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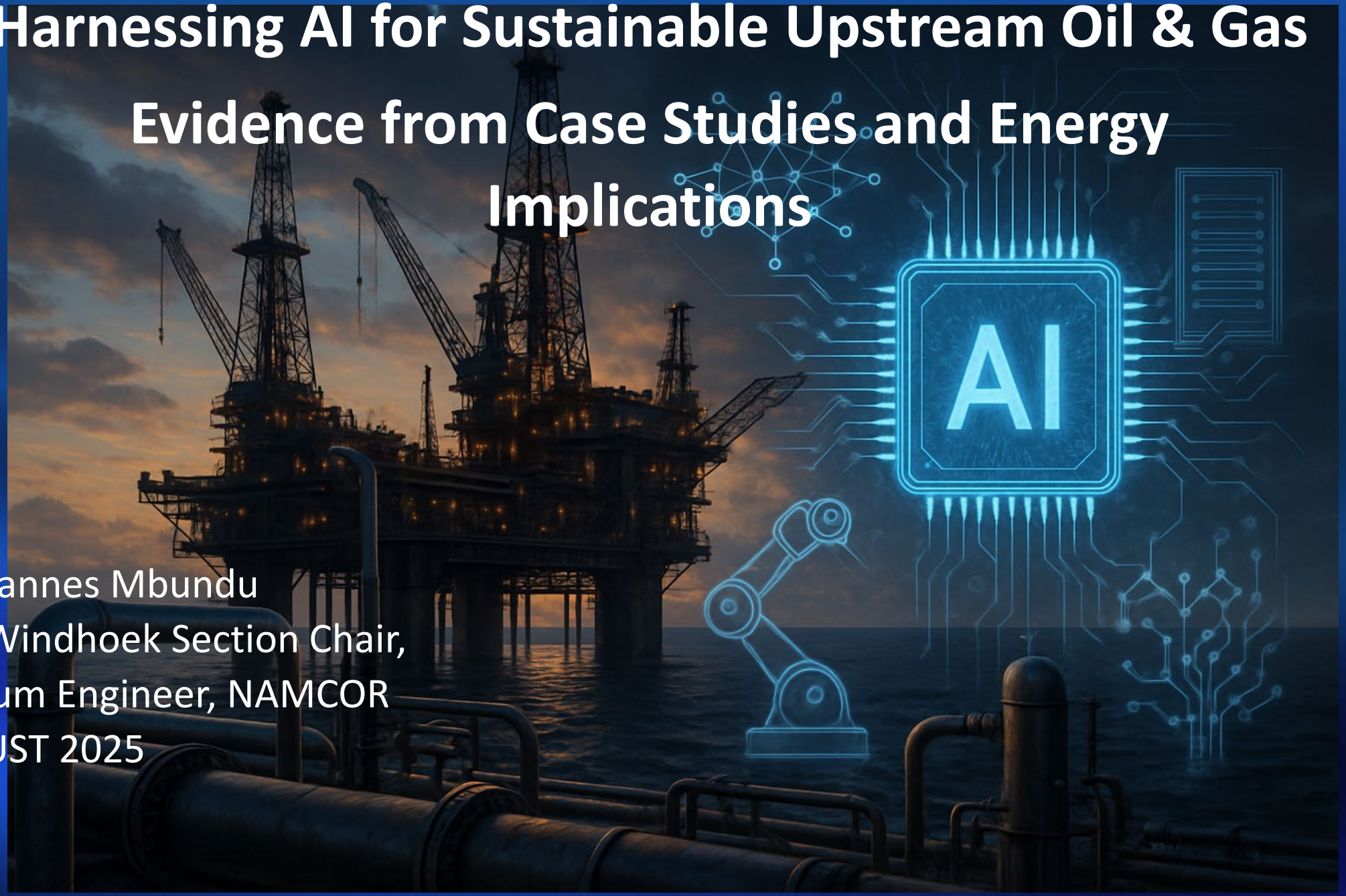
Harnessing AI for Sustainable Upstream Oil & Gas

Evidence from Case Studies and Energy Implications



Presenter: Johannes Mbundu

Position: SPE Windhoek Section Chair, Senior Petroleum Engineer, NAMCOR

Date: 14 AUGUST 2025

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Agenda

- Upstream challenges and gaps
- AI's transformative benefits
- Real - world case studies
- The hidden energy costs of AI
- Sustainable solutions and the road ahead
- Key takeaways and Q&A

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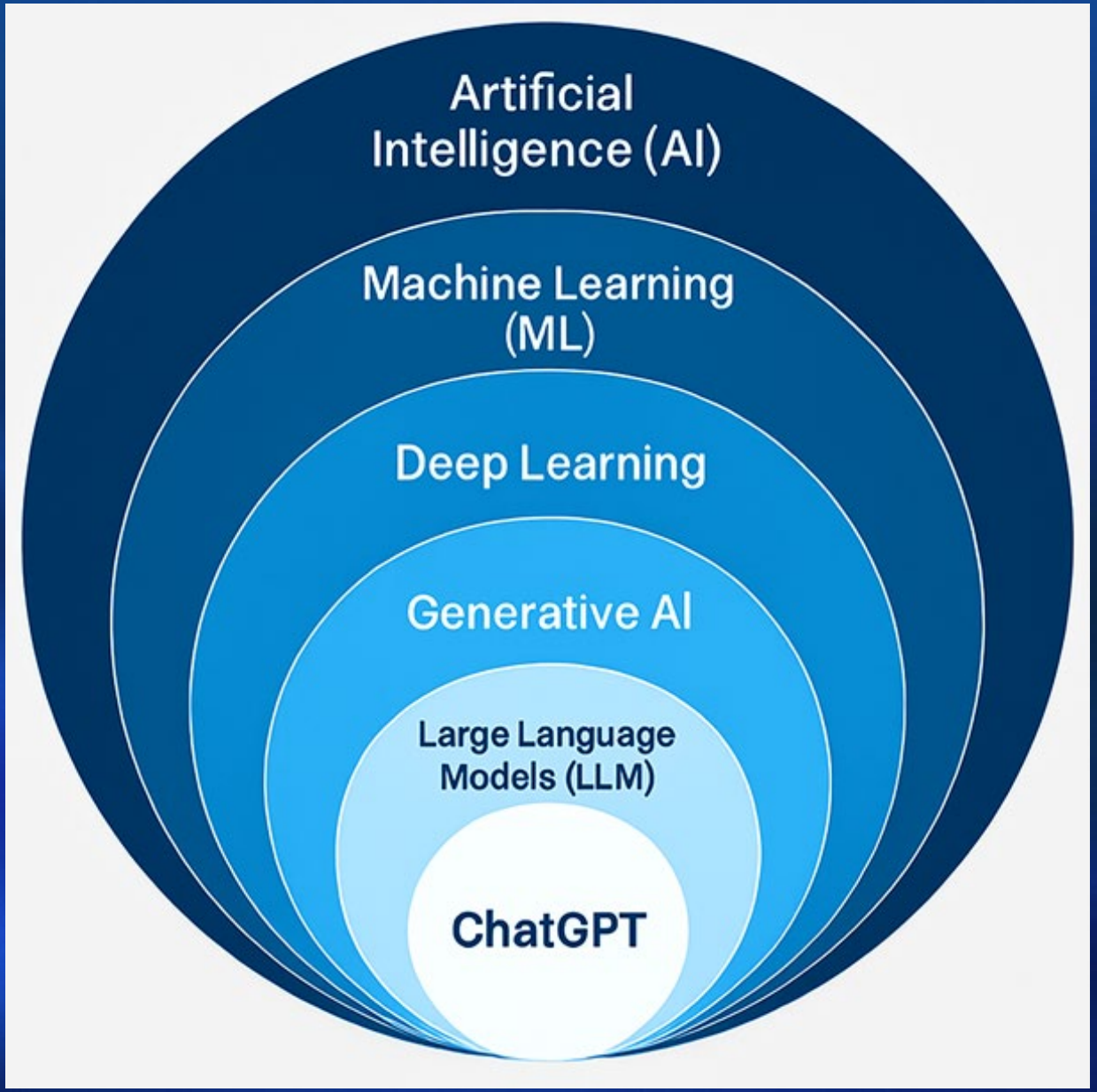
AI – Artificial Intelligence



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Upstream Operation Challenges

- Exploration, drilling, and extraction power global energy but face rising costs and emissions
- Inefficiencies lead to 30%+ waste in drilling (IEA, 2023)
- Reactive maintenance causes downtime, safety risks, and high carbon footprints
- Legacy systems contribute to operational waste and environmental pressure

Citation:

- IEA (2023), *"The Role of AI in Energy Transition."*

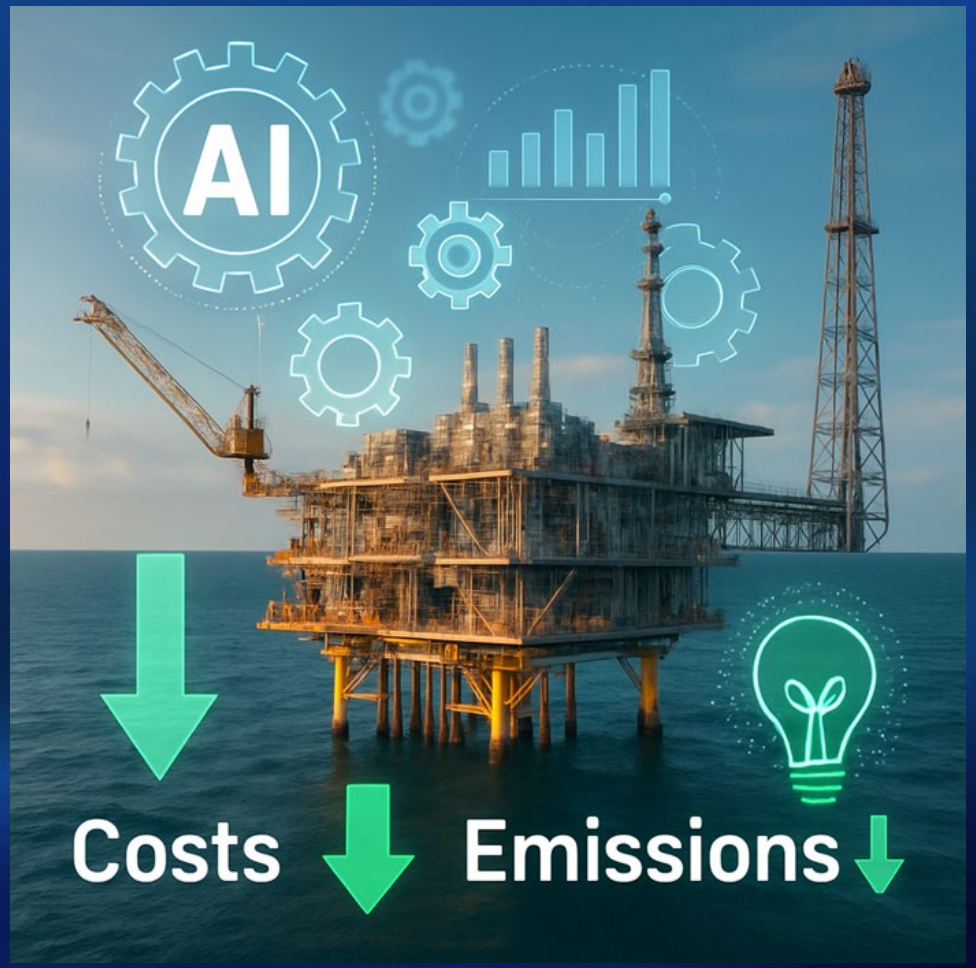
Gaps in Traditional Practices

- Outdated methods cause unexpected downtime and billions in annual losses (McKinsey, 2022)
- Lack of predictive analytics turns operations into reactive guesswork
- High emissions from inefficient processes hinder net - zero goals
- Opportunity: Shift to data - driven intelligence for proactive management

Citation:
- McKinsey (2022), *"Digital Transformation in Oil & Gas."*

AI Benefits: Efficiency and Sustainability Gains

- Predictive maintenance cuts downtime
- Reservoir optimization costs via smarter resource allocation
- Reduces emissions and enhances safety through real - time insights
- Overall ROI: Lower costs, greener operations and data turned into foresight



Citation:

- Shell Annual Report (2023).
- BP Technology Review (2023).

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Case Study 1: BP's AI-Driven Exploration

- AI seismic analysis accelerates processes 10x and cuts costs by 15%
- Drones enable 50% faster pipeline inspections with higher accuracy
- Autonomous systems reduce human error and boost safety
- Outcome: Improved efficiency and environmental compliance (BP Technology Review, 2023)

Citation:

- BP Technology Review (2023).

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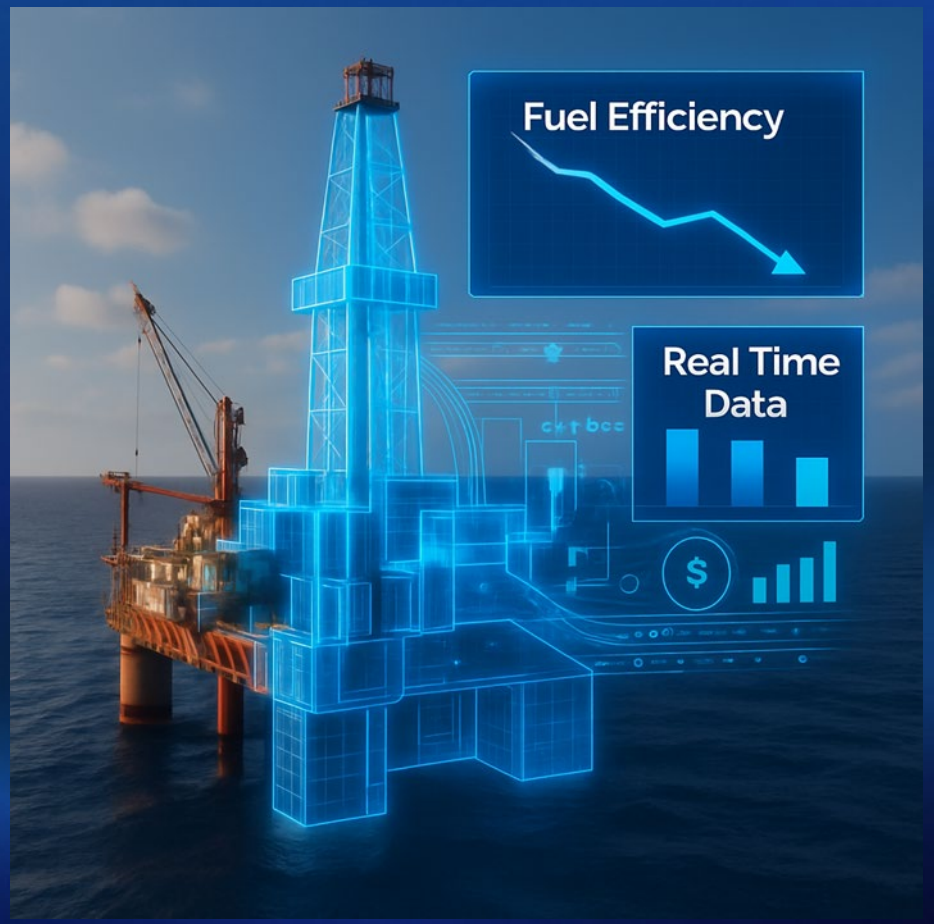
Case Study 2: Shell's Efficiency Leap

- AI-optimized drilling delivers 12% fuel savings via real-time adjustments
- Digital twins simulate assets for better decision-making
- Transforms raw data into actionable insights for continuous improvement
- Result: Enhanced precision and reduced environmental impact (Shell Whitepaper, 2022)



Citation:

- Shell Whitepaper (2022).

Case Study 3: Equinor's Green Wins

- Real-time emissions tracking achieves 25% CO2 reductions
- AI integration with carbon capture boosts efficiency by 40%
- Focuses on profitability alongside planet-friendly outcomes
- Makes carbon management proactive and smart (Equinor Sustainability Report, 2023)

Citation:

- Equinor Sustainability Report (2023).

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AI's Energy Dilemma: The Hidden Bill

- Training models like GPT - 4 emits CO2 equivalent to 300 transatlantic flights (Strubell et al., 2021)
- Data centers consume 1% of global electricity, with rapid growth projected
- Risk: AI's energy hunger could offset upstream efficiency gains if unmanaged

Citation:
- Strubell, E. et al. (2021), *The Carbon Footprint of AI Training, Nature Climate Change.*

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Powering AI Sustainably: Renewable Shifts

- Today, 60% of AI relies on fossil fuels (Greenpeace, 2023)
- Leaders like Google/Microsoft are transitioning to renewables
- Build solar/wind - powered data centers in optimal regions (IRENA, 2023)
- Integrate AI for energy management to minimize waste

Citation:
- IRENA (2023), "Renewable Energy for Data Centers"
- Greenpeace (2023)

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Challenges with Solar/Wind for Data Centers

- Intermittency: Weather - dependent supply leads to inconsistencies
- High initial costs and large land requirements
- Storage issues: Batteries not yet scalable for 24/7 operations (NREL, 2022)
- Need for reliable backups to ensure uptime

Citation:

- NREL (2022), "Challenges in Renewable Energy Adoption"

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Data Center Sizes and Energy Consumption

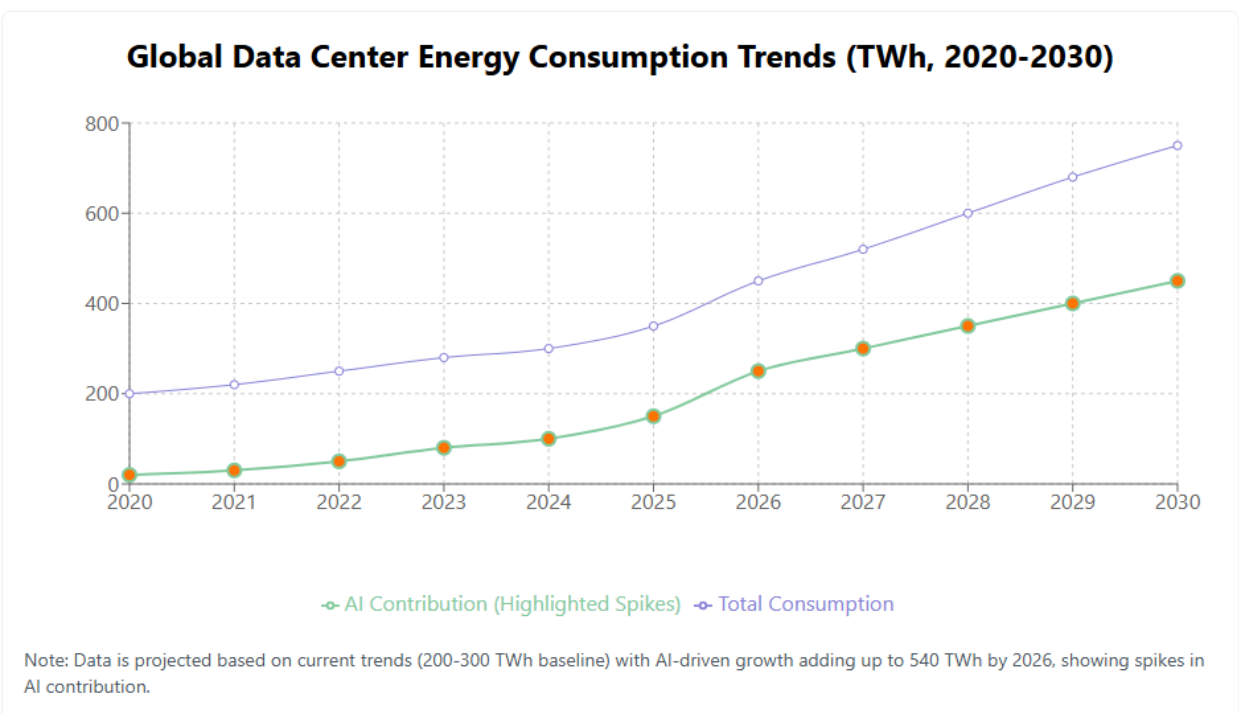
Type	Typical Size (sqm)	Description and Examples
Small/Edge Data Center	100–1,000 sqm	Power: <1 MW. Example: A small on-site server room for a business.
Traditional Enterprise	1,000–10,000 sqm	Power: 1–10 MW. Example: A bank's regional data hub.
Large Enterprise/Colocation	10,000–50,000 sqm	Power: 10–50 MW. Example: Multi-tenant centers in urban areas like those operated by Equinix.
Hyperscale	50,000–200,000+ sqm per building	Power: 100+ MW. Example: Amazon or Microsoft data centers, which can span football-field-sized buildings.
Mega Campus/Cluster	200,000–1,000,000+ sqm (total campus)	Power: Up to 1,000 MW (1 GW). Example: Google's mega-campuses in the US or Europe, equivalent to a small industrial park.

Citation:

- IEA (2024), "Data Centre and AI Boom Analysis"; BNEF (2024), "New Energy Outlook."

Energy Consumption: Rising Demands

- Current global use: Data centers consume ~1 - 2% of world electricity, or 200 - 300 TWh annually.
- Hyperscale example: A 100 MW facility uses power (e.g. Google's facilities).
- AI-driven growth: Projected to add 160 - 540 TWh by 2026
- Local impact: In Ireland, data centers take 20% of national power; Virginia, US: 10-15%.



Citation:

- IEA (2024), "Data Centre and AI Boom Analysis";
- Gartner (2024), "AI Infrastructure Forecast."

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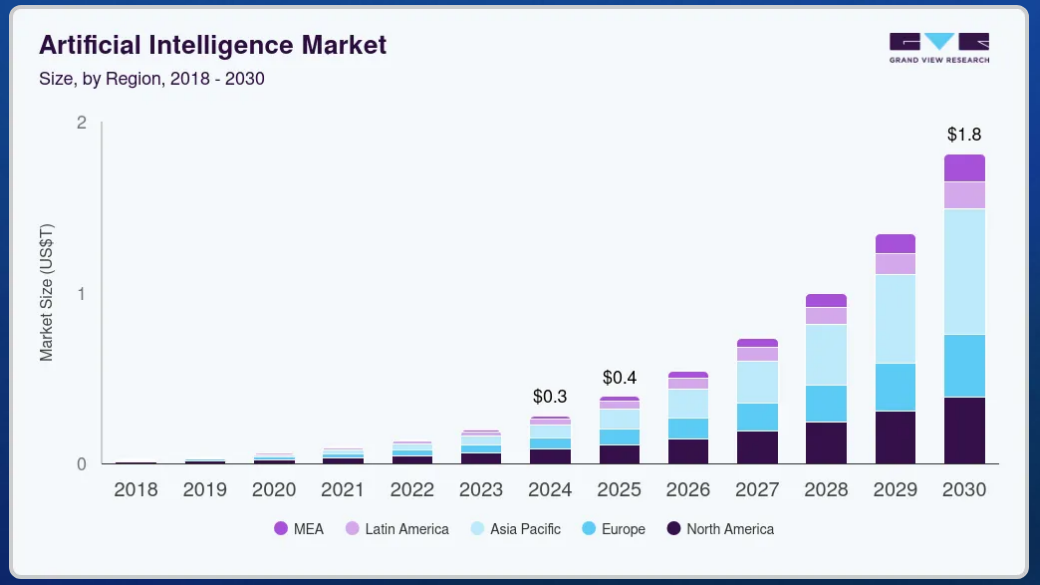
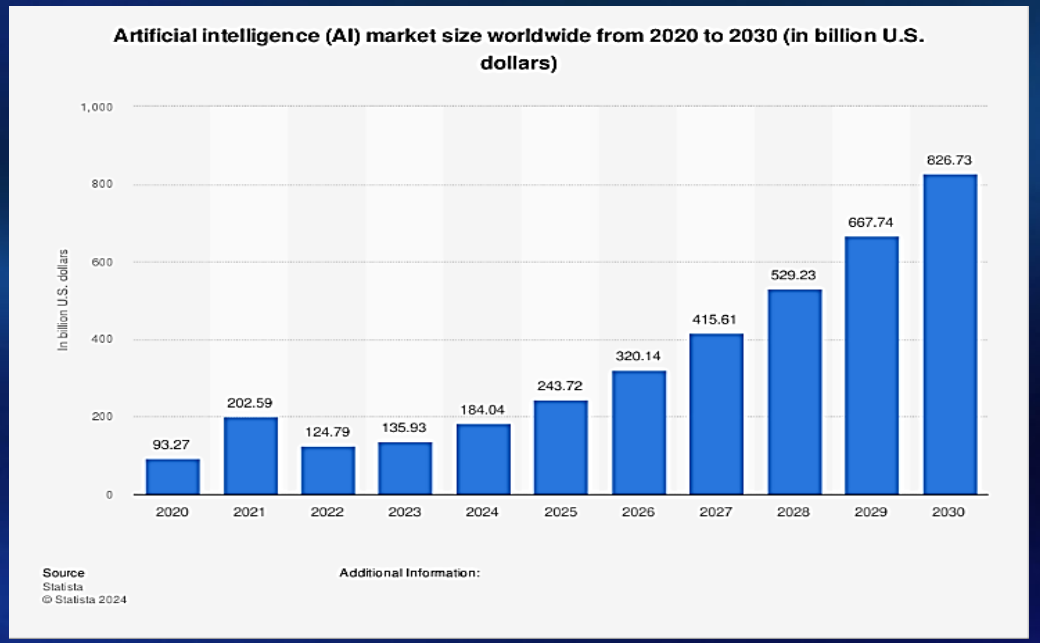
Artificial Intelligence Market Size

- The global AI market is worth around $391 billion, Expected to reach $1.81 Trillion by 2030 (Grand View Research)
- $244 Billion and Expected to reach $827 Billion by 2030 (Statista)
- During this forecast period, the AI market is predicted to increase by a CAGR of 35.9% and 28% (Statista)





Citation:

- Statista. (2024). *Artificial Intelligence Market Worldwide - Statistics and Forecasts.*
- Grand View Research. (2024). Artificial Intelligence (AI) Market Size, Share & Trends Analysis Report.

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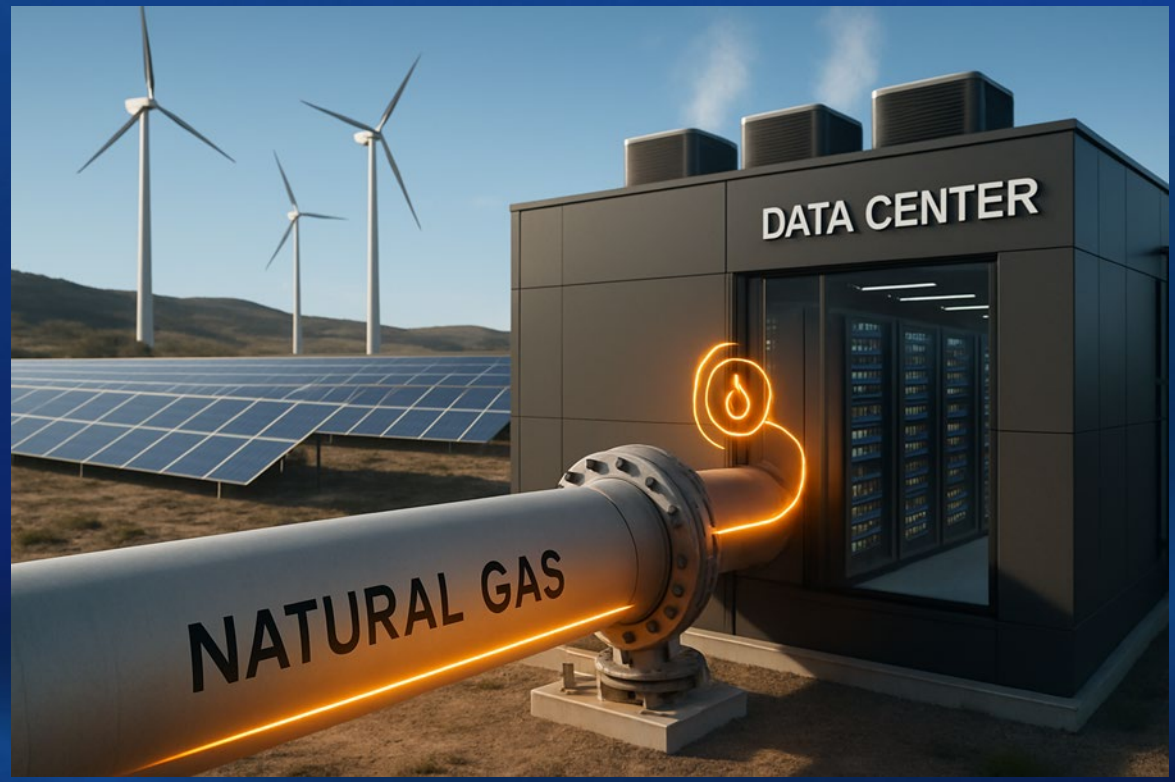
Natural Gas: Bridge to Reliable AI Power

- Acts as backup during low renewable output, preventing downtime
- Enables hybrid systems for peak computing demands (EIA, 2023)
- Pairs with carbon capture for minimized impact



Citation:
- EIA (2023), "Natural Gas in Energy Transitions"

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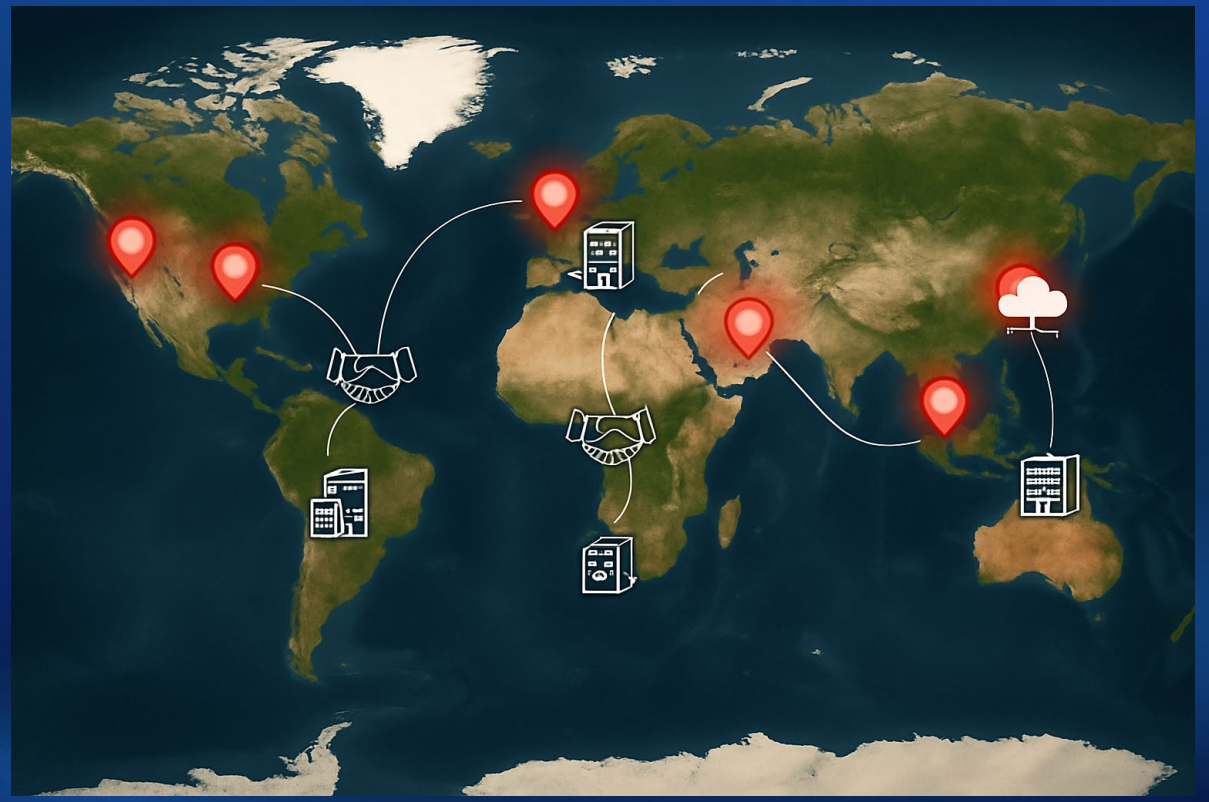
Opportunities for Gas-Rich Nations

- Invest in hybrid infrastructure to draw tech firms and boost economies
- Export gas expertise for global data centers, creating jobs (World Bank, 2023)
- Position as reliable partners in the AI boom
- Gas-rich countries (e.g Namibia) can capitalize by attracting AI investments



Citation:

- World Bank (2023), "Energy Resources and Economic Development"

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Key Takeaways: The Big Picture

- AI is crucial for upstream oil & gas, driving efficiency and sustainability as shown in BP, Shell, and Equinor case studies reducing costs and emissions
- Data centers' high energy consumption creates sustainability challenges, demanding innovative powering solutions to avoid offsetting AI's benefits
- Wind/solar energy offers promising paths for data centers but faces issues like intermittency, high costs, land needs, and storage limitations
- Gas is essential for data center reliability as a bridge fuel, enabling hybrids and backups; gas-rich countries can benefit by attracting investments and boosting economies. E.g. Namibia

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THANK YOU

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