

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

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

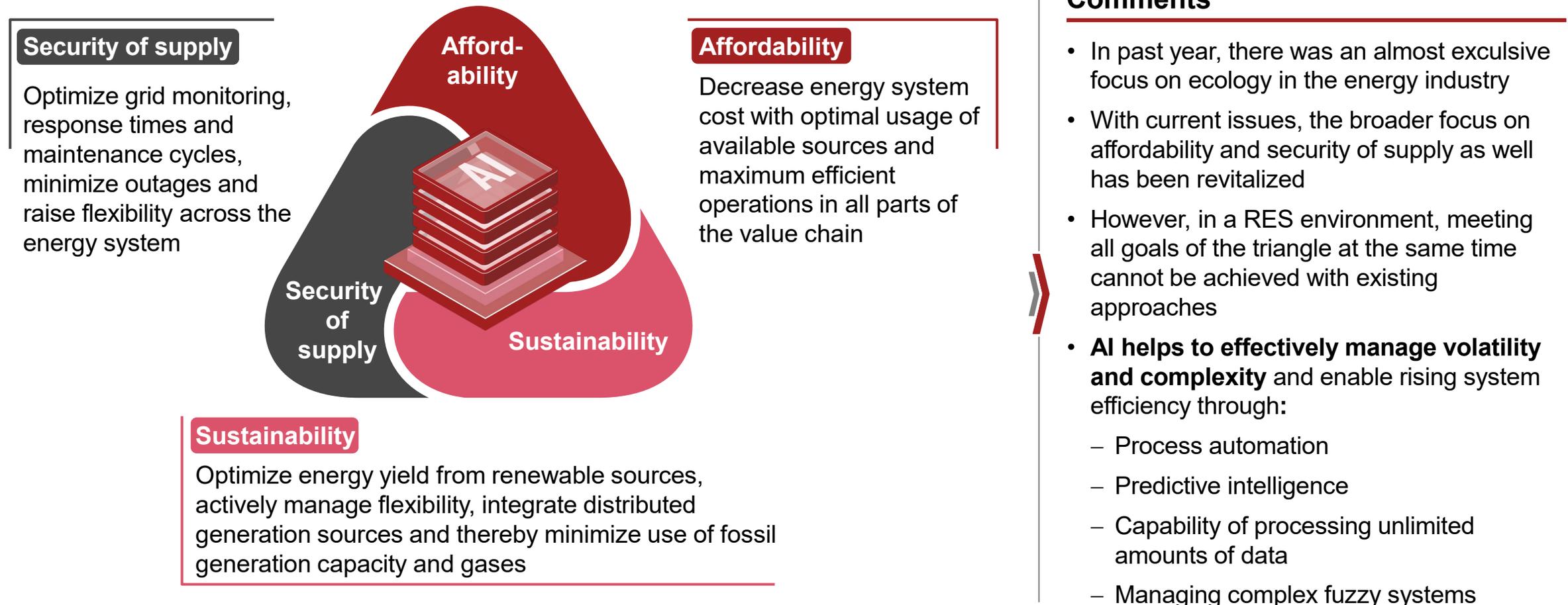
Energy supply	Rising share of intermittent, non-dispatchable energy generation adds complexity to the energy system
	Time-correlated load patterns and limited flexibility across distributed energy resources affect energy system stability
Energy demand	Energy demand is accelerating with the electrification 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⁾	<p>Average intraday price volatility for May in EUR/MWh</p> <p>+13%</p> <table border="1"> <tr><th>Year</th><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr> <tr><th>Volatility (EUR/MWh)</th><td>49</td><td>42</td><td>60</td><td>59</td><td>53</td><td>70</td><td>138</td><td>293</td><td>176</td><td>147</td></tr> </table>	Year	15	16	17	18	19	20	21	22	23	24	Volatility (EUR/MWh)	49	42	60	59	53	70	138	293	176	147		
	Year	15	16	17	18	19	20	21	22	23	24														
Volatility (EUR/MWh)	49	42	60	59	53	70	138	293	176	147															
Increasing complexity of energy systems ²⁾	<p>Redispatch volume for German transmission grids in TWh</p> <p>+18%</p> <table border="1"> <tr><th>Year</th><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr> <tr><th>Volume (TWh)</th><td>4</td><td>11</td><td>7</td><td>11</td><td>9</td><td>9</td><td>11</td><td>15</td><td>22</td><td>25</td><td>22</td></tr> </table>	Year	14	15	16	17	18	19	20	21	22	23	24	Volume (TWh)	4	11	7	11	9	9	11	15	22	25	22
	Year	14	15	16	17	18	19	20	21	22	23	24													
Volume (TWh)	4	11	7	11	9	9	11	15	22	25	22														
Increasing wholesale energy prices ³⁾	<p>Average annual price in EUR/MWh</p> <p>+11%</p> <table border="1"> <tr><th>Year</th><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr> <tr><th>Price (EUR/MWh)</th><td>32</td><td>29</td><td>34</td><td>44</td><td>38</td><td>30</td><td>97</td><td>235</td><td>95</td><td>80</td></tr> </table>	Year	15	16	17	18	19	20	21	22	23	24	Price (EUR/MWh)	32	29	34	44	38	30	97	235	95	80		
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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



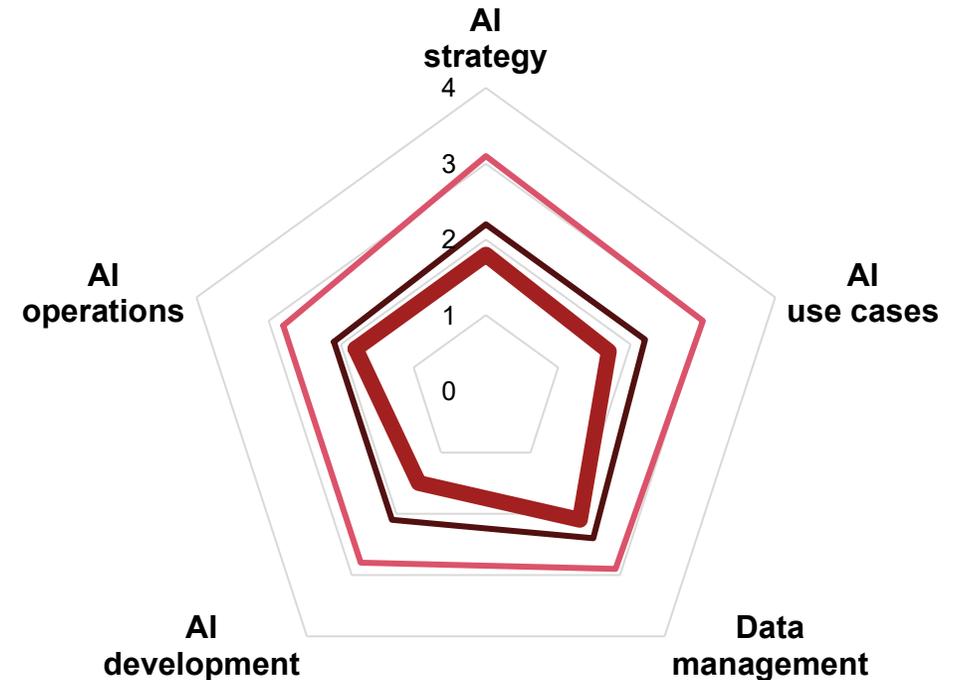
Manifold AI domains offer significant benefits to energy market players – yet AI adoption in energy/utilities is lagging behind other industries

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



Maturity: from 1 AI novice ... to ... 4 AI visionary

Scope: — Average — Services industry — Energy and utilities

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	1 Automated plant design, budgeting and scheduling	6 Virtual plant simulation and automated asset optimization	11 Sensor- and image-based inspection of grid	16 Autonomous, agent-based trading systems	21 AI-powered, integrated demand-side management	
	2 AI-driven site search, assessment and selection	7 Integrated commercial asset operations	12 Intelligent grid fault location, isolation and service restoration	17 Integrated market simulation and portfolio management	22 Dynamic personalized pricing and demand response offers	
	3 Automated permitting and regulatory compliance	8 Augmented work instructions for asset repair/maintenance	13 Proactive grid load, voltage, flow and congestion mgmt.	18 Optimized automated intraday market forecasting and bidding	23 Smart energy product and decarbonization solution sales	
	4 E2E supply chain planning and integration	9 Predictive asset maintenance	14 Gas pipeline leak detection and risk monitoring	19 Automated virtual power plant (VPP) operations	24 Smart home and prosumer energy management	
	5 Predictive geological analyses (e.g., for geothermal plants)	10 Optimized flexibility marketing	15 Gas network flow optimization and nomination support	20 Anomaly detection in trading for regulatory supervision	25 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

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

AI domain (major)

Generative AI, machine learning, 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

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



Automated permitting and regulatory compliance

Natural language processing, automation systems, smart big data processing

- 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

- Reduced effort for document creation by 30%-40%
- Decreased permitting time through less re-work
- Improved accuracy and timely regulatory compliance

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)”



Power plant operator/trader

Integrated commercial asset operations

AI domain (major)

Machine learning, smart big data processing, automation systems

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

Benefit

- Increased commercial uptime and revenue by 5%-10%
- Additional profit uplift of 2%-3% through intelligent dispatching



(Hydrogen-ready) CCPP operator

Virtual plant simulation and automated asset optimization

Machine learning, smart big data processing, physical AI (partial)

- 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

- Increased ramp rate by up to 20%
- Increased power output by up to 5%
- Increased firing temperature by up to 5-7K

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

Intelligent grid fault location, isolation and service restoration

AI domain (major)

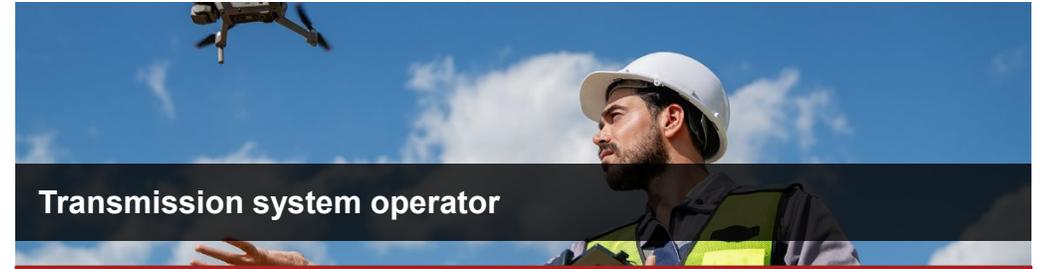
Perception systems, machine learning, agentic AI (partial)

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

Benefit

- Reduced outage duration by 30%–50%
- Prevented 45% of service disruptions
- Improved grid reliability and customer satisfaction



Transmission system operator

Sensor- and image-based grid inspection

Perception systems, machine learning, physical AI (partial)

- 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

- 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

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

AI domain (major)

Agentic AI (partial), machine learning, smart big data processing

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

Benefit

- Reduced human error, with faster trade opportunity identification and execution
- Higher (often by 5%-10%) and more stable returns, with reduced earnings volatility



Automated virtual power plant (VPP) operations

Machine learning, smart big data processing, automation systems

- 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

- 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

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)”



Energy retailer

Smart energy product and decarbonization solution sales

AI domain (major)

Natural language processing, generative AI, smart big data processing

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

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



Energy retailer

AI-powered next-level customer care

Natural language processing, generative AI, automation systems

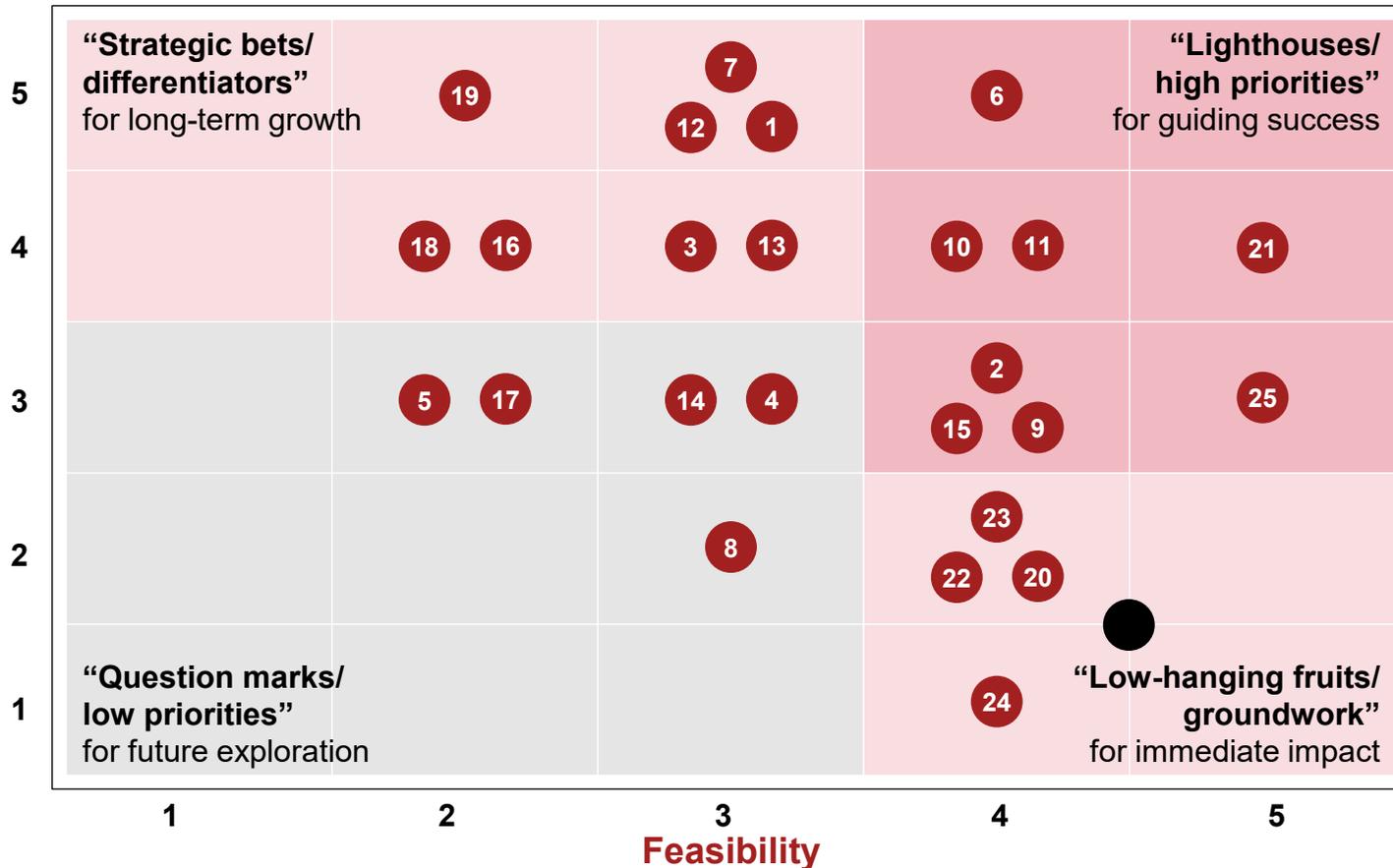
- AI is leveraged to provide an integrated web-first customer interface where customers can chat with well-trained AI bots, upload documents, seamlessly switch between mobile and laptop access
- The bot performs natural language discussions, supported by human third-level backup – the AI model is integrated into third-level support to improve learning and service quality continuously

- 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

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

AI use case prioritization

Value contribution

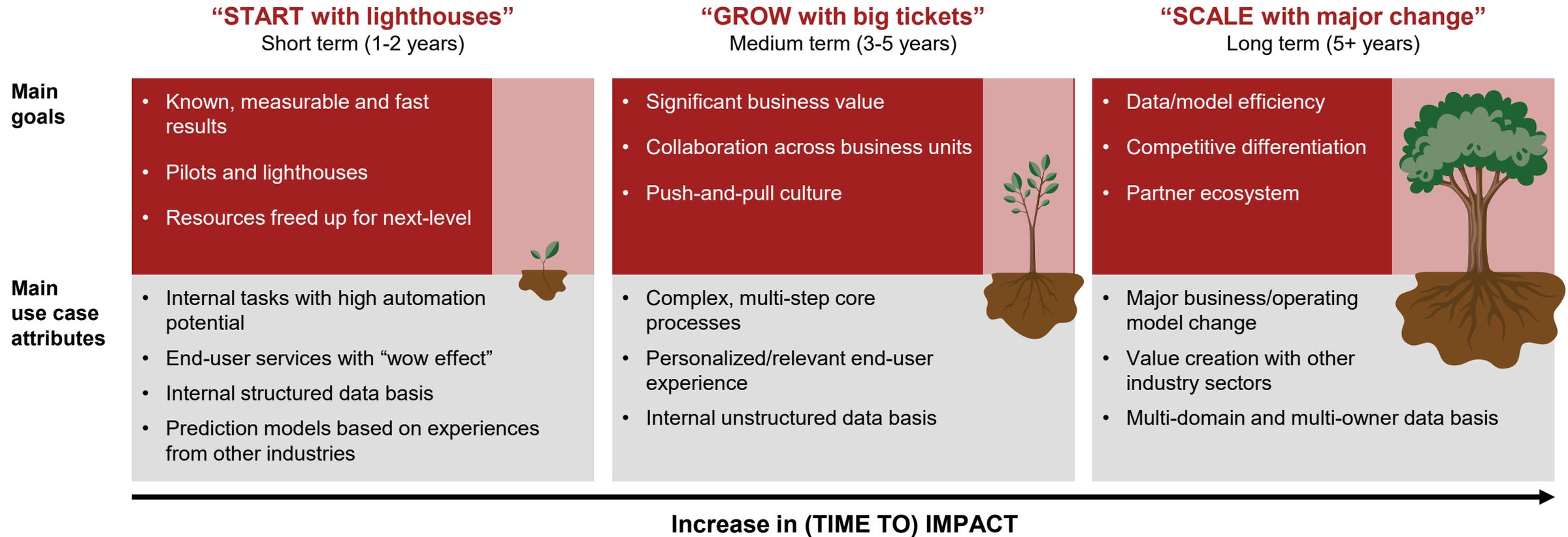


Comments

- 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
 - Existence of required algorithms,
 - Regulatory constraints
- Evaluation needs to be done considering individual company’s situation, objectives, AI capabilities and data availability

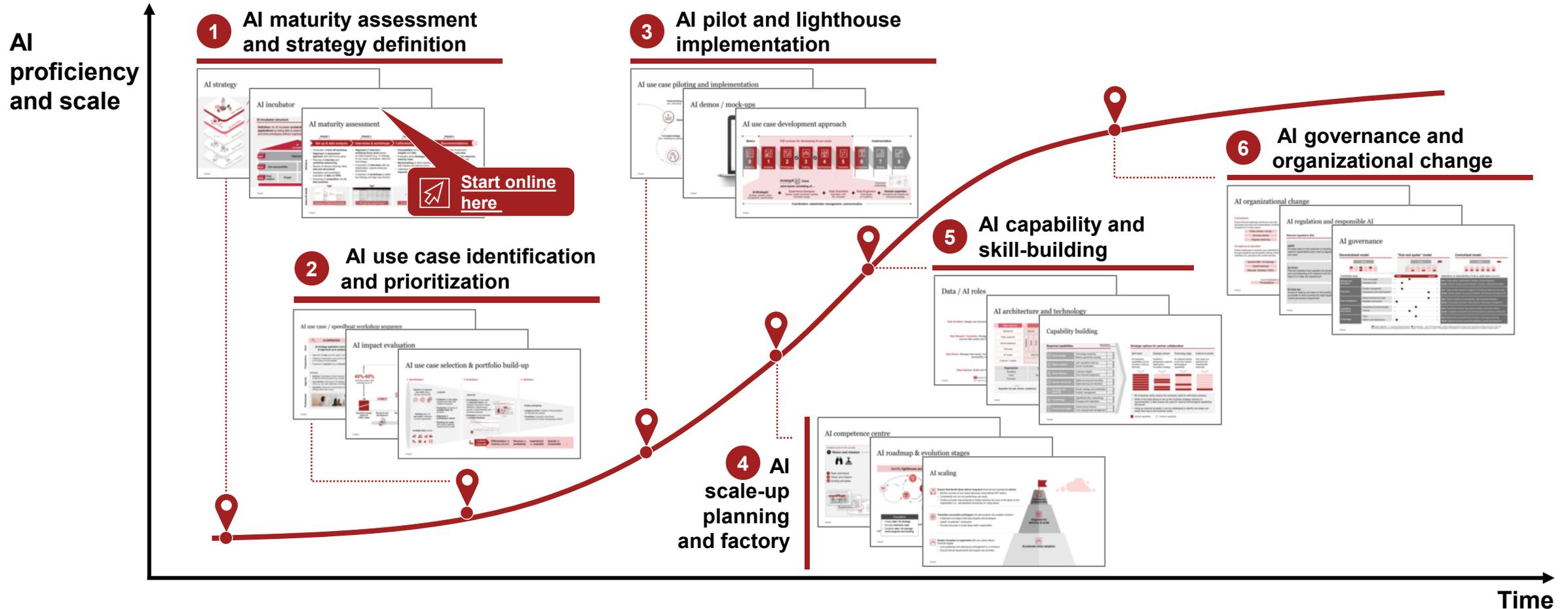
In our experience, AI initiatives are best started with lighthouses to produce visible success and then grown/scaled up in the organization

AI development stages from start to scale



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

Major Strategy& AI offerings



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



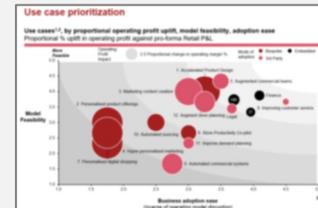
Long list

- **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

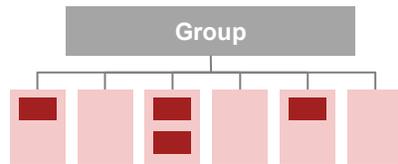
Specific vs. transferable

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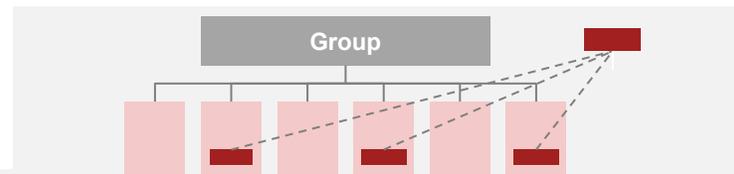
Tailored governance is key to effective AI scale-up – the “hub and spoke” model balances centralized control and decentralized innovation

Deep dive on 6 AI governance and organizational change

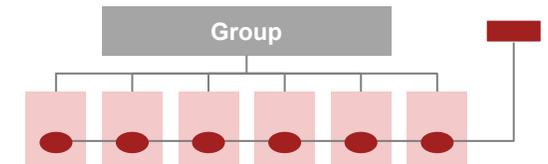
Decentralized model



“Hub and spoke” model



Centralized model



Coordination areas

		Hub	Spokes
Strategy and processes	Vision and targets	●	●
	Operating model	●	●
	...	●	●
Use cases	Portfolio management	●	●
	Development and implementation	●	●
	...	●	●
Data management	Data processing and usage	●	●
	Regulation and policies	●	●
	...	●	●
Capabilities and culture	Awareness and communication	●	●
	Training	●	●
	...	●	●
Technology	Tools	●	●
	Platform and infrastructure	●	●
	...	●	●

Implications for responsibilities of hub vs. spoke teams (selection)

Hub: Target setting, organizational changes, process blueprints
Spoke: Data/AI strategy operationalization, business unit/functional targets
Hub: Target portfolio structure, budget and monitoring, lighthouse use cases
Spoke: Domain-specific use case prioritization, development and deployment
Hub: Data/AI compliance and guidelines, data standards/catalog
Spoke: Data quality assurance, data stewards, data access management
Hub: Foundational training, best practice sharing, community-building
Spoke: Capability development and training specific to business unit/function
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

Kickstart your AI journey today by reaching out to our team



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