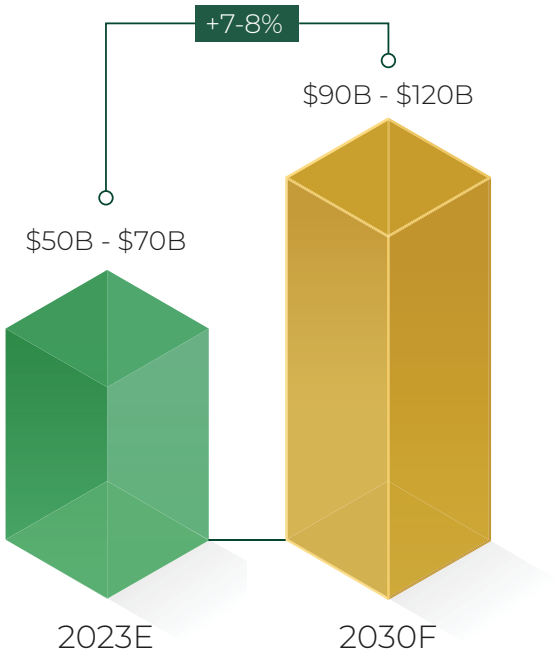
06

Appendix
Sector Deep Dives and Case Studies

Aerospace & Defence sector Deep dive

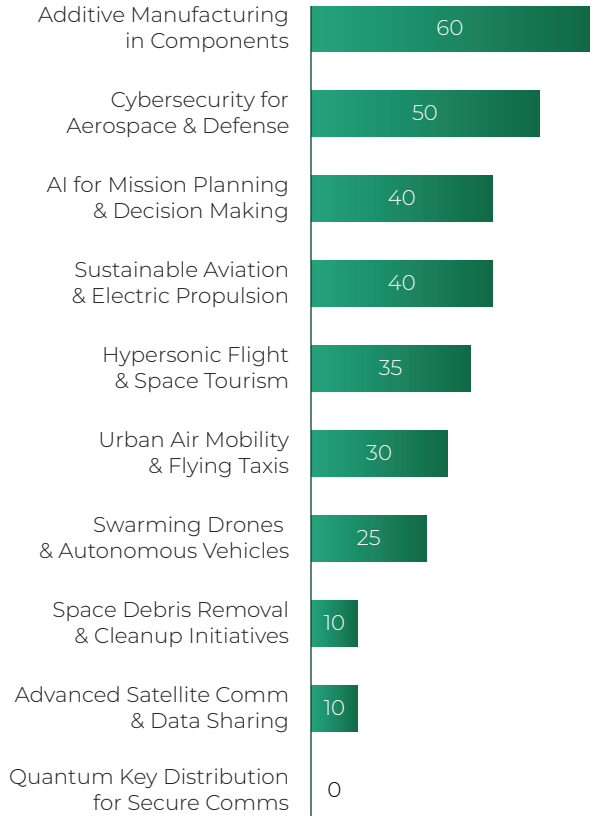
Aerospace & Defence: ER&D spend expected to reach $90-120B by 2030 growing at ~7-8% CAGR with high focus on additive manufacturing & tech in defence

SECTOR'S ER&D SPEND EXPECTED TO REACH $90-120B BY 2030...



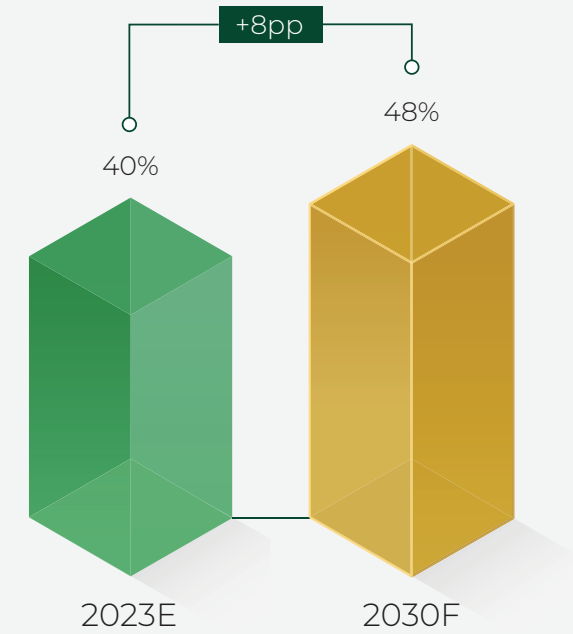
Sector's Business ER&D Spend ($B)

...WITH ADDITIVE MANUFACTURING & CYBER SECURITY AS KEY FOCUS AREAS IN THE SECTOR...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY SHARE OF DIGITAL ENGINEERING REACHING ~50%



% of sector's ER&D spend on digital engineering

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Three major shifts will strategically impact and lead to increased aerospace & defence ER&D

SWITCH TO MORE FUEL-EFFICIENT AIRCRAFT

Sustainable Aviation Fuel, Open rotors / bigger fans, New wings / airframe architectures, Hydrogen fuel are technologies to increase fuel efficiencies of aircrafts

Driven by:

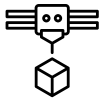
- IATA members' decarbonization commitments by 2050
  - » 0% Net CO_2 increase after 2020 (carbon neutral growth)
  - » 50% Reduction in net aviation emissions by 2050 (2005 levels)
- 20-30% reduction in costs due to higher fuel efficiency

TACKLING CONCERNS OF CYBERSECURITY

Innovation in products, systems and services of ER&D players in aerospace & defence, e.g., encryption, quick response system for detection, etc.

Driven by:

- Complex infrastructure of multiple interconnected systems, leveraging plug-&-play software from the industry has increased risk of cyber attacks



ADDITIVE MANUFACTURING CAPABILITIES (E.G.,: 3D PRINTING)

Driven by:

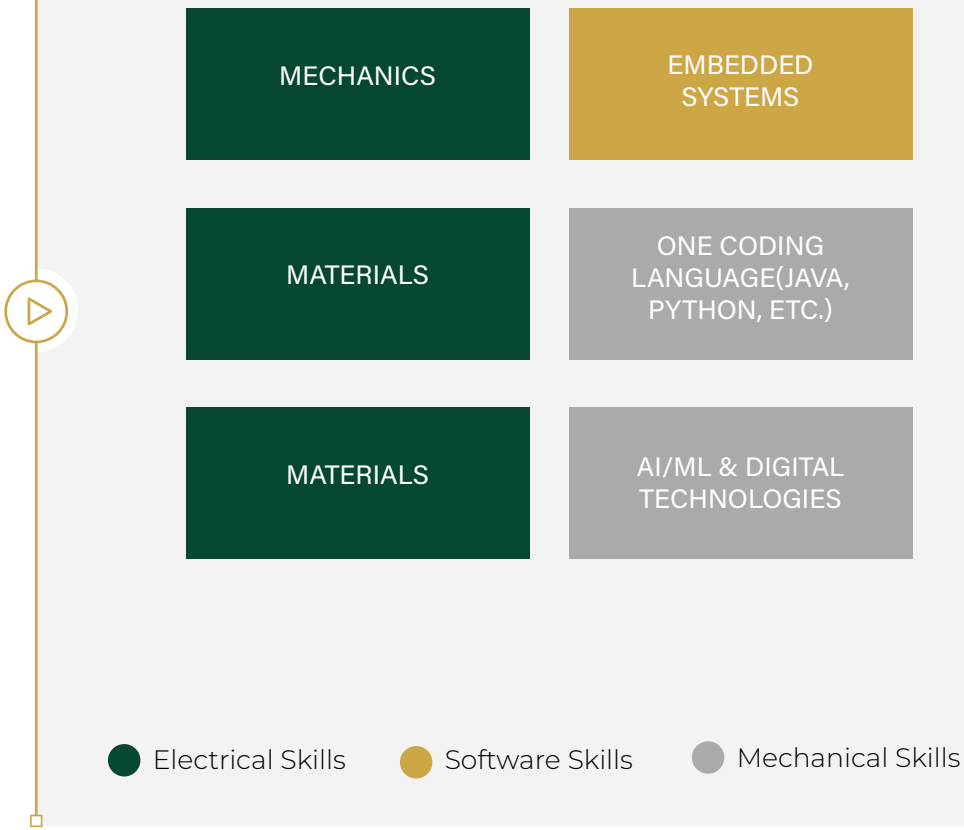
- Increasing pressure on OEMs for reduced product development timelines (80% reduction in tooling manufacturing lead time)
- Up to ~40 % savings in tooling costs dependent on tooling family (avg. ~20%)

Source: BCG Analysis

Key concern in the industry is sustainability as focus on net-zero increases, along with cybersecurity & skill-gap as sector becomes increasingly more connected

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR

KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge
Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Collins Aerospace | RampNet℠ Connectivity in air and on-ground

ABOUT THE COMPANY

Company: **Collins Aerospace**
Sector: **Aerospace**

INNOVATION BRIEF

Provides seamless connectivity in the air and on ground using different communication media

NEED OF ER&D

Acquiring, maintaining, and operating a fleet of aircraft Ground Support Equipment (GSE) represents a substantial capital expenditure

- GSE fleet owners and managers are continually looking to monitor, control, and **contain these costs**
- Among greatest opportunities for cost savings are improving maintenance efficiencies, “right-sizing” the fleet, and reducing costs resulting from fuel wastage and vehicle accidents

DESCRIPTION OF SOLUTION

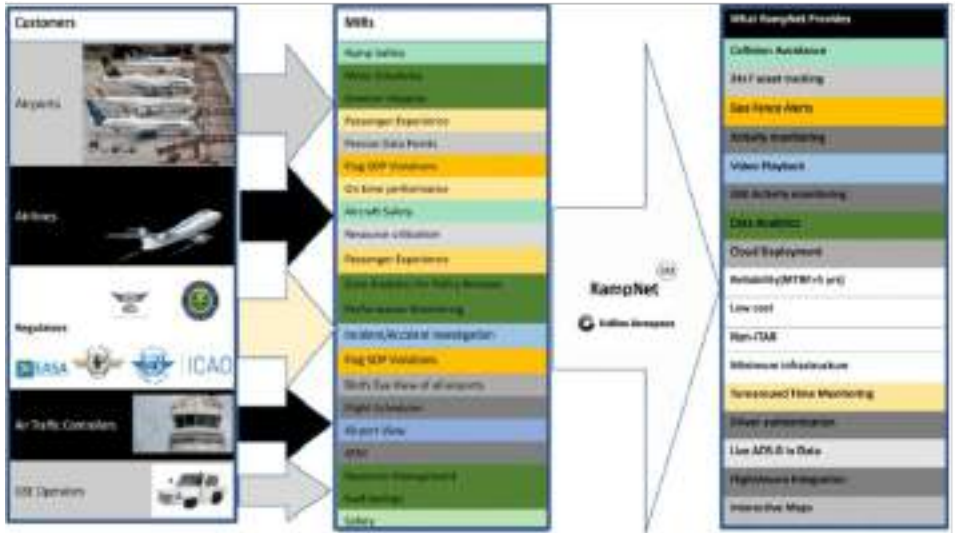
- Solution links connected ground assets and ADS-B equipped aircrafts into an effective **tarmac data collection and monitoring tool** by providing information of the aircraft upon approach, monitoring the airside (aircraft, vehicles, equipment) on ground in real-time, and sending alerts to operators
- RampNetSM uses **IoT-based long-range and low power sensor network** to track both motorized and non-motorized GSEs
- 24x7 without dependency on cellular networks or WiFi

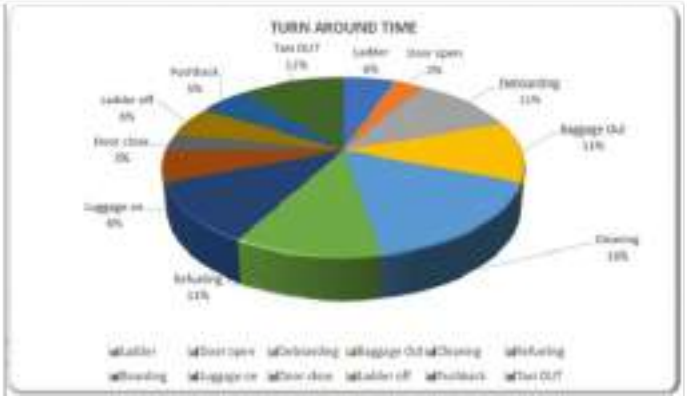
IMPACT

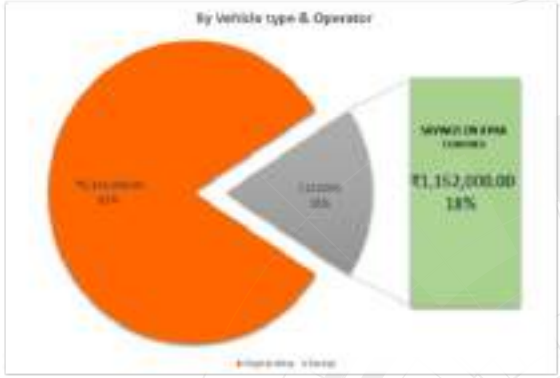
Implemented in Cochin International Airport

- **Low-cost telemetry** infrastructure without expensive cellular network recurring charges
- **Low-cost solution** replaces expensive Advance Surface movement guidance and control systems (A-SMGCS)
- Data integration contributing to Airports, Airlines and ATC database, **optimizes operations and reduce carbon footprint**

Collins Aerospace | RampNet℠- Connectivity in air and on-ground







Cyient | Fuel Efficient Aircraft Engine

ABOUT THE COMPANY

Company: Cyient
Sector: Aerospace

INNOVATION BRIEF

World's Most Fuel-Efficient Aircraft Engine saving over three million metric tonnes of CO_2 emission, 5% productivity enhancement.

NEED OF ER&D

- Supporting customer in **developing lighter, more economical, greener engines through Multi-Disciplinary design optimization** to meet component, modules and system design goals and Manufacturing Engineering & Process Planning

DESCRIPTION OF SOLUTION

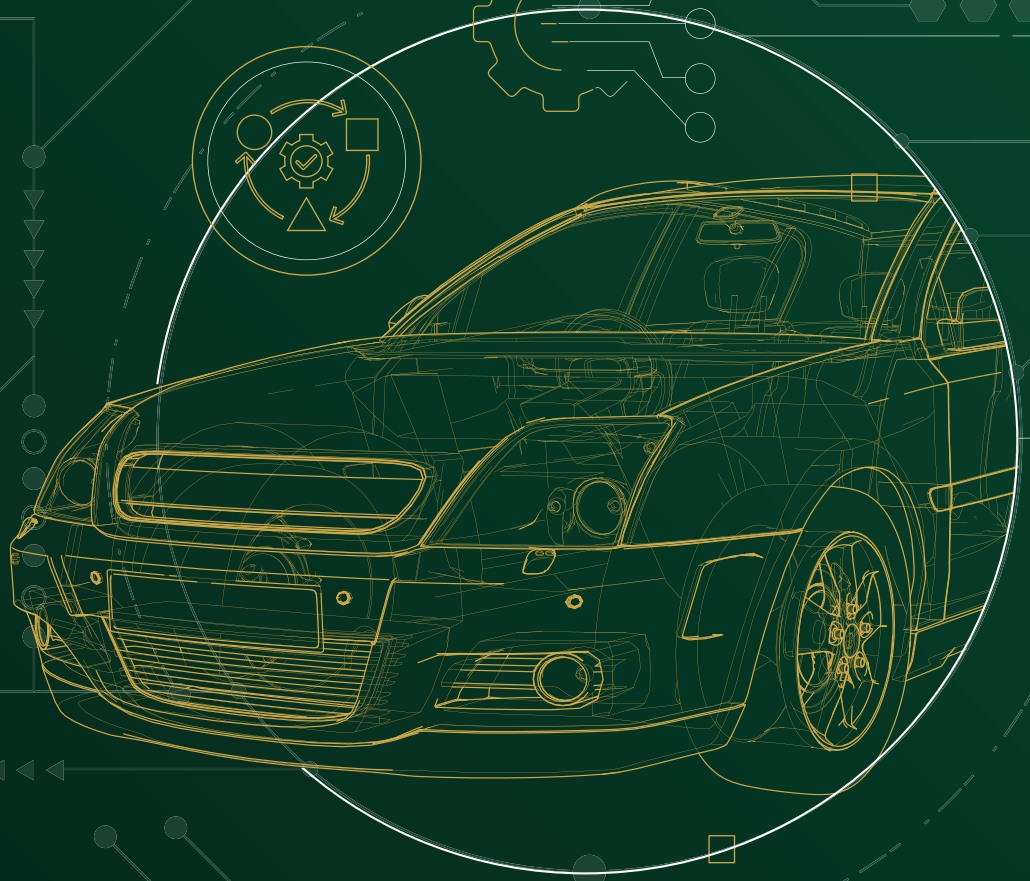
- Greener Engine that delivers game-changing environmental performance. **Which include Design to build solutions for engine part families (Compressors, Combustors, Rotors, Cases, Turbines, etc.)**
- **Prototype build and test support (onsite support & documentation for testing), Installation & Certification support, including technical publications,** perform the testing operations at the Aero Engine OEM's facility on the engine to lower weight and cost, which helped improve Fuel Efficiency

IMPACT

- The solution delivered substantial benefits including **Improves fuel burn by 16+% compared to today's top engines, Exceeds strict emission regulations by more than 50%**
- **Reduces aero plane carbon emissions by 3100K tonnes per year,** equivalent to growing over 900,000 trees, Reduces aircraft noise footprints by more than 75%

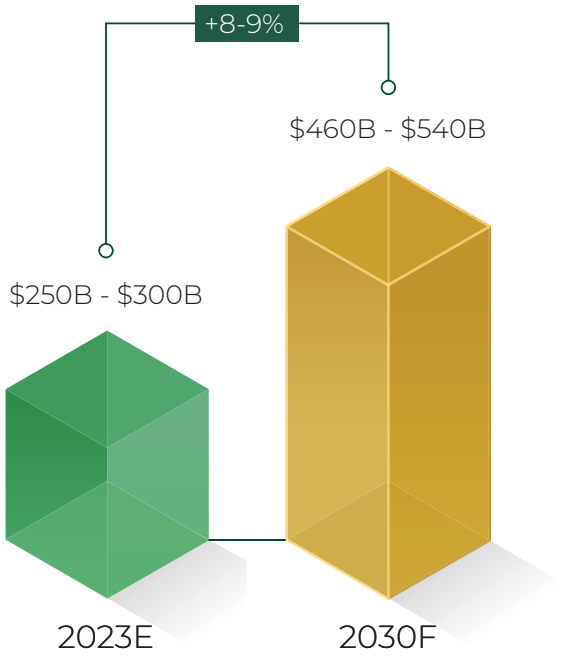
Cyient | Fuel Efficient Aircraft Engine

Automotive sector Deep dive



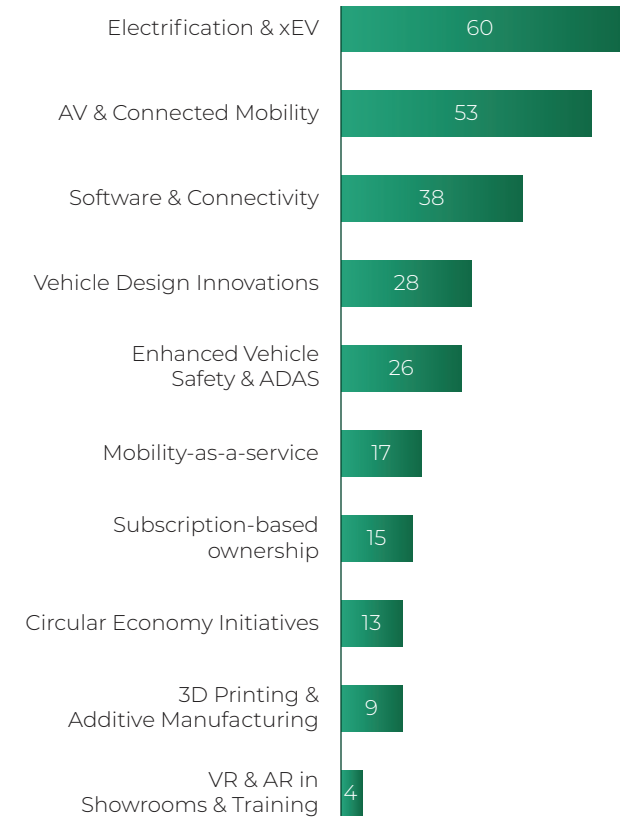
Automotive: ER&D spend expected to reach $460-540B by 2030 driven by xEV, connected mobility and vehicle software priorities

AUTOMOTIVE BUSINESS ER&D SPEND EXPECTED TO INCH TOWARDS ~$460-540B BY 2030 GROWING AT 8-9% CAGR...



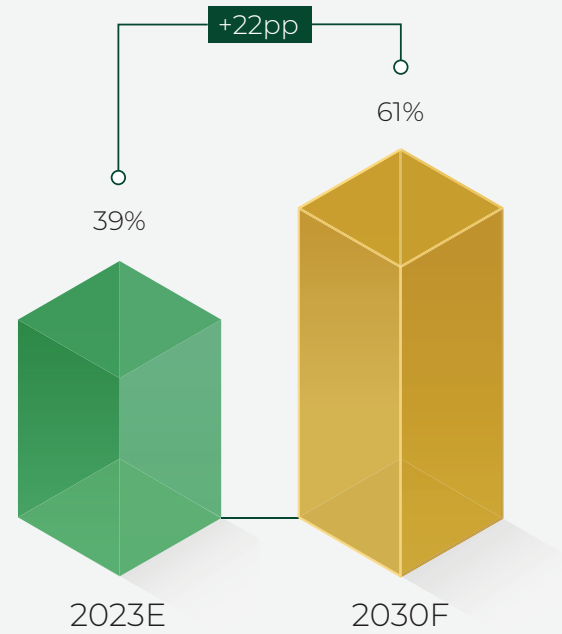
Sector's Business ER&D Spend ($B)

...WITH ELECTRIFICATION, CONNECTED VEHICLES & SOFTWARE AS TOP 3 ER&D PRIORITIES FOR THE SECTOR...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY SHARE OF DIGITAL ENGINEERING INCREASING BY 22PP



% of sector's ER&D spend on digital engineering

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Three trends will strategically impact automotive ER&D

ELECTRIC POWERTRAINS

Move away from ICE vehicles to electric-powered engines

Driven by:

- Increasing advantage of EV vs. ICE
- Battery cost reductions
- Reduced adoption barriers (e.g., range, charging stations)
- Changing user sentiment

VALUE CHAINS WILL RADICALLY CHANGE WITH HW/SW DECOUPLING

Unbundling of Hardware and Software in automotive sector

Driven by:

- Need for improved speed to market in the automotive industry
- Own the platforms while sourcing software from others

CONNECTED CAR AND IN-CAR TECHNOLOGIES

Connected car services to enhance customer experience and offer new features

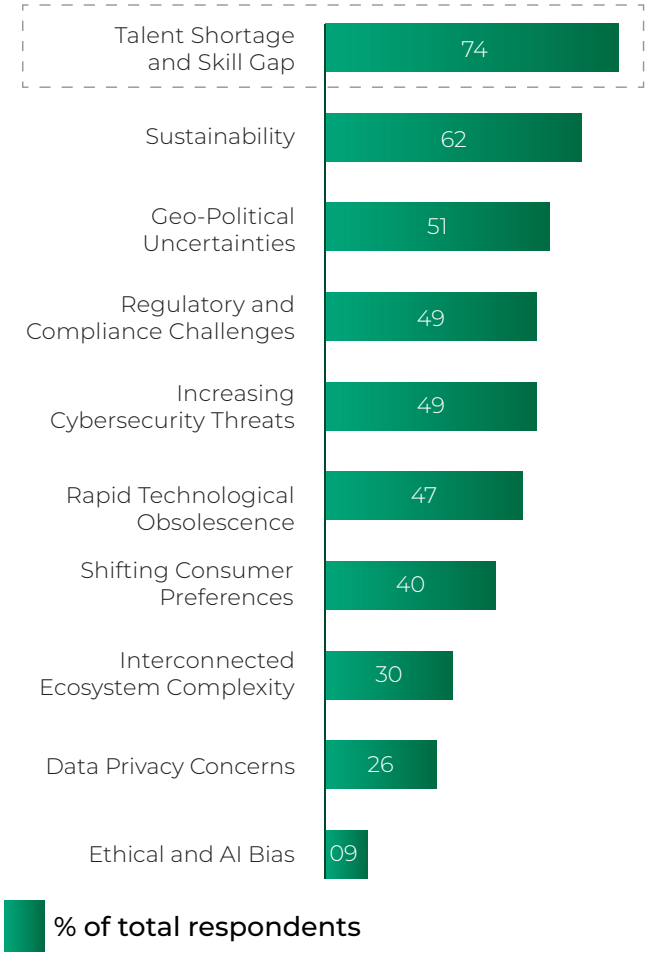
Driven by:

- Technological readiness: Increasingly more cars to be connected
- Strong investments: Big tech moves into automotive sector
- New Business for OEMs: Significant cost-savings and new business opportunities
- Customer expectations: Majority of future car features to be software-based

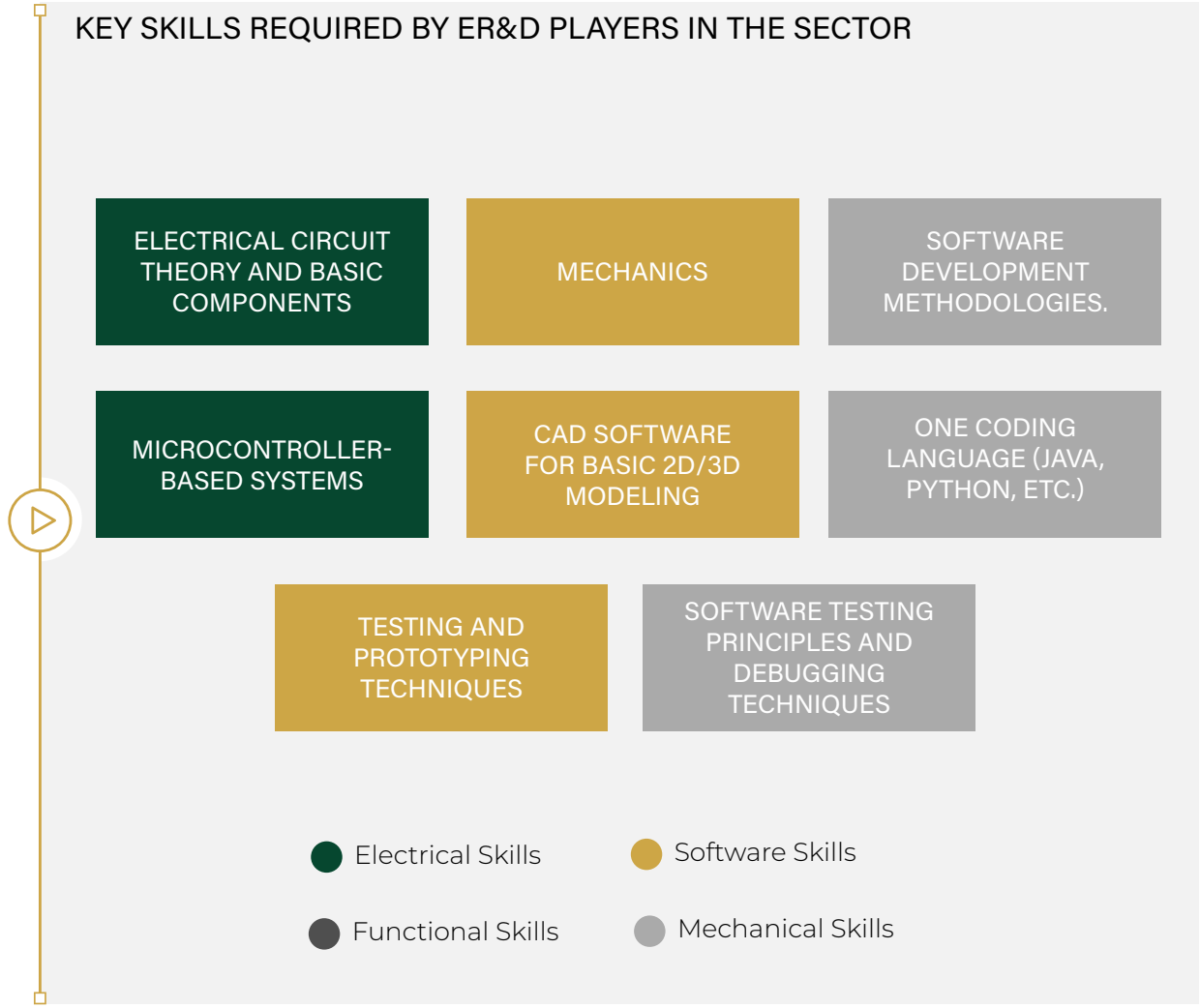
Source: BCG Analysis

Talent shortage & skill gap is the key challenge faced by automotive ER&D players; need for cross-functionally skilled workforce with new niche skills

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Jaguar Land Rover | Software Over The Air Updates with Dual Memory Architecture

ABOUT THE COMPANY

Company: **Jaguar Land Rover**
Sector: **Automotive**

INNOVATION BRIEF

Introducing dual memory architecture for Electronic Control Units (ECU) to deliver new capabilities and fix existing issues over the air (SOTA) to the vehicle

NEED OF ER&D

Time, cost and effort for both the customer and JLR to update software

- Software update using Diagnostics **requires physical presence** of the vehicle at dealer's place
- Vehicle should be kept in **Ignition ON state** which adds additional carbon footprint
- Each ECU needs to be updated separately and **each takes ~1 hour for a successful update**
- **If update is unsuccessful** it takes more time

DESCRIPTION OF SOLUTION

- Introduced dual memory architecture for **seamless software updates** to vehicle where it can be updated **while in park mode as well as drive mode;** this brings down recalls of the vehicles due to software issues
- By implementing dual memory, **software is downloaded and updated in the background** in smaller deltas while the original software is running from the active memory; this **reduces failures due to software updates** because the active memory always have the last working software

IMPACT

- **7M+ customers saving $300M+** annually for JLR for a single ECU; future software updates to their vehicle without having to visit their Retailer
- Around 65 ECU's gets updated remotely which is **cost effective and saves lot of engine running time and emissions**

Jaguar Land Rover | Software Over The Air Updates with Dual Memory Architecture

Bosch | Diesel Exhaust Burner Ignition

ABOUT THE COMPANY

Company: **Bosch Global Software Technologies**
Sector: **Automotive**

INNOVATION BRIEF

Introduction of Spark Ignition and Burner module in the Diesel Exhaust in order to reduce the tail-pipe emissions at low operating temperatures

NEED OF ER&D

- To comply with the **stringent EU7 emission norms, exhaust emission from vehicles must be further reduced.** This necessitates heating of the catalyst in the exhaust especially under **low operating temperatures** in order to increase the conversion efficiency

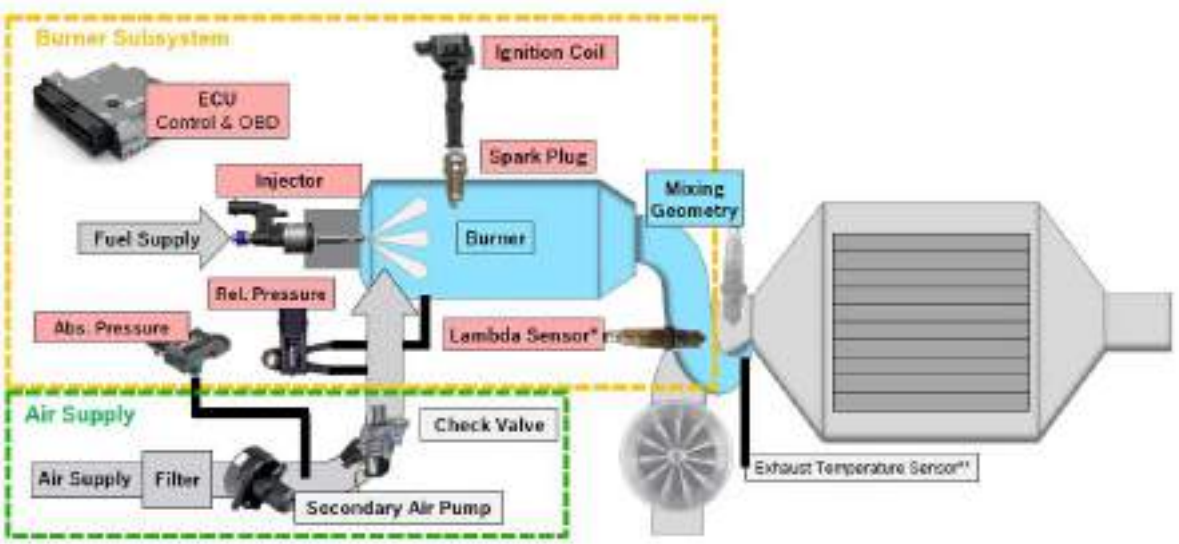
DESCRIPTION OF SOLUTION

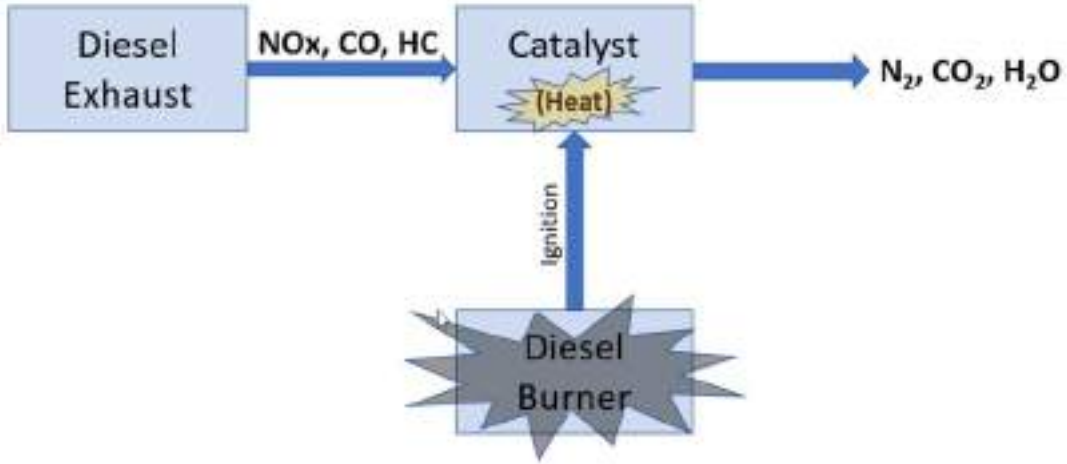
- Burner module is introduced in the **exhaust pipe of the diesel vehicle** in order to heat up the catalyst and reduce harmful exhaust gas emission. The burner is powered by a spark plug and Ignition coil system. The Ignition system needs to be controlled precisely by the **ECU software** in order to achieve optimum emission reduction
- The Burner Ignition system is new to **Diesel segment** and had to be entirely re-engineered from spark ignition used in Gasoline engines

IMPACT

- Better conversion **efficiency of exhaust catalyst independent** of the engine operating temperature
- **Reduction of Diesel exhaust emissions** of NOx, unburnt HC, CO and Particulate Matter
- **Compliance with upcoming Emission norms** worldwide, including EU7
- **Improve Air quality and reduce pollution** caused due to diesel vehicles

Bosch | Diesel Exhaust Burner Ignition





Tata Technologies | Conversion of ICE to EV

ABOUT THE COMPANY

Company: **Tata Technologies**
Sector: **Automotive**

INNOVATION BRIEF

Innovation to convert the existing ICE vehicle to EV without developing a new EV platform through a novel PMXU approach and packaging solution of electrical systems

NEED OF ER&D

- OEMs are in a race to launch new electric vehicles, however, associated **high product development cost is one of the major challenges** that OEMs are facing
- To reduce these costs, OEMs are exploring the conversion of existing ICE platforms to EVs, which would use 70% carry-over parts. However, this comes with **challenges of space and packaging constraints, part commonality with ICE vehicles, and reduced manufacturing flexibility**

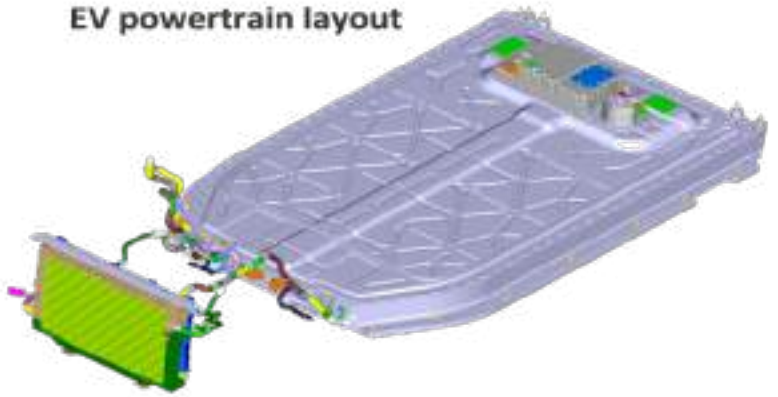
DESCRIPTION OF SOLUTION

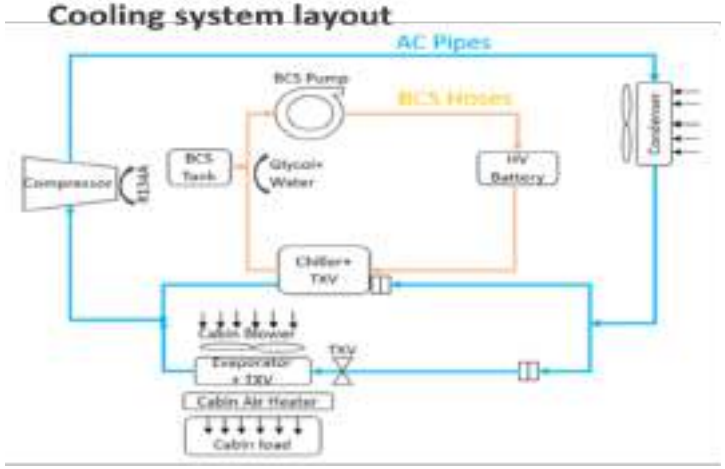
- A novel **ICE to EV conversion process templatized for packaging the electrical sub-system** with minimal changes to other sub-systems based on changes in weight distribution and packaging requirements
- It is **based on the PMXU approach (P – Carry over, M – modified, X transfer, U- unique). It is backed by our NPI process that is based on clearance of checkpoints and gateway audits.** Digital validation is used throughout the project, resulting in timely detection of errors & reduced costs

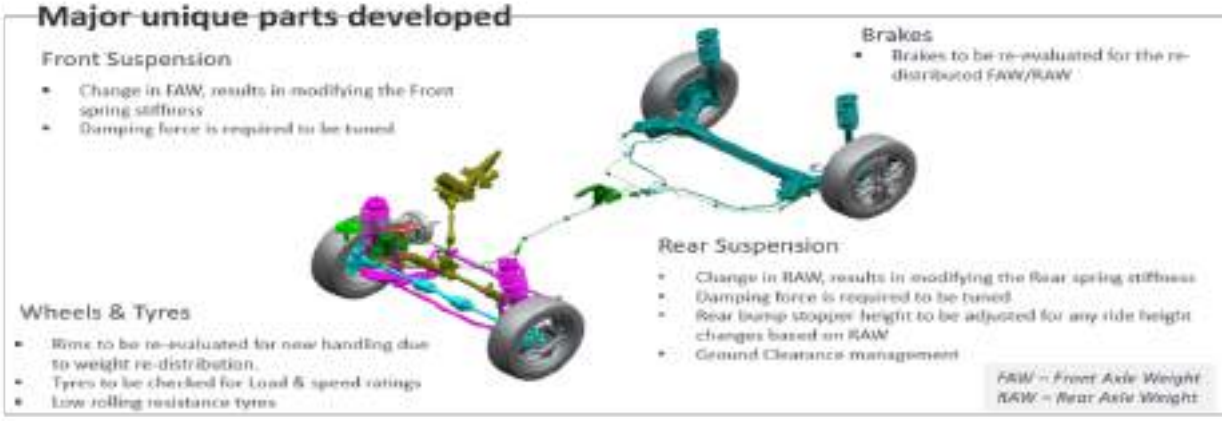
IMPACT

- EV launch time reduction from **28 months to 18 months** from concept to production
- Product development **cost reduced by 30%** (no. of prototypes typically 48 vs 35 for EV, other costs)
- Manufacturing Capex **reduction by 20%**

Tata Technologies | Conversion of ICE to EV



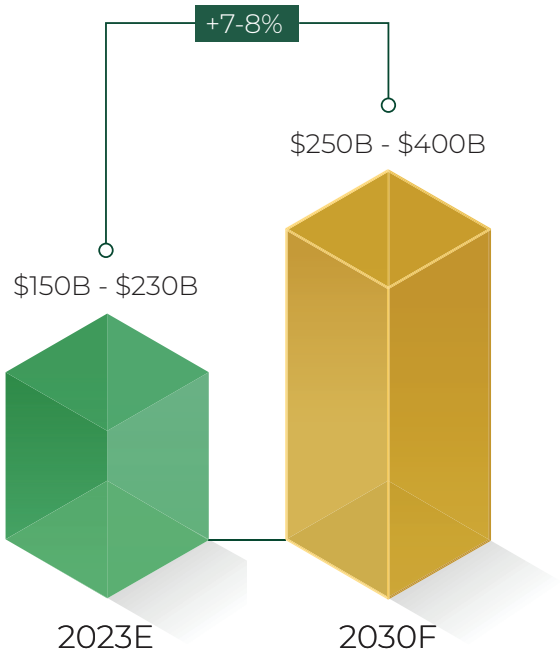




Consumer Electronics sector Deep dive

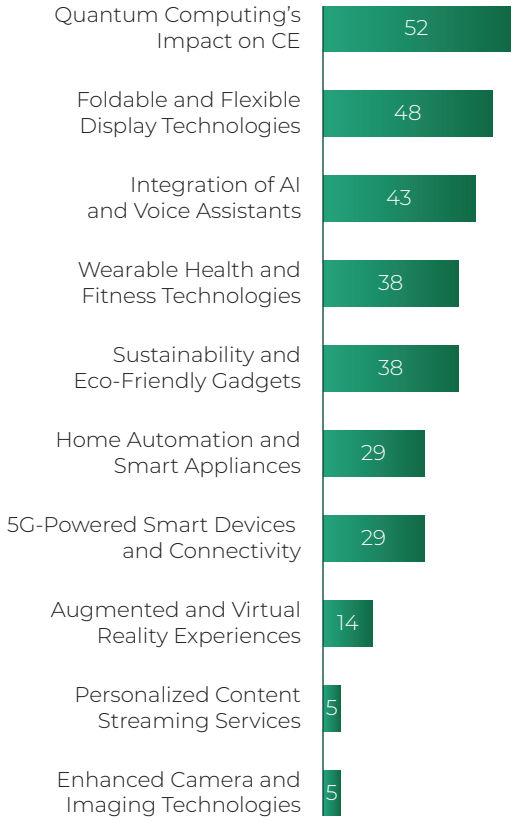
Consumer Electronics: ER&D spend expected to reach $250-400B by 2030 owing to impact of innovations in computing, display technologies and AI

CONSUMER ELECTRONICS ER&D SPEND EXPECTED TO REACH ~$250-400B BY 2030 GROWING AT ~7-8% CAGR...



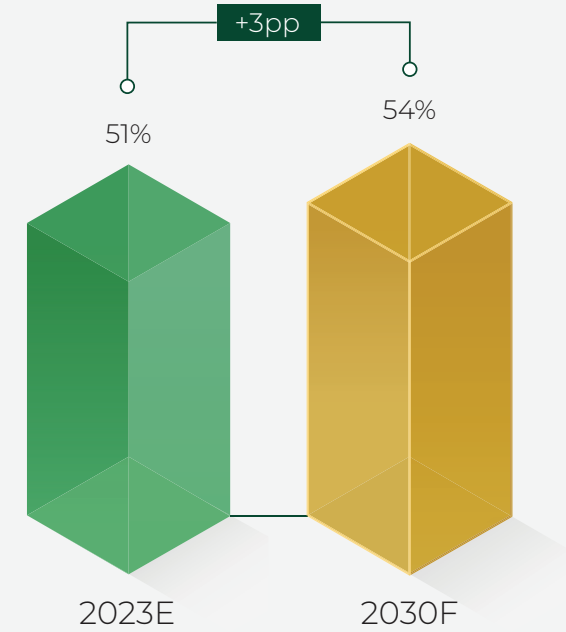
Sector's Business ER&D Spend ($B)

... WITH QUANTUM, FLEXIBLE DISPLAY & AI AS TOP 3 ER&D PRIORITIES OF THE SECTOR...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

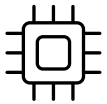
...ACCOMPANIED BY SECTOR'S DIGITAL ENGINEERING AS A % OF ER&D SPEND REMAINING HIGH



% of sector's ER&D spend on digital engineering

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

4 Trends Shaping the Consumer Electronics & Consumer Appliances industry



AI-LED FASTER MARKET LAUNCHES

Speeds up design validation and time-to-market & facilitates new material commercialization through enhanced simulations

Driven by:

- Need for quick turnaround of product designs
- New product innovation to attain higher performance standards

FOLDABLE & FLEXIBLE DISPLAY TECH

Flexible displays, made on substrates like plastic, paper, metal, or flexible glass

Driven by:

- Demand for aesthetics by consumers
- Extended beyond smartphones to other consumer electronics incl. smart watches, tablets, etc.

CONNECTIVITY: SMARTER DEVICES & HOMES

Focus on interoperability to avoid using different apps to control different devices & instead use a common app as central hub

Driven by:

- Increase in internet usage & uptick in regulatory trends are driving the acceptance of Interoperability
- AI tech integrated into various consumer electronics to enhance user experience and to offer value-added support

SUSTAINABLE ELECTRONICS

Focus to make consumer electronics supply chain and usage more sustainable

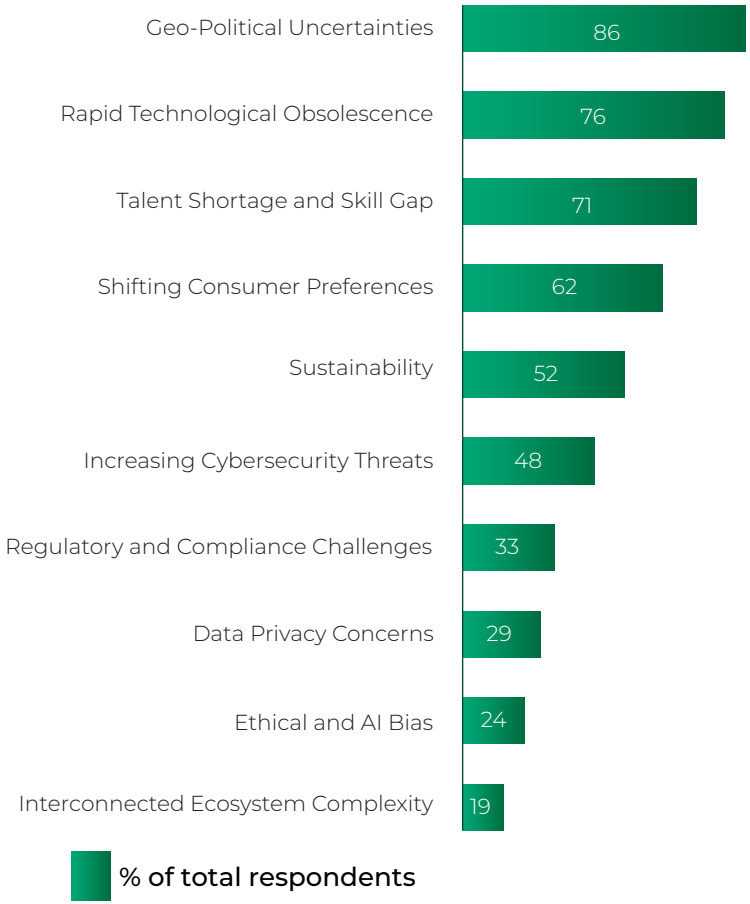
Driven by:

- Sustainable Product Offerings: Advanced sensors for energy conservation etc.
- Supply chain decarbonization for consumer electronics to meet Net-Zero emissions by 2030

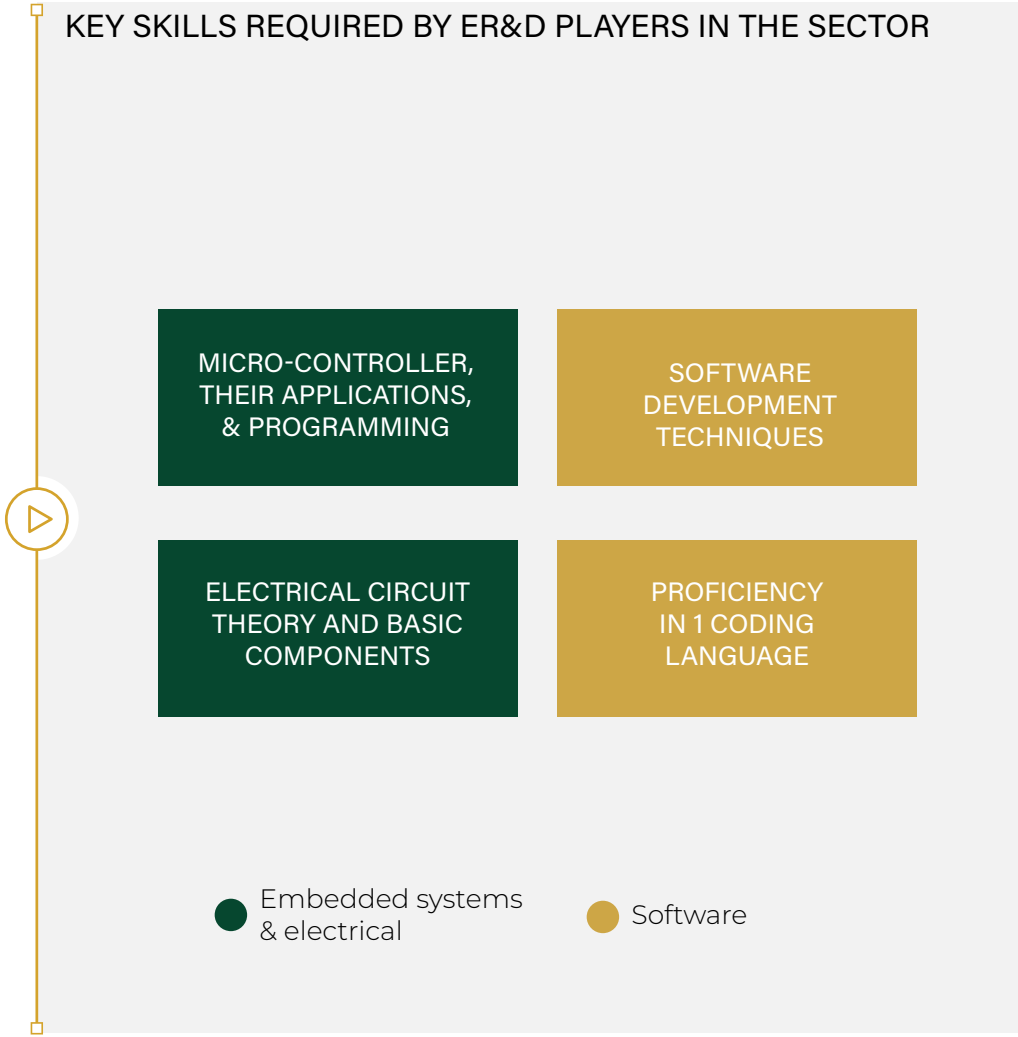
Source: BCG Analysis

Geopolitical uncertainties, rapid technological obsolescence and talent shortage are top three challenges faced by ER&D players in consumer electronics space

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Samsung Research | Carbon Emission Awareness & Reduction using AI power energy management in Smart Homes

ABOUT THE COMPANY

Company: **Samsung Research**
Sector: **Consumer Electronics**

INNOVATION BRIEF

SmartThings Energy, employs AI powered algorithms to reduce the energy consumption by smart devices, lowering the resulting carbon emission. It also provides detailed real-time carbon footprint information based on the energy usage. consumption of RAN leading to energy savings

NEED OF ER&D

- Global carbon emissions hinge on household energy use; viz. USA averages 16 tons/person, with homes responsible for 20%
- Smart home users must grasp this, curbing energy consumption by their smart home devices (AC, fridge, washer etc.) for impact

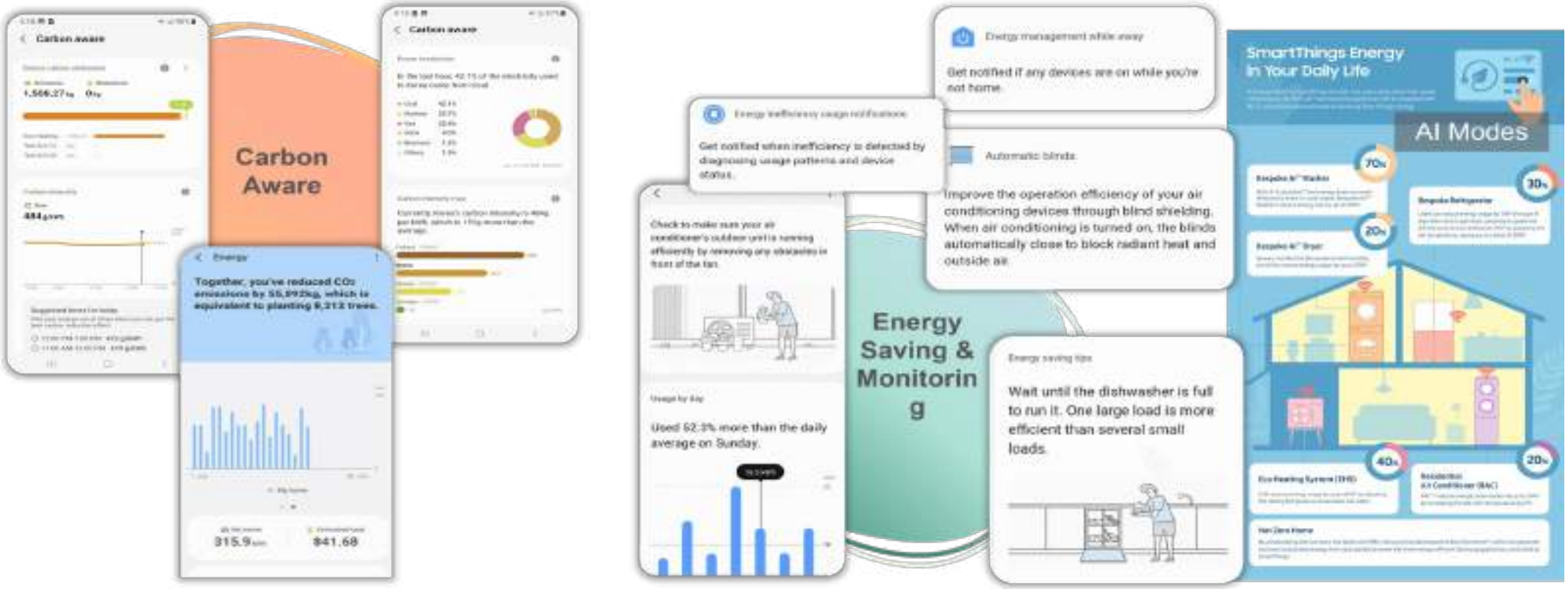
DESCRIPTION OF SOLUTION

- The solution details users' carbon footprint based on smart home energy use
- AI-driven algorithms on smart devices minimize this carbon footprint by lowering energy consumption
- SmartThings Energy's AI Energy Mode saves **70%** energy on select cycles and devices
- Participating in **Automatic Energy** Demand Response Program through the solution, users earn rewards by cutting peak energy use

IMPACT

- Provides user a detail analysis of their carbon footprint which intern will be used to plan employing an energy efficient provider or adding green energy producer like solar panel
- Managing and automating connected devices it helps consumers to gain insights into their energy use, thereby inspiring energy-saving behavior, reducing costs and helping to facilitate demand response measures that minimize stress on the grid

Samsung Research | Carbon Emission Awareness & Reduction using AI power energy management in Smart Homes



Tech Mahindra | Smart Mixer

ABOUT THE COMPANY

Company: Tech Mahindra
Sector: Consumer Electronics

INNOVATION BRIEF

IA stand mixer that is designed for assisted cooking using Auto Sense Technology, Built-In Smart Scale, and IOT features for enhanced cooking experience

NEED OF ER&D

- With the **rise of connected home technology, consumers are increasingly looking for ways to incorporate smart features** into their home appliances. The smart mixer is trying to full-fill this need with its innovative features

DESCRIPTION OF SOLUTION

- **Auto Sense Technology actively monitors changes in texture and viscosity through motor torque** feedback to optimize mixing performance. Mobile/tablet connectivity with the smart mixer provides app based guided recipes
- **Built in smart scale** precisely measures ingredients in the mixing bowl based on the guided cooking recipe. **Bidirectional rotation of the blending mechanism** helps in better mixing. **New attachments** design helps improve mixing of ingredients

IMPACT

- The **appliance features optimized mixing** performance. **OTA** for new recipes and software updates
- **Wi-fi feature** for connected appliance experience and app-based guided cooking
- The device features **voice control** for hands-free cooking and a **digital display** for speed, time, and weight information

Tech Mahindra | Smart Mixer

PRODUCT INNOVATION OVERVIEW

A stand mixer that is designed for assisted cooking using Auto Sense Technology, Built-In Smart Scale, and IOT features for enhanced cooking experience.

PROBLEM OR OPPORTUNITY

With the rise of connected home technology, consumers are increasingly looking for ways to incorporate smart features into their home appliances. The smart mixer is trying to full-fill this need with its innovative features.

PRODUCT INNOVATION OVERVIEW

Auto Sense Technology actively monitors changes in texture and viscosity through motor torque feedback to optimize mixing performance. Mobile/tablet connectivity with the smart mixer provides app based guided recipes. Built in smart scale precisely measures ingredients in the mixing bowl based on the guided cooking recipe. Bidirectional rotation of the blending mechanism helps in better mixing. New attachments design helps improve mixing of ingredients.

PRODUCT INNOVATION BENEFITS

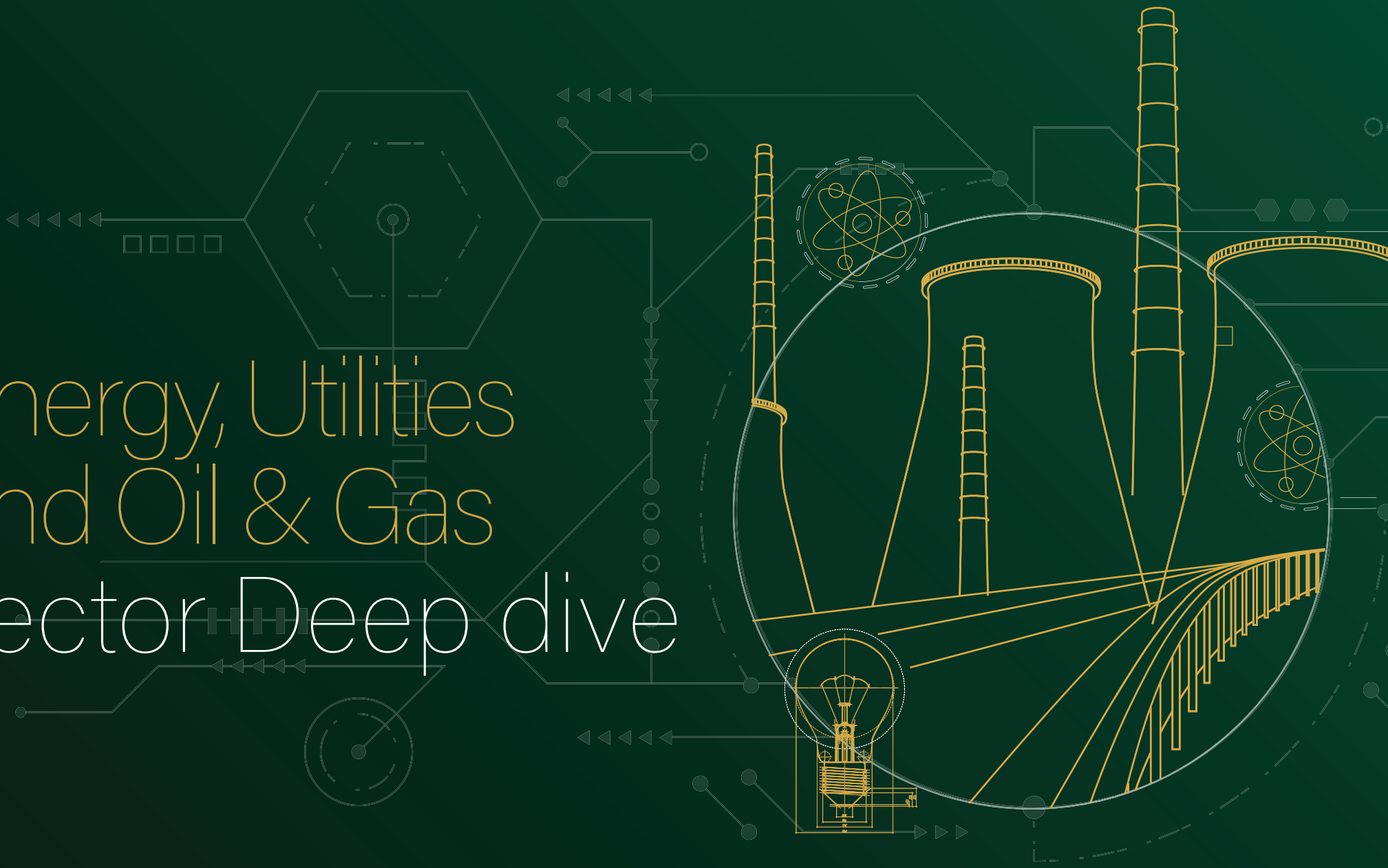
Optimized mixing performance will prevent under\over mixing for specific recipes.
OTA feature allows for new recipes and software updates. Wi-fi feature enables connected appliance experience and app based guided cooking. Inbuilt scale helps with guided cooking and precise weighing of ingredients resulting in better cooking. Voice control of the device for hands free cooking. Digital display on device for displaying details of speed, time and weight.

A SMART MIXER FOR ASSISTED COOKING

Tech Mahindra partnered for design and development of esthetics & features for Smart Mixer for enhanced cooking experience & futuristic appearance. Smart mixer enables assisted cooking utilizing Auto Sense Technology, Built-In Smart Scale and IoT features. The Auto Sense Technology actively monitors changes in texture and viscosity through motor torque feedback to optimize mixing performance. The Wi-Fi feature enables a connected appliance experience and app-based guided cooking. The inbuilt scale aids in guided cooking and precise weighing of ingredients, resulting in better cooking

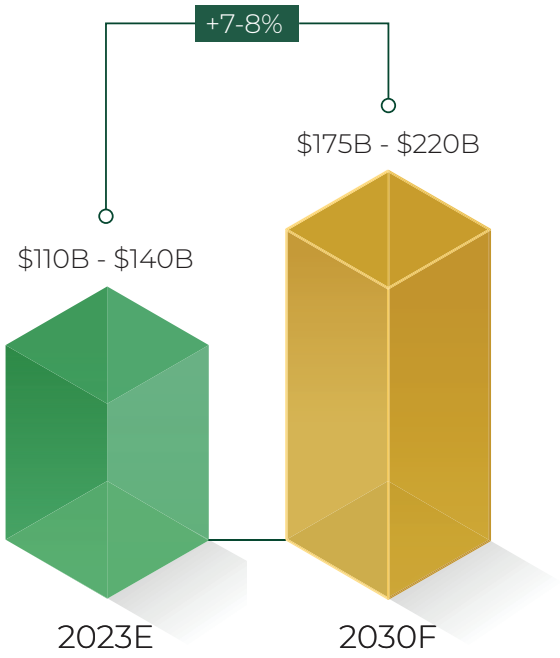
CES Innovation Award Honoree, USA

Energy, Utilities and Oil & Gas sector Deep dive



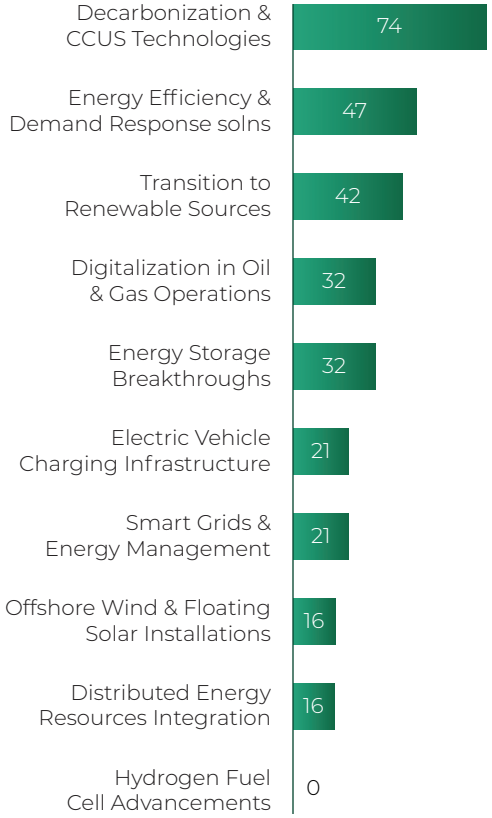
Energy, Utilities and Oil & Gas: Increased focus on green technologies & digital expected to take sector's business ER&D spend towards $175-220B by 2030

ENERGY, UTILITIES AND O&G ER&D SPENDS EXPECTED TO REACH $175-220B+ BY 2030...



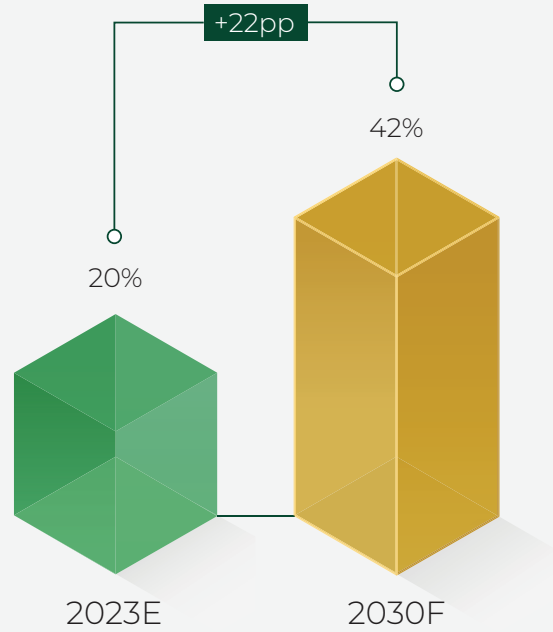
Sector's Business ER&D Spend ($B)

...WITH DECARBONIZATION, ENERGY-EFFICIENCY & RENEWABLE ENERGY AND DIGITIZATION AS TOP ER&D PRIORITIES...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...WITH SHARE OF DIGITAL ENGINEERING IN ER&D INCREASING BY 22PP



% of sector's ER&D spend on digital engineering

Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Two major trends are driving ER&D in the sectors

NET-ZERO TRANSITION:

Low-emission technology

DIGITIZATION:

Improve efficiency with technology

Power Generation

- Renewable energy, esp. solar: **Global Solar PV market is expected to grow significantly from 2023 until 2030**
  - » Solar PERC cell technology dominates; to be replaced by TOPCon & HJT technologies
- CCUS: Carbon capture capacity projected to grow significantly
- Increase in nuclear fission R&D: Emergenceof several start-ups & investments by O&G players

- New technologies using of AI/ML, drone, etc. **in power generation through renewables and conventional sources – e.g., wind design & array layout, predictive maintenance, drone for inspections, etc.**
- Use of digital twin to simulate development, operations, etc. – thus, lowering costs, improving efficiency, etc.

Power Distribution & Transmission

Grid Modernization:

- Increased volume of data from grid assets—e.g., smart grid, smart meters, etc. to improve efficiency of transmission& distribution
- Integration of renewable energy to the grid; introduction of storage, specially for renewables

Oil & Gas

- Biofuel usage to grow; R&D focus on fuels derived from algae & microbes

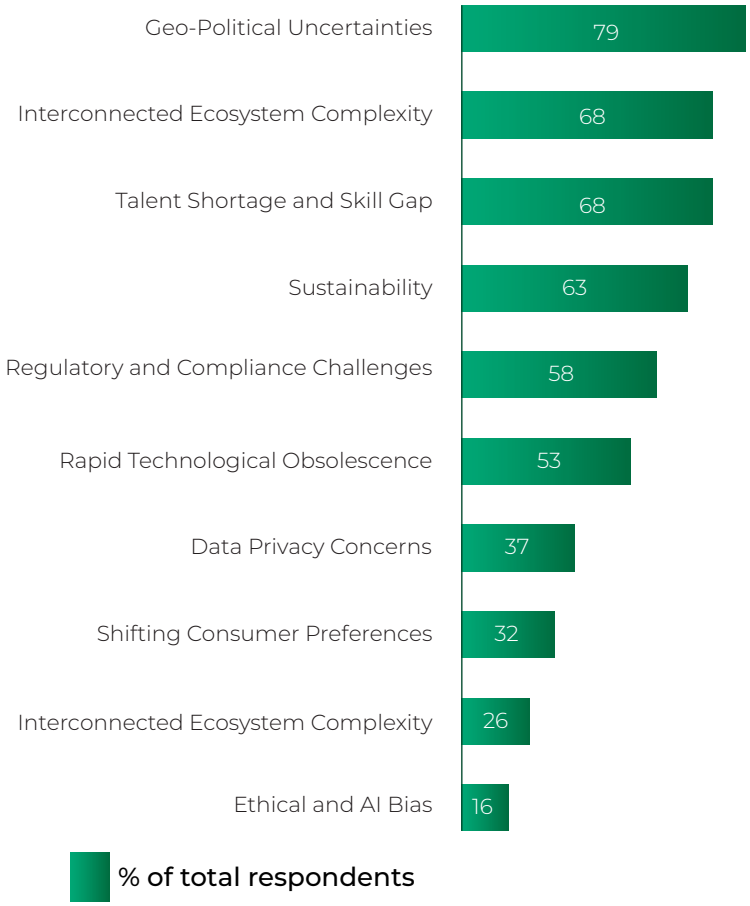
- Use of digital twin to simulate development, operations, etc. of O&G sites and plants
- AI/ML **used in production optimization, drilling automation, predictive maintenance, etc.**

Note: 1. Stated Policies Scenario reflects the impact of existing policy frameworks and today's announced policy intentions 2. Sustainable Development Scenario assuming all new policies proposed by governments take place and the world will comply to COP21 and hence rise of temperatures will stay within 1.5°-2°C

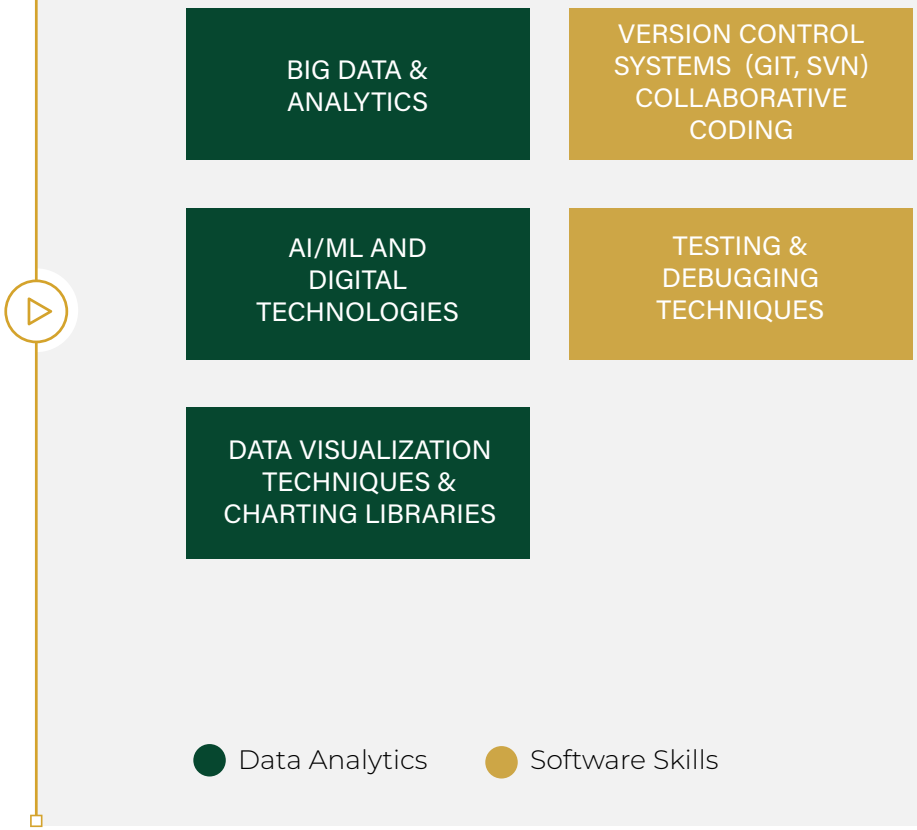
Source: BCG Analysis

Key concerns from industry leaders include interconnected complexities driven by geo-political uncertainties, and skill gap due to increasing digitization

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Honeywell | Ethanol to Jet Fuel

ABOUT THE COMPANY

Company: **Honeywell**
Sector: **Energy, Oil & Gas, and Utilities**

INNOVATION BRIEF

Ethanol-To-Jet Fuel (ETJ) is a processing technology that allows producers to convert corn-based, cellulosic, or sugar-based ethanol into Sustainable Aviation Fuel (SAF). SAF is a high-quality, renewable jet fuel with similar properties to conventional jet fuel

NEED OF ER&D

- The demand for SAF is increasing, but the aviation industry is facing a shortage of traditional SAF feedstocks like vegetable oils, animal fats, and waste oils
- However, there is a readily available and economically viable alternative - ethanol

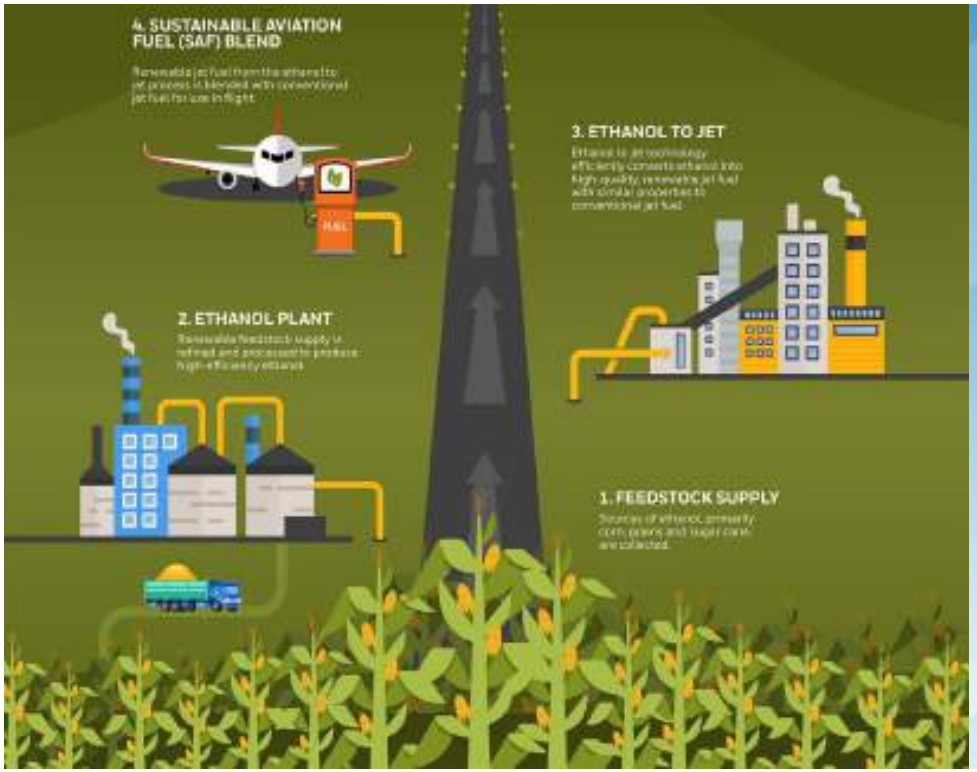
DESCRIPTION OF SOLUTION

- Honeywell's ETJ process leverages more than a decade of Honeywell **UOP's Ecofining** experience, low process carbon intensity, and high yield of the jet as proven by UOP's track record in catalyst development and ability to economically scale from **30 thousand to a billion gallons per year**
- ETJ technology is not dependent on the type of ethanol used and does not require high-purity ethanol or more expensive feedstock

IMPACT

- This represents a critical development in the drive to meet the **2030 sustainable aviation fuel (SAF) mandates and India's 2070 emission reduction targets**
- ETJ process has the potential to reduce greenhouse gas (GHG) emissions by **80%** on a total lifecycle basis, compared to petroleum-based jet fuel
- It has an overall **distillate yield** (including both renewable jet and renewable diesel) of over **90%** on a carbon basis

Honeywell | Ethanol to Jet Fuel



TCS | AI Digital Twin Boiler Combustion Thermal Power Plant

ABOUT THE COMPANY

Company: **TCS**
Sector: **Energy, Oil & Gas, and Utilities**

INNOVATION BRIEF

A Holistic solution for Thermal power plant through digital integration to optimizes combustion cost and emissions

NEED OF ER&D

- **Growing environmental and economic pressure on coal-fired power plants** to operate with high efficiency, reduced emissions
- **Modern coal power plants rely on complex network of sensors, actuators, digital controllers,** and supervisory computers to operate and coordinate each of the plant subsystems
- Customer had **tried many technological options** to improve the operational KPI and was not successful

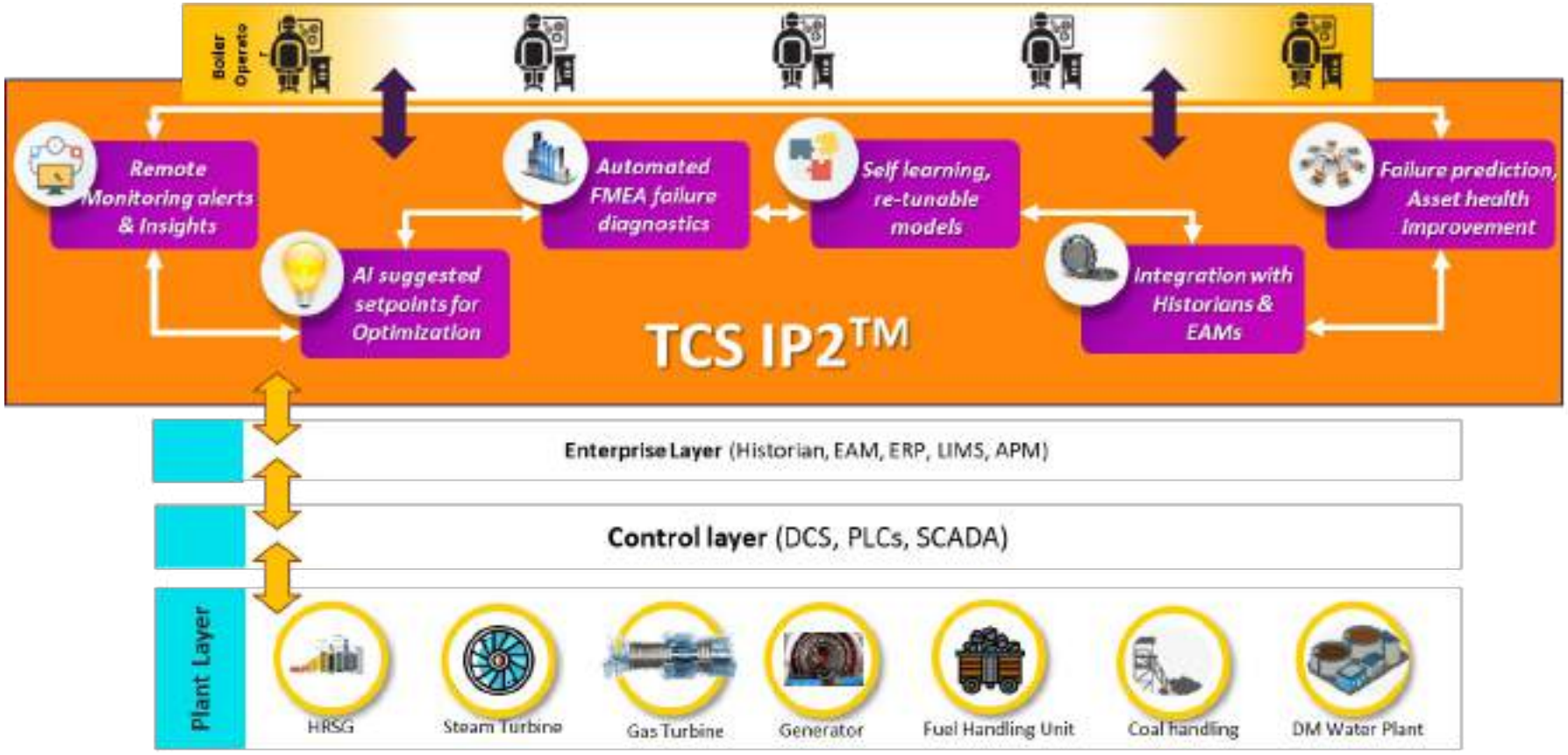
DESCRIPTION OF SOLUTION

- TCS IP2™ , an intelligent digital solution that uses AI, IoT, and digital twin technologies
- TCS IP2™ Product leveraged to conceive and deliver Digital Twin within 1 year
- Explore 5 years data and extract the knowledge to AI/ML based Model
- Implemented scalable, modular Digital Twin for various plant operation process such as Combustion, Emission, Balance of Plant

IMPACT

- Combustion Digital Twin System **reduced Operation cost by 1.5%** (0.5-1.5 MUSD per year)
- Efficiency of Boiler **increased by 0.5%**
- Balance of **Plant Twin reduced Auxiliary Power by 4.4%**
- NOx **Emission reduced by 8%** and unburnt carbon rate by **1.6%**

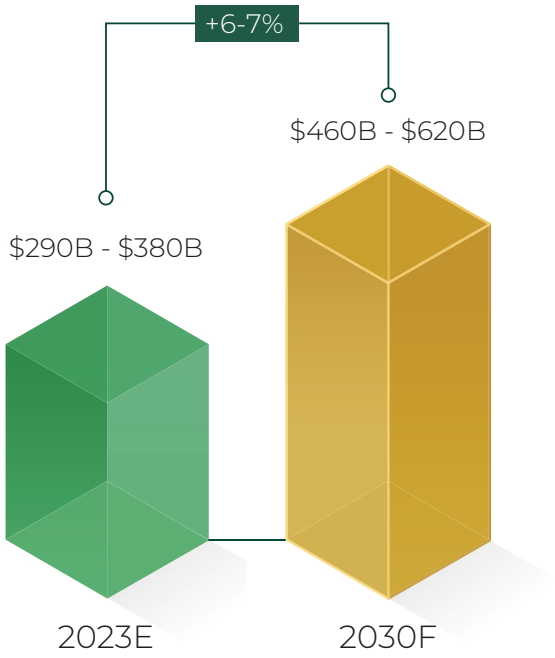
TCS | AI Digital Twin Boiler Combustion Thermal Power Plant



Healthcare & Medical Devices sector Deep dive

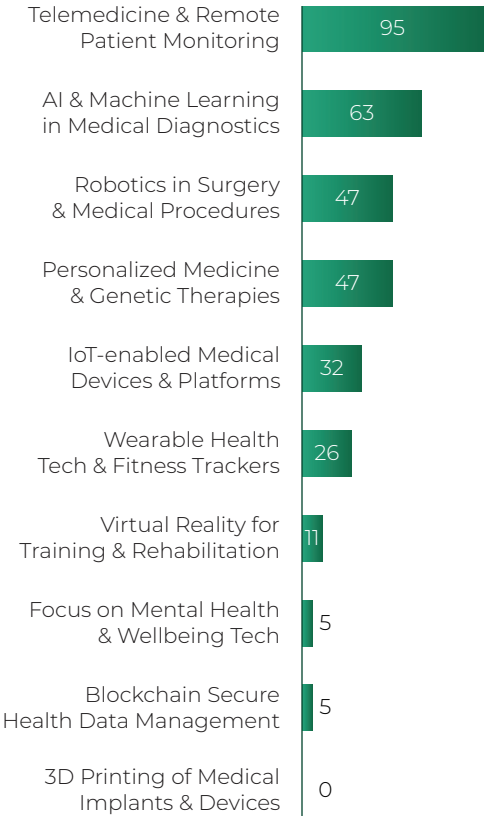
Healthcare & Medical Devices: ER&D spends expected to remain high in healthcare & medical devices making it the highest ER&D spender across sectors

BY 2030, SECTOR EXPECTED TO LEAD ER&D SPENDING, INCHING TOWARDS $460-620B...



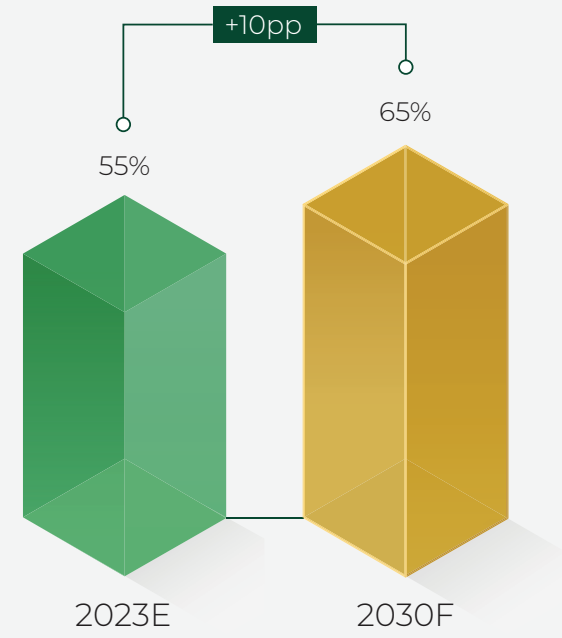
Sector's Business ER&D Spend ($B)

...WITH TELEMEDICINE, AI/ML IN DIAGNOSTICS, ROBOTICS & PERSONALIZED THERAPIES AS KEY FOCUS AREAS...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY DIGITAL ENGINEERING SHARE OF ER&D SPEND REACHING 65% BY 2030



% of sector's ER&D spend on digital engineering

Includes prevention & tracking, diagnostics, therapies, surgeries, etc.., 2. Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge **Source:** BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

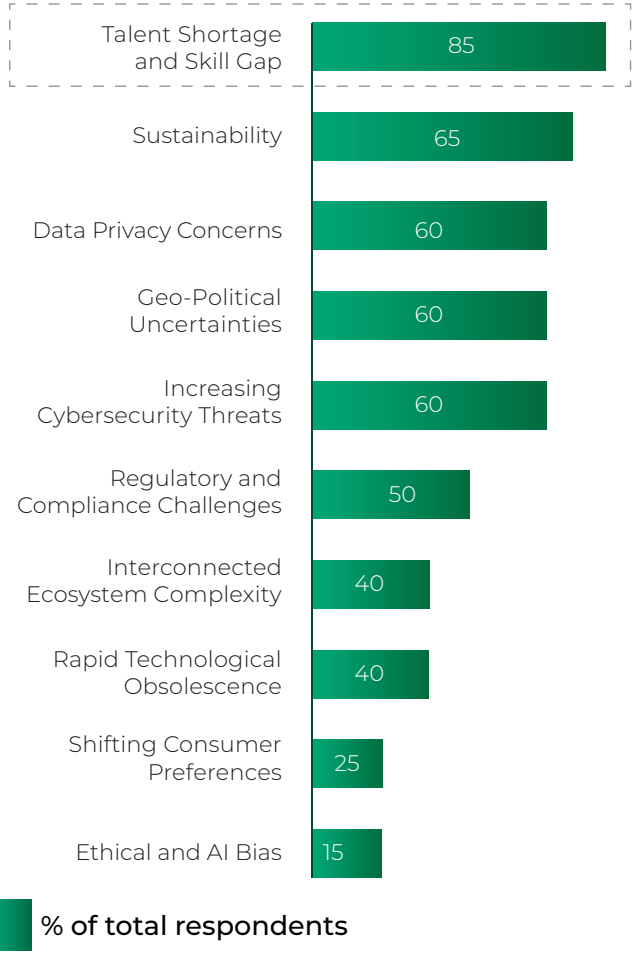
Development of therapies increasingly involves technological collaboration, with growth coming from multiple new technologies

HEALTHCARE & MEDICAL DEVICES RESEARCH TRENDS	DESCRIPTION	DRIVEN BY NEED FOR
Consumer-driven digital health	Penetration of mobile devices and digital technologies is increasing the demand for remote services and innovative technologies that empower consumers to take a more active role in their healthcare	• Remote care • Preventive care • Wearable devices
Real-world data and AI-enabled treatment and discovery	Advances in data processing power and the exponential growth of medical data are enabling AI to lead to better care outcomes, including better targeting of therapies, early intervention, and improving productivity of care delivery	• AI enabled analysis of medical imaging • Machine-learning enabled drug discovery
Rise of precision medicine	Precision medicine relies on increasingly detailed molecular characterisation of disease states using the biologic omics platforms to better individualise diagnostics, prognostics and therapeutics	• Multiplexed genetic profiling • Personalised clinical therapeutics (e.g., CAR-T)
Robotics in Surgery, etc.	Robots aid healthcare workers in clinical settings, expanding their roles beyond the operating room to improve patient care	• Surgeries • Hospital cleaning, medicine sorting, etc. • Research laboratories

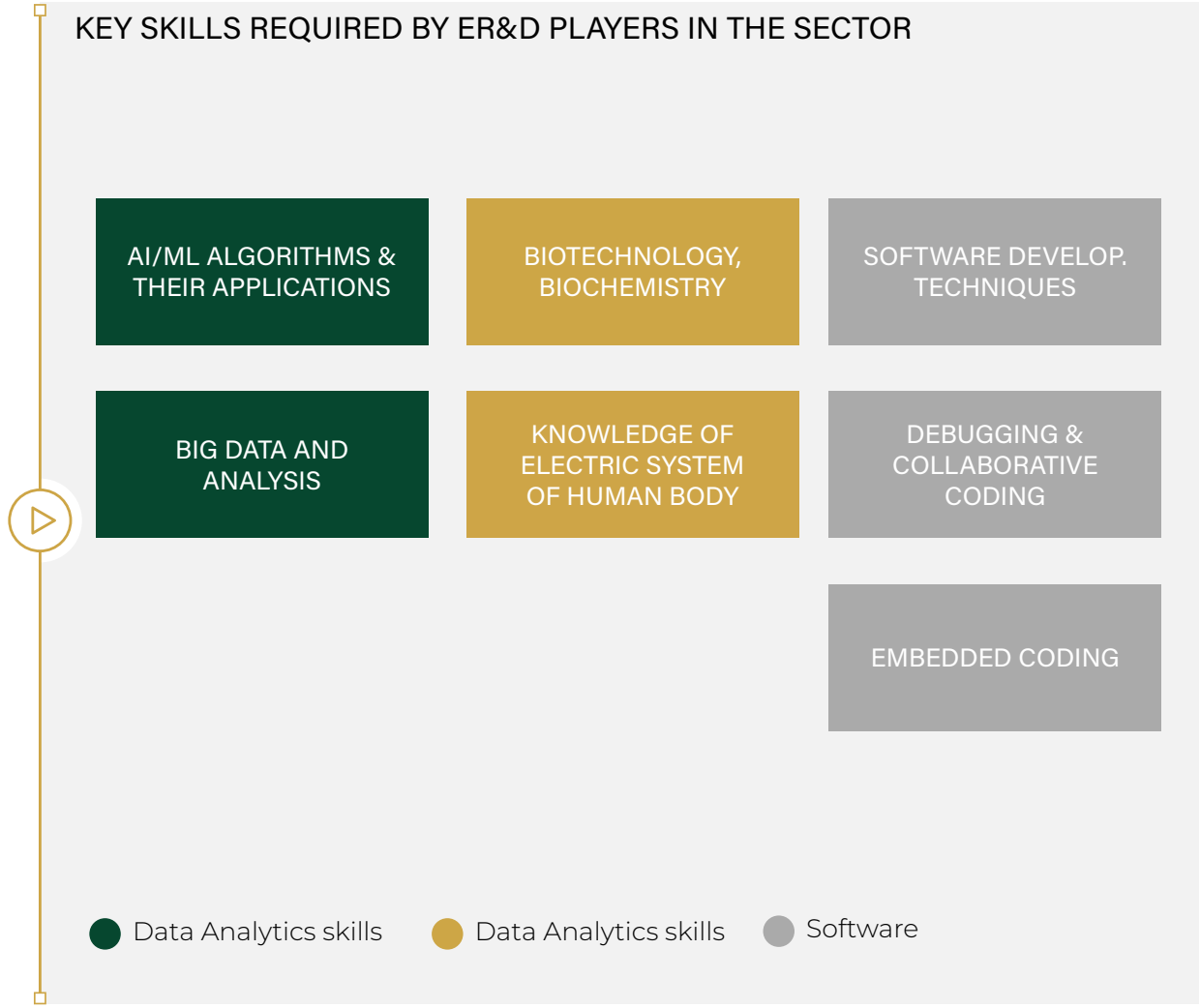
1. Advanced drug delivery market size and forecast, Verified Market Research report; 2. Point of care diagnostics Market Analysis Report, Grand View Research. 3. Cell and Gene Therapy Global Market Report 2022; Grand View Research Remote Care Market Analysis Report 2021. 4. Global AI in healthcare Market, Precedence Research; 5. Precision Medicine Market, Precedence Research; 6. Statista

Key concern in the industry is talent shortage & skill-gap, along with data privacy issues as digitization of healthcare & medical devices sector increases

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Capgemini | Medical Device Connector (IoT in a box)

ABOUT THE COMPANY

Company: **Capgemini**
Sector: **Healthcare and Medical Devices**

INNOVATION BRIEF

An effective solution for securely linking legacy medical devices and transmitting data to and from the chosen IoT platform with ensured security

NEED OF ER&D

- Create an automated mechanism for **cost-effective transfer** of system logs between medical device and IoT platform **without human intervention** while ensuring security and privacy of data in an existing healthcare environment and no regulatory re-certification

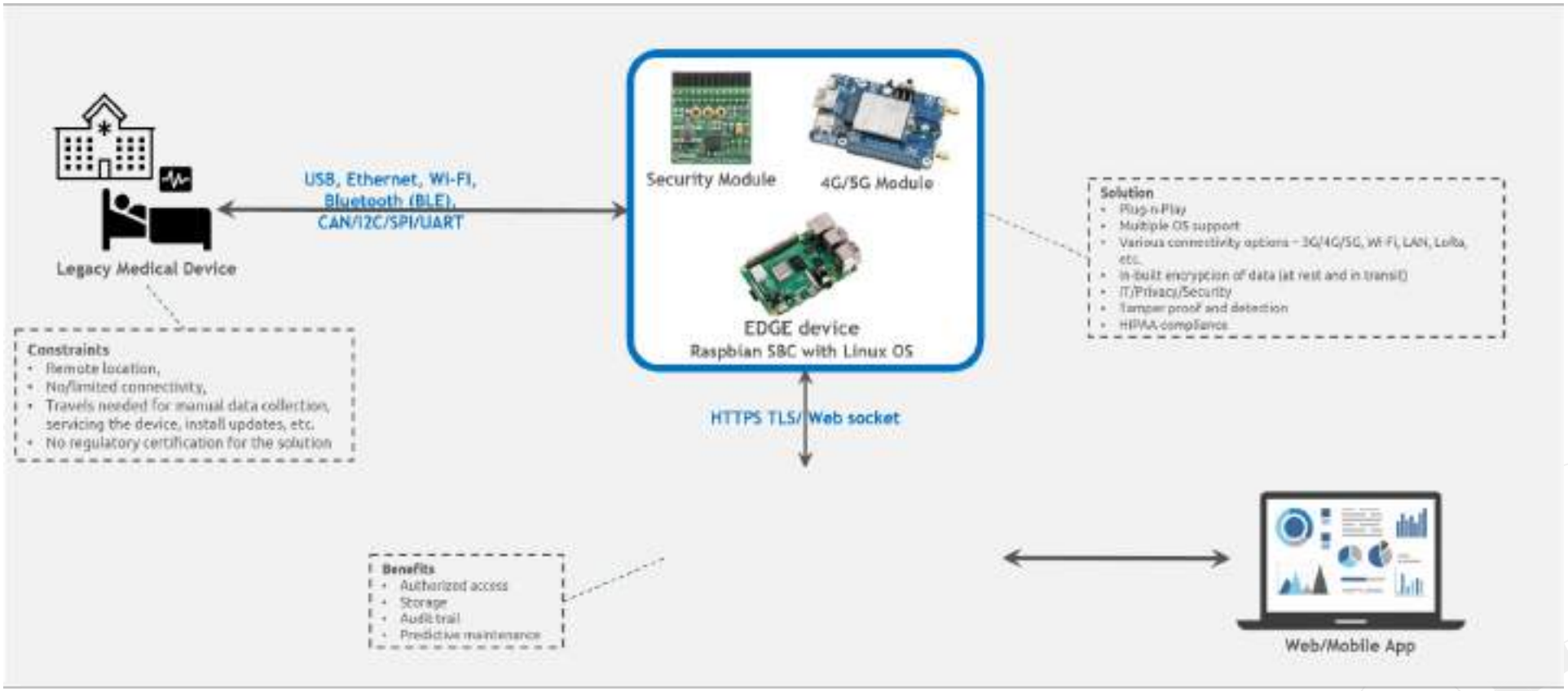
DESCRIPTION OF SOLUTION

- **Used an inexpensive SBC with Security and Connectively modules, and plug-n-play connection to any legacy Medical devices through standard ports**
- Established mechanism for routine and automated upload of data
- **Addressed IT/Privacy/Security concerns in healthcare environment**
- **HIPAA compliance** wherever Clinical data is involved

IMPACT

- Security, hospital network independent, HIPAA compliance, Automated system Updates, Enabled remote connectivity, Extended Device life employing Predictive Maintenance, Reduced Green house emissions by reducing travel, inbuilt support for Software as Medical Device (SaMD) and tele-medicine solutions

Capgemini | Medical Device Connector (IoT in a box)



Tata Elxsi | TEngage - healthcare

ABOUT THE COMPANY

Company: **Tata Elxsi**
Sector: **Healthcare/Medical Devices**

INNOVATION BRIEF

An Omnichannel Care platform that acts as a “Digital Front Door” to essential healthcare services to provide a unified healthcare experience throughout the continuum of care

NEED OF ER&D

- Today the **“doctor to population”** ratio is alarming across the globe, in India it is at **1:1511**
- TEngage is an effort to improve this ratio by making healthcare services more accessible esp., for the rural/remote/low economy locations
- Specialist hospitals at urban areas, would be able to quickly set up remote clinics at **rural locations, cost efficiently** with TEngage

DESCRIPTION OF SOLUTION

- **Cloud-based, customizable,** and compliant platform centralizes care team-patient communication with personalization and shared features
- Providers and patients access **various healthcare services: appointments, video consults, chats** and more
- Seamlessly **integrates with hospital IT,** deploys on any server (cloud or on-premises)
- **Integrates clinical and non-clinical functions, offers insights** for seamless digital, personalized care transition

IMPACT

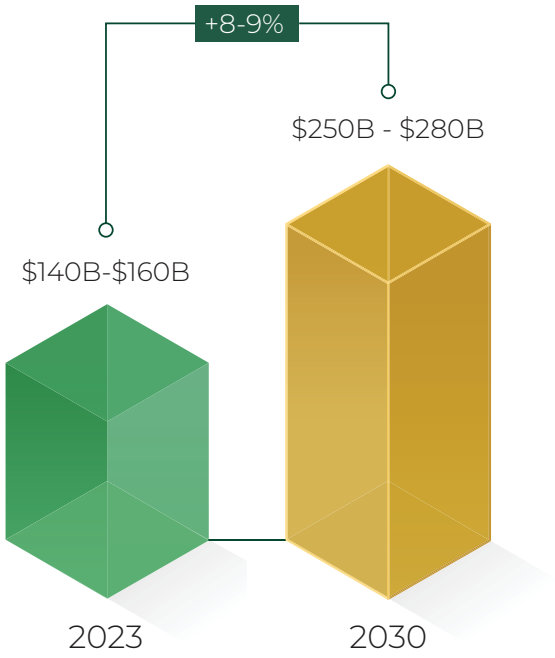
- **Deliver Healthcare Anytime,** with a unified patient experience
- **Pick and plug** modules for hospital specific needs
- **White labelling** to boost hospital brand
- **Minimize Hospital Operational Cost** and enable speedy, seamless deployments with cloud agnostic architecture
- **Privacy and security** with technical
- **Improved market reach**

Tata Elxsi | TEngage - healthcare

Industrial (incl. construction) sector Deep dive

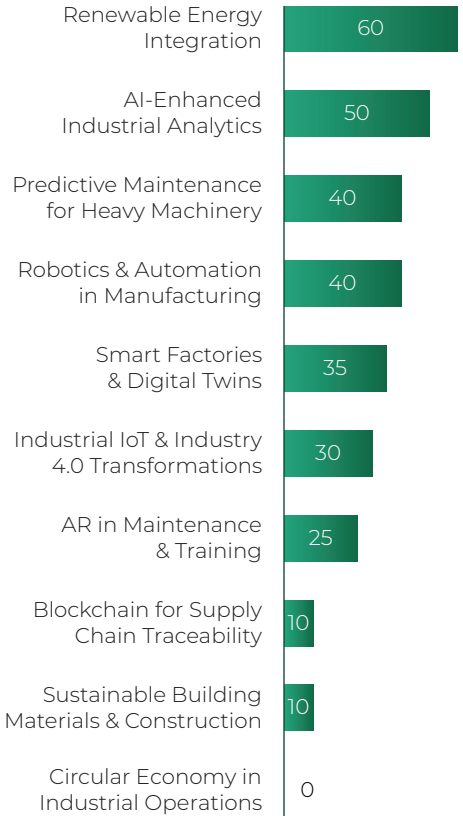
Industrials including Construction: ER&D spend driven by focus on advances in data backed ops, improving efficiency and quality of output through digital

INDUSTRIAL ER&D SPEND EXPECTED TO REACH $250B-280B BY 2030 GROWING AT ~8-9% CAGR[1]...



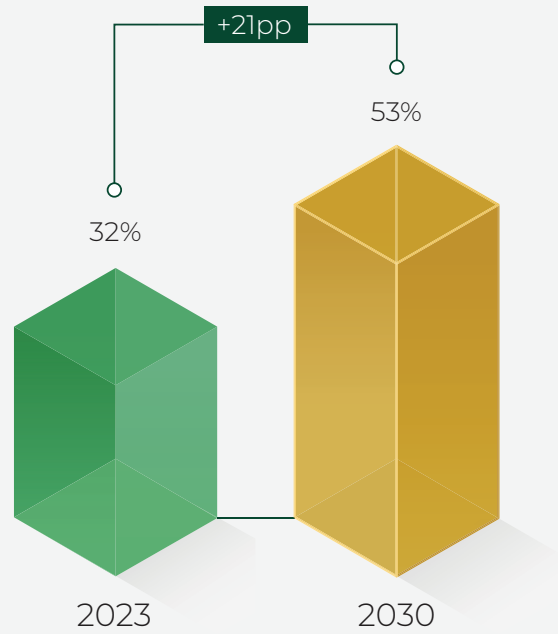
Sector's Business ER&D Spend ($B)

...WITH SUSTAINABILITY, AI-ENHANCED ANALYTICS & AUTOMATION AS TOP 3 ER&D SPENDS...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY INCREASING SPEND ON DIGITAL ENGINEERING BY 21PP



% of sector's ER&D spend on digital engineering

1. Does not include major Chinese companies.Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge **Source:** BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Three major shifts will strategically impact and lead to increased industrial ER&D spends

AUTOMATION & ROBOTICS

Use of control systems (such as computers or robots) & information technologies for handling different processes & machineries in industry for work otherwise done manually

Driven by:

- Deeper penetration of industrial robots driven by need for faster & more efficient industrial processes
- Industry driven by technological advancements in AI, IoT, etc.

PLATFORMIZATION

Development of basic structures for industrial tools, etc.; it uses re-use of parts saves money & time across platform and product launches

Driven by:

- Accelerated new product launches at lower costs
- Need for improved insights into product design for best performance through cross-functional input and engagement

DATA IN INDUSTRIALS

Data is being leveraged across sector to optimize factory operations, manufacturing processes, improve construction quality in construction sector, etc.

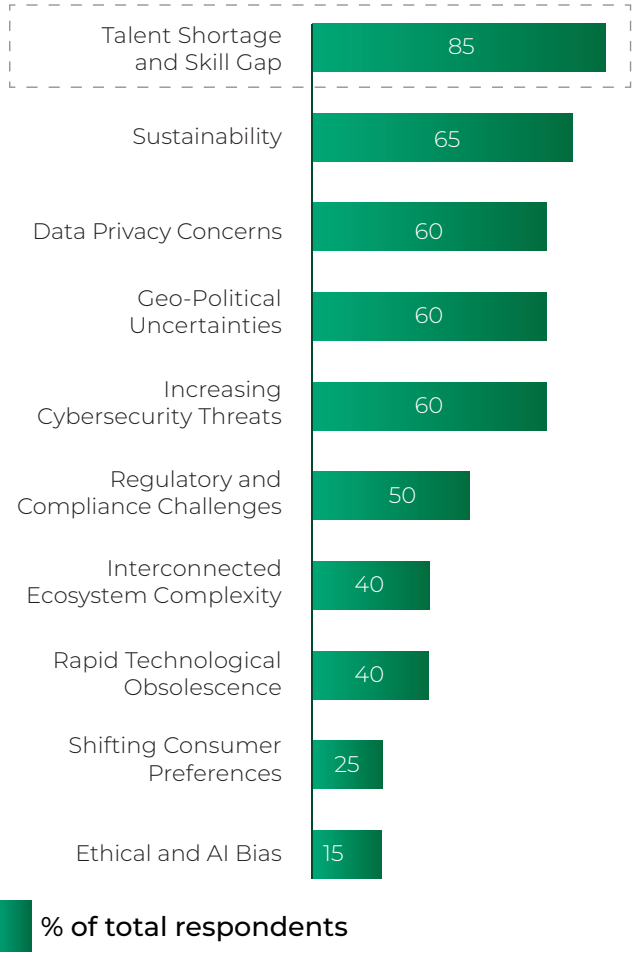
Driven by:

- Demand to optimize and improve manufacturing processes with analytics, digital twins & smart factories
- Predictive maintenance in industrials to ensure business continuity, etc.

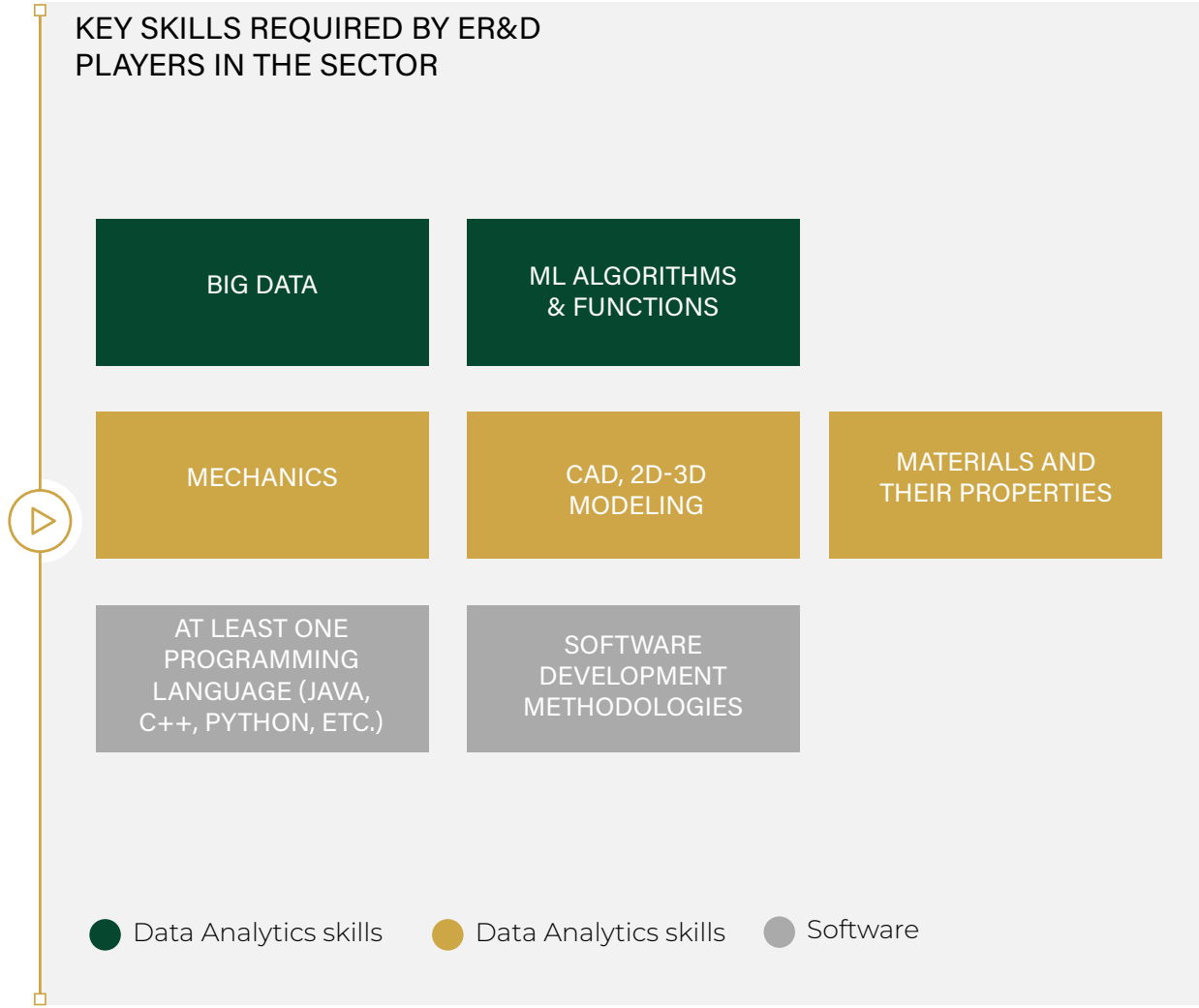
Source: BCG Analysis

Key concern in the industry is talent shortage & skill-gap as digitization increases in an otherwise traditional industry

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Schneider | Decarbonized steel enclosure

ABOUT THE COMPANY

Company: Schneider
Sector: Industrial incl Construction

INNOVATION BRIEF

First in class solution (Within segment / Schneider) of incorporating Green steel produced with renewable energy with the reduction of emissions in its scope 3 which limits carbon footprint and substantially boosts global goal of Net Zero emission

NEED OF ER&D

- The steel Industry is responsible for around 7% of CO2 emissions globally
- This drives Schneider for an innovative solution and to align with 1.5°C scenario from CoP 21 agreement

DESCRIPTION OF SOLUTION

- Schneider has developed a groundbreaking solution by replacing half of normal steel with **decarbonized steel** that transforms the traditional metal production process into sustainable one through which end user can significantly reduce their carbon footprint and contribute to a greener future
- By embracing this cutting-edge technology, businesses can achieve their goals while minimizing environmental impact

IMPACT

- This solution offers excellent environmental benefits without compromising the basic design intent, by reducing Co2 footprint by **34% (395 kgco2eq. savings/unit)** thanks to **50%** decarbonized steel
- Also, the other paybacks are **0% Single use Plastic, minimizing(0 to 5%)** paper usage (leaflet) through QR code, **70%** recycled cardboard in its packaging, with recyclability potential of **98%**

Schneider | Decarbonized steel enclosure

"Only by choosing Decarbonized steel box you can save around **31.600 tree seedlings grown** for 10 years*"

* Average done with a project with 5 columns

LTTS | Automatic Recovery Circuit Breaker

ABOUT THE COMPANY

Company: LTTS
Sector: Industrial incl Construction

INNOVATION BRIEF

A 230V/415V AC circuit breaker for commercial and industrial use. Combines MCB and ELCB features, includes pre-detection for short circuits, overload & electric shocks.

NEED OF ER&D

- ELCBs and MCBs **protect against electric** leakage in areas with electrical devices, safeguarding people and property
- ELCBs detect earth leakage after a brief electric shock; **not before turning ON**
- ELCB **may trip seconds after an electric shock,** while MCB only detects short-circuits or **overcurrent when turned ON**
- This may **therefore cause damage to sensitive electrical equipment or wiring**

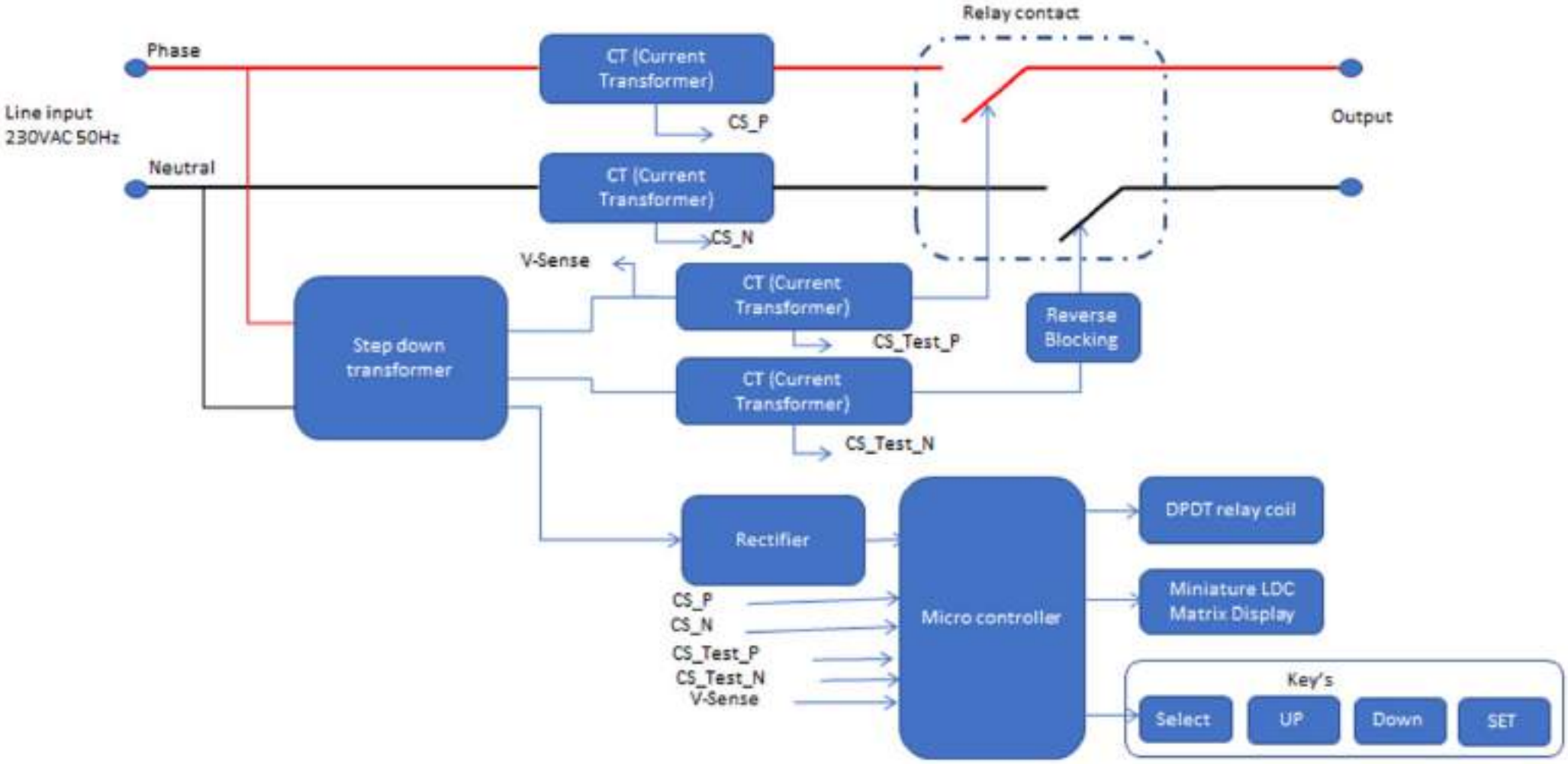
DESCRIPTION OF SOLUTION

- **A step-down transformer, followed by two current transformers (CTs),** detects faults in phase or neutral lines by sending a low-voltage AC signal before powering the load
- Both **CTs sense current, detect earth leakage, and identify human contact with phase or neutral lines**
- A microcontroller **monitors the circuit's analog signal,** detects earth leakage and output shorts before powering ON, and **controls a relay to switch the circuit load**

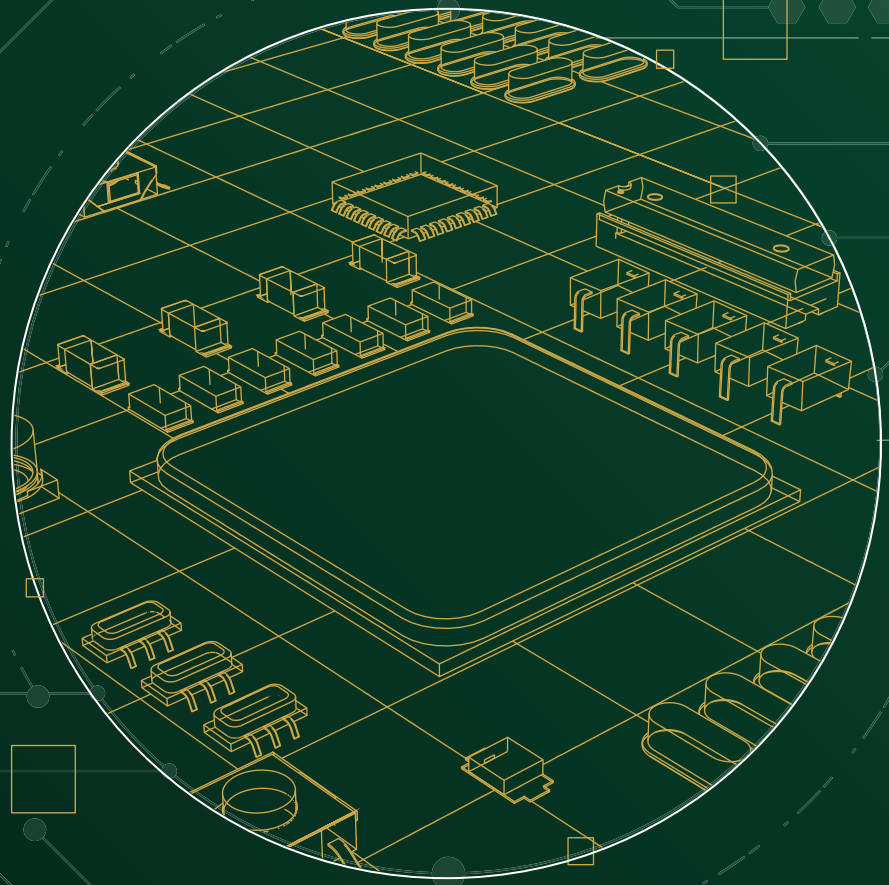
IMPACT

- **ARCB ensures electrical and human safety by combining MCB and ELCB features:** short circuit, overload, and earth leakage protection, along with pre-detection of electrical shock and short circuits
- **It offers automatic recovery** if the fault clears within 10 seconds; otherwise, it permanently trips the circuit

LTTS | Automatic Recovery Circuit Breaker

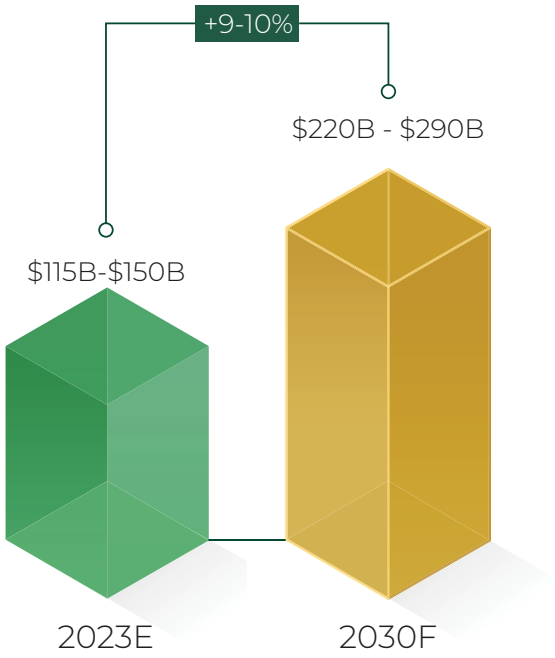


Semiconductor sector Deep dive



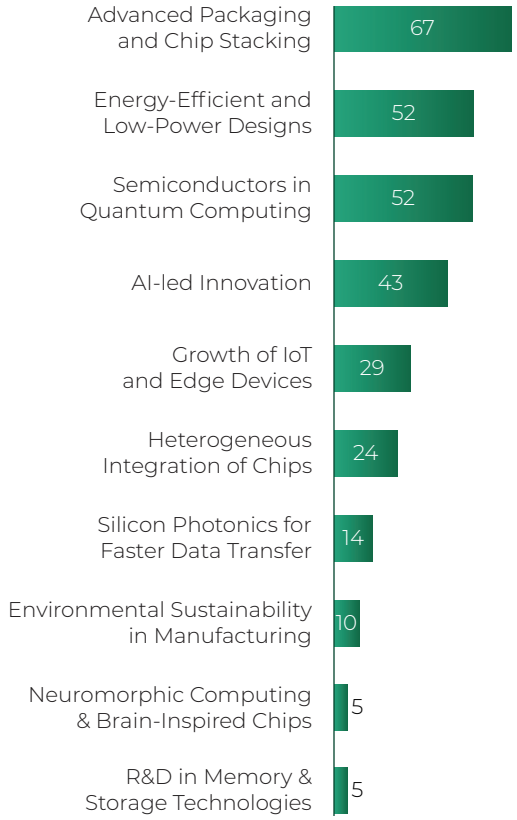
Semiconductors: ER&D spend expected to reach $220-290B with focus on areas of packaging and new application specific developments

SEMICONDUCTORS ER&D SPEND EXPECTED TO REACH $220-290B BY 2030 GROWING AT 9-10% CAGR...



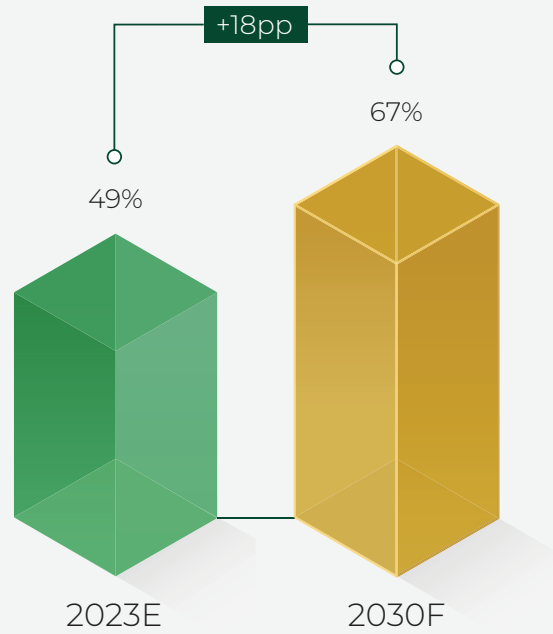
Sector's Business ER&D Spend ($B)

...WITH PACKAGING, ENERGY-EFFICIENCY & QUANTUM COMPUTING AS TOP 3 ER&D PRIORITIES...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY AN INCREASE IN SHARE OF DIGITAL ENGINEERING AS PART OF ER&D SPEND BY 18PP



% of sector's ER&D spend on digital engineering

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG Analysis

Two shifts will strategically impact Semiconductor ER&D spends

AI IN CHIP DESIGN

Use of AI to enhance chip design, testing, and manufacturing – to improve performance and cost-effectiveness

Driven by:

- Need to manage intricate semiconductor designs efficiently
- Need to manage vast data for insights and improvements
- Acceleration of product development, meeting performance demands and gaining a competitive advantage due to AI-driven innovation

Innovation in Advanced Packaging & Chip stacking

Innovative techniques for enclosing and connecting microchips, enhancing performance, energy efficiency, and device size reduction

Driven by:

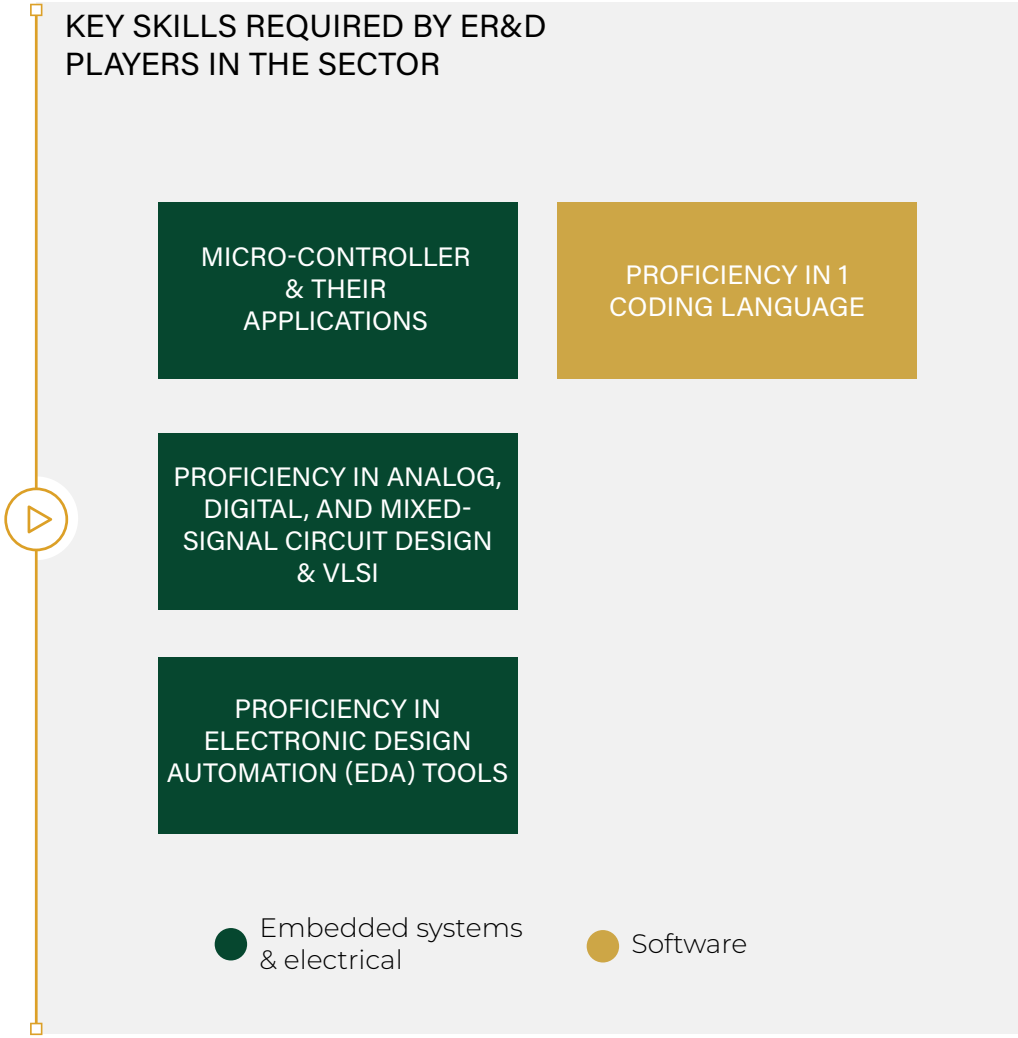
- Requirement of enhancement of microchip speed and efficiency to boost overall device performance
- Demand for lower power consumption & longer battery life
- Demand for compact device design in various industries

Source: BCG Analysis

Rapid tech obsolescence & talent shortage are the two key concerns faced by ER&D players in the industry

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR

KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



1. Japan Electronics and Information Technology Industry Association; 2. China Institute for Educational Finance Research; 3. Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Micron | 232-layer NAND SSD Chip

ABOUT THE COMPANY

Company: **Micron**
Sector: **Semiconductor**

INNOVATION BRIEF

The Micron® 2550 NVMeTM SSD delivers the latest, most advanced industry-first 232-layer NAND technology with outstanding PCIe® Gen4 performance and a superior user experience

NEED OF ER&D

- Enables fast, responsive applications and consumes extremely little power, dramatically helping extend compute time
- The Micron 2550 SSD is designed to meet the rigorous requirements of both the Intel® Modern Standby Partner Platform Component List and the Open Labs' SSD test requirements of Intel's Project Athena
- Product projected to deliver hundreds of millions of revenue for Micron

DESCRIPTION OF SOLUTION

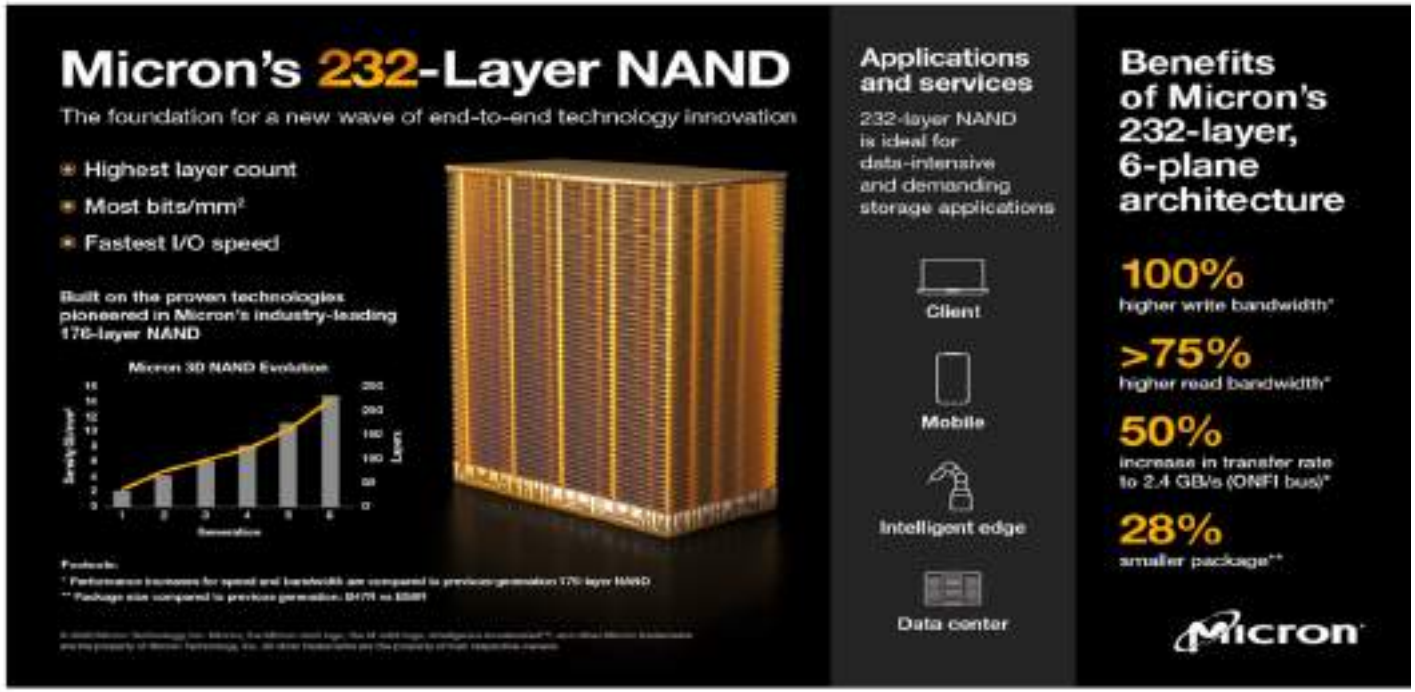
- The **Micron 2550 SSD** is built with Micron's industry-leading 232-layer NAND
- This leading-technology NAND offers **100% higher write bandwidth and more than 75% higher read bandwidth per die than our prior generation** and is the world's **first six-plane production TLC**
- This new firmware is optimized for the needs of client devices with features like **Predictive Cache Optimization & Modern Standby using Host Memory (HMB) technology**

IMPACT

- The Micron 2550 SSD enables faster, more responsive applications in mainstream PC platforms, including **gaming, consumer,** and **business** client devices
- It enables longer **battery life** on PC devices and allows to quickly wake up from low-power sleep to active working modes
- The SSD performance surpasses competitors' in **PCMark® 10** benchmark scores

Micron | 232-layer NAND SSD Chip

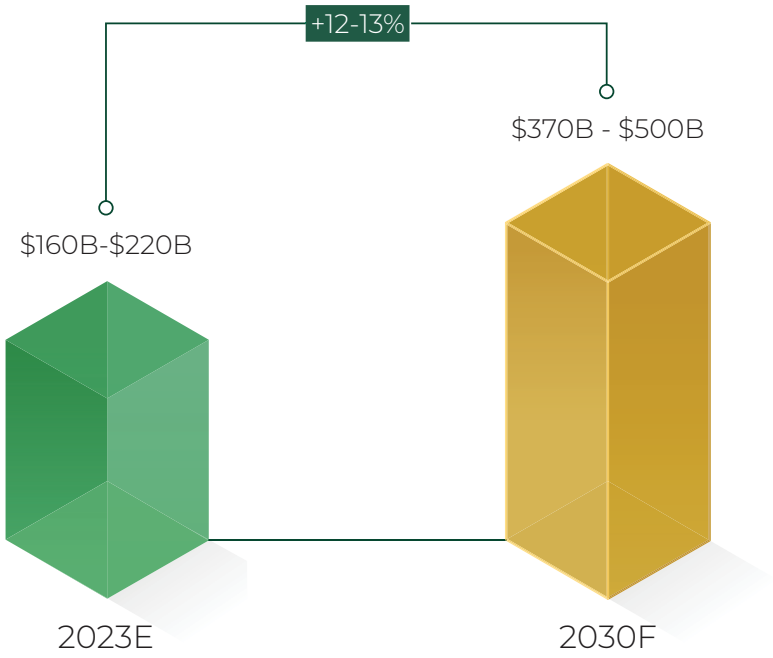
Micron* 2550 NVMe SSD			
Category	PCIe Gen4 PCs and Notebooks		
Model	Micron 2550 NVMe SSD		
Form Factor (mm)	M.2 (22x30mm, 22x42mm, 22x80mm)		
Interface	PCIe Gen4, NVMe 1.4		
Capacities[1]	256GB[2]	512GB	1TB
Sequential Read (MB/s)[3]	4,500	5,000	5,000
Sequential Write (MB/s)	2,000	4,000	4,000
Random Read (IOPS)[4]	380K	500K	550K
Random Write (IOPS)	400K	600K	600K
Read Latency (TYP)[11]	50µs	50µs	50µs
Write Latency (TYP)	12µs	12µs	12µs
Endurance (TBW)	150TB	300TB	600TB
MTTF (Million Hours)	2	2	2
SleepPS4 Power (mW)	<2.5	<2.5	<2.5
SlumberPS3 Power (mW)	<30	<30	<30
Active Idle Power (mW)	<150	<150	<150
Active Read Power (mW)[11]	<5,500	<5,500	<5,500
Advanced Features	Hardware-based AES 256-bit encryption[13] Power-loss protection (data at rest) RAIN & S.M.A.R.T. Power-loss signal support TCG Opal 2.01, TCG Pyrite 2.01 Micron Storage Executive management tool		



Software sector Deep dive

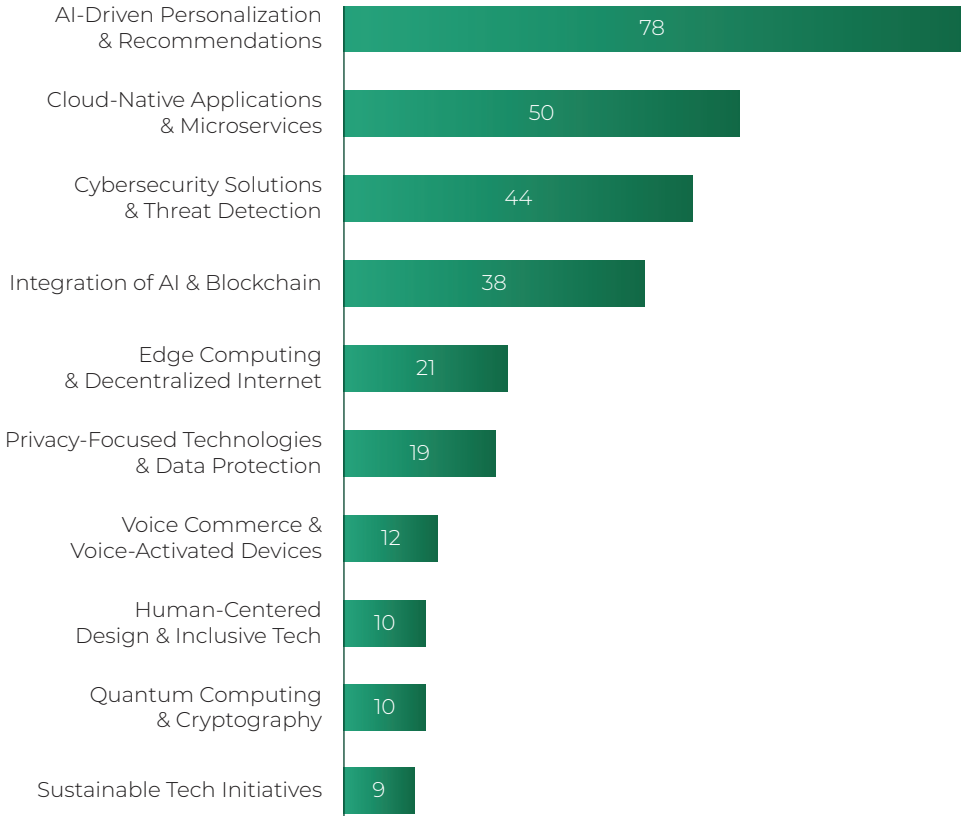
Software: Continuous innovation in software space will leverage new AI breakthroughs; Focus on cloud and cyber security expected to take ER&D spends to $370-500B by 2030

SOFTWARE ER&D SPEND EXPECTED TO REACH $370-500B+ BY 2030 GROWING AT ~12-13% CAGR...



Sector's Business ER&D Spend ($B)

...WITH AI-DRIVEN PERSONALIZATION & CLOUD APPLICATIONS AS TOP TWO PRIORITY AREAS



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG Analysis

Four major trends will strategically increase software ER&D spends

PLATFORM TOSUPER PLATFORMS

- Strong ecosystems drive sizeable engineering development work from vendors and partners (developers) as the super platforms grow(AWS, Azure etc.)
- Platforms leverage advantage by expanding marketplaces through ER&D to accommodate more3rd party solutions

INTEGRATION OF ADVANCED AI/ML INTO ENTERPRISE SOFTWARE SUITE

- Advances in Enterprise software focusing on sector specific data needs
- Enterprise infrastructure software will grow significantly over next few years, with fastest growth projected in AI Platforms
- Potential to increase automation as NLP and other AI driven outcomes can maximize productivity gains

HUMAN-MACHINE INTERACTION AT SCALE

- High growth for AR, VR, MR over coming years
- Abundant internet Bandwidth capabilities & enhanced hardware (Compute and sensor advances) to drive continued adoption ofHMI at scale

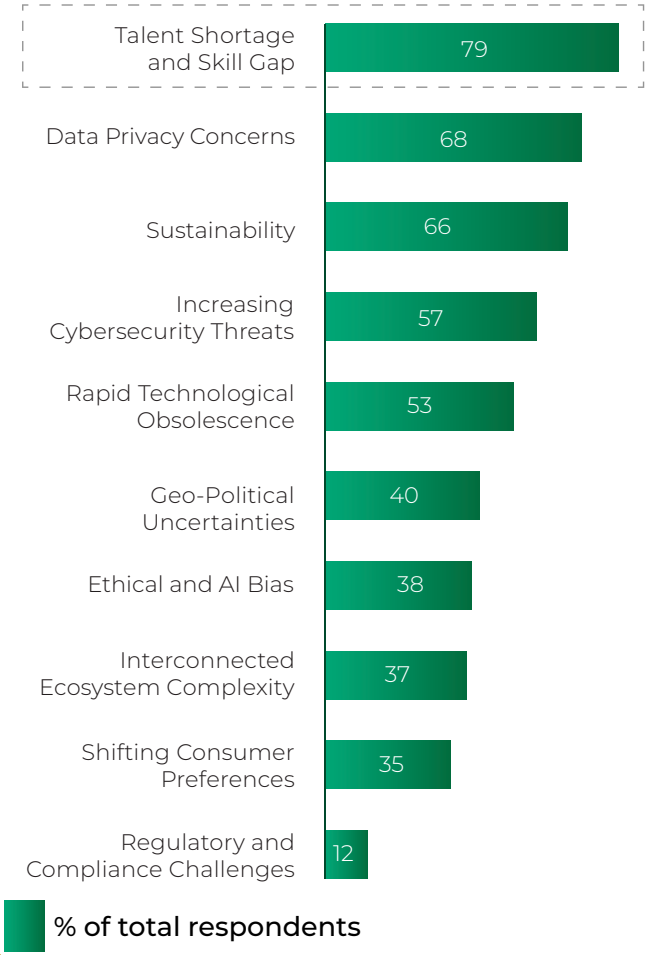
CONTINUED FOCUS ON CYBERSECURITY

- Rising cyberattacksdemand stronger software security measures
- Growing reliance on software intensifies the need to protect critical systems and data.
- Stringent regulations

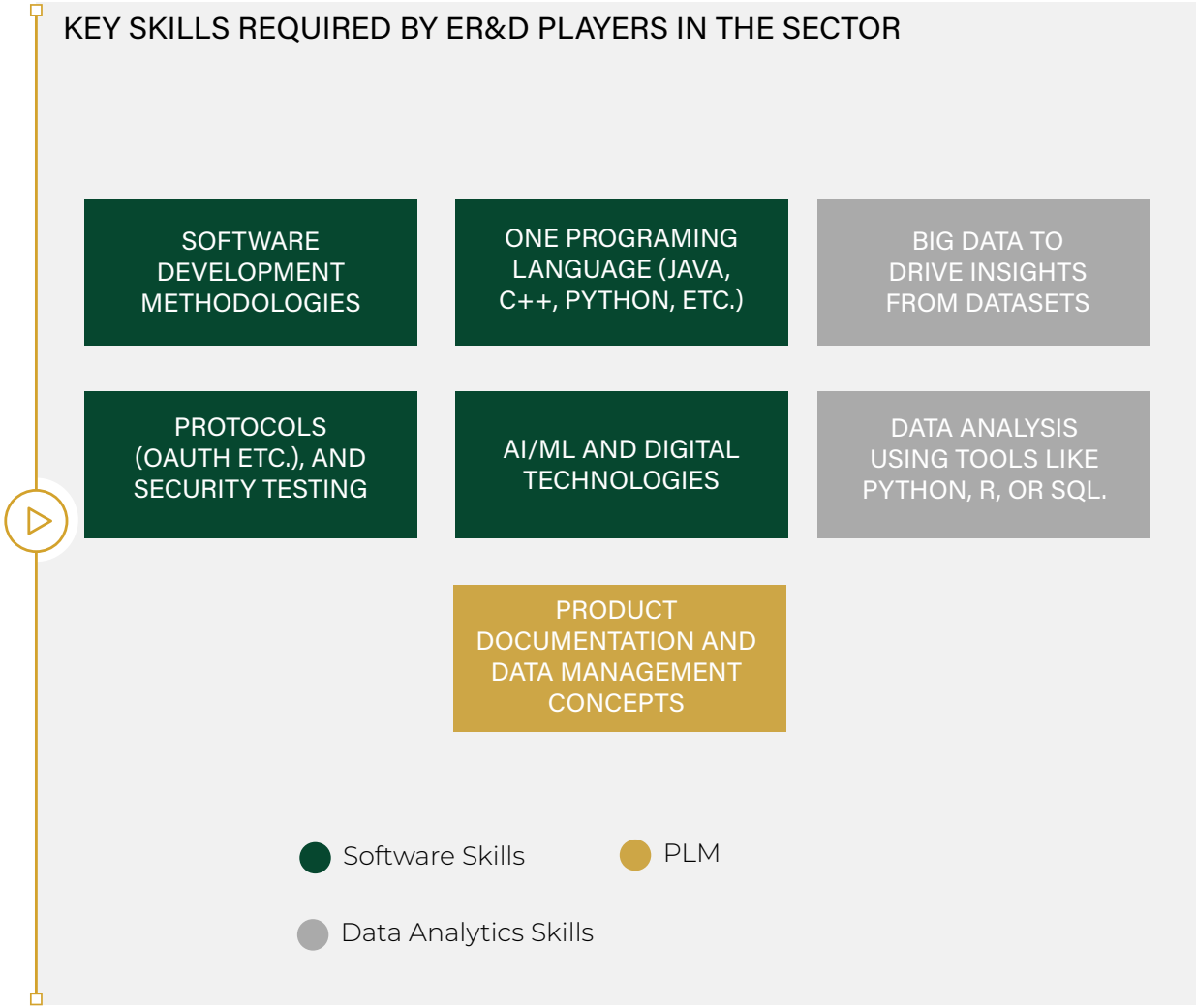
Source: Global AR & MR Market, 2021-2026, Mordor Intelligence; Global Virtual Reality Market, 2016-2028, Grand View Research; BCG Analysis

Key concern in the industry is talent shortage and skill-gaps

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



Multiple choices permitted per respondent. % shows the percentage of experts within a class that determined the choice as a future challenge

Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Carrier | Healthy Buildings

ABOUT THE COMPANY

Company: **Carrier**
Sector: **Software**

INNOVATION BRIEF

Carrier.AI is delivering sustainable solutions to maximize energy efficiency, optimize operating & maintenance costs, ensure unparalleled asset uptime and occupant comfort for our Commercial buildings, residential and transport refrigeration customers

NEED OF ER&D

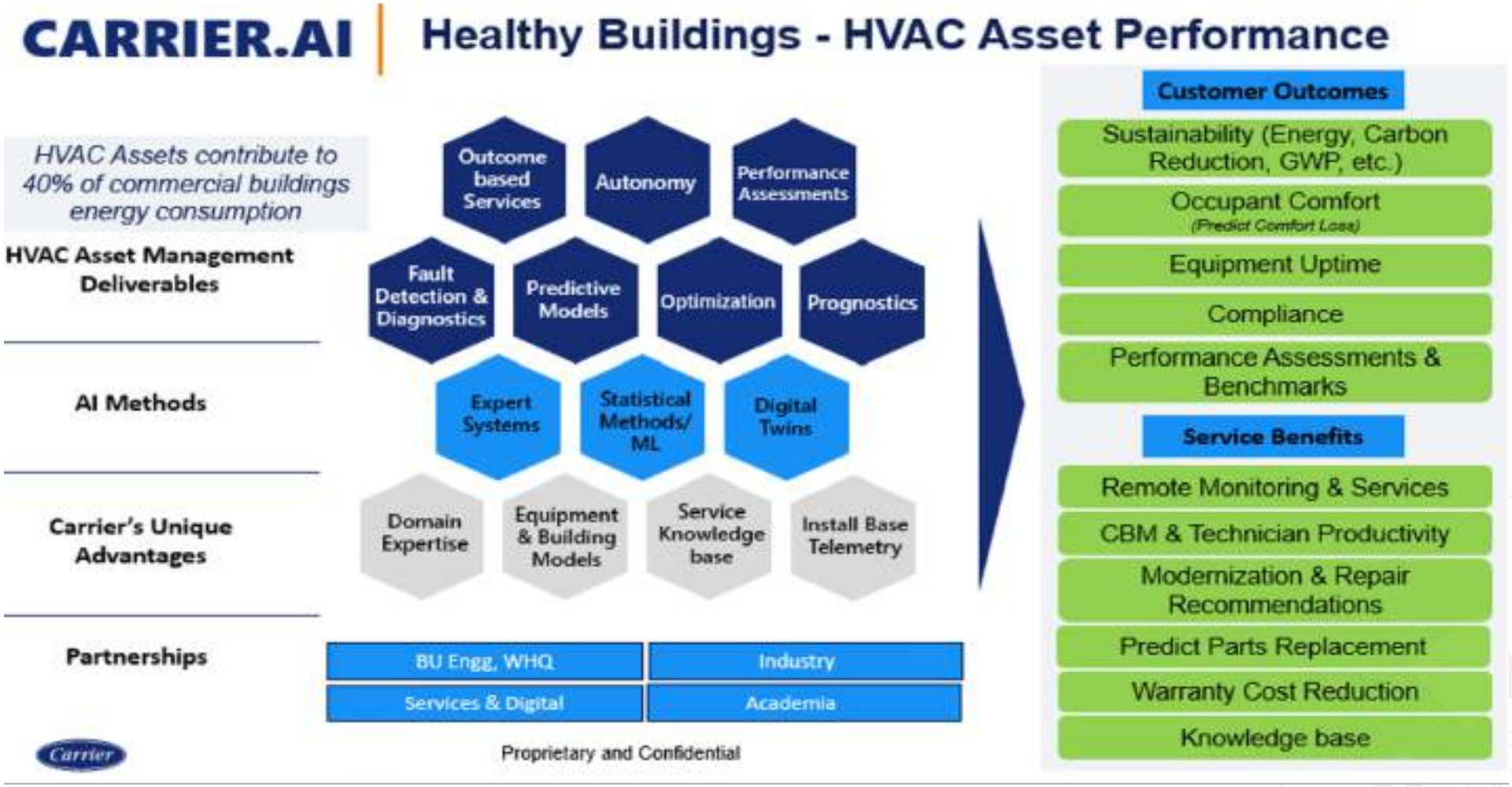
- **Carrier.AI** invests and benefits from cutting edge Research and Innovation in scientific approaches to Model driven AI, Machine learning, Digital Twins, Digital Thread, matured IIOT infrastructure coupled with unmatched product expertise
- HVAC Assets contribute to 40% of commercial buildings energy consumption

DESCRIPTION OF SOLUTION

- **HVAC Asset Management Deliverables -** Services, Autonomy, Performance Assessments, Fault Detection & Diagnostics, Predictive Models, Optimization, Prognostics
- **AI Methods -** Expert Systems, Statistical Methods/ ML, Digital Twins
- **Carrier's Unique Advantages -** Domain Expertise, Equipment & Building Models, Service Knowledge base, Install Base Telemetry

IMPACT

- **Customer Outcomes -** Sustainability (Energy, Carbon Reduction, GWP, etc.), Occupant Comfort (Predict Comfort Loss), Equipment Uptime, Compliance, Performance Assessments & Benchmarks
- **Service Benefits -** Remote Monitoring & Services, CBM & Technician Productivity, Modernization & Repair Recommendations, Predict Parts Replacement, Warranty Cost Reduction, Knowledge base


CARRIER.AI
Healthy Buildings - HVAC Asset Performance
HVAC Assets contribute to 40% of commercial buildings energy consumption
HVAC Asset Management Deliverables
AI Methods
Carrier's Unique Advantages
Partnerships
Outcome based Services
Autonomy
Performance Assessments
Fault Detection & Diagnostics
Predictive Models
Optimization
Prognostics
Expert Systems
Statistical Methods/ ML
Digital Twins
Domain Expertise
Equipment & Building Models
Service Knowledge base
Install Base Telemetry
BU Engg, WHQ
Industry
Services & Digital
Academia
Customer Outcomes
Sustainability (Energy, Carbon Reduction, GWP, etc.)
Occupant Comfort
(Predict Comfort Loss)
Equipment Uptime
Compliance
Performance Assessments & Benchmarks
Service Benefits
Remote Monitoring & Services
CBM & Technician Productivity
Modernization & Repair Recommendations
Predict Parts Replacement
Warranty Cost Reduction
Knowledge base
Carrier
Proprietary and Confidential

Wipro | Manufacturing Intelligent Quotient - LC/NC

ABOUT THE COMPANY

Company: Wipro
Sector: Software

INNOVATION BRIEF

MIQ is a scalable platform with dynamic UI, configurable low-code. Features digital manufacturing, supply chain, execution, and sustainability platforms

NEED OF ER&D

- Globally, customers **need a low-cost and scalable solution** in digital manufacturing, supply chain, manufacturing execution and sustainability
- However, COTS platforms are **very costly and global deployment takes years**
- MIQ addresses all these problem statements and **can scale to 100 plants/unit in 100 days**

DESCRIPTION OF SOLUTION

- MiQ is **Cloud-agnostic it uses latest tech, scales** globally for 100+ plants, high performance with minimal setup
- The platform **can be configured and deployed quickly** for any customer
- MiQ **scales 100 plants/business units in 100 days,** crucial for global customers as in-house solutions take years to scale

IMPACT

- Comprehensive solution for connected enterprises: **digital manufacturing, supply chain, execution, and sustainability**
- **Low-cost solution** that saves millions of dollars on costly license fees
- **Highly scalable platform** that improves deployment time by **90%**
- Cloud-agnostic, works on-premises too

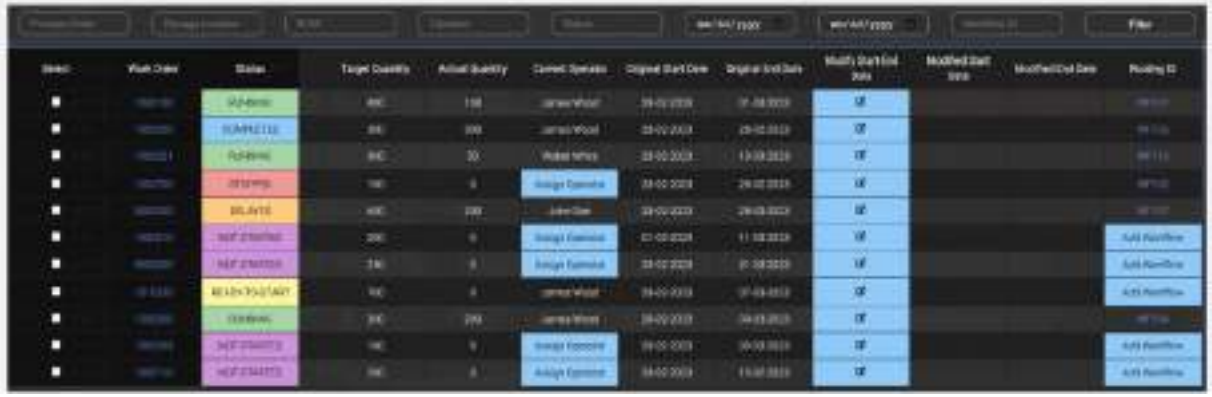
Wipro | Manufacturing Intelligent Quotient - LC/NC

Connected Supply Chain- Smart Dock management

Digital Manufacturing Platform – Asset Analytics

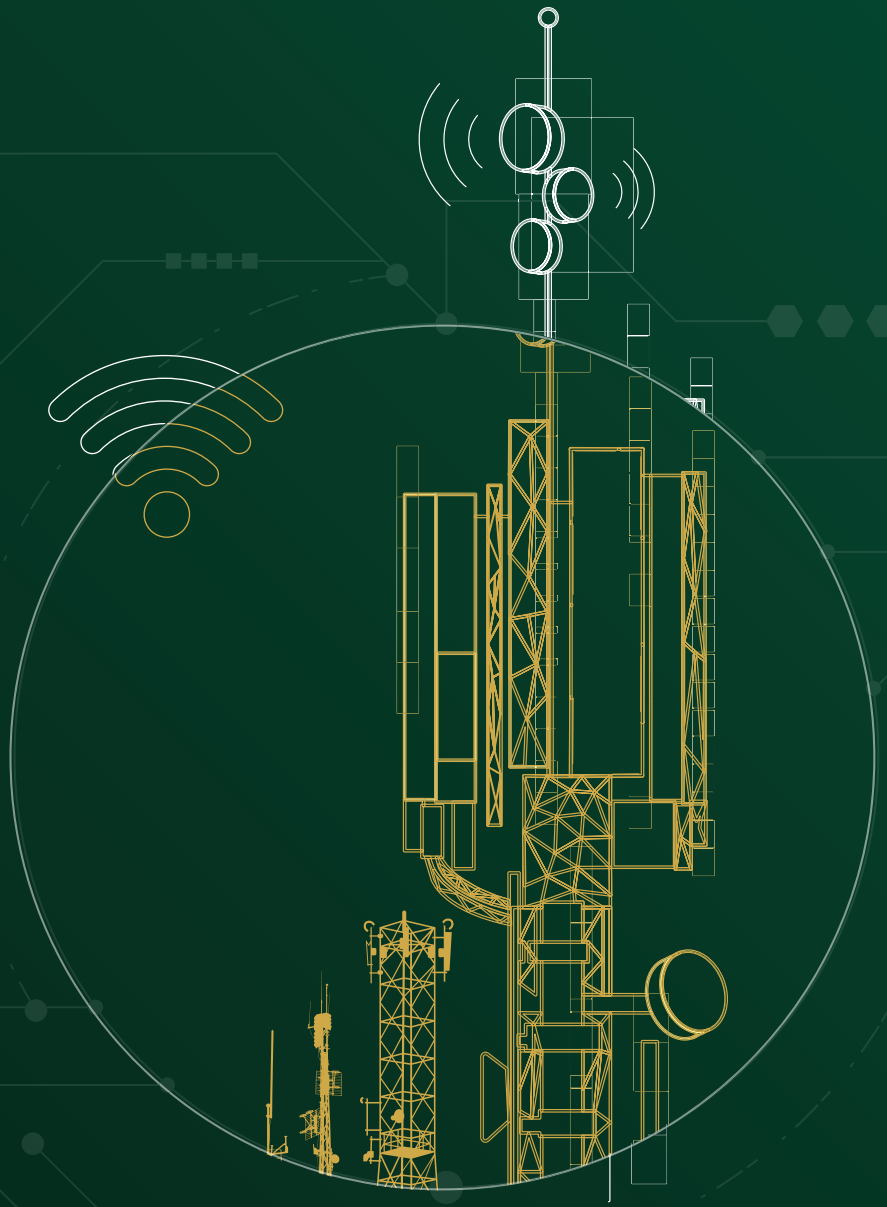
Enterprise Sustainability and Reporting Platform – GHG Emissions

Lite Manufacturing Execution System – Process Orders



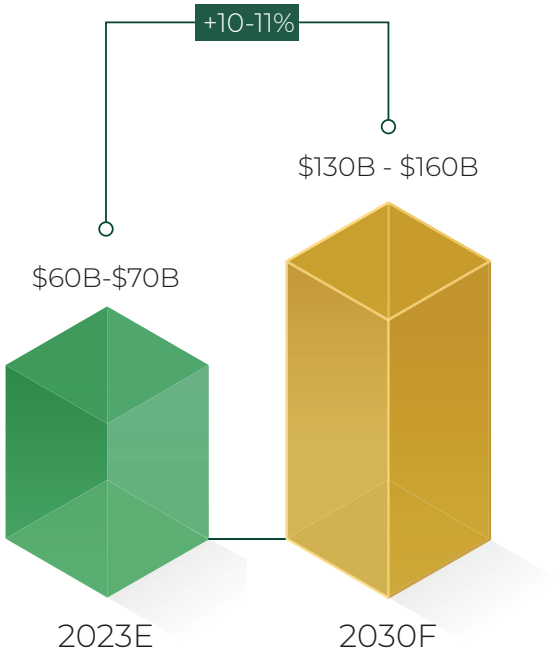
Connected Supply Chain- Vendor, Manufacturer, Delivery Hub & Dealer

Tele-communication sector Deep dive



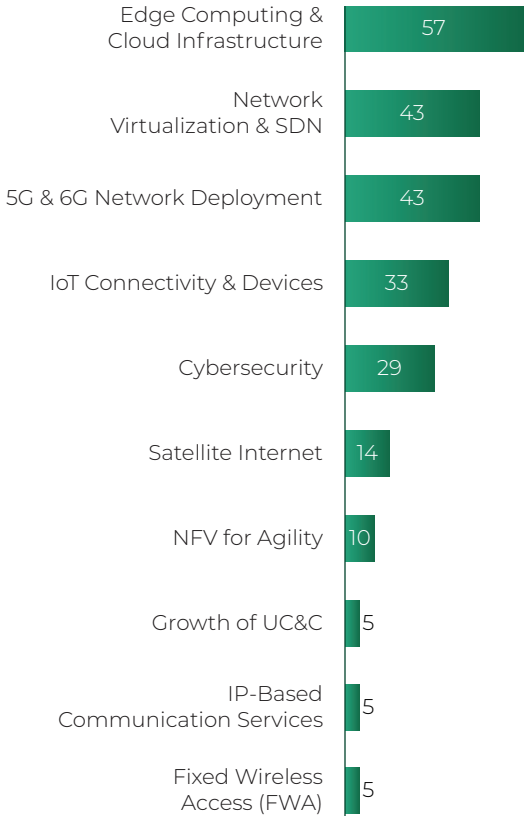
Telecommunication: ER&D spend expected to grow at 10-11% CAGR to reach $130-160B by 2030, maintaining the high share of digital engineering in spends

SEMICONDUCTORS ER&D SPEND EXPECTED TO REACH $220-290B BY 2030 GROWING AT ~10-11% CAGR...



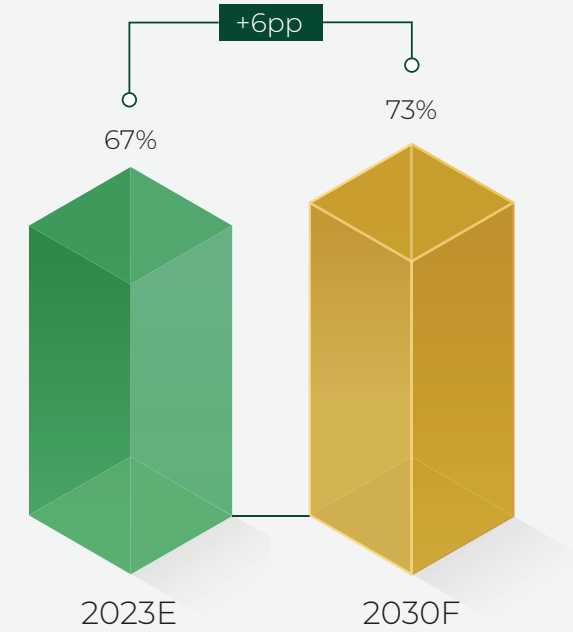
Sector's Business ER&D Spend ($B)

...WITH EDGE, CLOUD, SDN, 5G & 6G AS TOP ER&D PRIORITIES...



% sector respondents who selected the topic as one of top 3 ER&D priority in coming 5-10 years

...ACCOMPANIED BY AN INCREASE IN SECTOR'S DIGITAL ENGINEERING SPEND AS SHARE OF ER&D SPEND



% of sector's ER&D spend on digital engineering

Source: BCG ER&D Survey 2023 n=281, Press Search, BCG Analysis

Three trends will drive ER&D in Telecom sector

HYPERCONNECTIVITY

No constraints on the data rate, coverage, and computing newer technologies

Driven by:

- Development of 6G for low latency network
- ER&D players are focusing on the following emerging technologies for 6G - blockchain, quantum communication, energy harvesting & frequency bands
- IoT solutions to increase connectivity & productivity

ODA & VIRTUALIZATION

Openness & virtualization will increase speed to market of new software, increasing vendor options & flexibility

Driven by:

- Open API market growing at over 20% CAGR, Open Digital Architecture (ODA) has 30+ signatories from telecom industry allowing for plug-&-play deployments
- Move towards xRAN (ORAN & vRAN); vRAN to grow at ~19% CAGR b/w 2020 & 2030; ~$6.4Bn in 2030
- 37% reduced costs b/w traditional RAN & vRAN; 23% b/w C-RAN and vRAN

MOVE FROM "TELCO TO TECHCO"

Telcos moving towards providing Cloud/ICT solutions

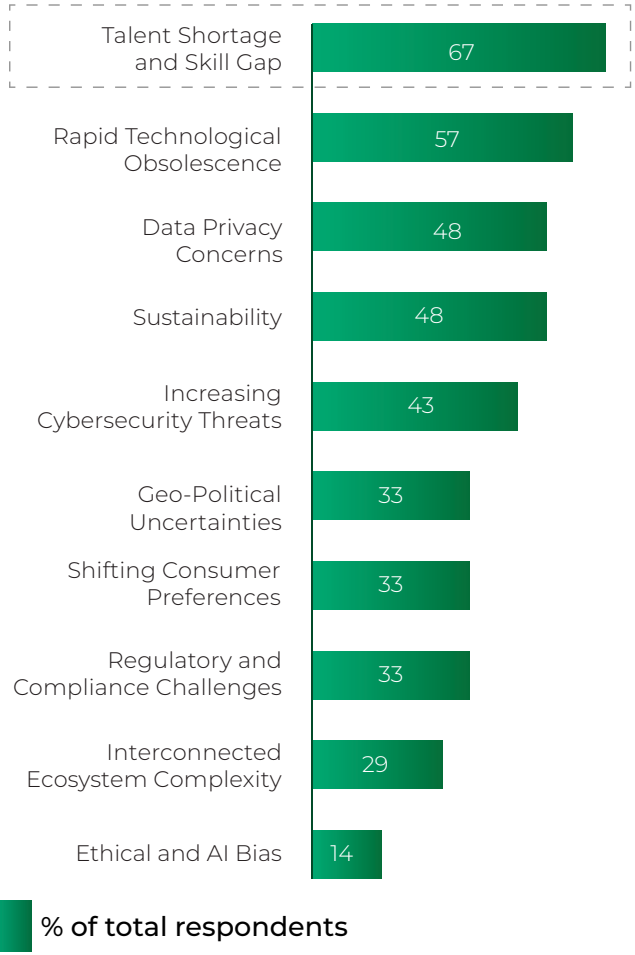
Driven by:

- Increasing partnerships of Telcos with Hyperscalers
- Growth of Network-as-a-Service at over 30% CAGR b/w 2022 & 2025

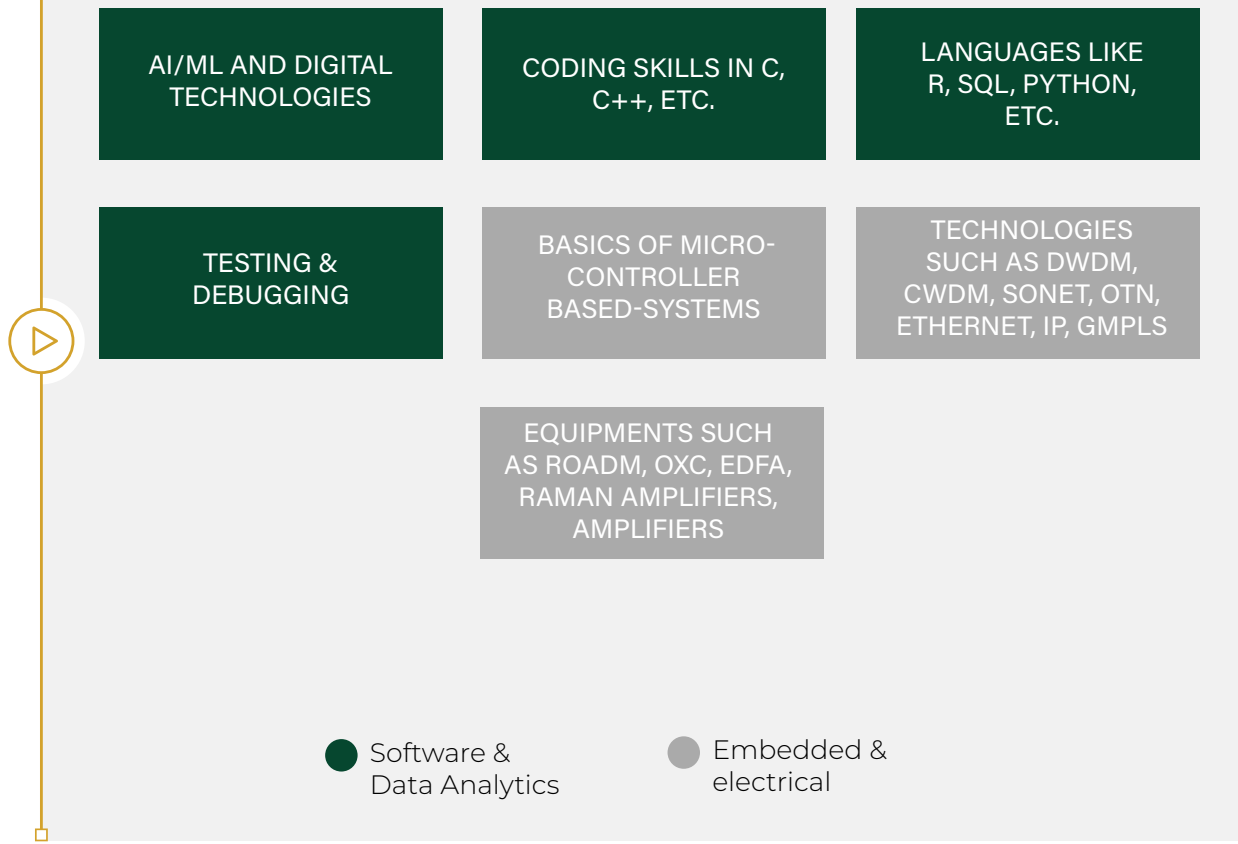
Source: Press Search; BCG Analysis

As new technologies come up with development of 6G, focus on cloud offerings, etc. – talent shortage & skill-gap coming up as key issue in ER&D of telecom sector

CONCERNS HIGHLIGHTED BY ER&D LEADERS IN THE SECTOR



KEY SKILLS REQUIRED BY ER&D PLAYERS IN THE SECTOR



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Source: CapitalIQ, BCG ER&D Survey 2023 n=281; Press Search; BCG Analysis

Capgemini | AI native sustainable network for 5G and beyond

ABOUT THE COMPANY

Company: **Capgemini**
Sector: **Telecommunications**

INNOVATION BRIEF

Capgemini 5G Intelli-RAN framework is based on O-RAN architecture and supports 3GPP Release-16/17. Intelligent resource allocation mechanism is supported in RAN to help in optimizing the power consumption of RAN leading to energy savings

NEED OF ER&D

- Per GSMA, **network accounts for 90% of energy use for operator,** with RAN representing **>80%** of this
- Capgemini 5G Intelli-RAN framework provides SW based approach aided by ML techniques to reduce power consumption in 5G RAN leading to energy savings from network

DESCRIPTION OF SOLUTION

- Capgemini has taken SW based approach with 5G Intelli-RAN CU/DU framework having inbuilt **"Resource Monitor (RM)"** module that can dynamically monitor and ensure efficient allocation of air-interface and compute resources
- RM based on cell/UE/slice KPIs and interference measurements, ensures efficient allocation of resource blocks adapting to the radio conditions, that in turn helps in improving power use

IMPACT

- Capgemini 5G Intelli-RAN framework has demonstrated that with dynamic monitoring of node KPIs and radio conditions and efficient scheduling of radio resources or cores, **~10% power saving** can be achieved within node itself
- The framework is also highly optimized with respect to capacity/throughput supported per core leading to **~30% higher capacity** that can be supported within same compute node

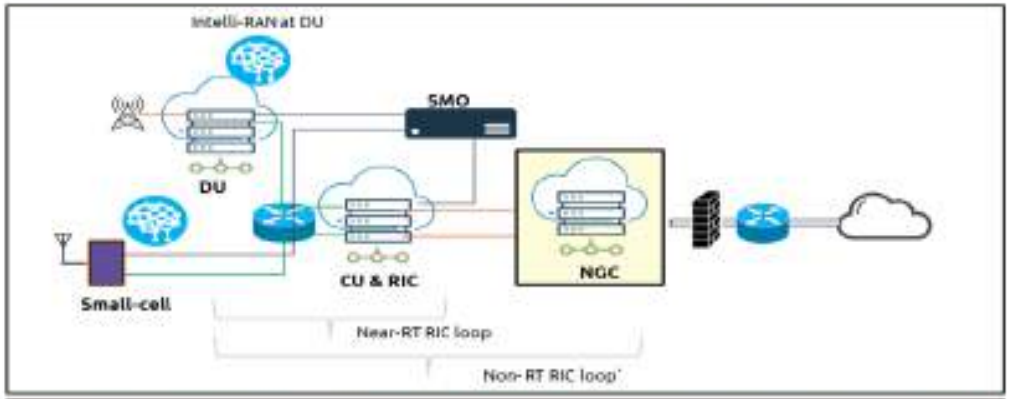
Capgemini | AI native sustainable network for 5G and beyond

Capgemini 5G Intelli-RAN Framework has inbuilt SW functinality that helps in optimizing the radio resources and compute resources that inturn leads to energy saving of the node, and overall network. The savings in order of ~10% for typical Enterprise/Private 5G deployment

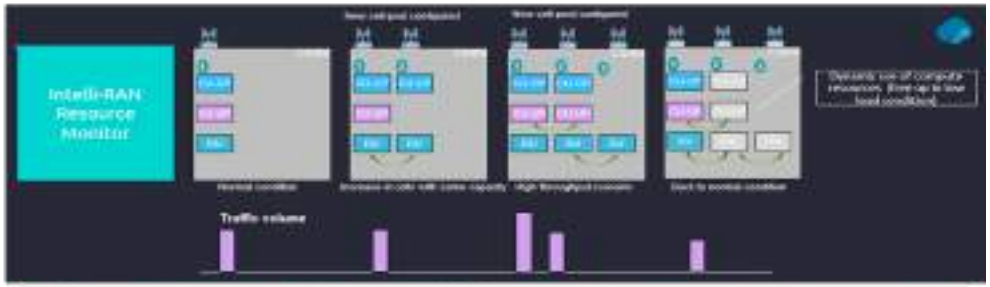
The Intelli-RAN Framework is based on O-RAN based architecture and support both PNF based nodes (like small-cells running on embedded SOC) or CNF based nodes (running on COTS HW) deployments.

The “Resource Monitor” module of the RAN runs in inner-most loop and handles the optimizations without an external interface. The 5G Intelli-RAN Framework also supports E2 nad O1 interfaces to be able to leverage benefits with xApps/ rApps that can be deployed in network for energy saving or other use-cases.

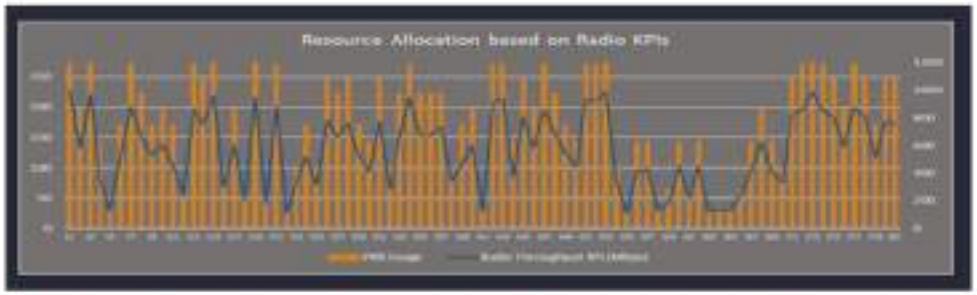
Few details of the Intelli-RAN Framework are shown where the compute resources, radio resources and resource alocation is handled dynamically leading to energy saving and improved user experience.



Intelli-RAN logic running as part of the Capgemini 5G CU/DU Framework



Dynamic Scaling of Cells and efficient allocation of **compute resource** handling based on Traffic and Cell load conditions



Dynamic Allocation of Radio resources based on Radio KPIs leading to reduced Tx power leading to energy saving

Dynamic Allocation of resources based on traffic conditions leading to efficient network performance

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nasscom

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