Sarnia-Lambton Economic Partnership
Response to:
Ontario Low-Carbon Hydrogen – Discussion Paper

January 2021

A. Introduction

Canada has played an important role in the development of the growing global hydrogen economy, starting more than a century ago with innovation in hydrogen production technology and four decades ago as pioneers in fuel cell technology. Canada continues to be an R&D and technology leader in the sector. Canada is not alone in seeing hydrogen as a critical part of the solution to combat climate change and improve air quality, while driving economic growth in a carbon-constrained world. Countries around the world have developed strategies to inform the optimal supply pathways and end-use applications for hydrogen, as well as to define export strategies.

The demand for hydrogen in global energy systems is dramatically increasing, with projections indicating at least a tenfold increase in demand over the next three decades. Studies indicate that hydrogen could provide up to 24% of global energy demand by 2050. The number of countries with polices that support investment in hydrogen technologies is increasing, along with the number of sectors they target. Canada is uniquely positioned to become a large-scale exporter of hydrogen to serve this growing market, but domestic deployments must lead.

Canada is known for its leading hydrogen and fuel cell technology companies and expertise. As of 2017, there were >100 established companies, employing >2,100 people, generating revenues >$200 million. Canada also has significant expertise in carbon capture technology, one of the keys to the production of low CI hydrogen from fossil fuels.

Clean hydrogen has the potential to deliver up to 30% of Canada's end-use, Canada's rich feedstock reserves, skilled energy labour force, strategic energy infrastructure assets, and leading position in innovation in hydrogen and fuel cell technologies position Canada to become one of the top global producers of clean hydrogen.

Canada is one of the top ten global producers of hydrogen today, producing an estimated 3 million tonnes (Mt) annually via steam methane reformation (SMR) of natural gas. While SMR is not considered a clean hydrogen pathway without carbon capture, Canada is well placed to transition to clean pathways going forward.

Canada is at a crossroads in its fight on climate change and ensuring an equitable future for all. Colleges are uniquely positioned to help Canada leap forward in this effort thanks to how deeply they are integrated into every type of community in every region of the country, with over 95% of all Canadians living within 50 kilometres of a campus or community hub.

B. Role of Colleges to Advance Hydrogen Strategy

The mandate of colleges is to provide flexible and innovative learning opportunities that are adapted to the needs of learners, the needs of the labour market and the needs of employers. Additionally, Colleges are deeply connected to their communities and play a critical role in their economic, social, environmental, health and cultural strategic plans and initiatives. The Colleges can contribute to the Hydrogen Strategy in Ontario and Canada in the following pillars:

1) *Educating Highly Qualified Personnel (HQP) to support Hydrogen Economy:*
   Strategic partnerships between industry, Colleges, and government will be instrumental in training the next generation of talent for the sector. Electrochemical Engineering, Fuel Cells, Hydrogen Storage, Energy Management, Hydrogen Production Processes, Hydrogen Conversion are a few among many topics which will be at utmost demand to grow hydrogen economy.
   The education and training objectives can be summarized as follows:
   - Develop and implement accredited level hydrogen programs.
   - Prepare students to work as hydrogen technology professionals in government, industry, and academia.
   - Prepare program graduates to demonstrate an appropriate mastery of the knowledge, techniques, skills and modern tools related to hydrogen and fuel cell technologies.
   - Prepare program graduates to demonstrate an ability to apply current knowledge and adapt to emerging applications of hydrogen technologies.
   - Disseminate program information and activities to community colleges, high schools, industrial partners, governmental agencies and universities.

2) *Hydrogen Innovation:*
   In the past 20 years, Colleges have greatly expanded both the capacity and the output of applied research in Canada, leveraging their strong business and industry connections to create value in their communities. Applied research is the development of innovative solutions to real-world challenges. It tackles practical problems by applying the latest technology and knowledge to create new products, services, and processes, or improve current products and practices. This growth has generated clear benefits, including thousands of innovative partnerships, new products and services, and unique work-integrated learning experiences for students. The Applied Research focus in Colleges with very flexible Intellectual Property (IP) policy in favor of industry has enabled more than 8,000 industrial projects in less than 10 years across Canada and built a perfect platform to stimulate economic development, industrial diversification and cluster building in many regions in Ontario and Canada. Sarnia-Lambton is a great example of how Lambton College involvement through applied research has helped the community to diversify the local economy by building “Bio Hybrid Chemistry Cluster”.

   Since 2012, Canadian funding to hydrogen clean tech and innovation has dropped, allowing other countries to catch up. Canada is also lagging other countries in starting hydrogen pilot projects. As a result, there have been examples of Canadian companies developing research centres and/or moving parts of their operations to other countries where there is more support for technology advancement. It is important for Canada to take action now to prevent loss of critical IP. Reinvesting in research and development will enable Canada to capitalize on our head start and maximize Canadian technology penetration in emerging global markets.

Colleges like Lambton College with 14 years of Hydrogen research can play a big role to develop, pilot, optimize and commercialize cutting edge technologies. Technology development and innovation are needed for core materials, end-use products, as well as in the hydrogen production, storage and distribution value chains. Technology development and innovation require local deployments to foster collaboration between industry and Colleges. Critical hands-on experience can be gained to understand market needs and develop practical and commercially ready solutions. Canada's lack of domestic deployments is currently hampering innovation in the sector.

3) *Awareness:*

Increased awareness about hydrogen as a viable decarbonization pathway that is safe and provides economic benefits is critical to establishing a vibrant hydrogen sector. Targeted awareness campaigns for public and in certain industry sectors, including providing easy tools for end-users to evaluate hydrogen options, will be an important step in supporting adoption. There is currently a lack of awareness about the opportunities for hydrogen and around safety issues, both by the public, as well as within industry and government. Limited domestic hydrogen deployments have further resulted in a lack of tangible case studies to increase awareness and support long-term planning and buildout.

Colleges have built and deployed renewable energy and sustainable houses the for the purpose of education, research and awareness. Many of the pilot and demonstration technologies developed through research and development projects in partnership with industry will have the capacity to be utilized for public, industrial and government awareness purposes. Lambton College build "Sustainable Smart House" in 2010 and embedded 6KW hydrogen production, storage and conversion facility as a platform for training, research and awareness. Similar projects can be deployed in Colleges for multi purposes including awareness.

In addition, there is also the need for targeted awareness of the career opportunities for talented and skilled labour in the hydrogen economy. This includes the transition of midcareer workers and the training of the next generation of workers to the low carbon technology sector.

4) *Community and Regional Initiatives*

It is very critical to grow hydrogen strategy in the community and region level. Building collaborative approaches between government, industry and academia in community and region to enable develop and facilitate the development of regional socio-economic hydrogen initiatives and plans for hydrogen production, end use and awareness.

As an example, Sarnia-Lambton is home for the biggest Petrochemical & Refining cluster outside of Alberta which has the most immediate opportunity for Ontario to strengthen and grow its existing hydrogen economy through the diversification of existing assets of both producers and users, and access to infrastructure and demand. Hydrogen is critical to

transforming these industries to net-zero emissions. It provides an opportunity to leverage Canada's diverse talent pool, valuable energy reserves, and infrastructure assets in a way that is carbon-free at the point of use, providing a future pathway to utilize these assets. This transformation needs be accelerated and supported by the innovation institute such as Lambton College to design and pilot technologies and analyze and optimize the processes.

5) Strategic Partnerships

Collaborative and strategic partnerships are essential for growing the production and use of hydrogen across Ontario. Partnerships that emphasize environmental protection, cultural recognition, community energy planning aligned with traditional values, economic development, and project participation, will be essential to maximize benefits for various groups including Indigenous peoples in the hydrogen economy. Colleges, as a training and research hubs, are a critical member of these strategic partnership developments. Colleges provide studies, research and development services to map out the future of hydrogen economy considering the environmental, cultural, economic and health aspects in the region and Ontario.

C. Lambton College Research

Lambton College's Research & Innovation department has positioned itself as the sole provider of research and development for industry within the region, striving to develop suitable working models for collaborative applied research and commercialization activities. Additionally, Lambton College has significantly expanded its reach to companies across Canada and internationally. Since 2006, the department has developed and executed more than 1100 projects in collaboration with more than 800 industries and has resulted in more than 300 new prototypes, 40 pilot plants and 700 new/improved processes, technologies and services. Currently, Lambton College is ranked #1 in Ontario and #2 in Canada for Research in 2020 and in the top 3 spots for five straight years as ranked by Research Infosource Inc (only ranking system for Colleges). Lambton College is also the highest recipient of funding among Ontario Colleges from Ontario Centres of Excellence and the Natural Sciences and Engineering Research Council of Canada (NSERC). Lambton College has received more than $45M funding for industrial research since 2006. Support to Small and Medium sized Enterprises (SMEs) has been provided through the establishment of 6 research centres and 4 research groups:

1. Lambton Energy Research Centre (LERC),
2. Bio-Industrial Process Research Centre (BPRC),
3. Lambton Water Centre (LWC),
4. Lambton Manufacturing Innovation Centre (LMIC),
5. Centre for Industrial Materials Development (CIMD),
6. Information Technology and Communication Research Center (ITCRC),
7. Sustainable Energy and Nano-Engineered Research and Electrochemical Engineering Group
8. Advanced Biotechnology and Natural Health Product Research Group

9. Advanced Process Control Research Group,
10. Health and Social Science Research Group.

D. Lambton College Hydrogen Focus:

Sarnia-Lambton's energy sector is a core contributor to the economic development of Southwestern Ontario, providing employment to many people in the region. Lambton College has taken a leadership role in the region through establishment of Lambton energy Research Centre (LERC) and Sustainable Energy and Nano-Engineered Research and Electrochemical Engineering Group performing applied research in the areas of hydrogen, renewable energy, energy storage, energy system optimization, and materials for energy.

Since 2006 and due to industrial demand, Lambton College started developing and executing collaborative industrial research projects focused on hydrogen generation, production and storage, utilizing faculty and staff expertise and College's infrastructure. Throughout these years, Lambton college has executed more than 12 research projects with industry which has resulted in two pilot units, 3 prototypes, 7 new and improved technologies/products for partner industries. These projects were supported with more than $5.5M in research grants and company contributions.

Figure 1. Lambton Energy Research Centre's Sustainable Smart House which has Hydrogen Generation, Storage and Conversion Facilities

Figure 2. Two views of Hydrogen Lab with 3 electrolyzers and 5 fuel cells and required piping to the storage facility outside of the building

Research projects Examples

1. Renewable Energy Conversion and Storage Research (RECSR) - *Partners: Paton Controls, Provincial Controls, Bilco Consultants, Electrozad Supply Company, Bluewater Power Distribution Corporation, and BioSonic Technologies Inc.*

The Lambton College RECSR project was aimed at the development of an integrated modular 14 kW Wind and Solar Renewable Energy Source (RES) system with the capability of optimizing captured energy at varying production levels and operating conditions. A 6KW scalable hydrogen fuel production, and storage and dispensing system is designed to manage RES use. The captured and stored energy is used to regenerate electricity and produce alternative fuel as hydrogen whenever RES is available through specified electrical, thermal and fuel-based energy dispensing outlet.

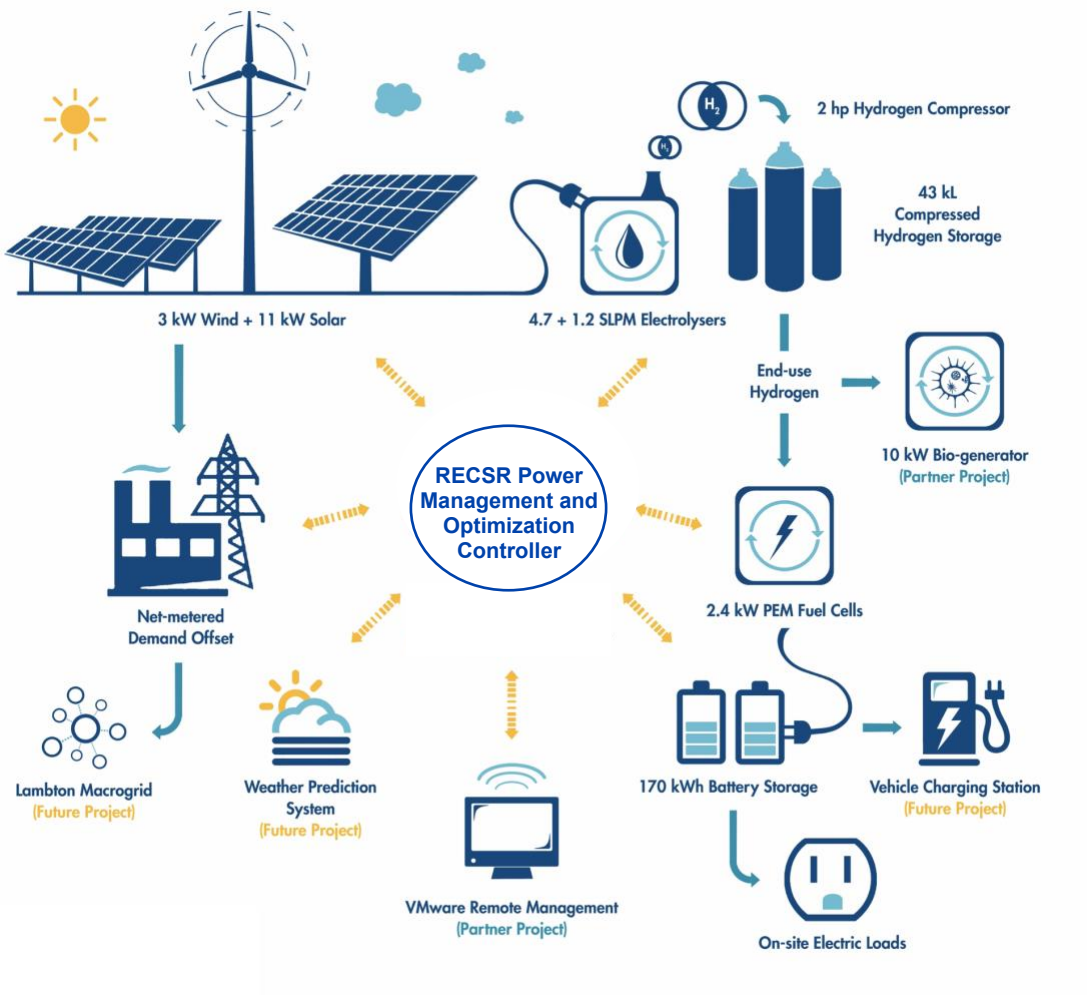

Figure 3. Renewable Energy Conversion and Storage Research (RECSR) Process Flow

2. Gasification of Phraqgmites for the production of Green Hydrogen - *Partners: Wessuc Inc., City of Sarnia and County of Lambton*

Wessuc Inc., in collaboration with Lambton College, plans to undertake a research project to develop high efficiency refining processes that would enable commercially viable mass production of high purity hydrogen & co-products from Phragmites (European Common Reed), which is an invasive plant causing damage to Ontario's biodiversity, wetlands and beaches. Phragmites is a perennial grass that has been damaging ecosystems in Ontario for decades. It is not clear how it was transported to North America from its native home in Eurasia. Phragmites is an aggressive plant that spreads quickly and out-competes native species for water and nutrients. This presents an opportunity to rescue native vegetation while utilizing the significant amount of biomass produced by phragmites. The proposed project will initially focus on a refining process development for hydrogen production from phragmites biomass. The basis for production of hydrogen from phragmites biomass will be production of Syngas and a purification of hydrogen. The overall goal of the research project is to control the spread of invasive phragmites, reduce its

negative effects on local ecosystems while utilizing the significant biomass for a valuable commodity.

3. Photocatalytic Hydrogen Production Using Doped Titania Nanotubes Under Visible Light – Optimizing Doping Process and Photobioreactor - *Partner: Volta Energy Inc*.

The primary objectives of this applied research project are twofold: to develop and optimize a novel electrochemical process to create highly photo-responsible TNTs for green fuel generation and to design, fabricate and optimize a series of photoreactors for efficient hydrogen generation using natural and artificial lights. This project has now expanded to include utilization of doped titania nanotubes (TNTs) for wastewater treatment.

4. Syntheses and Characterization of Doped Titania Nanotubes for Solar Hydrogen Generation – *Partner: BioSonic*

This project focus is to design novel reactors using titania nanotubes, as well as systematic exploration and evaluation of the effectiveness and efficiency of doped photocatalysts for hydrogen generation under visible and near-UV range of radiation.

5. Optimization and Integration of Novel BioGenerator Process in Pilot Scale - *Partner: BioGenerator Energy Solutions Inc.*

The BioGenerator is the world's first microbial fuel cell for large-scale power generation and is the first biotechnological converter of hydrogen to electricity. BioGenerator Solutions Inc. in close collaboration with researchers at LC are building a 10-kW pilot plant BioGenerator system at College's campus for evaluation, optimization, and demonstration purposes for use in distributed generation systems. This pilot system will be used to store electrical energy for the smoothing of the power generated from LC's renewable energy conversion and storage infrastructure, consisting of 11-kW solar array, 3-kW wind turbine and 5-kW hydrogen generation unit.

6. Design Optimization, Evaluation, and Integration of a SOFC-based CHP System with Electic Energy Storage for Residential Applications - *Partner: Energex Industries Co.*

The proposed applied research project is aimed at optimization, integration, and validation of a novel, stand-alone, renewable hybrid energy system designed to deliver electrical and thermal energy on demand to residential and small commercial buildings.

Hydrogen Laboratories and Facilities

a) Hydrogen Lab:

1. Hydrogen Electrolyser
2. PEM Fuel Cell
3. Hydrogen Storage Unit

b) Electrochemical and Sustainable Research Lab

1. SEM-EDX

2. SECM
3. Mercury intrusion porosimeter
4. Ezlab Fuel Cell Test Station
5. MTSA-NL Fuel Cell Test Station
6. Potentiostat/Galvanosat
7. X-Ray Diffractometer
8. Battery Analyzer
9. Gas Chromatographer
10. UV-Spectrometer
11. HMV Microhardness Tester
12. Frequency Response Analyzer
13. Vertical Knee Milling Machine
14. Ultrasonic Processor
15. Mini CVC Tube Furnace
16. Dynatronix Pulse Power Supply
17. Single/Triple Output DC Power Supply
18. Solar Simulator
19. Electronic Load
20. VWR Heated Circulating Water Bath
21. Conductivity Meter
22. pH Meter
23. High-Temperature Furnace
24. Low-Temperature Oven

c) Material Testing Lab

1. TA Instruments Differential Scanning Calorimeter (DSC Q2000)
2. TA Instruments Thermal Gravimetric Analysis (TGA Q500)
3. Dynamic Mechanical Analysis (DMA Q800)
4. Mastersizer Particle Size Analyzer
5. Agilent Fourier Transform Infrared Spectroscopy (FTIR)
6. Gardner Impact Tester

7. Qualitest Q Impact 50 IZOD/Charpy Tester
8. Tinius Olsen H25KS Mechanical Multitester (Flexural, Tensile, Tear)
9. Asylum Research Atomic Force Microscopy (AFM)
10. Sample Cutting dies
11. APM – SA27L Hydraulic Die Cutting machine
12. Rheological Digital Analyzer

References:

1. NRCan Hydrogen Strategy for Canada, Seizing the Opportunities for Hydrogen, December 2020.
2. 2018-2019 CICan Applied Research Comes of Age, 2019.