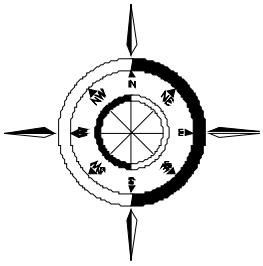


TransNorthern Consulting, Whitehorse, Yukon

Concept Paper on Developing a Biomass Fuels Industry

Prepared for the Yukon Development Corporation

David Loeks, MFSc, MBA
5-7-2019

EXECUTIVE SUMMARY

This paper outlines a concept for developing a Yukon biomass fuels industry based on fire risk reduction activities.

An increasing number of people understand that Whitehorse faces an extreme risk of catastrophic forest fire comparable to what occurred with Fort McMurray. A major component of managing and reducing this risk must involve reducing the forest fuel load on public lands, coupled with reducing the flammability of private properties, both in accordance with accepted "FireSmart" principles. Treated areas would be encouraged to revegetate as aspen stands which are more fire-resistant, natural to this forest ecosystem, and attractive.

A serious constraint to implementing the necessary scale of forest fuel management has been its great expense compared with current public budgets. A general estimate for achieving a defensible landscape by current contract means would be between $18 million and $30 million. At current rates of operations it would take more than 30 years to achieve. There is a ready use as fuel for the solid wood that would be produced, but not for the immense volume of slash, tops, and small stems that would be generated. Currently these materials are burned in a open-air piles, but this would not be tenable in truly large volumes. The volume of slash anticipated would constitute a waste disposal challenge of unprecedented magnitude.

This paper proposes a concept that brings together the means for reducing the wildfire risk to Yukon communities and an approach for using the resulting biomass in the most economically and environmentally sustainable way possible. It looks at the whole lifecycle of the biomass fuel market, from stump to boiler, as the whole system must be integrated in order to achieve the expected social, economic, and environmental benefits.

The retail value of biomass as fuel to be removed through risk reduction efforts (cordwood and chips from slash) can be up to $14,000/ha. The private forest industry sector is capable and interested in undertaking this work if it can do this as a timber harvesting operation – i.e. process and market the biomass it cuts as fuel. Government has a crucial role to play as an anchor customer for woodchips produced from the slash. Public buildings, converted to modern woodchip boilers, serviced and operated by private contractors, can provide the stability needed to create a reliable and market that can economically absorb what will otherwise be a serious waste problem. Up to 63 100-kw boilers may be needed to absorb the expected volume of chips – Whitehorse has ample capacity for this. The private sector is prepared to negotiate mutually beneficial contracts for installing, operating, and supplying these boilers.

The biomass fuel sector can be expected to provide jobs, help achieve climate change goals by replacing fossil fuels, and eliminating all or most of the $24 million annually "leaked" from the Territorial economy through the importation of fuel oil. And most importantly, it will achieve badly needed fuel abatement to improve the safety of Whitehorse.

Developing a biomass fuels industry as proposed, would need considerable detailed and technical study in many areas including fire risk management, forest management, building engineering, industry logistics, and finance. Co-management and consultative relationships between the Yukon Government, First Nations governments, and the City of Whitehorse must be observed and nurtured.

1. Biomass Fuels Development Concept

PREFACE

The purpose of this work (from Terms of Reference) is to:

"Prepare and present a concept for developing a solid biofuels sector based on fire risk reduction treatments in forest stands. The concept will consider a draft strategy that proposes a coordinated sequence of steps to establish an economically viable biofuels sector in Whitehorse and other suitable communities. These steps will address key elements such as infrastructure, investments in wood chip heaters and other equipment, fuel management treatments, logistics of wood chip production and delivery, and social license. The concept will identify the roles and responsibilities, were government to foster coordinated and effective action to stimulate and support a biofuels sector. It will also address the roles and responsibilities of the private sector … "

Having been given a dual purpose, this document will focus first on the need for fire risk reduction and the volumes of woody material that would be produced from removing forest fuels. This will provide the scope for discussing how this material would be the basis for developing a solid biofuels sector.

The thesis of this report is not new. It was explored in two works done in 2009 and 2011 for the City of Whitehorse Fire Chief and has been developing incrementally since then.

This is a situation in which an existential public imperative: providing for community-scale public safety can promote a public good: sustainable economic development, jobs, energy security, fossil fuel replacement with benefits to reducing climate impacts.

Definition of "Strategy": A high-level plan to achieve one or more goals under conditions of uncertainty. Strategy generally involves setting goals, determining actions to achieve the goals, and mobilizing resources to execute the actions.

Whitehorse will be the initial focus for developing a template and sequence of steps that can be generally applied to other Yukon communities. Note that a strategy does not supply a timetable – that is a subject of implementation planning.

TABLE OF CONTENTS

Introduction 1

A. FOUNDATION OF BIOFUELS DEVELOPMENT CONCEPT

Natural Resources, Industrial Capacity, Structure and Relationships 4

1. Potential Volume of Fuel: How much are we talking about? 4
2. How Could This Woody Material be Disposed Of? 6
3. Operations: How to do it. 10
4. Costs and Business Relationships: How to finance this. 19
5. Economic Effects of an Expanded Biomass Sector. 23
6. Issues and Management Questions. 26
7. Allignment of Roles and Responsibilities. 28

B. PROPOSED STRATEGY

8. Sequence of Steps to Make this Happen 29

1. Obtain high-level approval for concept.
2. Obtain staff-level buy-in and provide direction.
3. Undertake needed policy and planning work.
4. Undertake detailed research on aspen propagation
5. Negotiate and confirm one or more long-term heat supply contracts with ESCOs.
6. Devise policies and financial instruments to support ESCOs and encourage uptake of biofuels heating
7. Ensure heat supply contractor has access to adequate places for stockpiling, drying, processing and inventorying product as needed.
8. Ensure that the responsibilities and authorities of each involved party are clear.
9. Issue necessary permits.
10. When previous steps have been completed, begin. {Ongoing: monitoring, inspection, compliance}

9. Concluding Notes 32

Appendix: Canadian Fire Behavior Prediction System 33

INTRODUCTION

It is generally understood that Whitehorse is positioned at the end of a forest fire blowtorch created by topography, prevailing winds, and abundant forest fuels. The fate of Fort McMurray, AB, and recently, Paradise CA as a result of forest fire is not just possible here, but in time, probable. It is difficult to overstate the seriousness of this risk. It may not be hyperbole to say that if you are not frightened – or are at least seriously disturbed – by the forest fire risk facing the Whitehorse, then you might not understand the problem.

Whitehorse is no less vulnerable than Ft. McMurray, or Paradise, California.

The scale of the risk is underscored by these recent events. The direct and indirect costs of the Fort McMurray forest are estimated to be $9.5 billion CAD, while for the recent Camp Fire in California, the costs to the state, insurers, and homeowners will top $19 billion USD. But putting money aside, lives lost cannot be recovered, and the disruption to how we live may be permanent. In a real sense, Whitehorse might be irreplaceable.

There is strong agreement between the stakeholders involved in the development of this report. Efforts to improve public safety (Fire Risk Management) can be coordinated into four general policy areas which influence each other and overlap to some extent:

- Risk reduction
- Preparedness
- Response
- Recovery

This proposed strategy addresses an aspect of Risk Reduction: reducing forest fuels on public lands, coupled with developing a biomass industry, as part of the foundation for improving public safety from forest fire. Think of it as one chapter that reinforces the three other policy areas to achieve a comprehensive fire risk management and public safety strategy.

On the economic development side, biomass heating is nothing new. As recently as the mid 1950's, virtually all of the Yukon's space heating was from wood.

In Canada, an overall methodology for community fire risk reduction has been developed and disseminated as the "Firesmart" approach[1]. The Firesmart approach considers all combustible materials from the foundation of a structure to the broad forested landscape.

It is critical to accept that if reducing fire risk to Whitehorse is the generally accepted goal, treatments on public lands must be complemented by applying Firesmart principles to private property. A recent study by Alan Westhaver analyzed what structures survived in the Fort McMurray catastrophe. The conclusion is plain: the survival of structures throughout a community besieged by a general forest fire

[1] https://www.firesmartcanada.ca/

depends on effectively managing fuels on private properties. This applies to the periphery and to properties well within the residential zone.

The benefits of well-executed treatments on public lands are largely voided if private properties do not adopt FireSmart practices. This proposed strategy does not address private properties. It takes note that a focussed effort for this important topic is essential to the overall goal.

This concept provides more specific support for two recent documents: the 2016 *Yukon Biomass Energy Strategy*, and the 2015 *Timber Economy of the Whitehorse Southern Lake Forest Resource Management Planning Area*. Both make strong cases for the economic benefits and viability of establishing a biomass fuels sector in southern Yukon, based primarily on space heating. A comparable, scaled down logic can be applied to the smaller communities.

As commissioned by the Yukon Development Corporation, the purpose of this document is to propose a specific sequence of steps that links establishing a biofuels sector with performing essential forest fuels reduction. In this, there is a remarkable convergence of the public interest with private sector economic opportunities:

- The public desperately needs to perform significant fuel abatement to reduce fire risk for Whitehorse. Some 4000 ha have been provisionally identified as meriting treatment. The costs for this under present contractual arrangements can be as high as $30 million using current practices. At present rates of forest treatments, the progress of work will be so slow (over 35 years) as to be of questionable use.

- The fire return interval for the Whitehorse area (cataclysmic fire returns approximately on a 130 year cycle) increases the odds of fire with each passing year and adds to the standing fuel loading of the forest at the rate of 0.5m^3 per hectare each year. The recent Whitehorse Southern Lakes Forest Management Plan shows that the forest cover is 90% conifer (highly combustible). Fire risk mapping studies undertaken since 1998 show that large portions of the forest cover have reached high fire-risk status. The public cannot afford to pay for meaningful fuel abatement treatments for Whitehorse – yet it cannot afford not to do this.

- There is a market opportunity for biofuels to compete with, and even largely replace fossil fuels for space heating. Biofuels can be significantly less expensive than fossil fuels and have a lower environmental impact.

- Replacing fossil fuels with biofuels will effectively contribute to the Yukon's objectives for reducing greenhouse gas emissions. Biofuels are carbon neutral: they recycle carbon that has been circulating in the environment for millions of years, while fossil fuels are additive, injecting carbon that has until now been locked underground. Reducing fossil fuel carbon is an urgent policy priority.

- Developing a biofuels sector will produce economic benefits through increased employment and investment, and will reduce economic "leakages" out of the territorial economy. The Yukon exports some $60 million annually for heating oil.

- The private sector has the experience, the capacity, the equipment and the interest to undertake extensive fuel abatement, and to produce significant volumes of biofuels in the form of fuelwood, wood chips and pellets.
- Public sector fire and safety officials at Yukon, City, and local levels are communicating directly and productively with each other forming working relationships and improving coordination. The City has recently commissioned a 20-year fire risk management strategy.

Clearly there is a convergence of interests: the public has a pressing need for fuel abatement, there is an economic opportunity for biofuels, there is a intent to replace fossil fuels, there is an abundant local source of wood, and there is a private sector that is prepared to furnish a biofuels product and service.

But there is a "chicken-and-egg" problem. The private sector cannot gear up without secure access to wood in volume and without solid customers purchasing biofuels in volume. Moreover, public fire safety will not much be improved by incrementalism in forest fuels abatement. Conversely, the public sector cannot make significant accomplishments in fuel abatement with limited budgets and an inability to deal with the serious volumes of wood that must be removed.

This proposed strategy sets out a template for resolving this conundrum. Briefly put, it proposes this:

- The Yukon Government and the City of Whitehorse invest in becoming "anchor customers" for the biofuels sector by switching public buildings from fossil fuel heat to heating by high-efficiency wood chip boilers. The proposed schedule of treatments will require approximately 63 100-kw boilers to absorb the quantity of chips that would be produced each year from slash and tops.
- The two governments commit to implementing a 10-year fuel abatement plan in the Whitehorse area that will be undertaken by the private sector.
- The schedule of treatments will require approximately 63 100-kw boilers to absorb the quantity of chips that would be produced each year from slash and tops. To provide startup stability as an "anchor customer", Government would need to commit to having these boilers installed.
- The private sector will enter into long-term (likely 10-20 year) heating supply contracts with different fee schedules that depend on whether the customer installs and owns the boiler, or the contractor.
- Fuel reduction treatments will be done at no cost or at low cost with the provisos that the contractor will own the biofuel stock removed from the stands and that each stand is left with specified conditions met. In general, the objectives for treated areas will be to establish aspen and other deciduous forest cover.
- The biofuels providers will expand into other markets as the sector develops. There is a market opportunity for wood pellets for heating private homes, and a market for high efficiency woodstoves – government policies can encourage this development.

With this structure of confirmed public support, the private sector can obtain the necessary financing and make the necessary investments in equipment and employees to effect meaningful fire risk reduction while building a sustainable industry.

Supporting this strategy, the success story of the State of Upper Austria in fostering a biofuels sector will be examined for applicable lessons. Biomass supplies 48% of the thermal heating energy in Upper Austria from a sustainable yearly production of 1,150,000 tons of wood biomass. This is from a forest land base of 4900 km^2.

By comparison, the forested landbase in the Whitehorse/Southern Lakes management area is 6080 km^2 and has a theoretical sustainable biological production of 150,000 tons/yr on a 100-yr rotation. (Current total demand is about 20,000 tons/yr.)

Renewable energy heating systems are installed in 85% of all new single-family homes in Upper Austria. Since 1999, all new or renovated public buildings must use renewable thermal technology for heating and hot water. Since 2008, all new private sector buildings larger than 1,000 m^2 (10,800 ft^2) must also use renewable energy for heating and hot water. The state is a leader in Europe for the manufacture of high-efficiency biomass heaters and the biomass sector maintains a well-trained workforce. It may be noted that the woodchip boilers successfully operating in Teslin and at Raven Recycling in Whitehorse were manufactured in Upper Austria.

The successful development of a biomass industry in Upper Austria did not come about by accident. For 20 years, both state and federal governments have employed a coordinated set of policy and financial measures to foster and support the development of this sector. Several of these measures may be worth considering as Yukon fosters a biomass fuels sector.

A. FOUNDATION OF THIS BIOFUELS DEVELOPMENT CONCEPT

Natural Resources, Industrial Capacity, Structure and Relationships

1. POTENTIAL VOLUME OF FUEL; How much are we talking about?

The analysis began by asking the Yukon Wildland Fire Management Branch to identify which areas might be treated if Whitehorse was to be reasonably protected from wildland and interface fire. Several things must be considered, including direct approach of the “wall of flames” from a crown fire; the “rain of embers” that are carried downwind from a general fire, providing protected access for fire fighters to fire zones and water sources, providing routes of evacuation and escape for residents. In the broader landscape, breaking up large contiguous blocks of flammable forest is also strategically desirable.

The initial map is static and considered the tactical needs close in to zones of settlement. It used the published reports from Embers and TransNorthern Consulting (1998, 2002, 2006) as a point of departure and incorporated the perspective of fire professionals who had been studying the problem for many years. This map should be considered to be provisional only: a working template that will be

modified with further study and consultation. As a theoretical exercise, the map does not factor land ownership, nor does it consider forest management and planning responsibilities, or First Nation partnerships.

An important limitation is that this map does not consider treatments that would reduce risks for "satellite" neighborhoods such as Robinson and the Carcross Valley, Marsh Lake area, and those north of Whitehorse, such as the Mayo and Hotsprings Road, and Ibex Valley. Sound fire risk reduction strategy would identify natural features and vegetation communities that can help break up the fuel continuity outside of Whitehorse and provide lines of defense or opportunities to steer a fire.

The idea is to provide ways of controlling a fire approaching from south or north before it becomes unmanageable. An important part of overall fire risk reduction, the "outer landscape" should be addressed once a program for treating the nearby stands has been started in earnest.

The total area identified for initial nearby treatment is 4081 hectares, with the suggestions distributed as follows:

Embers 2002	965 ha
Embers 2006	371 ha
Wildland Fire Management Suggestions	2,197 ha
Loeks & Thorpe suggestions	548 ha
TOTAL	**4,081 ha**

To provide a sense of scale, this is 1/20th the area of Whitehorse. The recent Camp Fire in California burned 40,000 ha in its first two days. At current rates of contract crews hand clearing (av $7500/ha), treating the entire area identified as needing treatment would cost $30,607,500. If this was done by a mechanized logging contractor it would be roughly 60% of this: $18,364,500.

The current (2019) City of Whitehorse budget for fuel abatement is $200,000. There is an unallocated sum from 2018 of $350,000 that could be added to this. This combined amount could contract for 73 ha (hand crews) or 122 ha (mechanized). The Yukon Government's Wildland Fire Branch can allocate as much as $300,000 to the greater Whitehorse area or 40 ha (hand crews); 66 ha (mechanized).

At current rates of treatment, it would take between 37 years and 21 years at a cost of between $30 million and $18 million to treat the identified areas.

The following estimates were used to calculate the total woody biomass of these recommended sequences:

- Average solid wood (est 125 m^3/ha) in 4081 ha 510,125 m^3
- Total tops, branches, and fines (est 25m^3/ha): 102,025 m^3

To estimate the volume of biomass to be removed, we presume two objectives:

1. Remove sufficient conifers so that the stand cannot support a crown fire, and
2. Where possible convert the area to a more fire-resistant forest cover such as aspen/birch/willow; widely spaced, open mature pine.

The treatment assumption for how the volume of wood is to be removed was estimated as follows:

- remove an average of 75% of woody material overall (i.e. 94 m^3/ha overall) over 4081 ha.
- Yield: 382,593 m^3 of fuelwood; (approx. 170,000 cords)
- Yield: 76,518 m^3 tops and fines (chip material: approx. 38,000 tons)

The treatment areas contain a variety of forest fuel types, so in practice they will have different prescriptions. The stand fuel types are categorized by the Canadian Forest Fire Behavior Prediction (FPS) System. (See Appendix for more description.)

Treatment objectives follow from the fuel type in each stand:

- D1, D2 (Aspen): Do not treat. Sustainable harvest per site plans.
- M1, M2 (Boreal mixed wood): Retain aspen, willow, mature pine, 100% removal of spruce and immature pine. Encourage conversion to deciduous.
- C2 (Closed canopy mature spruce): 90% removal, propagate aspen.
- C3 (Mature lodgepole pine, naturally limbed): Increase spacing by 60% removal.
- C4 (Immature pine/spruce, densely stocked): Complete removal, propagate aspen.
- C7 (Mature, open spaced lodgepole pine). Remove deadfall.

2. HOW COULD THIS WOODY MATERIAL BE DISPOSED OF?

Current practice in fuel abatement treatments is to cut solid wood into 8’ or 4’ lengths, stack them, and leave on site free for the public to pick up. Slash (tops and fines) are piled and burned in the winter. Attendant problems include incomplete combustion of slash producing smoke and adding carbon to the atmosphere.

The projected fuel management treatments would produce a volume of wood to be removed so great that it would overwhelm current disposal methods which are economically inefficient and environmentally harmful.

In devising a better method of disposal, we will assume that all solid wood will be salvaged and used for stove wood, and suitable sawlogs will be diverted to local sawyers. An economical, effective, and low-emissions way to dispose of substantial slash (tops and fines) must be considered, as the volume of this material is staggering.

Here is the current demand in WSL for biomass fuel according to the 2015 report “Timber Economy in the Whitehorse Southern Lakes Forest Resource Management” (Thorpe, Zanasi):

- 15,600 cords per year (35,000 m^3/yr)
- 200 tons chips per year (Raven and Yukon Gardens)
- 1100 tons pellets per year. Chiefly private homes.

These figures help inform a reasonable schedule for completing treatments. The key idea is to optimize three variables:

1. Treating as much of the 4081 ha as rapidly as possible for reasons of public safety.
2. Treating as much of the area as can be reasonably done with current private sector capabilities.
3. Treating no more hectares per year than can be absorbed by Whitehorse's annual demand for fuelwood.

As it happens, the current annual demand for fuelwood (approx. 15-17,000 cords) is the yield of approximately 400 ha (at an average of 75% removal of biomass). The current capacity of mechanized logging firms is between 350 and 400 ha/yr (approximately 40,000 m^3/yr). Combining these two considerations gives a treatment schedule that can be completed over 10-12 years at 400 ha/yr.

Fuel management becomes economical if all woody debris is treated as commercially valuable. The proposed strategy includes these elements:

- Treatments will be mechanized wherever suitable and will occur over a 10-12 year period.
- Hand crews can be contracted to work in sensitive areas and on the margins of areas cleared by equipment.
- All materials including slash will be removed.
- Biofuels will no longer be left in the forest for free public pick-up.
- The standing solid wood to be removed would be used mostly for woodstoves and furnaces. Sawlogs would be selected out.
- If the rate of treatment produces fuel wood in excess of current demand in any year, it will have to be stored out of the stands (because of fire hazard) or disposed of by converting to woodchips or pellets. There should be little or no need for open air burning.
- The fuelwood produced will be used to meet existing local demand. *Note: fuelwood will require a year of storage and seasoning before it can be marketed.*
- The small trees, tops, and fines from fuel modification on 4000 ha would total 38,000 tons, producing 3,800 tons of chips per year if a 10-year schedule is adopted. This would supply the equivalent of 63 100-kw boilers per year (@60 tons/yr). *Note: We are referencing this size of boiler as an example of a flexible and adaptable design type. It is not intended to be a recommendation.*

- Current chipping equipment can produce about 35 tonnes of chips per hour. 3800 tonnes would be 110 hours of production from the slash (tops and fines) left over from fuel wood salvage. *Note: this slash would have to be stacked and dry in the field for one year.*
- A pellet mill purchased by Bear Creek Logging has not been set up yet. It is estimated to produce 1 tonne/hour. At this rate, it could meet current demand in 6 months/yr of operating.

Most treated stands would be converted to fire-resistant aspen. The exceptions would be stands better suited to fire-resistant, widely spaced mature pine. Converting mixed aspen-conifer stands is straightforward: remove the conifers to release the retained aspen.

Converting conifer stands to aspen or birch will require more study. The most reliable – but costly - method is to plant root cuttings that have been sprouted. More practical may be to scarify the upper soil layer to expose mineral soil to provide a seed bed for the abundant and highly mobile, wind-dispersed seeds that occur in a "mast year". Further research or expert consultation is needed to achieve the coordination necessary between scarifying and seed years.

At full extent of 4000 ha of treated areas and with an estimated yearly increment of 0.5m^3/ha, there would be 2000 m^3 per year growth. Assuming there are 63 100-kw boilers consuming 3800 tonnes/yr (approx 7600 m3), in principle the area under fuel management could be sustainably managed to supply one third the demand of the boilers once these stands reach maturity. We can expect that maintenance activities on road and powerline right-of-ways, and land development can contribute to a sustainable yearly chip supply.

Infrastructure Needed to Consume Fuel Management Wood Fiber.

Whitehorse has the potential to absorb the fuel wood that would be produced by treatments of 400 ha/yr. The round wood market is currently close to this volume. There exists a modest residential market for wood pellets, which could be increased if there was a reliable local supplier. The question is creating a market for 3800 tons of wood chips – the capacity of 63 100 kw boilers. This would require buildings, or clusters of buildings, of 10,000 sq. ft or more (the capacity of a 100-kw boiler).

- The Yukon Government operates non-residential buildings with a total area of 252,364 sq m (2,716,423 sq ft). This represents the capacity of 271 100-kw boilers. 5 of these buildings have a combined area of 72,131 sq. m (776,411 sq ft); the capacity of 77 100-kw boilers. In addition, YG operates approximately 120 residential buildings currently heating with electricity, some of which potentially could be clustered and heated by boilers, or heated individually by wood pellets, also a product of slash and fines.
- The City of Whitehorse has 5 buildings with a combined area of 39,638 sq. m (426,666 sq. ft); the capacity of 42 100-kw boilers.

By virtue of their capacity, public sector buildings in Whitehorse have the potential to be anchor clients for biomass heating that could consume all the chips from the small tress and tops produced by fuel abatement.

Figure 1Woodchips for Teslin boilers

Figure 2 100 kw Hargassner Woodchip Boilers – Teslin

3. OPERATIONS: How to do it.

3.1 Logging logistics

Mechanized harvest in the forest, whether for commercial logging or for fuel abatement requires careful planning and operations to accomplish objectives, which include:

- Operating only in specified locations
- Achieving fuel management and sylvicultural objectives
- Minimizing or avoiding adverse environmental and social impacts
- Achieving target harvest volumes (subject to above)
- Achieving timeline objectives
- Attaining financial objectives (and avoiding adverse costs)

Timber harvesting includes these phases:

Planning.

It would be best to consider fuel reduction activities as timber harvesting and regulate them as such. Timber harvesting areas are typically identified in the context of forest management planning. This considers multiple values and it is done in close collaboration with First Nations.

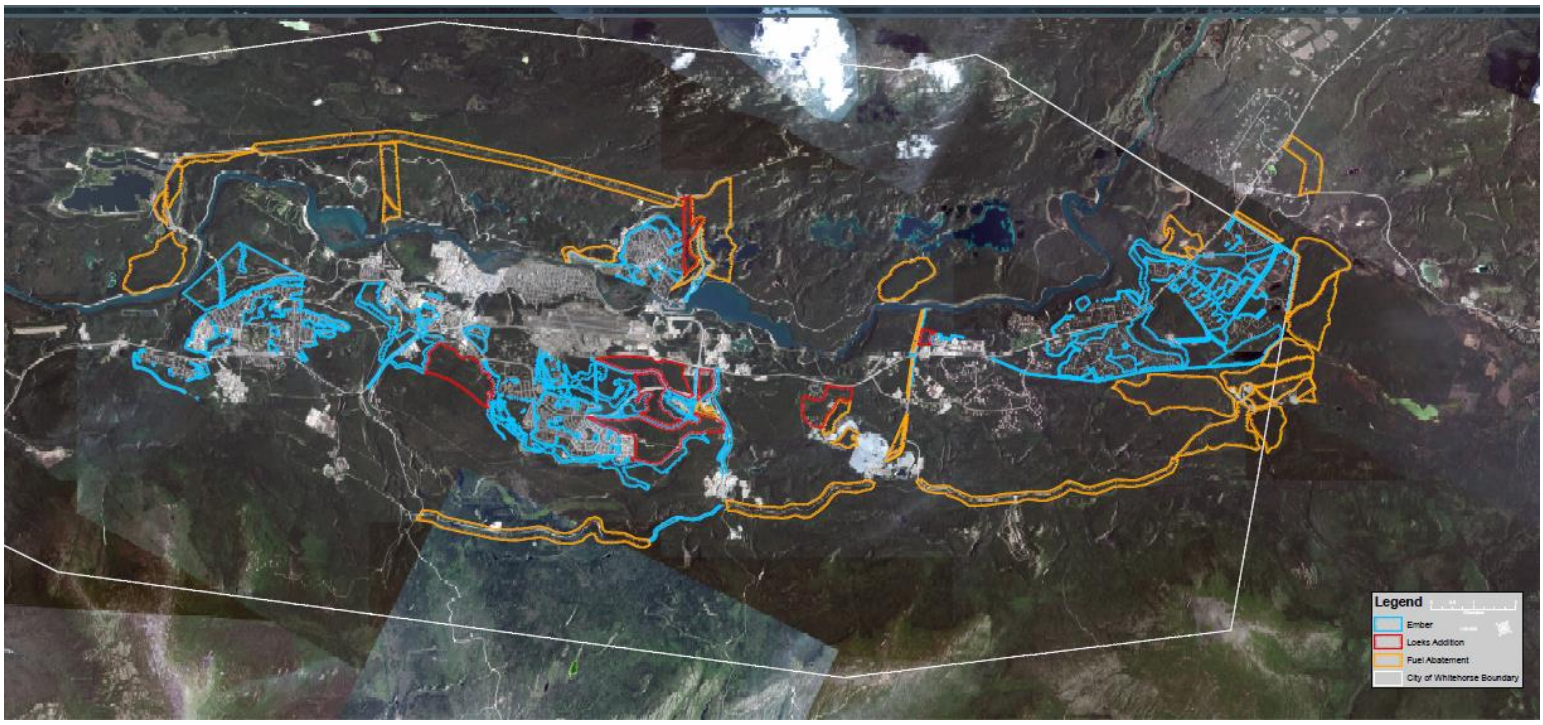
A Timber Harvesting Plan (THP) and a Site Plan (SP) outlines the actions to be undertaken during harvesting. Typically, the THP is designed at the watershed or landscape level. In the case of meeting fire risk reduction (fuel abatement) for Whitehorse, the THP map presents the overall pattern of fuel reduction sites. The Site Plan is at a finer level of detail. It will show the outline of cutting sites and route of access roads. It will also map important non-timber features that must be protected or mitigated for. An accompanying document presents the plan itself: describing the map and the actions taken to implement the plan. This document must proceed through the Yukon Environmental and Socio-economic Assessment Act process.

The draft fuel abatement map prepared for this study could be the basis for a draft THP map. It shows the pattern and the locations of the 4081 ha that fire experts have identified for treatment. This map can be projected onto the Yukon Vegetation Inventory maps to obtain initial information about the forest species, structure and an approximate indication of volumes. This can be the starting point for site plans.

The current understanding of treatment priorities is to focus on forested areas within .5 km of settlement to reduce the volume and intensity of the immediate wall of inflammatory heat and the intensity of the “rain of embers” that are the chief causes of building ignition. The secondary focus is farther out at the landscape level to break up fuel continuity and provide lines of control for fire fighters, and access/evacuation corridors.

In the {draft} map below of proposed fuel management treatment areas around Whitehorse, North is to the left; South to the right. It should be emphasized that this is a provisional, discussion map. It is static and has not been informed by fire risk modeling. Further work in risk assessment is needed before an

actual Timber Harvesting Plan is prepared. The 20-year fire risk management study commissioned by the City of Whitehorse should yield a better-formed map



Engineering and layout. Once the plans are approved and the timber harvesting is authorized, the engineering phase can commence. This includes the layout and construction of main haul roads to cut blocks and the marking of cut block boundaries.

Logging. Includes felling, skidding, log processing, decking, loading and hauling. This is accomplished with a variety of equipment and hand operations depending on the site and the harvest objectives. Objectives for fuel abatement and stand conversion to aspen will be different from typical timber harvest objectives.

> **Example below:** A fireguard cut across the hillside below McCrae in 2010 set these objectives: reduce fire risk, effect a conversion from spruce dominant to aspen dominant. The prescriptions were: remove 80% of conifers, retaining old pine with no basal fire scars; retain all aspen and willow regardless of size (as practical); remove all stems, burn all slash. This operation used a feller buncher and removed the log piles with a grapple and truck in winter.

Figure 3 McCrae - mechanized cutting was half the cost of hand falling, including removing stems from site

Figure 4 McCrae - aspen were retained during cutting

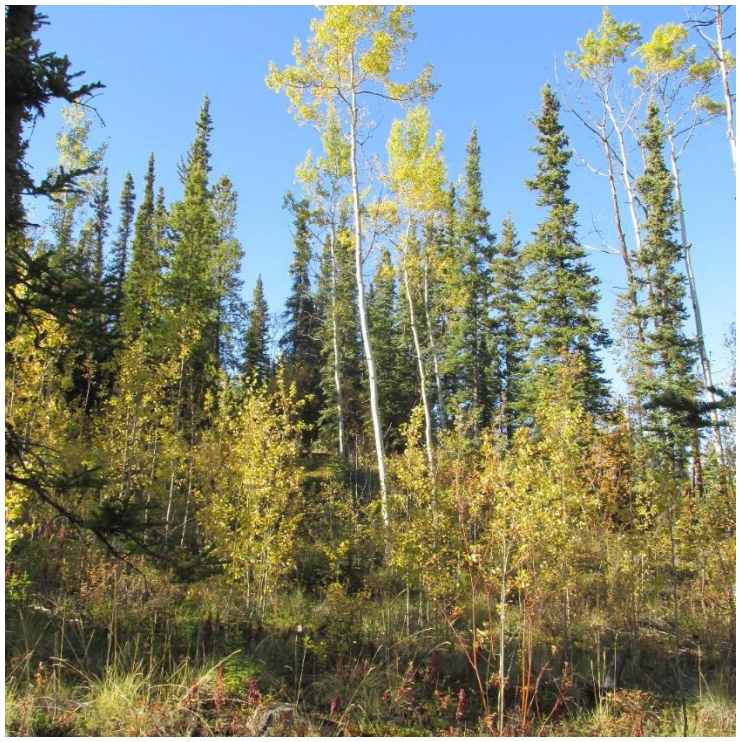


Figure 5 McCrae - eight years later - good deciduous regeneration, evidence of moose browsing

Slash (tops, branches, small diameter trees) will be piled on site for drying. Logs will be delivered to the log yard and unloaded from logging trucks.

Stumpage is customarily billed and paid upon arrival at the log yard and is included in the logging cost calculation. The Yukon Government could consider suspending stumpage for fuel abatement work.

Processing. The final phase is the breakdown of the timber into fuelwood by the energy producer. Delimbing will perforate bark and will speed its drying in stacks. When dry, fuelwood processor cuts to length and splits. It is sold by volume; a truck with dump bed delivers.

- Sawlogs will be identified at the sorting pile, separated and removed to a sawmill.
- Chips will be produced in the woods from the slash piles after 12 months of drying. It will be most efficient if these chips can be delivered to energy clients directly from the chipping site. Chipping sites should be cleaned of debris by removal or burning.

Figure 6 Industrial Scale Woodchipper (Bear Creek Logging)

Figure 7 Woodchip delivery truck

Decommissioning. When all site activities are concluded, roads would be deactivated and rehabilitated. Final inspections would be made.

Reforestation. Prescriptions would vary with the site. These must be implemented and the re-established forest must be nurtured until they reach free to grow status. After 5-10 years, any conifer juveniles should be cleared manually with a brush cutter. (See below.)

Figure 8 Spruce and pine regeneration must be removed from an aspen conversion site

3.2 Capabilities and status of Yukon forest industry

Collectively, the forest industry in the Yukon currently has the equipment and the experience to undertake mechanized fuel management work at volumes up to 40,000 m^3 per year. Moreover, the private sector has invested in wood chippers, fuelwood processors, pellet mills, and delivery vehicles sufficient to service a biofuels industry. The margin of capacity is clearly sufficient if the biofuels/fuel abatement effort ramps up to 400 ha/yr over a 2-3 year period. On the strength of anchor customer contracts, industry should be able to finance increased capacity.

The logging industry can be supported by a number of small companies experienced in hand-clearing contracts to handle sensitive areas.

Through incremental growth and experience, the private sector in the Yukon has developed the expertise to design, install, and service woodchip boilers, both as new projects and as retrofits.

It is demonstrable that the Yukon forest industry has made the necessary investments in equipment and experience and is prepared to build a biomass industry based on fuel management.

3.3 Environmental and aesthetic concerns.

Most forest activities produce impacts and fuel management and abatement is no exception. Here are areas of concern:

- **Wildlife impacts.** Changes in forest cover affect various species differently. Since the prescription is to change the forest type - not to deforest any site – the main wildlife impacts will be to change the mix of species.

  Very thick, closed canopy spruce and pine have less species diversity compared with mixed stands. Chiefly they support wildlife that feed on pine and spruce seeds, bark, and buds. Common examples include red squirrels and hares (and their predators), grosbeaks, cross bills, siskens, and chickadees. Typically absent are moose, caribou, and deer.

  Caribou will benefit from stand conversions that favor open formations supporting lichen on the forest floor. Moose, deer, and elk respond to increases in deciduous browse.

- **Road Access.** The second most influential cause of impacts that affect wildlife is increased vehicle access over logging trails. Although off-road vehicles are a recreational activity, they impact other recreational uses as well as wildlife. It is generally desirable to decommission road access to treated stands and to devise a vehicle access management plan that provides effective and fair rules for vehicle activities of all kinds.

- **Drying of surface**. The efficacy of fuel abatement is sometimes challenged by claims that opening a stand will dry the surface, actually increasing the fire hazard. Drying can occur in conifer stands that have been limbed and thinned. However, if surface fuels have been removed, it will not support a surface fire. And if thinning has been sufficient (canopy limbs

no closer than 3 meters) it will not carry a crown fire. This criticism has validity for some local treatments that remain too closely spaced. This can and should be corrected.

- **Windfall.** Opening a stand by thinning increases exposure to winds. Spruce, having the greatest surface area, are most exposed to being blown over, followed by mature pine carrying fire scars near the roots. In areas where the prescription will be to remove conifers and replace them with aspen, this will not be a major consideration. In areas where the prescription will include retaining mature conifers, care must be taken to select large healthy specimens. In the area below McRea which was treated in 2011, wind throw has in fact been minimal – the very few trees can be easily cleaned up. In time residual trees become more wind-firm.

- **Impacts on Recreation.** Most areas adjacent to settlement have recreational trails, both formal and ad hoc. Treatments will certainly change the ambiance of trails (except perhaps for trails in aspen). In time a growing aspen cover will create a different but acceptable aesthetic. Careful discussions and public engagement is needed to minimize these impacts.

- **Visual disruption.** The periphery of most or all neighborhoods merit fuel management, affecting the visual character of Whitehorse's boundary zones. It is important to acknowledge this while emphasizing that fuel management prescriptions do not involve creating permanent clear-cuts. The objectives are aspen forests and open mature pine stands. Both are common to southern Yukon.

4 COSTS AND BUSINESS RELATIONSHIPS: How to finance this.

4.1 Business case.

The business concept is to convert wood unwanted by the public (that which must be removed to reduce fire risk) into biofuels which have a market value. The sale of the biofuels (woodchips, fuel wood, pellets) should offset the costs of fuel reduction activities, processing, and delivery while yielding a profit for the private sector entrepreneurs.

We have already established that there is a large supply of wood that must be removed for public safety and that the cost of removal by conventional contracts is prohibitive. We have also established that the large volume of wood to be removed could be scaled to meet the current demand for cordwood over at least a decade.

Now to examine price structures. The Yukon Energy Solutions Centre (2014) provides comparative prices for wood, fuel oil, propane, and electricity, displaying prices per Gigajoule

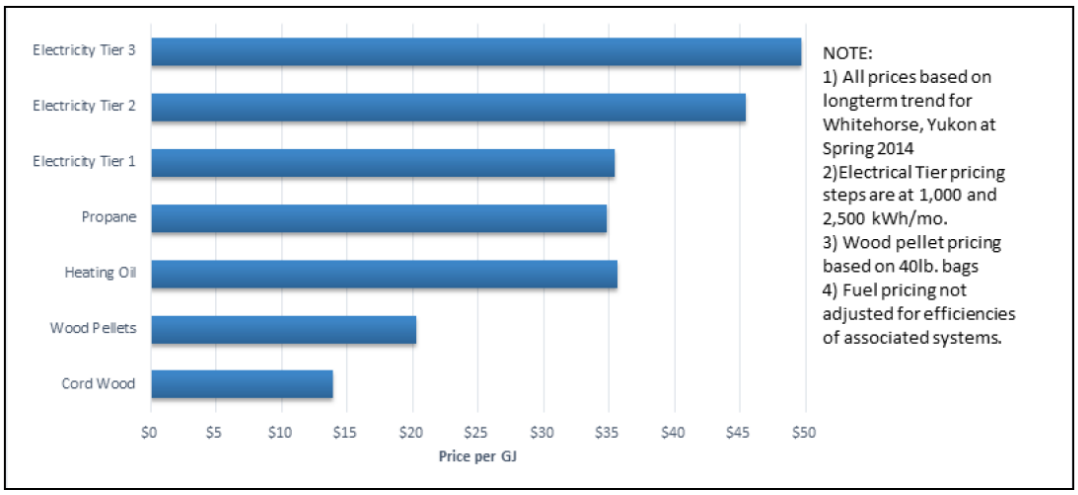


Figure 2: Relative Net Cost of Heat Options 2010 (includes O & M) in $/GJ
Source: Energy Solutions Centre, 2014.

Cord wood is the most cost-effective heating energy listed: at $14/Gj, it is less than 40% of the cost of fuel oil at public prices, and 30% of the cost of electricity. Pellets are 30% more than cordwood, but are still just 55% the cost of heating oil. Wood Chips (not listed) are cheaper yet: at its current market price of $150/ton delivered (50% of the cost of cordwood) they are $7.50 / Gj – or 20% of fuel oil. To equal this, the price of fuel oil would need to drop to $0.30/liter.

In principle, it is clear that biofuels can compete on price with conventional heating fuels. Other benefits to wood as a heating fuel include replacing fossil fuels for reducing greenhouse gasses, reducing fire risk, reducing the environmental risks of oil leaks and spills, and the economic benefits of jobs, import substitution, and resulting multiplier effects.

Example: 20-year cost comparison of woodchips, fuel oil, electricity

Let us compare the costs of installing and operating heating units capable of delivering the same amount of heat per year. We will use the 100 kw Hargassner boiler as the unit of comparison. It uses on average 60 tons of wood chips per year. This is an equivalent of 1200 Gj (gigajoules) which enables us to work up comparisons with fuel oil heaters and electrical heaters. It should be noted that these numbers are generalized, but they are not speculative.

20-year Projected Costs of Energy Systems in Whitehorse

Energy type	Installed unit	Yearly fuel 1200 GJ/yr	20 year fuel cost	20 year combined	Cost /yr
Wood chips @$150/ton	$130,000	$9,000	$180,000	$310,000	$15,500
Fuel Oil @$1.33/l	$40,000	$43,092	$861,840	$901,840	$45,092
Fuel Oil @$0.80/l	$40,000	$25,920	$518,400	$558,400	$27,920
Electricity @ $0.15/KWh	$7,000	$50,004	$1,000,080	$1,007,080	$50,354

It is likely that the costs of installing a wood boiler will drop if industry is able to negotiate volume prices from suppliers, and as engineers and technicians gain experience and efficiency in installation. The table demonstrates that industry has a demonstrable market opportunity for a viable biomass sector.

4.1.1 Current business model for fire risk reduction:

Up to now, the practice is for government to contract for fuel management treatments. Government pays for forest operations and gives away the wood, so as not to compete with the private sector. Costs for contract clearing range from $7500/ha for hand ("FireSmart") crews, to approx.. $4500/ha for mechanized operations. The total estimated cost range for fuel abatement on the 4000 ha provisionally identified: $30 million - $18 million.

The current model has a serious drawback: It is costly and budgets remain limited no matter how urgent the danger. With current priorities, there are insufficient means to fund what is necessary. The greatest amount of funds allocated to fuel management to date would be this year at approximately $500,000. This would treat between 66 ha and 111 ha; not nearly enough to make a meaningful difference in overall fire risk reduction. At 111 ha/yr, it would take 36 years to treat 4000 ha. Not nearly good enough if public safety is a real goal.

4.1.2 Current Business model for providing biomass fuels:

Currently, the private sector vendor supplies biomass wood fuel obtained from conventional forest permits. Customers own and operate their own heaters/boilers and purchase the biomass fuel for them. Local examples:

- Raven Recycling, Yukon Gardens: woodchips at $150/ton
- Whitehorse Correctional Center: wood pellets at $350 - $400/ton

Drawbacks: Currently, the client must bear the costs of switching from fossil fuel furnaces, and must operate and maintain boilers. The delivery pipeline and the market are still developing, so there may be a "chicken-and-egg" problem with the limited supply of biomass fuels and the limited number of customers. Both suppress the potential growth for the adoption of biomass energy.

4.2 Alternative Business Model: "Biomass Heat Contracting"

This model integrates fuel abatement with producing and delivering biomass fuels. It can deliver cost effective fuel abatement and it can reduce upfront infrastructure costs to the consumer.

The concept is simple: **an energy service company (ESCO) invests in and operates a biomass installation** located on the premises of a company or public agency and sells the heat to the owners/users of the building at an agreed price. The customer can purchase the woodchip furnace over time, or the arrangement can be continued. This model is successful in Upper Austria and elsewhere.

The ESCO approach eliminates many of the reservations of switching to biomass. The upfront costs to the consumer can be reduced and the contractor provides the specialized knowledge of installation, operation maintenance, and supply of biomass heaters. It can be implemented over a range of building sizes and more than one company can enter into this business.

- Contractor is responsible in defined sectors for forest operations to accomplish fuel management and in return can produce wood-based fuels from the treatments.
- Contractor is responsible for supply and delivery of woodchips.
- Price structure: This paper does not presume to speak for industry but it can report on current thinking.
    - Customer owns and operates boiler: $150/ton delivered by ESCO.
    - Customer owns boilers; ESCO operates and services: a set fee per unit of delivered energy. Heat would be metered and billed like any utility.
    - ESCO owns and operates boiler; no upfront cost to customer: A long-term contract is required, a higher set fee per unit of delivered energy. One possibility is benchmark delivered biomass heat to the price of fuel oil. Heat would be metered and billed.

The ESCO model is proven to be practical, with two-decades of successful operations in Europe.

4.3Pre-conditions for establishing an ESCO in southern Yukon.

1. **Economically attractive raw wood supply**. This is ample as discussed above.

2. **Potential private sector operators**. The basis for such a service already exists in the Whitehorse area. There are several businesses with services to offer. One example, a private sector, Yukon company has been formed to provide biomass heat on a contract basis. An ESCO, in other words. The company has expertise and equipment for:

    - Engineering and design of heating systems
    - Installation, operation and maintenance of biomass boilers
    - Forestry and forest regulations, site layout.
    - Logging, transport, processing, and delivery of fuelwood and wood chips. It is projected to have this capacity for wood pellets soon.

    As a value proposition, the biomass company mentioned above will do the engineering and system design, provide and install the woodchip boiler, and then supply, operate, and maintain it. The customer will not incur immediate switching costs and there will be no carbon tax on the delivered heat. A customer possessing and operating a wood chip boiler can purchase delivered woodchips at the current market price; a considerable savings over fossil fuel prices.

3. **Potential customers**. A building using a wood chip boiler should be a minimum of 10,000 square feet, so potential clients are either large public sector buildings, large commercial buildings and apartment blocks, or a concise collection of houses that can be "ganged". Whitehorse has ample opportunities for suitably sized installations.

4. **Anchor customers**. The ESCO proposition depends on an economy of scale in order to get launched. The biomass company will need to finance the installation of boilers, on-site hoppers and feeding mechanisms, delivery vehicles, and operators. The capacity of the logging equipment must be diverted from its present operations and dedicated to supplying the biomass business. The company must be able to hold substantial volume of wood and slash in inventory for 12 months of drying.

    - Clearly, the company must have a substantial volume of sales secured by long-term contracts in order to secure financing, justify the allocation of logging equipment, and build infrastructure.
    - The public, specifically the Yukon Government and the City of Whitehorse, would need to act as "anchor customers" to enable this enterprise to become established.

    Government has two critical roles:

    a. to authorize the biomass company to operate at scale, carrying out fuel reduction and salvage activities on several hundreds of hectares per year, and

b. to contract with the ESCO to provide an anchor customer for the energy produced from fuel abatement woodchips.

- Benefits to governments and the public:
  - Replace fossil fuel at no extra cost over current heating systems.
  - Enhanced public safety by completing fuel abatement in a realistic time frame and at comparatively little net cost.
  - Direct savings on effective fuel abatement of up to $30 million; costs of fire avoided: up to $10 billion (estimates for direct and indirect costs of Ft. McMurray fire).
  - Increased economic benefits including increased employment, economic impacts, and import substitution.
  - Minimize or eliminate risks of oil spill contamination. For example a significant oil tank rupture or tanker turnover in Riverdale – just 6m above the aquifer - could be catastrophic.

5 ECONOMIC EFFECTS OF AN EXPANDED BIOMASS SECTOR

Thorp and Zanasi (2015) provide information on the employment, production, and economic effects of the Yukon's forest sector in the Whitehorse/Southern Lakes region. Their data was 2006, but there is reason to consider that this remains a good approximation. They estimate an annual value (gross output) of $3.6 million in forestry sales in the region. Total current economic impact (direct, indirect, and induced): $5.5 million.

The annual economic value of wood products from fuel abatement activities on identified treatment areas, if generated on a 10-year schedule is estimated as $7,825,000. If demand for biofuels increases just a bit further, the annual output of the sector could equal the "high" scenario presented in the Thorp, Zanasi report. The table below is derived from PolicyModels Corp's "Canadian Regional Input-Output Model" (CRIOM).

Table 8 Economic impact of $3.6 million and $8.2 million value of forest harvest

	Direct Effects	Indirect Effects	Induced Effects	Total Impact
$3.6 million forestry sales				
Employment (FTE)	15.1	5.1	4.6	24.7
GDP	$1,606,450	$402,474	$356,111	$2,365,035
Gross Output	$3,600,000	$1,338,617	$557,266	$5,495,883
Wages & salaries	$885,106	$239,746	$138,271	$1,263,123
Tax revenues	$272,062	$143,663	$86,238	$501,963
$8.2 million forestry sales				
Employment (FTE)	34.4	11.5	10.4	56.3
GDP	$3,659,136	$916,747	$811,141	$5,387,024
Gross Output	$8,200,000	$3,049,073	$1,269,327	$12,518,400
Wages & salaries	$2,016,074	$546,089	$314,950	$2,877,113
Tax revenues	$619,698	$327,232	$196,432	$1,143,361

There are additional Induced Effects not accounted by the CRIOM:

- Employment created by a 2-year to 5-year period of installing infrastructure (chiefly woodchip boilers and building boiler facilities and chip container/feeder structures). This is estimated to be 10 – 15 full time technician positions for boiler installation; 15 positions for carpenters and builders.
- Economic effects of import substitution. According to the Yukon Biofuels Strategy (2016) 75% of the Yukon's heating is done with imported fossil fuels ($50 million annually). And 82% of the market is in the Whitehorse area, or $41 million. Moreover, 60% of fossil fuel expenditures leave the territory as economic "leakage". This amounts to a leakage of $24.8 million from the Whitehorse economy. A Yukon biofuels sector will reduce this leakage and circulate these funds locally.

5.1 Summary of Economic Impacts:

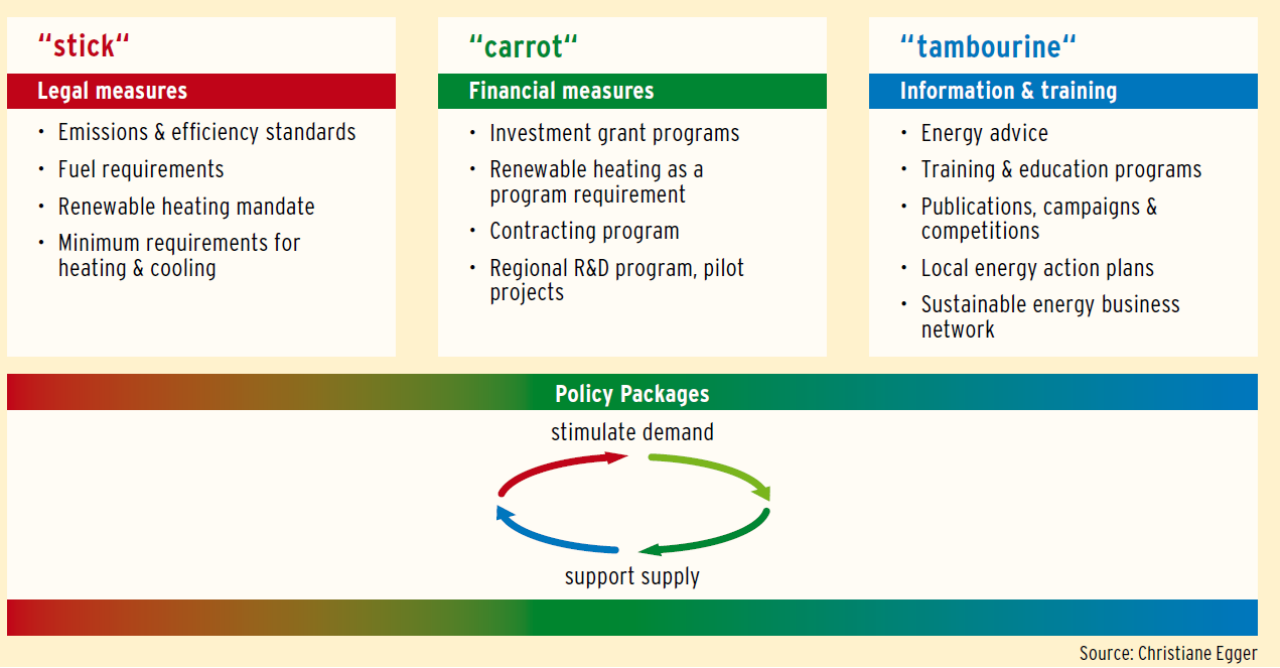
A summary of total annual economic impacts from the strategy proposed would be some 56 jobs, $20,782,537 of direct, indirect, and induced effects, and the effects of eliminating all or part of the $24 million of fossil fuel expenditures "leaked" out of the Yukon economy.

An important implication of these figures is that the private sector should have the financial means and the incentive to perform fire risk abatement activities for the Whitehorse region at no or at low cost.

But there is an essential proviso. The statement is valid – provided that government reduces risk and uncertainty by becoming an anchor customer at a suitable volume by converting public buildings to

biofuels heating systems. A 10-year time horizon – approximately 400 ha/yr, would generate chips each year to feed the equivalent of some 63 100-kw woodchip boilers. This scale would be financially suitable, practically feasible, and would rapidly reduce fire risk. It could displace approximately 2,041,200 liters of fuel oil per year.

There are other ways in which governments can foster a Yukon biomass industry. As pioneered by the State of Upper Austria – certainly a leader in the biomass heating field – government can assist the sector by coordinating measures in these areas:



The "stick" (efficiency and emission standards), "carrot" (financial incentives and supports), and "tambourine" (i.e. promotion and education) policy package has been successfully pursued by the Upper Austria state government for over 20 years with the result that the biomass sector there is a world leader in innovation, research, and uptake. Over 48% of thermal heating energy is currently biomass and the stated goal is 100% renewable sources for electricity and heating. For a full discussion of the development of a biomass industry in Upper Austria, see:

https://www.land-oberoesterreich.gv.at/files/.../esv_biomass_heating_2013.pdf

A graphic of how the state government sees their integrated policy package:

We are not suggesting that the Yukon can mimic the development trajectory of the State of Upper Austria. There are significant differences in scale, society, economy, and environment. Rather, the point is that this, and other jurisdictions have achieved considerable success in developing a biomass industry, and in so doing, have developed policies and approaches that the Yukon can adapt. We do not have to invent a development strategy entirely from scratch.

6 ISSUES AND MANAGEMENT QUESTIONS

6.1 Contracting relationships.

An ESCO relationship with government requires secure, long-term contracts not subject to unilateral changes. ESCOs in Upper Austria have been established for nearly two decades and can provide a model for an effective structure. Upper Austria also has examples of financial supports and incentives that have proven helpful. The ESCO relationship can be put out as a Request For Proposal call so that there need be no complaints about sole-source or uncompetitive contracts. There should be no need to advertise outside of the Yukon.

6.2 Schedule:

This strategy has proposed a 10-year schedule for completing fuel management treatments in the "inner ring" of the Whitehorse area as identified in the draft map above. This corresponds with the current capabilities of private sector forest equipment. Apart from the fuel management contract work planned for 2019, there is substantial preparatory work to be done this year to start an ESCO-type operation in 2020. Topics include:

- attaining political support in government (including the Yukon Government, the three First Nations, the City of Whitehorse, and outlying districts),
- attaining social license,
- forest management planning, YESAB, and permitting for treatment areas,
- Identifying suitable public buildings and associated work in engineering and financial planning, and
- Negotiating mutually advantageous contracts with the private sector. The participants in an ESCO operation should be party to setting schedules.

Upshot: Recommend that political approval is sought so that government efforts are marshalled and coordinated, and agencies can get started.

6.3 Responsibilities for Planning.

Implementation and costs of planning (including consultation and collaboration with First Nations), identifying treatment areas, inspections, and monitoring of forest activities are normally for government to bear. Government should collaborate with the forest companies to ensure that layouts and stipulation are operationally realistic.

6.4 Responsibilities for Regeneration.

Specific measures must be identified and taken for effecting stand conversion to aspen and preventing conifer recolonization. Stand conversion measures should be written into the forest operations section of ESCO contracts. Technical staff at the (Yukon) Forest Management Branch can provide advice on field scale aspen generation and stand conversion questions. In the long term, maintaining treated areas by removing young conifers should be a public responsibility which can be fulfilled by contractors.

6.5 Obtaining social license.

Government must take lead in messaging:

- Necessity and Effectiveness of fuel management
- Wildlife impacts
- Access management
- Aesthetics and management of treated areas.
- ESCOs and conversion of public buildings to wood chip heating
- Emergency measures and evacuation plans.

Government has a willing and effective partner in the informal citizen advocacy group “Citizens for a Firesmart Whitehorse”. They have already begun public education on the need for fuel management. The Yukon Wood Products Association is an effective link to responsible industry partners.

7 ALLIGNMENT OF ROLES AND RESPSONSIBILITIES

If this concept were to be implemented, the re would have to be broad cooperation and collaboration between the public and private sectors. The stakeholders would include the territorial government, municipal government, First Nations governments, First Nations development corporations, industry representatives, and some representation from property owners (both commercial and residential). The following issues will nEed to be addressed if the Biofuels Industry Development Concept as discussed is to be implemented.

7.1 Public Sector

Yukon Government and City of Whitehorse:

- All levels of government agree that wildfire risk reduction is a priority.
- A comprehensive, operational-level fuel abatement program is developed and implemented.
- The resources and capital required to implement fire abatement are identified and allocated
- The policies and regulatory changes needed to implement the plan are in place.
- Develops financial instruments and policies to support biomass conversions and applications
- Develops financial instruments and policies to support biomass conversions and applications to new buildings and retrofits.
- Consults with Kwanlin Dun, Ta'an Kwatchan, ensures contract opportunities are open to them.
- Undertakes public education, secures social license.
- Works with industry stakeholders and other economic development agencies (e.g. First Nations development corporations) to develop and implement the operational model for both the abatement and energy aspects of the proposed strategy.
- Sees project through YESAB and issues permits.

7.2 Private Sector:

- Engineering and design for both conversion to and operation of biomass heating systems.
- Installations of boilers and infrastructure.
- Forest activities and processing including stand conversions and maintenance of treated sites.
- Heat delivery including supply of woodchips, boiler operations and maintenance.

B. PROPOSED STRATEGY

8. SEQUENCE OF STEPS TO MAKE THIS HAPPEN

A strategy generally involves setting goals, determining actions to achieve the goals, and mobilizing resources to execute the actions. The preceding section proposed goals and outlined a general course of action for integrating forest fuels management with a biofuels sector. This section proposes actions for achieving the proposed goals. It is premature to identify timelines.

This proposed strategy would need support, cooperation, and participation from several governments and would include a number of departments and their branches. Effective communication and coordination would be essential. Budgets must provide the means for branches at the operational level to take on additional responsibilities.

1. Obtain high-level approval for strategy. This is the foundation for proceeding.

   Since forestry and wildland fire is a Territorial responsibility, as is economic development, Yukon ministers must take lead. If they approve this strategy, it would follow that they authorize:

   - High-level approaches to other levels of government (City of Whitehorse, Ta'an Kwatchan, Kwanlin Dun) to consult and secure their support.
   - Policy direction to YG departments. At present there are efforts and interest in improving public fire safety from a number of departments and branches. To modify a familiar metaphor, there many cooks laboring in many different kitchens. In recent months there has been increasing outreach and communication between the various parties. It is advisable to ensure that all are working to common purposes in the most effective ways.
   - **Suggestion**: Government could agree on a lead agency and appoint a knowledgeable and empowered representative to provide leadership, coordination, and accountability to the ministers for refining and enacting this strategy. This function could be a performed by a seasoned government employee, or it could be fulfilled by an effective, experienced contractor with no built-in allegiances to any branch.

2. Policy commitments would be needed from YG and City in the following areas. The objectives of the Coordinator suggested above would be to assist these being put into effect:

   - Commitment to heat public buildings with biomass (sufficient to the analysis presented above). Identify these buildings.
   - Commitment to permit treatments on public lands identified above on a meaningful time scale (suggest 400 ha/yr over 10 - 12 years).
   - Commitment to enter into contractual relationships with ESCOs to enable fuel management treatments and the provision by private sector of biofuels to heat public spaces, and the installation of woodchip burners.
   - Commitment to develop policies and financial instruments to support uptake of biomass by public and private sector buildings.

- Commitment to complete the landscape and site-level planning for fuel management treatments.
- Commitment to attain social license for this.
- Commitment to see fuel management program through YESAB.

Other supporting commitments recommended that are outside of scope of this strategy

- To determine if forest fire response procedures need to be updated.
- To write a comprehensive emergency response plan covering public notification, communications, evacuation, medical needs, care and security for evacuees, keeping track of evacuees.
- Determine (specifically) if Taan or Kwanlin Dun want to participate in biofuels heating option and in fuels management contracts. Conduct Consultations as appropriate to the topic.

3. Obtain staff-level buy-in and provide direction.

- This should be a chief duty of the person designated to lead and coordinate government actions and private sector commitments. Cabinet should ensure that this person has effective authority or shall be backed up by people who have effective authority.
- Communicate biofuels policy and strategy clearly with directors and managers.
- Identify the means for attaining Social License. Designate a lead department; identify preferred means (contractor or in-house), write a program and schedule for doing this. ** Determine if City of Whitehorse is addressing this in its Fire Risk Management project.*

4. Write a comprehensive implementation plan. Suggest keeping this lean and in point-form with timelines and responsible people identified.

5. Undertake needed policy and planning work per implementation plan.

- Coordinate inter-agency cooperation and funding for fuel abatement work to be done in 2019. Ensure these projects are effective demonstrations for public education.
- Implement the program for educating public and attaining social license. This may be done by a variety of parties, but messaging should be congruent even if not identical. Partner with "Citizens for a Firesmart Whitehorse" and with First Nations.
- Identify which public buildings YG and City will heat with woodchips. This is a technical exercise that considers engineering, finances, building life-cycle, location, and other matters. ** Suggest a focussed study.*
- Do a focussed fuel abatement plan for Whitehorse/Southern Lakes, using the 4000 ha treatment map as a starting point. Confirm a sequence of stand treatments, and identify which stands will be treated in what time frame. The effort will need input from Yukon

Forest Management Branch, Yukon Wildland Fire Management Branch, City of Whitehorse, Kwanlin Dun and Ta'an Kwatchan, NGOs etc. ** Determine if City of Whitehorse is addressing this in its Fire Risk Management project. There is no point in duplicating efforts.*

- Write a fuels reduction plan based on this strategy. This would include Timber Harvest Plans and Site Plans that can be submitted to the Yukon Environmental and Socio-economic Assessment Act process. Secure the needed approvals. Lead would be Forest Management Branch with input from Wildland Fire Management.

6. Negotiate and confirm one or more long-term heat supply contracts with ESCOs. (Yukon Development Corp? YG Property Management? City of Whitehorse, First Nations, if interested)

    - Confirm timelines. (Must this be done building-by-building?)
    - Authorize necessary design and engineering studies for building hook-ups, fuel storage facilities – (This might be done by the contractor with government input and review.)
    - Confirm operations plans for fuel treatments, removal of wood, regeneration, and project termination.

7. Devise policies and financial instruments to support ESCOs and encourage uptake of biofuels heating by public and private sectors. Woodchips will be most cost-effective for buildings or groups of buildings 10,000 sq ft and greater; pellet stoves for individual homes.

    - Implement these policies and deliver the financial incentive programs.
    - Ensure that a clear timeline with coordinated steps is agreed to.

8. Ensure that the ESCO has access to locations for stockpiling, drying, processing and inventorying product from treatment areas as needed.

9. When it is clear that all participants understand and accept their responsibilities and are prepared to exercise their authorities, issue necessary permits and begin.

10. Inspect, monitor, support as needed per implementation plan. Each year should have measurable objectives for accomplishments in fuel management.

11. Continue with public education and outreach. Essential to accept that a more fire-safe landscape is a permanent commitment to a changed forest structure.

9. Concluding Notes.

This report has provided a rationale and supporting analysis for accomplishing badly needed forest fuel reduction on public lands by fostering a private sector biofuels industry. The concept presents a way to break a financial and logistical logjam that impedes significant progress in fire risk reduction. Government's role, should it accept the analysis, would be to enable the private sector to monetize the wood that must be removed from treatment areas. Government would also need to provide a market for chips made from currently useless slash – material that would otherwise be a daunting disposal liability.

The private sector, organized as ESCOs (Energy Service Companies), can accomplish the needed treatments, supply heat that replaces fossil fuels, while building a productive new economic sector.

Canada has a long history of providing the stimulus for new economic sectors - and even incubating them. Agriculture was founded on "free" land. The timber and mining industries similarly benefited from free or nearly free access to raw resources, low tax structures, and the public providing necessary infrastructure. Key industries (railroads and aviation, famously) have been nurtured by government supports, contracts, and infrastructure. Tourism is yet another example of government nurturing.

This paper proposes that government continues this tradition and helps develop Yukon's fledgling biomass sector. The papers recommends that government support this industry with enabling policies and regulations, access to biomass, and by providing a commercial "jump-start" as an anchor customer. Amazingly, government stands to be a net beneficiary of the assistance it provides. It will save millions of dollars by enabling fire risk reduction that it cannot afford to do, it will achieve part of the important objective of displacing fossil fuels, and it will broaden the local economic base.

It is not clear that a Yukon biomass industry would need subsidies. But even if it did, there would be large net financial savings for government *as a whole* – and an even larger promotion of the public good. This opportunity needs wholistic thinking across departmental boundaries.

Appendix

Canadian FBP System fuel types: Yukon examples

1. C2: Boreal Spruce

This fuel type is characterized by moderately well-stocked black spruce (Picea mariana (Mill) B.S.P.) stands on lowland sites (excluding Sphagnum bogs). On upland sites, white spruce (Picea glauca) and white spruce/ lodgepole pine (Pinus Contorta). Tree crowns extend to or near the ground, and dead branches may be draped with bearded lichens (Usnea spp.). Low to moderate volumes of downed woody material are present. Shrub layer may contain soapberry and Labrador Tea. The forest floor is dominated by a carpet of feather mosses and/or ground-dwelling lichens (chiefly Cladonia). Sphagnum mosses may occasionally be present, but they are of little hindrance to surface fire spread. A compacted organic layer may exceed a depth of 20 – 30 cm.

2. C3: Mature Lodgepole Pine

This fuel type is characterized by pure, fully stocked (1000–2000 stems/ha) lodgepole pine (Pinus contorta Dougl. ex Loud.) stands that have matured at least to the stage of complete crown closure. The base of live crown is well above the ground. Dead surface fuels are light and scattered. Ground cover may be needles, or communities of kinnikinnik, soapberry, or lowbush cranberry over a compacted organic layer. A conifer understory may be present.

3. C4: Immature Lodgepole Pine

This fuel type is characterized by pure, dense lodgepole pine (Pinus contorta Dougl. ex Loud.) stands (10 000–30 000 stems/ha) in which natural thinning mortality results in a large quantity of standing dead stems and dead downed woody fuel. Vertical and horizontal fuel continuity is characteristic of this fuel type. Surface fuel loadings are greater than in fuel type C3, and organic layers are shallower and less compact. Ground cover is mainly needle litter suspended within a low shrub layer e.g. lowbush cranberry (Vaccinium spp.).

4. C7: Open stand Lodgepole Pine.

This fuel type is characterized by uneven-aged stands of lodgepole pine (Pinus contorta Dougl. ex Loud.). White spruce may be significant stand components on some sites and at some elevations. Stands are open, with occasional clumpy thickets of multi-aged lodgepole pine and/or white spruce and/or trembling aspen as a discontinuous understory. Canopy closure is less than 50% overall, although thickets are closed and often dense. Woody surface fuel accumulations are light and scattered. Except within conifer thickets, the forest floor is dominated by perennial grasses, herbs, and scattered shrubs. Within tree thickets, needle litter is the predominant surface fuel. Duff layers are nonexistent to shallow (<3 cm).

5. D1, D2 : Aspen

This fuel type is characterized by pure, semimature trembling aspen (Populus tremuloides Michx.) stands. A conifer understory is noticeably absent, but a well- developed medium to tall shrub layer is typically present. Dead and downed roundwood fuels are a minor component of the fuel complex. The principal fire-carrying surface fuel consists chiefly of deciduous leaf litter and cured herbaceous material that are directly exposed to wind and solar radiation. In the spring the duff mantle (F and H horizons) seldom contributes to the available combustion fuel due to its high moisture content

The photograph below shows a typical deciduous stand in the study area, with a newly- established conifer understory, showing the process by which a deciduous stand becomes a mixedwood stand.

6. M2: Boreal Mixedwood

This fuel type (and its "leafless" counterpart, M1) is characterized by stand mixtures consisting of the following coniferous and deciduous tree species in varying proportions: white spruce (Picea glauca (Moench) Voss), trembling aspen (Populus tremuloides Michx.), willow (Salix spp.) and balsam poplar (Populus balsamifera.). On any specific site, individual species can be present or absent from the mixture. In addition to the diversity in species composition, stands exhibit wide variability in structure and development, but are generally confined to moderately well-drained upland sites. M2, the second phase of seasonal variation in flammability, occurs during the summer. The rate of fire spread is weighted according to the proportion (expressed as a percentage) of softwood and hardwood components. Thus, M2 75%C is a mixedwood stand in which approximately 75% of the trees are conifers. In the summer, when the deciduous overstory and understory are in leaf, fire spread is greatly reduced, with maximum spread rates only one-fifth that of spring or fall fires under similar burning conditions.

7. O1: Grass/wet willow openings

This fuel type is characterized by seasonal wetlands with communities of grass, various species of willow in both high and low shrub form, with no more than occasional trees or shrub clumps that do not appreciably affect fire behaviour. Two subtype designations are available for grasslands; one for the matted grass condition common after snowmelt or in the spring (O1-a) and the other for standing dead grass common in late summer to early fall (O1-b). The O1-b designation has been used throughout the study area, which may over estimate flammability in wet conditions.