Transportation in a Low Carbon Future

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EIA EDMONTON INTERNATIONAL AIRPORT

Introduction

Greenhouse gas emissions from transportation account for 15 percent of total global emissions (24% in Canada), making decarbonizing the transportation sector a key focus in the effort to meet the world's climate goals.

This shift to a low carbon transportation future could have major negative impacts on Alberta's hydrocarbon-driven economy, as changes in transportation technology lessen demand for oil and other hydrocarbons. To manage this risk, Alberta needs to identify new opportunities in this low carbon mobility future and develop technologies and markets to seize those opportunities.

The transition to low carbon transportation will also have significant effects on how people and goods move within Alberta, specifically on the infrastructure needed to transition to less carbon intensive transportation systems. Transportation accounts for around 23 percent of climate change causing emissions in Alberta, adding to the challenge of reducing emissions.

In late November, the Energy Futures Lab (EFL), in collaboration with Alberta Energy, held a one-day Accelerator workshop sponsored by the Edmonton International Airport with the purpose of convening relevant collaborators and partners to identify opportunities presented by a low-carbon mobility future, and to help Alberta overcome the challenges to seizing those opportunities. The objectives of the Accelerator were to:

- Gain insight into the latest economic, policy and social trends on low carbon transportation;
- Identify points of relevance to Alberta and the implications of these trends to the province;
- Generate enhanced understanding of demand for low carbon transportation technologies and the feasibility of transport-related technologies as opportunity areas for Alberta;
- Help accelerate initiatives in four key transport-related sectors that can help Alberta thrive in a low-carbon future. These sectors are: biofuel, lithium, hydrogen production, and smart mobility technologies that lead to energy efficiencies or decarbonization in the transportation sector.

The EFL Accelerator on Transportation in a Low Carbon Future consisted of presentations by Alberta Energy's CoLab team, who provided insights into leading edge and future-oriented research in low carbon transport along with their implications for Alberta. The Accelerator also crowd sourced ideas from participants on meeting the challenges of developing biofuels, lithium, and hydrogen industries within Alberta, along with implementing smart mobility technologies. The hydrogen portion of the EFL Accelerator was developed and presented in partnership with the Canadian Energy Systems Analysis Research (CESAR) initiative at the University of Calgary (www.cesarnet.ca).

Why Low Carbon Transportation?

The morning of the workshop focused on Alberta Energy's CoLab team sharing trends for low carbon transport and engaged participants in a discussion to think through the implications for Alberta.

Trends in Low Carbon Transportation

The adoption of low carbon transportation technologies is being driven by jurisdictional commitments of governments around the world to meet climate change goals, said one expert presenter. Around 64 jurisdictions around the world have targets or plans to electrify either part or all of their transportation fleets.

Governments further ahead in creating regulations to manage emissions from transportation are providing models for other jurisdictions to use, speeding up the process, the expert added. For example, California has set a target of 10 percent of vehicles being zero-emission vehicles or ZEVs by 2020.

In addition to electrifying transportation system, clean fuel standards are being established that set requirements on lifecycle carbon intensities for fuels used in transportation, industry and buildings.

Improved technologies including electric light vehicles, fuel cell and hydrogen powered buses and trucks, and biofuel for both ground and air transport are driving the effort to lessen the transportation impact on climate change. Internal combustion vehicles are also becoming more efficient, lessening demand for gasoline.

Smart city plans that use data and technology to create more efficient and sustainable transportation infrastructure are also taking shape globally.

Changing public attitudes concerning issues like car ownership and the use of public transportation are speeding the adoption of low carbon mobility technologies as well, the expert added.

Workshop attendees also pointed to a number of additional global trends driving the shift to low carbon mobility, and issues surrounding the shift, including:

- China is the single largest buyer of vehicles in the world and is driving the push to electric vehicles. However, the Chinese push to electrify transportation is driven more by air pollution concerns than climate change
- Government subsidies have encouraged the adoption of ZEVs, and without subsidies it will take much longer to change the fleet over from internal combustion vehicles
- There are two main types of ZEVs: Plug-in electric vehicles (PEVs) that draw their energy from the electrical grid and store it in batteries, and hydrogen fuel cell electric (HFCEV) vehicles that generate the electricity using fuel cells on board the vehicles with hydrogen as a fuel.
- ZEVs are not suitable for all climates and will likely be adopted only in places where they make sense. In colder climates like Canada there will be a greater challenge in switching over to electric vehicles.
- Clean fuel standards may drive change to low carbon transportation and give rise to new sectors and value chains for transportation, such as biomass, waste, and natural gas conversion technologies.
- Electricity is a carrier of energy not a fuel, so decarbonizing the power generation system will need to happen along with the turnover to ZEVs. This will also require subsidies.
- HFCEVs may be more useful for heavy-duty and longer distance transportation since they have an on-board fuel (hydrogen) and therefore can go further between refueling/ recharging. Experiments are happening worldwide.
- Autonomous vehicles will have a major effect on low-carbon transportation. An autonomous truck could address challenges faced by the freight sector in recruiting drivers, and increase in the utilization rate of freight vehicles. In the case of personal mobility, one autonomous shared vehicle could replace 6-8 personal vehicles. The autonomous shared model will be a cultural change but ridesharing was adapted very quickly so it appears possible.
- There are some reservations regarding biofuels, including the effects on ecosystem carbon stocks, life cycle emissions, in terms of greenhouse gas emissions, water and nutrient cycles plus possible impacts on food production.

Implications for Alberta

On Alberta's Oil and Gas Sector

Using data from over 100 sources, the Alberta Energy's CoLab team came up with three scenarios for how quickly the transition to low carbon transportation will impact the province's oil sector:

- Current Outlook: Traditional Transportation fuels (gasoline, diesel, jet fuel) will be displaced in key Alberta markets relatively slowly up to 2040, with minimal impact on demand for Alberta's crude oil.
- Anticipated Disruption: Biofuels and electrification of transportation will accelerate rapidly in key Alberta markets in the late 2020s, resulting in increased competition for market share and acutely impacting demand for Alberta crude.
- Wildcard Disruption: Transportation fuels displacement will occur quickly post- 2025 due to changing societal values and accelerate further post 2030 due to changing societal values and technological innovation, resulting greater than anticipated impacts on Alberta derived crude.

The presenter said the rapid uptake of new mobility technologies is making the Anticipated Disruption scenario more likely than the Current Outlook, tightening timelines and increasing pressure for Alberta to adapt.

On Transportation Within Alberta

Alberta is already seeing some of the impacts of the transition to low carbon mobility, said the expert. Part of that impact is behavioral, with young adults more likely to use public transportation, rideshare, walk or bike. This has resulted in a 30 per cent decline in vehicle registration in the province.

While Alberta has been slower than other provinces to adopt ZEVs, with only around 5,300 registered in 2018, that is expected to change as the technology improves and becomes more cost-effective. The expert said over the next decade ZEV ownership in Alberta could increase 100-fold, creating some major infrastructure issues. For example, the City of Edmonton's current residential electrical grid can only support 10-15 percent ZEV adoption.

Challenges and Opportunities for Alberta

Given these implications, the workshop attendees saw a number of challenges and opportunities for the energy industry in transitioning to a low-carbon mobility future. Among them:

- Changing Alberta's transportation model from hydrocarbon-powered vehicles to ZEVs won't help Alberta's export based economy. We need to make use of the resources we have
- Alberta needs to become a clean energy supplier to the world rather than focusing on electrification. This includes hydrogen production and biofuels
- However, initial costs to develop hydrogen or biofuel production industries will be high and will need massive investments at a time when the Alberta government is running massive deficits
- The biggest opportunities for Alberta are hydrogen from methane with zero emissions, hydrogen from water, and lithium out of the brine from oil and gas reservoirs.
- There is a need to leverage existing revenues from hydrocarbons. Alberta needs to keep its current energy structures to help get the province where it needs to be long-term
- There is a need to look at what we can do with carbon dioxide emissions from oil and gas production. There is a big future in using carbon dioxide for building materials or other things. Carbon capture has large potential
- Lithium has great potential to become an export commodity replacing some lost revenues from decreased oil exports
- Biofuels also have export potential but production is still very expensive

The workshop attendees said reworking Alberta's transportation system for a low carbon mobility future would present a number of challenges, including:

- Government leadership is needed to ensure the province invests in the right technologies
- Alberta has a bigger diesel need than gasoline being it is a major transportation hub. There is not enough feedstock to convert diesel-powered vehicles to biofuels. Hydrogen is the only realistic option
- There is opportunity to switch smaller delivery trucks to ZEVs
- There is also opportunity to switch refrigeration units on trailers to electric power with the added benefit of limiting noise pollution
- Without a massive investment in the electrical grid, a switch to renewable energy will be very difficult
- An investment in the grid will also be needed for home-charging of ZEVs
- Massive infrastructure changes will be needed to switch from diesel to hydrogen-powered trucks. The Highway 2 corridor between Calgary and Edmonton would provide the best opportunity to start due to the amount of freight movement

Developing Opportunities for Alberta

The afternoon of the workshop was focused on developing four existing opportunities that would help position Alberta to thrive in in a low carbon mobility future: biofuels, lithium, hydrogen and smart cities.

The biofuel/ biojet opportunity

Led by Geoff Tauvette, Director of Environment and Fuel, WestJet

Biofuels have a long history as an alternative fuel in North America, particularly in the United States where mandates to blend ethanol in gasoline have resulted in production of over one million barrels per day, according to U.S. Energy Information Administration (EIA) data. Canada, on the other hand, produces only around 28,000 barrels per day of ethanol, and imports the corn-derived fuel from the U.S. to fill regulatory requirements, according the EIA.

With the expected transition to ZEVs over the next few decades, it is unlikely biofuels will play a major role in low carbon mobility systems for personal vehicles in the future. But options are more limited in marine, aviation, rail and long distance transport, and biofuels could be part of the solution.

There is an opportunity for biofuels to play a significant role in the aviation industry, where electrification, natural gas, or hydrogen is impractical. An expert laid out the opportunities for biofuels in the aviation industry to the workshop attendees.

The Canadian aviation industry is focused on monitoring its fuel performance, and is making progress towards its long-term goal of carbon neutral growth from 2020, and reducing emissions by 50

per cent compared to 2005 levels by 2050, said Geoff Tauvette, Director Environment and Fuel at WestJet. Currently, the aviation industry accounts for around two per cent of total global emissions, but it is a growing emissions source, especially because of increasing international flying.

To make biojet fuels a reality the expert said industry must address its high costs, including:

- Feedstock costs
- Capital costs
- Operational costs

Workshop attendees suggested a number of ways to address feedstock costs for biojet fuel, including:

- Using a variety of feedstock ranging forestry and agricultural waste to natural gas, coal, vegetable oil, sugar, Isobutanol, ethanol, and sewage sludge, They noted there are different approval processes and blending considerations for each feedstock and some are not yet approved for use in Canada. They also noted that not all feedstocks are equal in process and quality. The fuels will need rigorous testing to ensure it is good for the engines and the running of the planes
- Giving equity stakes in biofuel production projects to feedstock suppliers to create sustainable feedstock supplies
- Instituting government policies on what crop and forestry residues must be gathered for biofuel use
- Partnering with other renewable fuel processors like renewable diesel operations to share feedstock
- Institute a new fuel charge on flights to improve the economics of biofuels
- Subsidize feedstock producers

To help manage high capital costs to construct bio-refineries and high operational costs that result in high biofuel prices, the attendees suggested:

- Co-processing using existing petroleum refineries or upgraders
- Having government invest in refining and other infrastructure
- Developing and improving the supply chain to cut costs

The hydrogen opportunity (co-developed with CESAR)

Led by Canadian Energy Systems Analysis Research (CESAR)

Vehicle electrification using hydrogen as an on-board fuel offers a major opportunity for Alberta, especially for heavy duty and long distance transportation, an expert told the EFL workshop.

While plug-in, battery-electric vehicles make sense for light duty vehicles and urban trips, the heavy batteries and long recharge times challenge the utility of this technology for heavy duty vehicles, long trips or demand cycles requiring minimal down-time for refueling.

Hydrogen fuel cell electric vehicles (HFCEV) can be refueled as quickly as a diesel vehicle, yet have only a fraction of the moving parts so maintenance costs should be much reduced compared to diesel vehicles. If the heavy freight sector moves to autonomous, connected vehicles that are expected to be in service up to 24 hours per day, the benefits of HFCEV's may extend beyond the lower GHG and air emissions.

A big challenge for HFCEVs is the lack of hydrogen production and fueling infrastructure. There are three major pathways for the production of hydrogen: water electrolysis, steam-methane reforming of natural gas, and gasification of hydrocarbons (e.g. bitumen) or biomass. While electrolysis produces no GHG emissions if the electricity source is carbon-free, steam-methane reforming and gasification technologies do produce a significant amount of carbon. However, these technologies can be easily modified, at relatively low cost, to produce pure CO2 streams that can either be utilized or permanently stored underground. Even with carbon management, electrolysis of water is the most expensive pathway and steam methane reforming the least expensive, especially in Alberta where natural gas prices are the lowest in North America.

Moreover, per kilometer travelled, it should be possible for HFCEV to be cost competitive with diesel-fueled vehicles.

It would be in Alberta's interest to lead in the development and deployment of a hydrogen economy, initially based on hydrogen generated by steam methane reforming and gasification, and eventually shifting to electrolysis from wind and solar electricity.

- Developing a hydrogen-based transportation system would utilize and add value to the province's existing hydrocarbon resources, leverage existing knowledge and expertise, and create export opportunities for both the hydrogen resource and the expertise in hydrogen production.

The expert pointed out that producing hydrogen to supplement and eventually replace diesel demand in North America would provide major environmental and economic benefits. Since Alberta produces nine times more diesel than it consumes, in the future Alberta could be a major exporter of hydrogen to other jurisdictions that lack the strategic advantages of the province for the low cost, low carbon production of this zero-emission transportation fuel.

Workshop attendees agreed hydrogen production should be a priority for Alberta, but some issues remain to make it a reality, including:

- Timing and urgency – if things don't move quickly the opportunity will be lost as electric vehicles (perhaps with on road charging) may become the standard;
- A lack of hydrogen distribution infrastructure within the province and to export markets;
- The need to further develop the domestic market until exports become economically and technically feasible;
- Pipeline infrastructure upgrades would be needed to export hydrogen;
- New systems would be needed to store hydrogen to meet variable demand;
- There is a need to create a market before development begins

However, the attendees also had suggestions for meeting these challenges, including:

- Alberta is already a major producer and user of hydrogen for fertilizer production, bitumen upgrading and petrochemical production, so we have the expertise
- We need to engage trucking companies to develop and deploy demonstration projects to test the performance of HFCEVs under Alberta conditions; Developing the hydrogen transportation infrastructure in Alberta first, creating revenues to drive exports;
- Developing and implementing a 20-30 year deployment strategy for a 'Made in Alberta' hydrogen economy where the freight sector is the anchor tenant;
- Building a compelling business case as to why the province needs this, by demonstrating how a hydrogen economy will stimulate the economy while reducing GHG emissions, not only in the hydrocarbon sector but in downstream sectors as well.

The Lithium opportunity

Led by Liz Lappin, Vice President Project Development, E3 Metals and Amanda Hall, CEO, Summit Nanotech

As with hydrogen, producing lithium in Alberta as a means of helping the transition to a low carbon mobility future has a lot of potential. There is a large and exponentially growing market for lithium in ZEVs and in other energy storage applications, an expert told the EFL workshop. The province also has significant lithium resources defined using produced water from existing oil and gas wells, with a large amount of infrastructure and technical skills from the oil and gas industry already in place to capture it. E3 Metals Corp has developed a large inferred resource of 6.7 million tonnes lithium carbonate equivalent, which represents a small fraction of the overall potential in Alberta.

But lithium production using oil and gas methods (eg. wells and pipelines) also has some challenges. It is a new sector in Alberta and the regulatory environment isn't fully formed. Traditional mining methods such as salars (evaporative ponds) are not suitable for Alberta's climate and require 18-24 months for processing. Despite this, Alberta is well positioned with solutions and expertise to produce some of the world's most sustainable lithium.

Direct brine processing methods under development process brine much faster (<2 days), are low disturbance and are capable of processing large volumes of produced water to access relatively low concentrations of lithium. Lithium extraction can have high energy demands, use large volumes of fresh water and can be chemically intensive. However, new technologies and processes are currently being developed to address these challenges. Summit Nanotech Corp. is a Calgary-based company that is being supported with government funding to develop greener lithium extraction processes through the Women in Cleantech Challenge. E3 Metals Corp, also based in Calgary, has developed a proprietary lithium extraction technology specifically for Alberta's brine. The system, currently being scaled towards commercial readiness, quickly and efficiently concentrates lithium brine and removes >99% of impurities. E3 Metals also plans to take advantage of the geothermal energy contained within the brine to reduce emissions, and capture waste streams for recycling into the overall process.

The workshop attendees said while lithium production in Alberta was in early stage development, it has potential to help Alberta's export based economy transition to a low carbon mobility future. However, regulatory and public concerns will need to be addressed first, and strategic partnerships will need to be created to manage supply costs. Here are the key issues identified by the workshop participants:

- There is a need to work with government and regulators to form policies and regulations that foster industry development
- There is a need to develop a system that clearly defines ownership of resources and ownership of liability on wells where lithium will be produced
- A tax and royalty system that fosters development is needed
- An understanding of how the industry will create jobs, what kind of jobs, and where the jobs will be, needs to be developed
- An association, either of lithium producers or energy storage companies, needs to be created to forward the industry and help get ahead of public concerns about development

The workshop attendees said a number of collaborative efforts would also be needed to get lithium production up and running, including:

- Partnerships with chemical companies for process development
- Working with upstream oil and gas companies to get access to wells and create economic models for production
- Working with drilling contractors and well completions companies for field development
- Working with oilfield service companies to keep wells producing
- Partnerships with EV manufacturers and battery manufacturers will be needed to sell final product

The smart city opportunity

Led by Howaida Hassan, General Supervisor Transportation for City Plan, City of Edmonton and Kristina Mlakar, National Operations Manager, CUTRIC-CRITUC

Alberta's major cities have seen a significant build-out of alternative transportation systems to the privately owned vehicle in recent years, with growth in light rail transit (LRT) dedicated bus lanes, bike lanes, and ridesharing programs. These efforts are already showing results, with vehicle registrations down 30 per cent in the province. This move to transportation as a service is expected to accelerate with the advent of autonomous vehicles and the use of data analytics and artificial intelligence to collect and analyze data to develop solutions to get transportation where people need it when they need it. Combined with ZEVs, this smart city effort is a major piece of the transition to a low carbon future.

One of the challenges remaining in the smart cities initiative, however, is getting people from home to transit or other transportation alternatives, and then on to their final destination, what the experts call, "the first mile-last mile challenge."

The workshop participants said they had no specific solutions to the challenge, but did have some suggestions that could help, including:

- Rethinking the transit system as mobility as a service. Municipalities have to collect data on how people move around and come up with solutions that match up with that demand
- Build out community hubs that allow people to connect. Then focus traditional transit on these hubs. This would include adding retail and residential around LRT stops and major bus routes. It would also include connecting transit to recreational and community facilities
- Longer term, these hubs could be used to store shared autonomous vehicles, shared bicycles, or other transportation methods

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. To us, this means 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.

To learn more about the EFL and its work please visit www.energyfutureslab.com.

Attendees List

Air Products
Al-Pac
Alberta Agriculture
Alberta Economic Development and Trade
Alberta Energy
Alberta Energy Regulator
Alberta Innovates
Alberta Transportation
ATB Financial
ATCO
Calgary Technologies Inc.
Canadian Fuels Association
CEASAR
Cenovus
City of Edmonton
CMC Research Institutes Inc.
Common Ground
CUTRIC
CWF
Delphi Group
E3 Metals Corp.
Edmonton Airports
Energy Efficiency Alberta
EnSciTech Corp.
ERA
Future Cities
Government of Alberta
Government of Alberta / CoLab
Government of Alberta, Climate Change Office
Impact Hub (Calgary)
JWN
Nexus Space
Permolex
Proton Technologies
Pure Enertech Solutions Inc.
Quest Canada
Strategy + Leadership
Summit Nanotech
Suncor
Suncor (Biofuel)
Trimac
University of Alberta
University of Alberta / Biomass Network
University of Calgary
West Fraser
Western Economic Diversification Canada
WestJet
Worley Parsons

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