

# CARS: Carbon Algae Recycling System

The Carbon Algae Recycling System (CARS) is an excellent investment opportunity in green technology. It offers the potential to turn a profit from turning greenhouse gas (GHG) emissions into a valuable renewable fuel.

CARS consumes flue gas and low grade heat to grow algae. The resulting biomass is then converted into value-added products. Innoventures Canada (I-CAN)—the research network leading this project—expects that the system will:

- ❖ Create valuable products (biodiesel, methane, bioethanol, fertilizer, animal feed).
- ❖ Avoid the cost of CO<sub>2</sub> disposal.
- ❖ Likely be eligible for GHG offset credits and credits for SO<sub>x</sub> and NO<sub>x</sub> emission reductions.

The research team conceptualized an innovative design that integrates the best features of open racetrack ponds and enclosed bioreactors. The deep, lighted, and covered hybrid system is specifically intended to work in the harsh extremes of the Canadian climate. In Stage I of the CARS project, the team established the “proof of concept” and the economic feasibility of the system. Industrial and government sponsors are now being invited to participate in further technology development in Stage II.

**Innoventures Canada** (I-CAN) members involved in advancing research on the biofixation of carbon dioxide to microalgae in Stage I were:

- Alberta Research Council (ARC)
- Saskatchewan Research Council (SRC)
- Manitoba’s Industrial Technology Centre (ITC)
- le Centre de recherche industrielle du Québec (CRIQ)

For more information on how to join this project, contact:

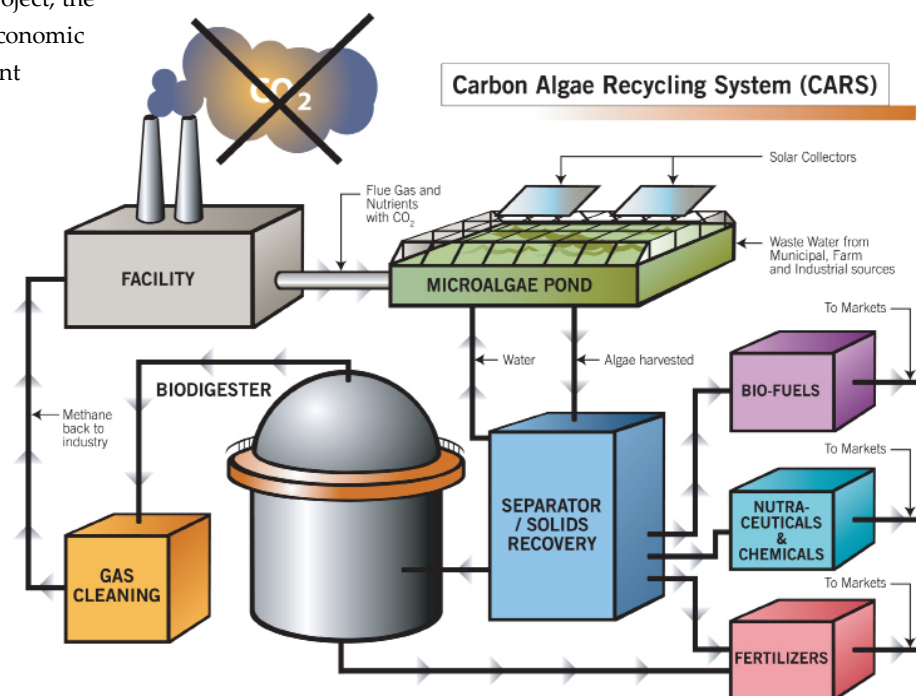
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Stage II will focus on optimizing the technical features that will make CARS economically viable by:

- ❖ Delivering lighting throughout the pond to enable increased photosynthesis and enhance algae productivity.
- ❖ Maintaining the temperature throughout the year.
- ❖ Minimizing the system footprint.
- ❖ Identifying an algae species with the highest attainable lipid (oil) content.

Depending on algae productivity, an economic model of the CARS showed that the system could produce biodiesel at \$0.59 to \$0.91 (USD) per litre. This compares favourably to the 2008 average price of \$0.76/litre (\$2.89/ US gallon) for fossil diesel (US Gulf Coast). By-products from the protein and carbohydrates contents of the algae would provide additional revenue streams.

Below: A schematic of the CARS. The system uses the photosynthetic mechanism to biofixate carbon dioxide to microalgae in a pond. The algae are harvested and converted into products like biodiesel.



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## Stage 1 Synopsis of the I-CAN Study: Technical and Economic Questions

### Algae Genetics & Strain Selection

Biodiesel enjoys an existing market and a broad usage. As well, competitively priced production of biodiesel will help the Canadian and provincial governments meet their goals for boosting use of renewable fuels.

The I-CAN research team modeled biodiesel as the main value-added product from algae. The team therefore sought a high lipid (oil) content in the algal strain. Five strains of Canadian algae were characterised for growth rate and composition (carbohydrates, fatty acids and proteins). The level of lipids extracted from one of the algal strains was an encouraging 34.8%.

### Engineering and Production

The I-CAN team used innovative engineering and systems design solutions to address Canada's climatic challenges. The CARS was designed to:

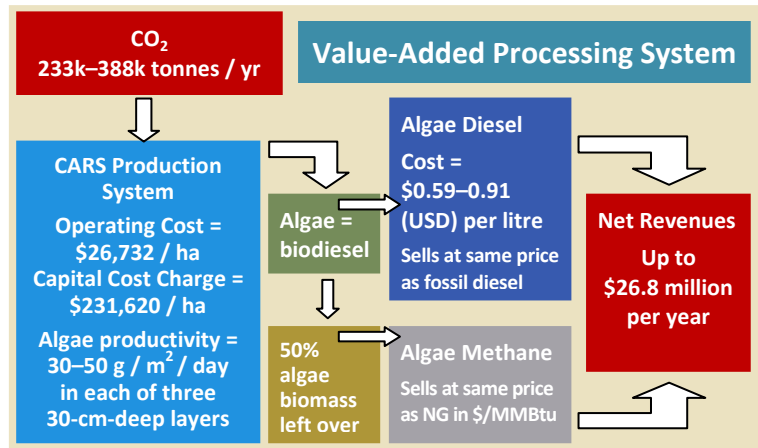
- ❖ Minimize heat losses.
- ❖ Minimize the ecological footprint of the facility.
- ❖ Optimize capture of solar energy, particularly low-angle, high-latitude sunlight.

The resulting hybrid covered pond system has the following advantages not offered by any other algae system:

- ❖ Lower capital costs.
- ❖ Optimized light conditions.
- ❖ Protection from contamination.
- ❖ Reduced evaporation.
- ❖ Effective temperature control.
- ❖ Higher productivities.

### System Footprint

Shrinking the footprint of the CARS is a key technical and economic goal of this work. The system is designed to consume about 233,000 or more tonnes per year of CO<sub>2</sub>—equivalent to taking about 50,000 cars off the road. If the system were designed as a conventional 30-cm-deep pond, it would require a surface of 1200 ha. Deepening the pond to 90 cm shrinks the footprint to 400 ha to capture this same amount of CO<sub>2</sub>.



### Stage I Economic Assessment

The CARS was modeled using algae biodiesel as the primary product and methane as the secondary product. Algae productivity was assumed to range from 30 to 50 g/m<sup>2</sup>/day (low to high productivity) for each of three 30-cm-deep layers.

The modeled price of algae diesel ranged from \$0.59 to \$0.91 (USD) per litre, corresponding to high and low productivity, which compares favourably to the 2008 average price of \$0.76/litre (\$2.89/gallon) for fossil diesel (US Gulf Coast). This shows that the system is close to economic viability on the basis of a single product stream. The secondary methane stream was modeled as earning, on the basis of \$6/MMBtu, additional revenues between \$1.6 million and \$2.7 million/yr.

Our model indicated that, given the above assumptions and depending on productivity, the CARS could generate an annual net profit as high as \$26.8 million. This estimate does not include the impact of carbon and NO<sub>x</sub>/SO<sub>x</sub> credits, which would further improve the bottom line.

### Next Steps — Stage II

- ❖ Construct lab-scale demonstration facility and conduct laboratory-based experiments.
- ❖ Carry out research related to strain selection/genetics for optimizing biomass production.
- ❖ Complete engineering design for an integrated field pilot.
- ❖ Build and operate a field pilot demonstration facility at an industrial site.

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