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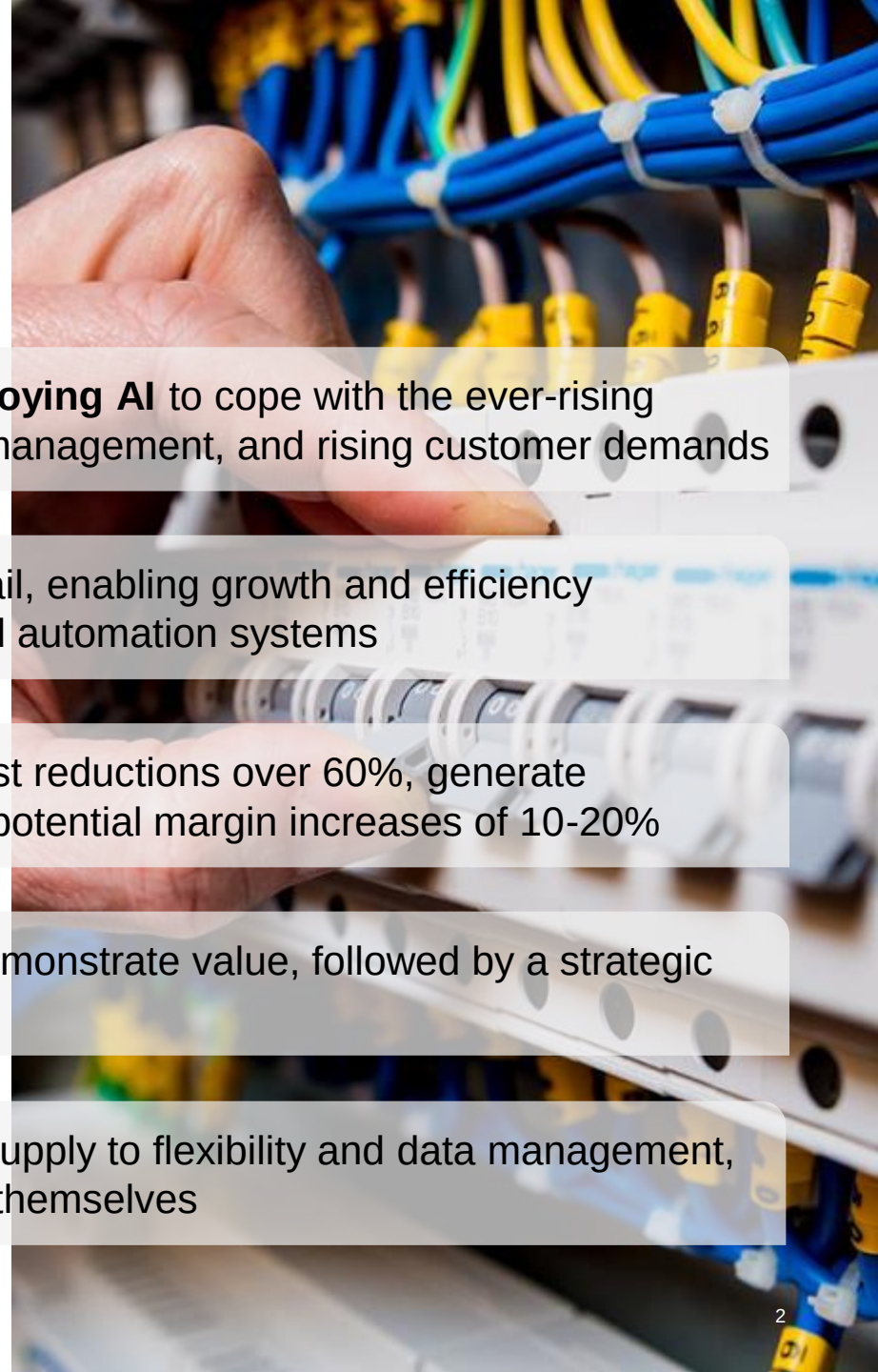
AI in Energy – Digitize or Disappear

July 2025

AI has significant potential in energy – companies must act to stay competitive

Key insights on AI for energy companies



1. **The future energy market will be dominated by companies heavily deploying AI** to cope with the ever-rising complexity from renewable power, a broad range of green gases, flexibility management, and rising customer demands

2. **AI use cases span the entire value chain** from project development to retail, enabling growth and efficiency increases – key domains include machine learning as well as perception and automation systems

3. **AI will deliver measurable financial benefits** – several use cases yield cost reductions over 60%, generate productivity increases over 50% or unlock new revenue streams, leading to potential margin increases of 10-20%

4. **Successful AI initiatives begin with pilot projects and lighthouses** to demonstrate value, followed by a strategic push of market differentiators and scaling efforts across the organization

5. **AI accelerates industry convergence –** value shifts from physical energy supply to flexibility and data management, and digital companies are ready to grab it if energy companies do not do so themselves

Abbreviation: AI = Artificial intelligence.
Source: Strategy& analysis.

Complexity and volatility have risen steeply with the shift to renewables – energy companies need to manage these challenges

Current trends and challenges for energy market participants

Current energy market trends

Energy supply

Rising share of intermittent, non-dispatchable energy generation adds complexity to the energy system

Time-correlated load patterns and limited flexibility across distributed energy resources **affect** energy system **stability**

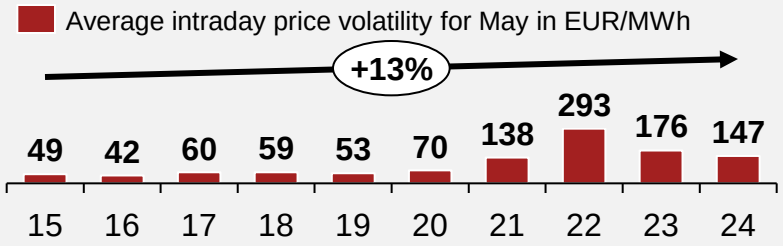
Energy demand

Energy demand is accelerating with the electrification of key sectors – at the same time, rising energy costs affect competitiveness

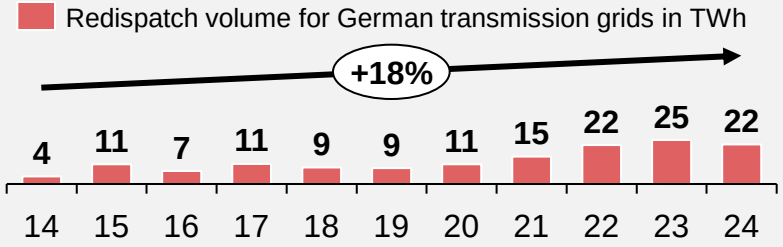
Demand load patterns are not aligned with supply load patterns – flexibility management is required

Resulting challenges

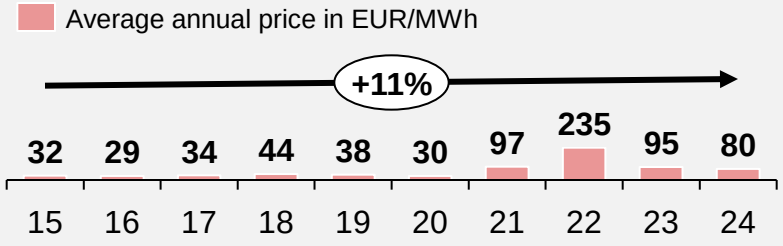
Increasing volatility of intraday energy prices [1)]



Increasing complexity of energy systems [2)]



Increasing wholesale energy prices [3)]



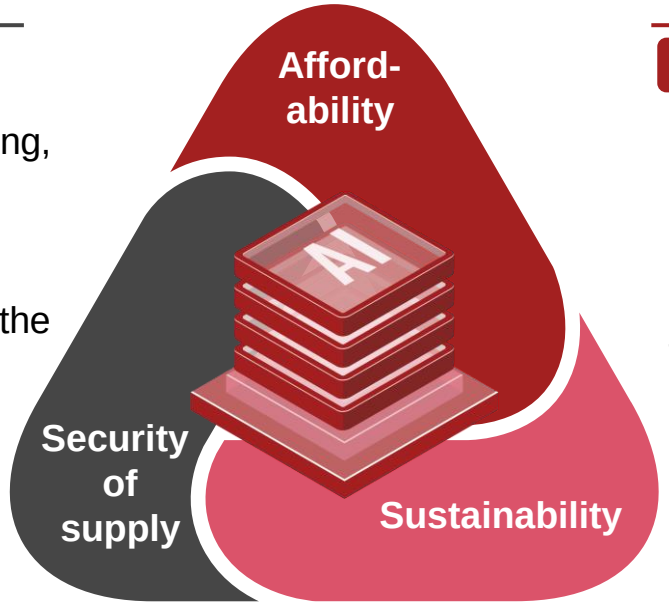
Abbreviations: MWh = Megawatt-hour, TWh = Terawatt-hour.
Sources: Strategy& analysis, 1) Intraday Auctions Epex, 2) Statista/Netztransparenz.de, 3) EXPEX. Note: All data is exclusively for Germany.

AI offers a response to these challenges and supports the achievement of energy triad goals by reducing market volatility and complexity

AI opportunity for energy market participants

Security of supply

Optimize grid monitoring, response times and maintenance cycles, minimize outages and raise flexibility across the energy system



Affordability

Decrease energy system cost with optimal usage of available sources and maximum efficient operations in all parts of the value chain

Sustainability

Optimize energy yield from renewable sources, actively manage flexibility, integrate distributed generation sources and thereby minimize use of fossil generation capacity and gases

Comments

- In past year, there was an almost exculsive focus on ecology in the energy industry
- With current issues, the broader focus on affordability and security of supply as well has been revitalized
- However, in a RES environment, meeting all goals of the triangle at the same time cannot be achieved with existing approaches
- **AI helps to effectively manage volatility and complexity** and enable rising system efficiency through**:**
  - Process automation
  - Predictive intelligence
  - Capability of processing unlimited amounts of data
  - Managing complex fuzzy systems

Abbreviation: RES = Renewable energy sources, LCOE = Levelized cost of energy.
Source: Strategy& analysis.

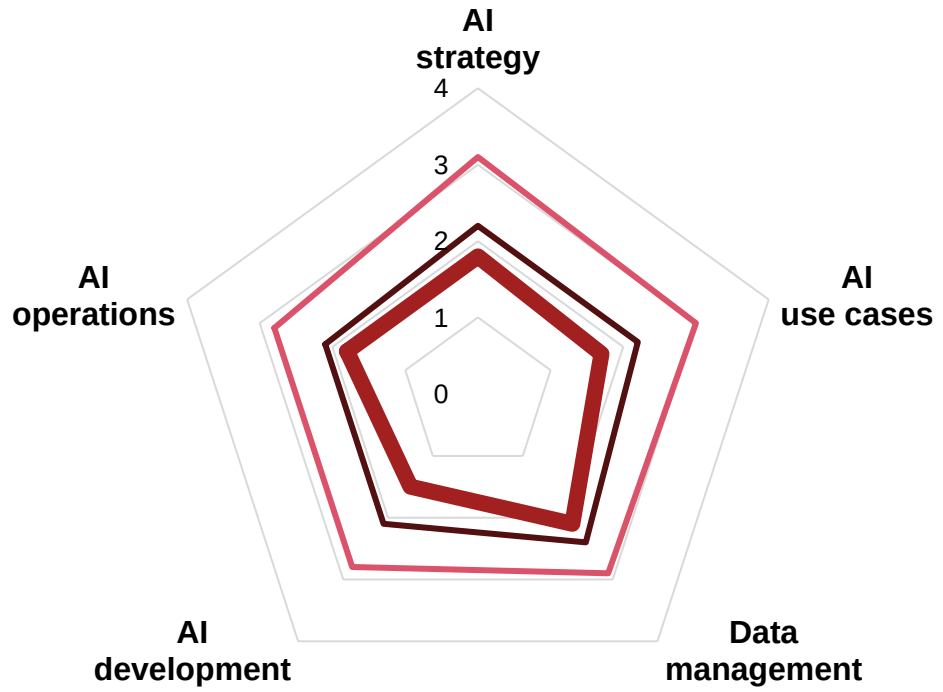
Manifold AI domains offer significant benefits to energy market players – yet AI adoption in energy/utilities is lagging behind other industries

AI adoption at energy companies

Top ten AI domains

1. **Machine learning (ML)**
2. **Perception systems**
3. **Natural language processing (NLP)**
4. **Speech-text-image conversion**
5. **Automation systems**
6. **Intelligent immersive systems**
7. **Generative AI (GenAI)**
8. **Smart big data processing**
9. **Agentic AI**
10. **Physical AI**

AI maturity of different industries



AI domains are selected and exhibit overlapping elements. AI maturity taken from Strategy& survey in 2023//24 with 161 business representatives.
Source: Strategy& analysis.

Attractive AI use cases exist across the entire energy value chain and corporate functions

Selected AI use cases

Value chain	**Project development and EPC**	**Production** (power, hydrogen, sustainable fuels)	**Transmission/transport, storage and distribution**	**Trading**	**Retail and consumption** (management)
Use cases	Automated plant design, budgeting and scheduling	Virtual plant simulation and automated asset optimization	Sensor- and image-based inspection of grid	Autonomous, agent-based trading systems	AI-powered, integrated demand-side management
	AI-driven site search, assessment and selection	Integrated commercial asset operations	Intelligent grid fault location, isolation and service restoration	Integrated market simulation and portfolio management	Dynamic pricing, demand response and personalized tariffs
	Automated permitting and regulatory compliance	Augmented work instructions for asset repair/maintenance	Proactive grid load, voltage, flow and congestion management	Optimized automated intraday market forecasting and bidding	Smart energy product and decarbonization solution sales
	E2E supply chain planning and integration	Predictive asset maintenance	Gas pipeline leak detection and risk monitoring	Automated virtual power plant (VPP) operations	Smart home and prosumer energy management
	Predictive geological analyses (e.g., for geothermal plants)	Optimized flexibility marketing	Gas network flow optimization and nomination support	Anomaly detection in trading patterns for regulatory supervision	AI-powered automated next-level customer care
	…	…	…	…	…

Corporate functions	**Support functions** (e.g., strategy, planning, M&A, IT, finance, HR)					
Use cases	Automated regulatory monitoring and compliance verification	ESG monitoring and reporting	Cybersecurity risk detection and mitigation	Financial planning and report writing	Advanced knowledge management and assistant	…

Exemplary use case deep dives on next pages

Abbreviation: EPC = Engineering procurement construction, E2E = End-to-end.
Source: Strategy& analysis.

AI applications in project development and EPC can improve plant engineering as well as permitting, leading to faster time to revenue

Selected real-world AI applications in “Project development and EPC”

	Automated plant design, budgeting and scheduling	Automated permitting and regulatory compliance
AI domain (major)	Generative AI, machine learning, smart big data processing	Natural language processing, automation systems, smart big data processing
Use case	• AI supports FEED studies and 3D model generation automation, intelligent clash detection and error prevention, advanced plant simulation and performance optimization, and pre-erection maintenance and repairs simulation • This also yields predictive analytics for material and resource planning, as well as risk assessment and mitigation modeling	• AI automates requirement analysis and data extraction, as well as document draft compilation and permitting process guidance • It also supports routine tasks ensuring fit to authorities’ needs through automated use of prior experience and regulatory source monitoring, with automated notification of new or updated regulations
Benefit	• Increased engineering efficiency and design quality • Cost savings through optimized design and waste reduction • Better long-term performance and lower operation and maintenance costs	• Reduced effort for document creation by 30%-40% • Decreased permitting time through less re-work • Improved accuracy and timely regulatory compliance

Abbreviation: FEED = Front-end engineering design.
Source: Strategy& analysis and project experience.

In plant operations, AI can support automation and optimized asset usage, maximizing investment yield for the operator

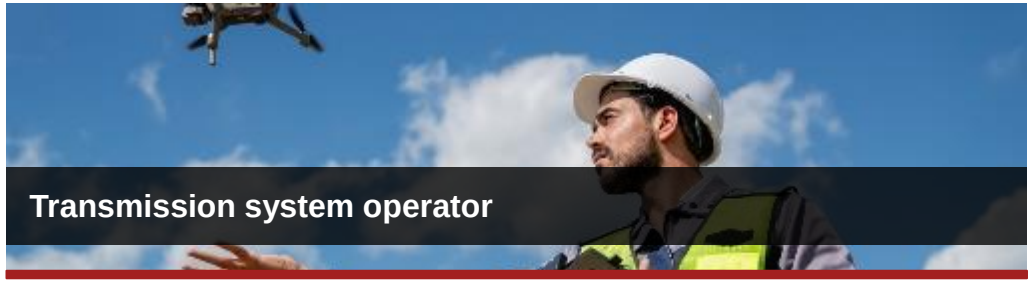
Selected real-world AI applications in “Production (power, hydrogen, sustainable fuels)”

	Integrated commercial asset operations	Virtual plant simulation and automated asset optimization
AI domain (major)	Machine learning, smart big data processing, automation systems	Machine learning, smart big data processing, physical AI (partial)
Use case	• AI integrates technical plant data (such as performance and maintenance) with forecasting of weather, power production, consumption and market prices • This enables automated plant dispatch decisions, optimization of renewable energy feed-in to market, storage, and balancing markets, as well as intelligent maintenance scheduling during low-revenue periods	• AI-powered digital twins simulate borderline plant operations (such as overpower, ramp rates and low-load conditions) • This allows the extension of safe operational ranges beyond original guaranteed values, particularly in post-warranty phases, allowing CCPPs to be operated more flexibly and aggressively without compromising safety or reliability
Benefit	• Increased commercial uptime and revenue by 5%-10% • Additional profit uplift of 2%-3% through intelligent dispatching	• Increased ramp rate by up to 50% • Increased power output by up to 5% • Increased firing temperature by up to 10,000 degrees

Abbreviation: CCPP = Combined cycle power plant.
Source: Strategy& analysis and project experience.

Grid operators can exploit AI to reduce downtimes and faults, as well as inspection and maintenance cost

Selected real-world AI applications in “Transmission/transport, storage and distribution”

	 Distribution network operator	 Transmission system operator
	Intelligent grid fault location, isolation and service restoration	**Sensor- and image-based grid inspection**
AI domain (major)	Perception systems, machine learning, agentic AI (partial)	Perception systems, machine learning, physical AI (partial)
Use case	• AI monitors substation and grid conditions by analyzing real-time sensor data and recognizing patterns • The system detects critical situations and upcoming faults instantly, autonomously initiating countermeasures to prevent outages or minimize their impact, thus enabling rapid self-healing of the power grid	• AI uses satellite and drone images for autonomous inspection of high-voltage stations and pylons • This facilitates the recognition of structural condition patterns, to replace manual human inspections
Benefit	• Reduced outage duration by 30%–50% • Prevented 45% of service disruptions • Improved grid reliability and customer satisfaction	• Saved over 50,000 working hours and 10,000 helicopter flight hours per year (over €20 million savings annually) • Increased inspection safety, speed and accuracy, improving operational efficiency

Source: Strategy& analysis and project experience.

Energy traders need to embrace AI to manage raising market complexity and exploit opportunities from decentralization

Selected real-world AI applications in “Trading”

	Autonomous, agent-based trading systems	Automated virtual power plant (VPP) operations
AI domain (major)	Agentic AI (partial), machine learning, smart big data processing	Machine learning, smart big data processing, automation systems
Use case	• AI optimizes trading algorithms that identify opportunities, execute trades autonomously within defined boundaries, perform automated trade validation, and learn to improve effectiveness over time • The system analyzes historic market data and forecasts in renewable energy trading, develops AI-derived future pricing models, performs real-time data analysis and with multitude capacity of human traders, offering significant additional value	• AI performs high-volume data processing, advanced forecasting and iterative optimization to integrate numerous small decentralized energy assets (including production, controllable consumers, and storage) into one virtual system • This enables dynamic optimization of production yield and maximizes achievable prices through intelligent market participation and real-time asset coordination
Benefit	• Reduced human error, with faster trade opportunity identification and execution • Higher (often by 5%-10%) and more stable returns, with reduced market volatility	• Low-risk revenue generation from third-party assets without asset risk • Profit optimization with AI-enhanced forecasting and dispatching • Improved asset utilization and grid flexibility

Source: Strategy& analysis and project experience.

Energy retail and customer service also exhibit huge potential to use AI to enhance customer care and differentiate offerings

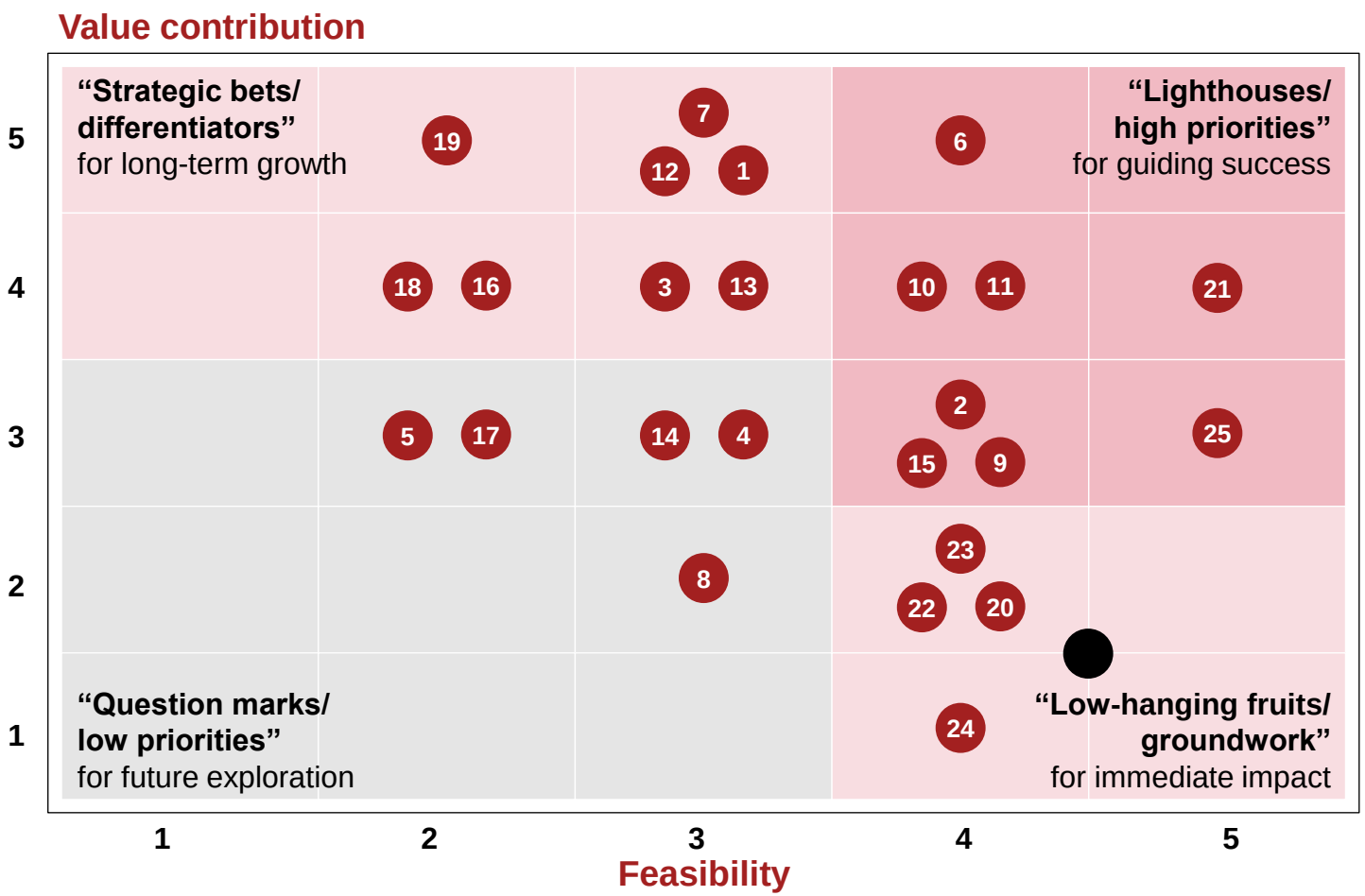
Selected real-world AI applications in “Retail and consumption (management)”

	Smart energy product and decarbonization solution sales	AI-powered next-level customer care
AI domain (major)	Natural language processing, generative AI, smart big data processing	Natural language processing, generative AI, automation systems
Use case	• AI analyzes customer energy consumption and production, CO2 footprint of supplied energy, operations, contracts, market trends and sentiments • Based on semi-standardized automated analysis, AI helps to optimize sales strategies in terms of who, when and how to approach for offerings • Furthermore, AI generates tailored and economically viable decarbonization solutions	• AI is leveraged to provide an integrated web-first customer interface where customers can chat with well-trained AI bots, upload documents, seamlessly switch between mobile and laptop access • The bot performs natural language discussions, supported by human third-level backup – the AI model is integrated into third-level support to improve learning and service quality continuously
Benefit	• Improved hit rate by up to 30% in customer acquisition, with a focus on those who are likely to renew their contract/switch supplier • Higher-value offerings for customers up for decarbonization solutions • Reduced backoffice staff in sales	• Reduced FTE and cost in customer support by up to 60% • Decreased churn due to increased customer satisfaction • Increased customer base via tailored word-of-mouth marketing

Abbreviation: CO2 = Carbon dioxide, FTE = Full-time equivalent.
Source: Strategy& analysis and project experience.

Prioritize AI use cases by value and feasibility — get the foundations done, create lighthouses, and invest in differentiators

AI use case prioritization



Comments

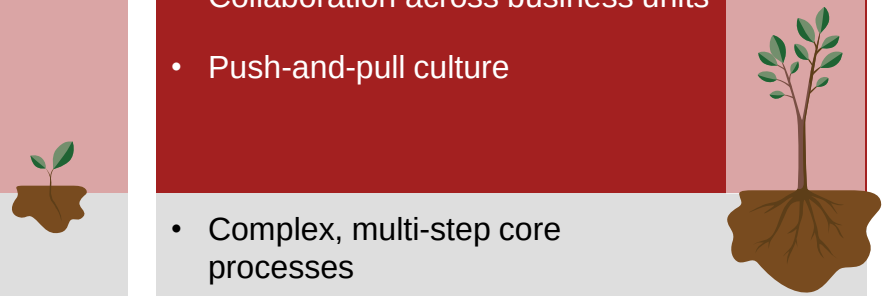
- Use case evaluation is typically done by
  - Value contribution, i.e.
    - Impact on operating margin
    - Strategic benefit.
  - Feasibility, i.e.
    - Data availability, quality and accessibility
    - Required process and system changes
    - Available expertise
    - Existance of required algorithms,
    - Regulatory constraints
- Evaluation needs to be done considering individual company's situation and objectives

Numbers reflect sequence of use-cases on chart 6, black dot represents support functions. Top-down qualitative evaluation based on expert opinions and market observations. Rating might vary for individual companies
Source: Strategy& analysis.

In our experience, AI initiatives are best started with lighthouses to produce visible success and then grown/scaled up in the organization

AI development stages from start to scale

	"START with lighthouses" Short term (1-2 years)	**"GROW with big tickets"** Medium term (3-5 years)	**"SCALE with major change"** Long term (5+ years)
Main goals	• Known, measurable and fast results • Pilots and lighthouses • Resources freed up for next-level	• Significant business value • Collaboration across business units • Push-and-pull culture	• Data/model efficiency • Competitive differentiation • Partner ecosystem
Main use case attributes	• Internal tasks with high automation potential • End-user services with "wow effect" • Internal structured data basis • Prediction models based on experiences from other industries	• Complex, multi-step core processes • Personalized/relevant end-user experience • Internal unstructured data basis	• Major business/operating model change • Value creation with other industry sectors • Multi-domain and multi-owner data basis

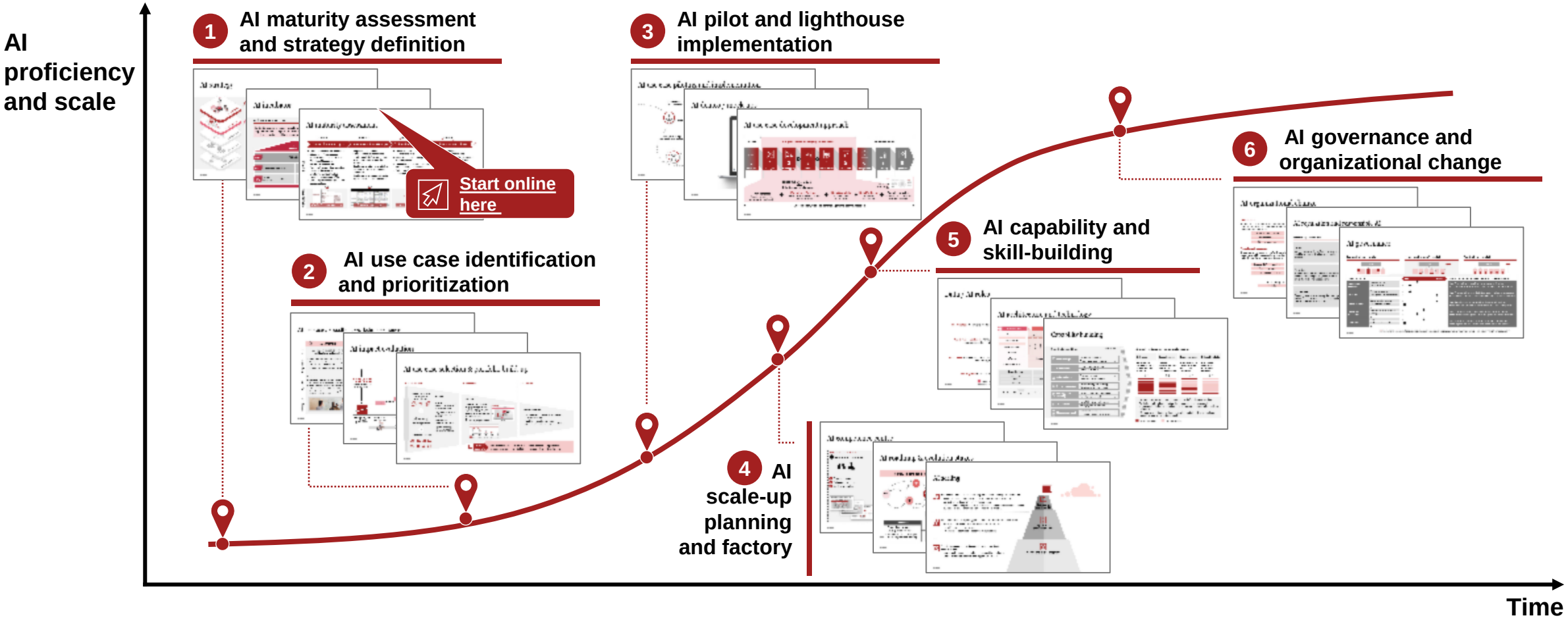


Increase in (TIME TO) IMPACT

Source: Strategy& analysis.

We offer energy players a comprehensive set of support offerings to start, grow and scale their AI journey

Major Strategy& AI offerings



Source: Strategy& analysis.

A systematic use case identification, evaluation and selection process is key to building a balanced AI portfolio

Deep dive on 2 AI use case identification and prioritization

1. Identification

Internal and **external use cases** along the key value levers

+

Existing data/AI **use cases**/initiatives at client organization

+

Available data sources

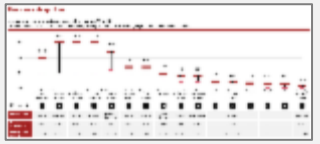
Long list

- **Collection** of **use cases** (existing and new) and creation of long-list
- **Clustering**/grouping of **available data/AI** domains
- **Alignment** of **prioritization criteria**
- **Stacking use cases** with similar capability requirements to scale

2. Evaluation

Short list

- **Prioritization** of use cases by **selected criteria**, e.g., impact (such as EBIT and strategic benefit) and feasibility (such as data/ model/system requirements)
- **Evaluation** to be conducted in **multiple iterations**



3. Selection

Initiate prototyping

- **Insight-to-action**: Creation of demonstrators for selected use case(s)
- **Feasibility:** Evaluation of technical requirements for further development of MVP

Portfolio trade-offs

Differentiation vs. **revenue** potential

Revenue vs. **profitability**

Inspirational vs. **scaleable**

Specific vs. **transferable**

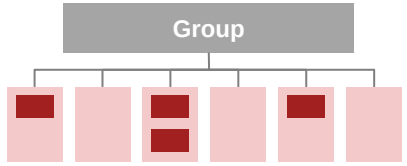
…

Abbreivation: MVP = Minimum viable product.
Source: Strategy& analysis.

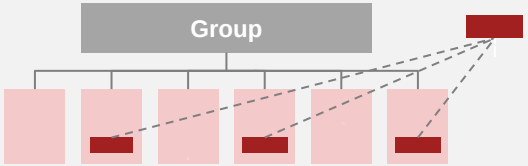
Tailored governance is key to effective AI scale-up – the “hub and spoke” model balances centralized control and decentralized innovation

Deep dive on 6 AI governance and organizational change

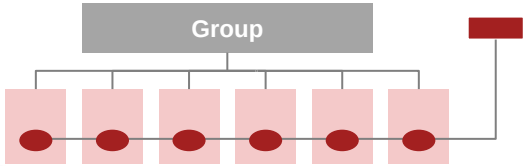
Decentralized model



“Hub and spoke” model



Centralized model



Coordination areas		Hub – Spokes	Implications for responsibilities of hub vs. spoke teams (selection)
Strategy and processes	Vision and targets Operating model …		**Hub:** Target setting, organizational changes, process blueprints **Spoke:** Data/AI strategy operationalization, business unit/functional targets
Use cases	Portfolio management Development and implementation …		**Hub:** Target portfolio structure, budget and monitoring, lighthouse use cases **Spoke:** Domain-specific use case prioritization, development and deployment
Data management	Data processing and usage Regulation and policies …		**Hub:** Data/AI compliance and guidelines, data standards/catalog **Spoke:** Data quality assurance, data stewards, data access management
Capabilities and culture	Awareness and communication Training …		**Hub:** Foundational training, best practice sharing, community-building **Spoke:** Capability development and training specific to business unit/function
Technology	Tools Platform and infrastructure …		**Hub:** Infrastructure and platform/tool provision, technology partnering **Spoke:** Specific technical requirement definition, specific tool operations

Data/AI capabilities Business (functions/countries) Power balance Note: The "hub and spoke” model for data/AI governance involves a lean central team providing core services (“hub”) and decentral/dedicated business teams operationalizing solutions (“spokes” with dotted reporting to the hub). The right degree of centralization of coordination areas depends on the specific company situation
Source: Strategy& analysis.

AI is not about technology, but a new strategic direction enabled with new capabilities

Strategic imperatives of AI for energy companies

1 **Start fast with AI to maintain or improve competitiveness**
AI has the potential to affect the competitive positioning of the whole energy value chain – scan opportunities and leverage them quickly

2 **Recalibrate existing data and AI activities to stay ahead**
Refine data strategy considering AI, adjust use case target portfolio, and identify implications for overall digital/IT transformation program

3 **Avoid the AI dilemma (high ambitions clash with reality)**
First launch AI lighthouses delivering measurable/fast results to create traction, then focus on initiatives with high P&L impact to show value

4 **Balance AI adoption with robust cybersecurity measures**
AI increases cybersecurity risks for critical energy infrastructure – invest in countermeasures, including using AI to strengthen resilience

5 **Foster AI culture development to implement AI successfully**
AI is usually described in technical terms – but creating a culture that encourages employees to learn and experiment with AI tools is vital

6 **Build cross-functional AI capabilities**
Combine energy domain expertise with data science and AI engineering, investing in talent development and change management

7 **Unleash AI's full potential in a connected ecosystem**
Data/AI experts are scarce and algorithms complex – work with external partners for speed/efficiency, yet without creating dependencies

8 **Build tailored AI governance to scale up AI effectively**
Define clear ownership and standards for AI initiatives – the "hub and spoke" model balances centralized control and decentralized innovation

Source: Strategy& analysis.

Accelerate your AI journey now and contact our experts for AI@Energy

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