Annual Report

CanmetENERGY in Varennes

Science at the service of all Canadians

2022-23

Natural Resources Canada
Ressources naturelles Canada

Canada

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Message from the Director General

In 2021, Canada committed to reducing its GHG emissions by 40-45% from 2005 levels by 2030, and laying the foundation for achieving net-zero emissions by 2050. In 2020, about 490 Mt (73%) of Canada's GHG emissions were from the combustion of fossil and biomass fuels[1]. According to the International Energy Agency (IEA), we cannot achieve net-zero emissions without a "significant and speedy ramping up of clean energy technologies across the entire energy sector."

Our Centre is precisely at the nexus of this transformation with its energy end-use technology research and development (R&D). The energy system modelling activities that we carry out on varying scales, from equipment-level to Canada's entire energy system, including the majority of the various uses and forms of energy, allow us to enable the Government of Canada and our partners to make better decisions.

The trajectory through time and space to achieve decarbonization by 2050 has to take into account the political, environmental, social, technological, economic and legislative aspects in order to minimize the repercussions on the population, including the most vulnerable.

In 2022-2023, with the Office of Energy Research and Development (OERD) and with the other federal laboratories, we established the R&D objectives for the next cycle (2023-2028) of the Program of Energy Research and Development (PERD).

We also created a Science Impact Unit at our Centre to imagine – from the very beginning – a trajectory that would maximize the positive individual impacts of all our R&D activities, while demonstrating their contributions to the overall net-zero trajectory. We position our technologies in terms of their value, potential users, required partners, communication strategies, and key financial resources. Beyond the tools we use, we will strive to instill an impact-oriented culture within our research community over the coming years.

Since March 2020, we have been working both on site and remotely. We were successful in ensuring the health and safety of our employees, completing all our projects and then some. In May 2021, we took the initiative and launched a collective project to reinvent work in a postpandemic world. We established a hybrid model that has enabled us to build on the lessons we learned during the pandemic, to be more efficient, to collaborate more with our external partners, and to improve our employees' quality of life.

We also established the 13 R&D projects that we will carry out by 2028 in support of these objectives. In 2023-2024, we will integrate our deployment and support activities into a scientific plan, over the entire process, from the idea to the design, to laboratory validation and value creation for the end user, all supported by a communication plan focused on our stakeholders.

Jocelyn Millette
Director general

1 https://publications.gc.ca/collections/collection_2022/eccc/En81-4-2020-1-eng.pdf

Who We Are

Clean Energy | Research Innovation | Leadership

The **CanmetENERGY in Varennes (CEV) research centre**, located on Montreal's south shore, is part of Natural Resources Canada's Energy Efficiency and Technology Sector (EETS).

With over 175 researchers, engineers, technologists, managers and support staff, we lead R&D activities and deliver programs aimed at developing clean and efficient science and technologies for a low-carbon future.

We collaborate with partners, such as non-government organizations, academia, industry and all levels of government.

We strive to put science at the service of all Canadians.

Our Values

The excellence and scope of our work, the accountability of public funds and resources, the well-being, excellence and motivation of our employees, as well as great and efficient teamwork, are at the centre of our decisions and actions. We value diversity within our team for a healthy, respectful and creative work environment. We are currently thriving in a hybrid work mode as we keep serving Canadians.

How We Use Our Results & Create Impact

The results of our R&D activities are namely presented in scientific journals and conferences, integrated in codes and standards, deployed throughout our software tools, in federal government facilities and in remote, off-grid communities. Our science and conclusive data enable us to:

- Support government policy decision-making
- Develop national strategies and guidelines
- Provide technical expertise to public deployment programs
- Ensure a successful energy transition for the benefit of all Canadians

Our Areas of Activity

Our facilities are equipped to develop, test and demonstrate clean energy solutions in real-world conditions to enhance their market uptake. Our activities and expertise in various sectors include:

Buildings

Renewable heating and cooling systems

Intelligent buildings operation

Energy systems for northern and remote infrastructures

Greening Government services and expertise

Industry

Eco-efficient processes for deep decarbonization

Advanced biorefinery processes and decision support systems

Artificial intelligence for energy-efficient process industry

Training in energy optimization and data analytics

Renewable Energy Integration

Transition to high renewable integration on the grid

Smart grid and microgrid control for resilient power systems

Smart cities and communities

Distributed energy resource assessment and technology

RETScreen Clean Energy Management Software

RETScreen Expert

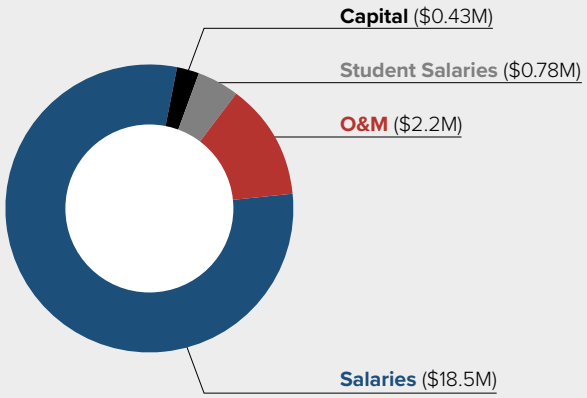
RETScreen Innovation Lab

RETScreen Data Onboarding

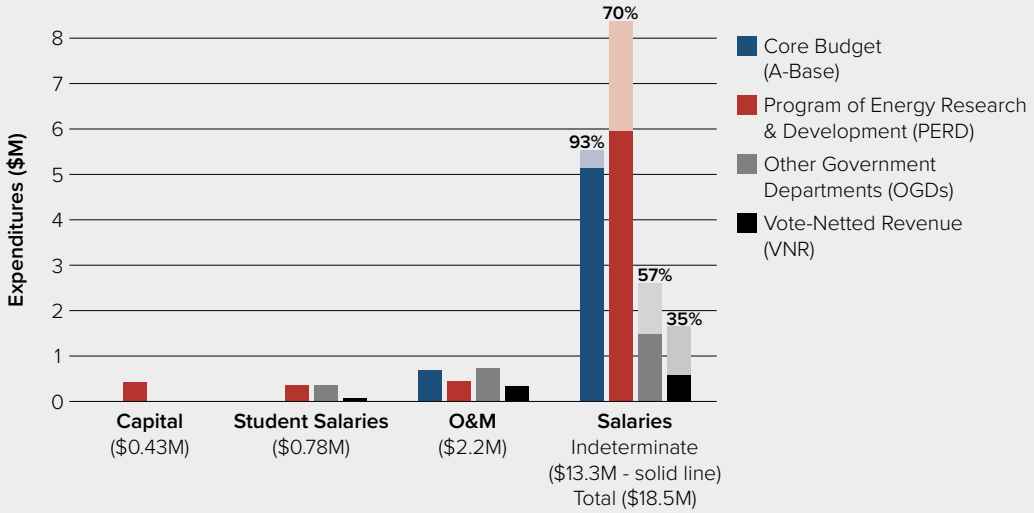
RETScreen Capacity Building

Structure & Annual Budget

DISTRIBUTION OF EXPENSES



SOURCE OF FUNDS



STRATEGIC & OPERATIONAL	R&D PROGRAMS	DEPLOYMENT
Science Impact Unit 3 employees $0.5M	**Buildings** 20 employees $4.0M	**RETScreen** 23 employees $2.9M
Scientific Outreach 4 employees $0.3M	**Industry** 35 employees $4.5M	**Greening Government Operations** 10 employees $2.3M
Operations 20 employees $3.2M	**Renewable Energy Integration** 30 employees $3.6M	**Energy Systems for Northern and Remote Infrastructures** 6 employees $1.5M

In $M, including salary, employee benefit payments, and O&M

We design our R&D activities, throughout the technology innovation chain, to ensure maximum effectiveness. Our Operations Group, Scientific Outreach Group and Science Impact Unit provide expertise and support to the different divisions responsible for implementing our R&D programs.

Our Future

The year 2023 marks the beginning of a new five-year scientific plan based on 13 projects funded under the Program of Energy Research and Development (PERD) / Energy Innovation Program (EIP) for the 2023-2028 funding cycle. The R&D plan focuses on delivering scientific results to achieve Canada's science and technology (S&T) mandate by providing maximum impact to Canadians.

Our PERD projects:

Buildings Division

- Efficient and Affordable Heating Systems for Cold Climate
- Low Global Warming Potential (GWP) Heat Pump Systems
- Integrated Systems for Building Flexibility and Resilience
- Data-Driven Building Operation for Energy Efficiency, Flexibility & Resiliency

Industrial Systems Optimization Division

- Sustainable Industrial Decarbonization
- Sustainable Solutions to Advance Clean Fuels Production and Utilization
- Artificial Intelligence-Powered Industrial Decarbonization
- Advanced Carbon Capture, Utilization and Storage (CCUS) Technologies and Systems
- National CCUS Assessment Framework

Renewable Energy Integration Division

- Testing, Characterization & Support of Variable Renewable Energy (VRE) and Smart Grid Resources and Devices
- Improving Technology Grid Interface and Interoperability to Support Grid Modernization
- VRE Resources and Electrified Grid-Active Neighbourhoods, Communities and Cities
- Low Carbon Regional and National Electric Grids and Energy Systems

Recognizing that we must reduce our energy consumption, electrify our energy use while increasing the capacity of our power grids and keeping them clean, and convert the uses that are difficult to electrify to low-carbon fuel, we will:

- Develop our testing infrastructures to equip ourselves with a thermal and electric microgrid with an approximate capacity of 250 kWe. This infrastructure will enable us to study a massive integration of solar energy, grid forming inverters, protection schemes in configurations with high penetration of renewable energy, load control for stability and a greater integration of renewable energies.
- Develop a greater ability to test and develop cold-climate, air-to-air, air-water and ground-source heat pumps that use low GWP refrigerants, such as CO_2.
- Structure and enhance our capabilities in energy system modelling – in terms of software, expertise and human resources – at the community, provincial and Canadian levels.

To improve collaboration and ensure results that are consistent with the efforts we put in place, we will develop a communication plan adapted to our different stakeholders.

Stay tuned!

Brief Report on the Progress of CEV Science and Technology Activities Carried Out During the Past Year

Renewable Energy Integration (REI) Division

Our R&D activites help to integrate an increasing proportion of renewable energy into the electricity grid in all regions of Canada, while ensuring sustainable, reliable, and affordable access to this resource.

Our mandate is well aligned with the Government of Canada's commitments to achieving net-zero electricity by 2035, and net-zero emissions in all sectors of the economy by 2050. To reach these targets, within the scope of electrification and renewable integration, advancements are required at several levels:

1. resource/technology
2. technology-grid interface
3. neighbourhood, community and city
4. regional and national

The REI Division includes R&D activities at all four levels to help develop effective solutions.

Selected highlights of these activities include, but are not limited to:

Distributed energy resource assessment and technology development

› Input was provided for the development of **six international standards** related to performance, quality, and safety of photovoltaic (PV) systems and components, including their integration to buildings. Contribution was also provided for the update of the solar PV module safety standard in Canada.

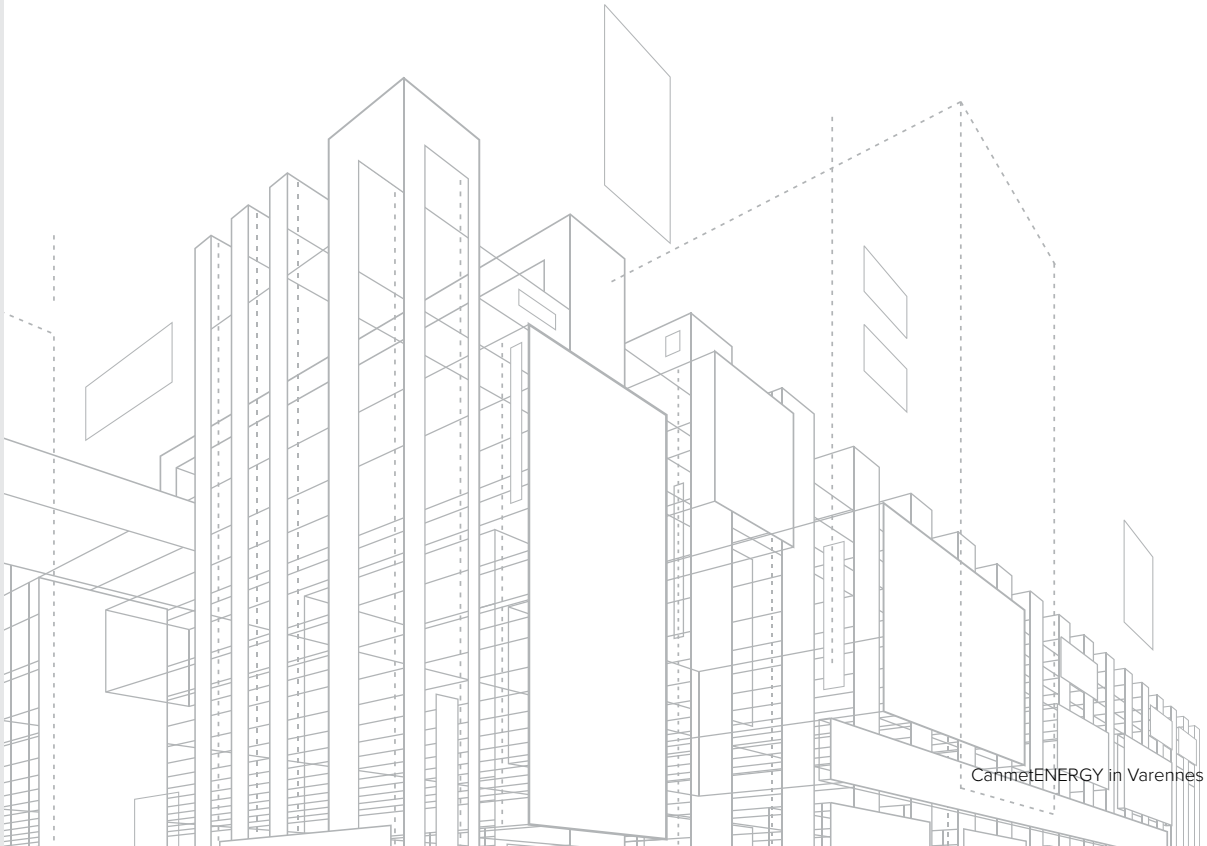
KEY OUTCOMES

This work contributed to harmonizing PV standards, improving product conformity on a global scale, reducing non-tariff trade barriers, and developing safe and reliable PV products.

› The **Varennes Library building-integrated photovoltaic (BIPV) roof was selected as one of five cases studies** analyzed by the **IEA PVPS Task 15**, of which CanmetENERGY is an active member, to provide insight on the performance of existing models when it comes to estimating the temperature in BIPV systems.

KEY OUTCOMES

The longstanding collaboration between CanmetENERGY and the Varennes Library allows to better understand the performance of real BIPV systems.



Smart grid and microgrid control for resilient power systems

› Recommendations were provided to interconnection standards to **improve test procedures on inverter grid support functions**. These recommendations were developed within a working group of the **International Smart Grid Action Network (ISGAN)** – a technology collaboration program of the International Energy Agency (IEA) and an initiative under the Clean Energy Ministerial (CEM).

KEY OUTCOMES

This international collaboration led to improvements in interconnection standards, which greatly influence public confidence in the operation and adoption of inverter-based resources.

› **A controller was developed for a community of smart electric water heaters (EWHs)**. The controller takes the probabilistic load forecast into account to find the optimal dispatch of EWHs given a specific objective such as peak reduction.

KEY OUTCOMES

This work on control methods to capture the flexibility of EWHs provides a better understanding of the amount of flexibility that these devices can have, and how that flexibility can be harvested.

Smart cities and communities

› The ongoing Varennes Interactive Grid (VARIG) project aims to **develop and demonstrate the operation of interactive grid concepts** encompassing electrification, decentralization, digitalization, and consumer participation. A methodology was established to define and implement test cases.

KEY OUTCOMES

These first steps will serve to: demonstrate that distributed energy resource (DER) can actively support grid operations through intelligent management; assess and prove the flexibility potential of existing residential, commercial and industrial assets; and validate how advanced controls can meet current and future needs of clients and the grid.

An **assessment of different REI concepts in remote communities** was conducted, enhancing the penetration level of inverter-based resources in remote networks. These studies included an assessment of enhanced solar PV grid penetration and its related fuel-saving opportunities in Aklavik, NT, in collaboration with the Northwest Territories Power Corporation. Future work will include the integration of solar and wind in the community of Cambridge Bay, NU, in collaboration with Qulliq Energy, to evaluate optimal integration level.

KEY OUTCOMES

These collaborations with northern utilities and remote Arctic communities aim to reduce their reliance on fossil fuel and to help them transition to clean energy.

Transition to high renewable integration on the grid

› A workflow was developed to identify, collect, and analyze the data necessary to **create synthetic distribution networks**.

KEY OUTCOMES

This project aims at assessing practical and affordable strategies, through a simulated representation of a real-world distribution system, for grid modernization and decarbonization. It provides a controlled and replicable environment for the study of power distribution systems.

› In collaboration with Canadian and U.S. stakeholders, CanmetENERGY led a **working group to foster the development of North American guidelines** for hosting capacity assessment (HCA). Since October 2022, CanmetENERGY has been leading the development of the HCA technical content, including hosting capacity calculation methods and metrics.

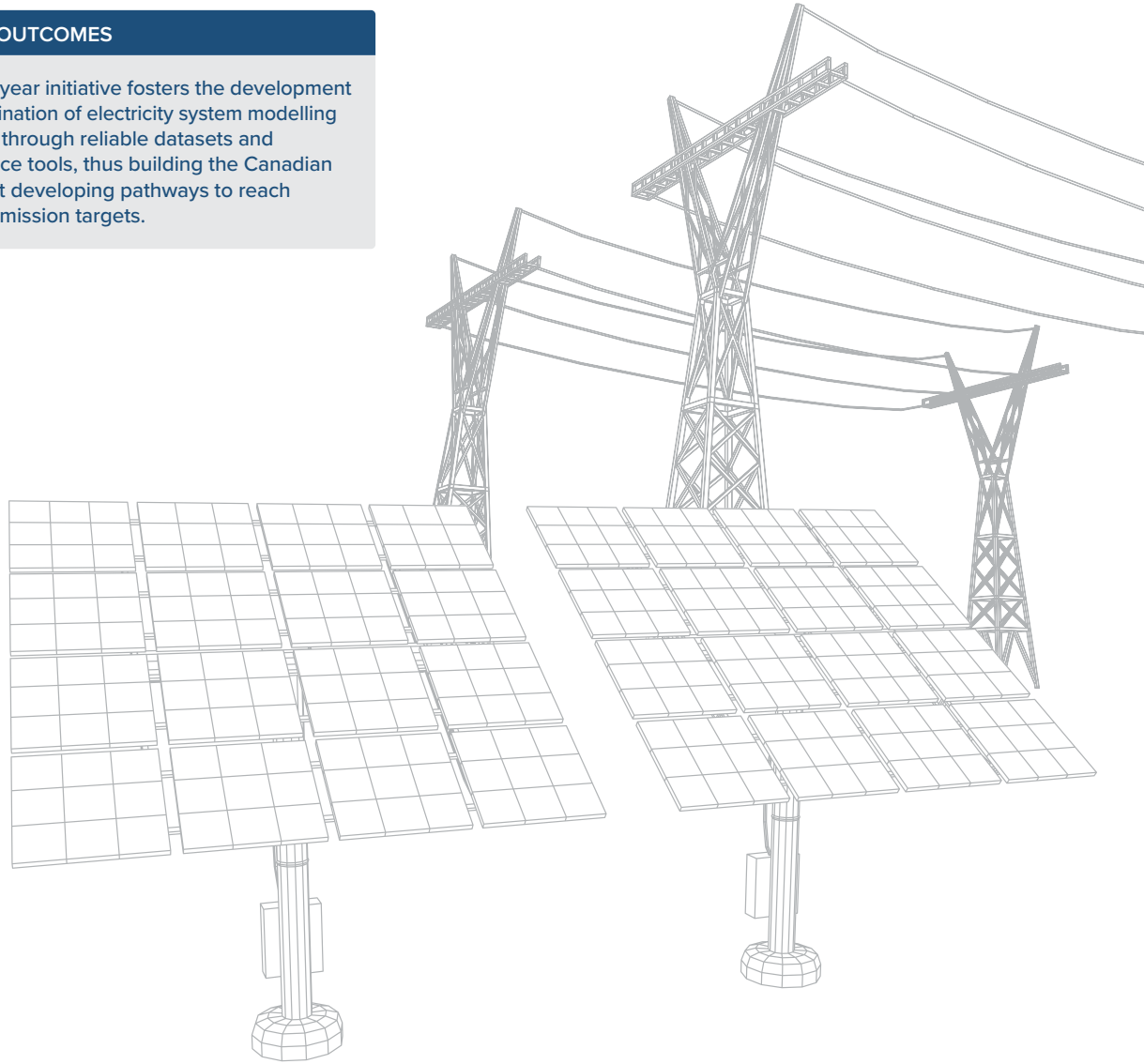
KEY OUTCOMES

This initiative will ultimately reduce the burden and capital expenses of utilities implementing hosting capacity evaluation, and will facilitate deployment for system developers.

› In collaboration with NRCan's Energy Systems Sector (ESS), CanmetENERGY contributed to the **creation of the NRCan-funded Energy Modelling Hub**.

KEY OUTCOMES

This multi-year initiative fosters the development and coordination of electricity system modelling in Canada through reliable datasets and open-source tools, thus building the Canadian capacity at developing pathways to reach net-zero emission targets.



Industrial Systems Optimization Division

Our team offers a broad range of expertise and is uniquely positioned to tackle complex problems related to large-scale energy systems optimization. We provide Canadian energy-intensive industrial sectors with whole-system design tools and knowledge to improve their global efficiency, increase their competitiveness, and reduce their environmental footprint.

Advancing science and technology

Big data and artificial intelligence

› An **AI-assisted maintenance tool** based on predictive and prescriptive machine learning methods was developed and tested on a black liquor concentrator of a kraft pulp mill.

KEY OUTCOMES

The tool resulted in improved process energy performance, reduced maintenance costs, and energy savings of up to 12%.

› A **novel data fusion approach** was developed using polygon generation and deep learning techniques to solve the integration challenge of multi-source, multi-format and time series data found in forest operations.

KEY OUTCOMES

This approach allowed to extract a higher level of information from datasets, boosting up the harvesting wood volumes prediction accuracy from 52% to 89%.

Biomass conversion and utilization

› The **benefits of using biomass in industrial applications** was demonstrated, with a potential GHG reduction of 15 million tonnes of CO_2-eq emissions annually.

KEY OUTCOMES

The use of biomass in high temperature applications is especially promising seeing as it would allow the generation of negative emissions credits when combined with carbon capture technology.

Hydrogen production and use

› A **harmonized system boundary and methodology** was established to assess the environmental impacts of five **hydrogen production pathways**, with and without carbon capture. A life cycle impact assessment determined the carbon intensity of these production pathways.

› Potential **industrial applications for green hydrogen utilization** were assessed against direct electrification, including high temperature heat production, direct reduced iron steel production, replacement of grey H_2 in refineries, and methanol utilization in maritime transportation.

12%

POTENTIAL IN ENERGY SAVINGS THANKS TO AN AI-ASSISTED MAINTENANCE TOOL

89%

ACCURACY FOR THE PREDICTION OF HARVESTED WOOD VOLUMES

57%

CO_2 EMISSIONS REDUCTION POTENTIAL FROM STEEL AND METHANOL PRODUCTION PROCESSES

Developing methodologies and decision support tools

Carbon capture, utilization and storage (CCUS)

› An industrial case study was carried out to assess the environmental and economic impacts of implementing a **Power-to-X** system (X stands for low carbon chemicals or fuels).

KEY OUTCOMES

Results demonstrate significant environmental benefits, enabling CO_2 emissions reduction from steel and methanol production processes by up to 57%.

› **AI and process knowledge** were used to accelerate the sizing and costing of two **solvent-based CO_2 capture technologie**s. Machine learning-based surrogate models have been trained to predict equipment sizing and process performance with errors of less than ±10% for a wide range of flue gas conditions and capture rates.

KEY OUTCOMES

The tool can predict design parameters, Capex, Opex and capture cost in mere seconds and can be used to quickly and accurately estimate the cost of CO_2 capture for emitters across Canada.

› **Bioenergy with CCS (BECSS)** represents a unique opportunity for Canada to generate negative emissions from pulp and paper, cement, and iron and steel operations. A complete model of an amine-based CO_2 capture plant was developed for a typical Canadian kraft mill.

KEY OUTCOMES

The model allowed to establish the cost and additional energy required to capture CO_2 from the plant's recovery boiler, power boiler and lime kiln.

Industrial decarbonization pathway assessment

› The techno-economic viability of several advanced strategies to achieve **net-zero emissions in steelmaking** was developed, starting from a representative plant baseline to a non-emitting factory in 2050.

KEY OUTCOMES

This work supported our industrial partner's strategic investment plan for decarbonizing plant operations.

› A simulation platform was developed to assess several potential configurations for **carbon negative kraft mills**.

KEY OUTCOMES

Ten new technologies and processes were added to a reference mill to propose several decarbonization roadmaps for eliminating fossil fuel use.

› A novel method and tools, combining the use of machine learning and commercial process simulators, were demonstrated to **accelerate material and process design**.

KEY OUTCOMES

First applications on CCUS and biofuel production technology and processes have shown promising results.

› Building on rigorous models and datasets, we are developing the National CCUS Assessment Framework to **assess the decarbonization potential of CCUS, its costs and the impact on policy decisions**.

KEY OUTCOMES

Our team is developing a high-performance optimization model – successfully validated on six U.S. DOE reference cases – for the cost-optimal design of CCUS value chains.

› An **Order of Merit multi-criteria methodology and tools** were introduced to help select the most GHG impactful uses of process electrification, biomass, and hydrogen in high-temperature processes.

Supporting policy

- Reports highlighting the **important opportunity for Canada to use biomass in industrial applications** were delivered to the Canadian Forest Service (CFS), Environment and Climate Change Canada (ECCC) and the NRCan Fuel sector.

KEY OUTCOMES

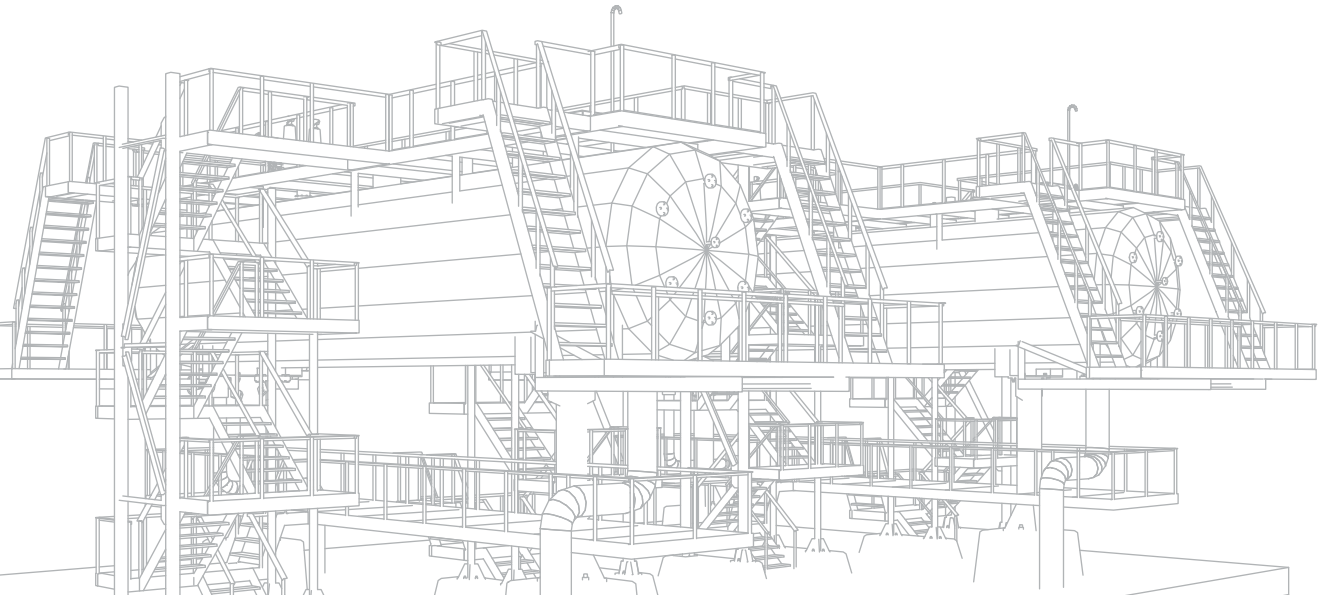
Our team showed that biomass use could offer a potential GHG reduction of 15 million tonnes of CO_2-eq emissions annually.

- Modeling work was performed to identify and estimate the GHG reduction potential of the most effective industrial electrification opportunities in Quebec.

KEY OUTCOMES

It was demonstrated that industry could increase its electricity demand by 45% all while reducing its GHG emissions by 75%. This would result in 30 TWh per year of additional electricity consumption in Quebec.

- Modelling and technical support was provided to NRCan's Fuel Sector to **estimate the future needs for hydrogen in Canada**. Support was also provided to the Government of Quebec in identifying a new list of criteria for supporting hydrogen-related projects.
- The literature review and synthesis of modelling-based net zero studies was strengthened to reemphasize BECCS and direct end-use electrification as the highest-merit decarbonization strategies for industry.
- In collaboration with the Institut national de la recherche scientifique (INRS), two Quebec Government departments and federal organizations, we organized the first workshop focused on the status and outlook of CCUS in Quebec.



Global outreach

We continue to play a **leadership role by supporting science, technology, and policy development** through numerous participations in expert committees and other consultation initiatives.

In Canada, we supported:

- CFS and ECCC departments with their **Clean Fuel Regulations** by evaluating the potential impact on the forestry sector.
- The Canadian Energy Regulator (CER) in providing **data and modeling hypotheses** for their new projections (Canada's Energy Future 2023: Energy Supply and Demand Projections to 2050).
- A workshop bringing together over 50 representatives from the Quebec forest industry. The event allowed to identify the needs and challenges of **developing and implementing digital solutions to reduce GHG emissions and increase productivity** of the forest sector.

Internationally, we are **co-chairing the executive committee** for the International Energy Agency's program on **Industrial Energy-Related Technologies and Systems**. We are also **leading two research tasks**, joined by over 50 experts from 12 different countries.

Buildings Division

Our Buildings Division conducts R&D activities and deploys cost-effective solutions and technologies aimed at decarbonizing buildings through energy efficiency and smart electrification strategies.

Selected highlights of the activities our team carried out include, but are not limited to:

Renewable heating and cooling systems for buildings

› **Cold climate air-source heat pump (ASHP) performance curves** were developed based on detailed performance testing of different cold climate ASHPs, and using manufacturer published test points.

KEY OUTCOMES

These performance curves fill in a gap since current performance curves need to be manually developed, and default performance curves for energy simulation do not reflect actual market data. The developed curves were used to develop an ASHP sizing guide and to identify optimal sizing strategies for Canadian residential buildings.

› A **low GWP refrigerant mixture** was identified and tested, yielding promising potential.

KEY OUTCOMES

This mixture could replace R410a in a cold climate ASHP while improving efficiency and heating capacity by 5 to 10%. Results are significant in that they allowed to identify a suitable mixture for the phase-out of R410a without diminishing heating performance – an important factor for the Canadian climate.

› **Construction and commissioning of a CO_2 heat pump with ejector test bench**

KEY OUTCOMES

With the test bench completed, simulation models will be validated and operation and control knowledge will be developed. CEV will be able to support Canadian equipment manufacturers in increasing their competitiveness by offering more efficient CO_2 systems.

› **Two patents granted for innovation in the field of ground source heat pump (GSHP) systems**

- Patent granted in the U.S.: "Multi-channel ground heat exchange unit and geothermal system"

KEY OUTCOMES

This innovation will facilitate the installation, improve performance, and reduce first cost of direct expansion GHSP systems using CO_2.

- Patent granted in Canada: "Jet pump apparatus and methods for standing column well systems and deployment thereof"

KEY OUTCOMES

This innovation will facilitate the installation of standing column well (SCW) systems, which are less capital intensive than conventional closed-loop geothermal systems, by reducing the number of boreholes required while providing stable savings over time. Additional benefits include the potential to integrate SCWs into buildings already constructed in dense urban areas.

› **Proof of concept for the CO_2 Thermal Network (CO2TN)**

KEY OUTCOMES

The patent pending CO2TN concept developed at CEV is expected to greatly improve the way thermal energy is used, recovered, and distributed in commercial and institutional buildings. This innovative technology comprises a single pipe that circulates two-phase CO_2 as a heat carrier fluid in a building, with heat pumps connected to the CO_2 loop to provide heating or cooling to the different zones of a building. Progress made by the means of a prototype test bench brings the CO2TN that much closer to technology transfer for commercialization.

› **Experimental work on a vertical ground thermosiphon test bench**

KEY OUTCOMES

The completion of experimental work demonstrated the potential of recovering ground heat extracted in a passive way (no electricity required) for space heating purposes. This application is particularly interesting for northern remote communities. Discussions with potential external partners for demonstration projects were initiated.

Optimal building operation

- **Data analytics methods** were used to analyze a heating plant's operational measurements and identify opportunities to **reduce natural gas usage for space heating**, at a large federal facility near Montreal, Quebec.

KEY OUTCOMES

Control strategies were developed to increase the usage of the electric boiler and minimize the usage of natural gas boilers, while maintaining occupant comfort. After implementing these strategies, results showed a significant 79% reduction in GHG emissions from the building's heating plant, with only a very modest increase (0.3%) of its total energy bill.

- **Predictive control strategies** were developed to **reduce natural gas consumption** at two federal district heating systems. These strategies use heating load forecasting models and data-driven boiler performance curves to achieve an optimal overall system efficiency that minimizes natural gas use while ensuring that the district thermal demand is met.

KEY OUTCOMES

Implementation results showed reductions of 3% in GHG emissions and annual savings of nearly $90K in energy costs.

- Strategies to **reduce the energy consumption of cooling systems** were implemented in a large commercial building in Montreal, Quebec. Solutions were developed to improve chiller sequencing, increase cold fresh air usage, and reduce energy use and dehumidification requirements.

KEY OUTCOMES

Preliminary results showed that the building's cooling load was reduced by 12%, while the cooling system's energy consumption decreased by 33%.

- Controls for **improving building energy flexibility** were developed and evaluated using a simulated community of 54 commercial buildings. These controls enable buildings to modulate their electric power demand according to the grid's needs.

KEY OUTCOMES

Results showed that the community would gain over $20,000 for a winter season if participating in Hydro-Québec's Demand Response program. GHG emissions would also be reduced by 13 tonnes of CO_2eq.

79%

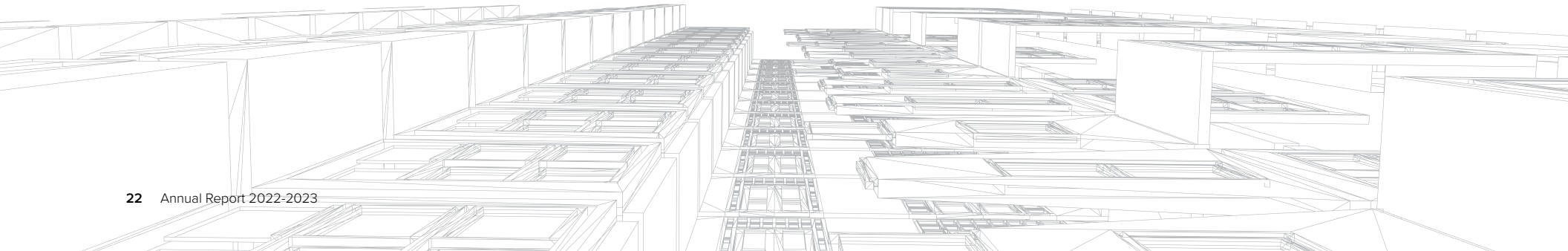
REDUCTION IN GHG EMISSIONS FROM A BUILDING'S HEATING PLANT AT A LARGE FEDERAL FACILITY

$90K

IN ANNUAL ENERGY COST SAVINGS THROUGH THE USE OF PREDICTIVE CONTROL STRATEGIES

33%

DECREASE IN ENERGY CONSUMPTION FOR A LARGE COMMERCIAL BUILDING'S COOLING SYSTEM



Energy systems for northern and remote infrastructures

› The NATO Science for Peace and Security project ended in May 2022. The project established a **harmonized methodology for NATO Nations** to follow ISO 50001 energy management practices in deployed force infrastructure. Tools were developed for engineers and camp planners to better understand and predict the power/energy requirements of deployed camps, in combination with energy metering training courses for project partners.

KEY OUTCOMES

A follow-on project proposal was developed to demonstrate how energy data and camp planning tools can lead to diesel reductions in deployed camps. Team members also helped develop a document to provide guidance for the main principles to design future NATO energy standards (known as Operational Energy Concept). The initiative is led by the NATO Energy Security Centre of Excellence.

› Several power and energy projects were undertaken to **reduce the reliance of diesel fuel for Arctic surveillance.** Energy audits were conducted of several long- and short-range radar sites of the North Warning System. The research project is in collaboration with Defence Research and Development Canada and National Research Council-Vancouver.

› Other research activities included the design of low power energy systems using direct methanol fuel cells for deployment and autonomous operation in the high Arctic with no reliance on diesel fuel. These research projects are in collaboration with Defence Research and Development Canada – Atlantic.

KEY OUTCOMES

Our team identified opportunities to modernize the sites and reduce diesel dependency through the use of solar photovoltaics, fuel cells, battery energy storage, and cogeneration.

› Continued support to the Department of National Defence Canadian Joint Operations Command was provided throughout the year for the energy management program.

KEY OUTCOMES

Two training courses on energy metering and camp planning tools were given to various Canadian Forces units across Canada. Efforts also focused on trialing variable speed diesel generators demonstrating close to 50% fuel savings versus conventional diesel generators for Canadian deployed camps. The findings helped provide recommendations for future procurements, while supporting the demonstration and proof of concept of this technology.

Greening government operations

CanmetENERGY in Varennes and the Office of Energy Efficiency (OEE) are mandated by the Treasury Board Secretariat's Centre for Greening Government to provide support to federal departments to help them **meet the GHG emission reduction targets set out in the Greening Government Strategy.** These support services are provided through the Greening Government Operations (GGO) program. Our Centre contributed to this program in several ways in 2022-23 by:

› **Developing and implementing tools and guides**, as well as supporting the implementation of existing building commissioning (EBCx) and ongoing commissioning (OCx) projects, in collaboration with the OEE, the Department of National Defence (DND), Public Services and Procurement Canada (PSPC), and Agriculture and Agri-Food Canada (AAFC).

› Exploring the possibility with Health Canada (HC) of **conducting simplified energy audits** using the RETScreen software.

› Collaborating to the **development of NRCan's Greening Strategy**.

› Leading discussions on the **use of high-temperature heat pump technology** in different contexts, be it for feasibility studies, demonstration projects, or retrofit projects especially in the case of heritage buildings.

› Providing **ad hoc or ongoing technical support to several departments**, such as the Treasury Board Secretariat (TBS) for the **development of policies and guidelines** related to the Greening Government Strategy, as well as the Canada Border Services Agency (CBSA) project team for a multi-regional **energy performance contract**.

RETScreen® Expert

RETScreen Division

The RETScreen Division develops and deploys the world-leading *RETScreen Clean Energy Management Software* platform, which enables low-carbon planning, implementation, monitoring and reporting for buildings, factories and power plants around the world.

The division undertakes several workstreams to advance NRCan's corporate mandate to ensure Canada's abundant natural resources are developed sustainably, competitively, and inclusively.

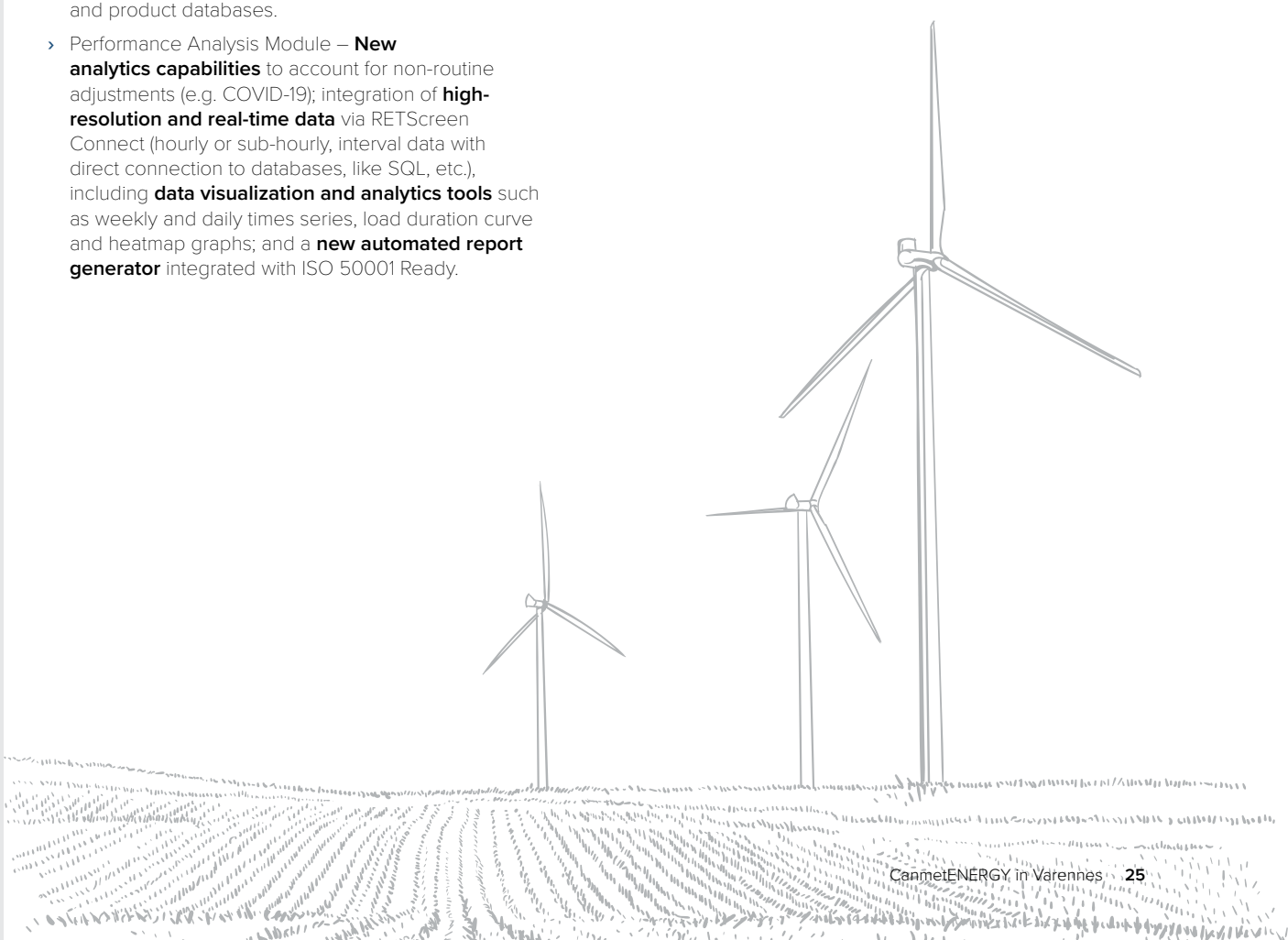
These workstreams include: *RETScreen Innovation Lab*, which collaborates with government and multilateral organizations to co-fund and develop advanced versions of the RETScreen software; *RETScreen Data Onboarding*, which delivers onboarding services on a cost-recovery basis, helping enterprise customers with their facility-level and portfolio-wide deployment of the platform; and *RETScreen Capacity Building*, which helps improve the knowledge, skills and capabilities of the 800,000+ energy, facility and sustainability professionals located around the world who use the RETScreen software.

Key highlights of the workstreams during the 2022-2023 fiscal year include, but are not limited to:

RETScreen Innovation Lab

Version 9.0 of the RETScreen Software was released. This updated version includes the following new features:

- Benchmark and Feasibility Analysis Modules – **30 deep emission reduction archetypes** incorporating AI; archetypes for water treatment and wastewater treatment plants; **a scaling tool** for archetypes – to actual facility size; a water efficiency project assessment tool; an EnergyPlus connector with **hourly simulation output results** linked directly into RETScreen; a new electricity and fuels rate database; and updated benchmark, cost, GHG emission factors and product databases.
- Performance Analysis Module – **New analytics capabilities** to account for non-routine adjustments (e.g. COVID-19); integration of **high-resolution and real-time data** via RETScreen Connect (hourly or sub-hourly, interval data with direct connection to databases, like SQL, etc.), including **data visualization and analytics tools** such as weekly and daily times series, load duration curve and heatmap graphs; and a **new automated report generator** integrated with ISO 50001 Ready.
- Portfolio Analysis and All Modules – **New automated portfolio creation and management tool** for portfolio-wide feasibility analysis, Measurement & Verification (M&V) and GHG reporting; Treasury Board Secretariat (TBS) – Life Cycle Cost Analysis (LCCA) example added to My portfolio; **various data analysis, visualization and comparison tool upgrades**; reprogrammed software to 64-bit environment – improves memory use and software performance; and a **38th language** added (Albanian).



RETScreen Data Onboarding

- The annual Government of Canada's Greenhouse Gas Emissions Inventory prepared by the Treasury Board Secretariat, with the support of the RETScreen Team in Varennes, uses the RETScreen Software to **report on the greenhouse gas emissions from federal facilities and conventional fleet operations** (Scope 1 & 2 emissions) and for air travel (Scope 3).
- Ongoing cost-recovery support to the Department of National Defence (DND) to implement and maintain a RETScreen portfolio, with **10,000+ military facilities.**
- Supported other cost-recovery customers to implement and maintain RETScreen portfolios:
  - Global Affairs Canada (GAC) – **300+ facilities** at foreign missions
  - Natural Resources Canada (NRCan) – **29 facilities**
  - Canadian Space Agency (CSA) – **15 facilities**
- Provided ongoing technical support to numerous energy, facility and sustainability managers at public and private sector enterprises, who use RETScreen for **portfolio-wide energy and GHG management for thousands of facilities** located across Canada and around the world.

RETScreen Capacity Building

- Organized the virtual ***RETScreen World Conference*** in collaboration with Energy Manager Canada, with more than 800+ participants attending from across Canada and from many other countries around the globe.
- Launched the inaugural ***NASA POWER / RETScreen Recognition of Excellence Awards*** in collaboration with the National Aeronautics and Space Administration (NASA) at the NASA POWER Global Community Summit.
- Undertook **outreach activity efforts with various key stakeholders** to encourage a continued software download rate at 40,000+/year and to further build the capacity of the 800,000+ RETScreen users across Canada and around the world.
- Coordinated **activities with the RETScreen trainers' network**, including developing and supporting the English, French and Spanish versions of "**Introduction to Energy Management Powered by RETScreen**" – a **massive online open course** (MOOC) provided by HEC Montréal.
- Provided in-depth technical support to subscribing customers and engaged high value potential customers on an ongoing basis to ensure the **continuous capacity building of key users**.
- Supported Infrastructure Canada's (INFC) $1.5B Green and Inclusive Community Buildings (GICB) Program to **review numerous funding applications** submitted to GICB via the RETScreen Software.
- Targeted outreach activities including regular email bulletins sent to **150,000+ newsletter subscribers** and completed **several new training videos**.

800+
PARTICIPANTS ATTENDING THE VIRTUAL *RETSCREEN WORLD CONFERENCE*

40,000+
CONTINUED SOFTWARE DOWNLOAD RATE, PER YEAR

800,000+
RETSCREEN USERS ACROSS CANADA AND AROUND THE WORLD

CEV Innovation: Two Success Stories

Forest Value Chain Optimization (FVCO)

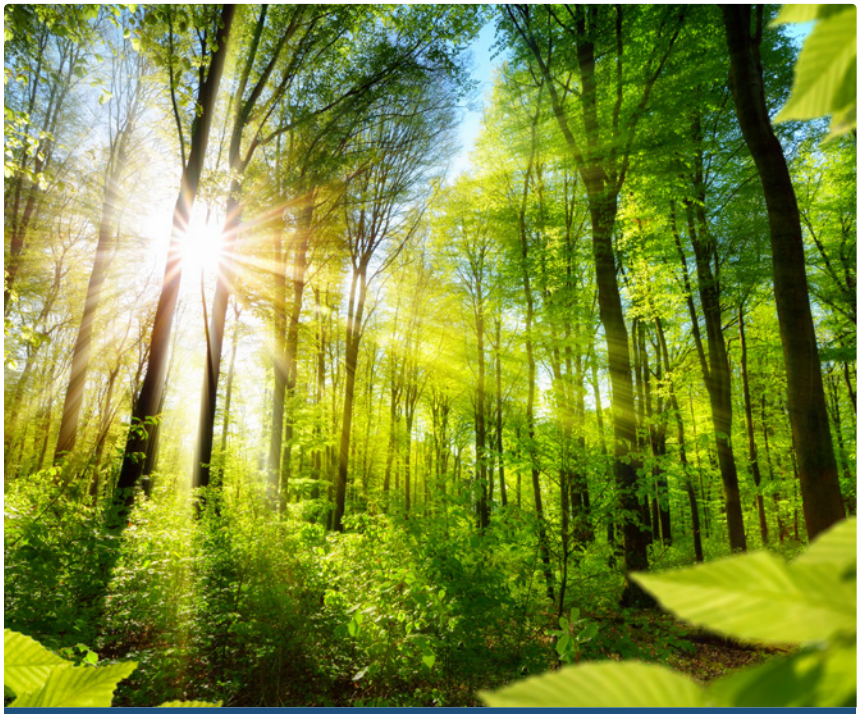
Recognizing the strong coupling between the energy, forestry and digital sectors, the Canadian Forest Service (CFS) and CanmetENERGY in Varennes are advancing a collaborative research initiative to develop a forest information ecosystem as well as a decision support platform – integrating big data and AI tools – to optimize energy/GHG performance and value chains. More specifically, this **Digital FVCO Initiative** strives to:

Enable:

- The enhanced use of resources and data along the value chain
- The valorization of forest biomass volumes
- An accelerated evaluation and integration of production opportunities for new bioproducts along the value chain
- The optimization of asset performance
- The enhanced scheduling and forecasts of demand and production

Through:

- Increased access and use of quality data and information
- Demonstration projects generating quick wins relevant to diverse stakeholders
- The development of high-fidelity models (digital twins) of equipment, units and supply chains
- The development of roadmaps for the deployment of digital tools and open digital platforms



Key steps taken to date:

- NRCan Forest Biorefining and NB Provincial workshops to establish the vision and key priorities
- Deployment of a NB testbed with proof-of-concept case studies
- Establishing cross-sectoral NRCan coordination

HP Simulation-Based Analysis

Heat pumps are essential to drive the decarbonization of the Canadian residential sector. However, their impact on energy use, GHG emissions, and utility and total system costs depends on regional parameters like climate and local utility rates and structures. Over the last year, a team at our Centre has used a simulation-based approach to better understand the implications of transitioning from common heating energy sources (natural gas, electricity, oil) to air-source heat pumps across Canada.

This analysis framework can be used to evaluate the steadily evolving landscape for air-source heat pumps across Canada. Results provide a snapshot of current energy, emissions, and cost implications, and how these may be influenced in the future under various policy and market scenarios (e.g. incentives, evolution of carbon tax, changes in system costs).

Key steps taken to date:

- Developed a flexible framework to evaluate the emissions, energy, and economic implications of air-source heat pumps in Canadian housing
- Assessed the emissions, energy, and economic implications of transitioning to air-source heat pumps from electric, natural gas, and oil heating (under 2022 economic parameters)
- Evaluated the sensitivity of system economics to changes in carbon pricing

Some of Our Collaborators

Visit our YouTube channel

Clean Energy | Research | Innovation | Leadership