Forest Futures Study:

Project Evaluation and Results for the City of Quesnel

Prepared by Tom Browne, Ian de la Roche and Chris Gaston

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Contact information:

Tom Browne: tom@tcbrowne.ca, 514-523-9508

Ian de la Roche: ian.delaroche@ubc.ca, 604-603-2710

Chris Gaston : chris.gaston@ubc.ca, 778-227-3962

Contents

1. Executive Summary 3
   1.1. Next steps in support of solid wood options 3
   1.2. Next steps in support of bio-energy pathways 4
   1.3. Overarching fibre requirements in support of all projects 4
2. Forest Futures Study: Project outline 5
3. Situation appraisal 6
4. Key learnings 7
   4.1. Interviews with key players 7
   4.2. Stakeholders 8
   4.3. Engaging regional industrial players 8
   4.4. Fibre supply, forest management, asset map 9
   4.5. Leadership role of the City of Quesnel 9
5. Project evaluation tool: Ranking the Best Bets 10
6. Summary of Projects selected for evaluation 12
   6.1. Regional forestry management pilot 12
   6.2. Local Education and Training Centre for forestry trades and careers 12
   6.3. Expanded secondary manufacturing capacity 12
   6.4. New pulp uses 13
   6.5. New cellulose products 13
   6.6. Kraft mill residual streams 13
   6.7. QRP to TMP-Bio 13
   6.8. District CHP 14
   6.9. Industrial gasification for lime kiln or lumber kiln 14
   6.10. Biocrude 14
   6.11. Pipeline-ready RNG plant 14
7. Results of the ranking exercise 15
   7.1. Next steps: Solid wood projects 16
   7.2. Next steps: Bio-energy projects 17
   7.3. Technology and market watch: Novel pulp-based products 19
   7.4. Overarching: new evaluation of available fibre 19
   7.5. Opportunities for the City 20

1. Executive Summary

Pathways to retaining and expanding the forest sector in the broader North Cariboo region were evaluated and ranked. The following table summarises results of the ranking exercise; details are provided in Section 7.

Rank	Project title	Pros	Cons
1	District heat (City of Quesnel) and CHP (First Nations)	Easy; large local impact	Funding
2	Regional forestry management	Large local impact	Funding
3	Expanded Secondary mfg.	Large local impact; market is known	Low GHG impact globally; needs investment
4	Renewable Natural Gas plant	Enormous global impact	High cost, needs fibre
5	Bio-crude plant	Enormous global impact	High cost, needs fibre
6	Training Centre for trades and careers	Cross cutting; supports all other initiatives	

1.1. Next steps in support of solid wood options

Two of projects (#2 and #3) relate to forestry and solid wood. While the concept of the Training Centre ranked 6th, this concept underpins every other project that involves moving to new products or services. Specific action items around a Training Centre include the following.

- Identify specific interested educational partners willing to participate in a Training Centre, with focus on education, training and retraining needs of current and future workforces; this may include pilot plant facilities for training in EWP and prefab technologies:
    - Identify training needs with industry, First Nations, educators and governments.
    - Identify potential collaborations and partnerships with other education and training institutions.
- Build on the 2019 Think Tank Workshop on Human Resources.
- Develop a business plan; identify funding opportunities.

Next steps in support of a Regional forestry management pilot include the following.

- Focus on climate change, wildfire control, and optimizing forest productivity, diversity and end uses.
- Include genetics, silviculture, harvesting of logs and residual biomass, a regional scaling and sorting facility for directing logs to best end-use, and transportation to mill gate.
- Engage primary licensees, the Quesnel Community Forest, First Nations, researchers and governments.
- Build on previous studies and workshops; promote a holistic integrated approach.
- Convene a follow-up Think Tank workshop of decision-makers and stakeholders, including governments, for this specific topic. The workshop would build consensus and lay out a Strategic Direction, Priorities and Action Plan.

Next steps in support of Secondary Manufacturing include the following.

- Develop an inventory (Asset Mapping).
- Carefully assess the position of existing manufacturers in components, systems and modular prefabrication and whether there is viable opportunity in this space.
- Identify unique niche construction projects e.g., custom designed First Nation housing.
- Focus on wood construction value chain; emphasis on productivity enhancements driven by technology and innovation, and on reduced carbon footprint (embodied and operational carbon emissions).

- Investigate opportunities for partnerships with existing companies within the value chain; what value proposition could the Quesnel area bring to the relationship.
- Engage stakeholders in a targeted workshop on value-added wood products/systems for structural applications, lay out priority areas and foster matchmaking opportunities.
- Explore federal and provincial investment opportunities.

1.2. Next steps in support of bio-energy pathways

Three projects relate to energy efficiency and novel fuels in a carbon-constrained world.

District heating and CHP ranked highest: next steps involve First Nations developing their own plans for community CHP, by reviewing progress by other communities, available technologies, and funding pathways. Funding applications have been submitted for a feasibility study on district heating for institutional clients and are currently under review.

A previous report outlined next steps for Renewable Natural Gas (RNG). Bio-crude will be similar. The climate change imperative will imply moving very quickly. These are repeated here, with added next steps:

- Bio-crude and RNG address the need for large-scale bio-energy supplies in a carbon-constrained world, but at full-scale, both will be expensive and will require large amounts of wood.
    - Costs and markets imply that partnerships with oil and gas may be the best approach.
    - Resolving wood supply issues will require intense collaboration between the Province (in terms of TSA, AAC and forest management practices), First Nations and the existing forest sector.
- For both projects, the key steps the City can take are to ensure the interest of the City in hosting such a plant is well known among all stakeholders:
    - Existing forest sector in the larger Quesnel region.
    - Canfor/Licella interest in developing a satellite bio-crude production site.
    - First Nations.
    - Provincial and federal agencies.
    - Potential investors outside the forest sector.
    - FortisBC, in the case of RNG.
    - Potential equipment suppliers (such as Haldor Topsoe, in the case of RNG).

1.3. Overarching fibre requirements in support of all projects

Volumes, quality, costs and risks associated with traditional and novel fibre supplies on a continuous basis over the next several decades are unknown, and this risk factor presents a large barrier to new investments.

Current forest management approaches are not well adapted to drought, insect infestation and forest fires. It is not clear what resilient and healthy ecosystems can deliver in terms of fibre types and volumes over a reasonable timeframe. In the spirit of the Alberta Roadmap[1], the City could move quickly to incent new studies to provide commercially necessary information on feedstock cost and availability.

There is a major opportunity for the City of Quesnel to position itself as a green champion, beginning by operationalising new BC government policies around forest and carbon management. Locally, GHG emissions can be targeted in local heating systems, in the production of building systems such as new greenfield housing, or light industry development. Globally, emissions can be targeted by exporting low-carbon building products, pulp and paper products and biofuels of various sorts, all from a sustainably harvested, non-food renewable resource.

[1] https://albertainnovates.ca/wp-content/uploads/2018/02/alberta_forest_products_roadmap_booklet.pdf, viewed 2021-09-09.

2. Forest Futures Study: Project outline

Based on previous reports prepared for the City of Quesnel by the authors and others, the project objective was to identify and rank a selection of Best Bets for the City of Quesnel and the forest industry in the broader North Cariboo region. Specifically, the following activities were undertaken:

1. Conduct a full review of all background documents.
2. Pull together what has already been done over last three years, including outputs from the current Clean Energy Consulting[2] study, two workshops and various reports commissioned by the City.
3. Identify gaps and complement or fill in missing information through telephone and face to face interviews, additional information searches and personal knowledge of consultants.
4. Develop a list of criteria to be used to identify a prioritized list of projects or "Best Bets". These were based on current and future fibre resources, maximum economic and social return, environmental sustainability, technology maturity and market readiness, amongst others.
5. Once "Best Bets" were agreed, determine the alignment of key stakeholders. Next steps would identify the infrastructure needs; the competitive advantage of a Quesnel location; a committed industry champion; potential private and public investors; SWOT analysis. A more detail examination would need to be done after potential stakeholder buy-in is better assessed.
6. Provide guidance to steer UBC Forestry students in a direction that is supportive of the above objectives.

The development of selection criteria, weightings and the ranking exercise represent one key input for arriving at the prioritized list of Best Bets. The criteria were based around current and projected fibre supply, economic and social return to the community including First Nations, environmental sustainability, technology and market risks amongst others. In addition, we considered the inputs from a review and assessment of studies and reports commissioned by the City of Quesnel and other relevant documentation made available to the consultants. These resources were complemented with interviews with key stakeholders.

An interim report was submitted to the client on July 31, 2021. It included a high-level situation appraisal, key findings and preliminary recommendations and an evaluation matrix for prioritizing Best Bets. City of Quesnel officials and consultants meet by Zoom on August 31, 2021, to review and comment on the evaluation methodology and to carry out a ranking exercise of potential projects. As a consequence, the consultants further refined the Evaluation Tool and summarized the prioritized ranking results for 11 proposed projects.

In preparation for a briefing session with City officials on September 13, a short list of the most promising project opportunities was prepared and evaluated based on regional benefits, investor interest, competitive position of a Quesnel area site, likelihood of private and public investment, benefits, infrastructural needs, technology and market risks, stakeholder alignment and project champion.

[2] Clean Energy Consulting, "Quesnel Biomass Utilization: Biopathways Scoping Study", 2021-06-30.

3. Situation appraisal

The Northern Interior, particularly the area around Quesnel, has faced the brunt of the effects of Climate Change: MPB, fires and drought. This is expected to worsen and will contribute to turning forest land from a carbon sink to a source. In addition, drought is affecting water levels in rivers and hydro generation, the prime source of clean energy in BC.

Current fibre demand in the Cariboo basket significantly exceeds supply. Primary producers are having to truck chips in from considerable distances (e.g., wood from Chetwynd). They are uneasy about encouraging new entrants that would compete for the existing fibre supply.

BC has introduced policies which are affecting forest land use e.g., “converted forests”, First Nations and Community FMAs, etc. These policy changes along with the fibre supply challenges have created uncertainty among primary licensees that in turn has affected decisions by current and future investors in the Forest sector.

The province must move on implementation and demonstrate how recent land use changes can lead to net benefits for forest sector stakeholders (Primary Licensees, Community Forests and First Nations). Opportunities exist to use Quesnel as a test bed to evaluate and optimize alternate forest management strategies for climate related disturbances.

BC has taken an aggressive position in favoring greater use of wood in construction. This includes procurement policy, promotion, grants, code changes, etc. These initiatives also support the use of Engineered Wood Products and prefabricated components (e.g., 12-storey wood construction and BC Step Code on energy conservation). This has created new opportunities for value added secondary manufacturing.

Recent IEA 2050 Targets for Net Zero Emissions and COP 26 are having a major impact on Canadian policy and action going forward. Biomass generally plays a minor role in the Clean Energy portfolio, but the BC government has mandated FortisBC to buy a certain amount of renewable natural gas at prices that reflect cost of production rather than the current price of the fossil incumbent. Quesnel could serve as a model on how to achieve Net Zero Emissions in a forestry dependent community.

4. Key learnings

4.1. Interviews with key players

A range of interviews were conducted with key players from First Nations, major forestry companies, educational institutions, governments and others. Anonymized feedback is summarised next.

Generally, there was agreement between most interviewees around the basic issues facing forestry in the region. Wood supply and its allocation is causing significant levels of anxiety; the state of relations between government and industry in the Interior is felt to have been better in the past. These and other factors are impeding a necessary discussion around maintaining the status quo (including a focus on existing products) versus evaluating new opportunities for making use of the resource. No one solution to this issue was proposed but the general consensus was one of concern going forward. In the views of several industry leaders, Quesnel has demonstrated strong leadership in forestry and an understanding of integrating forestry into the community; there is an opportunity and need for local political leadership to communicate with provincial leaders on how to work with industry to achieve new directions that leave no one behind. Some detailed thinking follows.

The province partnered with the Heiltsuk Tribal Council in Bella Bella, FPInnovations, UBC and Mitacs to build tiny homes. Four tiny houses were built using post and beam construction, local cedar siding and metal roofing. There are 22 FN communities in the College of New Caledonia (CNC) catchment area, and all have expressed a need for housing; several are looking at similar projects. One approach to accelerating implementation would involve on-site construction using nailed laminated timber (NLT) panels which allows for the use of softwood and harvest residuals which would otherwise be unusable. These panels have been built and tested at FPInnovations. A niche opportunity for Quesnel area First Nations could involve indigenous architectural designs using mass timber (NLT or CLT) constructed on NZE (Net Zero Emissions) principles along with associating training in component fabrication and assembly. There may be an opportunity to tie in solar, geothermal and/or bioenergy options, particular with locations off-grid or distant from easily accessible natural gas sources.

The concept of a carbon neutral neighborhood merits further consideration by the City of Quesnel. This ties in with the City's concept of integrating a minimal carbon footprint in new and retrofit construction with forest biomass for power and heat generation. The concept would also include strategies to manage the surrounding forest for climate change mitigation, enhanced productivity and increased carbon capture and storage capacity (moving from a source to sink). Building local capacity for targeted education and training of current and new workers would further support the concept. Significant synergies would be achieved by integrating City and First Nations initiatives. Athena Life Cycle Analysis could be used to monitor the impact on carbon footprint as the various initiatives are developed.

Most of the research and demonstration efforts in Passive and NZE construction has been in the Lower Mainland; there is an opportunity to showcase Northern solutions and make Quesnel a showcase for the North. There may be an opportunity to learn from and build on the Edmonton Cluster efforts, which focused on sustainable housing and prefab in a Northern climate. Climate conditions and interests may be more similar here than in the Lower Mainland. Education and training will help overcome the current culture of resistance amongst Northern builders; the Pembina Institute could also be approached to explore potential collaboration.

There was a general consensus among interviewees that current federal and provincial training programs for wood construction are not ideally suited for effectively meeting the unique needs of FN communities. First Nation communities, educators at CNC and UNBC, the CoQ and industry have all expressed support and an interest to work in collaboration to address this deficiency.

Discussions with CNC Prince George indicated strong support for enhanced training for primary and secondary manufacturing workers and particularly FN entrants into workforce. CNC also confirmed their willingness to see the Quesnel Community campus take on a lead role. A hub and spoke model whereby Quesnel could draw on expertise and training model innovations from other CNC satellite campuses in the North, is under consideration. Also, in selected forestry related areas, UNBC has shown a willingness to collaborate and integrate education and training programs with CNC. There is also opportunity to build on existing relationships with the Forest Enhancement Society of BC (FESBC).

The need for sustainable and affordable housing in the north will continue to grow and the desire and capacity to deliver exists in the region. All that is required is bringing the key decision makers together to develop the strategies, priorities and action plans to move forward.

There are relationships and potential synergies amongst the various initiatives that have been proposed as Best Bets, particularly around sustainable housing, the pilot to manage forest fibre productivity, climate change mitigation and secondary manufacturing. Hence strategies for individual initiatives should be developed within the context of the other related Best Bets.

4.2. Stakeholders

There is a critical need to engage all stakeholders for buy-in and culture change. It is essential that West Fraser engagement and support continues and grows, as they are the largest forest sector player in the region.

First Nations communities must also be effectively integrated within the forestry and forest products value chain (i.e., forest management, operations, merchandizing and sales and manufacturing) and not just functioning as an intermediate broker of timber sales. First Nations initiatives around new forest management and harvesting operations (Forestry 2.0) could include residual material handling from wildfire proofing, PCT (Pre-Commercial Thinning) and CT (Commercial Thinning) activities and a regional log sorting yard that would handle residuals and under-utilized species and ensure the right log goes to the right mill and product in order to optimize value and recovery. Partnership opportunities should be explored with local primary/secondary industries.

Training of First Nation workers was identified as a critical success factor. This need could be fulfilled by making it a component of the proposed Quesnel forestry and forest products training initiative. This component could have a separate First Nations oversight and governance structure. Education and training programs could be modelled after the nursing/caretaker model and the Barkerville Gold Mine model which funds a tailored training program for new employees.

More broadly, a lack of trained recruits to replace aging personnel was identified as a significant constraint with primary forestry manufacturers. Making Quesnel a regional training centre would help meet current and future primary, secondary and First Nation training, education and professional needs. The North Cariboo Community Campus appears to be a willing partner but will require additional resources. A strong business case will need to be developed addressing current and projected demand and specific needs as well as showing how this initiative is integrated within the overall forest sector development strategy.

4.3. Engaging regional industrial players

Sustainability and growth strategies should respond to needs and opportunities within the current forest industry. Primary producers are an anchor in the community, but new entrants are needed to help diversify the current forestry economy. A focus on synergies is needed when encouraging new entrants to avoid issues around

fibre substitution or competition. Exploiting these cross-sectorial synergies, such as between energy, mining and forestry, would add to overall prosperity of the region.

4.4. Fibre supply, forest management, asset map

Studies to date have not adequately quantified the current and projected fibre basket with respect to quantity, quality, species mix, residuals, access, cost and security of supply. This is crucial to maintaining investment in current operations and in attracting new investors. Ontario is doing an excellent job in addressing the inventory issue and BC could benefit from their experience.

Similarly, we currently don't have access to an asset map identifying related business activity and relevant available infrastructure when considering new diversification opportunities. The information may be available but is dispersed and will require compilation. It will be a critical component in developing a compelling value proposition to attract potential investments.

4.5. Leadership role of the City of Quesnel

In order to attract new investment and diversification opportunities, there is a need to portray the City as forward and outward looking, entrepreneurially friendly and a great place to live with all the valued amenities.

There is growing support to have the City of Quesnel become recognized as a Net Zero Emissions (NZE) community, and its surrounding TSA recognized for successfully integrating innovative forest management and harvesting practices directed towards forest sustainability, resilience and optimal fibre recovery and use.

Three overarching strategies that should underpin all activities going forward have been proposed to address emerging issues and opportunities:

- Mitigate impacts of climate change on forests and forest-dependent communities through forest management and genetic improvements.
- Reduce the carbon footprint of both forest operations and the City of Quesnel, thus showing leadership in driving towards Net Zero Emissions and Step Code construction.
- Extract greater economic and social value and benefits from forest fibre: reduce costs and increase efficiency in fibre extraction, handling and use; support a sustainable and profitable primary sector; diversify into value-added secondary manufacturing; valorize forest residuals, manufacturing side-streams and under-utilized species.

5. Project evaluation tool: Ranking the Best Bets

The project evaluation tool helps rank projects on the basis of qualitative criteria.

The approach attempts to provide a numerical or quantitative ranking for projects where the constraints or key criteria may be qualitative. Other numerical criteria, such as return on investment, may also be considered but were not the focus in this report. It is important to point out that results of the exercise are highly dependent on the criteria selected, and the weights given to each one. This is discussed next.

The first step is to identify up to a dozen criteria that are of interest to the group or organisation that is to choose where to invest time or money. Arguably, if all criteria are equally important, then none is really important; the next step is therefore to identify three criteria that are most important. These are given higher weights than the others. Weights, expressed in percentage, must add up to 100%; for twelve criteria, for instance, the three most important ones could carry weights of 15% each, totalling 45%; two more could carry weights of 10%, adding another 20%; and the remaining seven criteria would be weighted at 5% each.

Participants in a ranking exercise then assign ranks to each criterion in an attempt to evaluate how well a given project meets a given criteria. Allowable ranks are 1, 4, 7 or 9. Rankings, multiplied by weights, are summed; if a criterion does not apply to a given project, then that weight is deleted and the overall ranking, instead of being over 100%, will be over some lower total weighting.

The tool has been implemented as a Microsoft Excel spreadsheet. A group of senior staff at City Hall as well as the authors went through the exercise with the projects listed below. Criteria and weights selected for ranking those Best Bets are also listed below, followed by the ranked project list obtained through the evaluation process.

It is worth pointing out that the rankings are an artifact of the selected criteria and associated weights. The City of Quesnel puts a large importance on availability of fibre, on regional economic impact, and on generating an increased role and improved socio-economic conditions for First Nations communities. The same exercise, undertaken by an industrial partner or investor, might lead to different rankings due to a selection of different criteria and weights. Similarly, the main criteria and weights selected by provincial and federal governments may well be different.

The final list of selected criteria and weights follows.

Selected Must-Have Criteria:	Rationale:	Weighting:	Category:
Availability of fibre within AAC; progress towards full fibre utilisation including residuals	No fibre, no project	15%	Project risk
Increased role and improved socioeconomic opportunities for F.N.	Critical driver	15%	Regional impact
Regional economic value: population, jobs, industrial tax base, increased level of local entrepreneurship	Critical driver	15%	Regional impact
Regional environmental value: impact on forest health, resilience faced with fires, insects, local GHG reductions	Critical driver	10%	Ecological
Climate Change; impact on global carbon cycle	This will come only if top 3 are in place	10%	Ecological
Scale relative to market: Too big compared to addressable market? Too small to have an impact?	Market size versus volumes	5%	Project risk
Market risks (probability of uptake, distance to markets) (1 = high risk)	Technology and markets are of equal importance	5%	Project risk
Technology risk (TRL): Commercial = 9, Demonstration = 7, Pilot = 4		5%	Project risk
Regulatory risk (1 = high risk)	Depends on government action (climate change, forest tenure system, etc.)	5%	Project risk
Interested non-financial partners and value of their potential contribution	Non-financial contributions	5%	Regional impact
Availability of funding (private or public)	Money will flow to good projects	5%	Project risk
Availibility of critical infrastructure	Pipeline, road, rail; log handling/sorting; chip handling; effluent treatment; boiler/power house; etc. Will get built for the right project, if not available today.	5%	Project risk
	Total	100%	

6. Summary of Projects selected for evaluation

6.1. Regional forestry management pilot

This initiative would address climate change mitigation, wildfire suppression, forest productivity and uses and First Nation engagement, and act as a test bed for recent BC forest policy changes. A regional log and biomass sorting facility could be included as part of an effort to optimize the regional fibre supply chain.

A compelling argument has been made for the Quesnel area to serve as a test bed for new approaches and innovations in silviculture and harvesting operations, such as landscape level planning and management. These need to be aligned with changing Provincial policies on forest land use and international imperatives around climate change. Such an initiative would engage a unique group of stakeholders consisting of primary licensees, the Quesnel Community Forest, and Nazko and Lhtako Dené First Nations. Lessons learned could be then rolled out to other forest-based communities in BC.

As part of the overall strategy, the City could also serve as a living example showing how a forestry-dependent community can achieve Net Zero Emissions status, largely based on biomass. Strategies could include District Heat, CHP, NZE wood construction, etc. These are capacity-building initiatives that are typically attractive to both provincial and federal funding sources. Lessons learnt could then be rolled out to other interested communities.

6.2. Local Education and Training Centre for forestry trades and careers

The existing training facility at the North Cariboo Community Campus is limited to 'stick-built', light-frame wood construction. Demand for prefabrication of light-frame or heavy timber construction is likely to increase in the BC domestic market, including specific local projects such as student residence for the campus, elderly facilities and mining sector housing. This is in no small part being driven by a growing shortage of trained carpenters. Note that confirmation of such demand should be considered as a gap of knowledge.

The reach of the Training Centre should be expanded all along the value chain, from forestry to end-products, including topics such as sustainable forest practices, managing for carbon sequestration and storage, emerging forest products, etc. Another goal would be retraining of the current workforce to improve productivity and innovation as the industry moves to new products and processes. The key is to integrate existing initiatives and exploit their capacity through partnerships with organisations such as NAIT, BCIT, UBC, UNBC and CNC. There should be a focused inclusion of local First Nations, both for training and for local housing needs.

6.3. Expanded secondary manufacturing capacity

Quesnel's fibre supply is likely to shift away from lodgepole pine to a growing reliance on other species and on thinnings and residues. This would allow growing capacity for manufacturing EWPs, including the potential for strand-based lumber/timber/panels, glue-laminated timber and cross-laminated timber. Emphasis would be on productivity enhancements driven by technology and innovation and on reducing carbon footprint (embodied and operational carbon emissions) all along the construction value chain.

In addition to the production of EWPs, consideration should also be given to prefabricated components and systems. This could be focused on light-frame construction, where EWPs are used to reinforce dimensional lumber for large spans, large window openings and to support a greater number of storeys in multifamily or commercial buildings. The focus could also be on timber-frame construction of single-family, multi-family, and commercial units. A specific focus on Indigenous housing would be appropriate.

A pilot manufacturing facility to support this concept could be part of an expanded training facility.

6.4. New pulp uses

New applications for existing pulp fibres, such as textiles or fibre-reinforced composites, open the door to new markets. Pulp fibres from Cariboo or Quesnel River Pulp (QRP) may be used as-is, or may require additional processing, opening the door for new entrepreneurs. Examples include textiles (Spinnova process or similar); reinforcing fibres for automotive interior door panels or other applications; and cellulose insulation products in stand-alone after-market sales, or for use in prefab panels.

There is little or no impact on existing fibre demand or users, as these pathways generally start with purchased mechanical or chemical pulp fibres. This pathway, along with several others, was outlined in an earlier report[3].

6.5. New cellulose products

Novel fibre streams from cellulose are very high-value products, and two of the world leading technologies (cellulose nanocrystals made by CelluForce, and nanofilaments marketed by Performance BioFilaments) are Canadian. Partnerships with these companies or others can open up the opportunity to participate in novel markets. CelluForce's product starts with kraft fibres such as those produced by Cariboo, and is made in a stand-alone facility that could benefit from co-location with Cariboo. Performance Biofilaments' nanofilaments are made in a modified mechanical pulp mill such as the one operated by QRP. Both product lines are characterised by significantly higher performance than existing pulp mill fibres, and are therefore more expensive. The target markets are small and are ones where the increased performance is worth the increased cost.

There is little or no impact on the AAC, but modifications may be needed to existing pulp mills.

6.6. Kraft mill residual streams

The kraft mill generates a large number of residual and by-product streams which can be recovered and sold, with little or no impact on mill operations or existing product mix.

Lignin extraction at Cariboo would depend on WFM business decision-making process; the existing lignin plant at Hinton will likely have to be consistently sold out first. Methanol extraction is in place at an Alberta pulp mill. Tall oil and turpentines may be problematic as long as dead beetle-killed wood is used; but technologies and markets exist for these pathways if the wood supply permits.

There is no impact on AAC; all pathways described here require internal modifications to Cariboo.

6.7. QRP to TMP-Bio

The world is moving to bio-based chemicals in response to consumer demands, particularly in Europe. Early players who can convert wood to a range of petrochemical substitutes will stake out a space in this growing field. This opportunity involves repurposing existing pulp mill assets (specifically QRP) to move to new products via the TMP-Bio process. While this is a big step, it may be possible to engineer a demonstration plant in such a way that mill assets can easily swing back to existing products.

No new fibre is needed for this approach; the TMP-Bio process requires the same hardwood feed as QRP.

[3] "Forest-based bio-products: A review of potential pathways for the City of Quesnel", Sections 3.3 through 3.7, prepared by Tom Browne, 2021-06-14.

6.8. District CHP

Low-grade residual material with high bark content is best suited for fuels and energy applications which displace fossil-based fuels in mills or in regional district heating systems. Opportunities for combined heat and power (CHP) exist at the city level using pulp mill waste heat or small-scale gasification (e.g., Nexterra or European modular systems[4]). Technologies are mature and accessible. This has been described in earlier reports[5].

Industrial development and improving living standards in First Nation communities is particularly challenging. Heat and/or power generation via Organic Rankine Cycle or gasification should be explored further.

The fibre requirements do not need to impact users of white wood (lumber, pulp) as these processes will run on low-grade mixed residues such as bark, thinnings or slash. This has been described in earlier reports[6, 7].

6.9. Industrial gasification for lime kiln or lumber kiln

Industrial gasification processes convert biomass to a low-grade syngas that can be substituted for fossil-based natural gas, thus moving to a more renewable fuel source. The key is government policy in the form of carbon pricing that makes natural gas more expensive than a biomass-based synthetic gas (syngas). A gasifier for the lime kiln at Cariboo Pulp (e.g. Valmet and Andritz plants in Finland, Indonesia and China) could be considered; gasifiers for drying (e.g. Nexterra plants at Heffley Creek or New Westminster) are also feasible if the economics are right.

The impact on white wood users (lumber, pulp) is negligible.

6.10. Biocrude

A Quesnel area biocrude production facility using an approach such as the Arbios (Canfor-Licella) Catalytic Hydrothermal Liquefaction technology could be of interest. This would run on existing or new low-grade biomass such as bark, slash or forest thinnings. A spoke and hub model could be envisaged that includes decentralized production and shipping to Prince George, Vancouver or Edmonton for further upgrading. Technologies are still under development. As a biodiesel, the biocrude could have considerable carbon footprint impact within the forest sector value chain and other resource-based industries in the Central Interior (oil and gas, mining).

The market for biocrude is potentially very large, and economies of scale will dictate that the size of an eventual full-scale plant will be limited only by available biomass.

6.11. Pipeline-ready RNG plant

Consideration could also be given to a pipeline-ready RNG plant. Such an initiative would be attractive to oil and gas investors and would contribute significantly to Canada's climate change goals. However, investment costs are very high, technologies are still under development, and while the process can run on low-grade mixed residues, high biomass demand may pose fibre constraints on existing and future entrants interested in producing higher value products. See a previous report[8] on the topic.

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[4] https://www.holz-kraft.com/en/products/energyblock.html, viewed 2021-09-01. This system is in use at Alkali Lake First Nations.

[5] "Forest-based bio-products Biofuels pathways for the City of Quesnel in a carbon-constrained world", Section 2.3.4, prepared by Tom Browne, draft version 2021-09-01.

[6] "Quesnel Biomass Utilisation -- Biopathways Scoping Study", Sections 8.8 and 8.9, prepared by Clean Energy Consulting, 2021-06-30.

[7] Forest-based bio-products Biofuels pathways for the City of Quesnel in a carbon-constrained world", Sections 2.3.2 through 2.3.5, prepared by Tom Browne, draft version 2021-09-01.

[8] Ibid, Section 3.

7. Results of the ranking exercise

The following table summarises results of the exercise. Ranks are out of 10 unless specified, for example 6.15/0.85 implies that criteria worth a combined 15% were not considered for that project.

Rank	Project title	Rating (>6 is good)	Pros	Cons
1	District CHP	**7.27**	Easy; large local impact	Funding
2	Regional forestry management	6.15/0.85 = **7.24**	Large local impact	Funding
3	Expanded Secondary mfg.	**6.40**	Large local impact; market is known	Low GHG impact globally; needs investment
4	RNG	**6.05**	Enormous global impact	High cost, needs fibre
5	Bio-crude	**6.00**	Enormous global impact	High cost, needs fibre
6	Training Centre	4.20/0.75 = **5.60**		
7	Fibre products	**5.30**	No new fibre needed	Growing new markets is challenging; needs investment
8	Cellulose products	**5.05**	No new fibre needed	Growing new markets is challenging; needs investment
9	Kraft residuals	**4.80**	No new fibre; markets are known	Growing new markets is challenging; needs investment
10	Gas for kilns	**4.50**	Low fibre needs; relatively easy	Low local impact; requires investment
11	QRP to TMP-Bio	**3.50**	Innovative reuse of mechanical pulp mills	Technology not ready; markets not known

Some common threads arise. Criteria are strongly biased towards regional benefits, as befits analysis for a local government. Two themes arise as worth pursuing, and a third as worth watching; these are expanded below:

- Local solid-wood projects are important and should be pursued. Large local impacts and the existence of mature markets are key benefits. These include:
  - Regional forest management test bed.
  - Expanded secondary manufacturing.
  - Arguably the Training Centre also belongs here, even if its ranking was lower, as it is a cross-cutting project that will facilitate all other projects.
- Bio-energy projects are also worth pursuing. Very large climate change impacts, both locally (CHP) and globally (bio-crude, bio-RNG), were key drivers. These include:
  - District heating, possibly combined with off-grid power where appropriate.
  - RNG or biocrude (there isn't likely to be enough wood for both).
  - Small gasification projects for kilns also make sense, even if ranked low from the City's perspective.
- Novel pulp-based products need technology and market development, have lower impact on First Nations and tend to do poorly in the Project Risk set of criteria, but are worth watching. These include:
  - Novel uses for fibres from existing pulp mills.
  - New cellulose-based products using kraft pulp.

- Residuals from kraft mill operations (lignin or others).
- Wholesale conversion of an existing pulp mill to a biorefinery (TMP-Bio).

7.1. Next steps: Solid wood projects

Two of the top 5 ranked projects arising from this process involve forestry and solid wood projects. And while the concept of the Training Centre ranked 6th, this concept underpins essentially every other project that involves moving to new products; the low ranking is an artefact of the selected criteria and weights.

Next steps in support of a Training Centre include the following.

- Identify specific interested educational partners willing to participate in a Training Centre, with consideration given to addressing education, training and retraining needs of current and future workforce; may include pilot plant facilities for training in EWP and prefab technologies:
- Identify a potential pilot plant partner.
- Tie this to the need for the construction of student residences as a pilot project by partnering with a prefab construction company. Expand this to First Nations housing.
- Identify specific industrial training needs through consultations with industry, First Nations, Educators and Governments.
- Consideration should be given to needs along the full length of the value chain, upstream to downstream.
- Identify potential collaborators/partnerships with other education and training institutions (NAIT, BCIT, UBC, UNBC and CDC).
- Build on the 2019 Think Tank Workshop on Human Resources.
- Develop a business plan: identify a campus location; design and cost the facility; estimate the potential scale of the student population, etc.
- Identify funding opportunities.

Next steps in support of a Regional Forestry Management pilot include the following.

- Focus would be on addressing climate change mitigation, wildfire control and optimizing forest resilience, productivity, diversity and end uses.
- Include genetics, silviculture, harvesting of logs and residual biomass, a regional scaling and sorting facility and directing of logs to best end-use, and transportation to mill gate.
- Engage primary licensees, the Quesnel Community Forest, Nazko and Lhtako Dené First Nations researchers and governments.
- Build on previous studies and workshops; promote as a holistic integrated approach and involve the Forest Enhancement Society of BC (FESBC) in discussions.
- Convene a follow-up Think Tank workshop of stakeholders, including governments for this specific topic, The workshop would build consensus, lay out a Strategic Direction, Priorities and Action Plan.

Next steps in support of Secondary Manufacturing include the following.

- Combine various data banks on Secondary Wood Manufacturers in the region into a useful inventory (Asset Mapping).
- Carefully assess position of existing manufacturers in components, systems and modular prefabrication and whether there is viable opportunity in this space.
- Identify unique niche construction projects e.g., custom designed First Nation housing in wood-frame and mass timber, which tie into a training package for First Nations workforce for on-site assembly.

- Focus on the wood construction value chain with emphasis on productivity enhancements driven by technology and innovation and on reducing carbon footprint (embodied and operational carbon emissions)
- Investigate opportunities for partnerships within the value chain from primary producers to secondary manufacturing: what value proposition could the Quesnel area bring to the relationship.
- Engage stakeholders in a targeted workshop on value-added wood products/systems for structural applications (build on Think Tank 2018 recommendations), lay out priority areas and foster matchmaking opportunities.
- Explore federal and provincial investment opportunities.

7.2. Next steps: Bio-energy projects

Three of the top 5 ranked projects are related to energy efficiency and novel fuels in a carbon-constrained world. These can be subdivided into projects at two scales: local solutions to local needs at local scales in a business-as-usual context; and large-scale projects in response to global climate change issues as identified by IEA and IPCC scenarios.

Local energy needs can be met with local wood supplies, with the demand for wood being limited by the heating demand, whether this is a First nations community or institutional users in Quesnel.

Combined heat and power for First Nations ranked 7.60. This is an obvious next step for communities wanting a greater degree of autonomy; the Alkali Lake experience is a good benchmark. Next steps involve First Nations developing their own plans for this, by reviewing progress made by other communities, available technologies and funding pathways. These include glycol heating via wood-fired boilers or gasifiers, CHP-in-a-box systems, or Organic Rankine Cycle systems, and may include off-grid power generation where current systems involve imported Diesel fuel.

District heating for institutional clients in the City was ranked 7.05. (The combined average ranking for district heating and CHP was 7.27). Funding applications for a feasibility study have been submitted and are under review. Retrofit applications will be dependent on existing building heating systems and piping distances, but greenfield development of new housing can be built from the start with a district heating component and would offer a vision of a net zero community.

At a much larger scale, a previous report[9] prepared by one of the authors outlined next steps for Renewable Natural Gas. Given the global need for biofuels, the market is significantly larger than just the fuel requirements of the North Cariboo region. The conflicting economic drivers of these plants are, on the one hand, economies of scale: All else being equal, a larger plant will be cheaper, per unit of production, to build and run. But on the other hand, a larger plant requires more biomass, in turn requiring longer haul distances; this in turn drives up the cost of biomass which is usually the largest single operating cost. One way to look at this is in terms of the energy content of the wood entering a plant per unit time, in GW: Canada's largest pulp mill produces about 2250 dry tonnes of pulp per day, requiring about 5600 dry tonnes of wood per day. At 18 GJ/t, this is a scale, based on feedstock energy content, of about 1.2 GW. The largest pulp mills in the US South are a bit larger, because southern pine grows more quickly and can be harvested more frequently; Brazilian mills are of the order of 3 to 5 GW because of fast growing eucalyptus. But a small petrochemical refinery is typically 10 GW in scale (150,000 barrels per day at 6.1 GJ/bbl); by comparison the Port of Rotterdam hosts 5 refineries processing oil at a

[9] "Forest-based bio-products Biofuels pathways for the City of Quesnel in a carbon-constrained world", prepared by Tom Browne, draft version 2021-09-01.

combined rate of about 80 GW, with enough oil flowing through the port to feed 5 more refineries upstream in Belgium, Holland and Germany.

Wood-based biorefineries, especially in Northern climates with slow-growing wood, will therefore always be at an economic disadvantage compared to petroleum refineries. This is due to the distributed nature of biomass compared to concentrated oil and gas supplies and leads to much poorer economies of scale.

IEA and IPCC scenarios make a very strong case that the climate change imperative will require moving very quickly in this area. Business as usual assumptions around economic feasibility of these projects may change rapidly in response to actions by governments, both within Canada and elsewhere. With the essentially bottomless world market for biofuels required by IEA and IPCC scenarios, and given the economic disadvantages of smaller plants, biofuels plants are likely to need to be as large as possible, given biomass availability, once the technologies are fully commercial. If we are to make progress towards net zero emissions globally by 2050, large-scale plants will need to be in the pre-engineering phase within the next few years.

Furthermore, if the world moves all automobile capacity to electric by 2035, demand for gasoline, which represents about half of petroleum production, will essentially disappear. The oil and gas industry is aware of this threat and is starting to reposition itself as an energy industry writ large. These industries have the capacity to bring significant resources to bear where large-scale energy systems are concerned, regardless of feedstock.

It is worth pointing out that these technologies are not yet fully commercial; and that pilot commercial plants have, as a general rule, only been operated on clean white pellets. A major technical risk remains getting these processes to run on high bark content feedstocks with the attendant high ash contents. But the climate change imperative may require building a plant with Serial Number 001 to run on bark-heavy juvenile or residual material before the commercial demonstration plants are fully debugged.

Next steps from the previous report are repeated and expanded here:

- Bio-crude and RNG ranked about the same, at 6.00 and 6.05 respectively. Both meet the requirements for the large-scale bio-energy supplies needed for a carbon-constrained world.
- Both processes, at full-scale, will be expensive and will require large amounts of wood. It is unlikely that there is enough wood for both to go ahead at full scale in the immediate Quesnel area.
    - Costs and markets imply that partnerships with oil and gas may be the best approach.
    - Wood supply will require intense collaboration between the Province (in terms of TSA, AAC and forest management practices), First Nations and the existing forest sector (mainly WFM).
- For both projects, the key steps the City can take are to ensure the interest of the City in hosting such a plant is well known among all stakeholders:
    - Existing forest sector in the larger Quesnel region.
    - Canfor/Licella interest in developing a satellite bio-crude production site.
    - Oil and gas interest in the field of biofuels.
    - First Nations.
    - Provincial and federal agencies.
    - Potential investors outside the forest sector.
    - FortisBC, in the case of RNG.
    - Potential equipment suppliers (such as Haldor Topsoe, in the case of RNG).

Arguably, it is not too early to start talking to equipment vendors and potential investors. ThyssenKrupp and Haldor Topsoe are leaders in the RNG technology field, and the Gas Technology Institute (GTI) is well-placed to

provide advice. Potential investors include West Fraser and the oil and gas industry. French oil giant Total is a former investor in the oil sands and is active in the field of RNG and bio-crude. More detailed analysis for an RNG plant requires a site-specific engineering study. Cost of such a study is likely in the $50,000 to $100,000 range.

The potential to supply 500 to 1000 dry metric tonnes of wood per day, while not impacting existing fibre users, would need to be evaluated in extensive detail by a group including foresters, First Nations, existing fibre users and BC government policy experts. Without novel fibre supply options such as increased use of slash and thinnings, the fibre-constrained Central Interior will have trouble supporting this opportunity without impacting the existing forest sector. A new evaluation of available fibre today and in the future needs to be completed to support these pathways.

7.3. Technology and market watch: Novel pulp-based products

Five projects involving modified or expanded pulp mill processes did not make the cut off rank of 6.00 necessary for further consideration, but are nonetheless worth watching. In three of these, commercial demonstration plants are in operation and the real issue is growing the markets for these products (novel fibre products, novel cellulose products and kraft mill residuals) to the point where existing plants are consistently sold out and customer demand supports the building of new capacity. West Fraser, with its lignin plant, and Mercer, with its position in Performance Biofilaments, are no doubt watching market growth carefully. In a fourth pathway (gasification for kilns), the real limitation is the effective cost of carbon – displacing natural gas at $5/GJ is not commercially viable. Here the missing part is appropriate carbon pricing; FortisBC is offering to buy back fossil natural gas that is displaced in kilns, and the only limiting factor here is the scale of that support versus the cost of implementation. Only the last pathway (conversion of QRP to TMP-Bio) is still not commercially viable from either technology or market perspectives, even with proper carbon pricing. These pathways should be supported by the City if approached by an interested industrial partner.

7.4. Overarching: new evaluation of available fibre

Any project involving raw materials from the forest will require better knowledge of the existing and potential future fibre supply in the region, including not just high-quality white wood for lumber, EWP or pulp, but also under-utilised species such as aspen or other hardwoods, or lower-quality residuals such as bark, slash, thinnings, juvenile wood, etc. There is a need for a customized assessment of regional fiber supply and associated risks that a private investor would need in order to arrive at a business decision; this assessment goes beyond current estimates of sawlog availability.

Current forest management approaches do not allow for timely and sufficient adjustment for rapidly changing conditions and threats, such as drought, insect infestation and forest fires. New, more resilient forest management plans will likely involve more thinning and more deciduous plantations than is currently the case. It is not clear today what new resilient and healthy ecosystems can deliver in terms of fibre types and volumes over a reasonable timeframe; commercial opportunities are also unclear. For example, softwood lumber, with residual chips going to pulp mills, depends largely on mature lodgepole pine. A new juvenile resource from thinnings is difficult to debark and is not suitable for traditional dimensional lumber. On the other hand, thermochemical biofuels processes are able to handle high bark content or mixed wood such as hardwood and softwood. Volumes, quality, costs and risks associated with traditional and novel fibre supplies on a continuous basis over the next several decades are unknown, and this risk factor presents a large barrier to new investments.

The Alberta Roadmap[10], funded by the Alberta government and the forest industry, successfully addressed these questions. The City could move quickly to incent new studies to provide commercially necessary information on feedstock cost and availability. The example of other organisations such as CRIBE in Northern Ontario could serve as a sample path forward.

7.5. Opportunities for the City

There is a major opportunity for the City of Quesnel to position itself as a green champion. This starts with playing a role in operationalising new BC government policies around new forest management and net zero carbon approaches. Locally, this means reducing GHG emissions in local heating systems, in the production of building systems or in new greenfield housing or light industry development. On a global scale, it means supporting the export of low-carbon building products, pulp and paper products and, potentially, biofuels of various sorts, all from a sustainably harvested, non-food renewable resource.

[10] https://albertainnovates.ca/wp-content/uploads/2018/02/alberta_forest_products_roadmap_booklet.pdf, viewed 2021-09-09.