FUTURE STEEL FORUM
2026 3-4 JUNE • BOLOGNA • ITALY

ARTIFICIAL INTELLIGENCE GOVERNANCE, ECONOMICS, AND MANUFACTURING: AN OVERVIEW

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INTRODUCTION OF AI AND KEY CONCEPTS

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AI, governance, and economic development are interconnected issues.

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1. AI is a high-impact technology but it is also a technology with significant risks (including global ones). Therefore, a governance is needed
2. AI economic development and AI Governance Systems are mutually reinforcing, since governance frameworks influence how different nations balance innovation, competitiveness, security, and societal trust in the deployment of AI technologies.

ANALYSIS APPROACH

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1. Analysing the three Governance Systems of the three Key Players EU, US, and CHINA.

2. Analysing the economic scenario of AI referred to the Manufacturing sectors and forecasting the evolution in terms of expenditures/investments.

3. Carrying out an insight in the steel manufacturing sector focusing the Electrical Route (EAF).

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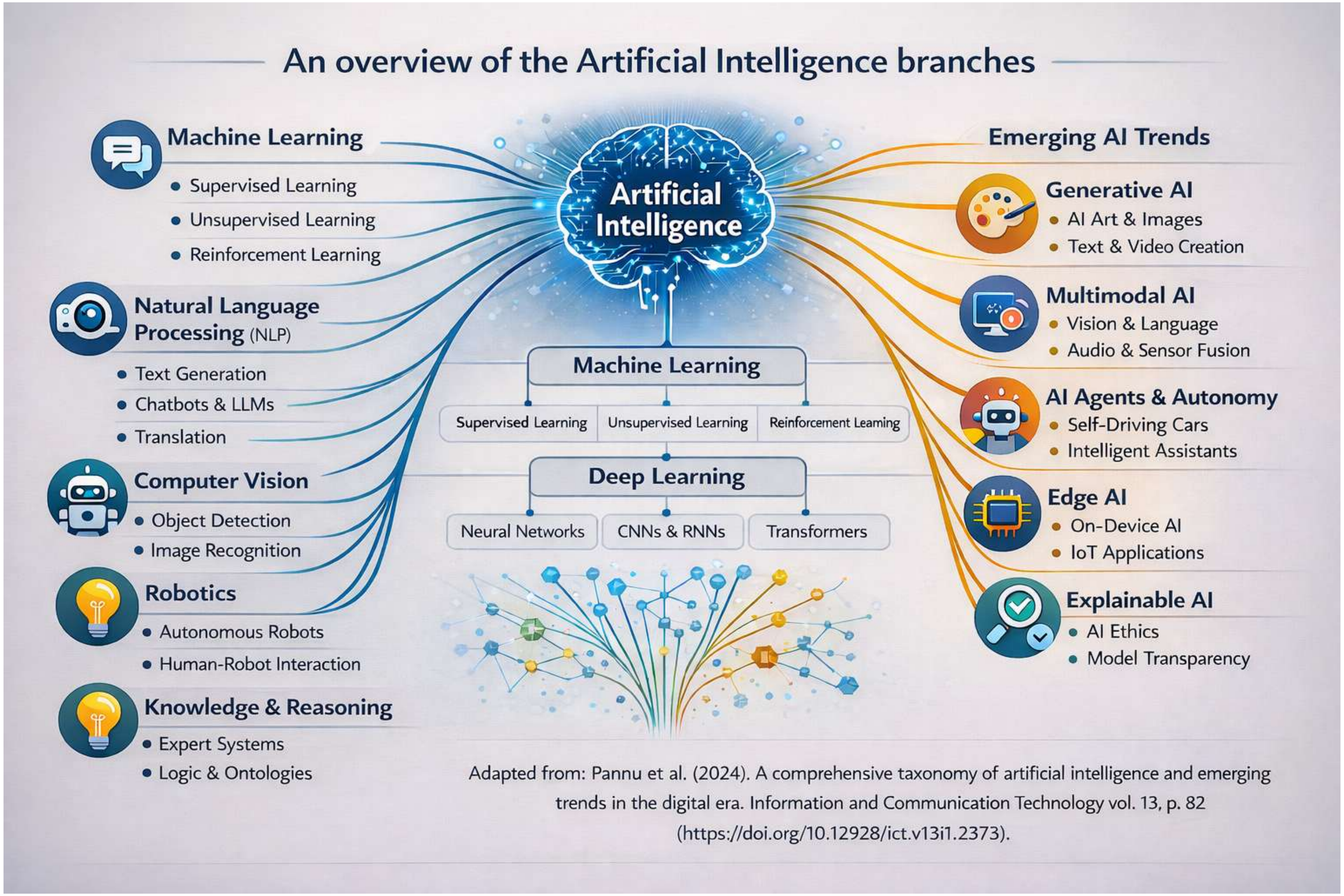
An overview of the Artificial Intelligence branches
Artificial Intelligence
Machine Learning
Supervised Learning
Unsupervised Learning
Reinforcement Learning
Natural Language Processing (NLP)
Text Generation
Chatbots & LLMs
Translation
Computer Vision
Object Detection
Image Recognition
Robotics
Autonomous Robots
Human-Robot Interaction
Knowledge & Reasoning
Expert Systems
Logic & Ontologies
Machine Learning
Supervised Learning
Unsupervised Learning
Reinforcement Learning
Deep Learning
Neural Networks
CNNs & RNNs
Transformers
Emerging AI Trends
Generative AI
AI Art & Images
Text & Video Creation
Multimodal AI
Vision & Language
Audio & Sensor Fusion
AI Agents & Autonomy
Self-Driving Cars
Intelligent Assistants
Edge AI
On-Device AI
IoT Applications
Explainable AI
AI Ethics
Model Transparency
Adapted from: Pannu et al. (2024). A comprehensive taxonomy of artificial intelligence and emerging trends in the digital era. Information and Communication Technology vol. 13, p. 82 (https://doi.org/10.12928/ict.v13i1.2373).

AI RISKS AND APPROACHES TO GOVERNANCE

Two statements on AI - 1

1st Statement:

The most considered disruptive ability of AI is reputed to automate not only manual tasks but also cognitive functions[1]

👉 However, such statement immediately draws the attention more towards the «job killing» impact (pessimistic view), rather than the potential opportunities (optimistic view).

👉 Now, may I ask whoever agrees to raise hands?

👉 Now, may I ask whoever disagrees to raise hands?

[1] This statement was not authored by a specific person but many thinkers are aligned to this definition (see Erik Brionjolfsson, Andrew McAfee, Kai-Fu Lee, Daniel Susskind, Geoffrey Hinton)

Two Statements on AI - 2

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2nd Statement: *AI is an Opportunity with serious Risks*

This is a drastic synthesis[2] of as much drastic some one-sentence statements:

Sam Altman (CEO of OpenAI):

Demis Hassabis (CEO of Google DeepMind)

Dario Amodei (CEO of Anthropic)

Geoffrey Hinton ("Godfather of AI")

Mitigating the risk of extinction from AI should be a global priority alongside other societal-scale risks such as pandemics and nuclear war.

Rishi Sunak (Former UK Prime Minister)

Yoshua Bengio (AI Researcher)

…. and more than hundred personalities entitled to talk about AI

So, it seems that managing RISKS is ethically and practically necessary. But, to do this, it would seem necessary to define what the result might depend on:

- Regulations and Governance
- Global cooperation
- Ethical design
- Public understanding

LET'S START FROM RISKS

[2] Synthesis attributed to Brynjolfsson & McAfee

Governance Systems vs Risks

- The issue of AI Risks is not the focal point. A more important question raises: a negligent management of AI risks must be obligatorily contrasted and punished or not?
- It depends on the infringed Risk. Some of the most significant risks are reported in this Table plus and addition:

The Top 15 AI Risks[3]			
Ordinal Risk	Risk identification	Ordinal Risk	Risk identification
1.	Lack of Transparency	9.	Economic Inequality
2.	Bias and Discrimination	10.	Legal and Regulatory Challenges
3.	Privacy Concerns	11.	AI Arms Race
4.	Ethical Dilemmas	12.	Loss of Human Connection
5.	Cybersecurity Risks	13	Misinformation and Manipulation
6.	Concentration of Power	14.	Unintended Consequences
7.	Dependence on AI	15.	Existential Risks
8.	Job Displacement		

The answer to the above question can be found into Governance Systems

[3]Source: B. Marr, "The 15 Biggest Risks Of Artificial Intelligence", 2023/06/18, https://bernardmarr.com/the-15-biggest-risks-of-artificial-intelligence/

[4]Added by the Authors. It addresses barriers due to excess of Governance restrictions.

Defining an AI Governance System

- ✓ An AI Governance System can be defined as:
  "… a system of rules, practices, standards, processes, and technological tools aimed at ensuring AI technologies aligned with the foundations of national entity's strategies, objectives, and values. It fulfils legal requirements, and meets principles of ethical AI adopted by each entity …[5]"

- ✓ The above definition dictated the comparison between the three main governance models of EU, USA, and China.

- ✓ Due to the political, social, and cultural differences, the analysis highlighted an inhomogeneous landscape of approaches and rules.

[5]Source: Taken and updated from: Mäntymäki, M., Minkkinen, M., Birkstedt, T. et al., *Defining organizational AI governance*. AI Ethics 2, 603–609 (2022). https://doi.org/10.1007/s43681-022-00143-x

Dominating characteristics and consequences of the three models

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Geographic Area	Dominating characteristics	Consequences
UE	Obligatory Strong regulation (AI Act)	Great control but risk of curbing innovation
USA	Free / Voluntary adoption of governance rules and market-oriented approach	More innovation but more risks
Cina	Central State Control and Priorities	Efficiency but political bias

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Comparison of the the three approaches. Synthesis.

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Aspects	EU Approach [3]	US Approach [4]	Chinese Approach [5]
Ethics and Privacy	GDPR-driven, prioritising rights and privacy. The EU AI Act is the only defined Framework for developing, deploying and commercializing AI solutions.	Nothing similar to GDPR exits. Strong emphasis on civil-liberties principles and sectoral privacy laws.	Balances privacy with national security concerns
Risk Categorization	Risk-based AI classification	Voluntary adoption of sectorial standards and risk-management guidance	Licensing for systems on the "Negative List"
Innovation Focus	Regulatory balance between ethics and innovation	Focus on innovation and competitiveness. Strong pushing for safety/security and while preserving flexibility for industry.	Pragmatic focus on state-led economy gains
Human Oversight	Emphasis on human-centric principles and opt-outs	Very strong state support for rapid development and deployment of AI, and balancing AI alignment with national priorities.	Focuses on content control and alignment with socialist values

Reference Documents:

[3] The European Parliament, "EU AI Act: first regulation on artificial intelligence", 08-06-2023, https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence,

[4] National Institute of Standards and Technologies – NIST, "The AI Risk Management Framework", January 2023, https://doi.org/10.6028/NIST.AI.100-1 , https://www.nist.gov/itl/ai-risk-management-framework,

5] China Law Translate, "Interim Measures for the Management of Generative Artificial Intelligence Services.", Translated from Chinese to English on 2023/07/13, https://www.chinalawtranslate.com/en/generative-ai-interim/

ECONOMIC ANALYSIS

The Economic Analysis: aim and perspectives.

The Economic Analysis is part of the answer to manage Risks. It is aimed at:

1. *Catching the orientation of investments/expenditures in AI considering the worldwide Manufacturing Sector and the Use Case of the EAF-DRI Route.*

2. *The current scenario is the basis to forecast the AI market evolution considering the timespan between 2025 – 2030[6].*

3. *Comparing the Steel Sector with other manufacturing sectors in terms of the economic indicator GMS i.e. the GSM in AI within the timespan between 2025 and 2030*

4. *Gaining an idea on the prevailing sentiment of AI, through the CAGR economic indicator i.e., the Compound Annual Growth Rate.*

[6]To achieve these aims, data are gathered from the most reputed observatory sources, validated by comparing different sources if any, for the same information, by other sources.
For 2025 interpolation/extrapolation needs, data of 2003 and 2004 have been considered.

The Global Market Size and Compound Annual Growth Rate

$$GMS_j = \left(\sum_{1}^{NI}{}_i InvP_i \times EXP_{i,j}\right) \quad [F1]$$

- NI = Total Number of considered Players (fixed or variable),
- $InvP_i$ = i^{th} Player (with i = 1, NI).
- $EXP_{i,j}$ = Total Expenditures of i^{th} Player on j^{th} Application Area.

The calculation of GMS considers the worldwide expenditures/investments including services, spare parts, stocks, etc. of any type.

$$CAGR = (V_{final} / V_{beginning})^{1/t} - 1 \quad [F2]$$

- V_{final} = the ending balance of investments at the end of the timespan.
- $V_{beginning}$ = the final balance of investments at the first year of the timespan.
- t = the considered timespan.

In the analysis relevant to the application of AI in the EAF steelmaking, CAGR was not interpreted solely as a measure of financial return, but rather as an indicator of **technological diffusion intensity**, **industrial transformation velocity**, and **strategic prioritization of innovation domains** within the manufacturing ecosystem.

Step 1.1: Steel position compared with other manufacturing sectors

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Sector	AI GMS 2025 ($B)	AI GMS 2030 ($B)	Absolute Growth ($B)	Multiple X	Confidence Level	Uncertainty Drivers	Source Basis
Total Manufacturing (all sectors[1]) i.e., Published global benchmark	7,1	4,79	40,8	~6,7	High	Strong multi-source agreement	**Grand View Research**, AI in Manufacturing Market Report 2030, March 1st, 2025
Electronics & Semiconductors	21,5	75	+40–65	~3–4	Medium	Rapid tech cycles, AI self-demand	Derived from sector share of total manufacturing AI + high-growth segments **Grand View Research**, AI in Manufacturing Market To Reach $47.88 Billion By 2030, March 2025
Automotive & Discrete	15	45	+20–35	~2.5–3	Medium	Electric Vehicle transition, cyclicality	Derived from manufacturing segmentation and adoption patterns **Grand View Research**, AI in Manufacturing Market To Reach $47.88 Billion By 2030, March 2025
Chemicals (Advanced)	11	32,5	+15–25	~2.5–3	Medium–Low	Energy prices, regulation	Derived from process-industry allocation within total AI manufacturing **Grand View Research**, AI in Manufacturing Market To Reach $47.88 Billion By 2030, March 2025
Oil & Gas / Refining	8	20	+10–15	~2–2,5	Medium–Low	Commodity cycles	Derived from industrial AI deployment benchmarks **Grand View Research**, AI in Manufacturing Market To Reach $47.88 Billion By 2030, March 2025
General Process Industries	5,5	14	+6–11	~2–2,5	Medium–Low	Fragmentation, low digitization level	Derived from lower adoption segments in manufacturing **Grand View Research**, AI in Manufacturing Market To Reach $47.88 Billion By 2030, March 2025
Steel / Heavy Metal (core focus)*	**0,9**	**7**	**+~5,8**	**~8**	**High (segment)**	**Direct dataset available**	**Grand View Horizon** (heavy metal segment) Heavy Metal & Machine Manufacturing - AI In Manufacturing Market Statistics
Steel (refined estimate)[2]	**2,5**	**6**	**+3–4**	**~2,5–3×**	**Low–Medium**	**Derived allocation uncertainty**	Derived from scaling heavy metal segment to steel share **Grand View Horizon**, Heavy Metal & Machine Manufacturing - Artificial Intelligence In Manufacturing Market Statistics

[1]Indicative sector-scale estimates (non-additive)

[2]Steel is not stagnant, more lykely it is a prudent approach

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Step 1.2: Steel position comparison through the use of CAGR

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Sector	AI CAGR (2025–2030)	Evidence / Source
Electronics / Advanced manufacturing	~30–40%	Cross-sector manufacturing AI growth benchmarks - **PR Newswire**
Automotive / Discrete	~25–35%	Same global manufacturing AI expansion - **PR Newswire**
Chemicals / Process (advanced)	~20–30%	Derived from manufacturing AI adoption patterns + segment variation **- Grand View Research**
Oil & Gas / Refining	~18–25%	Industrial AI adoption trends within manufacturing - **Grand View Research**
General Process Industries	~15–22%	Lower adoption intensity within manufacturing average - **Grand View Research**
Steel / Heavy metal	~44.9% (segment)	Heavy metal AI segment CAGR - **Grand View Research**

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Step 2: Breakdown of key topics for AI deployment in the EAF Route and forecast up to 2030

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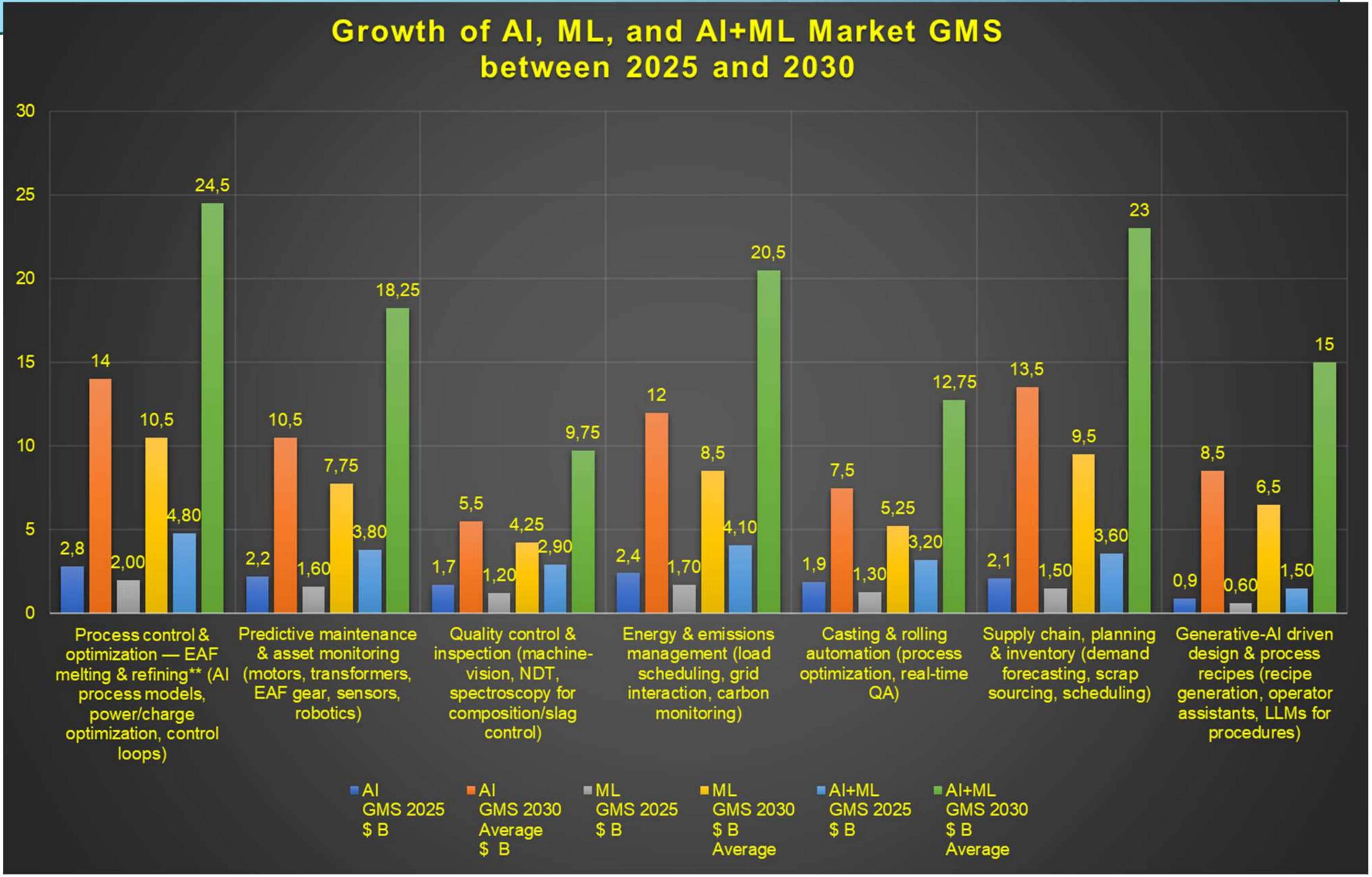

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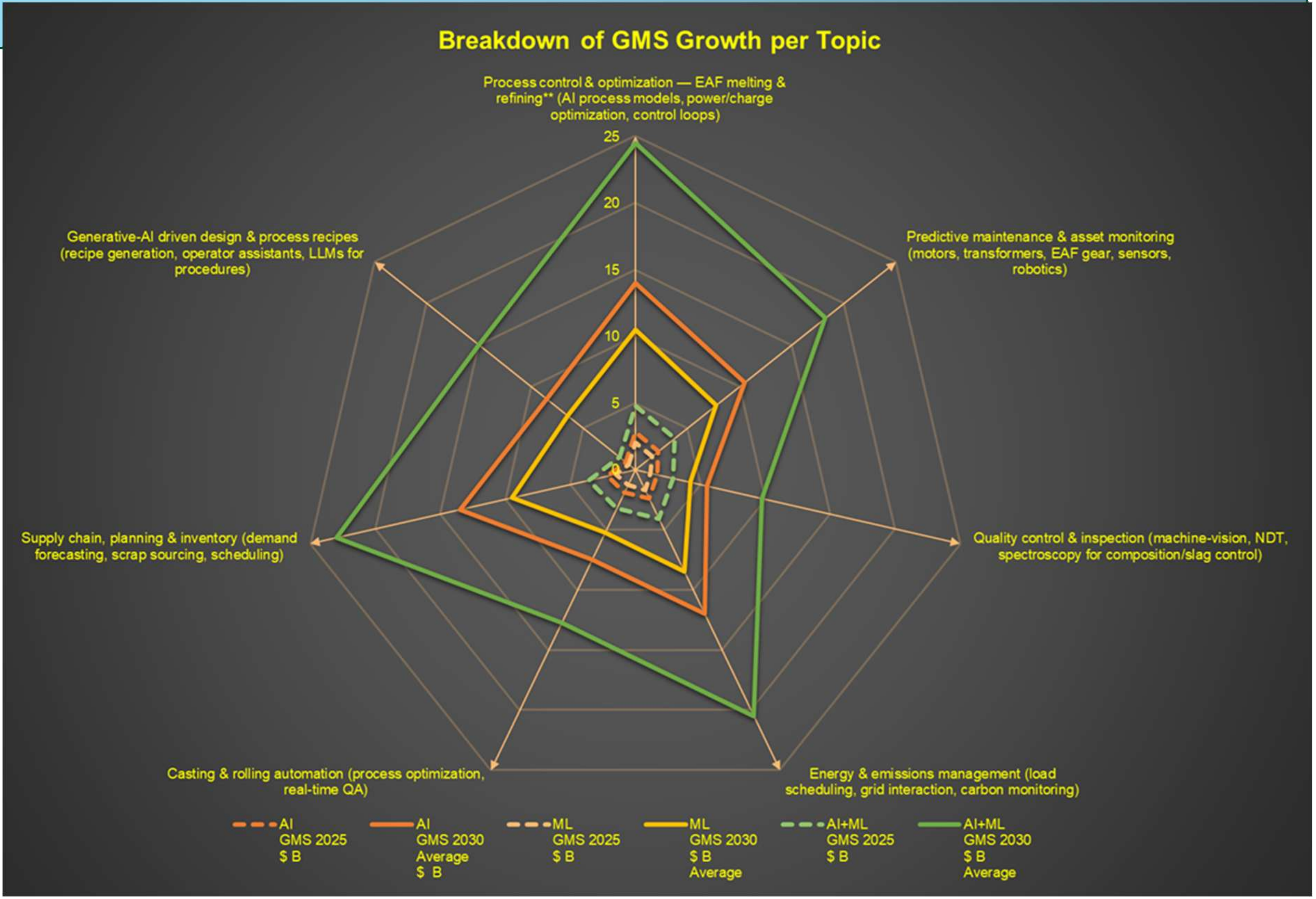

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The three Key AI applications trajectories

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Process control & optimization (Rank #1): This is expected to dominate because EAF profitability is extremely sensitive to **melting efficiency**, **power consumption**, **yield**, and **scrap-quality variability**. AI-driven control loops and predictive process models directly affect production cost and productivity.

Supply chain, planning & inventory (Rank #2): The high ranking reflects the growing strategic importance of **scrap sourcing**, **electricity-price volatility**, and **production scheduling**. Since **scrap availability**, **energy prices**, and **DRI & HBI quality fluctuate** strongly across regions, AI forecasting systems provide immediate economic benefits **through optimized procurement** and **production planning**.

Energy & emissions management (Rank #3): Energy has become a strategic variable for EAF steelmaking due to **decarbonization policies**, **CO_2 pricing**, and **grid interaction**. AI systems capable of real-time load scheduling and energy optimization are increasingly valuable because **electricity can represent one of the largest operating costs in EAF plants.**

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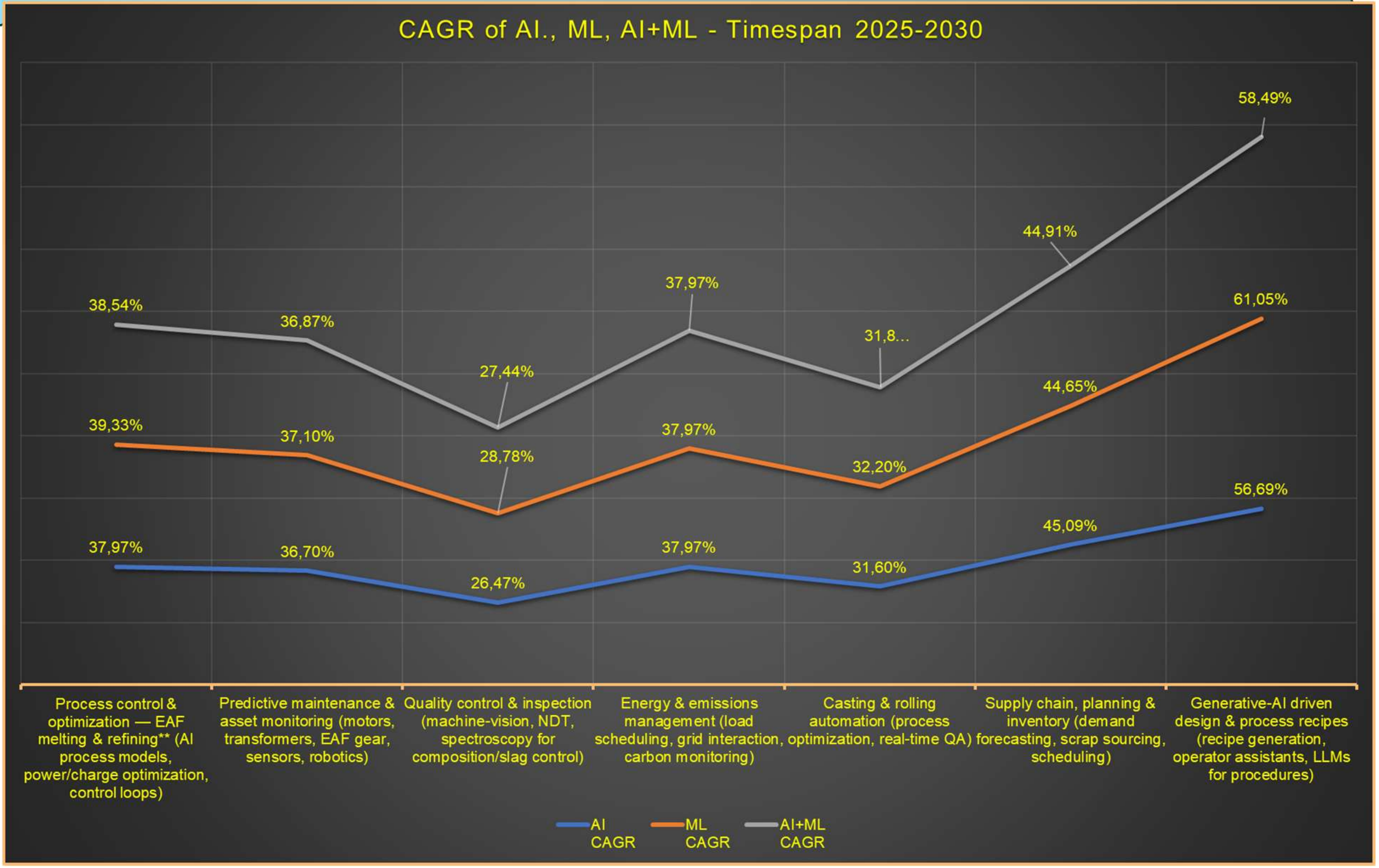
Breakdown per topic of CAGR for AI, ML, AI+ML in EAF Route GMS - Timeline 2025 – 2030



Commenting the CAGR trends by Manufacturing Areas - 1

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1. **Generative-AI (GenAI) driven design & process recipes (58,49% AI+ML CAGR).** This is the fastest-growing segment, suggesting an emerging transition toward AI-assisted operational management. Furthermore, the **particularly high ML CAGR (61,05%)** indicates increasing reliance on learning systems and the high involvement in training on operational data.
2. **Supply chain, planning & inventory (44,91%)** The second-highest level of CAGR reflects the growing strategic importance of the outer part of the direct manufacturing operations, such as scrap sourcing, electricity-price forecasting, logistics optimization, and production scheduling under volatile global supply chains and decarbonization constraints.
3. **Process control & optimization** and **Energy & emissions management (~38%)** These values confirm that **the EAF route is fundamentally energy-driven**. AI investments are therefore concentrated where direct impacts on productivity, electricity consumption, CO_2 reduction, and process stability are economically measurable.
4. **Predictive maintenance (~37%)** The relatively high CAGR confirms the importance of **operational continuity** in EAF plants, where unplanned downtime of transformers, electrodes, or power systems has immediate economic consequences.
5. **Casting & rolling automation (~32%)** Growth remains strong but lower than upstream EAF optimization because these technologies are already relatively mature within Industry 4.0 environments.
6. **Quality control & inspection (~27%)** This is the lowest CAGR segment, probably because machine-vision and inspection technologies have been primarily used in steelmaking and so, they are comparatively more established and already partially deployed in industrial steelmaking environments.

$$CAGR = (V_{final} / V_{beginning})^{1/t} - 1 \quad [F2]$$

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The Overall Comment

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The CAGR structure suggests that the next phase of AI adoption in EAF steelmaking will be increasingly driven not only by physical-process automation, but also by cognitive industrial AI capable of supporting operational decisions, energy optimization, adaptive production management, and other factors such as supportive infrastructures such as seamless H_2 distribution, and enough computing power.

Such consequence might be not related only to the EAF route, but the EAF is better known than other technologies and *per se* characterized by relatively limited CO_2 emissions as long as, we can rely on good quality scrap, or the upstream connection with the DRI to the flexibilization of charge and, 100% of green power, etc.

A step back on how the CAGR has been used in this journey

In the context of AI deployment in EAF steelmaking, CAGR should not be interpreted solely as a measure of financial return, but rather as an indicator of technological diffusion intensity, industrial transformation velocity, and strategic prioritization of innovation domains within the manufacturing ecosystem.

$$CAGR = (V_{final} / V_{beginning})^{1/t} - 1 \quad [F2]$$

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KEY CONCLUSIONS

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1. **CAPEX vs OPEX implications of AI deployment in EAF plants** (digital infrastructure, sensorization, cloud/edge computing, operational savings):AI deployment in EAF steelmaking tends to shift value creation from traditional capital-intensive optimization toward operational-efficiency gains, where reductions in energy consumption, downtime, electrode wear, yield losses, and maintenance costs can generate rapid OPEX benefits despite initially higher digital CAPEX requirements."

2. **AI governance implications for industrial automation**(cybersecurity, human oversight, accountability, data governance, regulatory compliance)"As AI systems increasingly influence industrial decision-making and autonomous process control in EAF operations, AI governance becomes strategically important to ensure cybersecurity, operational reliability, regulatory compliance, transparency of AI-assisted decisions, and effective human oversight of critical production systems."

The evolution of AI in EAF steelmaking increasingly reflects a convergence between industrial economics, decarbonization strategy, operational resilience, and AI governance frameworks

THANK YOU FOR LISTENING
Q&A

Some definitions of AI methodologies

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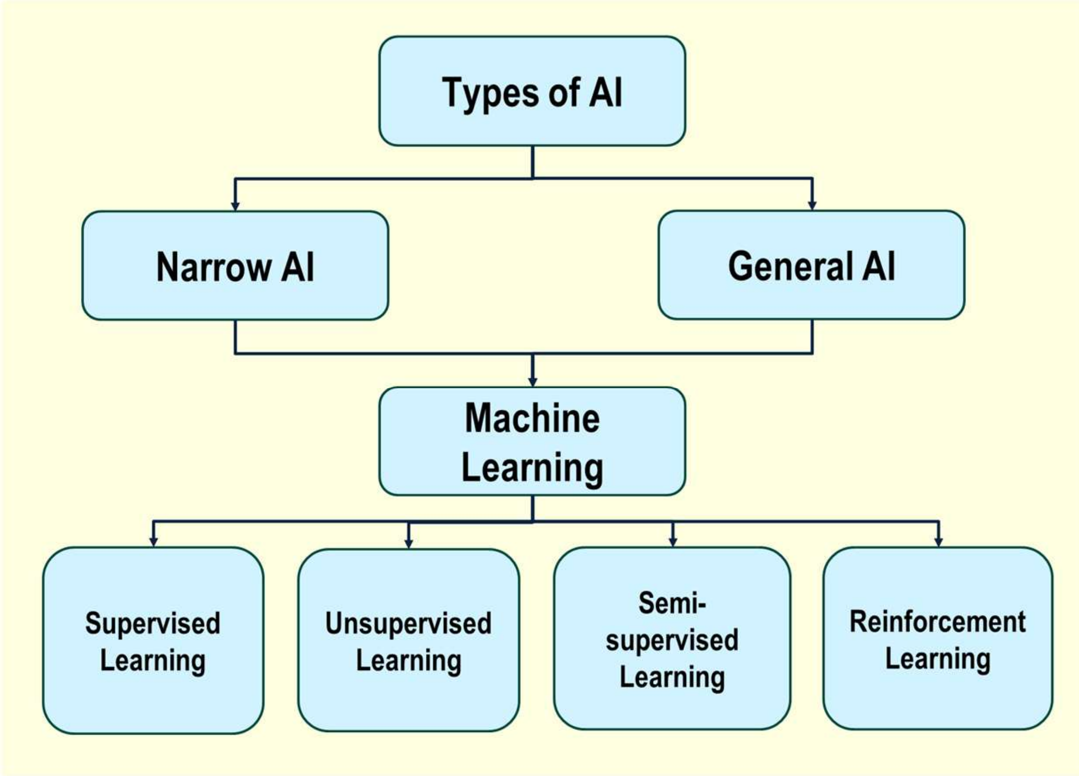
1. **Narrow AI** (or Weak AI) means an AI designed for a specific task.
2. **General AI** (not yet available) might have the abilities to understand, learn, and apply knowledge across a wide range of tasks, like a human.

a. **ML** is a branch of AI that enables systems to learn patterns from data and make decisions or predictions without being explicitly programmed for specific tasks.
b. **Supervised Learning** is a type of ML where the model is trained on a labeled dataset, which means each training example is paired with an output label.
c. **Unsupervised Learning** is a type of ML where the model is given data without labels and must find structure or patterns on its own.
d. **Deep Learning** is a subset of ML that uses multi-layered neural networks (deep neural networks) to learn complex patterns in large amounts of data.
e. **Reinforcement Learning** is a type of ML where an agent learns to make decisions by performing actions and receiving rewards or penalties in an environment.



The Hybrid Market-estimation Methodology (HME) at a glance