Forest biomass recovery for the production of bioenergy, biochar and green hydrogen.

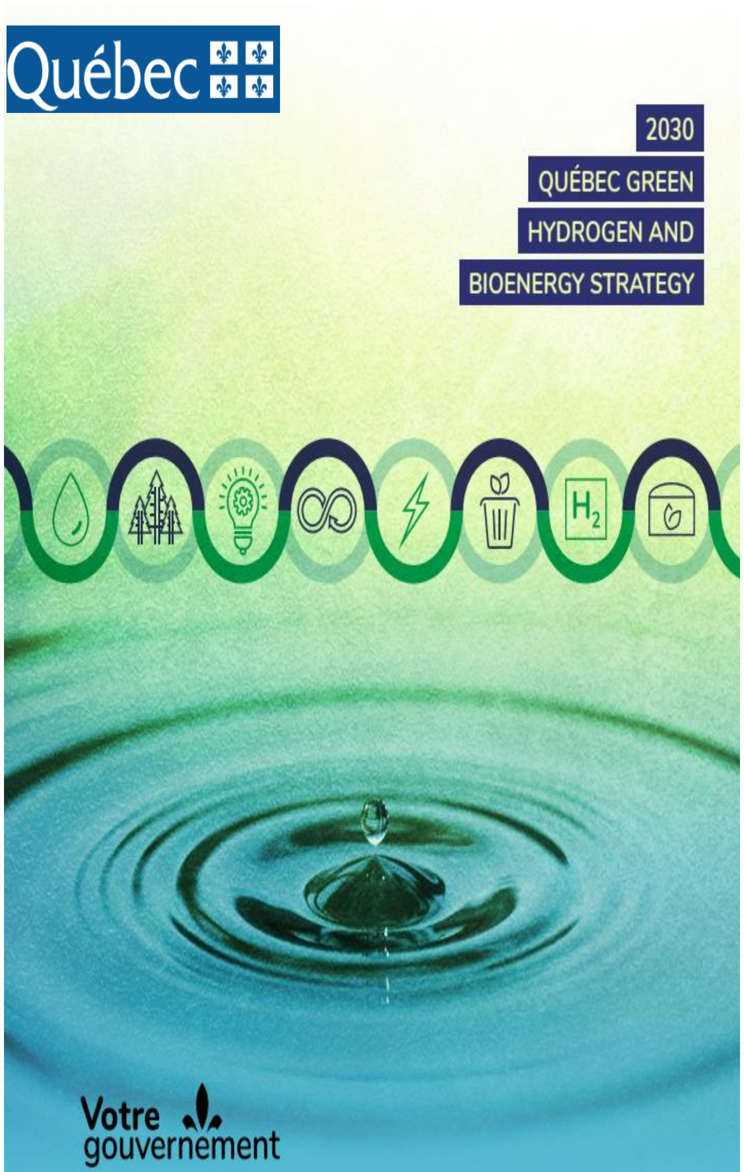
Towards a Regional Energy Ecosystem (REE)

Société de Cogénération de St-Félicien, SEC (SCSF) a subsidiary of;

Greenleaf POWER

REE and Project Partners

Québec’s Green Hydrogen and Bioenergy Strategy



Green hydrogen and bioenergy are key for Québec to meet climate change objectives:

- reduce its GHG emissions 37.5% below the 1990 level by 2030
- reduce its consumption of petroleum products 40% below the 2013 level by 2030
- eliminate the use of thermal coal
- achieve carbon neutrality by the 2050 horizon

The Québec Green Hydrogen and Bioenergy Strategy has the purpose of creating a coherent framework and a favourable environment to accelerate the production, distribution and use of green hydrogen and bioenergy.

Regional Energy Ecosystem (REE) is a model by which Quebec wishes to:

1. encourage the production and local consumption of green hydrogen and bioenergy,
2. stimulate the regional development of the bioeconomy sectors,
3. reduce risks and costs.

Société de Cogénération de St-Félicien, Société en commandite (SCSF) – a subsidiary of Greenleaf Power

Location	St-Félicien, Quebec, Canada
Net Capacity	22.5 MW
Primary Fuel Type	Mill residuals – fresh bark, landfill bark, forest biomass
Output	Electricity and steam
Fuel Burned	275 K WMT
In-service Date	Oct-01
Employees	31 (union/non-union)
Site	18 acres (owned)
REC Eligibility	Facility is qualified in Connecticut and Maine as a provider of Class I RECs
Ash	All flyash is certified "bio" and provided to agriculture users for soil amendment. Bottom ash is used as an aggregated for roads.
Steam	Sale of 95,000 MT/yr to Resolute Forest (sawmill) saving a 1000 CO2 emission

Why SCSF as anchor to the REE development?

1. Available residual thermal energy from a renewable source at favorable costs. Recovered energy from cooling tower and flue gas.

2. Sharing of infrastructure and equipment. SCSF will share certain equipment, including the scale house for weighing trucks and also certain mobile equipment. As SCSF operates on an industrial site, there is also infrastructure such as access to water and electricity that is available. The site also has very favorable road access located on Route 169.

3. Service sharing: SCSF will purchase unused pyrolysis gases and H2 produced in the CHAR biochar and biofuel project. SCFC will also provide specialized labor for the operation.

Regional Economic Development Partners

The Project brings together key regional partners and the local community that wish to diversify the local economy which faces issues with changing traditional markets of the forest products industry and its continued sustainability requirement. Initial 3 projects; 1) District Energy, 2) the forest biomass preparation; and 3) Biochar+ Green Hydrogen

VILLE DE SAINT-FÉLICIEN

- **SCFC granted the waste heat to the Ville de St. Félicien (the "City"). The waste heat is produced by the cooling towers and consists of water at a temperature of 38 ° C and a volume of 12,000 GPM.**
- **The City will be an investor in the waste heat distribution network which represents the first phase in the development. The network will serve the City and the MRC to attract businesses and technologies to exploit forest biomass in new niches of the bio-economy for the production of biomaterials, bioenergy and chemical bioproducts.**

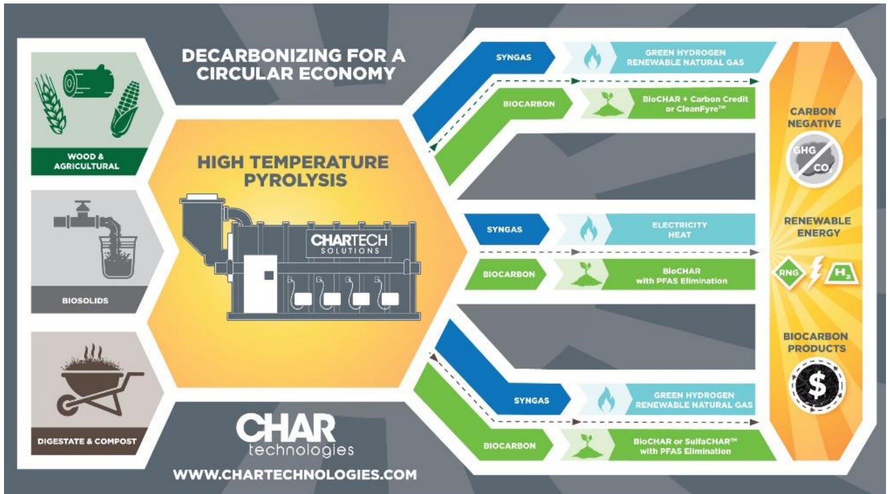
MRC Domaine-du-Roy
L'énergie nous habite !

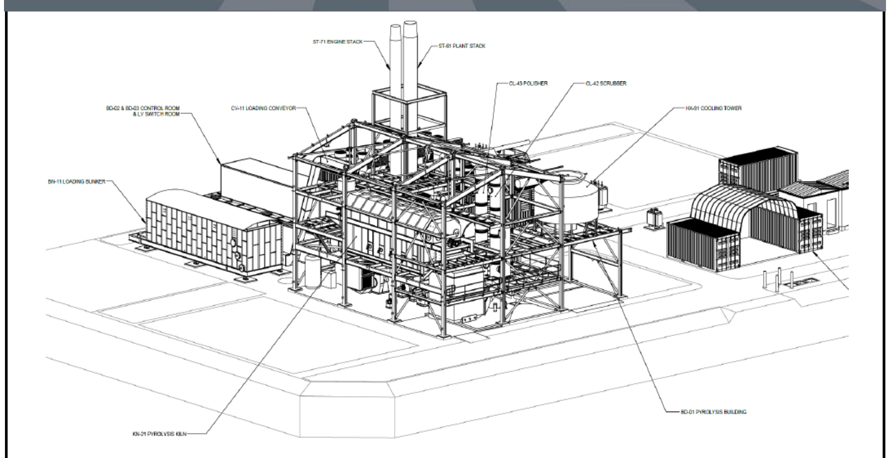
- **The MRC Domaine-du-Roy (MRC) will be a co-investor in the forest biomass recovery and preparation that includes drying equipment project, called "Centre de valorisation de la biomasse forestière (CVB). This project will use the waste heat provide by the district energy system to dry the biomass for energy and other purposes.**

CVB

- **La Coopérative pour la valorisation de la biomasse (« COOP ») will provide the CVB with 30,000 tonnes/yr of forest biomass. The COOP is a non-profit association which has 5 members:**
  - **L'Agence de gestion intégrée des ressources (AGIR) ;**
  - **La Coopérative forestière de Girardville ;**
  - **La Coopérative forestière de Petit-Paris ;**
  - **Développement Piekuakami Ilnuatsh (DPI);**
  - **Le CLD Maria-Chapdelaine.**

Technology Partner: Char Technologies Ltd





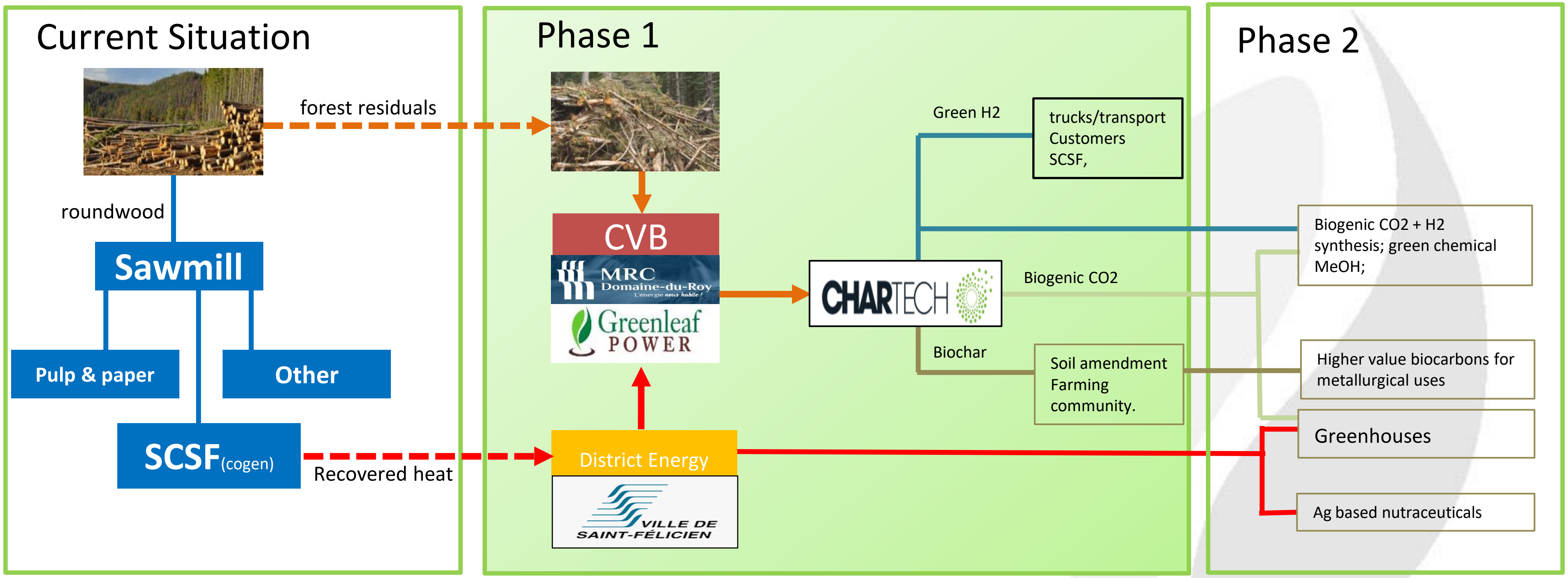
- CHAR Technologies Ltd. (https://chartechnologies.com) was founded in 2011 and is listed on the Toronto Venture Exchange, ticker symbol “YES.V”.

- CHAR’s core proprietary technology - High Temperature Pyrolysis (HTP) produces 2 products;
  - Hydrogen rich syngas that can be used as combustion fuel (electricity /heat) or upgraded/processed into Green Hydrogen or Renewable Natural Gas,
  - Biochar/biocarbon for sequestration and other industrial uses including metallurgical applications.

- Commercial demonstration project of CHAR’s technology platform based on modular design elements for a 2.1m HTP kiln

- Produce Green H_2, and biocarbons/biochars

Forest Biomass – Key resource to decarbonize the economy

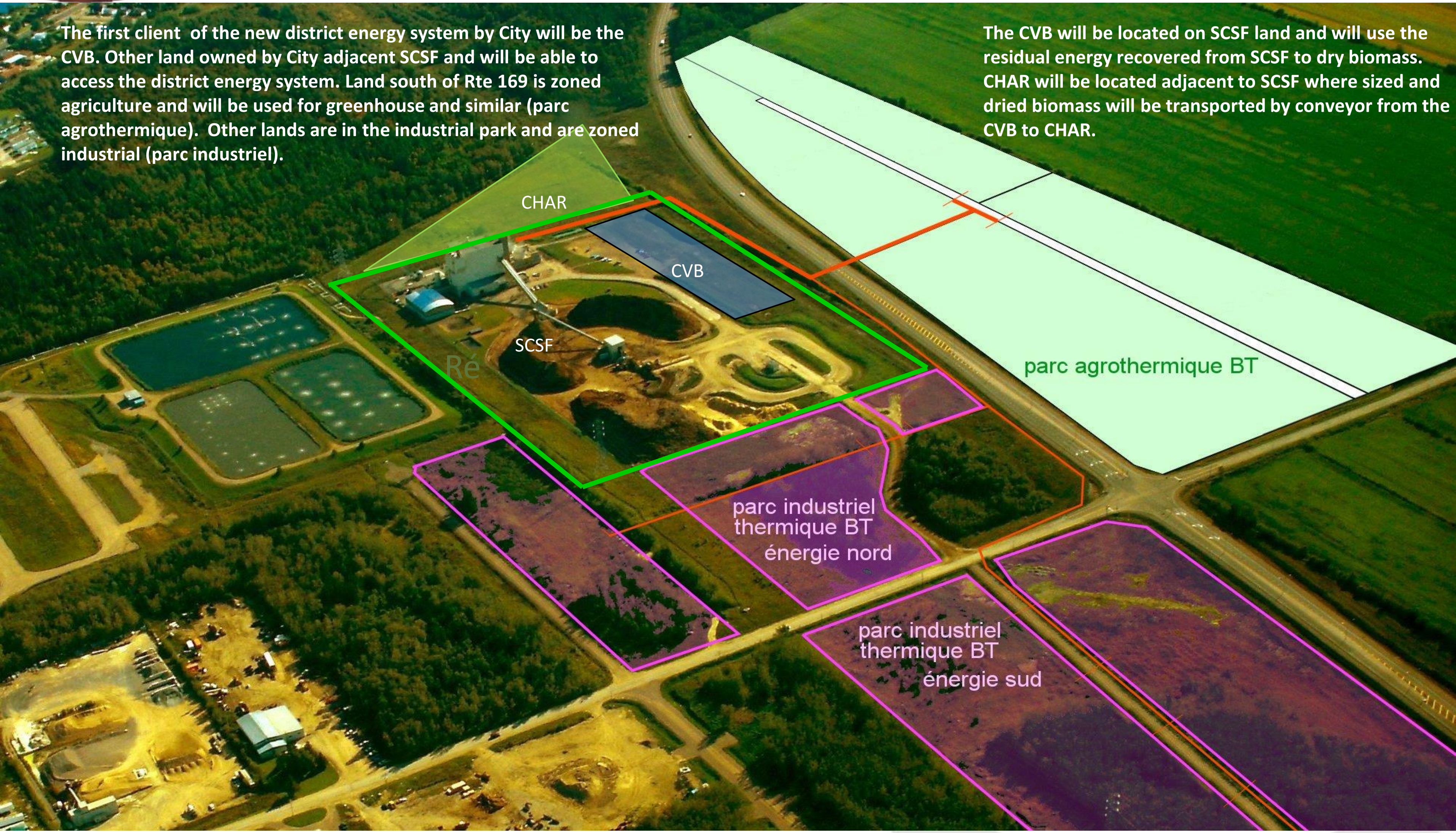


<u>Current situation</u>; forest residuals are not recovered and utilized. **<u>In Phase 1</u>** several partners will implement processes and technologies that will enable the economic recovery of forest residuals through the CVB which will supply CHAR to produce Green H2, biogenic CO2 and biochar. The CVB will access 90,000 tonnes/ yr of forest residual biomass including tree tops, affected (diseased) growths, and non-merchantile wood in a radius of 150 kms. This recovery will be integrated within the normal wood harvesting operations and not require special/additional machinery for collection. Residual forest biomass recovery and usage is better suited to a “distributed” based processing technologies such as CHAR’s modular platform that can be tailored/adjusted to supply levels, ie not requiring a large plant to be economically effective. The logistic/transportation cost for the aggregation of forest biomass forces the equation towards “diseconomies of scale”, meaning the most expensive biomass is the last ton in which is also the one that is furthest from the plant. Successful implementation would mean numerous smaller modular facilities rather than one large plant. This ensures that the model of the St. Félicien project is repeatable in numerous communities/regions. Successful implementation of Phase 1 will create add-on opportunities in Phase 2 that continue the process of creating the “circular” economy.

Regional Energy Ecosystem (REE)

The first client of the new district energy system by City will be the CVB. Other land owned by City adjacent SCSF and will be able to access the district energy system. Land south of Rte 169 is zoned agriculture and will be used for greenhouse and similar (parc agrothermique). Other lands are in the industrial park and are zoned industrial (parc industriel).

The CVB will be located on SCSF land and will use the residual energy recovered from SCSF to dry biomass. CHAR will be located adjacent to SCSF where sized and dried biomass will be transported by conveyor from the CVB to CHAR.



Forest Biomass and CVB

Logistical challenge: biomass in the Boreal Forest:

Harvester

Forwarder – tops with branches

Diesel grinder – chip trucks

<u>Why limited use of forest biomass? Its not the availability – it's the cost.</u>

In the boreal forest of the Project region, a large portion of wood harvesting is done with harvesters followed by forwarders – i.e. shortwood harvesting. This harvesting method makes the aggregation/assembly of forest biomass difficult and increases the costs at the roadside.

Recovery of branches reduces density and the total weight that the Forwarder can carry – reaching volumetric capacity before weight max. A debranched top increases density and requires fewer trips by forwarders per ton. This also allows enough matter to be left on the ground as a nutrient.

In the traditional approach, grinding is done in the forest at the edge of roads with diesel equipment and then transported with chip trucks to the plant. This approach requires bringing the material to a location accessible by the equipment both truck and grinder. Smaller piles will require frequent displacement of the diesel-powered equipment, which decreases productivity and uses more fuel increasing GHGs. The GHG impact is an important key element in the manufacturing of biofuels.

Grinding reduces the density of the material which therefore increases the number of trucks needed to transport this material to the plant which increases costs and GHG emissions.

The traditional approach requires chip trucks to drive through the forest even though this equipment was not designed for this purpose. This causes significant damage to equipment and sometimes requires additional road work to allow access. The labor shortage in transport and the impact of the new IT register are causing a negative impact on the transport capacity previously supported. The CVB approach will reduce demand on transportation vs. the traditional approach of 3,200 trips.

Makes the separation of the white fiber from the bark impossible, creating contamination of the material, thereby reducing the potential for use in higher value markets such as metallurgical quality biochar and wood pellets.

CVB – delimbed tree tops « baguettes » in 8 to 10 feet lengths

Forwarder – debranched

Truck with log trailer

Debarking & grinding electric equipment

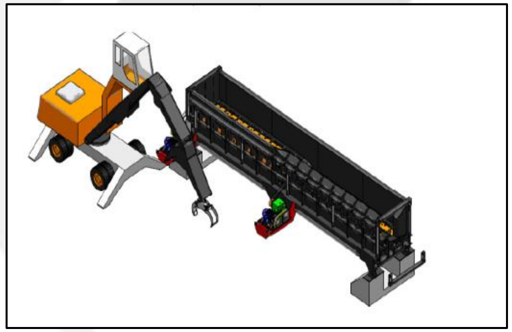
The CVB will implement a new approach to recovering forest biomass.

The biomass recovered will as debranched tree top in 8 to 10 feet lengths, ie a "baguette". This recovery will be integrated into the existing harvester work where the tops will be delimbed over an additional length of 8 to 10 feet which does not require much more machine time. Same with other biomass sources like affected wood

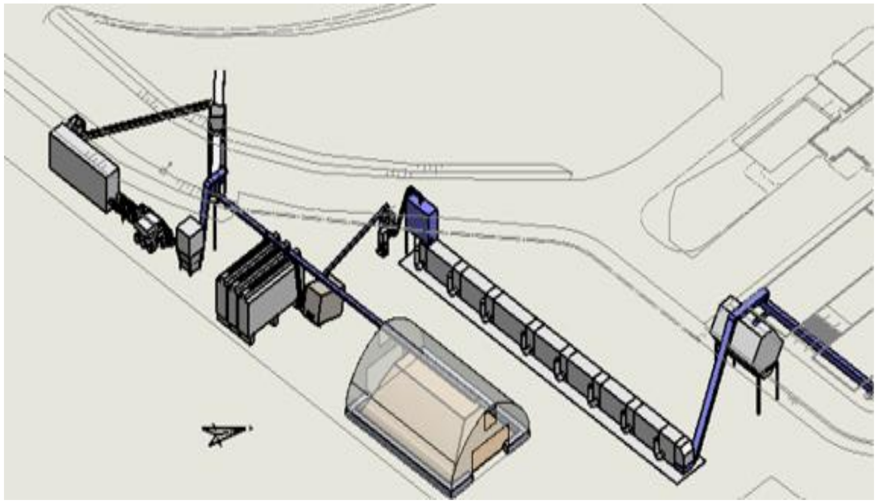
The baquettes increase the density for the forwarder and allows the full weight capacity of log trailer timber transport trucks per trip, which will minimize the number of truck trips. Less fuel used = less GHG.

Grinding with electrical equipment at the project site will increase efficiency minimizing displacement (more grinding and less travel) and the electrification of grinding equipment will minimize energy costs and GHGs. SCSF will use green electricity to power the electric grinder at a lower cost than diesel.

Debarking the baguettes at the plant using a roller debarker to separate the white fiber and the bark increases the possible uses. The bark will be used for combustion/bioenergy. The white fiber will be used for pellets and the biochar and biofuel plant. The separation reduces maintenance costs caused by abrasion and reduces the ash rate in the biochar and pellets, thus increasing quality.



Modular plant design: Impact on investment and operation costs



The CVB has 4 key components which will make the biomass economically viable:

1. **The harvesting and preparation of forest biomass in the form of baquettes (round wood)**
2. **The use of electrical transformation equipment reducing costs and GHG impact**
3. **Drying biomass using recovered energy to reduces costs and GHGs**
4. **Modular plant approach and integrating with cogeneration to reduce capital and operating costs**
    - **minimizes the necessary on-site construction and investment in infrastructure and buildings.**
    - **requires a very low level of labor as the system is integrated, automated and can easily be controlled with existing SCSF operators.**

The dryer is modular in construction and does not require a building, thus facilitating construction and minimizing investment costs. The belt dryer offers superior environmental performance: on particle and VOC emissions as well as an ability to recover residual energy at low temperatures and it also reduces the risk of fire.

CHAR HTP and Green H2 market

CHAR HTP Low risk & proven history

High Temperature Pyrolysis (HTP) is based on indirect fired calciner technology - consisting of a rotating cylinder made with alloys selected to resist high temperature and corrosion. Indirect calciners are industrially proven and used in many industries with a long operating history.

HTP is an indirect calciner specifically designed for the use of biomass materials coupled with CHAR know-how, knowledge and expertise in the operation of the unit to maximize results for production of biochar and syngas. **<u>The process is autothermal (ie no outside energy sources) and; is more robust, less complex and does not use oxygen like many gasification technologies.</u>**

HTP vs Standard Biomass Pyrolysis: The big difference is temperature. Most other pyrolyzers of similar configuration operate at temperatures that are 200 – 300°C lower than HTP. The higher operating temperature of HTP favorably impacts the quality of the biochar and the syngas. HTP's operating temperatures produces syngas with better characteristic and low in tars improving its versatility and the ability to be used in more value-added applications.

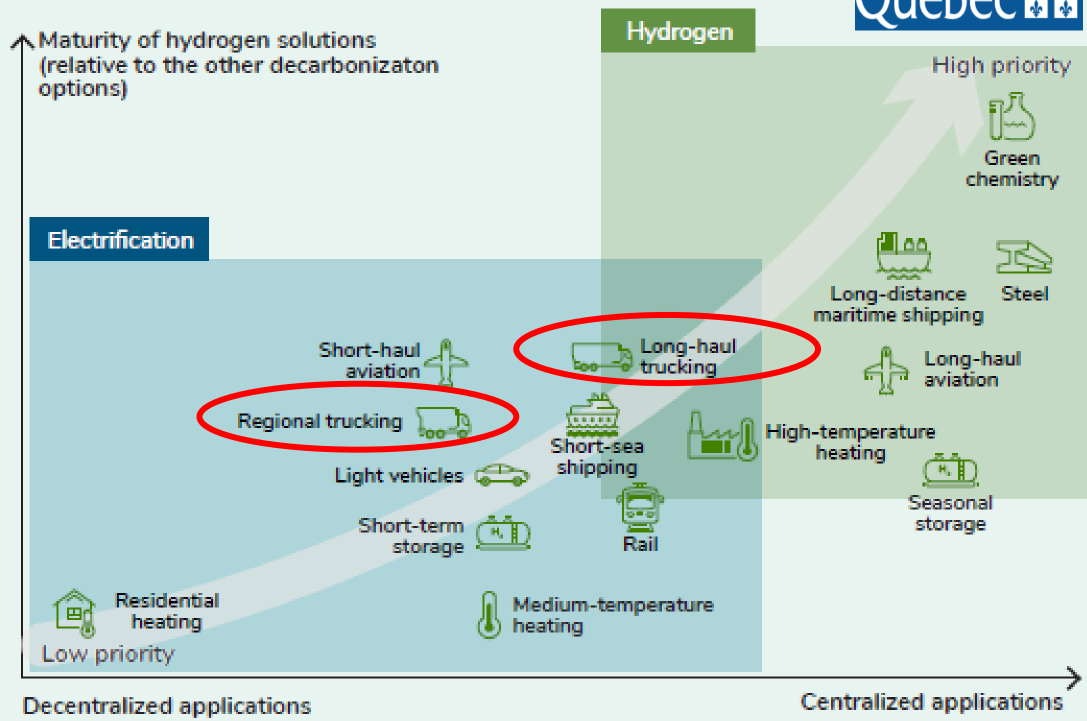
Reducing Implementation Risk via Modularity: Modular "skid mounted" equipment for simplified field erection, reduced schedule and construction risk. Increased cost control – shop fabrication.

Back Stop Client in SCSF: SCSF will purchase any unused syngas and H2 from CHAR. This reduces the risk of off-takes if H2 is not "transportation grade" or market for H2 does not materialize in time and scope,

Quebec H2 Strategy - Decarbonization & H2 Market

Decarbonization of Québec must depend on a multitude of technological solutions. Each technology has advantages and disadvantages.
To support the emergence of a sector like hydrogen, it is appropriate to capitalize first on the uses in which few or no options are available, while deploying the necessary efforts to ensure the evolution of the uses for which this sector could play a complementary role to direct electrification, in particular.

- 70 % of all the GHGs in Quebec are the product of fossil fuel combustion.
- While the total GHG have decreased by 2.7% since 1990, the gains of other sectors have been almost offset by the increase in the Transportation sector.
- Not only is the Transportation sector the largest sector it is the only sector that continues to grow especially for heavy road vehicles which is the largest component.

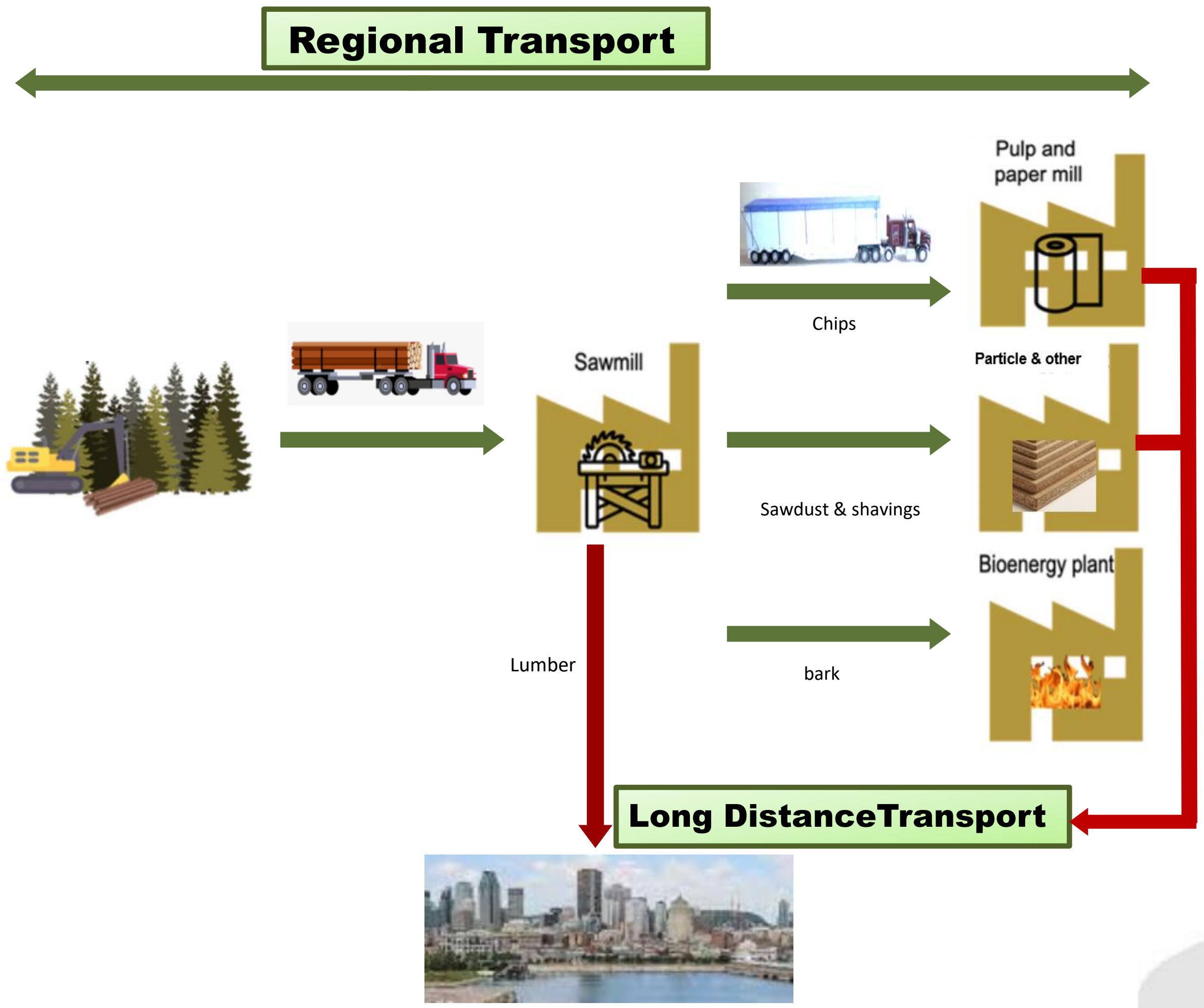


Source inspired by Geopolitics of the Energy Transformation - The Hydrogen Factor, produced by the IRENA.

Strategy to decarbonize road transport; cars, SUVs, light trucks – **Solution – electrification BEV**.

Problem - heavy trucks! In Quebec, outside urban centers, the majority of regional trucking is Class 8 heavy trucks mainly linked to the forestry and other primary industries. Options for decarbonizing heavy trucking are limited. Hydrogen should be used to address emissions that can't be eliminated in other ways.

Regional Heavy Transportation in the forest industry



- The forest sector is one of the economic pillars of Québec and its regions. It includes forestry, logging, and paper and wood products manufacturing.
- In Quebec, most of the harvested wood is sent to a sawmill to extract the highest value.
- Sawmills recover approx. 45% as lumber, with the remainder (55%) consisting of shavings, sawdust and bark.
- The co-products are then sold/sent to other parties or used within large vertically integrated players.
- The use of diesel from harvest until the product is sent to market represents a significant GHG footprint.
- Heavy transport fuel use is not only attributed to delivering the product to market (long distance), but also to transporting the fiber from the forest to the sawmills and then to the various processing facilities (regional transport).
- Regional trucks operate at a high rate 24/7 based on a short distance from an operating base.

- **This segment makes it an ideal starting point to begin the transition to alternative fossil fuels based on the reduced need for energy infrastructure.**