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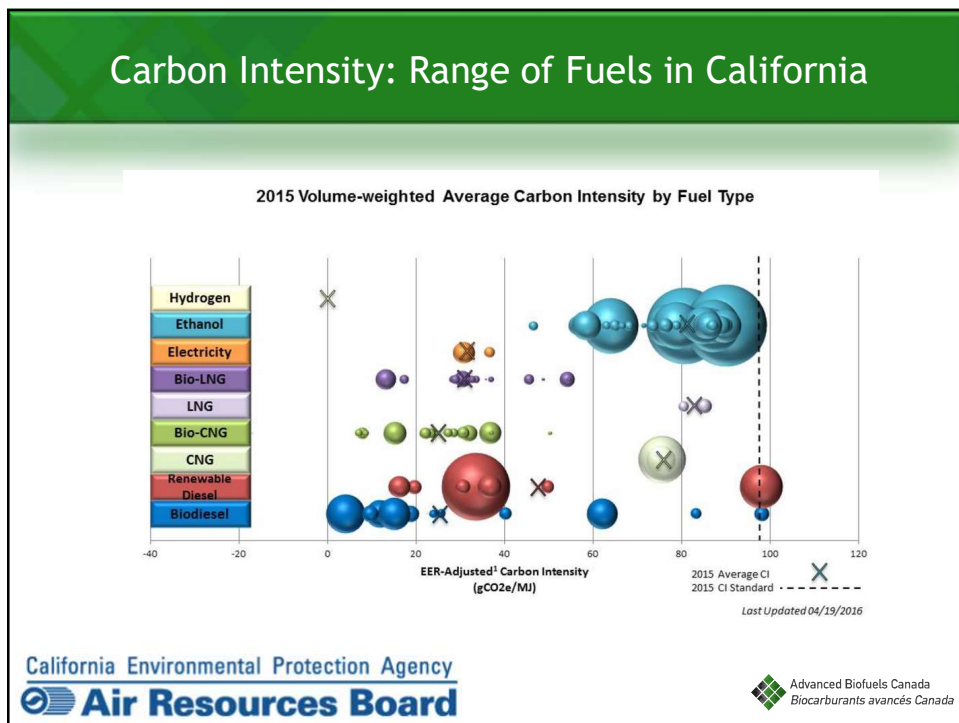
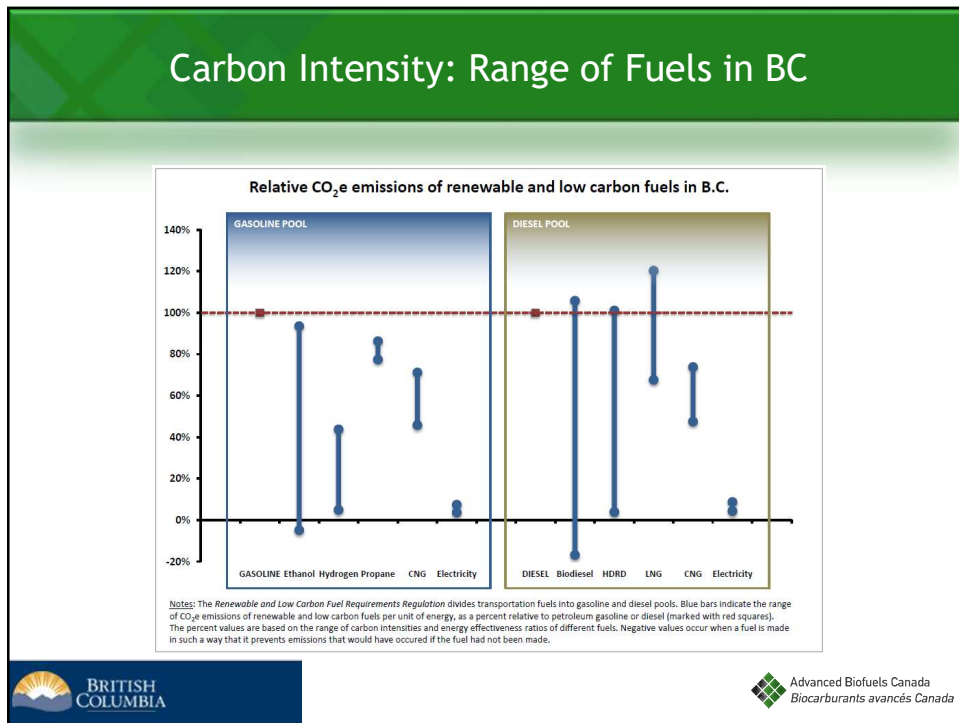
Life Cycle Assessment of Biofuels: *Measuring the performance of biofuels in carbon pricing & compliance schemes*

BioCleantech Forum
Ottawa, ON

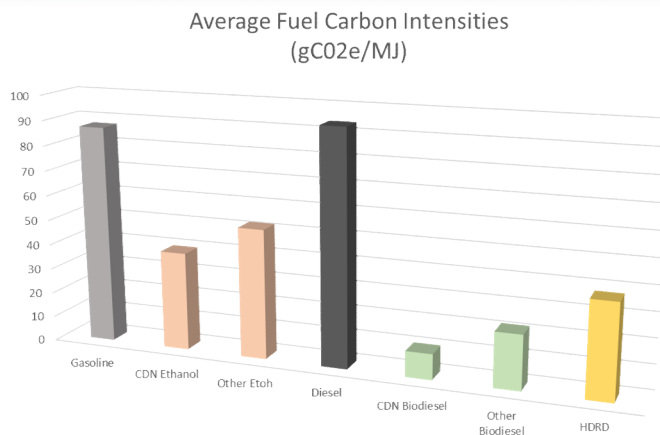
November 3, 2016

Biofuels: 'Performance' Metrics

- Carbon Emissions
 - Certified lifecycle carbon intensity
 - Low Carbon Fuel Standards - BC, CA, OR
 - ON (*Greener Diesel Regulation*)
 - Certified carbon reduction
 - AB RFS (-25%)
 - EU - Renewable Energy Directive
 - US RFS2
- Biomass Source
 - Renewable Biomass - e.g. date of land clearing, type of biomass
 - AB RFS
 - US EPA
 - EU-RED
- Assurance Type
 - Aggregate (e.g. feedstock, product type, country of origin)
 - Certified (facility-based, specific product, mass balance vs. IP)
 - Compliance Credits (e.g. QAP RINs, CA Verification)



Carbon Intensity: Canadian Biofuels

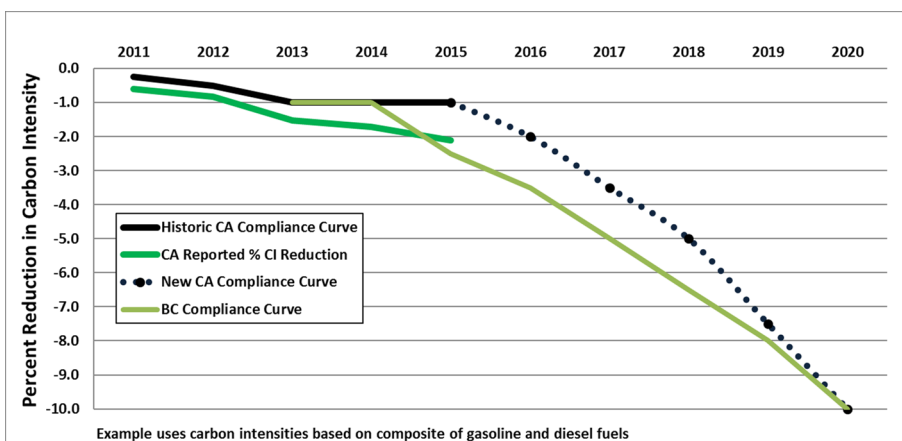


BC Energy & Mines: RLCFRR registered fuels of June 30, 2016

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Low Carbon Fuel Standards: Progressive Stringency on Fuel Emissions

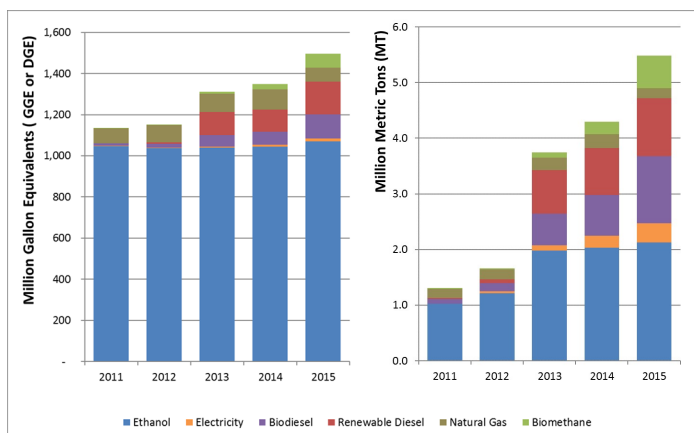
BC and CA have similar targets (... but BC Part 3 Credits = 25%)



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Low Carbon Fuel Standards: Flexible Approach

- Increasing use of advanced biofuels over time (greater reductions per gallon)



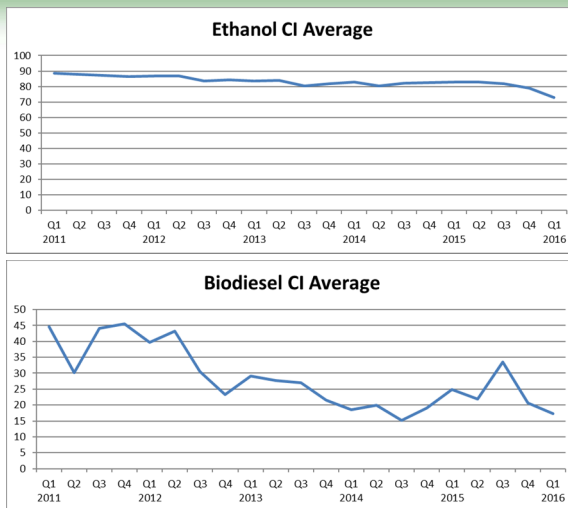
Source: CARB - October 2016

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Biofuel Carbon Intensities: 2011 to 2016

Improvement in
'first generation'
biofuels through:

- Technology improvements
- Energy & process efficiency gains
- Feedstock improvements & switching

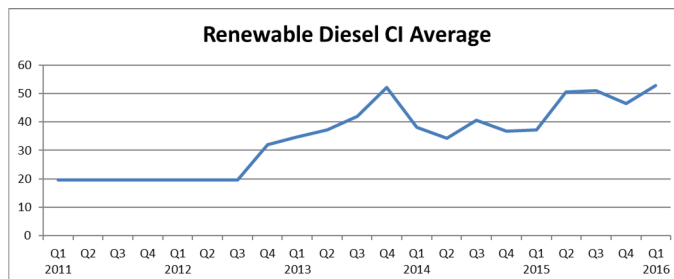


Source: CARB - October 2016

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CA Biofuel Carbon Intensities: 2011 to 2016

- Growth in production and use of HDRD (or 'Renewable Diesel' in US) has consumed lower carbon feedstocks

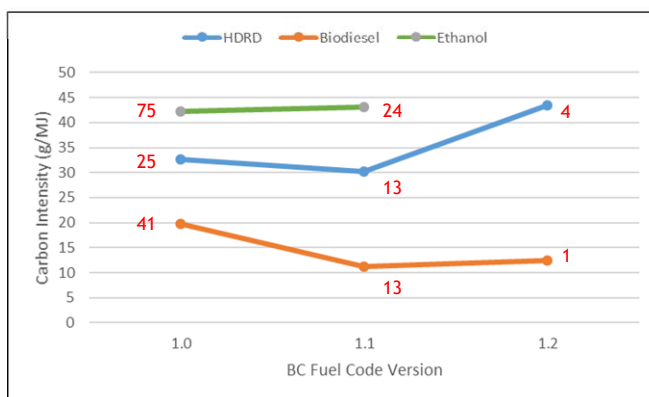


Source: CARB - October 2016

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BC Biofuel Carbon Intensities: 2013 to 2016

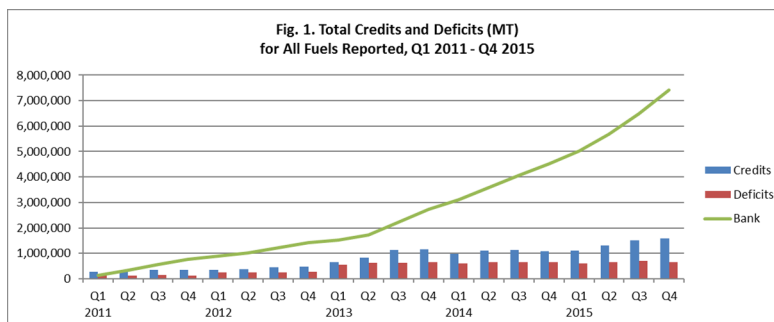
- 141 registered biofuels in BC LCFS
- 55 biofuels have extended expiry / updated pathways



Source: BC Energy - October 2016

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LCFS Compliance: Early Action & Credit Banking

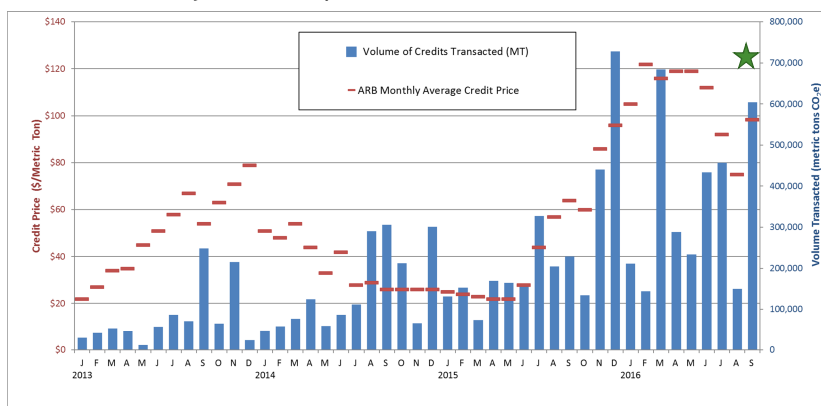


Source: CARB - October 2016

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Low Carbon Fuel Standards: Credit Trading

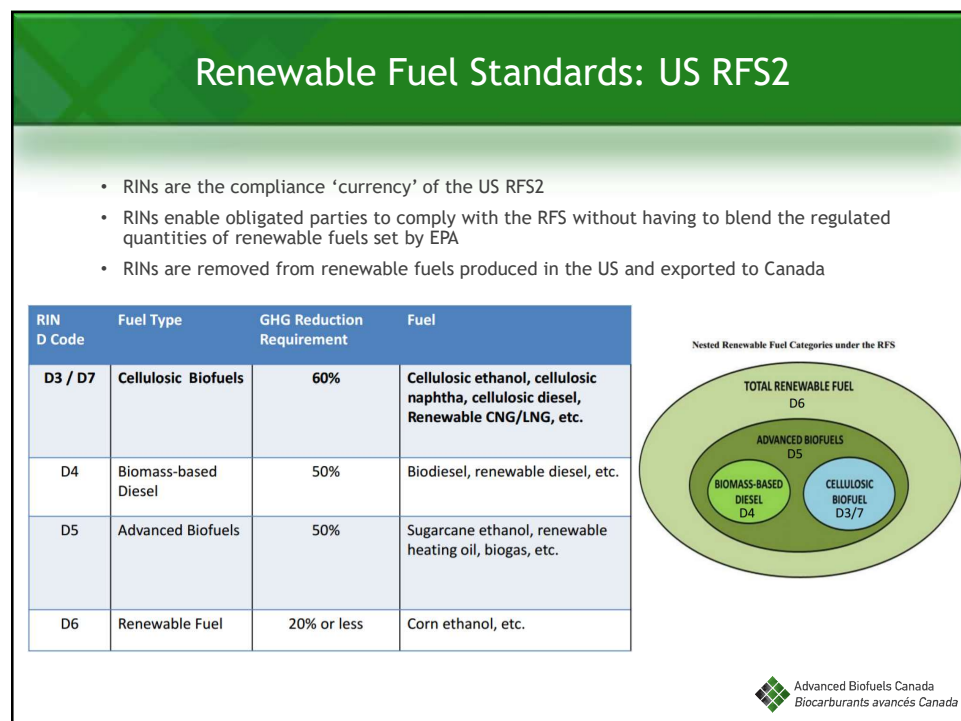
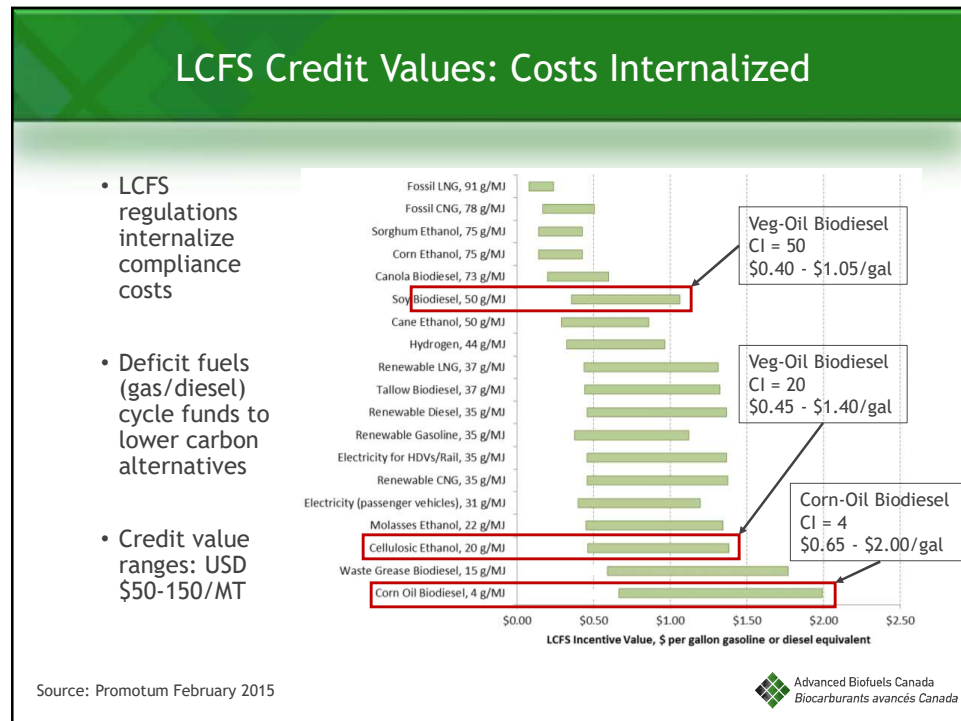
CA LCFS: January 2013 to September 2016



★ BC LCFS: 16 trades - 210,000 credits - average price C\$172 (USD \$129)

Source: BC Energy - September 2016 & CARB - October 2016

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RFS2 Compliance Credits: RIN Pricing

- RINs influenced by RVO each year
- Nested structure of RFS2 fuel types keeps pricing of RINs tightly correlated



Source: PFL Markets Daily - October 28, 2016

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Biofuels Carbon Offsets: Alberta Case

- Pro-forma pricing estimate ... NOT VALID as verification requirements impair creation and use of biofuels offsets

Offset Valuation for Biofuel Producers

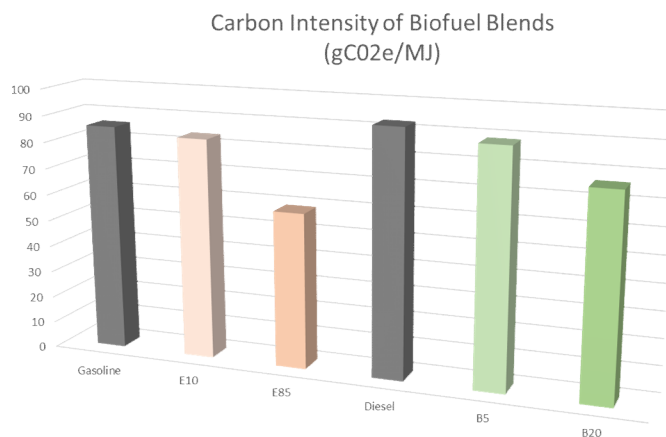
Alberta Carbon Price	\$ 15	\$ 20	\$ 30
% of CCEMF price achieved by offset	90%	90%	90%
Value per offset	\$ 13.50	\$ 18.00	\$ 27.00
Estimated transaction cost per offset (verification, serialization, registry material submission, etc.)	\$ (0.40)	\$ (0.40)	\$ (0.40)
Net Offset Value	\$ 13.10	\$ 17.60	\$ 26.60

Litres per offset estimate: Canola biodiesel 435
Tallow biodiesel 350
(w/RFS GHG % reduction and estimate for use of default factors in Biofuels Protocol - Appendix A)

Value per Litre of biofuel:	Canola biodiesel	\$ 0.030	\$ 0.040	\$ 0.061
	Tallow biodiesel	\$ 0.037	\$ 0.050	\$ 0.076

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Carbon Intensity: Biofuels Blends in Canada



GHGenius 4.03: Canadian average primary (corn, canola) biofuel defaults

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Carbon Tax on Fuels: Alberta & British Columbia

\$ / Litre (@ \$30/tonne)	Alberta	British Columbia
Gasoline / ethanol	\$ 0.0673	\$ 0.0667
Diesel / Biodiesel / HDRD	\$ 0.0803	\$ 0.0767

Alberta

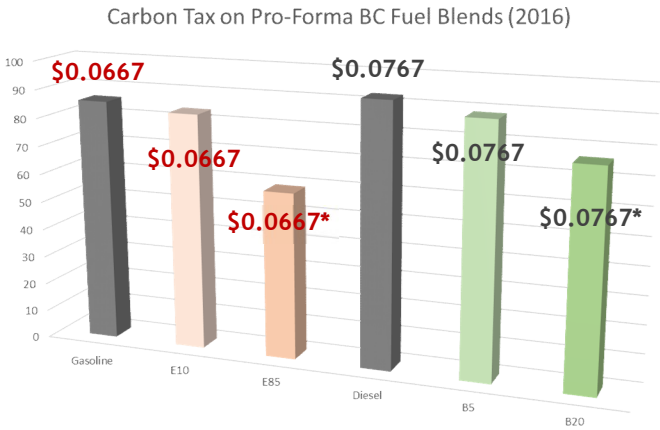
“Diesel means a substance, including renewable diesel... Gasoline means a substance including renewable gasoline.”

British Columbia

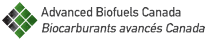
“Carbon tax applies to fuels at different rates depending on their anticipated carbon emissions... Motor fuel tax and carbon tax apply to ethanol at the same rate as gasoline, and to biodiesel at the same rate as diesel.”

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Carbon Tax on Fuel Blends: British Columbia



Source: Shell rack pricing (RUL / E10 and ULSD / B5) - October 29, 2016
 * Products not quoted (E85, B20)



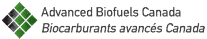
Cap & Trade Price on Fuels: Ontario & Quebec

\$ / Litre (@ \$18.59/tonne)*	Ontario	Quebec**
Gasoline / E10	\$ tbd	\$ 0.0388 / \$0.0350
Diesel / Biodiesel / HDRD	\$ tbd	\$ 0.0495

* Based on California-Quebec 2016 vintage auction prices on August 16, 2016
 ** Petro Canada rack prices as of October 29, 2016

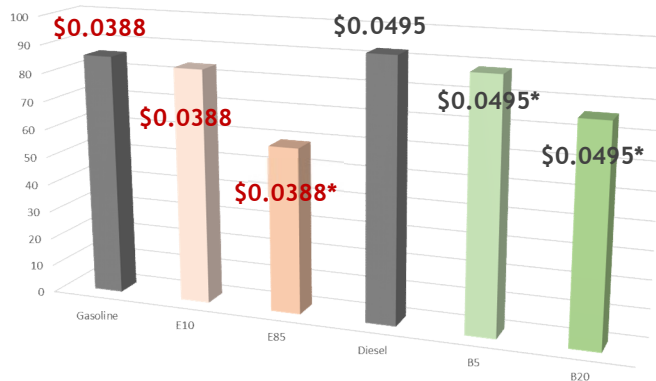
Ontario
 The 'verification amount' is the amount (tonnes CO2e) of greenhouse gas emitted from specified activities, less carbon dioxide emitted from the combustion of biomass.

Quebec
 "... 'fuel' means automotive gasoline, diesel fuels, propane, natural gas and heating fuel except ... the biomass and biomass fuel component of such fuel."



Rack Fuel Prices on Fuel Blends: Quebec

Carbon Price on Pro-forma Quebec Fuel Blends (2016)



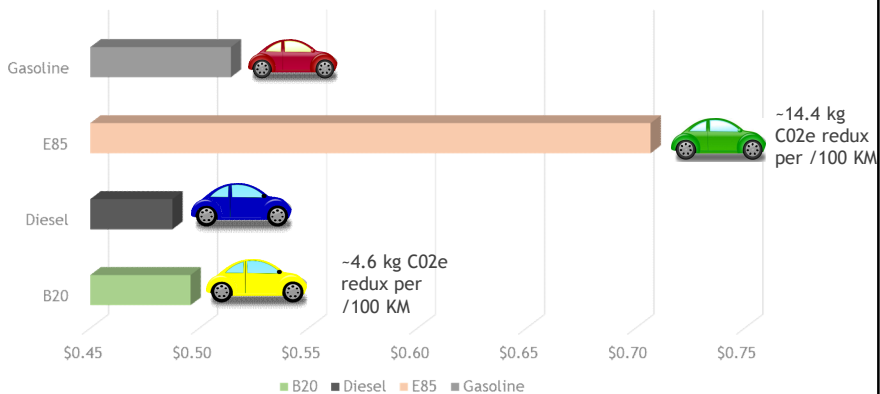
Source: Petro Canada rack pricing (RUL / E10) - October 29, 2016

* Products not quoted (E85, B5, B20)

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Carbon Price per Kilometer: British Columbia

Pro-Forma Carbon \$/100KM



BC carbon tax rates - 2016

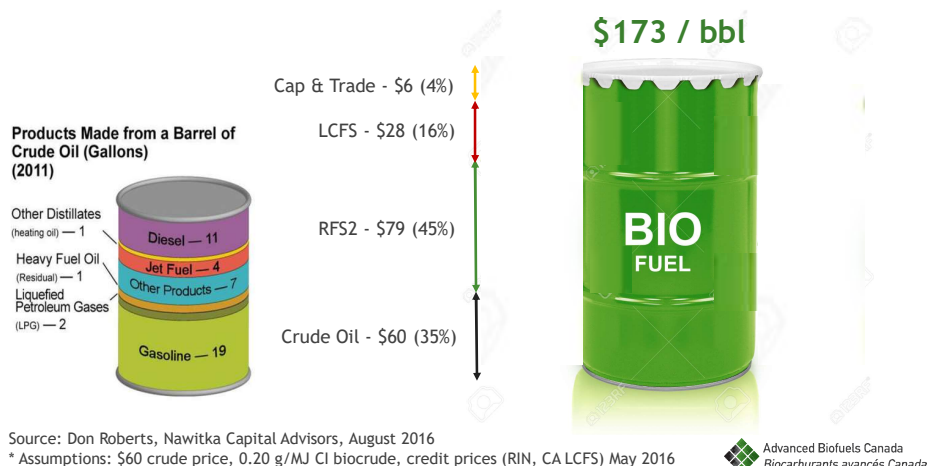
Volkswagen 2016 Golf SportWagen (Gas & Diesel) ratings

Canadian energy density defaults (GHGenius 4.03)

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A Barrel of Bio-Crude

- A 'barrel' of bio-crude will derive value from complementary carbon pricing & compliance schemes



Biofuels Performance: Market Evidence

In the past decade, renewable fuel use under carbon pricing and compliance regulations has demonstrated:

- LCFS regulations work:
 - Assured transport GHG reductions
 - Broad flexibility & adoption of innovation / technology
 - Fiscal impact internalized to fuel system
 - Demonstrated early improvement of alternative fuels
- RFS regulations work:
 - Capacity building: rapid development of supply & infrastructure
- Carbon pricing systems do not work ... yet?
- Assurance protocols are a 'work in progress'
 - Biomass provisions set clear standards for eligibility
 - LCA modeling improving, but high variability
 - Certification/verification systems in nascent stage

Transportation Emissions: A Canadian Approach

- Integrated approach to reducing greenhouse gas emissions, leveraging Canada's natural resources, & bio-cleantech growth

1. Carbon Pricing on Transport Fuels

- a. Based on full lifecycle fuel emissions
- b. Transparent, predictable and visible to fuel consumers

2. Clean Fuels Standard

- a. Progressively reduce GHG emissions (2020-2030)
- b. Increase minimum blending levels of sustainable biofuels
- c. Improve compliance flexibility
- d. Compliance credit market

3. CleanTech Growth

- a. Capital support to buildout new capacity
- b. Performance-based production credits (competitive N.A. market)
- c. Innovation & technology - SR&ED, ACCA, SDTC, BioFuelNet



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