The Dao of artificial intelligence in the Canadian electricity industry

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Electricity Canada
Our energy future

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About Electricity Canada

About Electricity Canada:

Founded in 1891, Electricity Canada (formerly the Canadian Electricity Association) is the national forum and voice of the evolving and innovative electricity business in Canada. The Association supports, through its advocacy efforts, the regional, national, and international success of its members. Electricity Canada members generate, transmit, and distribute electrical energy to industrial, commercial, residential, and institutional customers across Canada. Members include integrated electric utilities, independent power producers, transmission and distribution companies, power marketers, and system operators, who together deliver electricity to all Canadians, in every province and territory.

Executive summary

Artificial Intelligence (AI) has emerged as a powerful driver of innovation and efficiency in the modern business landscape. Organizations across all industries invest heavily in AI technologies, hoping to leverage their potential to enhance productivity, optimize operations, and create new business opportunities.

This paper, developed through conversations with members of Electricity Canada's Technology Committee, the creation of Electricity Canada's annual technology trends reports, and additional research into laws and regulations on AI, aims to inform the industry of the opportunities and challenges it faces when it comes to artificial intelligence. It also seeks to inform governments and regulators that AI is here to stay and must be carefully considered in system integration. AI is a solution that enables creative change within the electricity industry and establishes operational and cost efficiencies in an era of inflation, tariff threats, supply chain constraints and human resource shortages.

Integrating AI into the industry for grid management, renewable energy integration, and more, will require guardrails that speak to security, education, innovation, validation, and integrity. These applications, whether customer-facing, operational, or regulatory, will require continued monitoring and evaluation to measure their effectiveness.

Although Canada was the first nation to adopt an artificial intelligence strategy, it lags behind 20 OECD countries in terms of adoption. The Canadian government can streamline regulations and promote adoption within Canada through funding, cooperation, education, and regulation to ensure Canadian competitiveness across all industries.

Author's statement:

No artificial intelligence applications were used in content development for this paper.

Introduction and background

AI will become an inevitable tool in the electricity industry as applications are piloted across departments. Privacy and safeguarding customer information will be critical in future offerings. However, they will only be successful if the technology and processes that govern that technology are transparent and ethical.

Conversations across multiple Electricity Canada committees, councils, and working groups have raised the question of AI's application in their line of business. Different groups have explored the use AI in call centres, operations, reliability, data load management, accounting, data privacy, regulatory, enterprise architecture, and more. These discussions raise even more questions about AI usage, governance, ownership, general applicability, and interoperability with other systems.

"Energy Hog": The power demands of AI (and why we're not talking about it)

AI is the primary driver for increased energy demand from data centres. The amount of electricity used to power an AI script is up to 10 times more than a traditional internet search engine request, depending on the complexity of the request.

Over time, with improved coding and new hardware systems, the amount of energy is expected to decrease per AI request. Still, the number of AI systems will increase in usage across all lines of business as government policies catch up to the new technology and comfort levels increase in its widespread adoption.

As with many new technologies, there are implications for its adoption. However, this is out of the scope of this paper, which will focus instead on recommendations on operating guardrails for utilizing AI systems in industry, government, and regulation.

Generative artificial intelligence (GenAI) represents a new era of AI technologies characterized by their ability to learn, adapt, and make decisions in real-time. AI systems can analyze vast datasets, optimize processes, and enhance decision-making across various industries. Gen AI's natural language processing capabilities allow users with little to no computer expertise to produce content, images, computer code, searches and perform other many other functions that can add value across a value chain and business operations.

Agentic artificial intelligence can operate with a high degree of autonomy, making decisions and taking actions with minimal human intervention. It can plan and adapt based on its environment and objectives. The potential advantages for industries like utilities include improved ability to manage complex systems, such as a power grid, in real-time.

What is artificial intelligence (AI)?

Definitions of artificial intelligence (AI) vary widely as organizations and governments seek to establish foundations for this powerful driver of modern technology. The following is a short list of definitions by entity.

Table 1: Artificial Intelligence Description

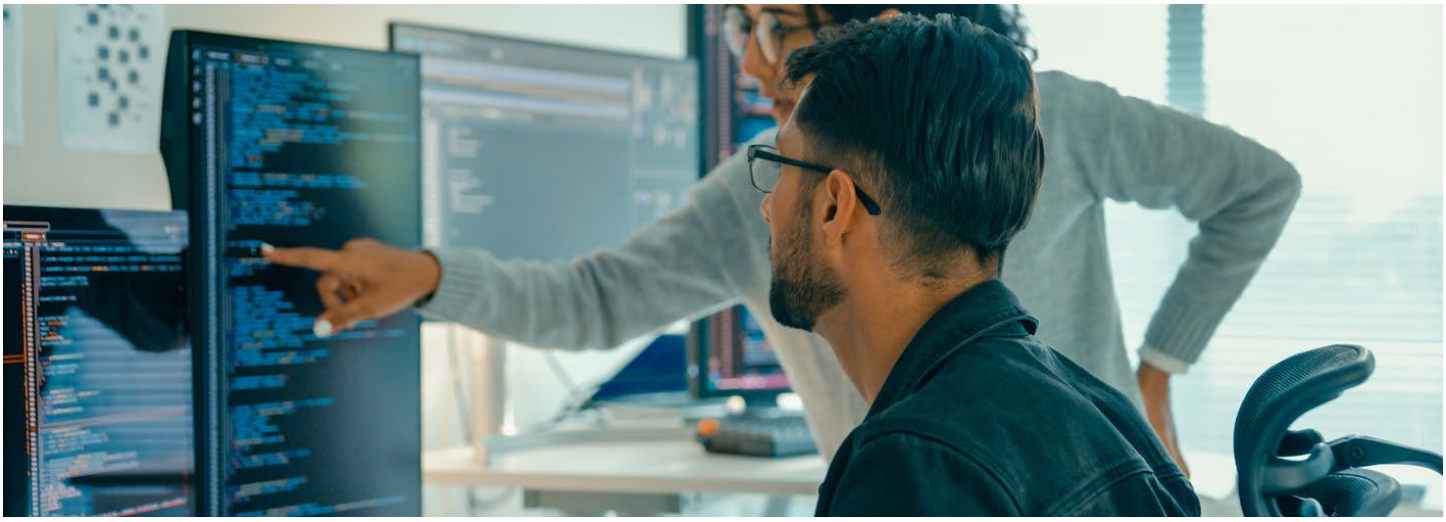
Act/Entity	Description
Artificial Intelligence and Data Act (Bill-C-27)	• "**Artificial intelligence system"** means a "system that, using a model, makes inferences to generate output, including predictions, recommendations or decisions." • **"General-purpose system"** means an "artificial intelligence system that is designed for use, or that is designed to be adapted for use, in many fields and for many purposes and activities, including fields, purposes and activities not contemplated during the system's development." • **"Machine-learning model"** means a "digital representation of patterns identified in data through the automated processing of the data using an algorithm designed to enable the recognition or replication of those patterns."

IEEE	"the theory and development of computer systems that can perform tasks that normally require human intelligence, such as visual perception, speech recognition, learning, decision-making, and natural language processing."[1]
ISED	"AI is the set of computer techniques that enable a machine (e.g., a computer or telephone) to perform tasks that typically require intelligence, such as reasoning or learning. It is also referred to as the automation of intelligent tasks. Scientific developments in AI, such as deep-learning techniques, have made it possible to design access to huge amounts of data and ever-increasing computing power. These new techniques have been rapidly deployed on a large scale in all areas of social life, in transport, education, culture and health."[2]
OECD	"a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions ... designed to operate with varying levels of autonomy."[3]

A foundational definition that spans laws or organizations can refer to artificial intelligence as a human-developed or designed non-biological system with human-like cognition. Regardless of a preferred definition, no AI definition will likely be error-free.

AI ownership

In many organizations, AI strategy is the purview of senior leadership, such as the Chief Information Officer (CIO), Chief Technology Officer (CTO), and Chief Data Officer (CDO). Multiple departments can share the responsibility of AI governance in their respective functional areas based on their AI system and the problems it is attempting to solve. This ownership model ensures that AI solutions are well integrated within the organization and should include the involvement of the Chief Executive Officer (CEO) and/or the Chief Strategy Officer (CSO).



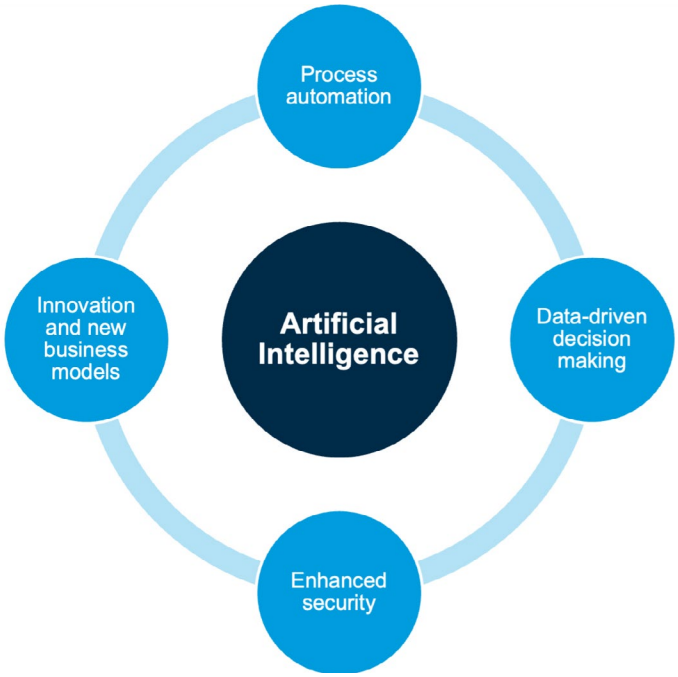
However, ownership of AI should reside with one organizational entity, a centralized AI hub. For example, an AI hub could reside with the IT department, data science team, or specialized AI team. In all cases, it is recommended that an enterprise architect review the required capabilities to maintain one or multiple AI systems to determine the best fit. A centralized model provides oversight on the tool and governance, ensuring its applicability in the organization and addressing the strategic needs of the electricity provider. In the centralized ownership model, data usage and analytics can be harmonized with content creation, while regulatory requirements are considered to ensure public safety and privacy.

Other models, such as decentralized or hybrid ones, can be incorporated into an electricity provider's operating environment. However, due to the regulatory framework under which electricity providers operate, the centralized ownership model currently provides the most structure and ease of implementation as AI is in its early stages of life within the industry.

Industry opportunities

Electricity providers have begun implementing AI and machine learning (ML) models to improve business and operational effectiveness and gain efficiencies in the mid- and long-term energy planning process within the power grid. Figure 1.0 highlights areas of opportunity where an investment in AI can provide value to the business and achieve positive business outcomes.

Figure 1: Artificial intelligence opportunities in the electricity industry



Future Benefits

- Economic growth
- Productivity gains
- Improved job quality
- Improved information distribution
- Improved forecasting based on better-decision making
- Accelerated scientific progress

Table 2: Descriptions of artificial intelligence

Opportunities	Description	Applicability functional areas
Process automation	Automation of routine tasks and processes can free up human resources for more strategic activities. Routine visual inspections using images from various sources, including drones, sensors, robotics, etc.	• Consumer engagement • Customer service • Field inspections
Data-driven decision making	Vast amounts of data and images can be analyzed quickly and accurately, uncovering previously hidden insights that are too complex for humans to discern.	• Energy market optimization • Enhanced grid management • Predictive maintenance • Vegetation management
Enhanced security	Cyber anomalies and potential threats can be detected faster than traditional methods.	• Cybersecurity

Innovation and new business models	Create new products and services. AI opens new avenues for previously unattainable innovation. Analyze historical usage data, weather patterns, consumer behavior, and smart device usage to improve energy demand prediction.	• Workforce transformation • Energy efficiency • Renewable energy integration • Energy load forecasting

Pilot programs

Several AI pilot programs across the industry have been implemented or are being assessed to demonstrate the transformative potential of AI capabilities within utility services.

Table 3: Pilot program examples

Function	Projects
Customer service	Implementing AI chatbots provides customer service agents with efficient search capabilities to enhance customer interactions.
Capital investment planning	AI can analyze load growth, distributed energy resource (DER) adoption trends, asset health and climate projections to rank infrastructure investment needs and project.
Asset management	Implementing ML algorithms to optimize asset life cycle and system operations to protect and enhance the reliability and efficiency of operations.
Market demand	Introducing an AI model in market demand and pricing forecasts enables proactive decision-making, optimizing resource allocation and market strategy. AI will have beneficial impacts on market demand through the analysis of weather data such as wind, solar and cloud coverage.
Outage detection and response	Natural language and computer vision processing may interpret calls, weather feeds, and sensor alerts to locate outages to facilitate and suggest dispatch actions.
Rate application assistant	Allows users to quickly search document archives for relevant information and data and ensures parity and consistency across past and future applications.
Personal assistant	Personal assistants, such as Microsoft M365 Copilot, are applications that may promote staff development by unlocking the value of business procedures.
Wildfire risk prediction and mitigation	Satellite imagery, vegetation data, weather forecasts and asset locations can be integrated into AI models to improve targeted vegetation management practices, reduce exposure and ultimately improve public safety.

Although AI pilot programs have proven to be technologically feasible, many organizations are still evaluating their potential to deliver timely and practical business value before proceeding with full-scale implementation. The introduction of AI solutions must weigh costs versus benefits. In general, AI professionals see immediate opportunities for all non-core business capabilities including planning, asset management, human resources, customer experience and more. To challenge the return on investment discussion, vendor solutions are introducing and integrating an expanding array of AI functionality into their products and services, leading to the ”Artificial Intelligence of Things”I or AIoT- the combination of artificial intelligence and ”Internet of Things “(IoT) infrastructure.

Internet of Things (IoT) was first coined by Kevin Ashton, a British technology pioneer. He envisioned a future of interconnected devices through the Internet in the late 1990's.

A critical success factor for AI adoption in use cases and applicability in the industry is data readiness.

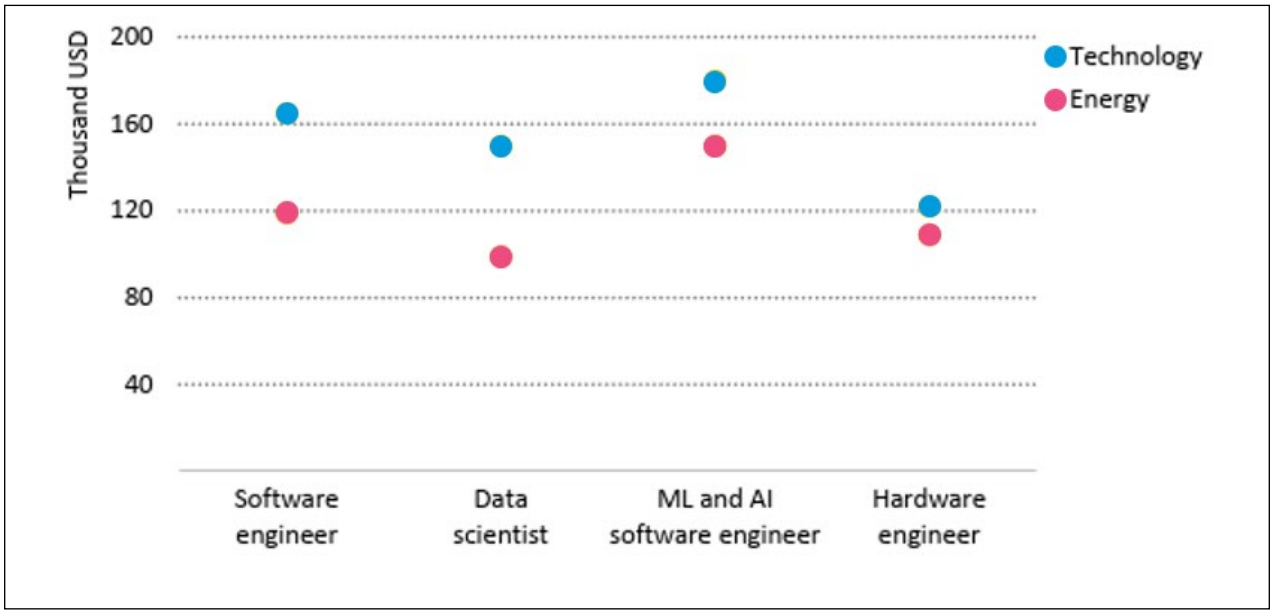
Data readiness can be defined as workforce data literacy, skillsets, available toolsets, standards, data infrastructure, data quality, data management policies, data governance and how aligned and mature your data is with your business practices.

Industry challenges

While the potential impacts of AI on the electricity industry in Canada are promising, there are several challenges.[4]:

1. **Data privacy and security:** As AI adoption increases, so does the need for strong data privacy and cybersecurity measures to safeguard sensitive information and critical infrastructure.
2. **Regulatory frameworks:** Canada must adapt its regulatory frameworks to accommodate the changes brought by artificial intelligence, ensuring fair competition and consumer protection.
3. **Infrastructure investment:** Deploying AI technologies may require significant infrastructure investments in hardware and software, which could pose financial challenges.
4. **Environmental concerns:** While AI can help reduce carbon emissions, the energy-intensive nature of AI training and computation raises questions about its environmental impact.
5. **Ethical considerations:** AI algorithms can sometimes perpetuate biases present in historical data. Ensuring fairness and ethical use of AI in the electricity industry is crucial.
6. **Data availability:** A significant amount of data is generated to develop foundational AI models. Data quality and data availability pose risks to developing AI model-generated solutions with incomplete information or gaps.
7. **Available capability:** To leverage AI, there must be a focused effort to enhance or upgrade the workforce's skillset. Several companies have identified a skills gap where employees must improve data literacy and technical proficiency to adopt and implement AI solutions.
8. **Workforce compensation:** In Figure 2, IEA highlights entry-level salaries for the energy sector, which are on average 30% higher in the technology sector. This creates a challenge in recruitment and retention efforts for electricity providers in Canada.

Figure 2: Median Entry level salaries in North America. Source IEA.



Three major themes underscore these challenges.

- **High costs versusrealized value:** The costs of developing, deploying, and maintaining AI systems often outweigh the realized business benefits. This gap is primarily due to a lack of precise alignment between AI initiatives and business goals.
- **Overhyped expectations:** AI hype often leads to unrealistic expectations among business leaders. Organizations can become disillusioned with the technology without clearly understanding its limitations.
- **Integration challenges:** Many businesses struggle with integrating AI technologies into their existing systems and processes. Legacy systems, data silos, user adoption (change management), skillset gaps and incompatible infrastructures make it difficult to achieve seamless integration, limiting the effectiveness of AI initiatives.

Recommendations for industry

To bridge the gap between AI investments, business outcomes, government laws, and regulatory requirements, electricity providers should consider the following recommendations:

Implementing an AI adoption governance framework

A governance framework should oversee AI policy compliance, adhere to regulatory and legal requirements, and maximize benefit realization. Additionally, the framework must support organizational change management, ensuring that AI initiatives are aligned with the organization's strategic objectives and ethical standards. Organizations can mitigate risks, enhance transparency, and foster trust in AI systems by establishing a robust governance framework.

Develop a clear AI strategy aligned with business goals

Utilities should start by defining a strategic vision for AI adoption that balances risk appetite, investments, and meaningful business outcomes. A well-defined technology roadmap that leverages industry-proven AI solutions will best enable the AI strategy. Aligning AI outcomes with company strategy will be a critical factor in the success of the AI integration. Electricity providers must build cross-functional teams of leaders to facilitate a conversation around use cases and where best to invest time and resources in AI implementation.

Invest in talent and skills development

To effectively leverage AI, utilities must invest in developing AI talent and upskilling their existing workforce. This investment will ensure the necessary skills are in place to manage and maintain AI systems to drive better results and ROI. Retained AI skills can also help facilitate the organizational and change management required in digital transformation programs. Employee data readiness and comfort with data will prove to be a critical success factor for AI adoption.

Focus on scalable and sustainable AI solutions

Utilities should focus on scalable and sustainable AI solutions that can be deployed across the organization, such as standardized ML and data input capabilities. This approach will enable businesses to realize economies of scale and maximize the impact of their AI investments. Each proposed scenario should be able to stand on its own merit concerning investment and business value.

Regulatory assist

To maintain a modern grid, regulators must acknowledge the need for highly sought-after skills and ensure the industry remains competitive with other sectors. This segment of the workforce must align with other industries to reduce turnover and create stability in a workforce that is highly sought after by different sectors. Regulators should evaluate compensation carefully to ensure long-term maintenance of smart grid applications.

Monitor and measure AI performance regularly

Utilities should establish objectives and key results (OKRs) to measure the impact of AI initiatives on business outcomes. Regular monitoring and evaluation will help identify areas for improvement and ensure that AI projects remain aligned with business objectives.

Establish an ecosystem

Utilities should build an ecosystem of trusted partners and preferred AI platforms. There are options to have several platforms vertically across different divisions in your organization and horizontally for citizen AI development and deployment across the organization, provided they adhere to your governance model.

Assess AI maturity

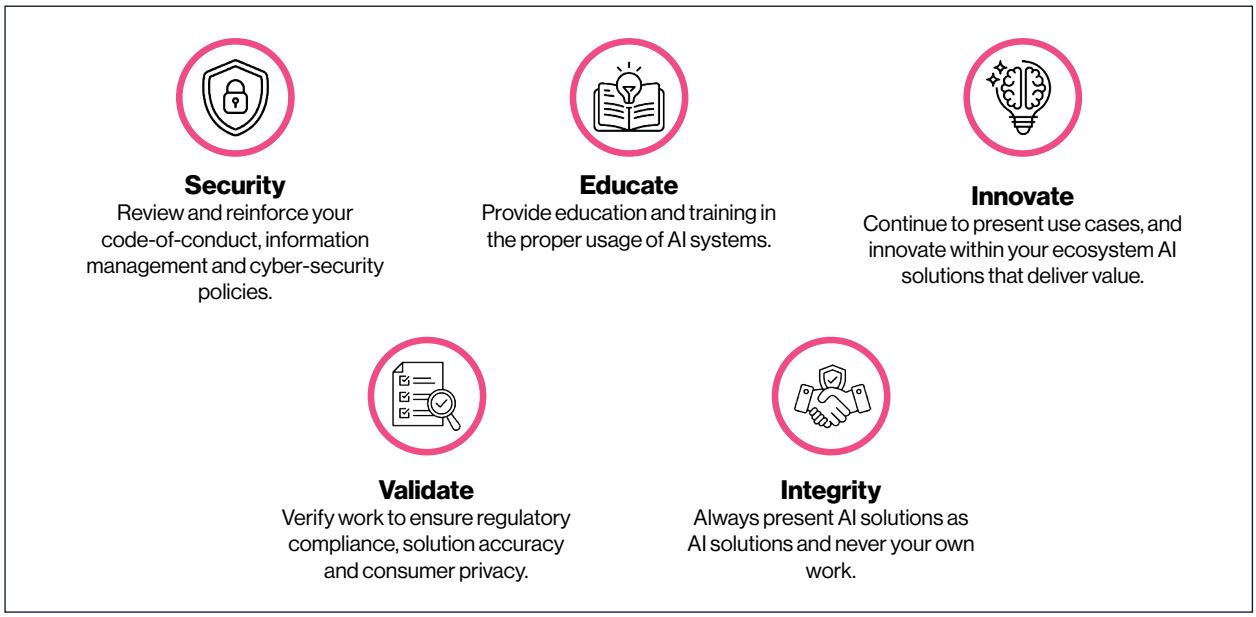
Consider using AI pilots around the most important use cases. Continually assess whether the organization is in an exploration, incorporation, proliferation, optimization, or transformation stage. Establish a periodic assessment cycle to continually determine maturity.

Apply recommended Guardrails

Electricity Canada's Technology Committee identified several guardrails for consideration during its2025 meetings. These guardrails can be built into company policies and procedures, applied at the governance layer, and/or built into AI systems. Along with the other recommendations, these guardrails will minimize risk and facilitate transparency and ethical application of AI models and technologies.

AI guardrails help meet ethical and regulatory requirements. When designed to address legal, safety, security, and privacy concerns, these guardrails help build trust with electricity consumers. To ensure responsible AI deployment, ethical standards should be embedded directly into enterprise platforms and integrated AI solutions.

Figure 3: Industry Guardrails



Making a smarter grid

AI's potential is demonstrated in a real-world deployment of AI-enhanced grid technology in China. In this case study, deep neural networks and AI applications improved operational efficiency by reducing energy waste (system losses) and enabling load adjustments through the analysis of vast amounts of data. This demonstrates that power grids can achieve enhanced load forecasting, optimize generation, and improve resource deployment. w

To achieve the realized benefits of this AI deployment, digital skillsets were required, IT/OT applications were analyzed, and smart meters served as the crucial catalyst for data collection, ultimately enabling the AI operations.

Regulatory implications

Artificial intelligence systems are discussed in government halls and big business. Governments aim to minimize the AI poses risks to their citizens, infrastructure, and national systems as adoption grows across their jurisdictions.The risks , challenges, and opportunities of artificial intelligence are being discussed worldwide, within individual governments or through collaborative organizations.

Various laws govern data protection, each reflecting agovernment's philosophies on data usage and protecting the individual rights of its citizens. For example, the European Union has established the General Data Protection Regulation, Singapore has established the Personal Data Protection Act, and Canada has the Personal Information Protection and Electronic Documents Act.

Penalties: AIDA offers two types of penalties for non-compliance. Monetary penalties and prosecution for true criminal offences.

Current and future legislation on AI regulations will use these acts as foundational documents to inform their respective AI legislation. In Canada, the proposed Artificial Intelligence and Data Act (AIDA) seeks to provide a legal overview of AI adoption. Once approved by Parliament, AIDA will serve as the cornerstone for consumer data protection and the use of consumer data in AI models. AIDA protects not only individual consumers' data but also their rights against discrimination, as set out in section 3 of the Canadian Human Rights Act, which AIDA describes as biased output.

Obligations under AIDA for high-impact systems

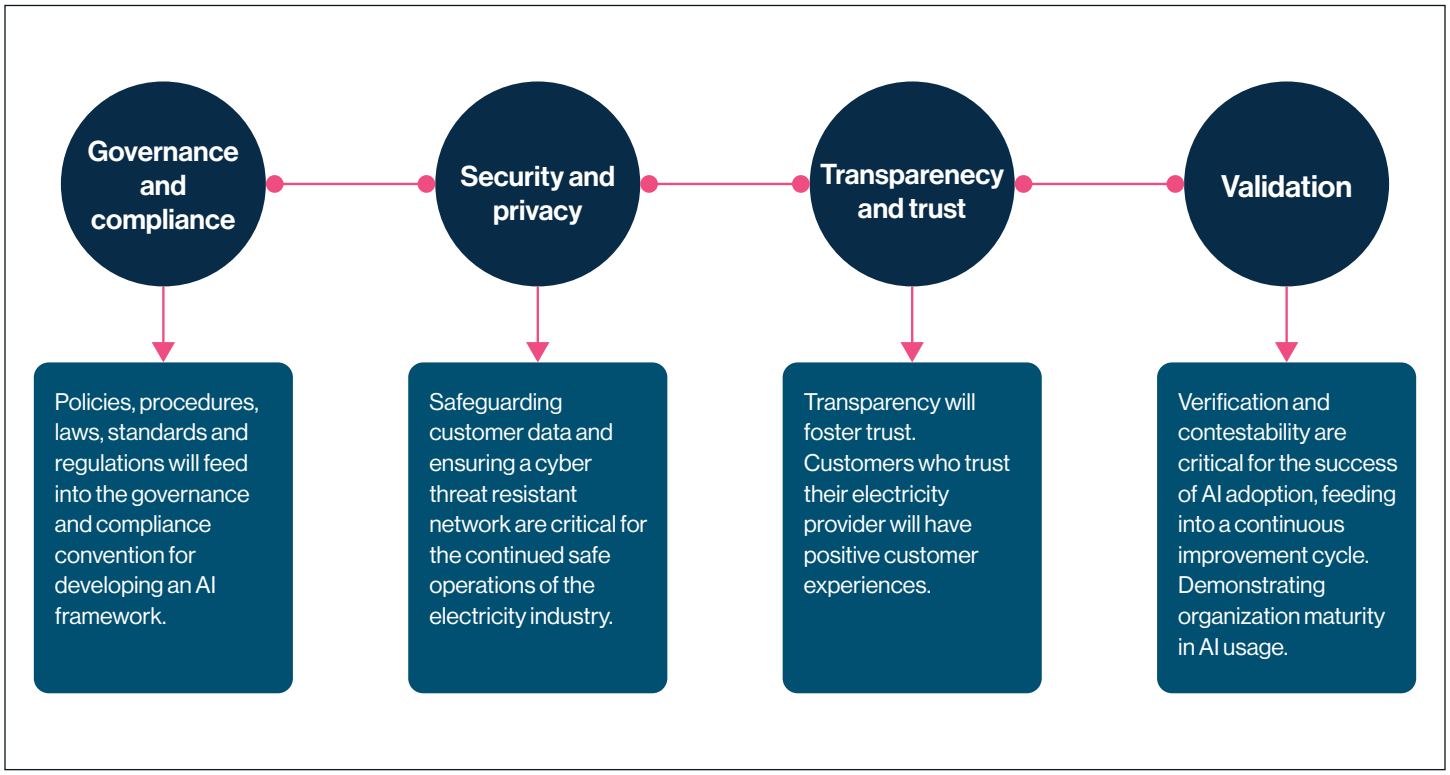
- **Transparency**
  Operators of AI systems that interact with the public must inform consumers that they are communicating with an AI system.
- **Mitigation measures**
  The operator of an AI system must maintain measures to mitigate any harm to consumers or society.
- **Demonstrate compliance**
  Maintain records of AI compliance and other information related to AI adoption.
- **Human oversight**
  Maintain the ability for a human to interact with and potentially terminate AI operations.
- **Maintain an accountability framework**
  The accountability framework must include a description of roles and responsibilities for those who contribute to the management of the AI system; policies and procedures respecting the use of the AI systems data and risks relating to the system; a description of the training personnel must receive about the AI system; anything that is prescribed by regulation; policies and procedures for AI staff to become aware of serious harm or identify mitigation measures that are not effective in mitigating risks.

High-impact system: an AI system of which at least one of the intended uses may reasonably be concluded to fall within a class of specific uses. (art. 5(1) AIDAI and Schedule 2 Bill C-27).

Proposed framework for regulating AI

Over the years, a common theme in adopting and developing an operating framework for AI systems has evolved in governments and industries. The keys to successful AI adoption are governance and compliance, security and data privacy, trust and transparency of the model and validation or contestability of the results.

Figure 4: AI framework



Court case involving artificial intelligence in Canada

A customer sought information on bereavement tickets on Air Canada's website. After finding nothing available on the site, he turned to Air Canada's chatbot, powered by OpenAI's ChatGPT. The customer filed his claim, but Air Canada refused, saying the AI chatbot was inaccurate. Air Canada argued it could not be liable for incorrect information provided by its agents, human or artificial. The court of law found the company liable, and the customer was able to recoup their expense.

Government call to action

Canada was the first country to create a national strategy for AI in 2017. With a $125 million effort led by three National AI institutes, Canada was poised to capitalize on AI opportunities. However, based on a 2021 report from the Organisation for Economic Co-operation and Development (OECD), Canada has been ranked 20th out of 25th countries in AI adoption. A recent study by IBM revealed that Canada is below the average global AI adoption rate. Table 4 identifies several areas where the federal and provincial governments can help the industry capitalize on AI's potential benefits.

Table 4: Government support

Support	Description
Funding	Encourage research and adoption of AI systems for managing a modern grid. AI adoption in demand load management, operations, security, reliability, renewables management, and more can facilitate grid modernization.
	Encourage and increase investment in Canadian AI solutions to remain competitive globally. Develop separate funding models that cater to research and another for commercial adoption.
	Support the development and adoption of AI governance tools in research. These tools will work within their applicable AI models and absorb the regulations and governance models within which they must operate.
	Encourage and support the application of Canadian AI solutions specific to the smart grid. Solutions that have a scalable impact on outage and load management. Solutions that impact system loss or energy waste.
Education and training	Support AI education across all industries with a focus on closing the skills gap. Provide opportunities for training and work with academia to develop and enhance programs that address adoption and integration into existing technologies.
Regulation	The government must improve its understanding of AI systems' data usage and outputs through their life cycle. This will ensure improved comprehension and reduce unnecessary regulations.
	Identify, recognize the usefulness of existing laws. Modify those laws to benefit the adoption process of AI models and algorithms without hindering or burdening business with added regulatory requirements.
Cooperation	Continue prioritizing international cooperation for ethical and trustworthy AI systems—form cooperative forums through international organizations such as the OECD on AI adoption and integration with critical infrastructure.
	Encourage national sharing of smart meter data across jurisdictions by creating a large national dataset to facilitate the development of smart grid AI solutions.
	The Canadian Centre for Cyber Security can continue to work with critical infrastructure in cybersecurity, however, with a renewed and strengthened focus on the applicability of AI solutions in managing essential elements of the grid.

Policy ask

As AI technologies expand across industries and the economy, the demand for skills to integrate AI models into existing systemswill significantly increase. Skills in machine learning, visual image recognition, and naturallanguage processing are particularly important. Governments must collaborate with academia and industry to promote research in artificial intelligence and support the adoption of AI technologies across sectors. Either through increased funding for training and educational programs, or by identifying and removing regulatory policies that hinder the adoption of AI tools in business. Forty-six percent of C-suite executives support the idea of AI education and training, as they recognized this skills gap in a 2024 McKinsey survey.

Tools to AI enable adoption in the electricity industry

- Provide grants for AI adoption through research, development and innovation.
- Create public awareness campaigns.
- Increase information services and access to large data sets.
- Promote the creation of industry-specific tools.

NRCAN case study

In 2024, NRCAN created a joint funding model that partners with the government, vendors, and electricity providers to develop AI-managed dynamic line rating solutions. This type of funding model exemplifies the necessary kind of funding and cooperation to develop innovative solutions that will efficiently manage the grid and provide sound operational practices that strengthen our national grid.

European Union - Overview

The European Union has classified AI systems that manage essential services and critical infrastructure, such as the provision of electricity, as high-risk. These systems may pose a significant risk to the health and safety of a given population. These systems or system owners must comply with minimum requirements and standards, establishing trustworthy AI systems throughout their life cycle. These guidelines must be in place before the AI system becomes active in any European Market.[5]

Conclusion

Artificial intelligence represents a transformative force in Canada's electricity industry. Its potential impacts range from enhancing grid management and integrating renewable energy sources, to improving energy efficiency and reducing carbon emissions. However, the successful implementation of AI also requires addressing challenges related to data privacy, regulation, infrastructure, talent, and ethics.

Canada, with its commitment to sustainable energy and technological innovation, is well-positioned to harness the benefits of AI. As AI continues to evolve, it has the potential to reshape the electricity industry, making it more resilient, efficient, and environmentally friendly for generations to come.

The promise of AI in driving business growth and transformation is undeniable and is increasingly achievable with thought leadership. To unlock AI's full potential, utilities must align their AI initiatives with strategic business outcomes. This requires a clear understanding of AI's opportunities, a realistic assessment of current industry trends, and a commitment to building the necessary infrastructure, skills, governance frameworks and guardrails.

By considering the recommendations outlined in this document, organizations and governments can bridge the gap between AI investments and business value, while safeguarding all stakeholders to ensure AI becomes a strategic enabler of success in the digital age.

Endnotes

1 IEEE-USA Position Statement. (February 2017). “Artificial Intelligence Research, Development and Regulation,”

2 ISED. (2022). Learning Together for Responsible Artificial Intelligence. Government of Canada.

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5 European Union. EU Artificial Intelligence Act. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1689

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