Fails to meet criteria	Not promising	Meets in some respects	Potentially meets criteria	Meets criteria

* For explanation of criteria see Box B, page 22

ASSESSMENT TABLE: **Agriculture and agri-food**

	Credible			Capable		Compelling			Priority approach
	Maturity	Economic viability	Social acceptability	Fit for purpose	Net-zero pathway potential	To critical stakeholders	Related costs and benefits	Economic development opportunities	
On farm energy use									
Battery electric farm equipment	Entering market but further battery development required for heavy loads	Will improve over time	No particular concerns	Yes, for lighter duty. But battery weight currently prohibitive for heavy duty vehicles	Yes, assuming net zero electricity supply and manufacture of equipment	Potentially to equipment manufacturers.	Clean operation. Reduced noise. Less maintenance. Challenge of battery recycling	Yes, for electric equipment manufacture	Yes . Potentially part of zero emission world
Biofuels for heavy farm equipment	Mature. Established technology	More expensive that fossil fuels today	No particular concerns	Yes.	Yes, depending on full lifecycle of the biofuel.	Yes, familiar to farmers. Appeals to producers.	Local production/ consumption Contributes to air pollution	Particularly for local producers	Medium to high. Potentially part of a low emission world
Hydrogen fuel cells for heavy farm equipment	Fuel cell technology is reasonably mature. But applications for heavy equipment require further work.	Low at present because hydrogen infrastructure not built out and fuel cell adaptation for heavy equipment not complete	Some concerns over safety of hydrogen fueling	Yes.	Yes. If hydrogen is made from decarbonized electricity such as renewables or from fossil sources with CCS and offsets. Longer term viability of fossil-based hydrogen depends on CCS and offset availability	Potentially compelling if hydrogen supply issues addressed	Improved driving (torque), lower maintenance, no air pollution, noise reductions	Good. Opportunities for fuel cell manufacture, equipment manufacture, and hydrogen production	High. Potentially part of net zero emission world
Renewable power generation (wind, solar, biomass)	Wind and solar, are mature. In practice biogas production (and manure digesters) can pose technical challenges.	Depends on the application. As cost and efficiency of solar continues to improve economics look more favorable.	Fine at farm scale. Some opposition to utility scale development on farmland	Yes, as a supplement to grid power. Stand alone systems (fulfilling all farm needs) more rarely.	Yes, compatible with a net zero future	Yes, can reduce farm energy costs.	Biomass systems can aid with manure and farm waste management. Can reduce pressure on grid.	Yes, but mainly local	Medium to high
Crop agriculture									
More efficient fertiliser use (Improving fertilizer source, rate, timing and placement)	Multiple technologies still evolving: EG: coatings for timed release, precision application (using sensors, data analytics, etc.)	Yes, many already coming to market	No particular issues from the public	Precision inputs can reduce waste and enhance profit and yield. Allows immediate reductions in N fertiliser use	Can dramatically reduce nitrogen emissions (if combined with CCS on fertiliser manufacture). But some escape to environment remains. So not net-zero on its own	Can appeal to farmers and fertiliser producers. But many farmers are risk adverse to changing established practices.	Reduction of ground water leaching, eutrophication, potentially improved soil health, lower input costs.	For companies producing improved fertilisers, production, precision application and analytics systems	Medium to high. Can be part of zero emission systems if offsets found elsewhere.
Improved crop regimes	Multiple approaches including complex rotations, cover crops, green manures. Many are well established, but research required to perfect for different regions/crops	Yes, for established practices. But defining individualized solutions can require practical experiments and be costly to the farmer	Yes, no particular issues	Yes. Over the longer term, yields can be stabilized or increase.	Yes, with appropriate approach for given crops, soils, and climate.	To some producers.	Improved soil health, water retention, reduced erosion, increased biodiversity	Can improve viability of farm operations.	High priority for research, trials deployment Key element of net zero agriculture

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ASSESSMENT TABLE: **Agriculture and agri-food**

	Credible			Capable		Compelling			Priority approach
	Maturity	Economic viability	Social acceptability	Fit for purpose	Net-zero pathway potential	To critical stakeholders	Related costs and benefits	Economic development opportunities	
Animal agriculture									
Manure management	Multiple techniques at different levels of development	Depends on approach.	No particular problems.	Yes.	Can contribute to significant (and immediate) reduction in emissions. But some escape to environment remains. So cannot meet net-zero on its own	To some producers, equipment suppliers	Improved nutrient retention, reduction in environmental burden	Unclear	High. Will be necessary for net zero animal agriculture
Food additives, food mixes, vaccines	At different stages of development	Depends on approach	No particular problems.	Yes	Can contribute to reduction in emissions. How far it can go to deal with enteric emissions remains to be seen	To producers of additives, novel food mixes, vaccines. For farmers potential non-disruptive way to reduce emissions	Shift to grain or oilseed crops in beef and dairy livestock diets could reduce economic viability of native prairie habitat (leading to biodiversity loss)	For producers of additives, food mixes, vaccines	Medium to high
Enhanced animal genomics	Continuously being developed	Yes	No particular problems.	Yes	Can contribute to reduction in emissions. But how far remains to be seen.	To suppliers and farmers (cost savings). For farmers potential non-disruptive way to reduce emissions	Higher production efficiencies. Potential for reduced herd size and environmental footprint	To industry. Canada has a significant breeding industry.	Medium. With other approaches
Dietary and production shift to plant-based proteins	Technologies already mature and new products being developed continuously	Yes. Can offer substantial cost savings for food producers (as compared to animal protein-based foods)	No particular problems. Increasingly positive social resonance	Yes, products can provide good nutrition. But concern over high salt, fat, sugar and additives in many products	Yes. Depending on net-zero crop agriculture practices.	Export market opportunity for Canadian agricultural producers.	Health benefits to consumers. Reduced environmental load from animal agriculture. Released land from animal agriculture. Some concerns of biodiversity loss from decline of extensive livestock systems in prairies.	In developing plant-based food products	High. But requires long term cultural shifts
Dietary and production shift to synthetic proteins	Fermentation: fundamental techniques well established, but still emerging for food (as opposed to pharmaceutical products). Cellular meat: still at research phase	Cost for fermentation falling rapidly, soon to be competitive for milk proteins. Cellular meat still at research stage.	Questions about consumer acceptance of lab grown meat.	Fermentation: yes. Proteins can substitute into the processed food industry with minimal disruption. Cellular meat: less clear about functional and nutritional characteristics.	Yes, in principle depending on growing of plant material used as feedstocks, chemicals required in the process, decarbonized energy inputs, and waste disposal	Can appeal to food processors (lower cost inputs than proteins from livestock) and companies involved in biotechnology.	Potential reductions in agricultural land (currently used for animal agriculture, feed production) and chemical inputs. Potential health benefits and risk: benefits reduction of animal born disease, antibiotic use and tailoring of protein production to human needs. Risks, nutrient loss, unforeseen issues.	A new industry to be built from the ground up. Balanced by potential loss of livelihoods in the dairy, beef and other livestock sectors.	Medium (For now until further knowledge of potential, impacts, etc.)

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Agricultural paradigms									
No till agriculture (minimizes soil disturbance)	Already widely practiced especially in western Canada	Yes, saves money on heavy machinery and fuels.	No issues	Yes. But challenging for some crops (eg potatoes, beets) and in some soils. May not be practical indefinitely in some contexts	Yes. But on its own does not reach net zero. Needs to be combined with other cropping practices.	Yes, already adopted by thousands of farmers. Manufacturers are already making light equipment to avoid soil compaction	Reduces erosion, increases moisture retention, raises organic matter. Can promote carbon sequestration	Already widely adopted so these are already largely achieved	Medium. Mainstream but more could be done in Eastern Canada
Organic agriculture (avoidance of chemical inputs)	Already widely adopted for many farm outputs (grains, vegetables, dairy, beef, etc.). Continuously advancing techniques.	Yes, but to some extent depends on the premium organic products command. There are high costs for certification	Positive public image. Sector continues to expand	Yes. But challenging with some crops. Yield penalty for many crops.	Depends on the practices. Animal agriculture can still emit substantial GHGs unless appropriate measures are adopted.	Yes, to some farmers and many consumers. Sector still expanding	Reduces chemical burdens on environment (pesticides, fungicides, etc.) and residues in food. Debate ongoing over whether it improves nutritional quality of foods.	Significant. Only 1.5% of agricultural land is farmed organically today. This could be substantially raised over time. Production does not satisfy consumer demand in Canada. Potential export markets	Medium
Precision agriculture (applies inputs tailored to conditions)	Already being deployed: monitoring equipment, machinery for weeding, fertiliser application, etc.	Substantial capital investment. Input savings may not be sufficient to cover costs unless the latter decline.	No particular problems.	Yes, water nutrients, treatments are delivered in appropriate amounts.	Could contribute to much lower nitrogen emissions. But how low this can go remains to be seen.	Yes, for manufacturers of precision equipment, data managers, and potentially farmers due to reduced input costs.	A variety of environmental benefits.	Yes for major suppliers of machinery and inputs	Medium to high
Vertical agriculture (Stacked cropping in greenhouses or fully controlled indoor environments often using hydroponics, aeroponics, etc.)	Based on decades of greenhouse agriculture, but stacked techniques, mechanization and robotization, still developing.	Yes, for high value crops, close to markets (leafy vegetables, tomatoes, and increasingly soft fruit) and plant propagation. Potential for remote communities	No particular problems.	Yes, but not applicable or economic for all crops – for example potatoes, grains, tree fruits, etc.	Yes, if lighting, heating, ventilation, etc. powered by net zero technologies, and wastes managed appropriately.	Yes, particularly for producers near large urban markets, or in remote communities.	Reduction in need for water, chemical inputs, pollution from waste and land required. Fresher produce can be delivered to nearby markets. Production can be linked closely to consumer demand.	Yes, for equipment manufacturers. Enterprises in remote communities.	Medium. Important, but scale at which it can be applied is still uncertain
Low input agriculture (hybrid that minimizes external inputs)	Still emerging as a hybrid. Many elements already well developed, others emerging	Depends on yield/input trade offs and particular techniques	No particular problem	Potentially. But remains to be seen if yields can be kept high enough	Yes. But low input does not necessarily entail net zero emissions. It depends on the actual practices and input/output relationships	Potentially appealing to farmers as alternative to conventional model	Reduction in pollution burdens. Unclear whether more land required	Unclear	Medium to high