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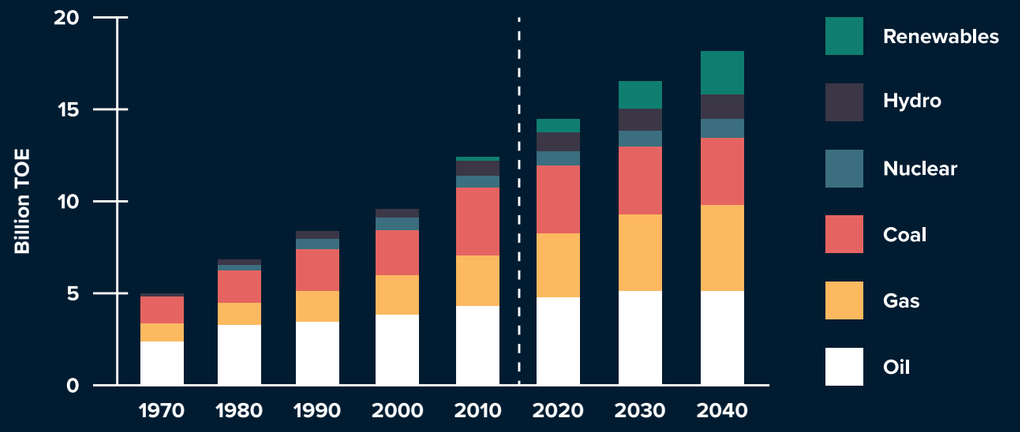
Alberta within the global energy transition

The global energy ecosystem is transitioning to a lower carbon future in an effort to battle climate change that presents a variety of opportunities and challenges for Alberta's traditional energy producers and suppliers, and its communities.

The opportunity lies in a world hungry for energy. Almost all long-term outlooks predict demand for all types of energy is expected to increase as global population grows and the population of developing countries move up the economic ladder and attain first world lifestyles.

Global energy demand is rising

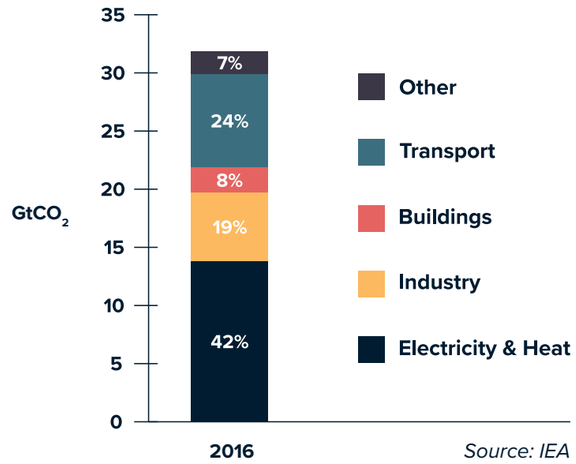


Source: IEA

The challenge facing Alberta is delivering this energy competitively in a carbon-constrained world. Not only must the province be a low-cost producer, it must also be a low carbon emissions producer if it wants to win its share of the future.

Additionally, the global effort to battle climate change also creates new opportunities in power generation and transmission markets as long-term energy outlooks predict more and more energy will be consumed as electricity. This presents opportunities throughout the power generation and transmission supply chain, as well as in the transportation, industrial, commercial and residential energy consumption, where the majority of greenhouse gases are produced.

Emissions from energy consumption



Source: IEA

Helping Alberta seize the opportunity

The Energy Futures Lab (EFL) is a collaborative platform that enables Albertans to work together and advance initiatives that leverage the province's energy knowledge and assets to realize "the energy system the future requires of us".

Through its work, artificial intelligence (AI) and machine learning technologies emerged as an important pathway that can in help Alberta seize the opportunities presented by the emerging transition through increased productivity and process improvements, distributed smart grids, smart cities and homes, as well as other applications.

With the support of the RBC Foundation, Spartan Controls, SAIT, and JWN Energy, the EFL hosted its Energy.AI workshop in Calgary in September to explore the question of, "How can artificial intelligence enable Alberta to thrive in a competitive, low carbon future?" The one-day event featured thought leaders and bridged innovators with a foot in both the AI and energy worlds, as well as innovative applications of AI currently under way. The sixty attendees at the event, coming from all areas of Alberta's energy ecosystem, were challenged to surface opportunities to leverage AI, surface barriers to implementing AI, and to crowd source ideas on how to build capacity to optimize the results of using AI in the energy sectors.

The workshop featured a combination of case study presentations and then group working sessions to draw out views from its participants. The attendees were separated into two streams in the afternoon to drill down into potential AI applications in smart oil and gas and smart grids and smart homes. This report summarizes the discussions and insights generated from the workshop.

It is clear that there is a need and desire from both energy and AI innovators to better bridge their two worlds, and that the EFL can be a platform to play this bridging role, and build a community to further take action.

The consensus coming out of the workshop is that AI holds great promise in positioning the province to prosper in the competitive, low carbon energy ecosystem of the future, but to get there is going to require changes in business culture, government policy, a significant investment in research and development to prove out technologies, and a major investment in workforce training. And it will require leadership throughout the energy supply chain.

Basic Forms of AI

Assisted	AI that improves what your business is already doing.
Augmented	AI that enables your business to do things it couldn't otherwise do.
Autonomous	AI that acts on its own, choosing its actions on behalf of your business goals.

Source: University of California, Berkely

What is the Energy Futures Lab?

The Energy Futures Lab is a platform for innovators and influencers in Alberta's energy system to work together to explore, experiment and take action on the following question: How can we leverage our leadership position in today's energy system to create the energy system that the future requires of us?

The EFL anticipates that by 2050 the world has made major advances in transitioning to a sustainable global energy system, where production and consumption aligns with the scientific principles of sustainability.

In the EFL's vision, Albertans are thriving in this future because we produce and use energy in a way that the future requires of us, mean that we are:

- Home to the world's most innovative, entrepreneurial and responsible energy citizens
- Net carbon-neutral for electricity, heat, mobility and industrial processes
- The world's leading source of energy technology, products, know-how, and future-fit hydrocarbons
- A leader in energy-based partnership toward reconciliation with Indigenous peoples in Canada

The EFL is working to create this future in the spirit of experimentation and learning through activities that:

- Support innovators in identifying, developing and pressure-testing solutions for accelerating the transition to the energy system the future requires of us;
- Strengthen the capacity of business and government to adopt and support innovative solutions;
- Align a growing community of leaders and their organizations behind a bold and transformative vision for the future of energy in Canada and the possible transition pathways to achieve it;
- Inspire and share narratives in the public and communities that help depolarize the public conversation about energy in Canada and accelerate progress toward the shared vision developed through the EFL.

AI, Energy and Climate: Opportunities and Barriers

AI, once in the realm of science fiction, is now commonplace in the consumer world. People use AI almost every day when they interact with their computer screens, often without even knowing it.

One example of AI at work is the Google Maps drive-time traffic predictions. Google feeds anonymous location data from smart phones through its proprietary algorithms to predict the speed traffic is moving at any given time or location. It also incorporates any user reported data like accidents or road construction to suggest the fastest routes to and from work.

AI is now moving from the consumer market into the industrial market. The Energy AI workshop opened with presentations from experts who work in both AI and energy. They shared their thoughts on opportunities and barriers to applying AI to address climate change and competitiveness challenges in the energy space. Participants added to these insights, with the results summarized below.

What is making AI possible in industrial settings is the installation of high quality sensors on machinery and equipment, improved data storage and transmission through wireless networks and cloud storage, the automation of repetitive processes, and better modeling software, said one workshop presenter.

Another presenter pointed out that AI technology is rapidly advancing, making it more useful to industry. AI based on fixed algorithms—the "if this, then do that" sequence—is giving way to evolutionary algorithms that give computers guidelines and then let it find the best solution. This is enabling AI to be used on more complex problems.

"AI is the next industrial revolution—it's easy to see where it fits on predictable work. It's the unpredictable work that is hard to become actionable but we are now seeing the unpredictable stuff—intelligent robots," said another presenter.

Unfortunately, Canada and Alberta are behind in the implementation of AI and machine learning technologies to industrial processes compared to other developed countries, ranking last in the top 10 economies in the world, according to one presenter.

The workshop presenters see broad opportunities to implement AI in the Alberta economy to make it more efficient and help meet the province meet its climate goals. These included:

- Doing away with more mundane tasks by using AI tools to automate predictable physical work. One presenter noted up to 78 per cent of repetitive tasks could be automated using AI by 2030
- Using AI tools to automate unpredictable physical work. Up to 25 per cent of these tasks could be automated by 2030 through the use of evolutionary algorithms
- Using software powered by AI to improve forecasting and decision-making. With the help of advanced sensors and software powered by AI, companies can digest a large amount of data and output real-time responses on the best course of action
- Applying AI to the province's developed industry has major potential. Intelligent robotics is an area identified as large potential in Alberta because of leveraging large-scale industrial enterprises

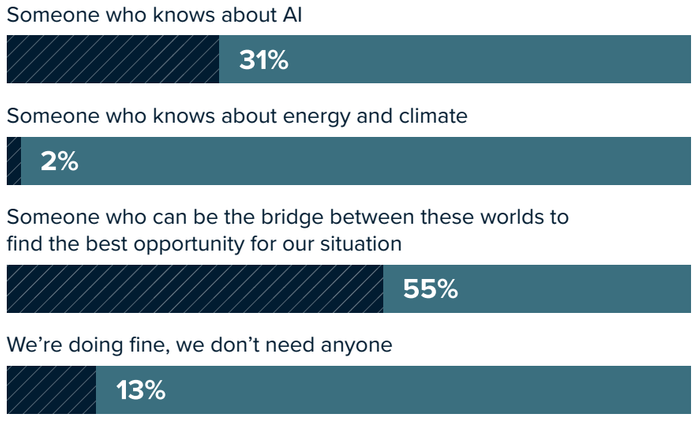
The workshop presenters also saw a number of barriers to integrating AI technology into the Alberta market. These included:

- A lack of understanding concerning AI technology amongst policymakers in government. AI is somewhat nebulous term within government, said one presenter. There is a role in broadening the understanding in how turn data into AI and in building awareness at the policy level
- No strong leadership at the top levels of corporations. Most companies don't have a chief technology officer to bridge the gap between operations and IT
- Fears about implementing technology
- A skills mismatch—need to bring on proper data scientists. Alberta has lots of experts in their particular fields but there is a need for expertise in data science
- Fears about job losses. One presenter estimated around 25 per cent of Alberta jobs could be affected by AI by 2030

To seize the opportunities presented by AI, the workshop participants suggested the following items to create an environment conducive to implementing new technologies:

- It is important to partner with others and align around solving specific problems
- Get people together and develop an alignment around industry problems
- There is a need to demonstrate value, whether it is efficiency, emissions reductions, or both
- Open data practices and data flow are key for research projects. Need a system to manage data between governments, industry data holders, and entrepreneurs
- Need to create a culture of pushing each other
- Focus on solving similar problems that stretch across multiple domains
- Develop systems that leverage collective knowledge
- Recognize competition is global, not just with competing enterprises
- Develop policies to maintain expertise here and create vibrant clean tech industry in AB plus in the energy sector

Attendees said their organizations needed people with expertise in AI and skills in bridging the AI and energy and climate worlds



> **"If we can automate actions and decisions we will get greatest opportunities."**

AI in Upstream Energy

Artificial intelligence is working right now in oil and gas operations around the world to drive predictive maintenance programs, automated production optimization, automated drilling optimization and robo-fracking, said one presenter.

And it's producing results. Energy giant BP is using AI on its natural gas operations in the US. So far, it has reduced gas venting by 74 per cent, increased production by 20 per cent, and cuts costs by 22 per cent.

BP's competitor Shell is also heavily invested in AI, partnering with Microsoft on a global predictive maintenance initiative.

In Canada EVOK Innovations, an investment partnership between Cenvous, Suncor, and the BC Cleantech CEO Alliance to fund targeting innovative companies with solutions to the energy industry's economic and environmental challenges, reports around one-third of its investments are targeting digital technologies.

But the workshop presenters say Alberta is behind the U.S. and other countries in implementing AI in its operations. It needs to move forward quickly to "disrupt the U.S." if it hopes to be competitive in the emerging energy transition to lower carbon energy sources.

The attendees reported one key reason Alberta trails the U.S. in AI implementation is the nature of its resource endowment. Alberta's oilsands are a long-life, low decline resource with high upfront capital costs so once operations are under way; operators tend to make few changes. In U.S. shale plays annual average decline rates are as high as 70 per cent, resulting in continuous capital investment to maintain production. As a result U.S. operators can make changes more quickly.

Climate Leadership in Upstream Energy: Opportunities and Barriers

In addition to AI providing economic benefits, it can also contribute to Alberta's climate leadership aspiration and goals, as laid out in the Climate Leadership Plan (CLP). Among the challenges are growing oil sands production while staying under the 100-megatonne emissions cap, and cutting methane emissions by 45 per cent by 2025. The attendees said they see the following opportunities to help Alberta meet its climate goals:

- The CLP has ambitious targets and carbon pricing. They saw a role for AI in looking at prices and forecasting
- They also saw a role for AI in reducing both carbon dioxide and methane emissions through improved operational efficiencies

Industry representatives at the workshop reported more specific opportunities in implementing AI in its operations. These include:

- Production optimization: this is compelling because it allows waste reduction
- Predictive maintenance: this will help reduce inefficiency due to maintenance driven downtime/ losses
- Autonomous processes: e.g. oil wells that run themselves
- Reduction in the need for human intervention/ presence: reduces GHG associated with travel to remote sites.
- Any case where data is being generated in a manner that makes it unmanageable conventionally, could make a case for AI and represent natural low-lying fruit
- AI could be effective in large, complex processes. Often in complex processes like the oil sands or petrochemical facilities small but significant gains can be hidden in the process and artificial intelligence might be able to extract the signal from the noise
- AI could provide the ability to control production capacity based on trends forecasting. It is not a stretch to link gas production rates, market price forecasts, said one attendee
- Today big organization operate in data silos and what we are doing with a new initiative in my company is to break the data silos and use AI to share the production data with the Gas traders. Using predictive operation

However, the workshop attendees saw numerous barriers to implementing AI including the Alberta business culture, economic challenges due to current low commodity prices, and technical hurdles surrounding data acquisition and sharing.

The Alberta business culture was seen as a major barrier to AI implementation. The attendees expressed a number of concerns, including:

- In Alberta there is no competition on commodity end, all competition at the tech end, meaning companies will not share knowledge with each other
- There's a challenge getting people on board at the executive level. Large companies have risk aversion. Everything goes through a couple of lawyers
- There is no mechanism or incentive for Canadian producers to share the well-site data. There needs to be a culture of sharing.
- We need the government to come in ask the producers to work together to share the well- data.
- One challenge is quarter-to-quarter thinking. Longer term projects like AI is a harder sell
- The separation of operations technologies and information technologies was seen as a major barrier to AI

The attendees also said the current economic environment, with low commodity prices and challenging capital markets, also make implementing AI difficult. Among the economic concerns:

- Every company is focused on operational efficiency, and they are looking for technologies that make them more efficient today, not tomorrow
- The focus on operational efficiency means companies are looking at what's worked well for them the last few years, and focusing on doing that but doing it cheaper
- Companies are risk adverse to adoption of AI given the current market environment - lack of market access and product price differential
- Attendees reported challenges implementing AI with employees. Some reported challenges just getting employees use digital technologies in the field despite training efforts

There was a general consensus among the workshop attendees that issues surrounding data collection and management were the key barriers keeping Alberta's upstream energy industry from implementing AI technologies on a wider scale. Some of the key issues identified were:

- Brownfield projects exist in old school, legacy ways. Companies don't put money into the old projects because it is not cost effective.
- Adapting legacy wells is very expensive. Technology much more relevant for new builds
- The integration of existing systems and new systems is a constraint using AI.
- Companies need massive amounts of data to power AI and that often isn't available
- Sharing data between companies is virtually impossible. There is no mechanism or incentive for Canadian producers to share the well-site data.
- In the energy industry, it is very hard to convince the company to store the data on cloud servers for data analytics and data mining.
- There is a resource shortage in data science; attracting local people to this relatively new area
- There is an aversion to collecting more data just for the sake of collecting more data. Many companies aren't even using the data they are collecting now
- Quality of data big issue—if you look at total effort to make AI work 30 to 40 per cent of time spent working on data quality—data cleansing, identifying anomalies, ongoing support
- Need cross-functional teams between IT and OT—huge barrier and huge opportunity

The workshop attendees identified some specific barriers to getting new AI technologies from concept through the piloting stage and onward to commercialization. Among their concerns:

- Access to equipment and wells to test new AI technology is difficult to get
- Access to data is hard to get as risk groups within companies only see the downside to sharing data

> *"Apply AI—measure, learn, act. Examine historical data, new data, learn from models powered by AI, apply it, and learn from that. You can get great results but need a magical formula"*

Recommendations & Advice

The workshop attendees saw a number of ways to move AI forward in the upstream energy industry, with the key being changing how senior leaders perceive the costs and benefits of implementing AI. Among the suggestions:

- If management can be technology agnostic, the value proposition can become apparent
- Transformational changes can be difficult for management compared to efficiency, but that is where a lot of the gains are
- AI has potential to change purpose and provide effective gains, not just efficiency gain and that value needs to be recognized by leaders
- Building an automation team requires engagement, as [AI] talent is looking for engagement or they will seek opportunities outside of energy space
- Adoption through change management will create a positive feedback loop if it removes repetitive tasks and if freed up employees are re-tasked to higher and higher value activities (we are going to see turnover).
- Need to be careful on pushing solutions rather than demand driven need for value by client
- Sometimes privacy, data sensitivity can hinder outsourcing even if the economical and practical solution

AI in Consumer Energy Consumption

With 80 per cent of greenhouse gas emissions coming from energy consumption, a number of workshop attendees identified the electricity generation and consumer end-use energy markets as a major opportunity for AI and machine learning to have a large impact on emissions in Alberta and globally. One attendee suggested lessening emissions reduction demands on the production sector and transferring those expectations onto energy users would better serve the province.

Attendees said the power and electricity market should focus on decarbonizing, decentralizing, and digitizing, and that AI could play a role in making this happen.

In the consumer end-use market the attendees saw opportunities for AI in the transportation and commercial and residential areas.

> *"At the end of the day AI is primarily about decision making—AI is like a superpower"*

Opportunities and Barriers in Electricity Generation

Alberta's power and electricity markets are undergoing major change as a result of the province's Climate Leadership Plan. Coal-fired generation is being phased out, and a plan to push renewable generation to 30 per cent of total provincial generation is in place.

The workshop attendees saw a number of opportunities for AI to play a role in optimizing the changing power market and making it function more efficiently. These included:

- Integrating distributed renewable energy sources into the grid
- Predicting power demand and matching supply with demand
- Fault diagnosis and fault triangulation, with one attendee saying if we could predict when things go wrong it would be really beneficial
- Software optimization for smart grid, ability to distribute generation, and manage electrical storage behind the fence with blockchain technology

While the group saw opportunities to leverage AI in the power and electricity market, it also saw major barriers to implementation, including regulatory roadblocks, market concentration issues, technological gaps, and socio-economic issues.

- Many attendees said Alberta's electricity markets are over-regulated and that with more regulation less innovation will occur. One example was the need to get approval from utilities to put in solar power.
- There was also concern the current over-supply of power and resulting low prices were discouraging innovations like AI
- Market concentration in generation, transmission and distribution makes it challenging for new entrants and limits the number of potential customers for AI
- The existing infrastructure built up the province is seen as a barrier to bring new distributed power generation that would benefit from AI on stream
- Cost was also seen as a barrier to bringing on distributed power sources that could be integrated into the grid using AI
- A lack of energy storage using batteries or pumps was seen as a key barrier. Once available, they will create AI opportunities

Opportunities and Barriers in Transportation and Energy Efficiency

Improving energy efficiency in end-use consumption including the transportation, and commercial and residential electricity and power markets was seen as a more challenging opportunity for AI by the attendees. A number of opportunities were identified by both presenters and attendees, including using AI in autonomous electric vehicles (EVs) used in mass transit to improve efficiency and cut emissions, using AI for transit planning, and using AI to identify and capture energy efficiency opportunities in the built environment.

In transportation, the attendees identified the following opportunities:

- The use of autonomous electric vehicles to cut emissions
- Transit modeling and route optimization using AI
- Diagnostic and preventative maintenance opportunities on trains and buses
- AI can help with ridership issues with forecasting, projecting, operational efficiencies and route tuning

However, there were significant barriers to seeing AI introduced in the transportation sector, including:

- The technology for autonomous electric vehicles that could benefit from AI is not yet ready for commercialization. Autonomous driverless vehicles right now only work in geo-fenced areas and need to progress before widespread usage. Battery technology also needs to advance before electric transit vehicles are ready for widespread use.
- High costs will make the transition to autonomous electric vehicles difficult. With current technology, electric buses cost twice of what a diesel bus costs, and it requires two electric buses to do the work of one diesel bus.
- Major greenhouse gas reductions from transportation would require a shift to mass transit, and many said the public is simply not ready for that

The workshop attendees saw the major opportunity in using AI in the commercial and residential energy end-use market to help identify energy waste and to help educate the public to make better energy choices.

A workshop presenter pointed out that the world wastes more energy than it uses every year across the whole energy spectrum. He added that in North America utilities spend around $9 billion annually on energy efficiency programs. One challenge facing these utilities in improving energy efficiency is the lack of an instant feedback loop that shows the impact of energy efficiency programs on costs.

The attendees pointed to a number of potential uses for AI to improve operational efficiency and cut greenhouse gas emissions in the building sector, largely through educating the consumer:

- The use of AI to identify the performance of individual buildings compared to surrounding buildings would provide an instant feedback loop
- The use of AI would show the implications of the technology buildings are using and see how it affects their energy usage
- Making GHG emission relevant to people and making them understand what it means for them. If we could personalize and make it relevant to their personal life especially if you are showing how your house is using energy compared to your neighbour. If we could show how the consumer is relative to the community, how efficient is your usage compared to your neighbourhood, your city. The only way we are going to come up with this rating is using machine-learning algorithms.

The workshop attendees didn't report any unique barriers to the use of AI to improve energy efficiency in buildings and to drive public sentiment on cutting greenhouse gas emissions.

Next Steps

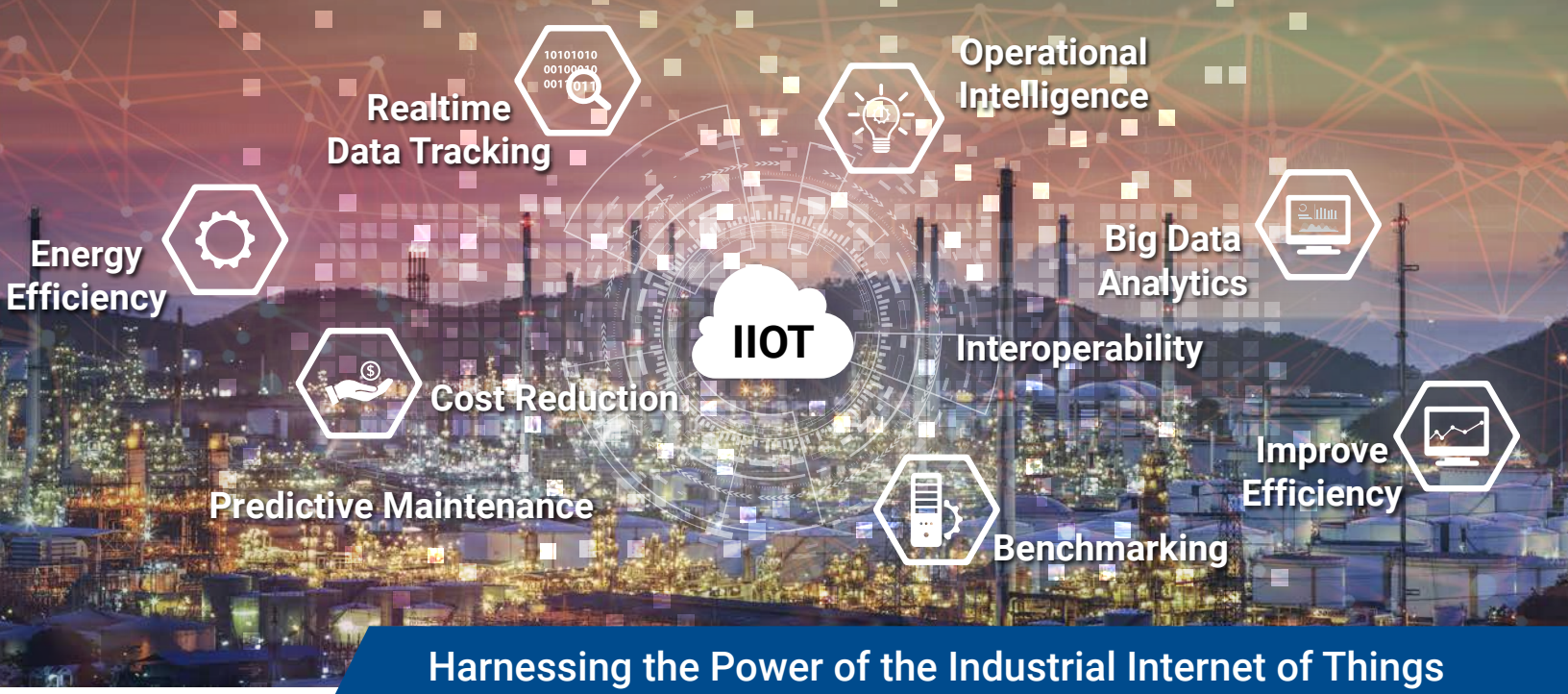
The Energy.AI workshop is a starting point to more deeply leverage AI technology to help Alberta align itself with the competitive low carbon energy ecosystem of the future. There was excitement at the potential for AI to help industry mitigate climate change and a strong desire of participants to harness the potential of this community. When polled, workshop participants on what they believe should be the next steps in continuing the conversation in hopes of leading to some concrete actions to leverage AI's potential.

Here are some of the key recommendations from the workshop attendees:

- Have a workshop walk through of a single case study
- Host companies at post-secondary institutions to bring their problems and have students / faculty propose solutions to seed projects
- Facilitate communication between the entities to share ideas, implementations and experiences
- Form subgroups with specific focuses coming from today's discussions
- Facilitate communication between the entities to share ideas, implementations and experiences
- Share actual success and failure stories from Alberta
- Create opportunity to post and then host open space discussion
- Review resulting report and pursue ideas impacting my company
- Create ideas workshops and then networking to make these things happen
- Develop a social media forum
- Encourage ongoing cross discipline collaboration

Attendees List

- AdamasDTS
- Aimsio
- Alberta Economic Development & Trade
- Alberta Energy
- Alberta Energy Regulator
- Alberta Innovates - Clean Energy
- AltaLink
- AltaML Inc.
- ATB Financial
- ATCO
- Bluwave-AI
- Calgary Economic Development
- Calgary Technologies Inc.
- Calgary Transit
- Canadian Natural Resources Limited
- Canadian Urban Transit Research and Innovation Consortium (CUTRIC)
- Cap-Op Energy
- Capital Power Corporation
- Cenovus Energy
- City of Calgary
- Common Ground Energy
- ConocoPhillips Canada
- DNV GL
- Drew Gillson
- Eclipse Sustainability Projects/Green Metrics
- EdgeMark Capital and Advisory Services Inc.
- Energy Futures Lab
- EQUS REA
- FAi
- Future Energy Systems, University of Alberta
- Government of Alberta
- Haskayne School of Buiness
- Hifi Engineering
- Imaginea AI
- InnoTech Alberta
- International Institute for Sustainable Development
- JWN ENERGY
- MadCann Alberta Inc.
- Microsoft
- MyHEAT Inc.
- Natural Resources Canada
- North West Refining
- NRStor
- Ntwist inc
- PTAC
- Pure Enertech Solutions Inc
- RBC
- Schulich School of Engineering
- Shell Canada
- Southern Alberta Institute of Technology (SAIT)
- Spartan Controls Ltd.
- Stantec
- Sub Rosa Monitoring LLC
- Suncor Energy Inc.
- The Delphi Group
- The Natural Step Canada
- Tocaitl Cryogenics Inc.
- TransAlta
- University of Alberta
- Veerum
- VizworX Inc.
- Young Women in Energy
- Zone Startups
- 2095871 Alberta Inc.



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