

Energy for the Common Good



UNIVERSITY OF
CALGARY

Energy Research
Strategy **2023**

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Over the past 40+ years, UCalgary has been a global leader in energy research and energy technology development. This stems from its early research in petroleum including heavy oil and bitumen oil sands reservoirs, reservoir characterization and simulation, oil recovery process design, oil and gas properties, process modelling, natural gas, and more recently, energy history, energy politics and policy, energy in society, hydrogen, hydraulic fracturing, and extraction from tight rock.

UCalgary's central vision is to enable and support safe, clean, secure, socially responsible, and affordable energy supplies for the world.

By approximately 2040, it is anticipated that the global population will grow by an additional 1.4 billion people and that electricity generation will grow by over 50% from current levels. Moreover, energy transition will change the sources of energy that people and businesses use.

Although today, much (~61%) of this electrical energy is produced from fossil fuel, petroleum will still be an important contributor to human activities in the form of not only energy but also petrochemicals and chemical feedstocks. However, energy sources will evolve. Meeting this demand is a daunting problem if future generations are to enjoy sustained prosperity with minimal environmental impacts, including significant reductions in carbon emissions.

UCalgary has grown major energy-focused research initiatives over the past 20 years. These include nanotechnology in the petroleum industry, electrochemical engineering (R&D in batteries, fuel cells, water treatment, solar cell technology), and natural resources, energy and environmental law.

New and urgent energy and economic challenges confront us — epitomized by the conflation of issues posed by climate change, the aftermath of the COVID-19 pandemic, rising energy prices, inflation,

renewed energy security concerns, the desire for low greenhouse gas emissive energy. Responding to these will require resolute public and private effort and massive financial flows.

Addressing the array of research questions posed by these challenges requires an open, imaginative, and comprehensive approach drawing on multiple disciplines across the university. This transdisciplinarity defines the institution's new *Energy Research Strategy — Energy for the Common Good*. It builds on our historic successes and expands research and training activities to promote collaboration across the campus with a focus on ensuring sustainable, climate-appropriate, secure and affordable energy services for society.

Moving beyond “comfortable”, traditional interdisciplinary research within the silos of the national research funding councils, we shall reach outside the campus community to engage more systematically with the public and targeted stakeholders. Through a transdisciplinary focus on challenges rather than discrete disciplines, the academy will grow its capacity and impact — whether on scientific, technical and business innovations, public policy, or understanding how different communities view and are affected by the evolving energy system. »



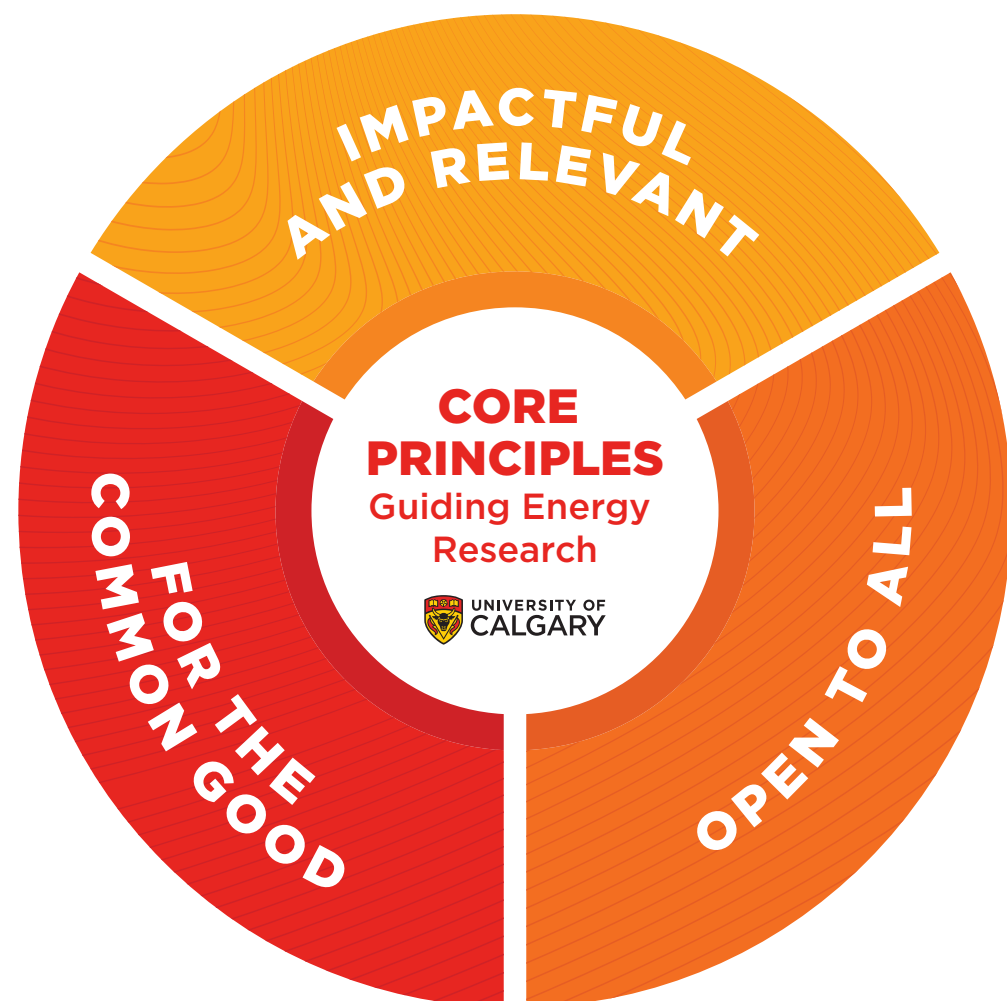
In 2013, our first Energy Research Strategy, *Energy Innovations for Today and Tomorrow (EITT)*, was created to foster an interdisciplinary culture within cross-cutting research themes to address key energy and environmental challenges.

A critical goal of creating the strategy was to focus on areas of research strength at UCalgary to deliver significant impact, not only in academia but also in our communities. The strategy consequently led to many major accomplishments and raised both the national and international profile of energy research at UCalgary.

Motivation: Launching a New Era of Energy Research

The world faces the existential threat of climate change while ensuring safe, reliable and affordable energy supplies. This presents a complex array of technological, economic, social, and political challenges. It will require fundamental changes in how society exploits, transforms and uses energy resources to meet its energy needs. The aggressive, substantial reduction of the emissions intensity of our energy system underpins the need for a new era of energy research at UCalgary.

The shift to new energy systems requires the combined use of novel materials, processes, and resources (e.g. water, land, people, capital), which pose their own set of environmental, social, policy, and economic issues. This energy transition, which is among the largest and most daunting challenges facing humanity, is also a multi-trillion dollar opportunity.



IMPACTFUL AND RELEVANT

Our strategy,

- ▶ Supports novel and original research that employs the latest methods, concepts and collaborative practices on campus, within Alberta, across Canada and beyond.
- ▶ Inspires high risk research, with potential high rewards — with outcomes that improve lives.
- ▶ Encourages research that questions existing paradigms, to change scholarly and societal thinking about energy and its challenges. For example critically engage with concepts and the various ways that society constructs and imagines energy systems and challenges.
- ▶ Welcomes both applied and fundamental research.
- ▶ Emboldens UCalgary researchers to think beyond their disciplinary areas to embrace transdisciplinary research.
- ▶ Integrates knowledge and methods from all relevant disciplines, sectors and domains.
- ▶ Fosters novel research frameworks beyond traditional disciplinary perspectives with transformative impact on existing paradigms and practices.
- ▶ Promotes nimbleness acknowledging that high-risk research may fail and that we will adapt and change direction. Not all research projects have the same time horizon.

While we focus on grand challenges, they do not constrain our research. Given the manifestly dynamic nature of the energy system and its governing policies, we will adapt and evolve our research.



OPEN TO ALL

Energy research at UCalgary is open to all our scholars, creating a vibrant research community and a welcoming intellectual home for all disciplines to contribute and influence ideas.

This strategy eschews inter-disciplinary boundaries. A standing, open invitation to participate is foundational to our energy research strategy. Scholars will be able to find or carve a place for themselves and their research within this strategy. They have equal access to a supportive and rewarding research environment and equal opportunity to pursue their energy research in an inclusive environment to test ideas, share insights, embrace new engagements and forge new partnerships.

Our energy research strategy explicitly promotes an inclusive research environment that is equitable and accepts diverse and divergent views on “energy” and its place in research, the academy, society, politics, policy, and the economy.



FOR THE COMMON GOOD

Energy research at UCalgary will enable impactful outcomes for the common good.

Working with communities, our research seeks discoveries, innovations and new insights that can improve societal wellbeing. It aims to have technical impacts, and inform public policies, discussions and practices, whether they are corporate, community-based, or government-led. Questioning past and present practices, our research will provide policy solutions for the near, medium and long-term and offer bold solutions to pressing problems to benefit society.

2

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Responding to Local, Provincial, National, and Global Goals

Energy research at UCalgary will be responsive to local, Indigenous, provincial, national, and international energy and environmental goals. Our research drives the discoveries and insights which will improve Alberta's prospects for a more diverse, resilient and sustainable economy while creating high quality employment opportunities within our communities.

How our energy research aligns with provincial, Indigenous, national, and international priorities:



Provincially

Research will support reducing GHG emissions and other environmental impacts, boost economic diversification and advance cleantech.

Indigenous

Research will support sustainable energy options for Indigenous and/or remote communities consistent with self-determination, self-sufficiency, autonomy, and economic and political sovereignty.

Nationally

Research will seek solutions and breakthroughs to help meet national GHG emissions targets and net zero goals.

Internationally

Research will align with the energy and environment-related United Nations Sustainable Development Goals (SDGs).



Equity, diversity, and inclusion (EDI) will be embedded at all stages of the research.

Ingraining Equity, Diversity, and Inclusion in Energy Research

It is critical that EDI is taken into account in formulating research questions, solutions are generalizable and outcomes benefit diverse segments of society. Research will be designed and interpreted in the context of all potential end-use communities (including marginalized groups).

The deliberate inclusion of EDI prerequisites, along with the recruiting of diverse perspectives in energy research, will help identify energy solutions that address differences and eliminate disparities amongst communities in Canada.

Building on our strengths and momentum.

UCalgary is a leader nationally and internationally in energy research, engagement, and technological development. Consequently, we have established significant critical mass in many facets of energy research. With several hundred researchers engaged in various aspects of energy research, we can claim to be Canada's energy research hub. Noteworthy, and building on our first Energy Strategy (EITT), we were successful in gaining a Canada Excellence Research Chair (CERC) in Materials Engineering for Unconventional Oil Reservoirs, and a Canada Research Chair in the History of Energy.

EITT's research focus strongly resonated with the federal government's Science, Technology and Innovation strategic goals, helped the university secure a major grant from the Canada First Research Excellence Fund — the largest research grant in the institution's history, thereby creating the university's Global Research Initiative (GRI). Other examples of achievements and recognized energy research capacity are listed to the right.

We endeavor to build on this momentum to continue to attract and retain the best and brightest talent to build new and diverse capacity including post-graduates with the tools to respond to and lead a rapidly evolving energy sector, while meeting associated societal and technological challenges.



The 2020 University of Calgary Global Research Initiative — Highly Qualified Personnel publication.

Current Energy Research at University of Calgary

Global Research Initiative
(a Calgary \$75M CFREF program)

Canada Excellence Research Chair

Tri-Council funded energy
research and training projects

Industrial Chairs

Endowed Chairs

CRC Tier I and II Chairs

Calgary Institute for the Humanities
(Energy In Society)

The School of Public Policy's Energy and
Environmental Policy Research Division

Center for Corporate Sustainability

The School of Public Policy's
Extractive Resource Governance Program

Natural Resources, Energy &
Environmental Law group

Canadian Institute of Resources Law

Arctic Institute of North America

Environmental Media Lab

Renewable Energy Education

Canadian Energy Systems Analysis
Research (CESAR) Initiative

Multiple degree programs

Spin-off companies

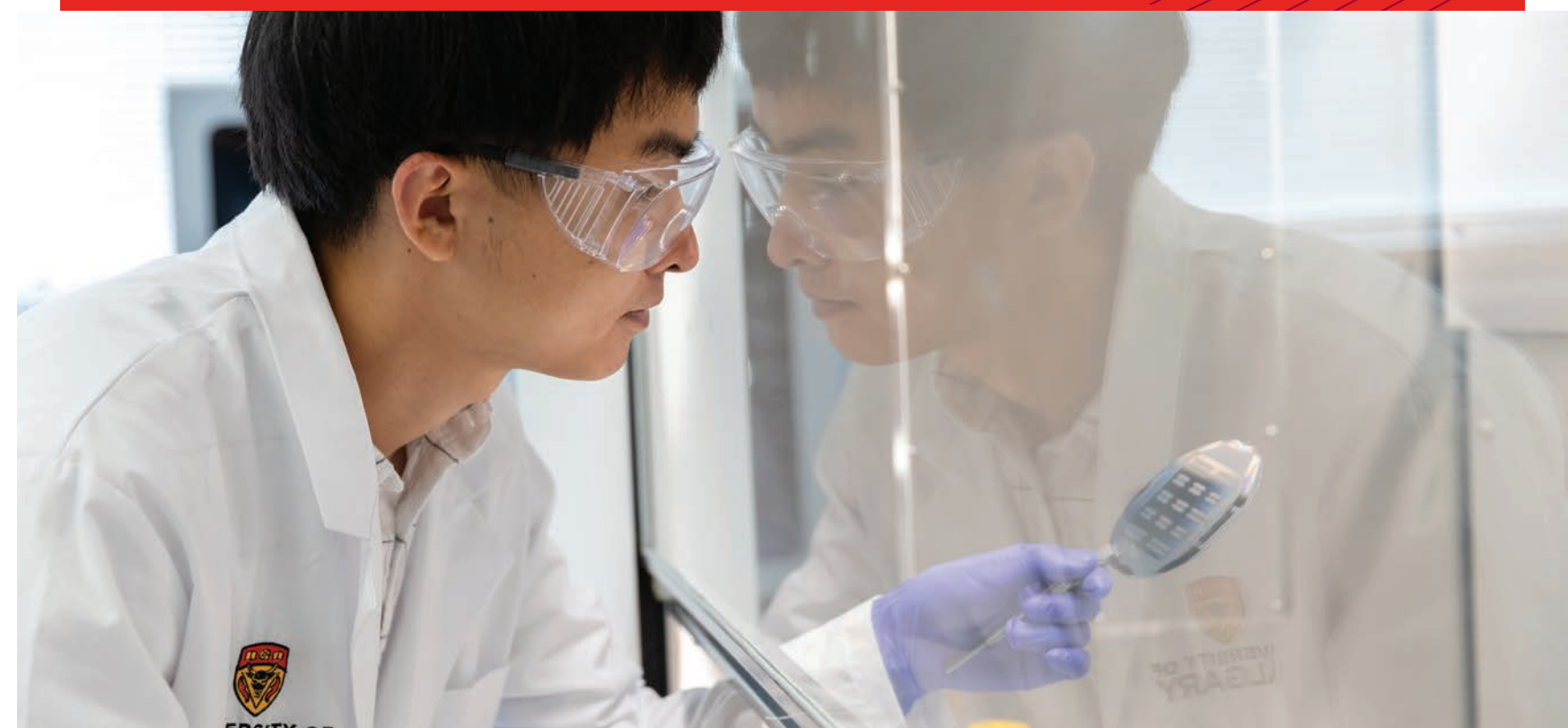
Our graduates in energy companies
and government

A Focus on Transdisciplinary Research

The energy challenges that society faces are driven by a set of three principal forces: economic, political/societal and technological.



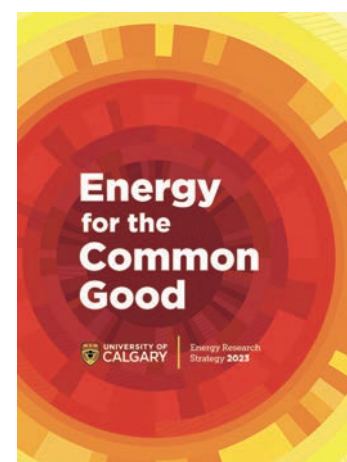
Energy researchers should feel inspired and eager to establish collaborative research with other faculties across campus, with this coalescence of disciplines being a voluntary, and spontaneous process.



Our strategy supports and motivates new collaborations across disciplines. Transdisciplinary research integrates knowledge and methods from all relevant disciplines, sectors, and domains. Focus is on the research challenge, not the discipline. It enables the creation of novel research frameworks beyond traditional disciplinary perspectives and boundaries. As a result, it can have a transformative impact on existing paradigms and practices.

To be effective, our research strategy requires flexibility, subject to changes of direction and emphasis. It is not a plan; rather it is the creation of a research environment. Therefore, we will continuously monitor, measure and evaluate transdisciplinary research and its outcomes to ensure the strategy is nimble, adaptive to societal needs, and delivers quality research outcomes.

Grand Challenges and Projects



↓
**No boundaries,
 no circles,
 no silos**
 ↓
**Teams
 focus on
 challenges**
 ↓
**Growth
 through focus**
 ↓
**Solutions
 for society**

Our first Energy Strategy was framed around selected research themes and Grand Challenges; our new strategy adopts a different approach.

New Grand Challenges will derive from the academy, and will evolve over time. As such, some will expand, some will emerge, and others will be answered. As reflected in the figure to the left, there is no shortage of potential research ideas and challenges in the energy/climate sphere. The setting of Grand Challenges in this strategy will be both proactive and responsive to society's needs. Examples of Grand Challenges include:

Hydrogen Systems and Economy
(Generation, Storage, and Transport)

Carbon-neutral or Carbon-negative Oil and Gas

Transportation

Achieving Net Zero GHG Emissions in a
Democratic Society

Business and Economic Implications of
Energy Transition

Global Carbon Economy (Carbon Dioxide Removal)

Clean Energy for Remote Communities

Nuclear

Grand Challenges can only be comprehensively addressed through a transdisciplinary approach.

Transdisciplinarity at its essence does not obviate individual researchers from pursuing their own research ideas. »



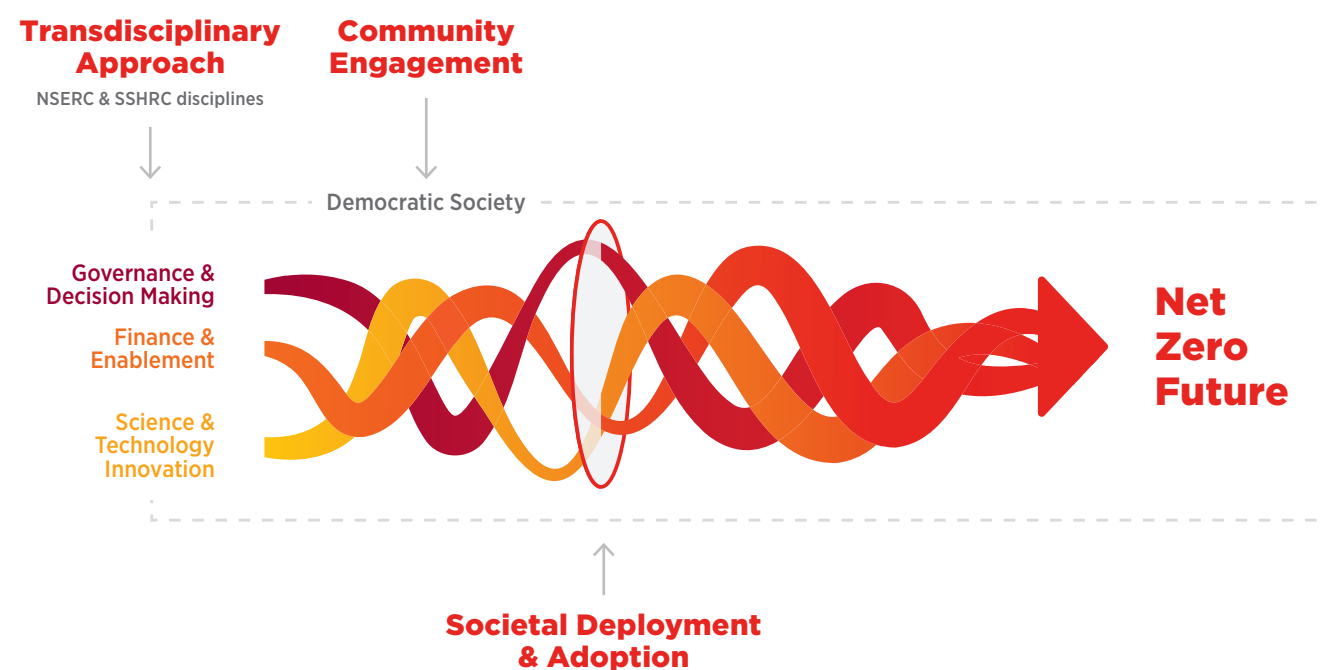
Decarbonization and Transition towards a Low-Carbon Economy »



GRAND CHALLENGE EXAMPLE 1

Social paradigms of achieving net zero GHG emissions

- ▶ This transdisciplinary challenge focuses on the human condition of energy transitions.
- ▶ It will research, devise, test, and apply the best ways for multiple sectors of society to engage as active participants — and even proponents and creators — in finding integrated social and technological solutions to achieving net zero greenhouse gas (GHG) emissions.
- ▶ Structured along three core, inter-twined knowledge areas, which are embedded in society, the project acknowledges that in a democratic society, technology build-out needs to have societal buy-in and requires participatory approaches.



GRAND CHALLENGE EXAMPLE 2

Hydrogen Systems and Economy

- ▶ Hydrogen fueled the first internal combustion engines over 100 years ago. Recent enthusiasm for hydrogen comes from diverse groups — governments, investors, ENGOs and several industrial sectors — and aimed at a variety of potential applications including transport, applications in refining and chemicals, iron and steel, fertilizer production, heating of buildings and energy storage as a complement to interruptible electricity from renewables.
- ▶ The central proposition is that hydrogen can play a significant role in reducing or eliminating emissions from energy and chemical value chains.
- ▶ Building on a conceptualized Hydrogen Hub, UCalgary will launch a transdisciplinary research project to critically examine candidate value chains for hydrogen, from production to end-use, and the myriad attendant social, scientific, legal/regulatory, commercial, financial and engineering questions posed by a shift to a hydrogen economy, at local, provincial, national or international scales.



GRAND CHALLENGE EXAMPLE 3

Transport Emissions Reduction

- ▶ The transport sector is responsible for a major and growing share of Canada's GHG emissions. Together with oil and gas, it accounted for 50% of total emissions in 2020.
- ▶ Achieving significant reductions in the sector's emissions poses major political, economic, technological and social challenges. These pose important research questions for disciplines such as engineering, economics, law, political science, history, geography, business and policy studies.



GRAND CHALLENGE EXAMPLE 4

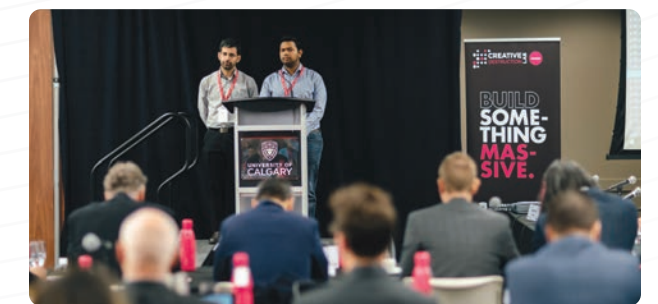
Business and Economic Implications of Energy Transition

- ▶ While an energy transition and adaptation to a low-carbon economy is the largest and most complex economic, political, technical and social challenge we face, it is also a multi-trillion dollar opportunity that we cannot afford to miss.
- ▶ The economic implications of energy transition are immense. They are already challenging financial institutions such as central banks, influencing business models, disrupting conventional approaches to commerce and with the dramatic increase in environment, social and governance compliance, profoundly influencing capital flows. Thus, the challenge is truly trans-disciplinary.

A successful and just energy transition, while drastically reducing GHG emissions, must also create economic prosperity and societal well-being — difficult to achieve simultaneously.



Engagement



Engagement with the UCalgary community at-large is necessary to gain the required input and collaboration needed for this strategy to succeed.

Internally, partnerships are fostered within and across many entrepreneurial initiatives/areas, including faculties, research groups, individual researchers, the Creative Destruction Lab — Rockies, the Hunter Hub, Innovate Calgary, UCEED, GRINStem, and others.

These partnerships, combined with transdisciplinary graduate and undergraduate training (together with the Faculty of Graduate Studies, Post-doctoral Office, and the Taylor Institute for Teaching and Learning), further enhance creativity and innovation in energy research efforts. Through liaising with the Office of Equity, Diversity, and Inclusion (EDI), the Office of Indigenous Engagement, and University of Calgary International, energy research will uphold EDI principles and incorporate both UCalgary Indigenous (*i' taa'poh'to'p*) and internationalization strategies.

Society and our communities, with their incredible diversity, are the ultimate end-users of our energy research and thus, it is critical that EDI is ingrained within research questions and solutions to ensure that our results have the breadth, depth and level of inclusivity needed to ensure that all segments of society benefit from the outcomes of this research program.

Moreover, this research will also endeavor to include engagement and consultation with various external stakeholders, including funding agencies (provincial, federal, and international), industry and business, government ministries and regulatory agencies, and communities — the public.

Anticipated Outcomes



UCalgary is a global leader in energy research and is now moving boldly to expand its impact with focus on new insights, societal buy-in of system changes, the accelerated development of technologies, more rapid streamlined field-scale testing, and the deployment of solutions that benefit all stakeholders.

The outcomes from this strategy follow from our core principles:



IMPACTFUL AND RELEVANT

1. UCalgary established as the Energy Research Hub in Canada
2. Solutions deployed to end-users (spin-offs, technologies, policies, regulatory guidance, financial structures, ...)
3. New major initiatives, retention and recruitment of leading researchers, and vibrancy of the UCalgary Energy Research Ecosystem



OPEN TO ALL

1. Transdisciplinary energy research is the norm not the exception
2. Inclusive yet diverse energy dialogue spanning the entire academy
3. A vibrant and exciting research and training environment — preparing students to be 'transition leaders'
4. UCalgary — the place where new energy researchers want to work



FOR THE COMMON GOOD

1. Energy research for and with the public
2. Solutions in public use with benefits realized
3. New community partnerships — NGOs, municipal, provincial, national, international

As part of this new Energy Research Strategy, we will monitor and measure our success. Given the rapidly evolving energy sector both in Canada and globally, we will also **re-visit this strategy every two years** to adapt it to new challenges and opportunities. •

The University of Calgary would like to thank those who contributed to the Energy Research Strategy 2023:

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To all of the **University of Calgary researchers** who have contributed to this publication — thank you for your continued dedication and commitment to research excellence. The impact of your work is laying the foundation for a clean energy future that will benefit the environment, industry, and generations to come.

Territorial Acknowledgements

The University of Calgary, located in the heart of Southern Alberta, both acknowledges and pays tribute to the traditional territories of the peoples of Treaty 7, which include the Blackfoot Confederacy (comprised of the Siksika, the Piikani, and the Kainai First Nations) as well as the Tsuut’ina First Nation, and the Stoney Nakoda (including Chiniki, Bearspaw, and Wesley First Nations). The University of Calgary is situated on land adjacent to where the Bow River meets the Elbow River, and notes that the traditional Blackfoot name of this place is “Moh’kins’tsis”, which we now call the City of Calgary.

The university recognizes that the City of Calgary is also home to Region III of the Métis Nation of Alberta. By virtue of the signing of Treaty 7 in 1877, the university recognizes that we are all treaty people. The City of Calgary is home to a culturally diverse community.

Together, we share this land, strive to live together, learn together, walk together, and grow together “in a good way.”

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something.**

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