Building Alberta's Bio-Industrial Talent Pool

Proceedings from the
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Overview:

In early October 2012, in Banff, the Alberta Biorefining Conversions Network (BCN) brought together approximately 85 senior leaders from industry, academia and government to discuss current global bioindustry landscape, the projected bioeconomy workforce and existing bioindustrial education programs; and develop a path forward for program development and workforce creation in Alberta. Experts from Europe, USA and across Canada attended plenary sessions addressing leading examples of the Bioindustry development from around the world, then met in dialogue sessions to identify and define the skill sets needed in the Bioindustry, assessing whether or not there are alignments with current programs and what other types of programs (i.e. internships) would be useful for industry.

Alberta has a unique natural wealth of conventional oil and gas, plus the oil sands; however it also has strong agriculture and forestry industries, related manufacturing/processing resources, high quality universities and community colleges, and access to a well-educated workforce. This combination of factors is ideal for further diversification of the Alberta economy, and growth of more value-add products from existing forestry and agriculture industrial segments as an important engine of economic output and increased prosperity.

The need to start now

Given the time it takes to develop and implement robust and complimentary training programs, action to build a strong bioindustrial workforce must begin now so that the availability of talent aligns with bioindustrial ramp-up and expansion. In order to create the right programs, it is important to engage industry and get feedback on where the sector is heading and the types of skilled workers and professionals needed to support the sector.

The Banff Workshop and this Proceedings document will address:

- What are the core competencies and skills that industry is looking for in High Quality Professionals (HQP) and skilled labour for the emerging bioeconomy?
- Current and forecasted local demand for a bioeconomy workforce?
- The bioindustrial landscape, in regards to workforce in other jurisdictions; and thus what is it projected to look like in Alberta.
- What institutions have programs dedicated to training HQP in the bioindustrial space? Have they been successful?
- What are the short and long term forecasts for both education and industry requirements?
- What can we learn from existing examples of programming in this space?
- What are the steps and timelines around implementing new programming? Do these align with industry?
- Is there any alignment between bioindustrial skills required by industry and the current system?
- What are the best paths forward?

Executive Summary:

Alberta's bioindustry is an important emerging sector for a province rich in natural resources and agricultural/forestry producing lands. It will leverage the province's competitive advantages including a strong economy, a highly-skilled and technical labour force, extensive pipeline and global distribution infrastructure, world-class research centers, and an abundance of natural resources, biomass and water.

Further it provides Alberta with the ability to create higher-value products from its existing *21.1 million (M) hectares (ha) of land used for crop and livestock production and 35.2M ha of land that is publicly managed for timber production and a range of ecosystem services. Alberta is Canada's second-largest agricultural producer, leading the nation in cattle inventories and producing over a third of Canada's major field crops. With over 200 facilities in operation, Alberta's forest industry manufactures lumber, pulp, newsprint, panel board and other products. The province's renewable biomass resources include 64.2M tonnes (T) from agriculture sources, 0.9-1.2M m3 of under-utilized forest biomass and roadside residue, 4.03M T from municipal waste and 78,000M T of slowly renewable peat.*
(Source: Government of Alberta/Alberta Innovates)

Alberta's evolving bioindustry is comprised of approximately 50 companies in biomaterials, 7 in biochemical, and 14 in bioenergy, generating over $230 million revenues/year. Bioindustry products and services include:

- Bioethanol, biodiesel, jet fuel, lubricating oil, and more from animal fat & crop seed oils
- Neutriceuticals, functional foods, non-sugar sweeteners and cosmetics from forestry, specialized crops and crop seeds
- Polyols (from canola oils) which get used for auto dashboards and headliners, rigid foam insulation for buildings, seals, gaskets, adhesives, etc.
- Bioremediation for oil sands, water quality purification of phosphorous, nitrogen, mercury
- ENERGY from various biomass conversion processes

Realizing Bioindustry Potential Requires Co-ordinated Educational Initiatives Now
There was strong support amongst workshop participants for taking immediate action in developing the key higher education ingredients for growth of this sector and mobilization into world-class, collaborative initiatives. The process of creating new educational programs will take several years to accomplish and then start graduating entrants into the bioindustry workforce; thus we must start now.

<u>Conclusions:</u>

1. The creation of a generalist, undergraduate bio-resources degree (BSc./ BSc. Eng) IS possible and has strong cross-institutional desire to proceed.

<u>Recommendations:</u>

Adaptation of an existing degree program to create a new "Major"

Development of a new cross-faculty, even cross-institutional "Program".

Bring together resources from various Faculties – joint programming, perhaps across 3 universities. Utilize lab space that is already available; identify additional resources to pull program together.

2. Clarify target audience for this program and build business case.	Involve bioindustry leaders, government and other external stakeholders to support/fund.
3. Enhance existing technologist programs to provide for focus on bioindustry application.	Add soft skills (project management, economics, entrepreneurship), co-op placements and specialty "Certificates"

Alberta's colleges are already very pro-active in their program adjustments. Creating a bioindustry specialty program should be relatively easy, and also adding specialty certificates could not only round-out a 2-year program, but these certificate programs can be used for professional development/update programs for those already in the workplace looking to transition into the bioindustry.

Alberta's universities have a number of complimentary programs and courses in existence now. Further, they have lab space and faculty knowledge. University leaders present at the conference indicated a clear interest to work together on a bioindustry program initiative, starting at the undergraduate level. Presentations from guests from Europe had some excellent advice and examples for Alberta academics to reference in their own efforts.

A caution to both colleges and universities was enunciated by participants: Avoid saturating the marketplace with graduates before the bioindustry growth is there to support them. Start small, and grow in-synch with the industry. In fact, it will be important for educators to collaborate and engage bioindustry leaders in both program design and content delivery.

Finally, loud and clear were the recommendations from other jurisdictions and industry alike – programs need to be cross-functional; incorporating bio-science related courses, and also including broader, softer skills areas such as: economics, business/marketing, international trade and regulatory environments, and communications.

Presentation & Dialogue Synopsis:

Alberta's bioindustry 70 companies, generate over $230 million revenues/year. The bioindustry products & services include:

- Biofuels: bioethanol, biodiesel, jet fuel, lubricating oil, and natural gas from animal fat & crop seed oils
- Neutriceuticals, functional foods, non-sugar sweeteners and cosmetics from forestry, specialized crops and crop seeds
- Polyols (from canola oils): polyesters, polymides, polyurethanes which get used for auto dashboards and headliners, rigid foam insulation for buildings, seals, gaskets, adhesives, etc.
- Bioremediation for oil sands, water quality purification of phosphorous, nitrogen, mercury
- ENERGY from various biomass conversion processes

Bioindustry Skills and Competencies Requires Cross-Functionality

When considering the key jobs in this sector developing towards 2020, they will include many different types of skills. For the purpose of this paper however, we concentrated on the following High Quality Professionals (HQP's):

- Primary producers: agriculture, forestry & biomass farmers/crop managers
- Trades: electricians, plumbers, machinery, other
- Technologists (primarily) and technicians
- Research scientists
- Engineers

Key phases in the bioindustry which require different applications, competencies and understanding by these job types, plus an ability to work across different functions and professionals are identified as:

Producing – breeding, agri-/silvi-culture, harvesting, storage and transportation logistics

Exploiting/Processing – extraction, enzymatic/chemical/thermal treatment, gasification

Transforming – using biotechnology, chemistry into end products

Managing – Commercialization, to market, cost/growth

In developing these competencies, whether at the technician, undergraduate or graduate levels, some common characteristics should be incorporated in all programs. These include:

1. ***Cross-Functionality***: in developing talent, especially HQP's for bioindustry, we need to balance *specialist* training with *generalist* understanding across the various dimensions of bioindustry.
2. Ensure bioindustry competencies, in whichever area of career or academic development, address understanding of the different phases of the bioindustrial processes: ***Biomass Production***, ***Exploitation & Processing***, ***Transforming***, and ***Business Management***.
3. ***Ensure theory and skills development is augmented with real-life problem-solving*** capacity development. Theory isn't enough, and case studies plus experiential modules should ensure the development of application and problem-solving intelligence.

4. ***Leadership from a consortium of industry to raise the industry profile*** politically, find funding to create university Academic Chairs, build a higher profile for the industry with on-campus recruitment, and get involved in the programming with faculty and institutions.
5. ***Leverage sustainable competitive advantage: focus Alberta bioindustry competency development on areas that can leverage off Alberta's energy industry and positioning***; and/or provide support to their unique challenges and their supply chain/network needs; and/or tap into their image or corporate social responsibility commitments or assist with 'waste' resources. While the Bioindustry can in fact diversify the economy, we would be wise to leverage off the existing major focus, drive and economic engine that we already have in place.

Rethink Assumptions of Traditional Bio-industry Towards *NEW* Bioindustry:

The potential of future bioindustry will only be fully realized if we change our perspective of our traditional approaches to agriculture and forestry, rethink such things as priority crops for the older applications/market, and adapt past priorities and land-use assumptions.

- ***Need to shift our emphasis in Alberta towards bioindustry benefit/potential***:
  Traditional forest products → Natural forest land base for higher value products
  Future products → nano-crystals, faster-growing hybrid feed stocks, energy, oils, etc.
  Modify focus to crops more in-line with bioindustry, faster growing, harvested earlier in lifecycle
  Organize to produce value-added elements beyond conventional/commodity products
- **Primary producers should *shift to***:
  - Reduction in waste
  - Find new uses for existing stock instead of playing to traditional and decreasing markets; for example, sell barley into fuel conversion instead of relying on the "malt lottery" for breweries
  - Tallow high value products
  - Seed oil high value products
  - Lifecycle analysis plus better crop selection for different land types
  - Better breeding/ planning for crop outputs
  - Material handling to address seasonality of supply and wet/decay issues

Priority competencies to develop in the different profession/programmatic areas include:

- **Trades:**
    - Bioindustry has different application understanding from other industries such as oil and gas or mining.
        - Early fermentation
        - Different analysers
        - Different biotics
        - Stainless steel processing units
        - Contamination & structural work is different
    - Expand focus: i.e. heavy duty mechanics expanding knowledge into fluid mechanics
    - Start multi-disciplinary requirements for programs and achieving journeyman papers: i.e. agriculture bio processes + engineering knowledge + biomass, transformation + expanded thinking in application of technical knowledge

- **Technologists:**
    - More multi-disciplinary technologies & instrumentation
    - Some added economics/business, project management competency
    - Support system for small and mid-sized enterprises (SME's)
    - More responsibility for problem-solving so as to handle 'routine' challenges (whereas difficulties or exceptions to routine go to engineers to handle)
    - Work in/lead cross-functional teams
    - Potentially move in from other sectors and need "re-set"
    - Rapid re-training & re-tooling mechanisms

- **Sciences**:
    - "Green" chemistry → lifecycle analysis, water efficiency
    - Reduced environmental impact
    - High-value end of biomass opportunities
    - Wide variety in Bioindustry – fermenting, virology, biotech
    - Conventional Focus → expanded/applied to new areas, natural health products
    - Again, multi-disciplinary, theoretical + practical application
    - Post-grad → more 'fluid' specializations

- **Engineers:**
    - Need to understand more bio-processes, build this into 4-year B.Sc. programs
    - Raw materials coming in → biomass handling & transport
    - Plant-wide process knowledge: know petro/chemical AND bio-systems
    - Adaptability → added knowledge in business, communications, economics
    - Multi-disciplinary in thinking and experience/assignments

Program Design Recommendations:

- **Alberta Technologists Program Development**:
    - Programs more defined by desired outcomes
    - Align to value/outcome – i.e. 100% use of skills and uptake of graduates
    - Include soft skills (project management, economics, entrepreneurship)
    - Specificity vs. mix 'n match
        - Deep-dive with co-ops
    - Why is 2-year program sacred? Perhaps co-ops/continuing-education?
    - Added "Certificates": Life Cycle Analysis
      (International) Biomass Technology
      Uniform Bio-conversion/Bio-refining Technology
      Quality Assessment/ Quality Control

  Conclusion: look at ways to augment existing programs to add bioindustry applications. Also, be sure to grow program offerings slowly, so as not to over saturate the industry with graduates.

- **Alberta Science/Engineering Degree Programs Development:**
  Hon BSc. Bio Resource Program – Integrated Business-Science Program
  Hon BSc. Bio Industry Technology
  Hon BSc. Food Science – Adapted towards BioIndustry

  Ensure labs and real-life industry application (capstone) courses are designed for students to apply to solutions for bioindustry. Decide what are the foundation Programs:
  B.Sc.? Food Sciences? Engineering? Business? Agriculture?
  Hybrid programs across different faculties?

Generalist Undergraduate Bio-Resources Degree

Core Program 1st & 2nd Year Basic Elements	**Minors/Majors** 3rd & 4th Year Specialization/Focus
• statistics • microbiology • molecular biology • genetics • organic chemistry – extraction/purification • chemical/biochemical conversions • genetically modified organisms • entomology	• synthetic biology • fermentation • industrial microbiology • life cycle analysis • advanced materials science/handling • capstone: systems thinking type • processing/transformation of biomass • biofuels
Options/Electives • macro/micro Economics • business/marketing • strategic communications • international trade & regulatory environ • ethics	• Non- Thesis M.Sc. - BioProcess Engineering?

Program Design Conclusions for Generalist Undergraduate Degree:

1. This kind of program IS possible – and there is a strong desire to advance
2. It might be an adaptation of an existing degree – i.e. a new "major"
3. Could be a new cross-faculty "program"
4. Clarify target audience, then build the "business case"
5. Involve leaders from industry & government and other external partners
6. Bring together resources from various faculties – joint programming, perhaps across 3 universities. Lab space is already available

APPENDIXES

Bioindustry Competencies – Leading Practices

Presentations from industry leaders:

- **Trevor Nickel – GM, Highmark Biogas; Alberta**
  An entrepreneurial company, Himark is basically in the business of technology development and commercialization, selling digester/fermentation systems to communities and other companies around the world. Their technology takes waste such as livestock waste, crop residues, agriculture and industrial waste; and turns it into 'clean energy, re-useable water, soil and plant nutrients, ethanol, and more.

  As far as talent goes, Highmark Biogas today employs 8 engineers, 2 medical doctors, 3 accounting/finance professionals and a growing sales/client service team, since start-up in 2006.

  Their experience has shown the need for significant investment in training of general professionals into truly understanding/developing the bioconversion processes and business/community problem solving their technologies provide.

  Most specific to the focus of this white paper, their need for talent and competencies includes:
    - ***Cross-functionality*** (i.e. engineers that can also sell, plus problem solve and achieve 'pay-back' uniquely for each client)
    - ***Knowledge workers with a commercial focus*** and ability to roll-up sleeves
    - ***Commitment to the long term*** and growth pay-off (vs. 'fast reward')
    - Everyone understanding that ***all jobs includes sales***
    - ***Specialists that also understand the whole*** operations
    - ***Appreciation of unique risks and health concerns of microbiology/biotech*** compared to heavy industry or oil and gas industry.

- **Art Froelich – AdFarm Alberta Food Marketing & Communications; Alberta**
  Art also serves as a lead in the investor community, particularly private equity firms/consortia.
  From an investor perspective, these are their main concerns for the evolving Bioindustry:
    1. ***The Technology involved must be 'proven' to some degree***
       Investors are looking for technology that has already been trialed, found to work and has been scaled up somewhat – maybe pilot plant/operations of some proven volume
    2. ***The Company has sustainable comparative/competitive advantage***
       While Alberta does have significant agricultural and forestry resources, so do many other parts of the world. Private equity not interested in economic "diversification", they want to find economic "leverage" opportunities off such drivers as oil sands and energy markets.
    3. ***The technology and business has to be scalable*** – to other parts of the world, to truly become global in nature. Global thinking and attitudes in management and employees is crucial.
    4. ***Capital can move*** wherever today, so investors look for: availability of talent, low costs in tax and legal systems, relatively low costs for getting to global markets, and positive cash flow.
    5. ***Talent & People is crucial*** – international experience, trades people that are adaptable, senior scientists with operational experience, logistics expertise – to global markets, etc. Entrepreneurial Management and employees are a must.
    6. ***Liquidity of Capital*** – ability to see how and when investors can get their money out!

- **Manfred Kircher – Cluster Industrial Biotechnology 2021 (retired); Frankfurt, Germany**
  A scientist, businessman and professor, Kircher has championed the bioindustry around the world and delivered operational/business success as well in Germany and other European areas.
  His framework for the bioindustry identified 4 stages to bioindustry and the type of talent required in each phase:
    1. ***Biomass Production*** – requires experts/specialists in breeding robust feedstock (grains, trees, plantations) along with agriculture or silviculture (forestry) technicians/managers to maximize product, the efficient and effective harvesting, storage to address seasonal supply variation and transportation logistics. The human talent must understand not only how to produce effectively, but also to reliably meet industrial standards and scale expectations.
    2. ***Processing & Exploitation*** – will need technicians/trades, technologists, scientists and more that can work to efficiently isolate/maximize the useful components of the feedstock using chemistry, thermal techniques, manual/ mechanical separation, etc. to reach the useful components: fruits, seeds, fatty acids, starch, oils, high density biomass.
    3. ***Transforming*** – will require chemists and chemistry technologists to design, oversee and operate fermenters, polymerization; biochemists to work with microbes, enzymes, filtering, fractionation; engineers to create industrial processors, and measuring/monitoring systems to achieve economies of scale, enhance value from both primary and side products, and look to develop closed-loop systems where "waste" from one system is potential "food" for another.
    4. ***Business Management*** – entrepreneurs of various backgrounds and specialties that can maximize the 'business' success of each stage above, plus move product to global customers and value chains/networks, leverage intellectual property, court and secure investors, engage in sales, infrastructure financing/maximization, recruit, lead and manage for growth and adaptability. This type of talent is not just job/task "doers"; they are initiative-takers, cross-connectors, systems/network-thinkers, and trail-blazers/explorers! They must be able to lead from: idea → concept →commercialization →business growth & investor returns.

- **Jeremy Heigh – Sift Every Thing, Economists; Alberta**
  Economist and pattern explorer – looking for opportunities, separating fact from idealism – Heigh gave us a sense of realism as to the potential of the bioindustry in Alberta as it relates to Canada and the world business environment. Jeremy's key suggestions to the bioindustry development include:
    - Being in Alberta, it is all about ENERGY, so even though the Bioindustry sees biofuels, clean-energy, oils, natural gas; neutriceuticals, foods, fertilizers, cosmetics; plastics, polyesters, foams; waste and water remediation or management; in the end we need to contextualize our thinking in terms of ENERGY and leverage off this focus and "positioning" of Alberta – into existing economic networks, value chains, and relationships to world markets.
    - Need to look at 5 Fronts of Business analysis when looking at our bioindustry potential:
      - Natural Environment
      - Capabilities
      - Supporting Infrastructure
      - Constructed Environment, and
      - Industrial Ecosystem

- ***Forestry in Alberta*** → 35 million hectares, 74% of exports go to USA, no patents in last 10 years, 11 Associations and 31 Non Governmental Organizations (NGOs), 12 NSERC grants totaling $0.5million annually, 8% of Canadian industry companies are in Alberta, only 1% of GDP comes from Forestry sector, 65% of co's have less than 4 employee's. Opportunities? Leverage potential?
- ***Mining-Coal*** → most energy generated in Alberta comes from coal. 34 billion tonnes/year; employment up 46% since 2000, Coal Association of Canada is Alberta based, only 1 venture capital investment since 2006, NSERC has done 186 projects in Alberta since 2000, mostly oil-related, TransAlta a Top 200 company in Canada, minimal exploration, 30% of companies are "micro" 66% are "small" businesses.
- ***Agri-Food & Forestry Manufacturing*** → Alberta has abundant arable land, livestock habitat and forested land; close to USA – major consumer of food and wood products; labour productivity increase since 2000 18% for food 34% for wood products; > 50 agri-food associations, 42 forest products assoc; 2 venture capital deals since 2006, $287k NSERC grants since 2000, food products up 10% since 2000, wood products down 50%; 90% of food and wood product companies are "small"; GDP for food $2.2 Billion, $1.1 billion for wood product, $0.5 billion for pulp.
- ***Agriculture*** → 31% of agriculture land is in Alberta, producing 20% of total Canadian Agriculture value; 3% of Alberta GDP ($4.8billion); 19 patents since 2000, employment down 19% from 2009 – 2010, labour productivity up 6% annually since 2000; University of Alberta & University of Lethbridge strong support, Agrium in Canada's Top 200, 80% of firms have less than 4 employees; 37 NSERC projects approx. $1.8million each; aggressive biofuel incentives; competition with oil and gas for employees.
- ***Core Manufacturing*** (incl. non-metal fabrication, metal fabrication, construction) → feeds directly into oil industry, agriculture and forestry; metal fabrication & construction in growth mode, apprentices up 25% to 128%, 13 patents since 2000; 47 associations for construction, 24 in metal fabrication & machinery; 3 venture capital deals since 2006 in manufacturing, 1 in construction; of Top 200 companies, 9 in construction, 7 in manufacturing; GDP of $14.1B in construction,
- ***Chemicals & Petrochemicals Manufacturing*** → Chemical industry in Alberta eroded by ethane supply, "Oil" drives Petrochemicals; 3 chemical and 13 manufacturing patents annually, employment declining; 16 chemical/petrochemical associations, 12 research chairs in chemistry, 5 in chemical engineering; 8 venture capital deals in machinery, 1 in chemicals since 2006, NSERC very active; 2 chemical companies in Top 200, exports growing significantly; GDP $2.5billion chemicals, 2.3billion machinery, $729million from petrochemicals.
- ***Oil & Gas*** – 13% of proven global oil, regular + non-conventional gas is approx. 5%; 31 patents/year, productivity improving; strong provincial and national associations, strong research centers; 1/3 of all venture capital deals done in Alberta since 2006, 107 NSERC grants/year average $6.7million; 109 of Top 200 co's, Exports up 55% from 2000; 19% of GDP, labour critical issue.
- ***Diversify within our area of strength*** → Bioindustry should leverage off Energy sector; no interest in "alternatives"; play to the manufacturing side.
- ***Hire people who technically understand what needs to be done AND also understand business productivity/profitability***
- ***Areas of Potential Leverage Opportunity*** :

- Biopolymers to treat water and complement filtration → green fluids
- Fracing solutions and disposal → hydraulic fluids, cutting fluids, wastewater
- Land reclamation & abandonment services, bioremediation & spill recovery

Conclusions from the first morning's presentations

Several key themes emerged from these diverse presentations:

- ***Cross-Functionality***: in developing talent, especially HQP's for bioindustry, need to balance *specialist* training with *generalist* understanding across the various dimensions of Bioindustry.
- Ensure Bioindustry competencies, in whichever area of career or academic development, address understanding of the different phases of the Bioindustrial processes: ***Biomass Production***, ***Exploitation & Processing***, ***Transforming***, and ***Business Management***.
- ***Ensure theory and skills development is augmented with real-life problem-solving*** capacity development.
- ***If the Bioindustry really wants improved academic development, then a consortia of industry should come together to raise the issue*** politically, find funding to create Academic Chairs, build a higher profile for the industry with on-campus recruitment, and get involved in the programming with faculty and institutions.
- ***Mid-sized companies are the most attractive to investors***; government and institutions can play an important role in nurturing small businesses into mid-sized, and taking conceptual technologies into trials and pilot-implementations that can prove scalability and viability on an industrial scale.
- ***Leverage sustainable competitive advantage: Focus Alberta Bioindustry competency development on areas that can leverage off Alberta's Energy industry and positioning***; and/or provide support to their unique challenges and their supply chain/network needs; and/or tap into their image or corporate social responsibility commitments or assist with 'waste' resources.

Bioindustry Competencies – What Industry Needs

From industry, academia and other participant break-out discussion groups.

- **Need to shift our emphasis in Alberta towards bioindustry benefit/potential:**

  Traditional forest products → Natural forest land base for higher value products

  Future products → nano-crystals, faster-growing hybrid feed stocks, energy, oils, etc.

  Modify focus to crops more in-line with bioindustry, faster growing, harvested earlier in lifecycle

  Organize to produce value-added elements beyond conventional/commodity products

  New types of jobs vs. re-tooling existing with technology to get better diversity of products

  i.e. Organic chemists → mandates from oil and gas clients → at least 5% biofuels

  → shift "bench research" thinking to "commercialization" thinking

- **Primary producers should shift to:**
  - Reduction in waste
  - Find new uses for existing stock instead of playing to traditional and decreasing markets; for example, sell barley into fuel conversion instead of relying on the "malt lottery" for breweries
  - Tallow high value products
  - Seed oil high value products
  - Lifecycle analysis plus better crop selection for different land types
  - Better breeding/ planning for crop outputs
  - Material handling to address seasonality of supply and wet/decay issues
  - Government →leases out land for a purpose → need to change policies, be flexible
  - Board of Alberta Barley Commission needs to see high value alternatives, market side needs to talk with producer side

  Skill sets:
  - Better breeding
  - Better planning for crop outputs
  - Biomass production, processing, transforming, and business management
  - Material handling to address seasonality of supply and wet/decay issues
  - "Pathfinder" person – what have we got in Alberta that I can *leverage*?

- Trades; Technologists; Engineers → train to work together, cross-sectoral in our thinking

- **Trades:**
  - 60,000 construction Trades needed and are being trained for oil and gas, and mining. But:
  - Bioindustry has different application understanding from other industries such as oil and gas or mining.
  - Early fermentation
  - Different analyzers (than oil and gas)
  - Different biotics
  - Stainless steel processing units
  - Contamination & structural work is different
  - Expand focus: i.e. heavy duty mechanics expanding knowledge into fluid

mechanics

- Start multi-disciplinary requirements for programs and achieving journeyman papers: i.e. agriculture bio processes, engineering knowledge, biomass, transformation, expanded thinking in application of technical knowledge
- Not likely to work for less money in bioindustry
- Maybe 'sustainable' world, work-life balance, beliefs will attract

- **Technologists**: Today: Hyper-focused, 2-year track, no 'fluff'
  Operate/repair a particular technology, instrumentation
  Understand what the engineers are needing

  Future:
  - More multi-disciplinary technologies and instrumentation
  - Some added economics/business, project management competency
  - Support system for SME's
  - More responsibility for problem-solving
  - Deal with/handle 'routine' challenges (exceptions go up to engineers)
  - Work in/Lead cross-functional teams
  - Potentially move in from other sectors and need "re-set"
  - Rapid re-training and re-tooling mechanisms

- **Engineers**:
  - 65,000 engineers and geologists today
  - Highest per capita level and growth rate in Alberta

  Bioindustry
  - Need to understand more bioindustry processes, build this into 4-year B.Sc. program
  - Raw materials coming in → biomass handling and transport
  - Plant-wide process knowledge: know petro/chemical AND bio-systems
  - Q - Is it better/easier to make an engineer, than teach them the biological elements; or
    take a biologist, then train engineering?
  - A – Engineering is a heavily certified/regulated disciplines → Take a Chemical Engineer or Mechanical Engineer, and give them the biology side;
    Or, start a new bioindustry engineering discipline?
  - Adaptability → added knowledge in business, communications, economics
  - Multi-disciplinary in thinking and experience/assignments
  - Transmit expectations for varied summer jobs/experience

- **Sciences**:
  Bioindustry
    - "Green" chemistry → lifecycle analysis "12 Principles", water efficiency
    - Reduced environmental impact
    - High-value end of biomass opportunities
    - Wide variety in bioindustry – fermenting, virology, biotech
    - Conventional focus → expanded/applied to new areas, natural health products
    - Again, multi-disciplinary, theoretical + practical application
    - Different things will evolve in the next decade
    - Different skills or different application
    - Post-grad → more 'fluid' specialization options/opportunities

- **Bioindustry Managers**:
    - Basic knowledge of the industry
    - "Jack of all trades" and yet able to get along with specialists
    - Versatile
    - International experience
    - Able to explain their role as an ambassador for the organization
    - Able to spot opportunities, new markets, new partnerships
    - Collaborative facilitation skills to engage & cross disciplines
    - Farmer entrepreneurs/lifecycle analysis

- **Bioindustry in Alberta:**
    - Needs an environmental scan desperately
        - How many companies
        - What type
        - Potential economic & employment impact
    - Overarching bioindustry association → BCN? BioAlberta?

- Agra-Managers/Trades/Technologists/Scientists/Engineers are important HQP's'; however, additional skills/career areas include economists, policy analysts, etc.
- The bioindustry value chain is slightly different from Manfred's. They are:
  1. Production and Supply of Feedstock
  2. Logistics of Raw Materials
  3. Conversion and Manufacturing
  4. Distribution of Transformed Materials
  5. Marketplace and Consumption

  The group agreed that Alberta is competent or excelling in #s 1, 2 and to a lesser extent 3, but is lagging in #4 and 5.
- This led to two questions that affect the future job and training market:

1. Is Alberta mostly/only committed to bulk production (that is, high volume feedstocks with most energy going into growing and shipping those feedstocks, and little time and R&D money attached to innovation, conversion, distribution and market development, and energy as output?)
2. Do we limit ourselves to jobs in areas that we are already strong in (e.g. train people in production of existing large-volume crops), or do we train to develop new skills in new areas?

It was the sense of several people in the group that there isn't much academic or political will to expand into new R&D or training

- Even within areas of current strength, those in Bioindustry need to have broader core competencies than they might in other fields. The most common framing of this was the sense that:
    a. Practitioners will likely work in smaller, more entrepreneurial venues and companies, and so will need broader skills sets and a better understanding of sales and marketing that other energy sectors workers
    b. They will be facing issues of innovation to a greater degree than other workers, and so will need better problem-solving and decision-making skills than their peers in more established sectors. They will need to be better at *process management*

- Within the Value Chain stages, the job/issues are:

1. Production and Supply of Feedstock

If feedstock species diversification is going to continue, then there will be a strong need for plant ecologists, geneticists, genomics specialists, soil scientists and talented farmers willing to take risks. There will also be an increased need for mechanical engineers who will design new equipment to plant and harvest new species.

2. Logistics of Raw Materials

This was felt to be one of the stronger current areas

3. Conversion and Manufacturing

It was agreed that this will be area of greatest growing demand for scientists and technologists, particularly those who have knowledge and interest in new processes of digestion and other forms of conversion.

It was also felt that there will be a growing need for mechanical and process engineers who will be trained in building and operating large scale conversion facilities

4. Distribution of Transformed Materials

This was also seen as a strength, with several models of successful shipping and transport systems (e.g. the energy sector) already in place

5. Marketplace and Consumption

This was felt to be the weakest link in the chain, but there was debate about the best way to increase skills in the area. Some people in the group suggested that direct training of these skills should be an essential element of an education program, while others felt this would lengthen the programs unrealistically.

Bioindustry Talent Development – Leading Programming

Presentations from:

- **Jim Bohun –University of Alberta**

  Manager, Student Services – Faculty of Agriculture, Life and Environmental Sciences (ALES)
  Currently the University of Alberta's ALES Faculty has 8 undergrad degree programs, each with a "Capstone" course (group work that involves solving a "real world" problem). They offer internships and focus on "preparing students to provide solutions". Environmental scan of biotech/bioscience programs.

  - University of Alberta ALES Programs: BSc Environmental & Conservation Sciences; BSc Forestry; BSc Forest Business Management; BSc Nutrition & Food Science; BSc Human Ecology; and BA Environmental Studies.
  - McGill: BEng Bioresource Engineering
  - University of Saskatchewan: BSc Agriculture, Food and Bioproduct Sciences
  - University of Illinois – BSc Biological Engineering
  - University of Wisconsin-Madison – BSc Bioproducts and Biosystems engineering
  - Ohio State University – BSc Food, Agriculture and Biological Engineering
  - Kansas State University – BSc Biological Systems Engineering
  - University of Nebraska-Lincoln – BSc Biological Systems Engineering
  - Purdue University – BSc Biological Engineering

  North American Programs focus on:

  - Sustainable production of food, energy, pharmaceuticals etc.
  - Sustainable management of natural resources
  - Career focus: biotechnical & biomedical engineering, biochemistry processing and bio-instrumentation
  - Engineering

  European Programs are very different:

  - Animal Biotechnology
  - Food Biotechnology
  - Microbial and Environmental Biotech
  - Plant and Forest Biotech
  - Molecular Biotech
  - Often integrate Undergraduate → Graduate programs
  - Fewer courses, more focused
  - Engineering an aspect, not the focus
  - Courses in biotechnology, microbiology, genetic engineering and process technology

  Creating a New Program (at University of Alberta) Options:

  1. Embedded "Certificate" in an existing program
  2. Create a new major in an existing degree program
  3. Create a new degree program

  Harder to mobilize and get implemented as you go from option 1 → 3.

- **Dr. Jim Sandercock – Northern Alberta Institute of Technology (NAIT)**
  Currently runs 2-year Diploma/3-year Advanced Diploma Technologist Program in **Sustainable Energy Technologies**.

  Fast changing environment for alternative energy today! For example, today in Alberta coal-generated energy is dominant technology. In USA, average electricity costs are about $12/Kwh.
  Meanwhile Solar Photo-Voltaic electricity costs are plummeting. Today Solar PV cost is about $2 per Kwh, total install costs approaching $12/Kwh. Estimated "cross-point" of Solar PV vs. Coal is estimated to be about 2015. ***Solar PV electricity*** = ***Potential Disruptive Change***!
  Bio-refining is potentially a similar disruptive change in the near future.

  How do we respond to such rapid changes to technology and the training for technologists?
  Bio-refining program development options:

  Choice Made →

  1. Continuing Education course targeted at installers
  2. Develop/offer a Post-graduate "certificate"
  3. Create a 2year Technologist Diploma program
  4. Bachelor of Technology 2-year diploma + 2-year work experience, with option of a further 2-year MBA.

  In considering a new program on Bio-refining…
  - Looked in the existing program – currently there are 2 direct courses, 4 technical supporting courses, and 3 allied skill courses. Is this good enough?
  - Decided to create a second "stream" for this program, common 1st year with of "tailored" 2nd year set of courses.
  - Also 1 year "retraining certificates" with different versions for those already with Technologist Diplomas, Trades, Professional degree, and prior learning base.
  - Believe there IS a market for this industry, but starting small, only 25 students/year, so as not to flood the market. Need a more detailed enviromental-scan for further growth.

- **Dr. Han De Winde – Delft University, Department of Biotechnology - Netherlands**
  TU Delft is largest Technology University in Netherlands; part of the IDEA League of European technology universities with strategic agreements: Imperial College (London), Budapest University of Tech and Economics, Norwegian University of Science & Technology, Middle East Technology University in Turkey; also Tsinghua University Beijing (China), Kyoto University (Japan), Osaka University (Japan), University of Tokyo (Japan), Bandung Institute of Technology (Indonesia), National University of Singapore (Singapore), The Hong Kong Polytechnic University (Hong Kong), KAIST (South Korea).

  38 Masters of Science Programs:
  - Integrated Product Design
  - Marine Technology
  - Civil Engineering
  - Aerospace Engineering
  - Applied Earth Sciences
  - Computer Science
  - Telecommunications

- Systems & Control

40% growth in Technical studies in last 5 years
Large community of international students – 20% Bachelor's; 60% PhD

3-year Bachelor's Program, integrated into a 2-3yr Master's Program:
3-year BSc, *combined with Leiden University*:

LST – Life Science and Technology ~ 135, 1st yr
MST - Molecular Science and Technology ~ 125, 1st yr

2-year MSc, TUDelft :

LST – 3 tracks; CF/Bcat/BPE
CE – Chemical Engineering (*with Dept. Chemical Engineering)*

'Honours track', TUDelft :

iGEM, international Syn Bio students competition

Post graduate:

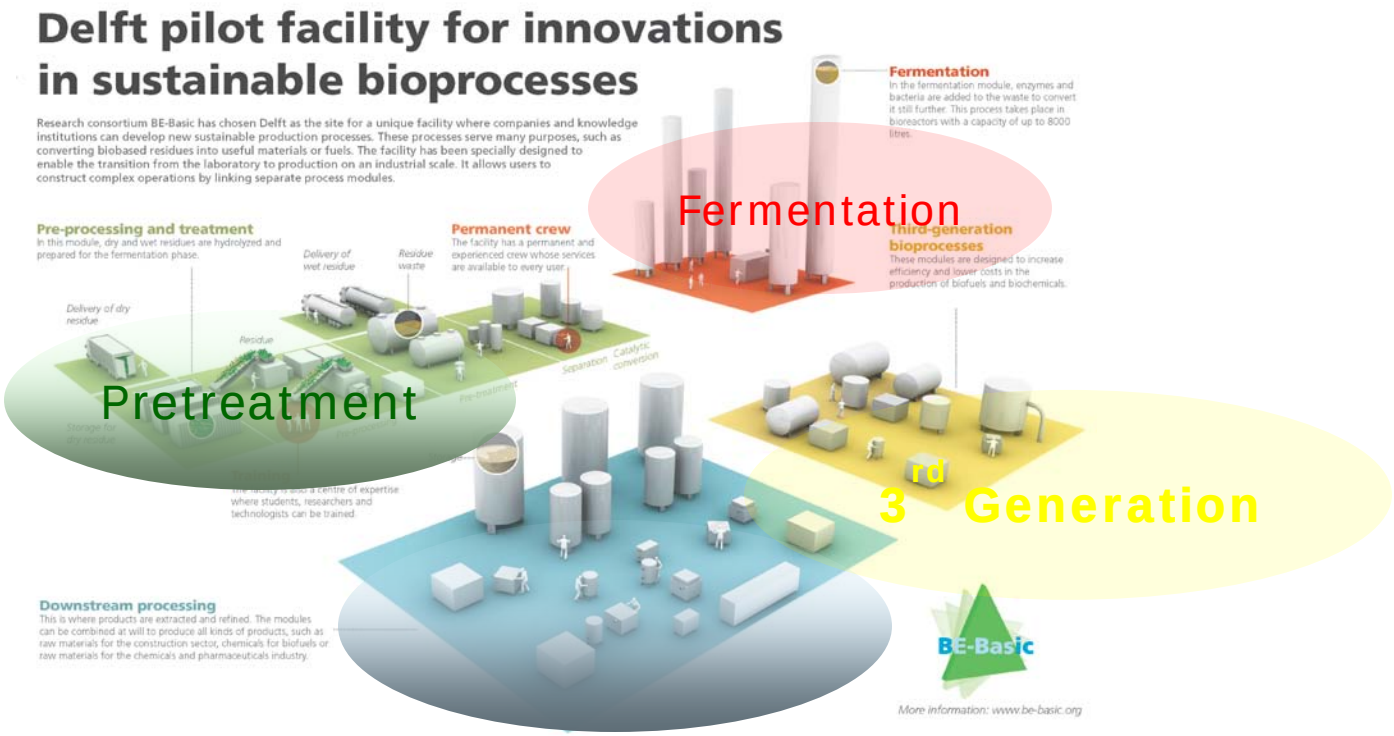
PDEng – Bioprocess Engineering BPE
PDEng – Bioproduct Design BPD

Advanced Courses (*Foundation BSDL*):

- Fermentation, DSP, BioCat, Environmental, Genomics and SysBio

TU Delft Spin-Offs:

- Centre for Entrepreneurship
- Valorisation Centre
- Yes! Delft
- Science Port Holland – Technopolis
- Delft Top Technologies

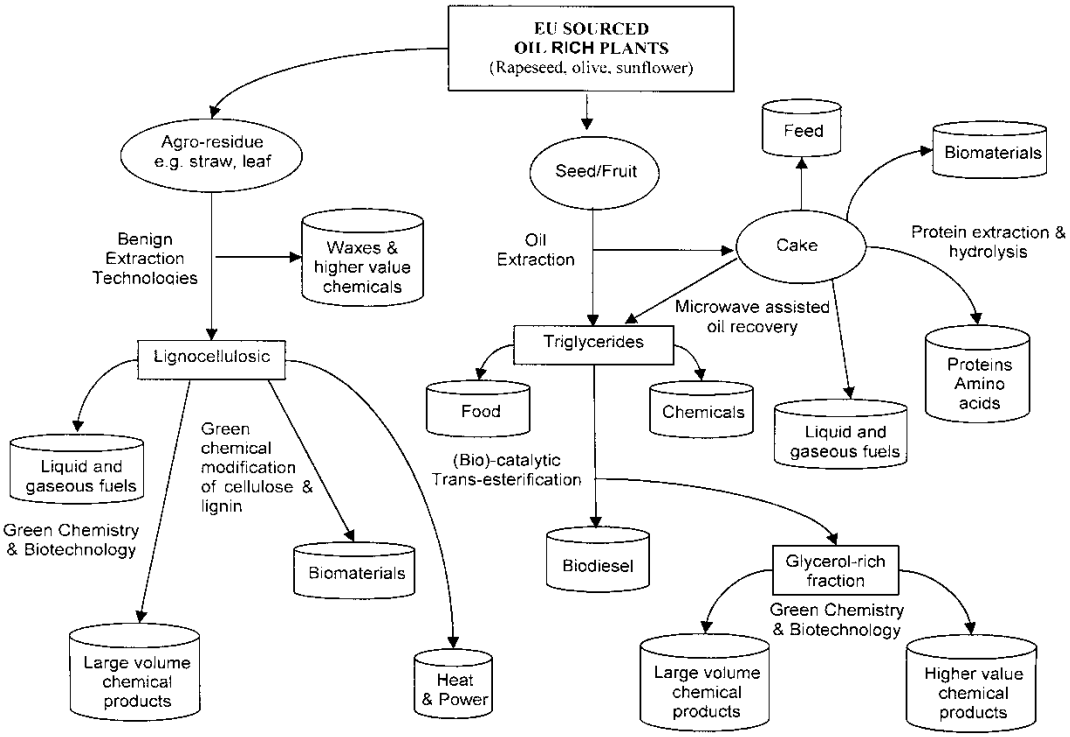


- **Roland Verhe – Ghent University, Belgium**
  Faculty of BioScience Engineering and Department of Organic Chemistry

  Why Bio-Based Economy:
  - Limited availability of petroleum/gas resources
  - Independence from political situation
  - Ecological and environmental benefits: integration in a closed carbon (CO2 production) cycle
  - Green image
  - Efficient bio-production
  - Alternative bio-resources (e.g. waste, new technologies)
  - Consumer assessment of sustainable production

  Integral Valorization of Bio-Production:
  The production of safe and healthy food and renewable resources for materials and energy production with the aim of achieving an efficient and complete use of each bio-product at each step in the agri-food chain. It involves the optimal utilization of ingredients, co-products, side and waste streams.
  Applying this principle the conversion of bio-production into food, non-food materials and products and biofuels results in a "BIO REFINERY" preferably on one location.

Example: The Oilseed Biorefinery
Source: Roland Verhe



Rodenhuize Docks Area – Example of Co-location of Bio-refinery Components (AlcoBiofuel, Bioro, Cargill, Eletrabel, EuroSilo, Oiltanking)
Source: Roland Verhe

Curriculum Development – Ensure integration similar to integral valorization of bio-production!

- Inter-disciplinary approach

Actual situation at Ghent University:

MSc-degrees:
- Food Science & Technology
- Agricultural & Biotechnology
- Forestry
- Chemistry
- Chemical Engineering
- Biorenewable and Agro-Resources

No integration e.g. Food Science & Biorenewable Resources:
- same basic sciences
- same primary materials
- similar processing and technologies
- identical logistics and management

Integrated Curriculum Development Aims and Objectives:

- To train critically reflective experts in the new developments in bio-production chain, providing technical and scientific education for the implementation of integral food, non-food and energy production
- To enable students to a critical evaluation of the introduction and acceptance of new technologies, new products and environmental impact
- To train bio-experts to understand and to analyze the variation in quality and safety of products
- To ensure students of the increasing importance of global environment, consumer perception and ethics

Interdisciplinary Approach: Use Total Production Chain Curriculum

- primary bioproduction
- Food engineering and technology
- Biotechnology
- Chemical and biochemical transformation of natural resources
- Quality and safety of bioproducts
- Biomaterials
- Bio-energy

Example: MSc – Integral Valorization of Bio-Production:

Not possible in any single university → need to integrate across different universities, with exchange programs, video-conference and curriculum co-ordination

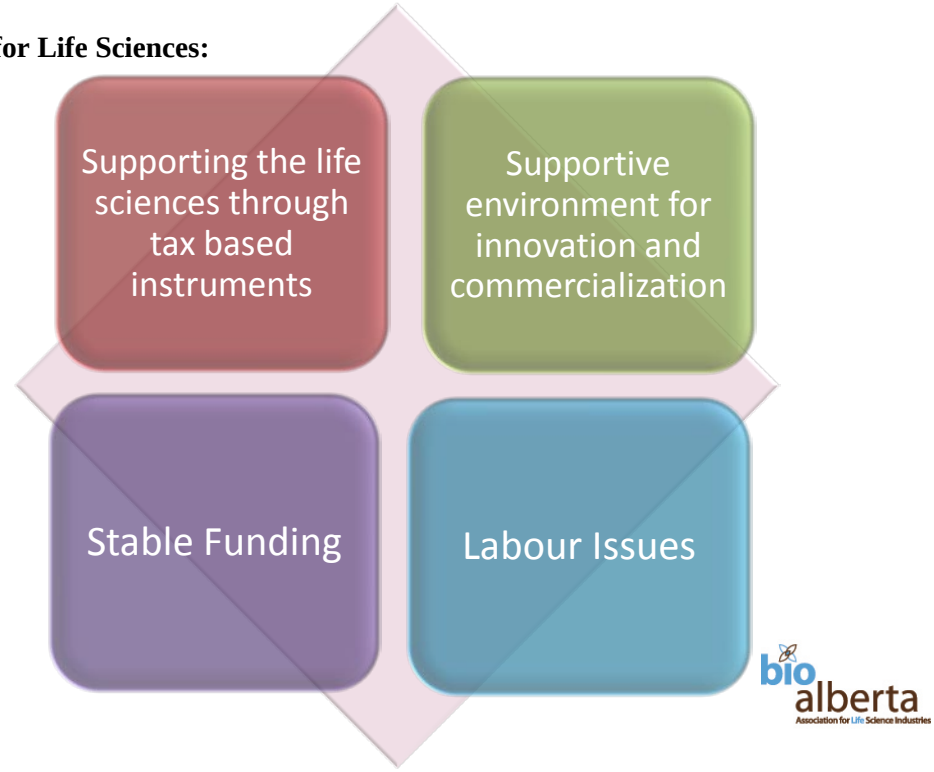
- Primary production of renewable bioresources: plant, animal forestry, aquaculture, biomass
- Technology and Engineering of renewable bio-production for food and non-food uses
- Food science and technology
- Quality and safety of food products
- Renewable biomaterials from carbohydrates and wood: e.g. fibres, biopolymers
- Renewable biomaterials from lipids and proteins: e.g. lubricants, biopolymers, detergents
- Production of biofuel: bioethanol, biodiesel, biogas, pyrolysis
- Principles of biorefining
- Conversion of waste-streams
- Life cycle analysis and exergy
- Bio-ethics: to e.g. conflict food versus non-food

Conclusions:

- Unique opportunity for the integration of various disciplines emphasizing the importance of a simultaneous conversion and/or modification of bioresources into food and non-food applications.
- Creation of new openings for graduates in bio-sciences in a rapid expanding and innovative field

- **Ray Bergstra – BioAlberta, Co-Chair Policy Committee**
  ½ Day workshop in 2010 – "Where do we want to be in 30 years?"
  Policy Committee struck with representatives from member organizations, including: Academia, pharmaceuticals, natural health products, health/med devices, industrial biotech (agriculture/forestry).
  Priorities and Strategies developed and validated with membership.

  Advocacy Platform for Life Sciences:



  Labour Issues:
  - Early stage biotech companies require multi-talented HQP (i.e., science plus business)
  - Lack of common objectives and outcomes between industry and education
  - Funding programs for training are not accessible or misaligned with industry needs
  - Biotechnology industry not fully understood by students
  - Objectives for commercial innovation misplaced
  - Lack of common post-secondary programs and transferability
  - No safe mechanism to learn entrepreneurship
  - Immigrating talent not utilized to full potential

  Three areas have been identified for as targets for recommendations that will increase the availability of skilled persons in Alberta.
  1. Education: Enhancing our Bio-Learning Continuum
     - Need more HQP with specific skills
     - Introduce biotechnology concepts in Grades 7 -12
  2. Professional Development: Industry Training Programs
     - Need retraining for experienced staff
  3. Streamlining Immigration
     - Need to maximise potential of new residents

Recommendations - Education:

1. Develop collaboration between industry and government to facilitate bioindustry careers
    - For introducing biotech in grades 7 – 12 curricula
    - In traditional science programs
    - In business schools
    - In placement services
2. Incentives to enhance co-op programs
3. Build capacity for entrepreneurship and management into non-business post secondary science programs
4. Enhance continuing education opportunities for “adults”
5. Develop specialized degree/diploma programs

What Can/Should Universities Teach?

Ability to solve problems by following a logic structure.

Bioindustry Talent Development – Recommendations for Adjusting Existing Programs (From industry, academia and other participant's discussion groups.)

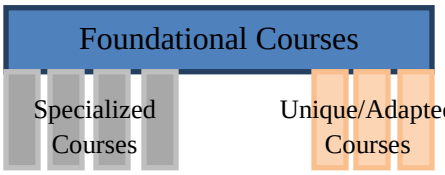
- **Alberta Technologists Program Development**:
    - Programs more defined by desired outcomes
    - Constant environmental scanning for needs
    - Align to value/outcome – i.e. 100% use of skills
    - Include soft skills (project management, economics, entrepreneurship)
    - List of 8 is too broad to program – encourage extracurricular pick-up of soft skills
    - Transferability
    - Specificity vs. mix 'n match
        - Deep-dive with co-ops
    - Why is 2-year program sacred? Perhaps co-ops/continuing-education?
    - Added "Certificates": Lifecycle Analysis
      (International) Biomass Tech
      Uniform Bio-conversion/bio-refining Tech
      Quality Assessment/ Quality Control

- **Alberta Science/Engineering Degree Programs Development:**
  Perhaps defined by various feed stocks
  Need certain labs for capstone courses
  What are the foundation programs?
  BSc? Food Sciences? Engineering? Business? Agriculture?
  Hybrid programs across faculties?

Generalist Undergraduate Bio-Resources Degree

Core Program 1st & 2nd Year Basic Elements	**Minors/Majors** 3rd & 4th Year Specialization/Focus
• statistics • microbiology • molecular biology • genetics • organic chemistry – extraction/purification • chemical/biochemical conversions • genetically modified organisms • entomology	• synthetic biology • fermentation • industrial microbiology • life cycle analysis • advanced materials science/handling • capstone: systems thinking type • processing/transformation of biomass • biofuels
Options/Electives • macro/micro Economics • business/marketing • strategic communications • international trade & regulatory environ • ethics	• Non- Thesis M.Sc. - BioProcess Engineering?

The Foundational courses are already there.
We can work collaboratively with other faculties to "pull" in their courses into a new grouping to create Program.
Then take existing courses and adapt/design to fill gaps.
Ensure Capstones are industry involving and cross-functional



Where there is a "will" there is a way – 18 months to pull together a program architecture.
Hons. Bio Resource Program – Integrated Business-Science Program
Hons. BSc. Bio Industry Technology
Hons BSc. Food Science → Adapted towards BioIndustry

Need to decide:

- What kind of degree? BSc., BSc. Eng, B.Com.
- Who is the target audience?

Conclusions:

1. This kind of program IS possible – and there is a strong desire to advance
2. It might be an adaptation of an existing degree – new "major"
3. Could be a new cross-faculty "program"
4. Clarify target audience, then build the "business case"
5. Involve leaders from industry & government and other external partners
6. Keep students' best interests at heart – ensure there are jobs and academic integrity
7. Bring together resources from various faculties – joint programming, perhaps across 3 universities. Lab space is already available
8. Will likely need additional resources to pull program together