MIES

ICE-HARVEST

an integrated approach to community energy

AN UNPARALLELED ENERGY COOPERATIVE

Integrated Community Energy and Harvesting systems (ICE-Harvest) advance the idea of Distributed Energy Resources (DER's) by embedding integrated thermal and electrical generation as well as storage within a community. This allows our communities to be powered, heated and cooled in an economic and carbon-reduced way.

The ICE-Harvest holistic approach has created unique synergies across traditionally siloed sectors of the energy system that allows harvesting and sharing of normally lost energy. The modular system superstructure creates seamlessly coupled thermal and electrical generation embedded in communities through integrated micro-electrical and micro-thermal grids to meet demand while maximizing total energy utilization. This integration creates multiple economical and environmental benefits.

The ICE-Harvest system packages technologies and energy storage in repeatable building blocks, allowing them to be optimally combined and then intelligently controlled to support both the thermal requirements and the electrical grid. Components are modularized into a "three-size solution" to be scalable to communities of varying sizes. This model provides solutions that are economically and technically feasible, flexible, resilient and effective in making a significant impact on GHG emissions.

McMaster Engineering has created a globally unique research facility to develop the needed tools to design and commercialize the system. This facility takes advantage of the fossil fuel-free baseload energy grid of Ontario to deliver thermal and electrical energy to pre-charge storage so as to reduce the peak electrical and thermal demand on the university campus. ICE-Harvest has the flexibility to accommodate future renewable energy sources and other technologies.

ICE-Harvest is led by McMaster University, in cooperation with Carleton University and in partnership with the GridSmartCity Cooperative, Siemens Canada, Enbridge Gas, Alectra Utilities, S2E Technologies, GeoSource Energy and HCE Energy.

19 Industry Partners **30+** Municipalities

1000+ Potential Sites **5** Pilot Projects

OUR PARTNERS

McMaster University ENGINEERING

NSERC CRSNG

Carleton UNIVERSITY

Ontario Centres of Excellence
Where Next Happens

SIEMENS

ENBRIDGE
Life Takes Energy™

s2e

GEOSOURCE ENERGY INC

HAMILTON COMMUNITY ENTERPRISES

ENWIN

OAKVILLE HYDRO

Energy+ INC.

Kingston Hydro

ESSEX POWERLINES CORPORATION

Waterloo North Hydro Inc.

KITCHENER WILMOT HYDRO INC.

npe niagara peninsula energy inc.

MILTON HYDRO

Welland Hydro ELECTRIC SYSTEM CORP.
POWERING WELLAND'S FUTURE

Burlington hydro inc.

Halton Hills HYDRO

alectra utilities

BRANTFORD power
Your delivery company

UNIQUE BENEFITS

ENSURING RESILIENCY

energy resiliency

The capacity to withstand and quickly recover from a disturbance to the energy system and continue to supply energy services.

ICE-Harvest systems inherently provide thermal and electrical resilience for their community nodes, most of which are the most vital or vulnerable spots in our communities. The island capable self-starting technologies of the Distributed Energy Resources combined with the integrated thermal and electrical storage will provide electricity, heat and cooling to critical processes. Community node buildings will remain functional and perform as places of refuge which is becoming an increasing concern of climate change. Embedding ICE-Harvest systems enhances community resilience to energy outages caused by extreme weather events by having self-powered micro-electrical and thermal grids with inherent multi-generation redundancy.

A HOLISTIC APPROACH

holistic

Relating to the whole of something or to the total system instead of just to its parts

ICE-Harvest utilizes a holistic and innovative energy system approach which ultimately redefines the way in which communities interact with energy. ICE-Harvest exploits synergies across traditionally siloed sectors of the energy system that allows harvesting and sharing of normally lost energy. Distributed Energy Resources with micro-electrical and micro-thermal grids are integrated to meet demand while maximizing total energy utilization and efficiency. As well, ICE-Harvest integrates with the electricity grid and acts as a demand management tool to balance and level the grid and improve its efficiencies as well as reduce curtailment of low carbon power generation. Advanced control technologies and artificial intelligence will be developed and utilized to optimize the complex operations of ICE-Harvest.

INCREASING ENERGY UTILIZATION

energy utilization

The total amount of energy a process converts into useful work and/or services from available energy resources.

Combining electricity, heating and cooling energy with the integrated thermal storage the ICE-Harvest Systems provides more useful energy outputs for the same amount of energy resources used compared to the traditional approach of centralized electricity generation and individual heating and cooling systems. ICE-Harvest Systems not only have the **highest energy utilization**, they can create demand and make use of otherwise unutilized carbon free energy resources during periods of excess generation potential. This is accomplished by displacing centralized natural gas fired electricity generators with **Distributed Energy Resources connected to thermal micro- grids**. This enables ICE-Harvest to harvest heat that would normally be lost and use it to serve a community's heating load.

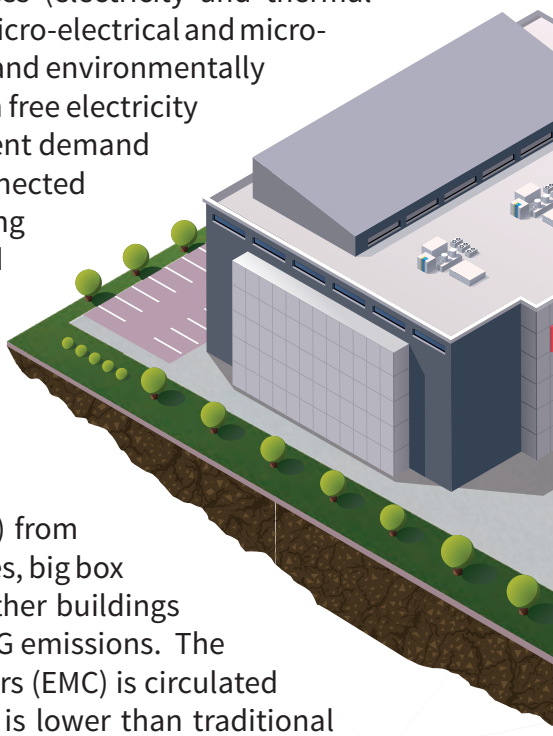
The thermal grid is also used to **enable energy sharing** (thermal energy transactions) between buildings that are cooling and buildings that are heating. Cooling dominated buildings, such as arenas and grocery stores, which would otherwise reject heat from cooling processes can transfer this heat to buildings that need the heat for space and hot water heating, such as a condo tower. ICE-Harvest Systems can **reduce curtailment** of carbon-free energy resources, which happens when there is insufficient electrical demand to meet generation. Electrical demand can be created to use this surplus carbon free energy by using electrically driven heat pumps to heat and cool buildings that are connected to the micro-thermal grid or to store thermal energy.

The **innovative balance of short- and long-term thermal storage** is key to maximizing utilization that allows unparalleled demand management and arbitrage services to economically maximize energy utilization while simultaneously minimizing greenhouse gas emissions.

ICE-Harvest System Operation Overview

ICE-Harvest will help communities produce, utilize and manage energy systems in a way that catalyzes multiple economic, public and environmental benefits. ICE-Harvest brings forward solutions addressing core climate change issues including adaptation, mitigation, resiliency and has a focus on innovation and creating community energy networks of the future.

ICE-Harvest builds on incorporating Distributed Energy Resources (electricity and thermal energy generators) and embedding them in communities through micro-electrical and micro-thermal grids to power, heat and cool buildings in an economically and environmentally sustainable fashion. At times when there is surplus carbon emission free electricity that could be generated but must be curtailed because of insufficient demand the ICE-Harvest create can create demand. Electric heat pumps connected to the micro-thermal grid are used to provide heat by either collecting it from the air or extracting heat from the geothermal storage and injecting it into the thermal microgrid. This provides carbon-free heating to all the buildings and allows them to store or pre-heat their buildings to reduce peak heating demands, reducing GHG emissions and helping to equalize electricity demand between night and day.



ICE-Harvest captures waste heat, (cooling is really removing heat) from various parts of the community—such as sport arenas, grocery stores, big box stores, apartments, and restaurants—and transfers this heat to other buildings which in turn reduces natural gas consumption and associated GHG emissions. The heat harvested in modular ICE-Harvest Energy Management Centers (EMC) is circulated through a low temperature thermal micro grid. The temperature is lower than traditional district energy systems to reduce losses and allow community members to share excess heat between buildings. For example, an arena cooling its ice pad would take heat out of the ice pad and inject it into the thermal loop, sharing its thermal energy and allowing recovery of that waste heat for another building to use. Excess heat is stored in short or long-term thermal storage, capturing the heat that is normally wasted. When the community nodes heating demand is larger than low carbon sources can provide, heat will be taken from either the short-term or seasonal thermal storage to ensure comfort is maintained.

Community resilience to power outages and greater utilization of carbon-free electricity sources is made possible through the melding of the thermal and electrical grids. Distributed energy resources of integrated and thermal microgrids provide the ability to power, heat and cool the ICE-Harvest node in the event of loss of normal supply from the energy grids.

ICE-Harvest utilizes a holistic and innovative energy system approach that increases resiliency and energy utilization which ultimately redefines the way in which communities interact with energy.

Four Key Research Milestones

Community

System

Storage

Controls

IMPACT

OUTCOMES

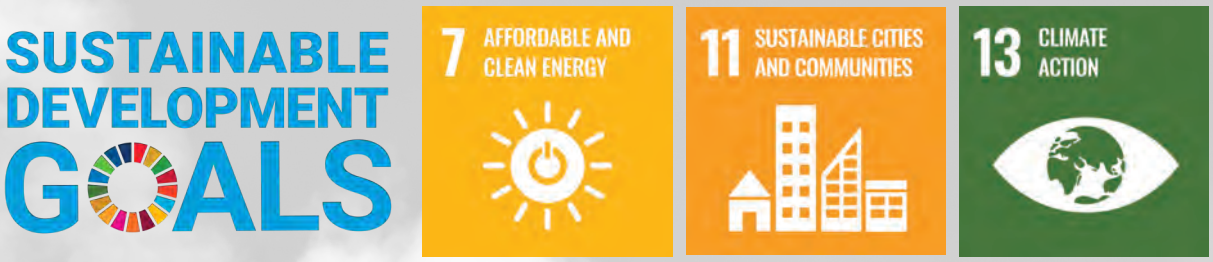
The proposed ICE Harvest project supports the federal government's Climate Change agenda as well as the vision of Canada's Economic Strategy Table on Clean Technology.
Looking forward, it is necessary for market adoption that several demonstration sites in partner communities be designed and piloted to de-risk the commercial viability of the ICE-Harvest technology and demonstrate its environmental benefits. Demonstration projects in diverse community nodes will be developed over a five-year period with each validating the commercialization of either key components of the ICE-Harvest system or the complete system. At present, demonstrations are planned in Hamilton, North Waterloo, Burlington, Essex and Milton. At an average cost of $5 million per node, an overall budget for technology demonstration of $25 million over five years is estimated.

Continued research by McMaster to model, design, measure and develop best practices and design tools to increase community resiliency, reduce GHG emissions and improve energy efficiency using a holistic and innovative energy systems approach is required. This research budget would require a budget of approximately $ 2 million over the five-year period.

With an estimated $27 million-dollar total cost, Industry Partners, Building Owners, Provinces, Municipalities, Communities and other sources are expected to provide approximately 50% of the required funding with the remaining being provided through Government of Canada and other levels of government programs.

PUBLIC BENEFITS

- Enhances community resilience to energy outages caused by extreme weather events by having self-powered micro-electrical and thermal grids with inherent multi-generation redundancy for heating, cooling and electricity.



ENVIRONMENTAL BENEFITS

- The potential to reduce GHG emissions, relative to the status-quo, by up to 100%.
- Substantial GHG emissions abatements made possible through harvesting energy that would otherwise be rejected at central power plants and energy intensive communities (up to 150% of energy used is often rejected as waste) by using a thermal microgrid that shares and stores thermal energy thereby reducing fossil fuel use.
- Reduces the loss of green electrical power through smart energy management, and the integration of thermal and electrical networks that allow storage of heat, cooling and electricity. This will offset the operation of fossil-fuel-based electricity generation and favour carbon-free electricity sources. (Note: the amount of electrical energy from carbon-free sources that is dispatched off is equivalent to ~7% of annual electricity generation in Ontario alone).

ECONOMIC BENEFITS

- Encourages local economic development opportunities to create new clean-tech jobs in each community to manage the operation of more efficient ICE-Harvest community nodes, paid for by a reduction in thermal and electrical energy expenditures that would otherwise leave the community.
- Reduces demand spikes and balances the electrical grid by turning communities from reactive consumers to interactive prosumers. Uses advanced demand management and energy control strategies such as load shifting to off-peak periods to reduce peak demands, which also utilizes otherwise dispatched off carbon-free electricity.
- Provides a scalable solution due to modularity of equipment, allowing rapid and cost-effective deployment within communities, especially remote communities, reducing risk and remaining flexible to adapt to changing energy profiles with time.
- Unleash the value of ICE-Harvest in Canadian communities and unlock the export potential of a globally competitive Canadian clean technology.

McMaster Highly Qualified Personnel

The vision for the ICE-Harvest Research Cooperative is to develop a globally recognized training program that imparts the right mix of technical and professional skills to meet the evolving needs of the distributed energy resource sector in Canada.

The team is trained in the multi-stakeholder arena of Integrated Community Energy and Harvesting systems to solve the significant challenges transitioning Canada to a low carbon economy.

McMaster ReFIBES Facility

The jointly funded Canada Foundation for Innovation and Ontario Research Fund McMaster Facility – RESEARCH FACILITY FOR INTEGRATED BUILDING ENERGY HARVESTING SYSTEMS (ReFIBES) is the only test facility of its kind globally. This facility enables research in integrated energy systems for community and urban use, such as sustainable energy management, harvesting and storage. The facility provides critical infrastructure needed to develop, test and validate the ICE-Harvest System. The integrated systems research lab within the Gerald Hatch Centre for Engineering Experiential Learning simulates the operation of the Energy Management Centre and Low Temperature Thermal Network creating a true Living Laboratory. The ReFIBES energy system incorporates advanced energy testing suites, including Distributed Energy Resources for heating, cooling and electricity production, a novel geothermal storage facility, short-term hybrid phase change material storage, electrical storage and electric vehicle integration. This facility enables research into a new superstructure that captures every feature of a community-based energy platform. ReFIBES is a facility that is unique not only in Canada, but globally.

Increasing community energy utilization and resiliency by:

Transforming our communities into reactive micro thermal and electrical grids using advanced demand management and energy control strategies

Harvesting and sharing unused energy otherwise wasted at central power plants and energy intensive communities using a thermal grid

Preventing turning off green power by using smart energy management and storage of heat, cooling and electricity

JIM COTTON, MCMASTER
cottonjs@mcmaster.ca
energy.mcmaster.ca