



SUSTAINABLE DEVELOPMENT
TECHNOLOGY CANADA™

Partnering for real results.

New Technologies Enabling Viable Biorefineries

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**“The Foundation will act as the primary catalyst
in building a sustainable development technology
infrastructure in Canada.”**

SDTC is a policy instrument of the Government of Canada to deliver environmental and economic benefits to Canadians.

As a delivery agent, we foster the development and demonstration of technological solutions that address:

- Clean Air;
- Climate Change;
- Clean Water;
- Clean Land.

Forge innovative partnerships and build a SD technology infrastructure.

Ensure timely diffusion - increase number and rate of uptake of technologies into the marketplace across Canada, providing national benefits.



SDTC operates two funds:



SD Tech Fund™

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\$550 million SD Tech Fund™ was launched on April 4, 2002.



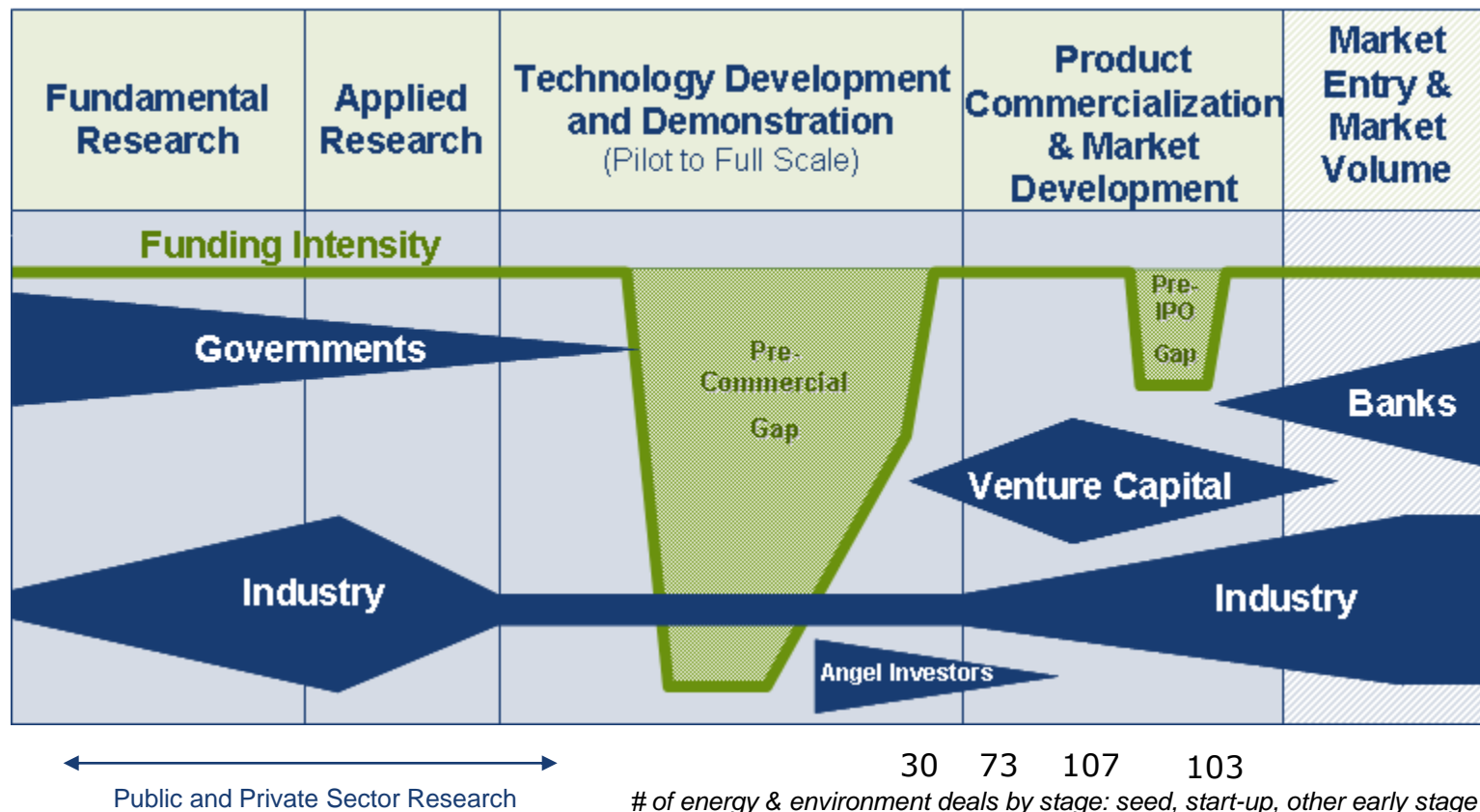
NextGen Biofuels Fund™

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\$500 million NextGen Biofuels Fund™ was launched on September 12, 2007.

The funds are complementary and address different gaps in the Innovation Chain

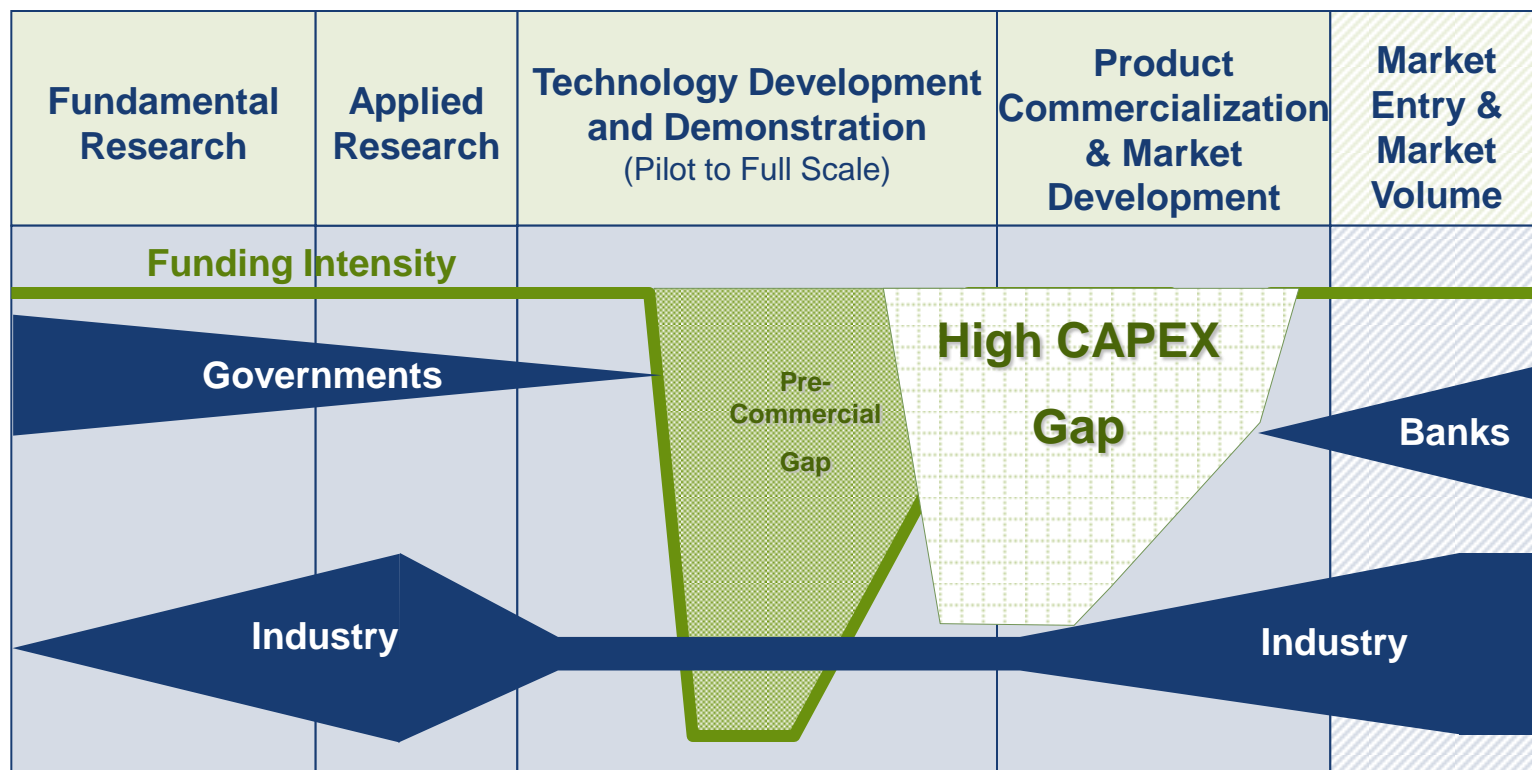
Funding Gaps



Source: Thomson Reuters

Lack of funding for technology development and demonstration creates a Pre-Commercial Gap in the Innovation Chain

Funding Gap – Capital Intensive



The absence of angel and venture capital funding leads to a second gap we call the High CAPEX Gap.



- Innovators in **financial need** approach SDTC
- The innovative technology is past research but not yet commercial
- Innovators are concerned about confidentiality of intellectual property (IP) when market value becomes apparent. SDTC maintains confidentiality.
- **SDTC sees a very large number of innovative SD technologies at various stages of development**
- SDTC knowledge from innumerable inquiries, >1,600 SOIs, >350 detailed proposals, stakeholder consultations, R&D organizations, and participation in the many communities of practice
- 30% on innovations are bio-based
- Canada has world leaders in the development of many innovations

Why biorefineries? -- Necessity



- Insufficient revenue from single products to cover feedstock and processing costs
- Resource investment by nature, forestry or farmers
- Sunk costs to harvest, handle and prepare
- Traditional products only use a fraction of the grown stock
- Stacked returns from minor components and wastes
- Bio-based residues or wastes emit GHGs and pollutants upon disposal and degeneration.
- Waste disposal is an increasingly costly environmental problem
- Environmental regulations are constraining conventional waste disposal
- New technologies can turn environmental burdens into benefits

Why Biorefineries? -- Opportunity



- Fluctuating, uncertain crude oil prices and awareness of depleting resources have increased the costs of fossil fuel based products.
- New technologies enable production of competitive bio-based products.
- R&D shows that many new bio-based products have equivalent or better properties than conventional products.
- Revenue from multiple products can share the prior sunk costs of harvesting, preparation, transport and storage of bio-based feedstocks.
- Disaggregated biorefineries are an alternative to large scale, central refineries.
- Incremental, **market responsive growth** vs big bang, disruptive growth.
- Multiple feedstocks, multiple processes, multiple markets = **resilience**.
- Large economic value in processing wastes with embodied, sunk costs
- BENEFITS -- energy security - price stability - decreased negative environmental impacts

Perceived Financial Barriers to Biorefineries

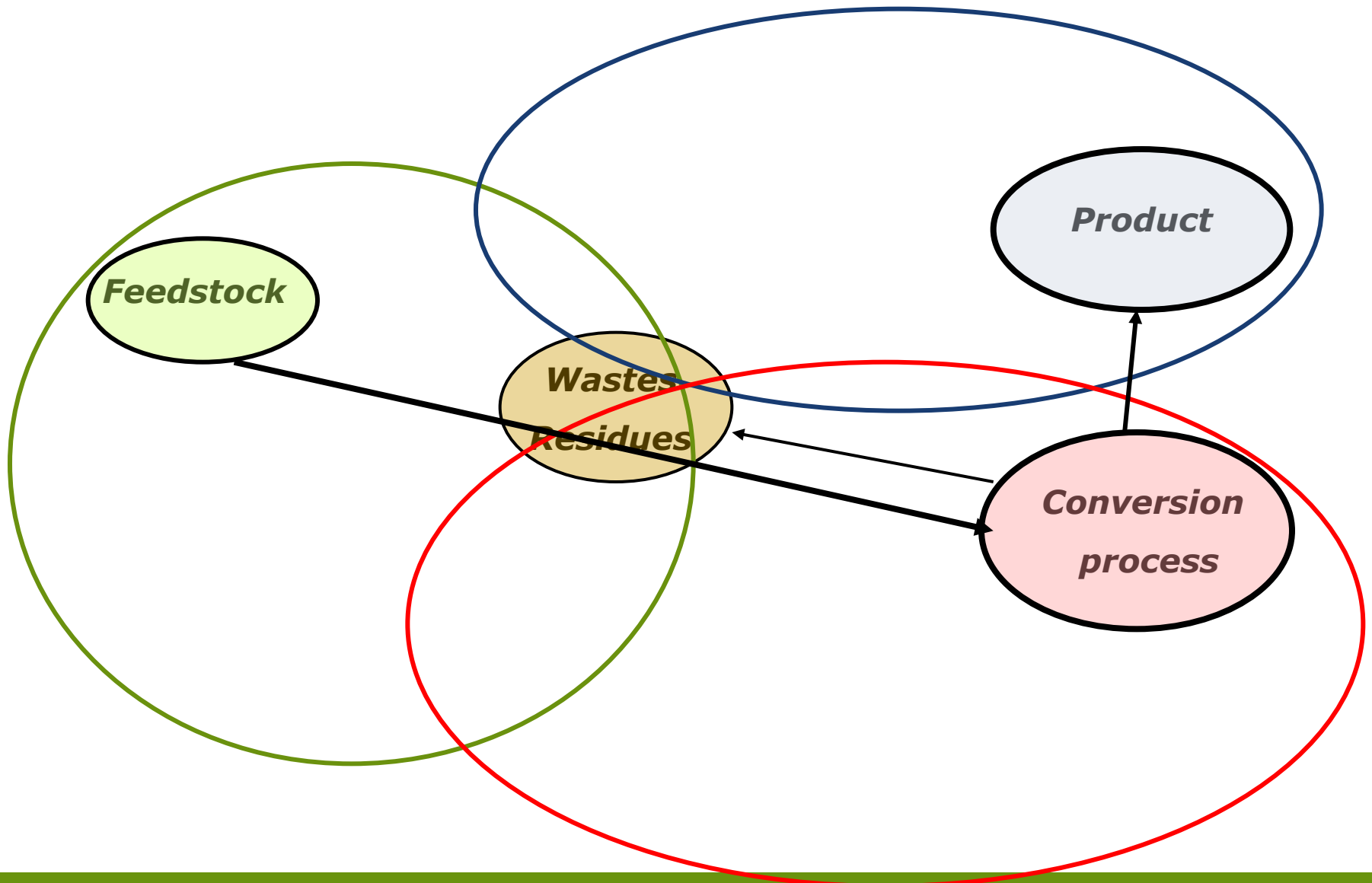


- Feed stock costs too high
- Operations costs too high
- Capital costs too high
- Availability of investment capital
- Insufficient revenue
- Established infrastructure of markets
- Environmental compliance costs too high or uncertain

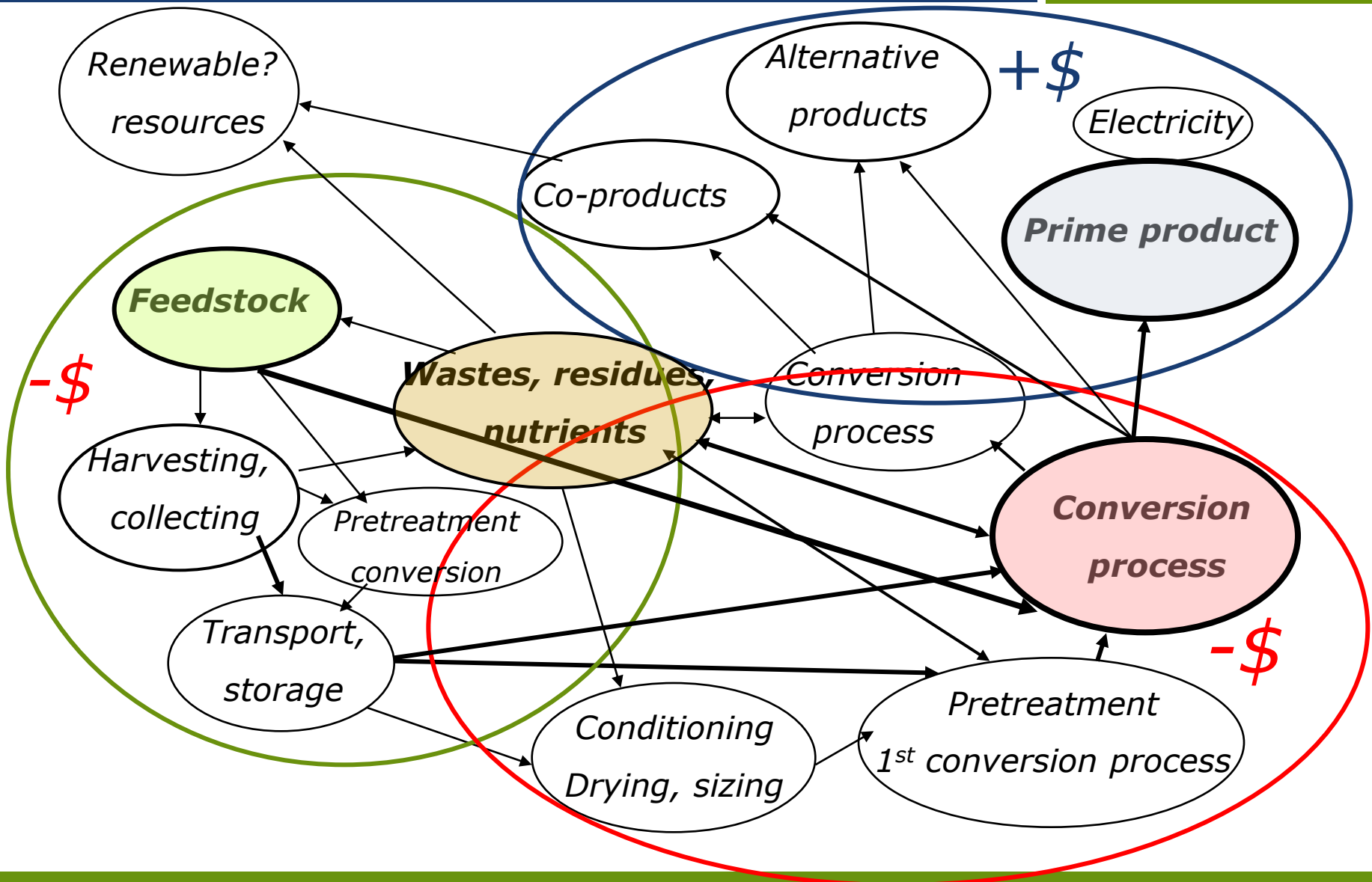


- Perceived barriers often reflect lack of awareness or analytical laziness
- SDTC projects develop solutions to problems, reduce costs and demonstrate viability
- Projects show progress on the implementation barriers
- Financing competitive innovations to overcome the barriers
- Surprises to conventional wisdom and rules of thumb
- SDTC buys down risks and uncertainties which have been unacceptably high for conventional investment analysts

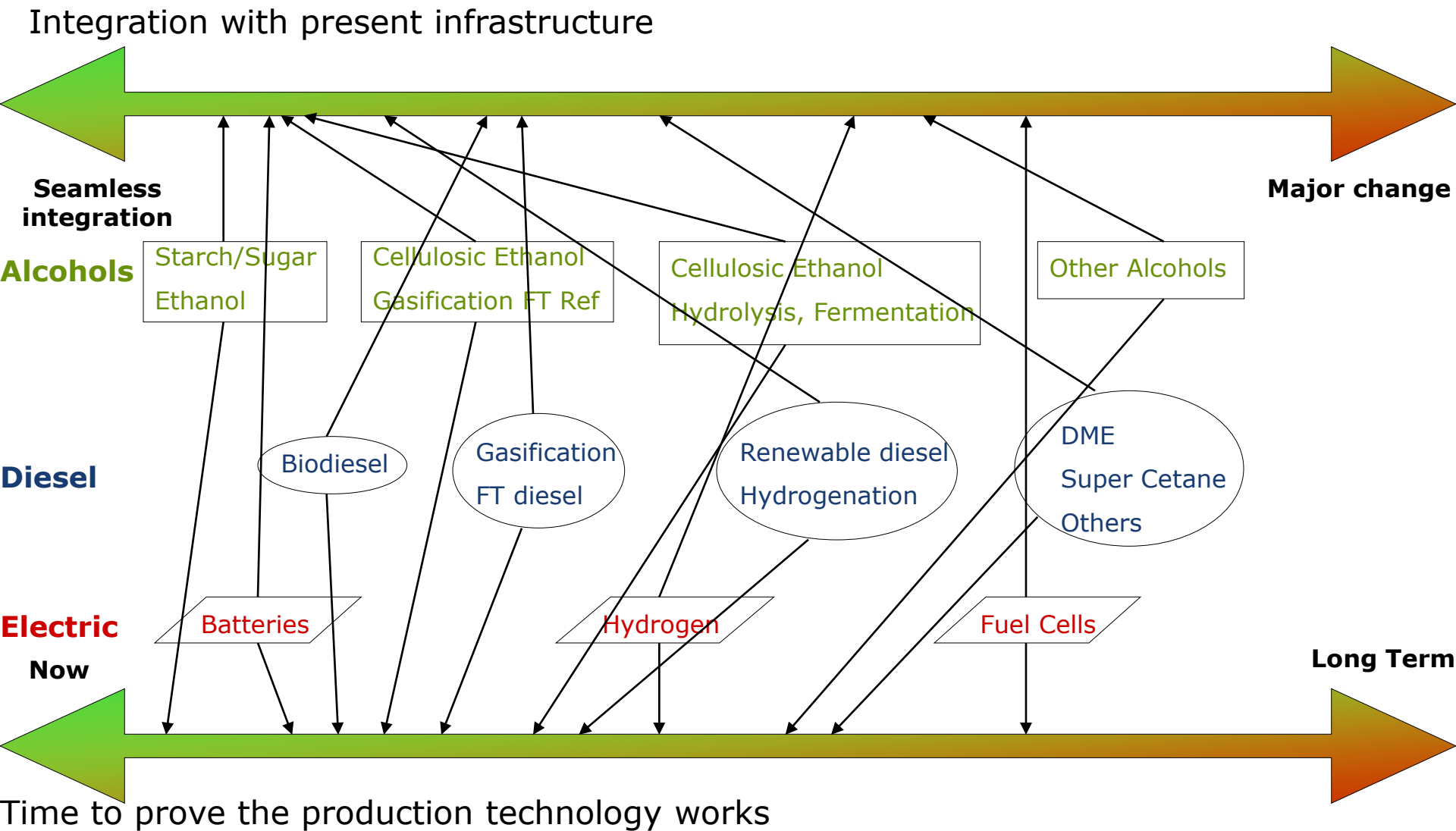
Simple model of Biorefineries



BioRefinery technologies – life cycle



Integration of low-carbon fuels in the existing transportation infrastructure in Canada



SDTC -- Bio-Based Innovative Technology Projects -- Areas of Impact



Feedstock Supply		Conversion Processes					Products, End Use, Markets				
Growing, harvesting, collecting, transporting	Pretreatment, Drying, comminuting	Fractionation, Digestion	Transesterification, hydrolysis, fermentation	Combustion	Gasification	Pyrolysis	Conversion, Purification	Power	Thermal	Products, Liquid Fuels	
Mikro-Tek Inc.		Bio-Terre Systems					Radiant Technologies		Bio-Terre Systems	Bio-Terre Systems	Medium
		Highmark Renewables						Highmark Renewables	Highmark Renewables	Highmark Renewables	Large
						Enerkem Technologies (1)	Enerkem Technologies (1)			Enerkem Technologies (1)	
						Ensyn Technologies	Ensyn Technologies		Ensyn Technologies	Ensyn Technologies	
						West Lorne Co-Gen		West Lorne Co-Gen	West Lorne Co-Gen		
	Paradigm Environmental	Paradigm Environmental						Paradigm Environmental	Paradigm Environmental		
		Lignol Innovations	Lignol Innovations				Lignol Innovations			Lignol Innovations	
		BIOX Canada Ltd.	BIOX Canada				Whitefox Technologies			BIOX Canada	
	Atlantic Packaging Products						Atlantic Packaging Prod		Atlantic Packaging Prod	Atlantic Packaging Prod	
							Great Northern Power	Great Northern Power	Great Northern Power		
							Vaperma		Alternative Green Energy Syst		
		AirScience Technologies					AirScience Technologies			AirScience Technologies	
Nutriloc	Nutriloc					Nexterra Energy			Nexterra Energy Corp*	Nutriloc	
						Plasco Trail Road		Plasco Trail Road	Plasco Trail Road		
		Bio Vision Technology	Bio Vision Technology				Bio Vision Technology			Bio Vision Technology	
	Mechtronix	Mechtronix								Mechtronix	
	Enerkem Technologies (2)					Enerkem Technologies (2)	Enerkem Technologies (2)			Enerkem Technologies (2)	
	Biothermica Technologies					Biothermica Technologies		Biothermica Technologies	Biothermica Technologies		
Milligan Bio-Tech	Milligan Bio-Tech		Milligan Bio-Tech				Milligan Bio-Tech			Milligan Bio-Tech	
						HTC Hydrogen Tech	HTC Hydrogen Tech			HTC Hydrogen Tech	
						Woodland Chemical	Woodland Chemical	Woodland Chemical	Woodland Chemical	Woodland Chemical	
Menova Energy	Menova Energy		Menova Energy				Menova Energy			Menova Energy	
Vidir Biomass	Vidir Biomass			Vidir Biomass				Vidir Biomass	Vidir Biomass		
		Corporation HET							Corporation HET	Corporation HET	
	Elementa					Elementa		Elementa	Elementa		
	Growing Power Harry Hill	Growing Power Harry Hill	Growing Power Harry Hill				Growing Power Harry Hill	Growing Power Harry Hill	Growing Power Harry Hill	Growing Power Harry Hill	
Aboriginal Cogeneration						Aboriginal Cogeneration		Aboriginal Cogeneration	Aboriginal Cogeneration		
Biodiesel Reactor Tech	Biodiesel Reactor Tech		Biodiesel Reactor Tech				Biodiesel Reactor Tech			Biodiesel Reactor Tech	
Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy				Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy	
Performance Plants		Performance Plants	Performance Plants							Performance Plants	
Greenfield Ethanol	Greenfield Ethanol	Greenfield Ethanol	Greenfield Ethanol							Greenfield Ethanol	
	Innovente	Innovente		Innovente			Innovente			Innovente	



- Implementation requires an **unbroken innovation chain**
- Must be a **+ve value proposition** to each participant in the new innovation chain
- Viability depends on monetary values
- Many innovators unaware of the enabling capacity of innovations in other links of the innovation chain
- Financiers even less aware
- Too many opportunities which involve integration of several technologies fail to proceed because some one tries to extract excessive profits



- SDTC requires quantification of environmental impacts
- Reveals many non-monetized benefits
- Many governments' policies and incentive/assistance programs have specific restrictive criteria
 - They need to be outcome or performance based relating to broader sustainability mandates
 - Incentive/assistance needs to be transferable or collaborative
- Many regulations have pass or fail criteria and do not credit improvement in sustainability or performance

Types of bio-based feedstocks & sources



Source	Type	Examples
Forestry	Logging residues	Tops, branches, culls, slash, stumps
	Environmental forestry	From plantations; prunings, thinnings Weed species, inferior trees, brush, scrub from stand improvement and clearings
	Energy crops Urban forestry	Fast growing species, harvested for energy such as hybrid poplars, willow Prunings, thinnings, removals, landscaping by municipalities, utilities, developers
Farming, agriculture	Crop residues	Stalks, straw, chaff, shells, stover, husks, branches,
	Energy crops	Purpose grown crops; switch grass, Jerusalem artichoke, Kochia, Vegetable oil seeds for biodiesel; canola, soybean, mustard, flax Sugar and starches for alcohols; sugar beets, corn, cereal grains Distressed seeds unsuitable for food processing; all of the starches and oil seed crops New varieties and species with characteristics for specific products
	Animal manures Animals	Manures and bedding; cattle, pigs, chickens, fish, marine animals, etc. Dead stock, offal
Forest products industry wastes/residues	Pulp & paper	Bark, rot, hog fuel, sludges, spent pulping liquors
	Wood Products industries	Bark, sawdust, shavings, sander dust, culls, trim, ends, lily pads, shorts,
Food & beverage	Crop processing	Stalks, straw, chaff, shells, stover, husks, branches, Etc., if delivered to the processor Seeds, pits, cores, peels, shells, skins, etc. Pulp, sludges, brine, wash water, chemicals, solvents, off gasses
	Animal processing	Offal, skins, bones, blood, fat, renderings, tallow, fur, feathers, shells, scales Brine, wash water, solvents, off gasses,
Industrial, Commercial, Institutional (ICI) wastes		Includes all of the forest and food products industries identified above Construction and Demolition wastes Paper, plastics, furniture, food, manufacturing wastes, etc.
Municipal	Municipal Solid Wastes	Household wastes
	Municipal organic wastes	Putricibles, food, gardening,
	Sewage	Sewage, sewage sludge waste activated sludge
Special organisms		Algae, bacteria, E. Coli, micro-organisms

Inputs – Feedstocks – Biomass – Crops – Materials handling



- Innovations

- New crops
 - Performance Plants & other genomics companies – hardier crops, higher yields, product characteristics
 - Microtek – enhanced growth, poorer quality land
 - Menova Energy – Solar Concentrating Photo Bio-Reactor for rapid algae growth for biodiesel
 - Paragon Soil – organic pellet injection for land reclamation
- Farm & food processing residues
 - Greenfield Ethanol & others – corn cobs, stover, fibre for cellulosic ethanol
 - HighMark, BioTerre – manure for anaerobic digestion biogas and cogeneration
 - Milligan – off grade canola for biodiesel
 - BIOX – greases, used cooking oils, tallow, veg oils for new biodiesel process
 - Atlantec Bioenergy – sugar beets for crop rotation and ethanol production supplemented by tropical cane sugar
 - Vidir/Entropic – straws with high silica content for combustion, cogeneration
 - Ostara – struvite for soil nutrients
 - Prairie Pulp & Paper – wheat & flax straw for paper
 - Nutriloc – low grade fruits & vegetables for superior micro-wave drying
 - Middle Bay Aquaculture – fish feces for fertilizer



- Forest & agriculture & processing industry residues
 - Lignol – residues and beetle killed Lodgepole pine for ethanol & co-products
 - Aboriginal Cogeneration – used railway ties for gasification
 - Innovente – farm wastes, manures, sewage sludges and pulp mill sludges for anaerobic digestion (AD) to dry combustion fuel
 - Ensyn, Dynamotive – wood wastes for pyrolysis to liquids and char
 - Advanced BioRefinery – forest and wood wastes for pyrolysis
 - Alterna Energy – forest and wood wastes for carbonization
 - Atlantic Packaging – recycled coated papers for energy and kaolin
 - ARC Resins – lignin free pulps for more durable, non-polluting railway ties
- MSW, ICI wastes, sewage, manures
 - Paradigm Environmental – waste activated sewage sludge (WAS) for accelerated AD
 - BIOX – waste cooking oils and greases for biodiesel
 - Enerkem, Biothermica, Woodland, Elementa, Plasco, Terragon – heterogeneous biomass (MSW, ICI, C&D, treated wood) for gasification to syngas for cleaning for fuel or catalytic reformation for many uses
 - HighMark Renewables – cattle manure for AD
 - BioTerre – pig manure for AD

Project with impacts on biomass feedstock



Type of feedstock, Growing, harvesting, collecting, transporting		Pretreatment, Drying, comminuting
Mikro-Tek Inc.		Enerkem Technologies
		Paradigm Environmental
		Atlantic Packaging Products
Nutriloc		Nutriloc
Innovente		Innovente
		Mechtronix
Advanced Bio-Refinery		Advanced Bio-Refinery
HTC Hydrogen Tech		Enerkem Technologies (2)
		Biothermica Technologies
Milligan Bio-Tech		Milligan Bio-Tech
Menova Energy		Menova Energy
Vidir/Best Biomass		Vidir/Best Biomass
		Elementa
Performance Plants		Growing Power Harry Hill
Aboriginal Cogeneration		Aboriginal Cogeneration
Biodiesel Reactor Tech		Biodiesel Reactor Tech
Atlantec BioEnergy		Atlantec BioEnergy
Greenfield Ethanol		Greenfield Ethanol

Small

Medium

Large



• Thermochemical

- Fractionation – TMP pulping, explosive defibration, sonic deceleration
 - BioVision
- Combustion – direct heat, boilers, flue gasses, particulates – Vidir
- Gasification – syngasses (of CO, CO₂, H₂, other minor gasses), cogeneration, ashes
 - Enerkem, Woodland, Elementa, Biothermica, Aboriginal Cogeneration, Nexterra, Terragon
- Pyrolysis, carbonization – gasses, liquids, char
 - Ensyn, Dynamotive, Advanced BioRefinery, Alterna
- Plasma – syngasses, cogeneration, vitrified slag -- Plasco
- Transesterification – biodiesel -- BIOX, Milligan, Biodiesel Reactor
- Hydrogenation
- Chemical conversions – Lignol, BioVision, Ensyn
- Catalytic reformation – FT catalysis and others
 - Enerkem, Woodland, Elementa, HTC Hydrogen
- Purification, separation, membranes, absorption, gas cleaning
 - Vaperma, Whitefox, Lignol, Enerkem, Aboriginal Cogeneration, Nexterra, Biothermica,
- Extraction of components – functional foods, essential oils, nutraceuticals, medicinals
 - Nutriloc



- Biochemical

- Fractionation into cellulose, hemi-cellulose, lignin – explosive defibration, organosolv
 - Lignol, BioVision, Greenfield Ethanol
- Aerobic digestion -- fertilizer
 - Innovente, Mechtronix
- Anaerobic digestion – biogas, landfill gas
 - Highmark Renewables, BioTerre, Growing Power Hairy Hill, Atlantec
- Sugar, starch, fermentation – ethanol and co-products
 - Atlantec, Growing Power, Greenfield Ethanol
- Cellulosic hydrolysis and fermentation – ethanol and co-products
 - Lignol, Greenfield Ethanol
- Chemical conversion, chemicals, co-products
 - Lignol, BioVision, Greenfield Ethanol, EcoSynthetix, HTC Hydrogen

Projects with processing innovations



Fractionation, Digestion	Transesterification, hydrolysis, fermentation	Combustion	Gasification	Pyrolysis
Bio-Terre Systems			Enerkem Technologies	Ensyn Technologies
Highmark Renew ables				DynaMotive Energy Syst
Paradigm Environmental			Nexterra Energy	
Lignol Innovations	Lignol Innovations			Advanced Bio-Refinery
BIOX Canada Ltd.	BIOX Canada		Plasco Trail Road	
AirScience Technologies			Biothermica Technologies	
Innovente		Innovente		
Bio Vision Technology	Bio Vision Technology		Enerkem Technologies (2)	
Milligan Bio-Tech	Milligan Bio-Tech		HTC Hydrogen Tech	
Mechtronix	Menova Energy		Woodland Chemical Syst	
Corporation HET	Biodiesel Reactor Tech			Small
Grow ing Pow er Harry Hill	Grow ing Pow er Harry Hill	Vidir/Best Biomass	Elementa	
Atlantec BioEnergy	Atlantec BioEnergy			Medium
Performance Plants	Performance Plants		Aboriginal Cogeneration	Large
Greenfield Ethanol	Greenfield Ethanol			



- Fuels for stationary and motive power
 - Device
 - Spark ignition engines
 - Compression ignition engines – diesel
 - Turbines
 - Furnaces, boilers, heaters
 - Types of fuels
 - Alcohols – ethanol, methanol, butanol, higher alcohols,
 - Gasses -- hydrogen, syngas, biogas
 - Renewable diesel
 - Biodiesel
 - Green diesel -- hydrogenation
 - Fischer-Tropsch diesel
 - Upgraded biogas and landfill gas
 - DME Dimethyl Ester
 - Pyrolysis liquids
 - Solid fuels
 - Pyrolysis chars, charcoal
 - Hog fuel, chips, legacy wood wastes, straws,
 - Pellets, cubes, briquettes
- Electricity, co-generation



- Solid and composite products
 - Railway ties,
- Reconstituted fibre, recovered fibre
 - Textiles from flax or hemp, paper
- Soil nutrients, fertilizers
- Platform chemicals
 - Furfural, acetic acid, methanol, polyols, glycols, glycerine
- Lignin
 - Resins, food and feed additives
- Hemi-cellulose
 - Alcohols, furfural, many chemicals
- Plastics
 - PLA, PHA, polyols
- Foods & feed
 - distillers grains, enriched and enhanced meal, extractives, essential oils,

Projects with product innovations



Conversion, Purification	Power	Thermal	Products, Liquid Fuels	Nutrients
Radient Technologies		Corporation HET	Corporation HET	Bio-Terre Systems
Enerkem Technologies	Paradigm Environmental	Paradigm Environmental	Mechtronix	
Ensyn Technologies		Ensyn Technologies	Ensyn Technologies	
Bio Vision Technology	DynaMotive Energy Syst	DynaMotive Energy Syst	Bio Vision Technology	
Lignol Innovations			Lignol Innovations	
Whitefox Technologies			BIOX Canada	
Atlantic Packaging Prod		Atlantic Packaging Prod	Atlantic Packaging Prod	
Great Northern Power	Great Northern Power	Great Northern Power	Nematrol/Peacock?Mustard Capital	Nematrol/Peacock?Mustard Capital
Vaperma		Alternative Green Energy Syst	Nutriloc	
AirScience Technologies		Nexterra Energy Corp*	AirScience Technologies	
Innovente			Innovente	Innovente
	Plasco Trail Road	Plasco Trail Road Inc.	Plasco Trail Road	
		Advanced Bio-Refinery	Advanced Bio-Refinery	
Enerkem Technologies (2)	Biothermica Technologies	Biothermica Technologies	Enerkem Technologies (2)	
Milligan Bio-Tech			Milligan Bio-Tech	
HTC Hydrogen Tech			HTC Hydrogen Tech	
Woodland Chemical Syst	Woodland Chemical Syst	Woodland Chemical Syst	Woodland Chemical Syst	
Menova Energy	Vidir/Best Biomass	Vidir/Best Biomass	Menova Energy	
Elementa	Elementa	Elementa		
Growing Power Harry Hill	Growing Power Harry Hill	Growing Power Harry Hill	Growing Power Harry Hill	Growing Power Harry Hill
Aboriginal Cogeneration	Aboriginal Cogeneration	Aboriginal Cogeneration		
Biodiesel Reactor Tech			Biodiesel Reactor Tech	
Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy	Atlantec BioEnergy
Greenfield Ethanol			Greenfield Ethanol	Performance Plants

Small

Medium

Large



- Disaggregate refineries into **stages** with processes located to minimize costs
 - Transport intermediate industrial products
- Modules do not have to be co-located nor directly connected.
- **Reduce transport, materials handling & storage costs.**
 - Remove the water content as close as possible to the source
 - only the valuable ligno-cellulosic material, starches, oils, organic wastes or intermediate industrial goods should be transported.
 - Densification, pelletization, compaction, voids reduction
- **Distributed small scale** primary processing locations for intermediate products for further processing at downstream biorefineries – hub and spoke.
 - Pyrolysis, gasification, defibration/fractionation, densification/pelletization, crushing & oil separation



- **Resilience**
 - Not dependent on one feedstock
 - Not dependent on one output or one buyer
 - Responsive to changing market demand
- Model works at the typical biomass production **scale** such as a mill, farm or group of farms, or community scale.
 - Many small scale primary conversion units can supply few, later stage, large scale, conversion plants.
- Financing can be done locally for which ever group has a problem and/or sees an opportunity.
- **Organic growth model** – processes or stages added as markets grow and opportunities arise.
- The reduction in front end costs of feedstock is often greater than the economies of scale of very large conversion processes.



- SDTC funds a portion of the innovations which make the new bio-economy possible
- There are many great innovations
- Do the hard work – check out the innovations and their impacts on financial viability and the environment
- Take a sustainability approach



Questions?

For more Information:

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