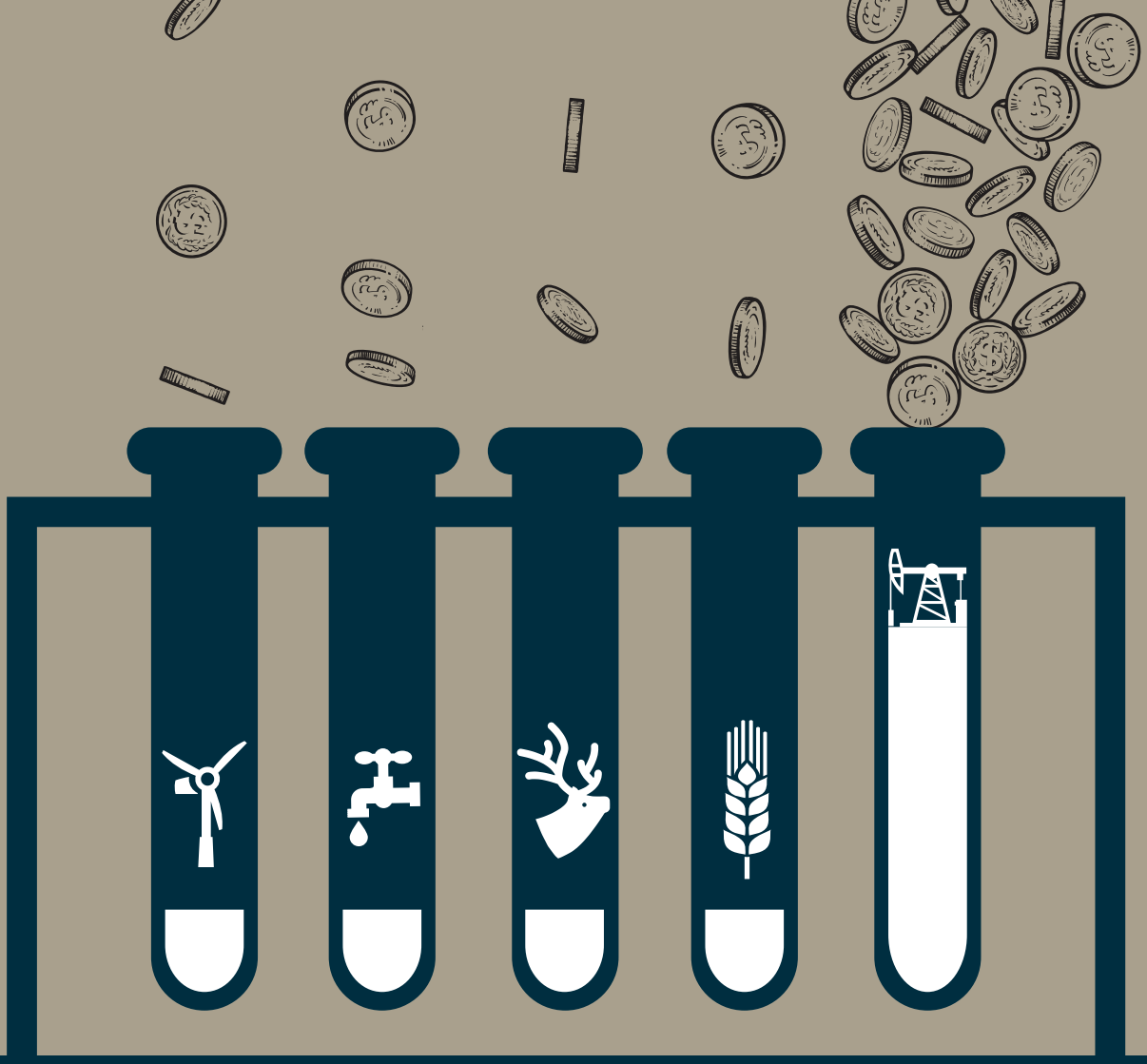

Knowledge for an Ecologically Sustainable Future?

Innovation Policy and Alberta Universities

PARKLAND INSTITUTE

CORPORATE MAPPING PROJECT

Laurie Adkin, with Laura Cabral

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Social Sciences and Humanities Research Council of Canada
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For more information, visit **www.corporatemapping.ca.**

List of Acronyms

ABMI	Alberta Biodiversity Monitoring Institute
ACR	Alberta Chamber of Resources
AEC	Alberta Enterprise Corporation
AERI	Alberta Energy Research Institute
AI	Alberta Innovates
AI-EES	Alberta Innovates—Energy and Environment Solutions
AIF	Alberta Ingenuity Fund
AI-TF	Alberta Innovates—Technology Futures
ALES	Faculty of Agriculture, Life and Environmental Sciences (UAlberta)
AMFI	Alberta Manufacturing and Fabrication Innovation
AOSTRA	Alberta Oil Sands Technology Research Authority
ARC	Alberta Research Council
ASRA	Alberta Scientific Research Authority
ASRIP	Alberta Science and Research Investments Program
AWRI	Alberta Water Research Institute
BCN	Biorefining Conversions Network
CABREE	Centre for Applied Business Research in Energy and the Environment (UAlberta)
CESAR	Canadian Energy Systems Analysis Research Initiative (UCalgary)
CAESR	Calgary Advanced Energy Storage and Conversion Research Technology Group
CAODC	Canadian Association of Oilwell Drilling Contractors
CAIP	Campus Alberta Innovation Program
CANMET	Canada Centre for Mineral and Energy Technology
C5MPT	Canadian Centre for Clean Coal/Carbon and Mineral Processing Technologies
CAPP	Canadian Association of Petroleum Producers
CARI	comprehensive academic research institution
CAUT	Canadian Association of University Teachers
CCEMC	Climate Change Emissions Management Corporation (Alberta)
CCPC	Canadian Clean Power Coalition
CCS	carbon capture and sequestration (or storage)
CEOS	Centre for Earth Observation Sciences
CEPA	Canadian Energy Pipeline Association
CERC	Canada Excellence Research Chair
CFI	Canada Foundation for Innovation
CFREF	Canada First Research Excellence Fund
CHORUS	Consortium for Heavy Oil Research
CH4	Methane

CIHR	Canadian Institutes for Health Research
CMC	Carbon Management Canada
CMIRO	Canadian Mining Industry Research Organization
CONRAD	Canadian Oil Sands Network for Research and Development
COSIA	Canada's Oil Sands Industry Alliance
CO2	carbon dioxide
CO2e	carbon dioxide equivalent
CPTC	Canadian Pipeline Technology Collaborative
CRC	Canada Research Chair
CREWS	Consortium for Research in Elastic Wave Exploration Seismology (UCalgary)
CSEE	Canada School for Energy and the Environment
EDT	Economic Development and Trade (Alberta Ministry of)
EG-COIN	Energy Geoscience and Geo-engineering Collaborative Open Innovation Network
EIF	Energy Innovation Fund (Alberta)
EIN	Energy Information Network (AERI)
EOR	enhanced oil recovery
ERA	Emissions Reduction Alberta (the rebranded CCEMC)
FESRI	Future Energy Systems Research Initiative (UAlberta)
FFR	fossil-fuels-related
FRIAA	Forest Resources Improvement Association of Alberta
GHG	greenhouse gas
GHGM	greenhouse gas mitigation
GRI	Global Research Initiative in Unconventional Hydrocarbon Resources (UCalgary)
HFII	Hydraulic Fracturing Innovation Initiative (UCalgary)
ICT	information and communication technology
IETP	Innovative Energy Technologies Program (Alberta)
IIPP	Intellectual Infrastructure Partnership Program (Alberta)
IOSSET	Innovation of Oil Sands: Social, Economic, and Technology (UCalgary)
IRC	Industrial Research Chair
ISEEE	Institute for Sustainable Energy, Environment and Economy
MARIOS	Materials and Reliability in Oil Sands
MIC	Microseismicity Industry Consortium
MMA	Mixedwood Management Association
NAICS	North American Industry Classification System
NAIT	Northern Alberta Institute of Technology
NDP	New Democratic Party
NEB	National Energy Board
NGO	non-governmental organization
NRC	National Research Council of Canada

NRCan	Natural Resources Canada (federal department)
NSERC	Natural Sciences and Engineering Research Council of Canada
N2O	Nitrous Oxide
OSRIN	Oil Sands Research and Information Network (UAlberta)
OSTRF	Oil Sands Tailings Research Facility (UAlberta)
PPRIC	Pulp and Paper Research Institute of Canada
PRI	Petroleum Recovery Institute
PSAC	Petroleum Services Association of Canada
PTAC	Petroleum Technology Alliance of Canada
R&D	research and development (of technologies, products)
RCP	Research Capacity Program (Alberta)
REE	Research Excellence Envelope (Alberta)
REM	remediation (environmental)
RSRG	Reservoir Simulation Research Group (UCalgary)
SAGD	steam-assisted gravity drainage (method of bitumen extraction)
SAIT	Southern Alberta Institute of Technology
SGER	Specified Gas Emitters Regulation
SSHRC	Social Sciences and Humanities Research Council of Canada
StatsCan	Statistics Canada
TOC	Tight Oil Consortium (UCalgary)
UAlberta	University of Alberta
UCalgary	University of Calgary
UCDN	Upgrading Catalyst Development Network
ULethbridge	University of Lethbridge
URSI	University Research and Strategic Investments Branch (Government of Alberta)

Executive Summary

As scientists and Indigenous elders have been telling us for decades, life on this planet as it has evolved over millions of years is on the brink of a precipice. Planetary ecosystems are threatened with collapse by the pressures of humans' appropriation of nature and their production of wastes, pollutants, and greenhouse gases. The urgency of making a rapid transition from economies based on fossil fuels and ever-growing consumption to net-zero-carbon economies that leave room for thriving biodiversity and make possible cultural diversity and secure, meaningful lives for Earth's human inhabitants simply cannot be overstated. If ever there were a time for universities to assume a leadership role in providing the knowledge needed for socio-ecological change, this is surely that moment.

Alberta has entrenched political, institutional, and cultural obstacles that must be overcome to achieve a transition to an ecologically sustainable and socially just way of living together. At the same time, Alberta is also one of the world's hopes for food production in the climate of the future, and for the preservation of spaces for remaining wildlife. We have exceptional opportunities for generating renewable energy, and for developing the technologies and materials the world needs to live sustainably. The Indigenous peoples that have lived on these lands for millennia have much to teach settler cultures about the relationships of kinship and respect for limits that are foundational to ecologically sustainable societies. Our universities have enormous capacities, drawn from all corners, to contribute to ecological and social sustainability in all their dimensions—both in Alberta and globally. The solutions lie not only in technologies, or in the infrastructures needed to scale these up quickly, but in institutional and cultural changes. We need to bring to bear all our diverse knowledges and experiences to make this shift—and we need to do it quickly. These are the possibilities that give hope and inspiration to our young people, and that many university researchers are committed to realizing.

All universities have leadership roles to play in this great transition. Alberta's universities are situated in a jurisdiction that has been for decades highly reliant for revenue and employment on the extraction of the fossil fuels that are forcing climate destabilization. Our universities helped to develop the technologies that made exploitation of the oil sands possible, but we have known for decades that greenhouse emissions from the combustion of fossil fuels are driving climate change. We have also known that oil and gas exploitation in the province has cumulative environmental and social costs—above all, for Indigenous communities whose traditional territories have been devastated by the expansion of the extractive industries. How, then, has knowledge production in Alberta's universities been responding, over time, to the growing recognition of the need to create a decolonizing, post-carbon path of development?

There are many ways of answering this question, such as tracing the evolution of curriculum and degree programs, making an environmental audit of university investment portfolios, or measuring efforts to reduce the environmental footprints of buildings and utilities used. In this report, we examine the type of *knowledge production* that has been prioritized within the universities by researchers and administrators, as well as by the agencies that fund research and technology development (R&D). We evaluate these types of knowledge production in relation to fossil-fuel or post-carbon paths of development. Research and development may serve to deepen our "carbon lock-in" by finding new reservoirs of fossil fuels or developing new technologies for their extraction. Even the research that aims to reduce the costs of production or transportation of fossil fuels or to remediate the environmental harms of carbon extraction may be used to prolong our reliance on these fuels while reassuring us that these are "clean" or "sustainable" sources of energy. In contrast, research that seeks to develop low-carbon, renewable sources of energy, environmentally sustainable substitutes for harmful chemicals and materials, planning and building designs for cities with net-zero-carbon footprints, sustainable agriculture, water conservation, green jobs, new forms of ecological governance, and a host of other needed technologies and reforms, puts us on a different path—a path of ecological and social sustainability.

One way to find out what kind of research is being done in our universities in relation to energy transition, climate change, sustainable agriculture, and related environmental areas, would be to send out a survey to all the continuing academic staff and ask them to report. Assuming that we received an excellent response and had the resources to analyze and code thousands of reports, this method could give us a very good picture of the terrain of current research. Even if feasible, his method would, however, give us a snapshot only of current research activity. We wanted to see if there have been any significant *changes in direction* over a longer time period. The timeframe of this study covers almost 20 years, from 1997/98 to 2016/17 (depending on the data source)—a period that is concurrent with the growth of investment in the oil sands, multiple scientific reports on climate change and rounds of climate policy, as well as other developments that have shaped Alberta and Canada's "innovation" policies. The priorities set out in government innovation policies are important drivers of the kinds of R&D performed in the universities.

To answer our research question about the contributions of the knowledge being produced in Alberta's universities to ecological and social sustainability, we looked for data sources that we could trace back to at least 1999/00 and that would allow us to classify both researchers and research projects according to a fairly fine-grained set of criteria. These data were available from the National Science and Engineering Research Council (NSERC), the Canada Foundation for Innovation (CFI), and the Alberta

Science and Research Investments Program (via its annual reports). They were supplemented by many other sources, as described in greater detail in the report. These data, however, cover only those researchers and projects that received funding from government agencies, giving us a picture of *externally funded* research. It is important to note that a great deal of research is carried out in universities that is not externally funded, either because of the nature of the research or the availability of funds "internal" to the university. The picture we are able to provide in this report, then, is necessarily partial, but it does show us what kinds of research governments and corporations (via partnerships or endowments) are prioritizing.

The introduction explains the objectives of the report in greater detail, outlines the scope of the study and its limits, and lists the data sources.

The second section maps the research priorities of the national funding agencies regarding energy, environment, sustainable agriculture and forestry, water issues, or other areas of research related to sustainable development. We identify the funding priorities—and changes in these over time—by observing the numbers of researchers working in selected areas as well as the flows of research funding to these areas. Our focus in this section is the University of Alberta and the University of Calgary, although we also examined CFI funding for projects at the University of Lethbridge. This section further documents the orientation of federal research funding toward university-industry-government partnerships and the heavy weight of corporations in the oil and gas sector in such partnerships.

In the third section of the report, we turn to provincial funding for energy and environment-related research. Here, we reconstruct the funding priorities of the Alberta Science and Research Investments Program (ASRIP) and of the innovation agencies and funds that finance government, university, and corporate-based R&D.

Section 4 describes the many research centres, institutes, research chairs, consortia, and networks that have been established since the 1970s in the areas of energy and environment. We identify which ones have received government and/or corporate investment and have been viewed as central to the province's economic development, and which have had to seek support from other sources. In this section we also document the dense network of connections among the corporate sponsors, university-based researchers, and government agencies involved in fossil-fuels-related R&D, and the significance of these relationships for knowledge production within the universities.

Section 5 reviews data from the provincial government and Statistics Canada that help us to construct at least a partial picture of corporate investment in energy R&D, and the implications of this out-sourced investment for the orientation of university research.

Finally, Section 6 summarizes the cumulative data on funding priorities by areas of research, highlights the evidence of changes of direction over time, and discusses the implications of our findings for the universities' role as producers of the knowledge needed to advance ecologically and socially sustainable development in Alberta.

The report documents—for the first time using systematized rather than only anecdotal data—the allocation of research investment in the areas of energy, environment, and sustainability, at the University of Alberta and the University of Calgary. The findings confirm the heavy weighting of this investment toward fossil-fuels-related research and technology development centred in the faculties of engineering. Highlights of the findings include:

- Of the NSERC funding to energy, environment, and sustainable development areas of research at the universities of Alberta and Calgary since 1999, 63 per cent has gone to fossil-fuels-related (FFR) research. Only 11 per cent has gone to alternative energies, and less than 3 per cent to sustainable development research.
- The number of NSERC-funded researchers in FFR-areas at the universities of Alberta and Calgary grew from 50 in 1999/00 to 138 in 2015/16, while during the same period the number working on renewable energies grew from 0 to 23 and the number of environmental researchers increased from 47 to 105.
- Of the CFI funding awarded in these areas to the universities of Alberta, Calgary, and Lethbridge, since 1998, the largest recipient was fossil-fuels-related research ($41.7 million, followed by environmental research ($39.2 million) and alternative energies ($9 million).
- The provincial government has committed approximately $3.4 billion to corporate tax credits for R&D in the energy sector since 2004.
- Another $3 billion in provincial funding for centres, institutes, or research chairs dedicated to fossil-fuels-related R&D has been documented for the period since 1997.
- The provincial funding of $6.4 billion for fossil-fuels-related R&D compares to $241 million spent on R&D in renewable energies, energy efficiency and conservation, fuel cells, and biofuels research, and $190 million on environmental and sustainable development research.
- Forty-five per cent of the Climate Change Emissions Management Fund's disbursements to corporations for R&D since 2010 have been allocated to fossil-fuels-related projects.

- Of the 25 Canada Research Chairs funded by the NSERC since 2000 (at the universities of Alberta and Calgary) in the area of energy, 16 were in fossil-fuels-related research. By comparison, 11 CRCs were created in environmental areas.
- Of the 36 Industrial Research Chairs created in the energy domain over the same period, 35 were in fossil-fuels-related research. Only three IRCs were created in the environmental area.
- Another 16 research chairs or professorships were established between 2005 and 2013 by energy corporation endowments, with these, too, focussing on fossil fuels research. Only a handful of endowed research chairs in environment-related areas were found.
- Going back as far as 1990 we found only nine centres in the two universities in environment or sustainability areas, and these have relied primarily on internal (university) funding. Only a handful of these are in operation today. On the other hand, we found 26 centres whose central focus is on energy (primarily, the oil sands), and 22 of these are operating today. At neither university is there a centre or institute for sustainable development, or an "initiative" with external funding on the scale routinely provided to the energy-area initiatives.
- We identified 25 consortia or networks in the energy area integrating university researchers, corporate sector scientists or managers, and government agencies, dating back to the AERI/ARC Core Industry Research Program created in the 1980s. Most of the research they conduct is related to fossil fuels reservoir exploration, extraction, processing, and transportation technologies. The handful of research networks in the environmental or sustainability areas were, for the most part, reliant upon internal university support and were not partnered with corporations or innovation agencies.
- In recent years there has been some increase in investment in renewable energy technologies on the part of Emissions Reduction Alberta and ASRIP, although these investments are still greatly outweighed by those in the oil and gas sectors.
- Water issues (important in Alberta in the context of climate change) are beginning to receive more support from Alberta Innovates.
- Funding for sustainable agricultural research from the innovation agencies is almost non-existent.
- No comprehensive record of industry funding of university research (by researcher or project title, or even by department or faculty) is publicly available. Statistics Canada did a survey of energy industry in-house and outsourced R&D spending in 2013/14, which found

that $115 million was outsourced to "Canadian organizations." Ninety-seven per cent of this amount was spent on fossil-fuels-related R&D. While $115 million is a very small fraction of the industry's total R&D spending in that year ($2.3 billion reported), it constitutes a substantial source of funding for the universities competing for a share of this pie. This $115 million is almost half the amount disbursed by NSERC for fossil-fuels-related R&D to the universities of Alberta and Calgary over the entire period from 1999 to 2016, and twice the amount disbursed by the CFI for fossil-fuels-related R&D over the entire period from 1999 to 2016. Statistics Canada data for 2014–2017 also show minimal industry investment in renewable energy technologies, hydrogen and fuel cell technologies, or energy efficiency technologies, compared to the amounts invested in fossil-fuels-related R&D.

Overall, some small steps are being taken in the direction of greater support from the provincial and federal innovation agencies for renewable energies, water research, and greenhouse gas mitigation technologies. The federal TriCouncil agencies are also facilitating cross-disciplinary grant applications in such areas as "environment and agriculture," "sustainable, resilient communities," "governance and institutions," and "environmental influences on population health" (SSHRC 2016). Some space may be opening for interdisciplinary, ecological knowledge production as governments come to grips with the impacts of climate change on essential infrastructure, insurance costs, food production, and global demand for fossil fuels. However, it is evident from our research that, until now, the interests of the fossil fuel industries have predominated in government funding of energy-related research, and that other dimensions of a sustainable development research agenda—such as sustainable food production—have hardly been on their radar (at least in Alberta).

In addition to being industry-driven, the innovation discourse and agenda are heavily technocratic and oriented toward the production of commercializable knowledge by researchers in engineering and natural sciences. By definition, then, the kinds of knowledge produced in other sectors of the universities by social science, humanities, and fine arts scholars—while also critically important to building an ecologically and socially sustainable future—fall outside of the "innovation" framework and are significantly underfunded. Moreover, the "sustainability" work being done in some parts of the universities related to climate change increasingly conflicts with the fossil-fuel-industry-driven work that is being carried out in other parts of the universities. Thus, the universities are producing contradictory knowledge and are divided in their interpretations of research and teaching that serve the public good.

The influence of corporations in the carbon-extractive and allied economic sectors on the research priorities of universities is visible in the presence of industry representatives on the boards of research institutes or university boards of governors, as well as in the corporate names attached to research labs, buildings, schools, or scholarship funds. However, our research suggests that less visible forms of influence on the production of knowledge in our universities are equally (if not more) important. Corporations have a privileged role in determining what will be funded by governmental agencies like NSERC, the National Research Council (NRC), Natural Resources Canada (NRCan), CFI, and Alberta Innovates by virtue of their economic power and relationship to the state.

Many university administrators, like politicians and corporate leaders, have adopted a sustainable development discourse that views technological innovation as the preeminent solution to the conflict between fossil-fuels-driven economic growth and the protection of the ecosystems that are the foundation of human life and biodiversity. This discourse has become a key element of what some scholars are now calling "the new climate denialism," in which the existence of climate change is acknowledged, but its urgency is downplayed, and incremental, market-friendly reforms, combined with investments in technology, are represented as constituting a sufficient response. Just as the governments of Alberta and Canada have pursued an incoherent two-track strategy of subsidizing fossil fuels production while implementing carbon taxes with the aim of reducing downstream greenhouse emissions, university administrators have presented their institutions' research on oil sands extraction and hydraulic fracturing as advancing "cleaner, more cost-effective ways of extracting energy" that are proceeding alongside research on "low carbon" energy systems.

Administrators may see this balancing act as a strategy for positioning their institutions to benefit from the external funding offered by the innovation agencies and the private sector. Substantial constituencies within Alberta's universities are now heavily—though not irrevocably—invested in fossil-fuels-related research. However, the conflicts over the mission of the university in relation to the climate crisis and the public interest (now being played out in fossil fuel divestment campaigns as well as struggles around research and teaching priorities) are not reducible to the political views of individual deans or university presidents, nor to differences of values between, for example, "engineers" and "liberal arts" scholars. Rather, these trenches have been dug and maintained by the interests and ideologies that governments have made central in the mandates of the innovation institutions.

Universities have room for manoeuvre in the setting of research priorities, but vocal, principled leadership is required on the part of students, academics, and administrators. University leaders can choose to "follow the money," trying to position their institutions to profit from the latest shift in government funding direction. Or, they can try to mobilize public and political support for an independent vision, generated from the bottom-up, through consultation with academics, students, and our surrounding communities about how the university can best serve the public interest.

1. Introduction

The wealth of its people and enormous natural resources provide Albertans with the opportunity not just to diversify their economy: Alberta could strive to become a model for the world, using its wealth to create a society dedicated to using knowledge, science and human ingenuity to improve the planet.

– Report of the International Board of Review on the Alberta Ingenuity Fund, August 2008, 38.

To make the transition to an ecologically sustainable society, universities and colleges must educate new generations to have a solid grasp of the complexities of such a transition and the possible paths forward. The solutions lie not only in technologies, or in the infrastructures needed to scale these up quickly, but in institutional and cultural changes. All sectors of the university have roles to play in creating and sharing their knowledges of the economic, social, political, cultural, as well as technical reforms and innovation that will lay the foundations for a good life in an ecologically sustainable society. We need to bring to bear all our diverse knowledges and experiences to make this shift—and we need to do it quickly. These are the possibilities that give hope and inspiration to our young people, and that many university researchers are committed to realizing.

And so, we should ask what roles the post-secondary education institutions and the research/innovation funding systems are playing regarding the production of the knowledge and the formation of the citizens that are needed to create a sustainable future. Over the past 20 years, as evidence of the need to transition away from a fossil-fuelled economy (globally and provincially) has become irrefutable, in what areas of knowledge production have governments been investing? How have governmental priorities shaped the kinds of knowledge produced by universities? What are the implications of these investment choices for the resources now available to us to make the transition to a carbon-neutral economy?

To answer these questions, we examined the flows of research funding to Alberta's leading research universities over a 20-year time period, focussing on the external funding received from federal and provincial innovation agencies. This relatively long timeframe allows us to track any changes in funding priorities, and to map these against developments in Alberta's political-economy and the deepening climate change crisis. The scope of the study was limited to research conducted in the areas of energy, environment, or "sustainable development," leaving aside research in medical and other disciplines. Narrowing the research scope in this way meant that most of the research we surveyed was carried out in faculties of engineering, science,

and (in the case of the University of Alberta) the Faculty of Agriculture, Life and Environmental Sciences (ALES), in large part because the science and engineering disciplines receive the lion's share of government and corporate funding in the energy and environmental fields.

While our research provides, for the first time, a picture of how governmental and industry-determined R&D priorities are shaping research on the ground in Alberta's universities in relation to sustainable development objectives, we are aware of the gaps that remain to be filled by further research. For example, this report does not examine the research being conducted in all of Alberta's post-secondary education institutions; instead, the focus is primarily on the major research institutions: the University of Alberta and the University of Calgary. Second, changes in curriculum, student enrolments, and student funding are not examined (although these are important indicators of what kind of "knowers" the universities are graduating). Third, data from the universities and from provincial agencies regarding projects receiving non-governmental sources of funding were largely unavailable to us, either because the institutions refused to provide the data or because the government had not maintained databases on their innovation agencies' funding of R&D projects. Future research may find ways around these obstacles.

Readers should keep in mind that the largest share of research funding from governments to these universities goes to medical faculties (disbursed by the Canada Institutes for Health Research, Canada Foundation for Innovation, and Alberta Innovates). While important work may be going on in these faculties in areas such as environmental health, this is not the focus of this study. Research relevant to ecological (un)sustainability is also being conducted in Faculties of Arts, Business, Education, Kinesiology, Sport, and Recreation, Law, and Native Studies, some of which has been surveyed recently (Adkin 2017a). However, social sciences, humanities, and fine arts are not the disciplines typically funded by the large granting agencies or targeted for funding by provincial "innovation" initiatives. (The funding provided to the Social Sciences and Humanities Research Council is only about a third of the amount given to the Natural Sciences and Engineering Research Council.[1]) In this study, we focus on funding to the Science, Engineering and the UAlberta's ALES faculties pertaining to areas of energy or environment. The goal was to see how the funding flows support either fossil-fuels-related research and technology development (R&D) or R&D that could be considered foundational to ecologically sustainable, post-carbon economies.

Much of what governments characterize as "environmental" or "clean technology" R&D falls into the category of fossil-fuels-related (FFR) research. These technologies aim to reduce the energy intensity or carbon footprint of fossil fuels extraction, refining, transportation, or combustion.

Examples are carbon capture and storage technologies intended to capture emissions from coal-fired power plants or oil refineries, and the substitution of solvents for the water/steam used in steam-assisted gravity drainage (SAGD) extraction of bitumen.[2] In this category, too, is R&D related to the remediation of the environmental harms generated by fossil fuel extraction (remediation of contaminated soil, reduction of water use, treatment of the tailings ponds, land reclamation). The remediation technologies are, of course, necessary and important, but they exist to mitigate the effects of a carbon-extractive model of development that needs, ultimately, to be replaced. In this sense, they are not sustainable energy system technologies.

Moreover, in the context of government commitments to prolong the extraction of bitumen for as long as possible, and in the absence of a green transition plan or policy that phases out the extraction of fossil fuels, the "clean energy technology" focus of funding has served a legitimation function (Adkin 2017b; Adkin and Stares 2016).

That is, governments routinely point to their investments in these areas as evidence that the fossil-fuel-based economy can be made "sustainable." Such claims have become central to government and corporate efforts to obtain "social license" for their continuing investments in fossil fuel extraction and exports (Adkin 2017b; Adkin and Stares 2016).

We can more easily see that research in areas such as renewable energy technologies (wind, solar, geothermal), passive heating, energy conservation, low-carbon public transportation, ecological economics and urban design, sustainable agriculture, water conservation, or integrated transition planning move us away from dependence on fossil fuels and toward ecologically sustainable development.

Not every research project or technology falls neatly into one or the other category (fossil-fuels-related or sustainable). For example, biofuels have been promoted as substitutes for fossil fuels, but are considered by many ecologists to generate other environmental and social harms.[3] Likewise, electric or hydrogen-fuelled vehicles and nuclear energy create new risks and may exacerbate existing problems. For these reasons, we have reported funding for multiple sub-types of R&D separately, rather than grouping them into only two categories.

The research presented here is certainly relevant to closely related questions concerning public subsidies to the fossil fuel industries and alternative energy sectors, the influence of dominant industries in the shaping of government energy, climate, and innovation policies, and the ways in which neoliberalism and corporatization have been restructuring university governance and mandates.[4] Our focus here, however, is mapping the "political ecology" of knowledge production that has resulted from government funding priorities over the past 20 years. More precisely,

the report documents the kinds of R&D being funded at Alberta's major research universities in the areas of energy and environment, and classifies these according to ecological criteria, allowing us to see the bigger, "ecological" picture of knowledge production and to consider the implications of this picture for Alberta's future path of development. The 20-year period permits us to discern changes that might correspond to changes in the province's economy or government policies.

Space limitations permit only minimal discussion of the history of the funding programs or policy rationales associated with these. We are primarily concerned here with the *outcomes* of decisions that have been taken by the provincial and federal governments in relation to knowledge production for sustainable development. Data sources include:

- the Natural Sciences and Engineering Research Council (NSERC) awards database, which was intensively searched, multiple times, in 2017/18;[5]
- the Canada Foundation for Innovation (CFI) awards database;
- federal government websites and reports;
- annual reports, business plans, government budgets, requests for information to relevant provincial ministries and agencies (including the annual reports of the Alberta Science and Research Investments Program (ASRIP));
- interviews with current and former civil servants with knowledge of the provincial funding programs; and
- publicly available documents and Statistics Canada data related to the corporate sponsorship of university-based research as well as funds available to corporations for R&D that may involve partnerships with university researchers.

The categories used in coding projects are listed in Table 1.1. We use the codes for the research categories as a shorthand throughout the report.

Table 1.1 Categories of Energy, Environmental, and Sustainability Research

	Research sub-categories
AGRIC	agriculture
SusAgr	sustainable agriculture (organic, biodiversity protecting, soil husbandry, integrated pest management, permaculture, crop diversification, stable farm income, water conservation methods, moving away from intensive livestock operations, reduction of fossil fuel use, maximization of carbon sinks, wetland protection, etc., i.e., not just about increasing yields)
BioFuel	biofuels and biomass technologies
CCSci	climate change science (earth sciences, natural sciences)
ECOSYS	ecosystem dynamics, conservation biology, ecological science
EECons	energy efficiency and conservation (insulation, building codes, machine engineering, construction, transportation, other)
FC	fuel cells and batteries (energy storage)
FOR	forestry
SusFor	sustainable forestry (selective harvest, biodiversity protection, local livelihoods, sustainable harvest rates, indigenous knowledge and uses, etc.)
FFR	fossil-fuel related CCS carbon capture and storage Coal (combustion, derivatives) EXPL exploration (reservoirs; petroleum geology; earth sciences) EXT extraction (mining, drilling) FRK hydraulic fracturing technologies SAGD steam-assisted gravity drainage GHGM greenhouse gas mitigation in extraction and upgrading through reduced use of energy or pollution abatement technology (GHG emissions) *if different from CCS* PROC processing of bitumen and basic upgrading DOWNST downstream petrochemical REM remediation of pollution or other environmental harms related to fossil fuels (water treatment, tailings pond reduction, land reclamation, etc.) TRANS transportation (pipelines, rail, trucks, roads, containers) Unknown (precise application to fossil fuels could not be determined)
Fusion	fusion energy
OE	other environmental research (toxic chemicals, pollution: soil science, plant science, biochemistry, paleobiology, water quality)

	SOIL (sub-category of "other environmental") AIR (sub-category of "other environmental") Water (sub-category of "other environmental")
NU	nuclear energy
RenEn	renewable energy (solar, wind, geothermal, materials and nanoscience related to renewable energy technologies)
SD	sustainable development (indicators, other research in economics, planning, social sciences)
UR	uranium (exploration, extraction, or processing)
Waste	waste management; recycling (municipal, industrial, but not from oil & gas extraction) Wastewater (municipal water treatment)

The report proceeds in four sections that set out the research findings, followed by a concluding section that summarizes the data and reflects upon their implications for the questions presented in the introduction. The time frame for this research is from 1997/98 to 2016/17, a period that is concurrent with the growth of investment in the oil sands and other political and economic developments that have shaped Canada's innovation policy.

Section 2 maps the research priorities of the national funding agencies (NSERC and CFI) in regard to energy, environment, sustainable agriculture and forestry, water issues, or other areas of research related to sustainable development. We identify the funding priorities—and changes in these over time—by observing the numbers of researchers working in selected areas as well as the flows of research funding to these areas. Our focus in this section is the universities of Alberta and Calgary, although we also examined CFI funding for projects at the University of Lethbridge. This section further documents the orientation of federal research funding toward university-industry-government partnerships and the heavy weight of oil and gas sector corporations in such partnerships.

Section 3 shifts the focus to provincial funding for the same areas of research and technology development. Using the data available, we reconstruct the funding priorities of the Alberta Science and Research Investments Program (ASRIP) and of the innovation agencies and funds that finance government, university, and corporate-based R&D.

In Section 4 we describe the many research centres, institutes, research chairs, consortia, and networks that have been established since the 1970s in the areas of energy and environment. We identify which ones have received government and/or corporate investment and have been viewed as central to the province's economic development, and which have had to seek support

from other sources. Our findings reveal a dense network of connections among corporate sponsors, university-based researchers, and government agencies involved in fossil-fuels-related R&D.

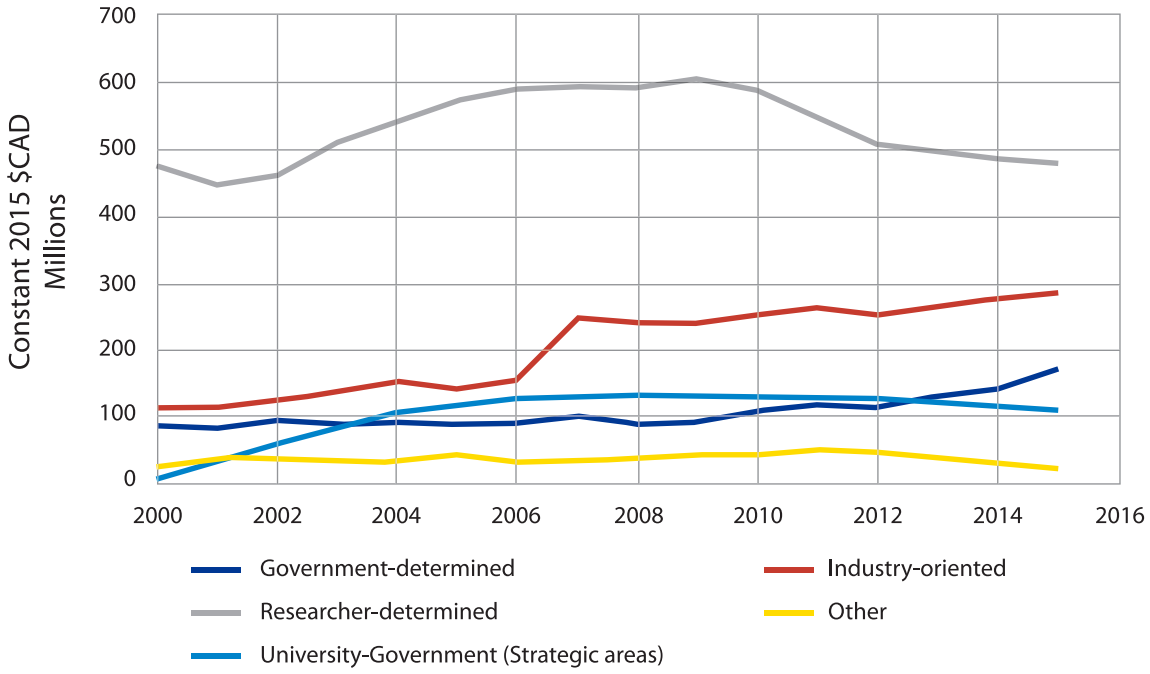
Section 5 reviews data from the provincial government and Statistics Canada that help us to construct at least a partial picture of industry investment in university-based research in the energy area, and the implications of this investment for the orientation of the research carried out in these public institutions.

Finally, Section 6 summarizes the cumulative data on funding flows by areas of research, highlights the evidence of changes of direction, and discusses the implications of our findings for the universities' role as producers of the knowledge needed to advance ecologically and socially sustainable development in Alberta.

2. Federal Funding for Energy and Environment R&D

Successive federal governments from the 1990s onward have failed to implement effective national climate change plans, in no small part because of resistance from the fossil fuel industry, backed by Alberta governments that have opposed regulatory measures that might reduce corporate investment in the oil sands (Adkin 2014). The preferred climate change policy approach of the large business associations could be summarized as government investment in technology funds that assist corporations to finance R&D aimed at reducing their greenhouse gas (GHG) emissions. This preference was accommodated, in part, through the shifting of funding available from government "innovation" agencies (especially the NSERC and National Research Council (NRC)) to programs that mandate university researchers' collaboration with private sector partners.[6] Figure 1.1 shows that the share of industry-oriented awards in NSERC's funding has increased significantly since 2006 (when the minority Conservative government was elected). Government-determined funding programs have claimed an increasing share of the NSERC budget since about 2009, while researcher-determined projects have received decreasing funding since 2009.[7] In this way, a growing share of federal research spending has been allocated to projects that serve the R&D needs of the corporations.

Figure 1.1 Evolution of NSERC Total Award Amounts by Year and Type of Program, 2000–2016



Source: NSERC Awards Database, using fiscal years and results displayed by program, http://www.nserc-crsng.gc.ca/ase-oro/index_eng.asp?new.

The NRC has also been restructured over time to provide services and investment in R&D in line with the priorities of the private sector. The 2012 federal budget allocated $67 million to reorient the NRC institutes towards more business-relevant research (Howitt 2013, 18). The federal government announced on May 7, 2013 that it would refocus the NRC to "… support Canadian industries by investing in large-scale research projects that are directed by and for Canadian business."[8] Elyse Amend and Darin Barney (2016, 15) note the number of ways in which the writing was on the wall for the future direction of the NRC in 2013:

> The revamped NRC would be a "business-driven, industry-relevant research and technology organization" (National Research Council Canada, 2013). In announcing the reorientation, along with a commitment of $121 million in public funds to aid the transformation, the minister of state for science and technology declared: "The NRC is open for business" (Allen, 2013). Underscoring the direction of this new mandate, NRC president John MacDougall observed: "Scientific discovery is not valuable unless it has commercial value" (Toronto Star, 2013).

Reviewing the legacy of the Harper governments over the 2006–2015 period, Amend and Barney conclude that "the government systematically reoriented state priorities vis-à-vis science away from long-term, disinterested inquiry and toward short-term investment in research supporting commercial and industrial development, productivity, and economic growth" (2016, 17). A journalist for the *Globe and Mail*, reporting on developments at the NRC in October 2016, wrote:

> Under the previous president, John McDougall, installed by the Harper government in 2010, the NRC was directed to focus on commercially relevant research in support of industry, a transition that seemed to exacerbate a growing identity crisis in branches of the NRC that did not fit this vision. Morale plummeted, according to interviews with current and former staff, and the number of scientists and technical staff at the NRC dropped by 22 per cent in five years (Semeniuk 2016).

This trend did not end, however, with the defeat of the Conservatives in October 2015. In October 2016, the Ministers of Innovation, Science and Economic Development and of Science jointly instructed the new NRC President Iain Stewart to consult with innovation stakeholders to determine how to better meet "the current and longer-term research and development needs of Canadian industry" and "identify current and forthcoming industrial R&D priorities and collaboration opportunities with firms."[9] The NRC's 2016/17 annual report stated that the agency's primary focus was to provide "business innovation support," although it also "works to advance

knowledge to address current and longer term national challenges" (NRC 2017, 7).

While the general orientation of the national research funding agencies has been to support industry-driven R&D priorities, the weight of oil and gas extraction and exports in the national economy, along with the political influence of this industry, have ensured that fossil-fuels-related R&D has received a disproportionate share of funding going to energy R&D, as this report will show in relation to Alberta's universities.

Conservative governments, beginning in 2006, sought to make Canada an energy "superpower," referring mainly to oil exports, and this goal was reflected in the rhetoric and funding flowing from the national research funding agencies. In 2011, NSERC proclaimed:

> Canada's oil sands are one of the world's largest accessible reserves of hydrocarbon fuel-energy. Bringing these resources into large-scale production has been one of the great achievements of Canadian innovation. Increasing their value now depends on making the mining and refining as efficient and green as possible. For this reason, the Government of Canada has made research on the oil sands a strategic national priority (NSERC 2011, 1).

NSERC reported that it had increased its funding for R&D related to the oil sands and heavy oil from $2.8 million in 2004/05 to $12.5 million in 2010/11 (Ibid. 1).

With low oil prices setting in since 2014, margins of profit for the oil sands producers have been squeezed, and pressure has intensified from the industry for government subsidization of R&D in a number of areas. Much has been invested, in recent years, in technologies to reduce energy and water use in steam-assisted gravity drainage (SAGD) extraction and to advance hydraulic fracturing in Alberta's geological formations. The Alberta New Democratic Party (NDP) government elected in May 2015 viewed upgrading and refining of bitumen in-province, growth of the downstream petrochemicals and plastics industry, and new uses for captured carbon as ways of "diversifying" Alberta's economy.

At the same time, both the Alberta NDP and the federal Liberal government (elected in October 2015) claimed to be committed to reducing the country's greenhouse gas emissions from 734 Mt in 2015 to just over 500 Mt in 2030 and to making environmental regulation and assessment processes more rigorous. One of our research questions, then, is whether—in light of these governments' stated climate policy objectives—there was any notable increase in investment in sustainable technologies and knowledges from 2015 to 2018.

With these key questions in mind, we turn, in the following sections, to the analysis of federal and provincial sources of funding for energy and environmental research in Alberta's leading research universities.

2.1 Natural Sciences and Engineering Research Council (NSERC)

2.1.1 NSERC-Funded Research at the Universities of Alberta and Calgary in the Energy and Environment Domains from 1999/00 to 2015/16

In a first step, we developed a picture of NSERC-funded research activity over the entire period under study. Multiple searches of the NSERC awards database using different keywords and names of researchers gleaned from other sources eventually yielded a total of 356 faculty researchers at the University of Alberta (UAlberta) and the University of Calgary (UCalgary) working in the energy production or the environmental science domain over the period from 1999/00 to 2015/16. Associated with these researchers were 4,567 projects that were coded and analyzed. Of the 356 researchers, 61 per cent (217) worked primarily on energy projects, and, of these, 73 per cent (159 of 217) worked on FFR projects. Highlights of this picture are presented below.

At the two universities combined, there were 356 faculty researchers and 4,567 projects coded for our study. Of these:

- 217 researchers, or nearly 61 per cent, worked on *energy* projects
- 159 of the 217 *energy* researchers (73 per cent) worked on fossil-fuels-related (FFR) projects
- 53 of the 217 *energy* researchers (24 per cent) worked on renewable energies (RenEn), biofuels, or energy efficiency/conservation (EECons), combined
- 146 researchers (41 per cent) worked on *environmental* questions[10]
- 26 of the *environmental* researchers (18 per cent) had projects related to fossil fuels

In total, 185 out of all 356 researchers in our database (including both "energy" and "environment" researchers), or 52 per cent, had projects related to fossil fuels.

For the entire 17-year period we found only 31 researchers (8.7 per cent of the total) with projects pertaining to sustainable agriculture, sustainable forestry, waste management, municipal wastewater treatment, or water conservation. There was only one project that satisfied our criteria for sustainable agriculture.

In the most recent year for which we collected data, 2015/16, there were 15 NSERC-funded "sustainability" researchers at UAlberta and four at UCalgary, for a total of 19. This compared to 151 researchers doing FFR R&D (including 13 researchers in the "environment" area and 138 in the "energy" area).

For the University of Alberta, our searches of the NSERC awards database for this period yielded a total of 228 researchers (in five faculties) who received grants for energy or environment-related projects. Altogether, 3,063 projects were coded for UAlberta. Of these:

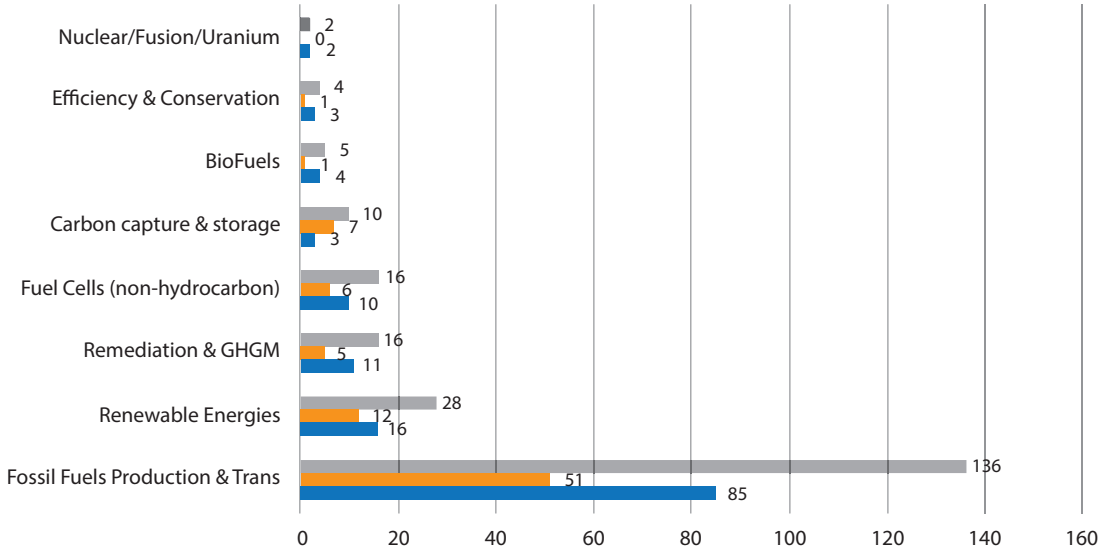
- 58 per cent of the 228 researchers worked in the energy domain
- 49 per cent of all researchers worked on fossil-fuels-related (FFR) projects
- 7 per cent of all researchers worked on renewable energy R&D (RenEn)

At the University of Calgary, we found a total of 128 (NSERC-funded) researchers working on energy or environment projects. Altogether, 1,504 projects were coded. Of these:

- 61 per cent of the 128 researchers worked in the energy domain
- 60 per cent of all researchers worked on FFR projects
- 11 per cent of all researchers worked on RenEn projects

Figure 2.1 illustrates the cumulative distribution of NSERC-funded researchers at the two universities across the sub-categories of energy-related R&D (i.e., this chart does not include those who were primarily classified as environmental science researchers).

Figure 2.1 Number of NSERC-Funded Researchers at the Universities of Alberta and Calgary Engaged in Selected Areas of Energy Research, 1999/00 to 2015/16 (n=217)



	Fossil Fuels Production & Transportation	Renewable Energies	Remediation & GHGM	Fuel Cells (non-hydrocarbon)	Carbon Capture & Storage	Biofuels	Efficiency & Conservation	Nuclear/ Fusion/ Uranium
Combined	136	28	16	16	10	5	4	2
UCalgary	51	12	5	6	7	1	1	0
UAlberta	85	16	11	10	3	4	3	2

Combined UCalgary UAlberta

Source: NSERC Awards Database

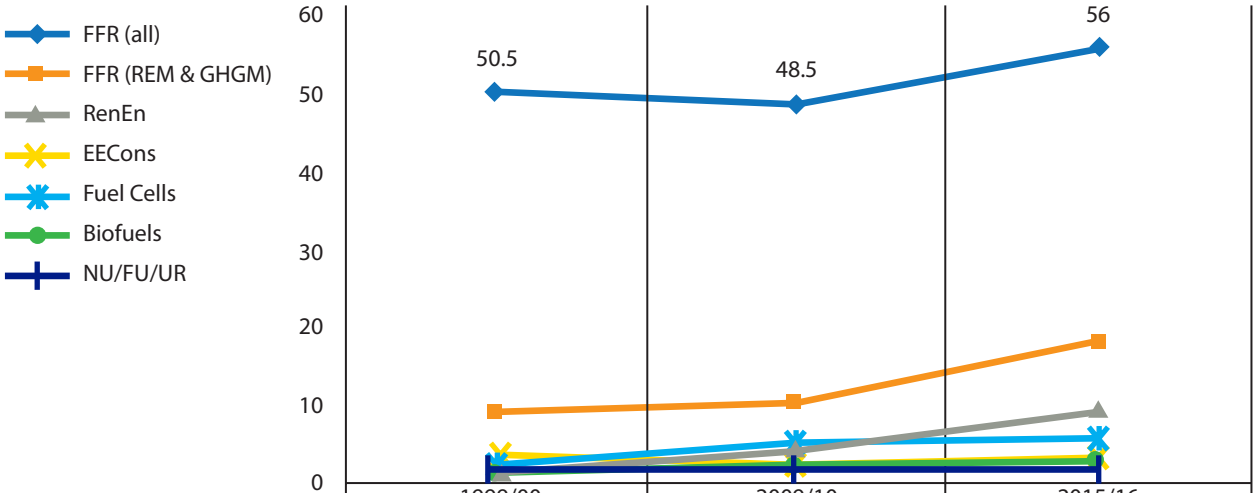
To shed light on the question of changes in energy research priorities over time, we took "snapshots" of the distribution of researchers at three different points in time: 1999/00, 2009/10, and 2015/16. Among our findings:

- The number of researchers in the energy domain more than tripled from 1999/00 to 2015/16 (from 56 to 174).
- The number working on FFR research grew from 50 in 1999/00 to 138 in 2015/16 (from 51 per cent to 56 per cent of all NSERC-funded researchers).
- The number working on environmental remediation or greenhouse gas mitigation R&D related to fossil fuels (FFR-REM/GHGM) grew from eight to 20 then dropped to 15. (This is an increase from 8.6 per cent of NSERC-funded researchers in 1999/00 to 18 per cent in 2015/16.)
- The number working on renewable energy technologies (RenEn) grew from zero to 23 (from 0 to 9.3 per cent of all researchers in 2015/16).

- The number working on biofuels went from zero to six (2 per cent)
- The number working on EECons went from three to six (from 3 to 2 per cent of all researchers)

As illustrated in Figure 2.2, there has been an increase in the percentage of researchers working on renewable energies and on environmental remediation or GHGM related to fossil fuels, but in 2015/16 these represented only 9 and 18 per cent, respectively, of all researchers with NSERC grants in energy/environment areas at the two universities, compared to 56 per cent working on technologies related to fossil fuel exploration, extraction, processing, or transportation

Figure 2.2 Percentage of NSERC-Funded Researchers in Each Sub-Category of Energy Research, 1999/00 to 2015/16



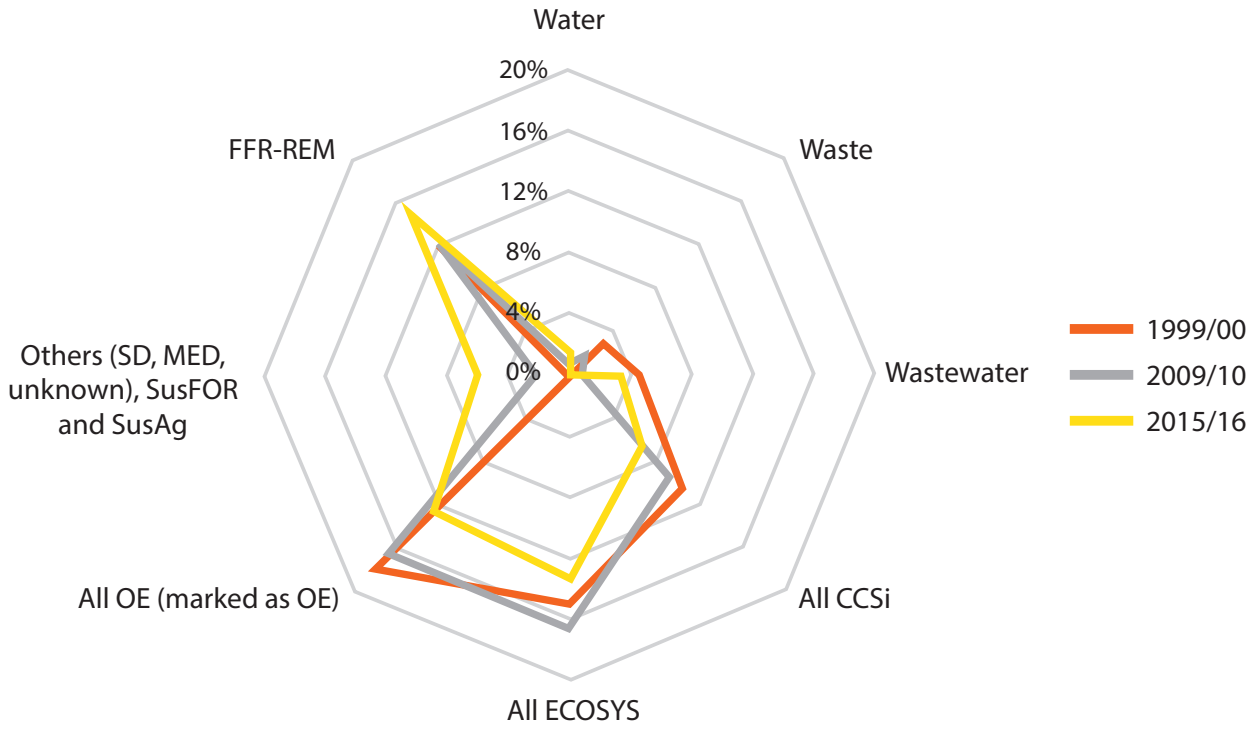
	1999/00	2009/10	2015/16
FFR (all)	50.5	48.5	56
FFR (REM & GHGM)	8.6	10	18
RenEn	0	4.5	9.3
EECons	3.2	1.5	2.4
Fuel Cells	2.2	5	5.3
Biofuels	0	1.5	2.4
NU/FU/UR	1.1	1.5	1.2

Source: NSERC Awards Database

The number of *environmental* researchers more than doubled from 47 in 1999/00 to 105 in 2009/10, before levelling off at 113 in 2015/16. (In 2015/16 there were 74 NSERC-funded environment researchers at UAlberta and 39 at UCalgary.) Proportionally, however, as a *percentage* of all NSERC-funded researchers, environmental researchers declined from their levels of 37 per cent in 1999/00 and 39 per cent in 2009/10, to 30 per cent in 2015/16.

An increasing percentage of environment researchers have been receiving NSERC awards for projects related to fossil fuels. The percentage of researchers in the "environment" domain whose work pertained to fossil fuels grew from 9 per cent in 1999/00 to 14 per cent in 2015/16 (Figure 2.3). After environment researchers working on various environmental science questions, they became the second largest group in 2015/16. Environment researchers working on some aspect of climate change declined from 10 per cent in 1999/00 (20 researchers) to 6.5 per cent in 2015/16 (16 researchers).

Figure 2.3 Percentage of NSERC-Funded Environment Researchers Working in Selected Areas of Research, 1999/00 to 2015/16, University of Alberta



Source: NSERC Awards Database

2.1.2 Agriculture, Forestry, Water, Waste

In general, NSERC funds much less research in these areas than in energy and other industry-related areas. At the two universities combined, we found:

- The number of NSERC-funded researchers working on environmental questions affecting forestry grew from seven in 1999/00 to 16 in 2015/16.
- The number working on environmental questions affecting agriculture was the same in 2015/16 as it was 17 years ago (five).
- In 2015/16 we found only five NSERC-funded scientists working on water quality and conservation problems.

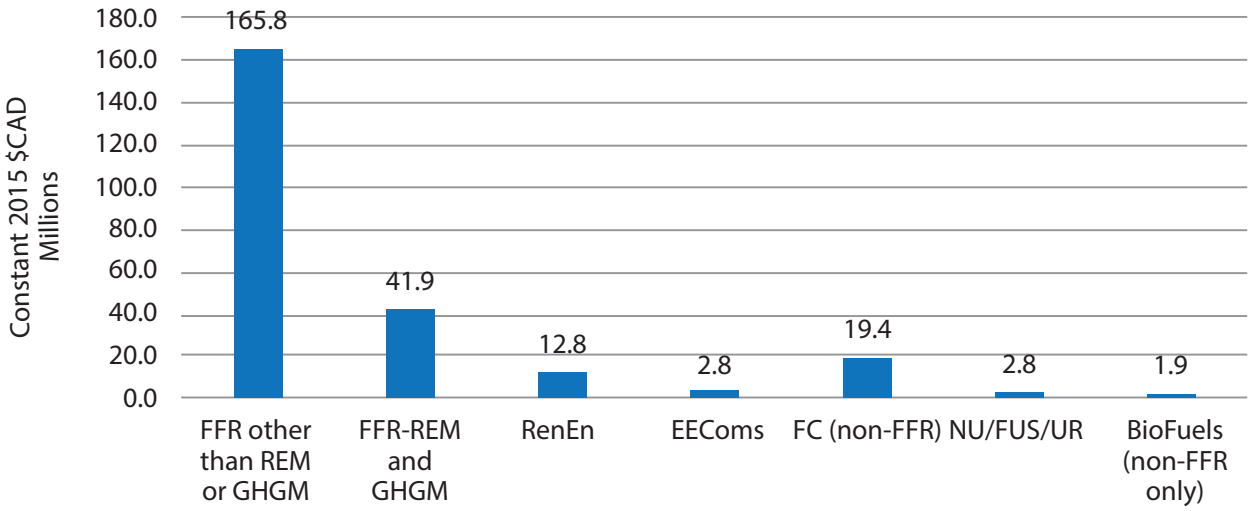
2.1.3 NSERC Funding Amounts for Energy and Environmental Research from 1999/00 to 2015/16 at the Universities of Alberta and Calgary

In this sub-section, we turn our attention from the number of researchers funded in areas of energy and environment research to the amount of funding that NSERC allocated to projects in the identified sub-categories of research.

Energy-Related Research

From 1999/00 to 2015/16, NSERC awarded a total of $165.8 million to UAlberta and UCalgary for research related to the exploration for, or the extraction, processing, or transportation of fossil fuels. This amounts to 67 per cent of all funding for energy-related research (which totalled $207.7 million). If we add REM/GHGM research related to fossil fuels to the FFR category, NSERC funding for this category amounted to 84 per cent of all energy-related research funding over this 16-year period. The cumulative amounts for each category are shown in Figure 2.4.

Figure 2.4 **Cumulative Amounts Disbursed by NSERC for Different Energy-Related Research Categories at the Universities of Alberta and Calgary, 1999/00 to 2015/16**



Source: NSERC Awards Database

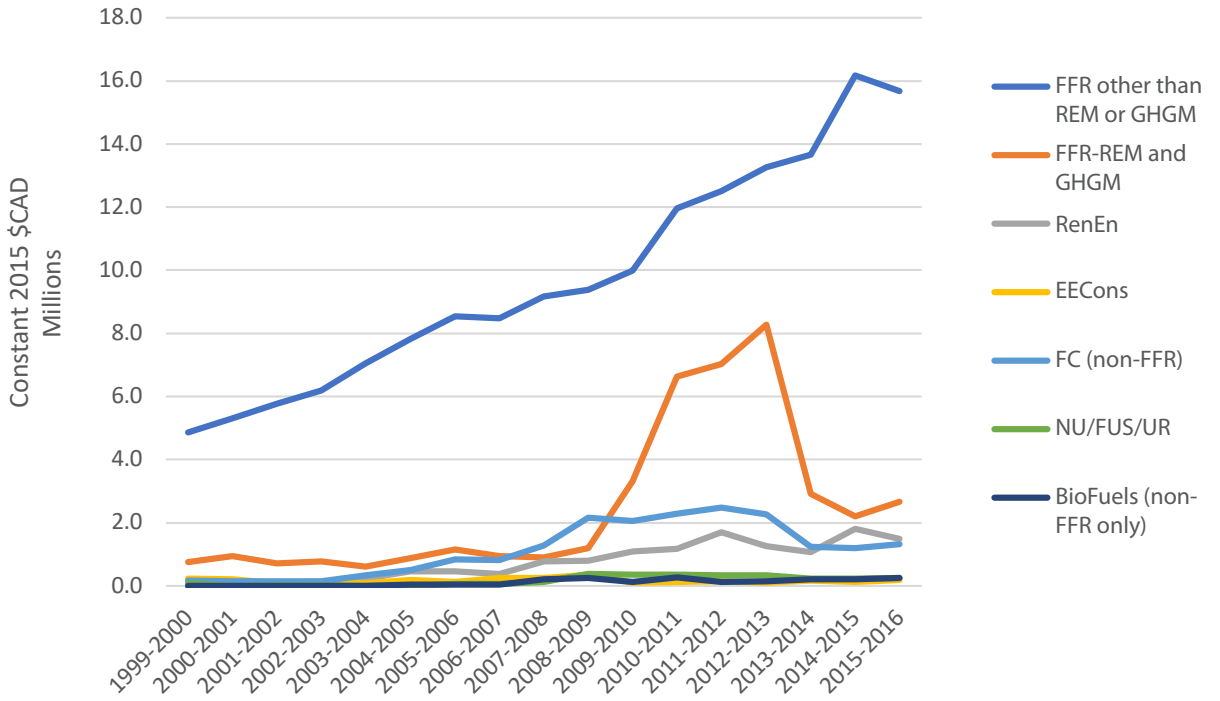
Research on oil *processing* (upgrading, refining) was the single largest recipient over this period of NSERC funding in the energy research categories, receiving $128.4 million, or 62 per cent of all funding for FFR research.

Figures 2.5 and 2.6 reveal the *trends* in NSERC funding of energy-related research at these two universities over the 17-year period. First, Figure 2.5 shows the allocation of funding to all the energy sub-categories by year, in constant 2015 dollars. We see that funding for fossil-fuels-related (FFR) research grew steeply from 1999/00 to 2015/16. From $4.9 million in 1999/00, NSERC awards grew to a peak of $16.2 million in 2014/15, falling slightly to $15.7 million in 2015/16. This was, simultaneously, the trajectory of industry spending (capital and operating spending combined) in the oil sands, which grew from $4.2 billion in 1999/00 to a peak of $58.2 billion in 2014, then fell to $35.5 billion in 2016 following the steep decline in global oil prices.[11]

These two trends are mapped together in Figure 2.7.

Funding for renewable energy research, as shown in Figure 2.5, has seen only a modest increase and has remained below $2 million per year. Fuel cells research had a boost in the 2007–2009 period but declined again thereafter.

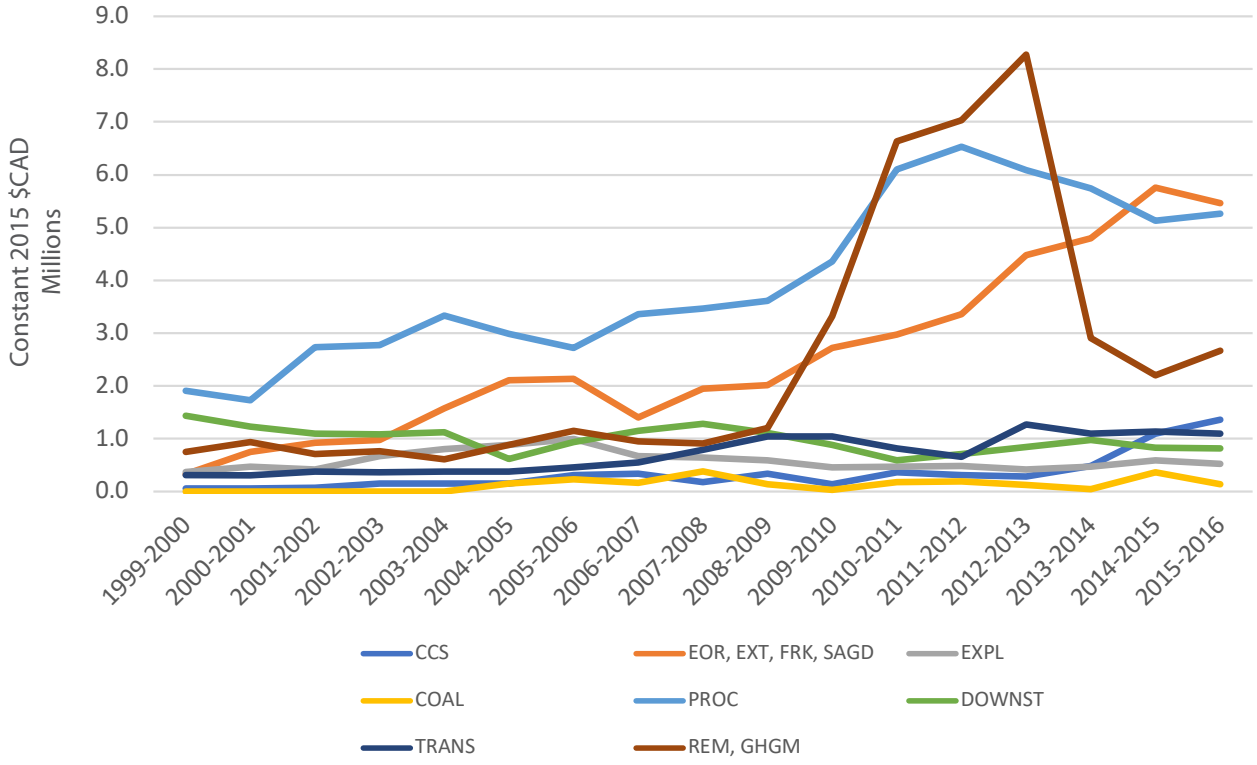
Figure 2.5 Amounts Disbursed by NSERC for Different Types of Energy Research Conducted at the Universities of Alberta and Calgary, 1999/00 to 2015/16



Source: NSERC Awards Database

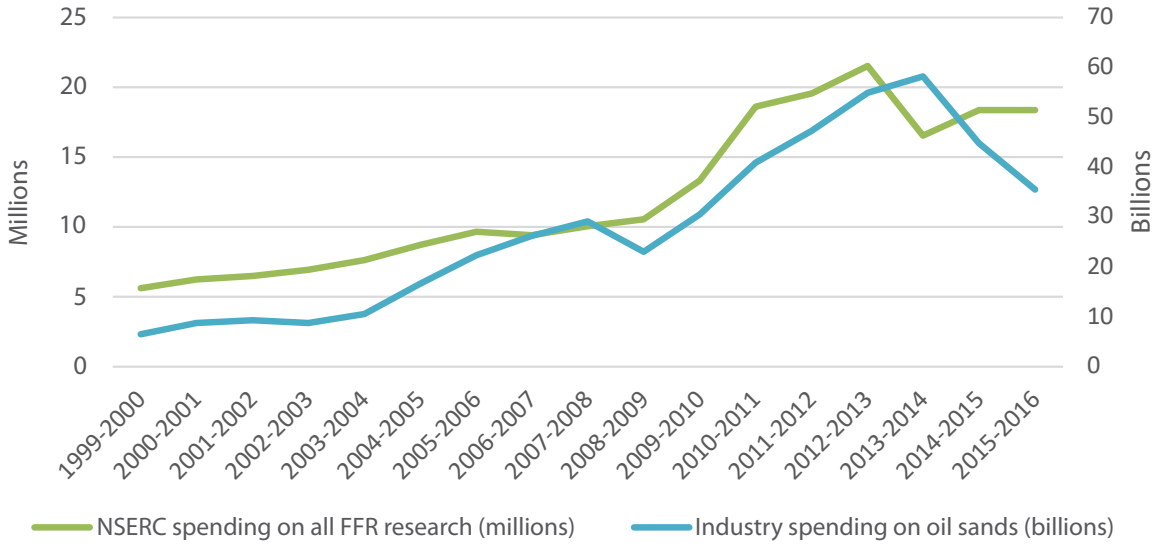
Figure 2.6 shows us that processing/upgrading has received the largest share of FFR R&D funding, followed by research on extraction technologies (EOR, oil sands, SAGD, fracking). NSERC funding for research on fracking technologies began to rise after 2008/09, and in 2014/15 accounted for 10 per cent of all the funding going to the two universities for environmental and energy-related research. There was a substantial increase in funding for REM/GHGM from 2009 to 2012, aligning with provincial investment in CCS and the Stelmach government's efforts to legitimize oil sands as "clean energy" (Adkin and Stares 2016). REM/GHGM awards had averaged $886,493 per year from 1999/00 to 2008/09, but in 2009/10 this amount began increasing sharply, reaching a peak of $8.3 million in 2012/13. Thereafter, REM/GHGM funding fell to $2.9 million in 2013/14 and has not exceeded $2.7 million since then.

Figure 2.6 Breakdown of NSERC Funding of Fossil-Fuels-Related Research at the Universities of Alberta and Calgary, 1999/00 to 2015/16



Source: NSERC Awards Database

Figure 2.7 NSERC Funding of Fossil-Fuels-Related Research Compared to Industry Spending on the Oil Sands, 1999/00 to 2015/16



Source: NSERC Awards Database

Environmental-Related Research

NSERC funding of *environment* research over the same period totalled $74.4 million, or just over one-third of the amount spent on energy research. As a percentage of NSERC funding, environmental sciences' best funding years were from about 2002/03 to 2006/07; their percentage of NSERC funding has declined since, from the high point in 2006/07 of about 28 per cent to about 22 per cent in 2015/16. In absolute dollar terms, awards to environmental sciences increased until 2012/13, after which time there has been a decline.

Sustainability-Related Research

We examined the allocation of funding to non-energy technology research projects that we grouped under the label of "sustainable development." These included sustainable agriculture, sustainable forestry, waste management, municipal water treatment, water conservation, and "other sustainable development" projects (e.g., on land use or indicators of well-being). Over the entire time-period, the awards to such projects totalled $8.4 million (in 2015 constant dollars). As a percentage of all NSERC funding to the two universities for energy or environment-related research, funding for (non-energy-related) "sustainability" research accounted for between 1 and 5 per cent, depending on the funding year.

2.1.4 Industry Partners

The NSERC database lists the partners in projects funded under multiple programs. Partners may include private companies, non-profit organizations, foundations or institutes, or government agencies. About 87 per cent of partners in research projects at UAlberta funded by NSERC were corporations (see Table 2.1). Below are lists of the "top 20" partners (those who were listed most frequently as partners in NSERC-funded projects. (Numbers in parentheses are number of times listed as a research partner. Government partners are bolded.)

For the University of Alberta NSERC partnerships, the only non-profit, non-governmental organization listed over the17-year period was Ducks Unlimited (3). Given the focus of the ALES Faculty at the University of Alberta on forestry, agriculture, and resource management, large pulp and lumber companies figure prominently in the UAlberta's list of corporate partners.

Table 2.1 University of Alberta "Top 20" List of Partners in NSERC-Funded Research

Syncrude (190)
Shell Canada (90)
Suncor (80)
Canadian Natural Resources Ltd. (52)
Nexen Inc. (52)
Imperial Oil Ltd. (51)
Weyerhaeuser Canada Ltd. (45)
Total E&P Canada Ltd. (42)
Natural Resources Canada (40)
Nova Chemicals Corp. (35)
Alberta Innovates—Energy and Environment Solutions (33)
Alberta-Pacific Forest Industries (32)
EPCOR Utilities Ltd. (25)
Champion Technologies Ltd. (23)
Alberta Energy Research Institute (21)
BP Canada Energy Company (20)
Daishowa-Marubeni International (19)
Atomic Energy of Canada Ltd. (18)
Statoil (18)
ConocoPhillips Canada (16)
Devon Canada Corporation (16)
Nalco Canada (16)
Petro-Canada (16)

At the University of Calgary, 91 per cent of partners were corporations or corporate-funded organizations (see Table 2.2). Apart from the oil-industry-funded Computer Modelling Group (CMG) Foundation, there were no non-profit, foundation, or research institute partners listed. The top position of CMG Reservoir Simulation Foundation reflects the scale of research into non-conventional oil and gas extraction that is taking place at UCalgary.

Table 2.2 University of Calgary "Top 20" List of Partners in NSERC-Funded Research

CMG Reservoir Simulation Foundation (44)
Nexen Energy ULC/Nexen Inc. (35)
Nova Chemicals Corp. (33)
ConocoPhillips (30)
Suncor Energy (30)
Imperial Oil Resources Ltd. (28)
Shell Canada (26)
Husky Energy (21)
Total E&P Canada Ltd. (20)
Canadian Natural Resources Ltd. (17)
Alberta Energy Research Institute (16)
Baker Hughes Inc./Baker Petrolite Corp. (13)
Husky Oil Operations Ltd. (12)
Devon Canada Corp. (11)
Aramco Services Co. (10)
Alberta Innovates—Energy and Environment Solutions (10)
Yara International ASA (10)
Schlumberger Canada Ltd. (9)
University of Calgary (9)
Natural Resources Canada (8)
Petro-Canada (7)
Syncrude Canada Ltd. (7)

The prominent role of AI-Energy and Environment Solutions (AI-EES) and AERI in partnerships with the two universities and energy sector corporations supports the findings of Carroll, Graham, and Yunker (2018) that provincial innovation agencies are "interlocked extensively with the fossil fuel sector." The lists further demonstrate that Natural Resources Canada joins NSERC in what these authors refer to as a "carbon-centred scientific-industrial complex."

2.2 Canada Foundation for Innovation (CFI)

When the federal Liberal government announced funding to create the CFI in its 1997 budget, it identified the agency's purpose as: "to provide financial support for the modernization of research infrastructure at Canadian post-secondary educational institutions and research hospitals in the areas of health, environment, science and engineering" (Government of Canada 1997, 4). In 2010, the CFI's mandate was amended by the Conservative government to place more emphasis, in partnership with provincial governments and other funding agencies, on the commercialization of R&D and on the "development of industrial clusters" (CFI 2012, 8).[12] As specified in the 2010 Funding Agreement, the CFI's mission is to enhance the capacity of Canada's universities, colleges, research hospitals and non-profit research organizations to:

- attract and retain the world's top research talent;
- enable researchers to undertake world-class research and technology development that lead to social, economic and environmental benefits for Canada;
- support private-sector innovation and commercialization; and
- train the next generation of researchers (Ibid., 7; see also, CFI 2015, 2).

Over the first two decades of its existence, the CFI invested more than $7 billion in research infrastructure (CFI 2017, 6).

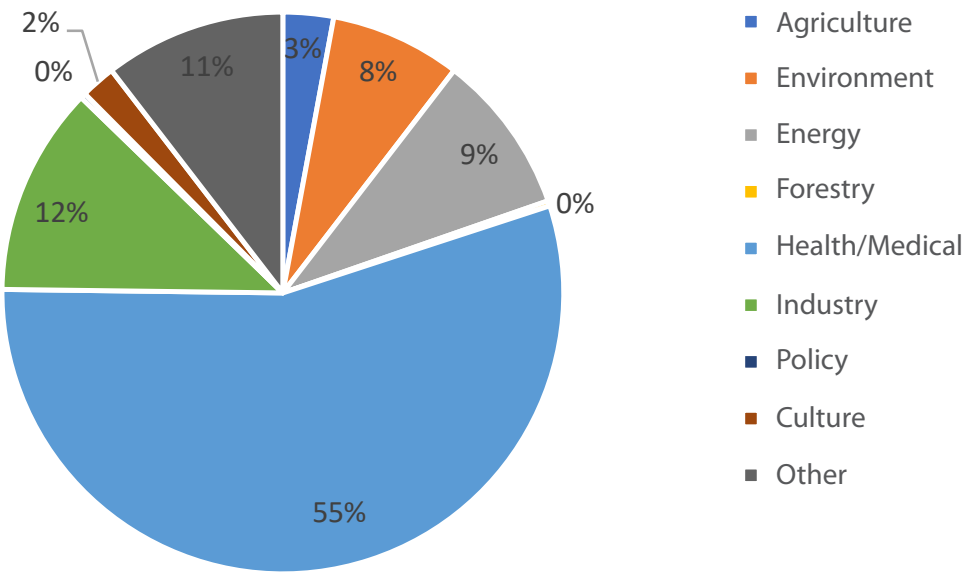
Priority areas for funding are determined through consultations with institutions that are eligible to apply for CFI funding. These institutions include universities, colleges, research hospitals, and non-profit institutions.[13] However, it is notable that the act establishing the CFI (Bill C-93) directed that half of the members representing "the public" on the institute's governing body would come from "the business community or non-profit organizations"; as of 2009, none had come from NGOs, non-profits, or trade unions (Guppy, Grabb, and Mollica 2013, 8). Moreover, "innovation" and "infrastructure" were interpreted to mean the kind of facilities used in science and engineering fields, largely excluding the social sciences and humanities (Ibid., 4). Thus, from 1998 to 2009, 58 per cent of funding went to the natural sciences and engineering, 33 per cent to health sciences, 5 per cent to fine arts, humanities and social sciences, and 5 per cent to "multidisciplinary" initiatives (Ibid., 5).

CFI-funded facilities are home to graduate student and post-doctoral researchers, and secure additional funding from industry and provincial government sources.

Including the University of Lethbridge in our analysis of CFI funding to Alberta universities covering the period from 1998/99 to 2016/17, we recorded a total of 833 CFI-funded projects at the three universities over this period: 493 for UAlberta, 301 for UCalgary, and 39 for ULethbridge. Associated with the CFI funding awards were 433 researchers from the University of Alberta, 264 from the University of Calgary, and 33 from the University of Lethbridge. Altogether, these three universities received $539.6 million in constant 2015 dollars from the CFI over this 19-year period.

The largest share by far of CFI funding to the three Alberta universities goes to health and medical research (Figure 2.8). However, our focus in this report is on funding to energy, environmental science, or sustainable development research, which is allocated, for the most part, to faculties other than Medicine.

Figure 2.8 Allocation of CFI Funding by Area of Research (Three Alberta Universities Combined), 1998/99 to 2016/17 (Percentages)



Source: CFI Awards Database

Energy-Related Research

As we see in Figure 2.8, energy-related research accounts for only 9 per cent (approximately $51 million) of CFI funding to these three universities combined. Within this relatively small share, however, fossil-fuels-related R&D again predominates in terms of the number of awards as a percentage of all energy awards: 61 per cent at UCalgary and 84 per cent at UAlberta.[14] In comparison, funding for R&D related to renewables amounted to only 16 percent of energy-domain awards at UCalgary and 12 percent at UAlberta.

We further examined the kind of research that has been funded *within* the "energy" domain, classifying each project as one of fossil-fuels-related (FFR), nuclear-related (NR), fuel cells (FC), biofuels, energy efficiency or conservation (EECons), or renewable energies (RenEn). All but one of the energy projects were conducted at either the UAlberta or the UCalgary. In Table 2.3 we see the breakdown of funding for sub-categories of energy-related research, the weighting of these categories as percentages of all energy R&D, and their shares of total CFI funding to these universities. It is notable that energy funding accounted for 15.3 per cent of Calgary's CFI funding, compared to 6.3 per cent of Alberta's CFI funding over the 1998/99 to 2015/16 period.

We also see in Table 2.3 that 27 out of 44 (or 61 per cent) of the CFI-funded energy *projects* at the UCalgary were fossil-fuels-related. Fuel cell and renewable energy projects competed for second place. Work on energy efficiency and conservation accounted for only 5 per cent of CFI-funded energy research projects at UCalgary. At UAlberta, the dominance of FFR research was even more pronounced, accounting for 48 out of 57, or 84 per cent of energy research projects over the 18-year period. At UAlberta, we found only seven awards related to renewable energies research—all made between 2009 and 2016.

In terms of *funded amounts*, fossil-fuels-related energy research at the University of Alberta accounted for 77 per cent of all CFI funding for energy R&D, while the comparable figure at the University of Calgary was 85 per cent. We noted that renewable energy research did significantly better at UAlberta than its share of awards (12 per cent), receiving a total of $4,712,727 (constant 2015 $CAD) over the whole period, or about 22 per cent of all *funding* for the energy category ($21,134,073). Renewable energy research received only 6.3 per cent of CFI funding for energy research at the University of Calgary. Funding for other areas of energy research was negligible, with the exception of fuel cells research at the University of Calgary, which received 6.6 per cent of energy-related funding from the CFI.

Table 2.3 CFI Funding for Energy-Related Projects at Three Alberta Universities, 1998/99 to 2015/16

Category of Energy Research	Fossil Fuel	Nuclear	Renewable	Fuel Cells	Energy Efficiency and Conservation	Biofuels	Totals	Total CFI Funding for Institution (all sectors of research)
Number of projects by energy category for **UCalgary**	27	0	7	7	2	1	44	
Percentage of CFI funded projects in energy at **UCalgary**	61	0	16	16	5	2	100	
Number. of projects by energy category for **UAlberta**	48	0	7	1	0	1	57	
Percentage of CFI funded projects in energy at **UAlberta**	84	0	12	2	0	2	100	
Amounts awarded to projects in this category for **UCalgary**	25,076,960	0	1,876,636	1,968,498	363,913	368,108	29,654,117	192,145,498
Percentage of CFI funding for energy-related projects **UCalgary** (rounded figures)	84.6	0	6.3	6.6	1.2	1.2	99.8	
Amounts awarded to projects in this category for **UAlberta**	16,224,035	0	4,712,727	90,675	0	106,635	21,134,073	333,804,593
Percentage of CFI funding for energy-related projects **UAlberta** (rounded figures)	76.8	0	22.3	0.4	0	0.5	100	
Amounts awarded to projects in this category for **ULethbridge**	424,309	0	0	0	0	0	424,309	13,599,955
Percentage of all **ULethbridge** CFI funding	3.1	0	0	0	0	0	3.1	
Category of energy research's share of funding as a percentage of institutions total CFI funding over the 17-year period: **UCalgary** (rounded figures)	13.05	0	0.9	1	0.19	0.19	15.33	
Category of energy research's share of funding as a percentage of institutions total CFI funding over the 17-year period: **UAlberta** (rounded figures)	4.86	0	1.4	0.02	0	0.03	6.31	

Source: CFI Awards Database

Environmental-Related Research

Table 2.4 summarizes the projects in the area of environmental research that received CFI funding at the three universities during the1998/99 to 2015/16 period. We again assessed the weight of different categories of environmental research, as a percentage of total environmental projects funded, as well as by each category's share of funding for environmental research. While the amounts of money awarded are significant for the research labs, one can see that, overall, they do not constitute a large portion of total CFI funding to these institutions.

Table 2.4 CFI Funding for Environment-Related Projects at Three Alberta Universities, 1998/99 to 2015/16

Category of Environmental Research	Sustainable Development	Other Environmental	Fossil-Fuels-Related	Ecosystems	Climate Change Science	Totals (sums)	Total CFI Funding to Institution
Number of projects at **UCalgary**	1	3	2	2	5	13	
Number. of projects at **UAlberta**	0	21	5	18	6	50	
Number of projects at **ULethbridge**	1	2	0	2	1	6	
Percentage of env. projects at **UCalgary**	7.69	23.07	15.38	15.38	38.46	100	
Percentage of env. projects at **UAlberta**	0	42	10	36	12	100	
Percentage of env. projects at **ULethbridge**	16.66	33.33	0	33.33	16.66	100	
Funding for category of research at **UCalgary**	117,399	12,590,820	598,229	452,520	1,034,851	14,793,821	192,145,498
Funding for category of research at **UAlberta**	0	10,744,709	920,952	9,270,131	2,662,591	23,598,384	333,804,593
Funding for category of research at **ULethbridge**	145,620	376,979	0	245,344	81,255	849,199	13,599,955
Percentage of env. research funding **UCalgary**	0.79	85.1	4	3.1	7	99.99	
Percentage of env. research funding at **UAlberta**	0	46	4	9.3	39.3	98.6	
Percentage of env. research funding at **Ulethbridge**	17.1	44.4	0	28.9	9.6	99.96	
Percentage of all CFI funding **UCalgary**	0.061	6.6	0.31	0.24	0.54	7.75 (7.8)	
Percentage of all CFI funding at **UAlberta**	0.0	3.22	0.28	2.78	0.8	7.08 (7.1)	
Percentage of all CFI funding at **ULethbridge**	1.1	2.8	0	1.8	0.66	6.36 (6.4)	

Source: CFI Awards Database

We see that environmental funding accounted for 7.8 per cent of UCalgary's CFI funding, 7.1 per cent of UAlberta's CFI funding, and 6.4 per cent of ULethbridge's CFI funding. (Overall, environmental funding accounted for $39.2 million of the $539.6 million in CFI funding received by the three universities over the 1998-2016 period, or 7.3 per cent.) Environment-related research at UAlberta has done better than energy-related research, which obtained only 6.3 per cent of total CFI funding. This relationship was reversed at the UCalgary, where energy projects have secured 15.3 per cent of all CFI funding compared to environment's 7.8 per cent.

Sustainability-Related Research

Lastly, we searched the CFI database for any projects that could be classified as making contributions to "sustainable development," no matter the general area of application. In this category we included sustainable agriculture, sustainable forestry, or policy/planning/design work focussing on sustainable development. Of the 833 CFI-funded projects that we coded for the 1998/99 to 2015/16 period for the three universities, only eight (0.9 per cent) fell into this category. Together, these accounted for $1,200,235 or 2.7 per cent of CFI spending. Such projects were funded in only seven of the 19 years for which we examined the data, and we found nothing earlier than 2000.

3. Provincial Funding

The role of the Ministry of Advanced Education in the provincial government's planning of, and investment in, Alberta's model of economic development, has attracted little scholarly or media attention, but is of great significance. Along with the earlier Ministry of Innovation and Science, and, very recently, the Ministry of Economic Development and Trade, Advanced Education in all its incarnations (paired with technology, enterprise, and innovation) has been a major conduit of provincial investment in science and technology research. The ministry responsible for post-secondary education institutions has been linked, over decades, to governmental visions and strategies of technology development in multiple sectors, including fossil fuel industries. While multiple ministries have been assigned roles in the planning, investment, and legitimation efforts surrounding fossil fuels extraction (in particular, the oil sands), the ministry responsible for "innovation" has overseen the investments shaping the priorities of the entire publicly funded research infrastructure, including those of the research-intensive universities and the polytechnic institutes. In 2006, for example, the Ministry of Advanced Education and Technology's four-year business plan identified "innovation" as its second "core business" (after "learning"), and its four "key research areas" as energy, life sciences, information and communications technology, and nanotechnology (Advanced Education and Technology 2006, 63). A 2012 review of the government's long-term strategy for the development of the oil sands and for management of issues related to the oil sands listed no fewer than 25 areas of investment for which Alberta Enterprise and Advanced Education was the lead ministry (Government of Alberta 2012).

In this section, we review the investments of provincial government ministries—and agencies that report to these ministries—in research and development in the environmental and energy fields. Some of this investment goes to the "in-house" science and technology development conducted in arm's-length agencies like Innotech. Some of the investment goes to fund research centres or research chairs based in the universities.

3.1 Alberta Science and Research Investments Program (ASRIP)

We recorded all the ASRIP-funded projects at the four "Comprehensive Academic Research Institutions" (CARIs), i.e., for the universities of Alberta, Athabasca, Calgary, and Lethbridge. We analyzed the period from 1997/98 (when ASRIP began to disburse funding) to 2014/15 (the most recent data available at the time of writing), *excluding* projects in the medical, ICT, and nanotechnology fields. Coded projects included those funded by the Intellectual Infrastructure Partnership Program (IIPP), Research Excellence Envelope (REE),[15] and Science and Research Fund (S&R) and

later, by the Research Capacity Program (RCP, from 2009–2015).[16] This gave us a total of 159 projects, funded to the amount of almost $95 million (in constant 2015 dollars). The projects were first coded by area of research: energy, environmental science, agriculture, forestry, social sciences (see Table 3.1). These categories were further broken down by types of energy or environmental research, and by whether there was a sustainable development focus (e.g., sustainable forestry, sustainable agriculture, urban planning).

Table 3.1 ASRIP Project Categories

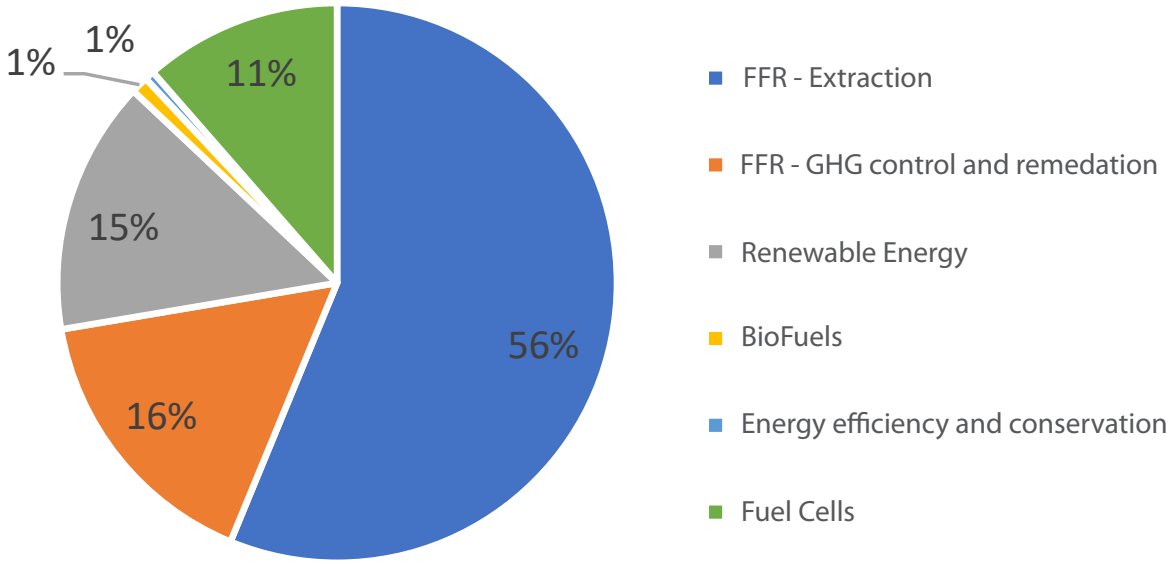
Category 1	Sub-categories
Energy	Fossil-fuels-related (FFR); renewable energy (RenEn); biofuels; energy efficiency or conservation (EECons); fuel cells (FC)
Agriculture	Prion research; sustainable agriculture (SusAgr); other agricultural research
Environment	Ecosystems/conservation (ECOSYS); climate science (CCSci); other environmental research
Forestry	Sustainable forestry; other forestry
Social Sciences	Sustainable development-related; other social science

ASRIP funding to the four CARIs totalled $395.2 million from 1997 to 2015. Most of this funding has, since 2000, gone to energy-related research. Indeed, about 52 per cent of the $95 million allocated to the five categories went to energy-related projects, followed by environment (28 per cent) and agriculture (19 per cent). Of the agriculture funding, only two projects were coded as being in the category of "sustainable agriculture." Only 1 per cent of ASRIP funding went to forestry, and we found only one project in the social sciences.

Energy Research

Figure 3.1 below displays ASRIP's "energy" research spending from 1997 to 2015, which amounted to approximately $49 million in constant 2015 dollars. The single largest recipient of funding, as we see in Figure 3.1, was research related to fossil fuel extraction (56 per cent, or $27.4 million). Second in priority was research on greenhouse gas emissions (including carbon capture and storage) and other forms of environmental remediation related to fossil fuels extraction, processing, or transportation (16 per cent). Research on renewable energies came third at 15 per cent of "energy" research spending.

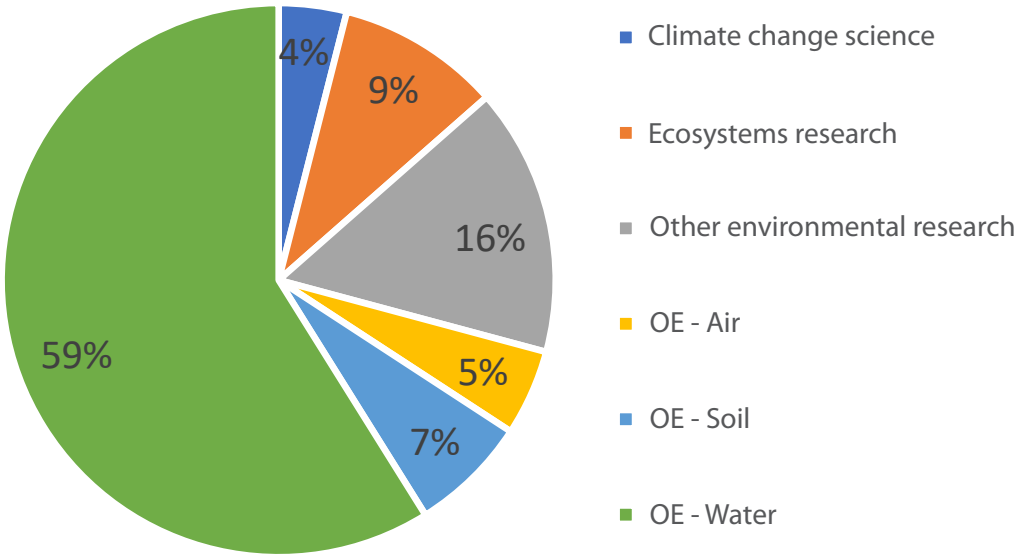
Figure 3.1 ASRIP/RCP Funding for Energy-Related Research, 1997/98 to 2014/15



Environmental Research

Regarding ASRIP's funding of environmental research, our breakdown of projects by types of research revealed that water research (wastewater treatment; the effects of water quality on fish health; mercury sources, deposition, and accumulation; general water chemistry) has received by far the largest share of the total expenditure on "environmental research" over the period of 1997–2015 (see Figure 3.2). However, 77 per cent of funding for water research went to only one project in 2008/09 (Advancing Canadian Wastewater Assets, UCalgary).[17] Discounting this one-off exceptional funding, environmental research infrastructure was funded, on average, by less than $1 million per year over this 18-year period. The second-most-funded category was "other environmental research," which includes a variety of research topics from microbial research to plant physiology and emerging organic contaminants. Climate change science received only 4 per cent of funding in the environmental category. We also note that the total expenditure for environment-related research was only about $26 million, compared to $49 million for energy-related research.

Figure 3.2 ASRIP/RCP Funding for Environmental Research, 1997/98 to 2014/15



Trends Over Time for ASRIP Funding

To see if ASRIP funding priorities had changed over time, we took snapshots of its funding allocations during four different periods: 1997/98 to 1999/00; 2000/01 to 2004/05; 2005/06 to 2009/10; 2010/11 to 2014/15 (see Figures 3.3 to 3.6). Four findings stand out.

First, the data show a marked decline in ASRIP funding for agriculture-related research from the first period (1997/98 to 1999/00) to the most recent period (2010/11 to 2014/15), with funding totals falling from $13.2 million to $300,000 (rounded figures)—a decline equivalent to a fall from 61 per cent of total funding (for our five categories) to a miniscule 1 per cent.

Second, energy-related projects' share increased, by contrast, from 28 per cent to 79 per cent. Most of ASRIP's (non-medical, non-ICT) funding since 2000 has gone to energy-related research.

Third, environment-related projects gained in importance from 1997/98 to 2009/10, receiving the largest share of funding in the third period (2005/06 to 2009/10)). However, the share of environmental research in ASRIP's allocations shrank hugely in the last period (from 48 to 20 per cent). Forestry-related research had only one period of notable funding, at 5 per cent in the 2000/01 to 2004/05 period.

Figure 3.3 ASRIP Funding for Five Categories of Research, 1997/98 to 1999/00 (total ~ $21.8 million constant 2015 CAD)

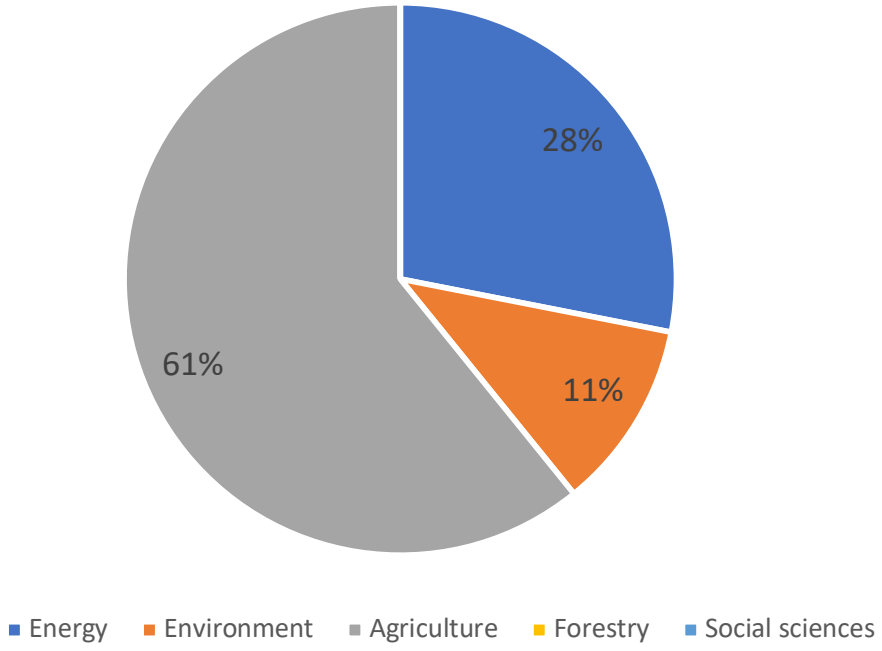


Figure 3.4 Funding for Five Categories of Research, 2000/01 to 2004/05 (total ~ $20.8 million constant 2015 CAD)

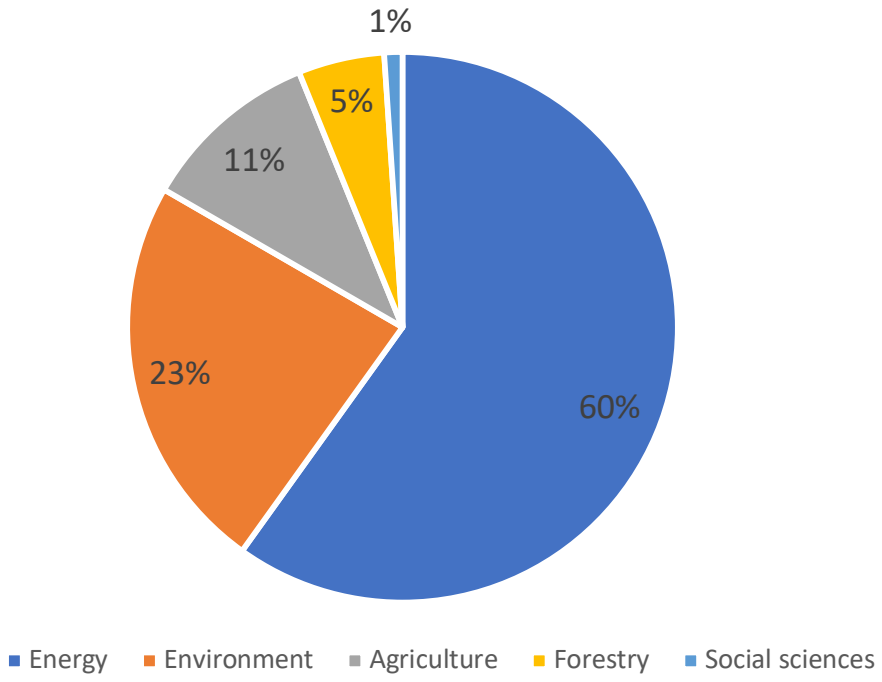


Figure 3.5 ASRIP Funding for Five Categories of Research, 2005/06 to 2009/10 (total ~ $30.3 million constant 2015 CAD)

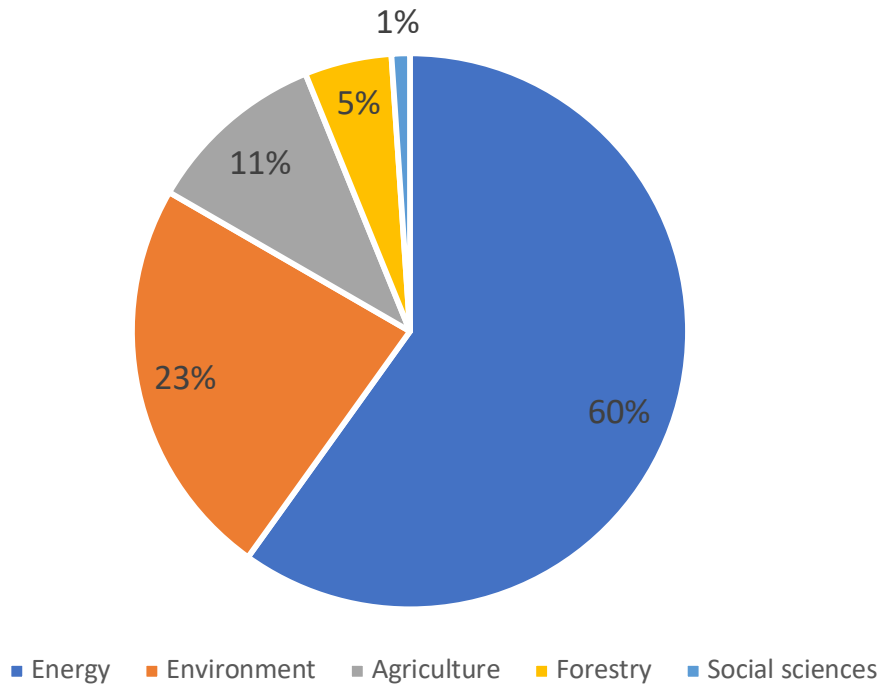
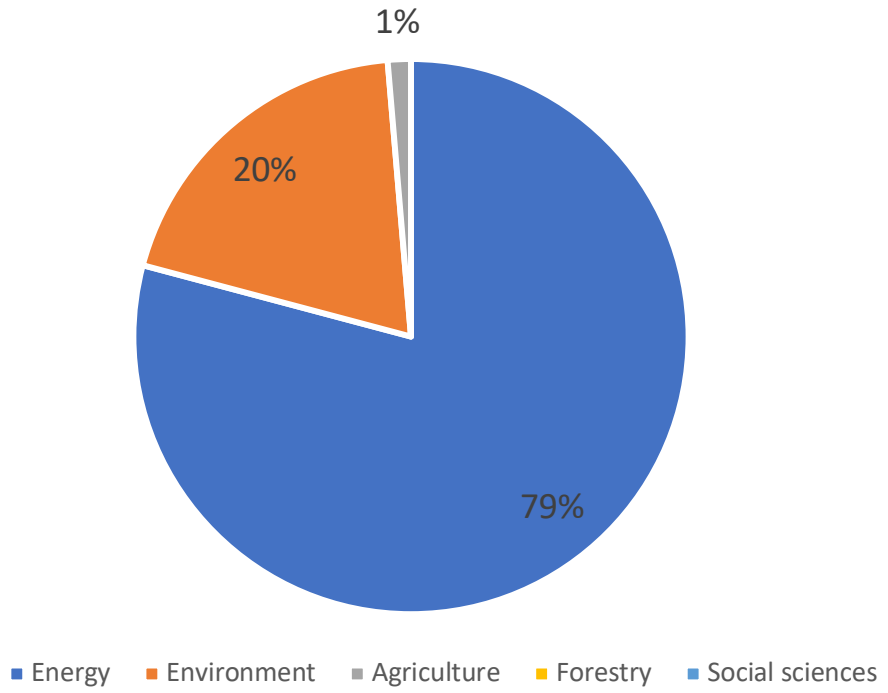


Figure 3.6 ASRIP Funding for Five Categories of Research 2010/11 to 2014/15 (total ~ $21.7 million constant 2015 CAD)



Fourth, within the domain of energy research, tracked in Table 3.2 below, ASRIP funding for renewables and fuel cells research increased substantially after 2010, accounting for 30 per cent and 26 per cent, respectively, of all energy-area spending between 2010/11 and 2014/15. Still, FFR-related research took the largest share of energy-related funding in this period, at 43 per cent.

Table 3.2 ASRIP Funding to Alberta PSEIs in Selected Categories of Energy R&D, 1997/98 to 2014/15 (2015 constant dollars)

Category of Energy R&D	1997/98 – 1999/00	2000/01 – 2004/05	2005/06 – 2009/10	2010/11 – 2014/15
FFR – Extraction	3,623,498	7,572,399	11,237,442	4,646,138
FFR – GHG control and remediation	1,188,895	2,761,802	1,053,937	2,898,617
Renewable Energy	823,826	916,914	242,114	5,214,733
BioFuels	0	488,595	0	0
Energy efficiency and conservation	0	270,941	0	0
Fuel Cells	0	436,374	753,838	4,410,875
Totals	5,636,221	12,447,027	13,287,333	17,170,365

Source: ASRIP reports on research funding to PSEIs (see note 16).

3.2 Alberta Innovates

Since the establishment of Alberta Innovates (AI) in 2010, about 40 per cent of its operating grant from the provincial government has gone to medical research, with the remainder divided among biotechnologies, sciences, and engineering fields. Agricultural research received about $4 million from AI-Bio-Solutions over this period, or 3.7 per cent of the agency's funding to universities.[18]

Alberta Innovates-Technology Futures (AI-TF) is the central organization for energy research, having incorporated the Alberta Research Council (ARC) in 2010. AI-TF provided $3 million in grants to Alberta universities between 2010 and 2016, and also funds six research centres, two "accelerator" programs (in nanotechnology and energy) associated with the universities of Alberta and Calgary, and multiple university-based research chairs. The research chairs expenditure for the 2010–2016 period alone was over $71 million. None of the other AI corporations funded research chairs.

From 2010 to 2016, AI-TF received 42 per cent of all government budget allocations to the four AI corporations, whereas AI-Energy and Environment Solutions (AI-EES) received only 10 per cent. Notably, almost half of AI-EES's grants to university-based research ($42.4 million) also went to energy-related R&D (see Table 3.3). Only a small portion of AI-EES's grants to universities over five years ($8.3 million, or 9 per cent) can be identified as going to environmental research not connected to the oil sands or to FFR R&D.[19]

Table 3.3 AI-EES Grants to University Research by Category, 2010–2016 (thousands $CAD)

Energy technologies	$23,384
Energy & environment research	$19,007
Alberta Water Research Institute	$16,824
Water and tailings research	$14,917
Water and environmental management	$8,330
Renewable and emerging resources	$5,860
Clean energy	$0
Total	$88,322

Source: Data provided by the FOIP Officer for Alberta Innovates, July 17, 2017.

3.3 Provincial Innovation Funds

In addition to the Alberta Science and Research Investments Program and the Alberta Innovates budgets, the provincial government periodically creates other funds to invest in priority areas for "innovation." These funds provide grants to university-based research, as well as grants or tax credits to corporate R&D. They may also finance research facilities that are used for joint university-private sector R&D.

Alberta Ingenuity Fund (the Alberta Heritage Foundation for Science and Engineering Research 2000–2009) had a mandate to fund science and engineering research and was initially endowed with $500 million from Alberta's Heritage Savings Trust Fund, to which another $500 million was added in 2004/05. The Government of Alberta appointed the Board of Trustees, which reported to the Minister of Advanced Education and Technology (Gartner 2007, 20). Between 2000/01 and 2006/07, the fund's annual spending grew from $600,000 to about $24 million (Ibid.). In addition to disbursing grants to hundreds of university-based researchers,[20] the AIF contributed to the Alberta Ingenuity Centres and Institutes. In the energy and environment areas, these included:

- Alberta Ingenuity Centre for In Situ Energy (AICISE) was created in late 2004 with a grant from AIF of $1.234 million per year. (In 2010 AICISE was moved under the umbrella of Alberta Innovates.)
- Alberta Ingenuity Centre for Oil Sands Innovation (COSI), established in 2007, received $3.46 million from AIF in its first three years (Alberta Ingenuity c. 2007, 33).
- Alberta Ingenuity Centre for Machine Learning, established in 2002, received $6 million from AIF between 2002 and 2006 (Alberta Ingenuity c2007, 4) and $8 million between 2010-2014.[21]
- Alberta Ingenuity Centre for Water Research, established in 2002, received $5.3 million between 2002 and 2006 (Alberta Ingenuity c2007, 4).[22]

By 2008 the AIF had invested "more than $20 million in the Centres program since its inception" (Alberta Ingenuity 2008b, 18). The AIF also funded "industrial associateships" (Ibid., 28–29).

Innovative Energy Technologies Program, administered by the Ministry of Energy, was established in 2004, and provides $200 million per year in royalty credits to firms that invest in "innovative technologies." The list of the 40 projects that have been approved for royalty "adjustments" since 2004 shows that recipients have included about 20 corporations operating in the oil sands.[23]

Energy Innovation Fund I was created in 2006 with a $200 million budget to support corporate "research, advanced technologies, market development and innovative projects focusing on energy supply and protection of the environment."[24] Information about only one of the projects funded by the EIF has been made available to the public.[25] Titanium Corporation has been granted more than $3.8 million to research recovery of bitumen, zircon, and titanium-bearing minerals from oil sands mine tailings.[26] Otherwise, there has, as yet, been no public accounting of the expenditure of this $200 million fund.

Alberta Carbon Capture and Storage Fund was established by an act of the legislature in 2009 to provide co-funding to corporate CCS projects up to the amount of $2 billion. To date, $495 million have been committed to the Alberta Carbon Trunk Line, and $745 million to the Quest CCS Project.[27]

Climate Change Emissions Management Fund was established in 2004 by the Climate Change and Emissions Management Amendment Act, although its regulatory framework was not in place until 2009/10. An in-depth study of CCEMC disbursements from 2009/10 to 2016/17 showed that 45 per cent of CCEMC funding ($197 million) had gone to fossil-fuels-

related technologies (with 56 per cent of this going to oil sands technologies) (Adkin 2019). Renewable energy projects took the second largest share of CCEMC funding, at 28 per cent. Following the election of the Alberta NDP in May 2015, CCEMC allocations for renewable energies R&D increased, with five of the 14 renewable energy projects that have been supported by CCEMC being funded in 2016/2017. Investment in energy efficiency projects not related to the fossil fuels sector received only 2 per cent of CCEMC funding over this seven-year period. Only 2 per cent of CCEMC funding went to climate change adaptation and science research, and 2 per cent to agriculture-related research.

Under the NDP government, the rebranded CCEMC—now Emissions Reduction Alberta (ERA)—was showing interest in increasing its support for "biological resource optimization" (biofuels, bio-products and materials, bioenergy, carbon retention, nitrous oxide (N2O) and methane (CH4) emissions (capture, use, reduction), and waste management technologies). Some of these technologies will have applications to agriculture and forestry and were linked to economic diversification goals as well as to GHG reduction goals. However, the CCEMC/ERA continues to be a vehicle for investment in GHGM investment in the oil sands sector, essentially recycling revenue from the levy on large emitters back into R&D conducted by the same corporations. Twenty of the large emitters regulated under the Specified Gas Emitters Regulation (SGER) were awarded a total of $168.8 million for 28 projects, or 39 per cent of all CCEMC disbursements between 2009/10 and 2015/16. In August 2018 the NDP government announced the appointment of a former president of the Canadian Association of Petroleum Producers as the new chair of the board of directors of Emissions Reductions Alberta.[28]

Energy Innovation Fund II was launched by the Alberta NDP government in December 2017, using revenue from the carbon levy on large emitters to fund $1.4 billion of R&D. This amount is divided among five categories: Oil Sands Innovation Fund ($440 million); Innovation Across Sectors to reduce industrial carbon emissions ($225 million); Industrial Energy Efficiency ($240 million); Bioenergy ($63 million); and Green loan guarantees for companies in the energy efficiency and renewable energy sectors ($400 million). The Oil Sands Innovation Fund, in particular, responds to requests from CAPP and its members for a "new AOSTRA" (referring to the Alberta Oil Sands Technology Research Authority created in the 1970s to develop the technologies for bitumen extraction and upgrading).[29] The "next generation" of oil sands technology aims to reduce the water and carbon footprints of extraction and upgrading—particularly in in situ extraction—so as to allow the industry to increase production while remaining under the legislated sectoral "cap" of 100 Mt of carbon dioxide equivalent (CO2e) and to sell Alberta heavy oil as a "clean energy" product in global markets.

Petro-chemicals Diversification Program, announced in February 2016, will provide up to $1 billion in royalty credits to firms converting methane, ethane, and propane into higher value-added products like methanol and plastics. The program aims to "expand Alberta's petro-chemical sector, increase the supply of natural gas liquids to encourage investment in additional petrochemical processing and, ultimately, diversify Alberta's economy."[30] (The United Conservative Party (UCP) government elected in April 2019 has decided to continue this program.)

4. Research Centres, Institutes, Research Chairs, Consortia, Networks

4.1 Research Centres and Institutes

Most of the energy centres and institutes are dedicated primarily to fossil-fuels-related R&D. Provincially funded AOSTRA (1974–2000), Petroleum Recovery Institute (1975–2000), Alberta Research Council (ARC) (1981–2009), Alberta Energy Research Institute (AERI) (2000–2010), and Alberta Innovates (AI-TF—now InnoTech—and AI-EES) have been the engines of R&D related to the oil sands, both in their in-house labs and through their funding of university-based R&D (predominantly in the engineering faculties at the universities of Alberta and Calgary). Many of the university-based centres are funded through a combination of grants and endowments from federal and provincial government agencies as well as corporate endowments or membership fees. Corporations also provide support in kind, usually in the form of laboratory, plant, or pilot-project facilities. The provincial and federal programs that fund research chairs often link the chair positions to the development or direction of a centre.

Table 4.1 provides a list of the centres or institutes in the energy domain that are based at the University of Alberta. Table 4.2 lists those based at the University of Calgary, and Table 4.3 lists those that conduct research in other settings (but with which university-based researchers may be connected).

Table 4.1 Energy Research Centres or Institutes Based at the University of Alberta

Centre/Institute	Year Established	Funders/Partners
Geomechanical Reservoir Experimental Facility (GeoREF)	n/a	Athabasca Oil Corp., BP Canada Energy Group, Brion Energy, CNRL, Cenovus, China National Petroleum Corp., ConocoPhillips, Nexen CNOOC, Shell Canada Energy, Suncor Energy, NSERC, CFI, AI-iCORE, AI-EES; CMG Foundation.
Centre for Computational Geostatistics	1998	30–40 supporting companies, including Teck Resources Ltd., Aramco Services Co., Chevron Energy Technology, ConocoPhillips, Nexen, Petrobras, and many others.
Alberta Centre for Surface Engineering and Science (ACSES)	2002	NSERC; AI-TF; $4,979,599 from CFI in 2002. Nanofabrication but some fossil-fuel energy applications.
Centre for Intelligent Mining Systems (CIMS)	2002	AI-TF, NSERC, Syncrude; In 2002, Syncrude paid $500,000 to lease the lab for three years and outfit it with new equipment.
Oil Sands Tailings Research Facility (OSTRF)	2002	Universities of Alberta, Victoria, UBC, Queen's, Ottawa, CFI, NRCan (Canmet), ARC, AB Science and Research Investment Program, Syncrude, Suncor, Albian Sands, True North Energy, CNRL; $10 million in October 2004 from Imperial Oil; $8 million in Feb 2007 from Alberta Ingenuity Fund; $10 million in Feb 2007 from Alberta Access to the Future Fund; $2 million in Feb 2007 from NSERC.
Centre for Oil Sands Innovation (COSI) (Renamed the Institute for Oil Sands Innovation in 2013) (IOSI)	2005	"The Centre is a close partnership between the University of Alberta and Imperial Oil. Imperial Oil sits on the executive committee of the Centre and participates in the research management committee" (CAUT 2013). Funding from: AERI, Alberta Ingenuity Fund, Imperial Oil, AI-EES, Canada's Oil Sands Industry Alliance (COSIA), NRC, Natural Resources Canada (NRCan), and NSERC.[31]
Centre for Applied Business Research in Energy and the Environment (CABREE)	2005	Govt of Alberta ($300,000 to $650,000 per year for seven years); Enbridge $500,000 (2005/06), Campus Alberta Innovates Chair; funded by corporate and other organizational donations. Other sponsors include AltaLink, ATCO, BluEarth Renewables Inc., Capital Power.
Centre for Earth Observation Sciences (CEOS)	2006	Funding from CFI, ASRIP, NSERC, Canada School for Energy and the Environment (CSEE), Barrick Gold, IOSI, iCORE (AI-TF), and other corporate sources. Has established partnerships with Syncrude and Suncor Energy for hyper-spectral characterization of the oil sands.
School of Energy and the Environment (SEE)	2006	Alberta Energy Innovation Fund ($3 million in April 2008); CSEE
Oil Sands Research and Information Network (OSRIN)	2007	CSEE ($250,000); other grants and contracts; $4.5 million in start-up grants, 2008–2010, from AB Environment.
Canadian Centre for Clean Coal/Carbon and Mineral Processing Technologies (C5MPT)	2010	$21 million in July 2010 from Capital Power Corp., Teck Resources Ltd., Hatch Ltd., Nexen Energy ULC, CMG Reservoir Simulation Foundation, Glencore Canada Corp., Mancal Corp.; grant from AI-EES; support from University of Alberta and Faculty of Engineering; $3 million endowment from Xstrata in 2012 for a Research Chair in Mining and Mineral Processing Engineering.
Oil Sands and Coal Interfacial Engineering Facility	2010	NSERC; Suncor

Table 4.2 Energy Research Centres or Institutes Based at the University of Calgary

Centre/Institute	Year Established	Partners/Funding
Canadian Energy Research Institute (CERI)	1975	Partners: Government of Canada, Government of Alberta, and corporations. Core funders: Natural Resources Canada, Alberta Energy, CAPP. Donors: Alberta's Industrial Heartland Association, Chemistry Industry Assoc. of Canada, Government of Saskatchewan, Korea Energy Economics Institute, University of Calgary. In-kind support from Petroleum Services assoc. of Canada, Advisian, Alberta Energy Regulator.
Petroleum Recovery Institute	1975–2000	Funded by industry and the provincial government. Incorporated into the ARC in 2000.
Pipeline Engineering Centre	2003	Located in Schulich School of Engineering; no info about how funded.
Institute for Sustainable Energy, Environment, and Economy (ISEEE)	2003	University of Calgary, Schulich School of Engineering, Haskayne School of Business, the Faculties of Science, Law, Environmental Design, and Social Sciences, and the School of Public Policy.
Alberta Ingenuity Centre for In Situ Energy (AICISE)	2004	Partnered with ISEEE; AERI, AI-EES, University of Calgary, Shell International E&P, ConocoPhillips, Nexen; Total E&P, Repsol YPF.
Canada School for Energy and the Environment (CSEE)	2008–2014	$15 million from Industry Canada in 2008.
Carbon Management Canada	2009	Federal Networks of Centres of Excellence; seven corporations; became CMC Research Institutes in 2013

Tables 4.4 and 4.5 list centres or institutes in the environment or sustainable development domains. Unlike the energy R&D centres, and with the exception of the Alberta Biodiversity Monitoring Institute (ABMI), the environmentally oriented centres have relied predominantly upon granting agencies and internal support for their operations, rather than corporate endowments or endowments from the provincial innovation institutions. Over the past two decades, the Government of Alberta has provided funding to only two institutes conducting environment-related research.

From 2002–2006, the Alberta Ingenuity Fund provided $5,300,000 to the Alberta Ingenuity Centre for Water Research (Alberta Ingenuity 2006, 27). The centre had university-based "scientific directors" and secured funding from 11 other sources—most importantly, the CFI. In 2007, this centre was replaced by the Alberta Water Research Institute (AWRI), also funded from the Alberta Ingenuity Fund, with an initial funding base of $30 million over seven years. Its management advisory board was chaired by Lorne Taylor, who served as minister of Alberta Environment in the Conservative government of Ralph Klein. While the AWRI had a wide scope of concerns, at least two of the projects it funded were related to research on the oil sands

Table 4.3 Energy Research Institutions with Multiple Bases of Operation

Institution	Year Established	Partners/ Funding
Alberta Oil Sands Technology Research Authority (AOSTRA)	1974–2000	Created as a crown corporation to develop technologies for oil sands and heavy oil production; funded research in the universities. Received an estimated $1.4 billion in 2019 dollars (Hastings-Simons 2019, 1).
Canmet Energy Technology Centre	1975–	Funded by Natural Resources Canada (one third), and oil sands companies (two thirds); located in Devon, near Edmonton.
National Centre for Upgrading Technology (NCUT)	1995	Located in Devon, near Edmonton. Funding from Natural Resources Canada; AI-EES.
Alberta Energy Research Institute (AERI)	2000–2010	Successor to the AOSTRA. $76.7 million granted to AERI for 2006–2009 from the Energy Innovation Fund, administered by Alberta Energy.
Metagenomics for Greener Production and Extraction of Hydrocarbon Energy: Creating Opportunities for Enhanced Recovery with Reduced Environmental Impact	2005	$11.6 million in 2009 from Government of Alberta and Genome Canada; also supported by Genome Alberta and Industry Canada. Alberta centre based at UCalgary.
Advanced Energy Research Facility (biofuels)	2011	City of Edmonton, AI-EES, Enerkem.
Alberta Carbon Conversion Technology Centre (located at Shepard Energy Centre in Calgary)	2018–	Owned and operated by InnoTech Alberta, with funding from NRCan, Alberta Ministry of Economic Development and Trade, Emissions Reduction Alberta ($35 million). Other partners: COSIA, Enmax, Capital Power

tailings ponds.[32] In 2010, when the Stelmach government replaced the Alberta Ingenuity Fund institutes with the Alberta Innovates corporations, AWRI became part of AI-EES.

The second environmental institute that received funding from the Government of Alberta is the Alberta Biodiversity Monitoring Institute, created in 2010 as part of the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring. It is supported by InnoTech, and its partners over the years have included Alberta-Pacific Forest Industries, oil companies, Canada's Oil Sands Innovation Alliance (COSIA), the Petroleum Technology Alliance of Canada, as well as both UAlberta and UCalgary.[33]

Table 4.4 Environmental or Sustainable Development Research Centres or Institutes Based at the University of Alberta

Centre or Institute	Year Established	Partners/Funding
Canadian Circumpolar Institute	1990–2015	University of Alberta, research chairs and grant funding from federal agencies.
Environmental Research and Studies Centre	1997–2010	Received a three-year grant from TransAlta, c. 2000–2003.
Institute for Geophysical Research (IGR)	c. 2003	Studies the Earth, its oceans, atmosphere and cryosphere, and its near-space environment. No mention of external funding.
Alberta Centre for Sustainable Rural Communities	2009	Core operating budget from Augustana Campus and Faculty of ALES; research grants from federal and provincial agencies.
Alberta Biodiversity Monitoring Institute (ABMI)	2010	InnoTech (formerly AI-TF), AI-EES, Royal Alberta Museum, University of Alberta, University of Calgary; Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring, Alberta-Pacific Forest Industries, Inc., PTAC, AltaLIS.
Rangeland Research Institute	2015	The Rangeland Ecology and Management Fund (REMF) was established as an endowment in 2015 and "included funding contributions from powerline construction, a contribution from the Alberta Beef Producers, and significant contributions associated with the placement of a conservation easement on the Mattheis Research Ranch. The current value of the REMF as of March 31, 2017 was $5,761,324."

Table 4.5 Environmental or Sustainable Development Centres or Institutes Based at the University of Calgary

Centre/Institute	Year Established	Partners/Funding
Arctic Institute of North America	1945	Governments of Canada, USA
Canadian Institute of Resources Law (CIRL)	1979	Registered charitable organization, Alberta Law Foundation. Receives grants and contracts from governments, foundations, private sector

As these tables show, we found only six centres with some connection to environmental studies for the period 1990–2015 at the University of Alberta; four of these were still operating in 2017. At the University of Calgary, we found only two centres conducting environmental research: the Arctic Institute of North America and the Canadian Institute of Resources Law. There is also a Centre for Environmental Engineering Research and Fabrication located in the engineering school.

4.2 Research Chairs

Research chairs, funded by multiple governmental and private sources, play a large part in defining the profile of faculties, schools, and universities. They typically come with considerable resources for operating laboratories or other research facilities, hosting conferences, and paying salaries for lab technicians, post-doctoral fellows, and graduate student research assistants. As we saw with the lists of "top 20" partners on NSERC-funded research grants, corporations and corporate consortia are sometimes keen to support collaboration between their in-house scientific staff and university researchers. Industry representatives are also key stakeholders in determining government research funding priorities through bodies like the CFI, NRC, and NSERC.

The close relationship between influential market actors and government also operates at the provincial level, with agencies like Alberta Innovates (or in earlier decades, the ARC, AERI, or the Alberta Ingenuity Fund) matching federal grants, providing grants for equipment, and co-funding research chairs in the universities and technical colleges. A review of the research chairs established in the province's two leading research universities from 2000 to 2018 provides another window into governmental and university priorities for knowledge production. Again, our focus is R&D related to energy and environmental research and the implications of investment choices for the province's future path of development.

4.2.1 Canada Excellence Research Chairs (CERCs)

The Canada Excellence Research Chairs (CERC) program, initiated by the Harper government in 2008, "supports Canadian universities in building a critical mass of expertise targeted within the government priority research areas." These areas included environmental sciences and technologies, natural resources and energy, health and related life sciences and technologies, and information and communications technologies. A CERC award provides $10 million over seven years, to pay the CERC holder's salary, the salaries of other research team members, and fund the direct costs of the research program. In announcing the successful "phase one" applications for the second CERC competition in 2012, the Conservative government's Minister of State for Science and Technology, Gary Goodyear, stated that his government was "committed to supporting research and innovation in areas that are vital to Canada's future economic prosperity and growth."[34] Official discourse about the purposes of the CERCs has shifted somewhat, under the Liberals, with more emphasis on gender equity and diversity in the awarding of the chairs,[35] as well as an apparent broadening of the fields of research that are considered.

In the first round of CERC awards, made in May 2010, the University of Alberta secured one CERC in the energy field. This was the Chair in Oil Sands Molecular Engineering, held by Thomas Thundat in the Engineering Faculty. The University of Calgary secured a CERC Chair in Materials Engineering for Unconventional Oil Reservoirs, held by Steven Bryant in the Schulich School of Engineering.[36]

The awards made to Alberta universities have been, predominantly, in the energy and medical fields, while universities in other provinces have forwarded candidates in a range of environmental, information technology, medical, science, and social science fields. Environmental/sustainable development foci of research appear to be located elsewhere. For example, the University of Manitoba secured CERCs in Arctic Ice, Freshwater Marine Coupling and Climate Change and in Arctic Geomicrobiology and Climate Change; University of Waterloo in Ecohydrology; Concordia University won a CERC in Smart, Sustainable, and Resilient Communities and Cities; and the University of Saskatchewan has obtained CERCs in Food Systems and Security and in Water Security.

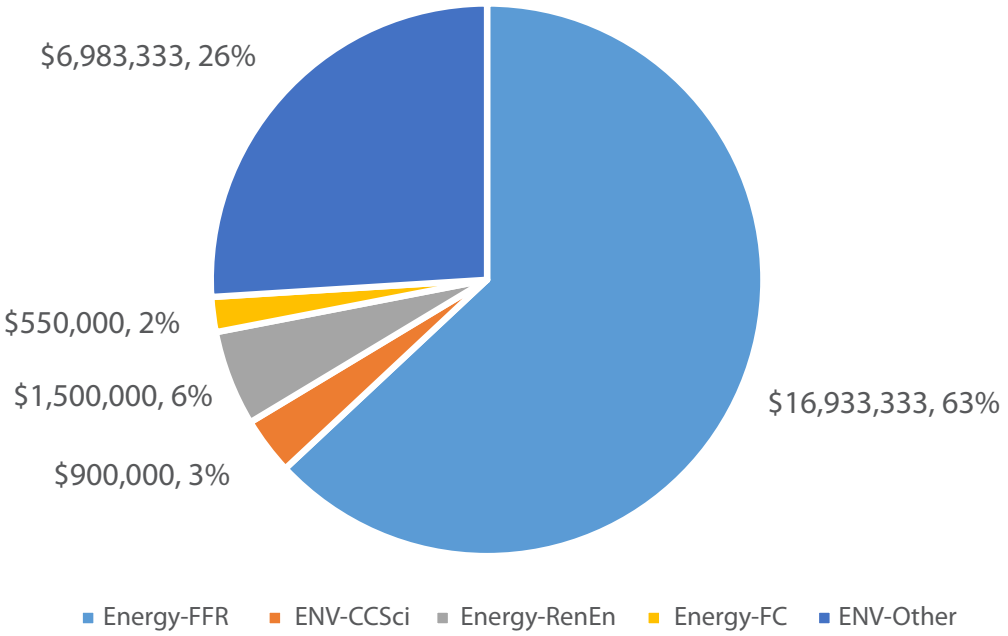
4.2.2 NSERC-Funded Research Chairs

Using the NSERC database and selecting for Canada Research Chairs (CRCs) and Industrial Research Chairs (IRCs) appointed between 2000/01 to 2016/17, we found 19 CRCs and 22 IRCs at the University of Alberta, and 17 CRCs and 17 IRCs at the University of Calgary. These 75 chairs were coded by area of research within the over-arching domains of energy and environment.

NSERC Canada Research Chairs

Starting with the CRCs, at the University of Alberta (see Figure 4.1) we found 13 in the energy domain and six in the environment domain.[38] Ten of the 13 Energy CRCs were doing research related to fossil fuels (extraction, processing, transportation, construction in the oil sands). One researcher was working on fuel cell technology, and two were working in the nanotechnology field on technologies with some applications to renewable energies. In the environment domain, one CRC was working in the area of climate science, and five in other areas. Totalling the NSERC funding received by these CRCs over this period, we see that research in the Energy-fossil-fuels-related (FFR) area received 63 per cent of all funding for the 19 CRCs (about $17 million). This compares to 6 per cent for renewable energy-related research and 3 per cent for fuel cell research. The environment-related CRCs together accounted for 26 per cent of funding.

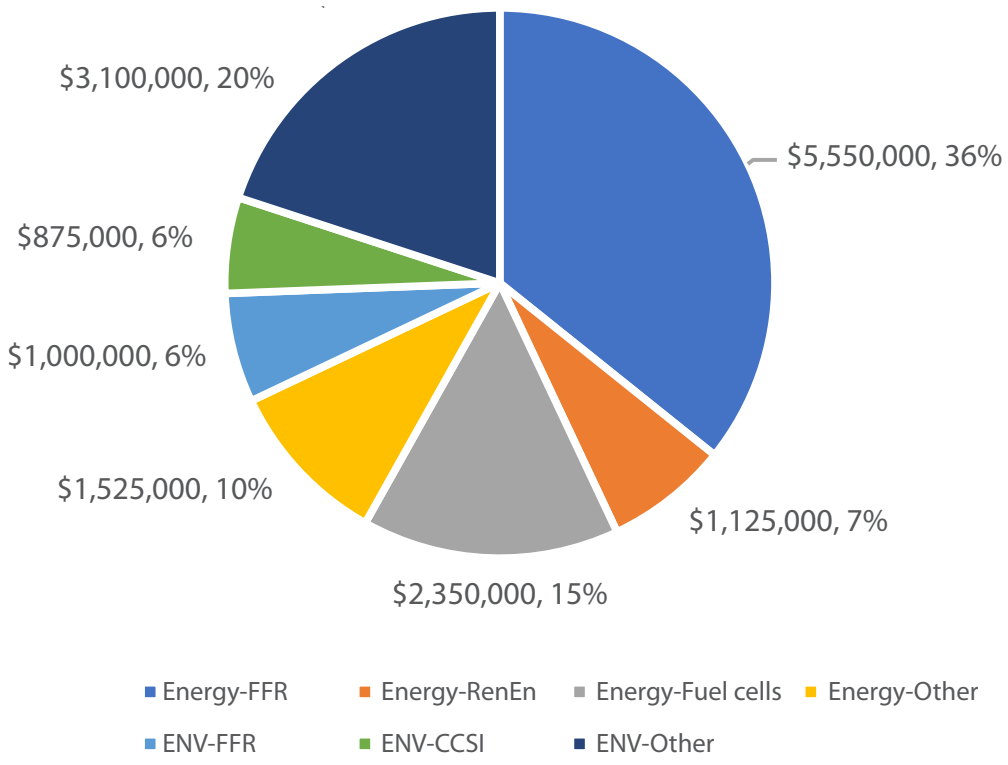
Figure 4.1 NSERC Funding for CRCs at the University of Alberta by Area of Research, 2000/01 to 2016/17



Source: NSERC Awards Database

At the University of Calgary (see Figure 4.2), we found 12 CRCs in the energy domain and five in the environment domain over the same period. Of the 12 Energy CRCs, six were in fossil-fuels-related R&D, three were in renewable energy areas, one in fuel cells research, and two in other energy areas (energy technology assessment and energy systems analysis/carbon capture and storage). In the Calgary case, we see that the fossil-fuels-related R&D, while still capturing the largest share of funding at 36 per cent, is part of a more diverse picture of energy-related CRCs than at the University of Alberta.

Figure 4.2 NSERC Funding for CRCs at the University of Calgary by Area of Research, 2000/01 to 2016/17



Source: NSERC Awards Database

NSERC Industrial Research Chairs

The NSERC IRCs are generally skewed heavily toward industrial, mining, and manufacturing areas of research. Starting again with the University of Alberta, we found a total of 22 IRCs awarded over the 2000–2017 period. As we see in Table 4.6, 20 of these were in the energy domain, and all were related to fossil fuels research, accounting for approximately $28.3 million in funding. The two IRCs in the Environment domain pertained to land reclamation and wildlife protection in the oil sands and forestry region.

Table 4.6 Number of Industrial Research Chairs and Funding at the Universities of Alberta and Calgary by Category of Research, 2000–2015

Research Area of the IRC	Number of IRCs at UAlberta, 2000–2015	Funding for IRCs at UAlberta. 2000–2015*	Number of IRCs at UCalgary, 2000–2015	Funding for IRCs at UCalgary, 2000–2015
Energy-FFR	20	28,265,596	15	18,845,447
Energy-REN	0	0	1	735,515
Energy-FC	0	0		0
ENV-CCSci	0	0		0
ENV-Other	2	2,797,124	1	111,200

*Nominal dollars

Source: NSERC Awards Database

At the University of Calgary, there were a total of 17 IRCs (in energy- or environment- related areas) over the same period. A full 16 of these were in the energy domain, and all but one of these were in fossil-fuels-related R&D (and that one was renewable energy related). The FFR IRCs captured approximately $18.8 million in NSERC funding, or 96 per cent of NSERC's funding of energy-related IRCs at the UCalgary. Only one IRC was coded as being in the Environment domain, and that was in municipal water engineering.

Industry Partners

Industry partners for IRCs held at the University of Alberta and Calgary are shown in Tables 4.7 (UAlberta) and 4.8 (UCalgary). We see that the UAlberta's Faculties of Engineering, ALES (Forestry Management), and Science IRCs are linked to at least three economic sectors (energy and petrochemicals; forestry and pulp; construction), whereas Calgary's IRCs are concentrated in the energy and petrochemicals sector.

Table 4.7 Industry Partners for IRCs Held at the University of Alberta

Economic Sector	Corporate Partners in NSERC IRCs at the University of Alberta
Oil, gas, coal, petrochemicals	Albian Sands Energy Inc., Angstrom Power Inc., Aramco Services, Baker Hughes, Baker Petrolite Canada, Canada's Oil Sands Innovation Alliance, Cenovus, Champion Technologies Ltd., CMG Reservoir Simulation Foundation, CNOOC Ltd., CNRL, ConocoPhillips Canada Resources Corp., Dow Chemical, Enbridge Pipelines Inc., EnCana, EPCOR Utilities, Husky Energy Inc., Imperial Oil, MacKay Operating Corp., Matrikon Inc., Nalco Canada Co., Nalco, Nexen Inc., Nova Chemicals, PEMEX Exploración y Producción, Petrobank Energy & Resources Ltd., Petro-Canada, Schlumberger Canada Ltd., Shell Canada Ltd., StatoilHydro Canada Ltd., Suncor Energy Inc., Syncrude Canada Ltd., Teck Metals, Total E&P Canada Ltd., TransCanada Pipelines Ltd.
Forestry, pulp	West Fraser Mills Ltd., Weyerhaeuser Canada Ltd.,
Construction	North American Construction Group Inc., PCL Constructors Inc., AECOM, Alberco Construction Ltd., Falcon Fabricators and Modular Builders Ltd., Finning Canada Ltd., Flint Energy Services Ltd. Graham Industrial Services Ltd., InSituForm Technologies Ltd., JV Driver Projects Ltd., Kellogg Brown & Root, Ledcor Group of Companies, PME Inc., Standard General Construction, Waiward Steel Fabricators Ltd., Clark Builders, Colt Engineering Corp., Construction Owners Association of Alberta, Landmark Master Builder, Ledcor Industrial Ltd., Licerbie & Hole Contracting Ltd.
Other	Atomic Energy of Canada Ltd., Sheritt International Corp., Apex Engineering, Outotec Canada Ltd., IOWC Technologies, QuestAir Technologies Inc.

Source: NSERC Awards Database

Table 4.8 Industry Partners for IRCs Held at the University of Calgary

Economic Sector	Corporate Partners in NSERC IRCs at the University of Alberta
Oil, gas, coal, petrochemicals	Suncor Energy, Nexen Energy, CNOOC Ltd., Shell Canada, EnCana, ConocoPhillips, Brion, CMG Reservoir Simulation Foundation, Computer Modelling Group, Devon Canada Corp., Japan Canada Oil Sands Ltd., MacKay Operating Corp., Penn West Petroleum Ltd., StatoilHydro-Canada Ltd., Total E&P Canada Ltd., Chevron Canada Resources Ltd., Athabasca Oil Sands Corp., Barrick Energy Inc., CNRL, Husky Oil Operations Ltd., Laricina Energy Ltd., Maersk Oil, Petroleum Technology Alliance Canada, Alberta Sulphur Research Ltd., ExxonMobil Upstream Research Co., Aramco Services Co., Baker Hughes Inc., BP Americas, Enerplus Corp., Intertek Commercial Microbiology, Oil Search Ltd., Shell Global Solutions, Dow Chemical, Yara International ASA, Nova Chemicals Corp., Canadian Association of Oilwell Drilling Contractors, Pason Systems, Talisman Energy Inc., Enmax Corporation, WSP Canada Inc.
Other	Virtual Materials Group Inc.

Source: NSERC Awards Database

4.2.3 Campus Alberta Innovates Program Chairs

In 2011 the Alberta government launched a research chair program in support of four "strategic priority areas" for the province's economy. These were: energy and the environment, food and nutrition, neuroscience/prions, and water. The government initially offered up to 16 research chairs to the four "comprehensive" post-secondary institutions: the universities of Alberta, Athabasca, Calgary, and Lethbridge. The positions would be funded for seven years in the amount of $300,000 to $650,000 per year.

As of May 2017, 18 CAIP chairs had been appointed at the four universities. If we classify them according to the four themes initially set out by the government, they are distributed as shown in Table 4.9. We see that all the appointments were made in the science and technology fields, with the exception of the CAIP awarded to the School of Business. None of the CAIP Chairs went to a Faculty of Arts, Education, Law, or Native Studies, or to social sciences, humanities or fine arts. When governments speak of "innovation" and "strategic priorities" they almost always mean R&D in applied sciences. While about half of the CAIP areas could produce knowledge or tools for government agencies charged with environmental management and health care provision, we also see linkages to the production of commercializable knowledge for the energy and agricultural sectors. Three of the five CAIP chairs appointed in the "energy and environment" category have applications for the oil industry. The designation of a "water" category may indicate a renewed governmental interest in this area in 2011. Eight of the 18 chairs were appointed in this area between 2012 and 2015. Government investment in the 18 CAIP chairs amounted, as of May 2017, to $51 million.[39]

4.2.4 Endowed Research Chairs

The endowed chairs listed in Tables 4.10 and 4.11 were identified from multiple searches of university and other websites. The main beneficiaries of these endowments have been the engineering schools; the UAlberta Faculty of Engineering alone has 12 endowed chairs or professorships related to energy research or funders. No chairs in environmental research were found at the University of Calgary (see Table 4.11); five were found at the University of Alberta.

Table 4.9 CAIP Chairs Appointed between 2012 and 2015

University	Energy & Environment	Neuroscience/Prions	Food and Nutrition	Water
Alberta	João Soares, Interfacial Polymer Engineering for Oilsands Processing (Engineering, 2013)	Michael Overduin, Structural Biology of Protein Mis-Folding Diseases (Biochemistry, 2014)	Carla Prado, Nutrition and Food Health (ALES)	David Olefeldt, "Watershed Management or Wetland Ecology" (ALES, 2014)
			Jens Walter, "Nutrition Microbes and Gastrointestinal Tract Health" (Science, 2014)	Susan Tank, Aquatic Ecosystem Health (Science, 2014)
				Emilson Silva, Innovation Policy & Technology Translation in Water and Energy (Business 2012)
				Maya Bhatia, Watershed Sciences (Science)
				Monireh Faramarzi, Watershed Sciences (Science)
Athabasca				Christopher Glover, Hydroecology and Environmental Health (Science & Technology, 2015)
				Junye Wang, Computational Sustainability and Environmental Analysis (Science & Technology, 2013)
Calgary	Marc Strous, Energy Bio-Engineering (Science, 2013)	Bruce Pike, Healthy Brain Aging (Hotchkiss Brain Institute, 2013)		
	Casey Hubert, Geomicrobiology (Science, 2014)			
Lethbridge	Nehalkumar Thakor, Synthetic Biology (Biochemistry) (biofuels)	Majid Mohajerani, Brain Health/ Dementia (Behavioural Neuroscience, 2013)		Gregory Pyle, Aquatic Health (Science/Water Institute for Sustainable Environments, 2013)
	Chris Hopkinson, Terrestrial Ecosystems Remote Sensing (Science, 2013)			

Sources: A summary of Campus Alberta Innovation Program Chair appointments was provided to the author by Mr. Neil Sulakhe, Director, Research Capacity Planning, Alberta Economic Development and Trade, May 15, 2017; web searches for researchers.

Table 4.10 Endowed Research Chairs in Energy at the Universities of Alberta and Calgary

Title of Chair	Institution	Funders (amounts)	Year Established (if known)
Suncor Energy Chair in Competitive Strategy and Sustainable Development	Calgary	Suncor Energy Ltd. ($200,000/year)	2010/11
Encana/Petroleum Society Chair in Petroleum Engineering	Calgary	Encana, Petroleum Society	
Encana Chair in Unconventional Gas	Calgary	Encana	
John Lau/Husky Endowed Chair in Bituminous Materials	Calgary	Husky Energy	2016
ConocoPhillips Industrial Professor in Engineering Safety and Risk Management	Alberta	ConocoPhillips, Dow Chemical	c. 2013
Nexen Professor in Catalytic Reaction Engineering	Alberta	Nexen	c. 2010
Alberta Chamber of Resources Industry Chair in Mining Engineering (petroleum reservoir characterization)	Alberta	Alberta Chamber of Resources	
Xstrata Chair in Mining and Mineral Process Engineering*	Alberta	Xstrata Canada Corp., Teck, Cominco Ltd., Syncrude Canada Ltd. ($3million)	2013
Ron Nolan/Hatch Professorship in Sustainable Energy and Mineral Process Technologies (oil sands)	Alberta	Hatch, COSIA, NSERC, Alberta Innovates, Natural Resources Canada	
William Magee Chair in Process Design and Suncor Energy Foundation Chair in Process Design for Sustainable Energy	Alberta	Dow Chemical, Suncor Energy Ltd.	
Teck-Cominco Professor in Mineral Process Systems (oil sands)	Alberta	Teck, Cominco	
EnCana Chair in Environmental Engineering	Alberta	EnCana ($3 million)	2008
Cenovus Energy Endowed Chair in Environmental Engineering	Alberta	Cenovus Energy ($3 million)	2013
CR Stelck Chair in Petroleum Geology	Alberta (Science)	Established by the University of Alberta	
Ernest and Gertrude Poole Chair in Management for Engineers	Alberta	Syncrude Canada Ltd., Atomic Energy of Canada Ltd.	
Enbridge Professor of Energy Policy	Alberta (Business)	Enbridge	c. 2005

*This Chair is located in the Faculty of Engineering's Canadian Centre for Clean Coal/Carbon and Mineral Processing Technologies (C5MPT).
Sources: University websites; Vivian Giang, "Faculty announces Foundation CMG Endowed Chair in Reservoir Geomechanics," Faculty of Engineering, November 25, 2014, https://www.ualberta.ca/engineering/news/2014/november/engineeringannouncesestablishmentofthefoundationcmg.aspx.

Table 4.11 Endowed Research Chairs in the Environment at the University of Alberta

Title of Chair	Institution	Sponsors	Year Established (if known)
Bocock Chair for Agriculture and the Environment (geochemistry)	Alberta (ALES & Science)	Alberta Ministries of Advanced Education, Sustainable Resource Development, and Environment; Canada Foundation for Innovation	2011
EnCana Chair in Water Resources	Alberta (Science)	EnCana ($3 million)	2008
Alberta Conservation Association Chair in Fisheries and Wildlife	Alberta (Science)	Alberta Conservation Association	
Alberta Biodiversity Conservation Chairs (2)	Alberta (Science, ALES)	Canada's Oil Sands Innovation Alliance (COSIA)	2013–2018

Sources: University websites; COSIA, https://www.cosia.ca/initiatives/land/projects/alberta-biodiversity-conservation-chairs; EnCana Corporation media release dated March 19, 2008 (copy in author's archives); Richard Cairney, "$4.4M investment in energy and environmental engineering at UAlberta," *Folio*, June 17, 2013.

4.3 Consortia, Networks, and Research Initiatives

Through the review of NSERC funding (especially of the Engage and Collaborate programs and the Industrial Research Chairs), as well as the orientation of the CFI and Alberta Innovates funding for research centres and chairs, we have seen how governments promote close relationships between university-based researchers and the private sector. These relationships are further cemented through researchers' participation in various industry-university-government consortia and networks. This section reviews consortia and networks associated with environmental or energy-related research. While not exhaustive, this review maps enough of the terrain to indicate how governments and corporations shape the priorities of university-based research. Not only academic faculty, but also graduate students and post-doctoral fellows are integrated into research groups whose objectives are significantly determined by private sector interests (as discussed in section 2). Given that most of the research carried out in these Alberta-based programs, networks, or consortia is related to the fossil fuel industries, this model of funding and training "highly qualified personnel" (re)produces technical knowledge and professional interests that are similarly tied to these industries. Indeed, graduate students, post-doctoral fellows, and junior faculty in our engineering faculties may have limited options to pursue other areas of research given the existing allocation of funding and investment in research facilities. [40]

4.3.1 Energy Consortia, Networks, and Initiatives

Table 4.12 sets out in short form the entities in the energy-related area that our search uncovered, listed chronologically according to the years in which they were established.

These 25 research consortia and networks indicate the density, interconnectedness, and decades-long history of industry-government-university collaboration on energy-related R&D. Given the province's political economy and the commitments of provincial and federal governments to the extractive development model, it is unsurprising that most of this research is related to fossil fuels reservoir exploration, extraction, processing, and transportation technologies.

EnergyINet, one of the networks listed in Table 4.12, illustrates the connections among corporations and government agencies involved in energy research. Participants in EnergyINet (formed in October 2005; dissolved in March 2008)[41] included the governments of Alberta (AERI, ARC, Ministry of Innovation and Science, Ministry of Energy, Ministry of Economic Development), British Columbia (BC Hydro, Ministry of Energy, Mines, and Petroleum Resources), Saskatchewan (SaskPower, Ministry of Industry and Resources), Nova Scotia (Nova Scotia Power, Dept. of Energy), and Natural Resources Canada, along with a list of corporations including: Agrium, CNRL, Encana, Luscar, Nexen, Nova Chemicals, Shell Canada, Suncor Energy, Syncrude Canada, TransAlta.[42]

Table 4.12 Energy-Related Research Consortia, Networks, and Initiatives

Name of network, consortium, program, or research group	Sponsors/funders/non-university partners	Location	Dates of operation
AERI/ARC Core Industry Research Program (AACI) (in-situ heavy oil research consortium)	AI/InnoTech, Alberta Energy, and multiple corporations	InnoTech	1984–
Consortium for Research in Elastic Wave Exploration Seismology (CREWES)	Corporate clients	UCalgary	1989–
Canadian Oil Sands Network for Research and Development (CONRAD)	Industry funded	Multiple	1994–2013
Canadian Clean Power Coalition	NRCan, AI, IEA, corporate partners	Multiple	2000–2017
Consortium for Heavy Oil Research (CHORUS)	Industry funded	UCalgary	2004–2016
Energy Information Network (EnergyINet)	AERI, other goverment agencies	AERI	2005–2008
Upgrading Catalyst Development Network (UCDN)	NRCan	Multiple	c. 2006
Reservoir Simulation Research Group	AI, Alberta Advanced Education and Technology, CFI, NSERC, and corporate partners	UCalgary	2007–
Materials and Reliability in Oil Sands (MARIOS)	AI, industry clients	InnoTech	2009–
Canadian Energy Systems Analysis Research Initiative (CESAR)	NEB, corporate partners	UCalgary	2009–
Carbon Management Canada (CMC)	NSERC, Govt. of Alberta	UCalgary	2009–2013
Biorefining Conversions Network	AI	UAlberta	2010–
Helmholtz -University of Alberta Research Consortium	Helmholtz Assoc. of German Research Centres, Govt of AB	UAlberta	2010–
Microseismicity Industry Consortium	NSERC, corporate partners	UAlberta and UCalgary	2010–
Alberta Manufacturing and Fabrication Innovation	Partnership between AI-TF and UAlberta Canadian Centre for Welding & Joining	UAlberta	2011
Energy Geoscience and Geo-Engineering Collaborative Open Innovation Network (EG-COIN)	NRCan, AI, IEA, corporate partners	UCalgary	2012–
Tight Oil Consortium	Alberta Advanced Education and Technology, CFI, NSERC, corporate sponsors	UCalgary	2012–
Calgary Advanced Energy Storage and Conversion Research Technology Group (CAESR-Tech)	UCalgary, AI, NRC, NRCan, and industry partners	UCalgary	2014–
Canadian Pipeline Technology Collaborative (CPTC)	Canadian Energy Pipeline Association (CEPA), CAPP, and AI-TF, Canmet, various academic institutions	Multiple	2014–
Foundation CMG Consortium on Reservoir Geomechanics for Unconventional Resources	NSERC, AI, corporate partners	UAlberta	2014–
Global Research Initiative in Unconventional Hydrocarbon Resources (GRI)	UCalgary, institutions in China, Israel, Mexico	UCalgary	2014–
Hydraulic Fracturing Innovation Initiative	UCalgary	UCalgary	2014–
Innovation of Oil Sands: Social, Economic, and Technology (IOSSET)	UCalgary	UCalgary	2014–
Future Energy Systems Research Initiative (FESRI)	Tri-Council (CFREF)	UAlberta	2016–2023
Global Research Initiative in Sustainable Low Carbon Unconventional Resources (GRI)*	Tri-Council (CFREF)	UCalgary	2016–2023

* This CFREF was initially named the Unconventional Hydrocarbon Resources GRI but has been renamed.

The integration of the functions of the NSERC, Alberta Innovates, private sector organizations, and a number of university faculties (most importantly, Engineering) is exemplified by the work on reservoir geomechanics summarized in the box below.

Foundation CMG Consortium on Reservoir Geomechanics for Unconventional Resources (University of Alberta) 2014–

This consortium is funded by a NSERC Collaborative Research and Development Grant (application year 2013) for five years starting in 2014/15 ($676,000 per year). It also receives funding from Alberta Innovates—Technology Futures and Alberta Innovates—Energy and Environment Solutions (both now amalgamated into Alberta Innovates). The corporate partners include Athabasca Oil Sands Corp., BP Canada Energy Co. (Gas & Power); Brion; CNRL; Cenovus Energy Inc.; CMG Reservoir Simulation Foundation; ConocoPhillips; MacKay Operating Corp.; Nexen Energy ULC; Shell Canada Ltd.; StatoilHydro Canada Ltd.; Suncor Energy Inc. The lead academic researchers (seven on the NSERC grant) are at the University of Alberta in the Faculty of Engineering and in the department of physics. The aims of the research are stated as: "Improved understanding of reservoir-geomechanical behaviour of the oil sands, bitumen carbonates and shales is critical in the efficient, safe operation of unconventional resource recovery projects and will also assist in improving reservoir surveillance techniques and production optimization activities. This will ultimately lead to more efficient hydrocarbon recovery and potentially lower energy consumption and lower greenhouse gas emissions."

The consortium's work was boosted in 2014 by the creation of a Foundation CMG Endowed Chair in Reservoir Geomechanics, held by Richard Chalaturnyk in the Faculty of Engineering. This chair was described as "an integral component of a new $15M research program aimed to develop novel technologies to optimize the economic and environmentally sustainable recovery of unconventional resources in Canada." The Engineering Faculty also obtained $4.3 million from the CFI and ASRIP to establish the Geomechanical Research Experimental Facility.

Chalaturnyk's group includes 39 graduate student researchers and technical staff investigating the properties and behaviour of various unconventional resources, including oil sands, shale caprocks, bitumen carbonates and more recently shale gas, during the recovery process. The program expected to train 52 highly qualified personnel in the reservoir geomechanics field over five years.

Sources: NSERC awards database: http://www.nserc-crsng.gc.ca/ase-oro/Details-Detailles_eng.asp?id=556762 (accessed March 13, 2017). Vivian Giang, "Faculty announces Foundation CMG Endowed Chair in Reservoir Geomechanics," Faculty of Engineering, University of Alberta, November 25, 2014, https://www.ualberta.ca/engineering/news/2014/November/EngineeringannouncesestablishmentoftheFoundationCMG.aspx.

By considering the establishment of research centres/institutes and consortia/networks chronologically, do we see any change in the direction of the research investment in the energy area? Looking first at provincial investment, while the "core" research program of AI-TF/InnoTech continues to be R&D related to the oil sands, there have been some investments in energy storage and conversion R&D (CAESR) since 2014 (although this group was established with funding from the University of Calgary, i.e., it was not a provincial initiative). We also see the recent involvement of AI-TF/InnoTech in the Alberta Carbon Conversion Technology Centre. The creation of this centre reflects the Alberta NDP government's push to diversify uses of captured carbon.

It is important to keep in mind that about half of AI-TF's revenue comes from contracts with government or private sector partners, and that its research program is not entirely government-determined. The corporation does, however, seek to align its investments with government innovation priorities. The AI-TF's Business Plan for 2015–2018 set out five "sector strategies": environment; food and fibre; oil and gas; pipelines; health (AI-TF 2016, 11–13). AI-TF does not indicate what portions of its government revenue were to be allocated to each of these areas. Under each sector strategy it set out "grand challenges," and it is notable that the two areas most lacking in details—regarding specific goals or projects—are environment and health. Regarding climate change, AI-TF sees its role as working with its partners to develop emissions monitoring technologies (Ibid., 11). Its "grand challenge" regarding climate change is to make Alberta a "globally recognized … leader in managing resource development to sustain environmental integrity" by 2030. This challenge does not however, entail specific targets (e.g., the reduction of provincial greenhouse gas emissions by a set number of megatonnes) and is not linked to investments in specific projects.

The "grand challenge" of oil and gas R&D, by contrast, does have specific targets. The first is to "increase Alberta's reserves by 30% by 2030" (12). This entails technologies for improving recovery rates (solvent-and-combustion-based processes), and for exploiting currently unexploited reserves (hydraulic fracturing technologies). Another goal of the oil and gas grand challenge is to "decrease operational inputs for production by 1/3" (12). The priorities here are the reduction of energy for *in situ* processes, increased reliability and run time for oil field processes (reducing wear and tear on materials to extend run times), and improved process control. The third challenge is to increase the value of bitumen, e.g., by using asphaltenes as nanoparticles and developing specialized plastics. Lastly, AI-TF aims to "decrease the environmental impact of production," e.g., through research on how to treat tailings and reclaim landscapes in the oil sands.

Regarding federal support for energy-related R&D in recent years, the two Canada First Research Excellence Fund (CFREF) awards made to the universities of Alberta and Calgary in late 2016, as well as federal investment in the Alberta Carbon Conversion Technology Centre in 2018 are consistent with the federal Liberal government's sustainable development discourse—one that has also been taken up by university administrators and corporate spokespersons. On the one hand, these investments aim to reduce the costs of fossil fuel extraction (in the oil sands and in carbonate formations), while increasing recovery rates from reservoirs. Engineering and Science R&D is supposed to find more "environmentally friendly" ways of doing this, thereby making conflicts between "the economy" and "the environment" disappear. Or, at least, these technologies are expected to make Alberta's

diluted bitumen and synthetic crude oil exports environmentally competitive with lighter crude oils. On the other hand, neither the problem of CO2 emissions from the downstream combustion of Alberta's oil and gas exports, nor the conflict between the growth of overall emissions from the oil sands and achievement of national GHG reduction targets are acknowledged in government discourse. A comparatively smaller investment is being made in R&D for renewable energy, energy storage, and environmental mitigation of oil sands exploitation. The latter areas are part of the $75 million FESRI at the University of Alberta.

4.3.2 Environmental Consortia, Networks, and Initiatives

As was the case with the research centres and institutes, we found that environment-related research consortia or networks were typically established by researchers drawing upon internal funds and were unlikely to have significant government funding or any private sector funding. A 2017/18 survey conducted by Adkin (2017a) found a number of research clusters active at the University of Alberta, including: Petrocultures (Arts); After Oil (Arts); Toxic Media Ecologies and the Convergence of Social and Ecological Crises Research Group (Arts); Intersections of Sustainability (interdisciplinary); Canadian Mountain Network (interdisciplinary), and; UAlberta North (interdisciplinary). In addition, there are groups in Science working on environmental modelling, biomonitoring, and other areas.[43] While funding sources for researchers are diverse, the social science-based clusters have depended heavily upon internal (university) funds held by Deans, the VP Research, and the Kule Institute for Advanced Studies.

A search of the University of Calgary's "key initiatives, research groups and centres" webpage turned up very little in the way of environmental/sustainability initiatives. The Advancing Canadian Wastewater Assets initiative is a partnership between the University of Calgary and the City of Calgary, working on wastewater treatment technologies. Since 2016, the UCCities—Global Urban Research Group has been supported by the VP Research.[44]

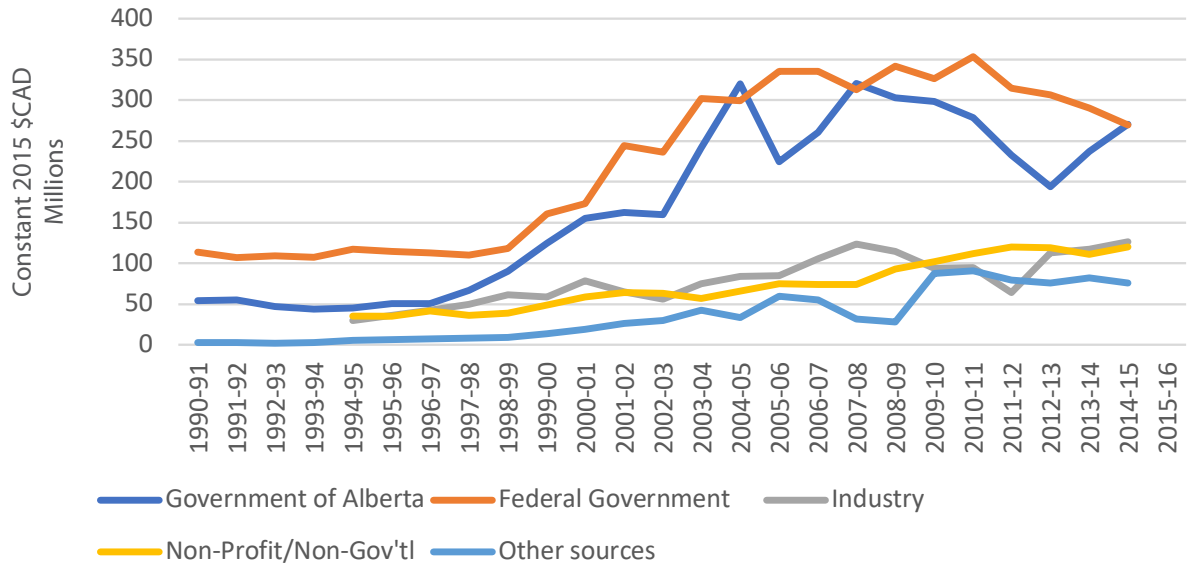
At neither university is there a centre or institute for sustainable development, or an "initiative" with external funding on the scale routinely provided to the energy-area initiatives.

5. Private Sector Sources of Research Funding

The provincial government's University Research and Strategic Investments Branch (URSI) collects data from the universities regarding the private sector research funding they receive and reports this in the aggregate (as a category of all R&D funding going to the universities).[45] Figure 5.1, using the available data (covering the period from 1990/91 to 2015/16) shows us that "industry" funding for sponsored research at Alberta's four CARI universities rose from approximately $29.6 million in 1994/95 to $126.3 million in 2014/15 (in constant 2015 dollars). The average yearly amount for this period is $79.5 million, and the total amount for the whole period adds up to nearly $1.7 billion. Industry funding for university research peaked at $123.3 million in 2007/08 and at $126.3 million in 2014/15. The universities of Calgary and Alberta received almost all of this $1.7 billion in private sector funding, with UCalgary receiving 47 per cent and UAlberta receiving 52.9 per cent.

Unfortunately, the URSI's data do not include details of funders or funded projects at the universities, and we have so far been unable to obtain these data from the universities. Some such data may be reconstructed from news reports and university, government, and corporate media releases, but to date no comprehensive record of private sector funding to the universities is available to the public.

Figure 5.1 Research Funding from Private Sector Sources for Alberta's CARI Universities, 1990/91 to 2015/16

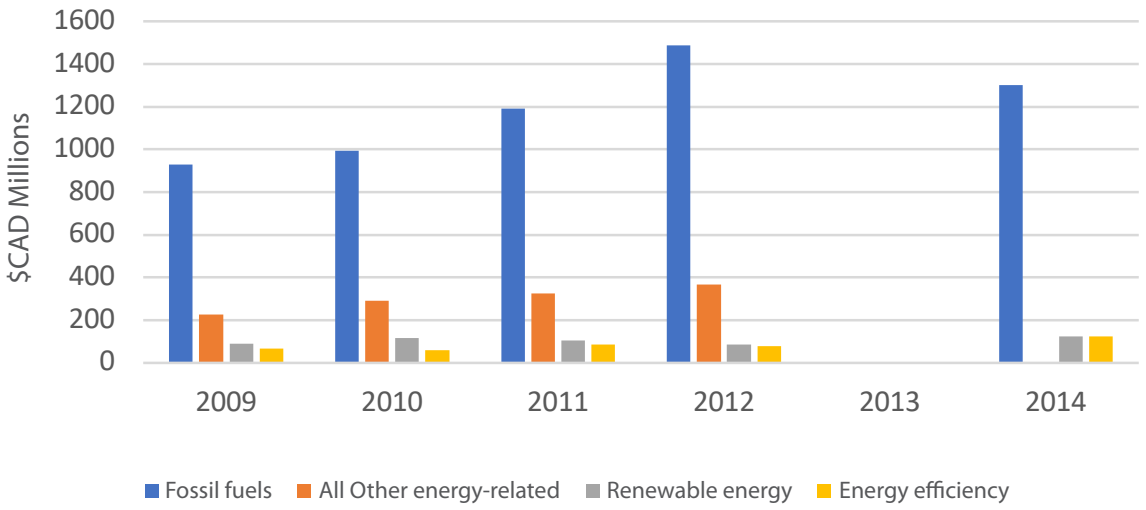


Sources: Annual reports on sponsored research funding to Alberta universities produced by the ministries of Advanced Education (1989–1996), Innovation and Science (1997–2006), Advanced Education and Technology (2007, 2009–2010), Alberta Enterprise and Advanced Education (2007, 2011–2013), Innovation and Advanced Education (2014–2015), and Economic Development and Trade (2016).

Among the business associations that fund and/or partner with university-based researchers in Alberta through participation in the networks and centres outlined in previous sections, and through direct funding of university-based research, are: Canadian Association of Oilwell Drilling Contractors, Canada's Oil Sands Innovation Alliance,[46] Canadian Mining Industry Research Organization, Forest Resources Improvement Association of Alberta, Mixedwood Management Association, Petroleum Services Association of Canada, Petroleum Technology Alliance of Canada, and Pulp and Paper Research Institute of Canada.[47]

Data collected by Statistics Canada on industry investment in R&D allow us to see the large picture of industry priorities regarding energy investment for at least part of the period since 2000. Statistics Canada reported in February 2017 that "Alberta's share of total [Canadian] industrial R&D, supported by higher spending in the province's energy sector, increased from 9% in 2007 to 13% in 2013," indicating that spending on in-house energy R&D grew along with the rise in oil prices and heightened concerns over social license to operate/expand over the same period.[48] Indeed, Statistics Canada reports that "Energy companies accounted for over 80% of the $604 million rise in resource-based R&D [in Canada] from 2010 to 2013, reflecting increased activity related to heavy crude oil extraction and environmental remediation."[49] Figure 5.2 shows industry spending on in-house energy-related R&D by area of research, from 2009 to 2014.

Figure 5.2 Industry Investment in In-House Energy-Related R&D by Area of Research, 2009–2014

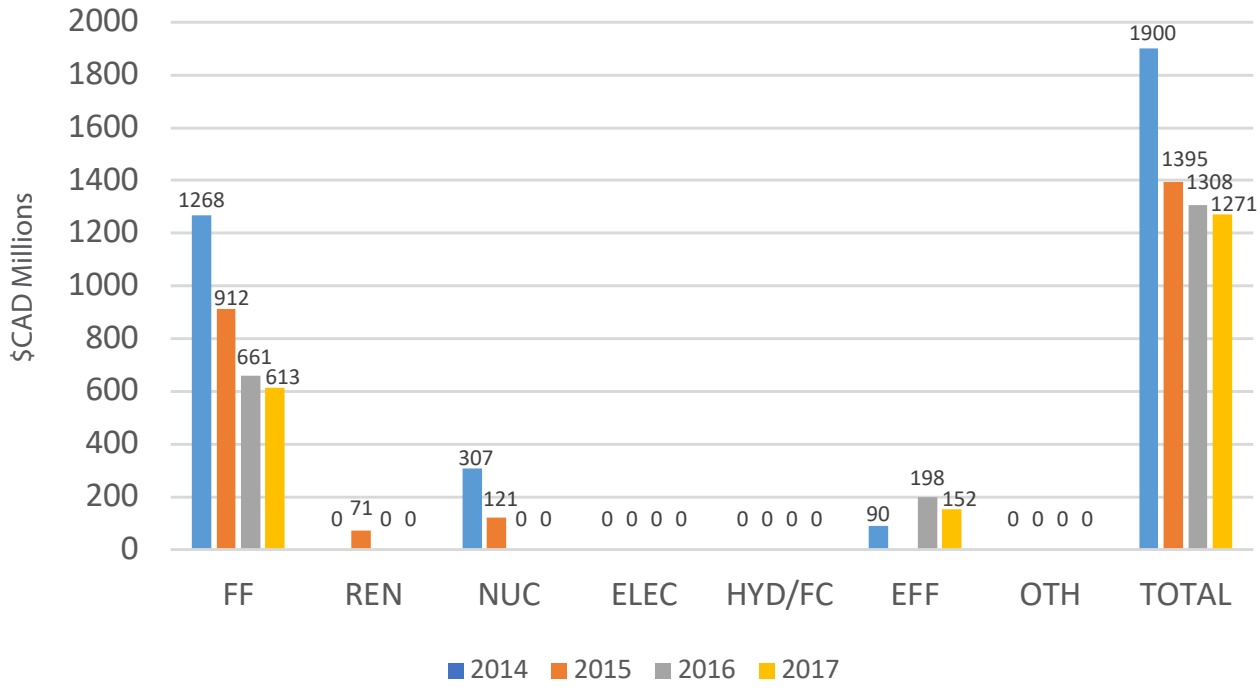


Note: Data for 2013 are not available.

Sources: Statistics Canada, Chart 3, "Energy-related industrial research and development spending by area of technology, 2009 to 2012," http://www.statcan.gc.ca/daily-quotidien/140819/cg-a003-eng.htm; Statistics Canada, "Energy research and development expenditures by area of technology, 2014," The Daily, released April 19, 2017, http://www.statcan.gc.ca/daily-quotidien/170419/dq170419b-eng.htm; Statistics Canada, Table 358-0524, "Industrial energy research and development expenditures by area of technology, by industry group based on the North American Classification System (NAICS) and country of control," 2014 data, http://www5.statcan.gc.ca/cansim/a47#F1.

Statistics Canada has incomplete data on corporate investment in various areas of energy R&D for the years 2014 to 2017. A considerable number of data are "suppressed" due to confidentiality requirements. The available data portray a continuing pattern of fossil fuels R&D taking the predominant, though declining share of energy technology R&D: 67 per cent in 2014, 65 per cent in 2015, 51 per cent in 2016, and 48 per cent in 2017 (see Figure 5.3). Expenditure on renewable energy R&D hardly appears (5 per cent of total spending in 2015 and zero in other years). Nuclear fission and fusion technologies fare somewhat better, accounting for 16 per cent of energy R&D spending in 2014 and 8.7 per cent in 2015. Energy efficiency R&D, of obvious interest to corporate cost-saving, accounted for surprisingly little of total corporate spending on energy R&D: 15 per cent in 2016 and 12 per cent in 2017.[50] Figure 5.3, which shows the investment figures in dollar terms, also reveals that total R&D spending has been declining since 2014, with investment in fossil fuel technologies falling by more than a half.

Figure 5.3 Energy R&D Funded by Canadian Companies by Category of Research, 2014–2017 (millions $CAD)



Source: Statistics Canada. Table 27-10-0347-01 Industrial energy research and development expenditures by area of technology, by industry group based on the North American Industry Classification System (NAICS) and country of control (x 1,000,000). https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2710034701

The percentages of total energy R&D spending that are "outsourced" to Canadian organizations are relatively small, ranging from 7.8 per cent in 2014 to 15.7 per cent in 2017.[51] Almost all of the outsourced R&D is in the fossil fuels area. It should be noted, however, that the dollar amounts of this outsourced investment are significant in relation to other sources of R&D funding for university researchers. The $115 million outsourced for fossil fuels R&D in 2014, for example, is almost half the amount disbursed by NSERC for FFR R&D to the universities of Alberta and Calgary over the entire period from 1999 to 2016, and twice the amount disbursed by the CFI for FFR R&D over the entire period from 1999 to 2016 (see Tables 6.1 and 6.2, below). The amounts outsourced for fossil fuels research in the three following years were $80 million, $173 million, and $164 million, respectively.[52]

Thus, the data available to us at this time indicate that the preeminent R&D priorities for corporations investing in the energy sector remain technologies related to fossil fuels.[53] This investment is reported as being predominantly "in-house," although it is not clear how corporations report research investment that occurs in the context of university-private sector R&D *partnerships* (which may rely on research infrastructure located in universities and involves the work of university-employed researchers). In any case, "outsourced" research investment on the scale of $115 million (as in 2013/14) in energy research alone constitutes a substantial source of funding for any university-based researchers competing for a share of this pie.

6. Discussion and Conclusions

6.1 Priorities by the Numbers

It is clear from these data that R&D funding to Alberta's leading universities has—over a long period of time—heavily privileged fossil-fuels-related knowledge and technology and that this continues to be the case. Investment in the knowledge and technologies that we consider to be foundational to an ecologically sustainable economy and society amounts to only a fraction of the sums invested in fossil-fuels-related R&D. In this section, we summarize the data, using broad categories that help us to see what types of research have been prioritized over the past 20 years. We begin with the funding from NSERC and CFI to our universities.

NSERC's funding has been heavily weighted toward fossil-fuels-related R&D, with this category accounting for 63 per cent of NSERC funding for energy or environmental research at the two universities over the 17-year period of our study (see Table 6.1). Alternative energy technologies combined have received only 11 per cent of this funding, and research in the areas of sustainable agriculture, forestry, or water management have received less than 3 per cent.

Table 6.1 NSERC Funding to the Universities of Alberta and Calgary by Category of Research, 1999/00 to 2015/16*

Category of Research	Amounts (millions)	Percentages
Fossil-fuels-related	207.7	62.8
Renewable energies, energy conservation, fuel cells, biofuels (combined)	36.9	11.2
Nuclear energy/fusion	2.8	0.85
Environmental research	74.4	22.5
Sustainable development	8.4	2.5

*Note: Amounts and percentages of the total $330.3 million; $330.3 million is the cumulative total funding for all 4,567 projects we selected from the NSERC Awards database as pertaining to Energy, Environment, or Sustainability research in selected programs (see note 5) over the period 1999/00 to 2015/16.

The CFI funding has been more evenly divided between energy R&D, on the one hand, and environmental research, on the other hand (see Table 6.2). But notable here is the small portion of CFI funding going to alternative energy technologies compared to FFR R&D. CFI funding for energy projects has favoured FFR R&D over the other categories of energy research by a ratio of 4:1.

Table 6.2 CFI Funding to UAlberta, UCalgary, and ULethbridge by Category of Research, 1998-2017

Category of Research	Amounts (millions)	Percentage of CFI Funding to the three Alberta Universities, 1998–2017*
Fossil-fuels-related**	41.7	7.7
Renewable energies, energy conservation, fuel cells, biofuels (combined)	9.0	1.7
Nuclear energy/fusion	0	0
Environmental research	39.2	7.3
Sustainable development	0.26	0.05

* The third column of the table shows percentages of the cumulative funding total of $539.6 million (in 2015 $CAD) for the 833 CFI projects awarded to the three universities from 1998 to 2017.
** Not including 0.6 per cent of CFI funding that went to environmental remediation research related to fossil fuels.

A similar breakdown of spending priorities for the provincial innovation agencies is more difficult to calculate, due the incomplete nature of the data. To begin with funding directed to fossil-fuels-related research, if we leave aside provincial funding for the Alberta Research Council (1930–2000), the Alberta Oil Sands Technology and Research Agency (1974–2000), and the Petroleum Recovery Institute (1975–2000), and report only on the period from 1997 to 2018, we are able to identify the amounts shown in Table 6.3, listed chronologically. Notably, $3.4 billion of the $6.4 billion in provincial investments in fossil-fuels-related R&D takes the form of royalty credits, and therefore goes directly to the private sector. Another $197 million, disbursed by the CCEMC/ERA, has also gone mostly to corporations. Corporations were allocated a further $440 million from the Alberta NDP government's Oil Sands Innovation Fund. This means that about 63 per cent of the $6.4 billion invested in FFR R&D by the provincial government since 1997 has gone to corporations in the form of royalty credits or grants (rather than to universities).

Table 6.3 Provincial Government Investments in Fossil-fuels-related R&D, 1997–2018

Funding Period	Provincial Investments in Fossil-fuels-related R&D	Amount (nominal $)
1997–2015	AB Science and Research Investments Program/RCP, 1997–2015 [1]	35,300,000
2000–2005	Alberta Energy Research Institute (funded by ASRA)	unknown
2006–2009	Alberta Energy Research Institute (from EIF)	76,700,000
2003–2008	AB Ingenuity Fund "Industry Associates Program" 2003–2008	14,200,000
2002–2006	AB Ingenuity Centre for Machine Learning (from AIF)	6,000,000
2010–2014	AB Ingenuity Centre for Machine Learning [2]	8,000,000
2007–2009	AB Ingenuity Centre for Machine Learning	unknown
2002–2010	Alberta Water Research Institute	15,000,000
2004–2010	AB Ingenuity Centre for In Situ Energy	7,404,000
2004–2016	Innovative Energy Technologies Program (royalty credit) (@$200M per yr)	2,400,000,000
2005–2015	Access to the Future Fund (project funding undisclosed)	unknown
2005–2007	Energy Innovation Network [3]	4,100,000
2006	Energy Innovation Fund	200,000,000
2007–2010	AB Ingenuity Centre for Oil Sands Innovation	3,460,000
2007	Oil Sands Tailings Research Facility (from AIF and Access to the Future Fund)	18,000,000
2008–2018	Oil Sands Tailings Research Facility	unknown
2008–2017	Alberta Carbon Capture and Storage Fund	1,300,000,000
2008–2015	Alberta Enterprise Corporation limited partnerships in energy sector (amt of $106M invested as of 2015 that is in fossil fuel firms is unknown)	unknown
2009–2017	Climate Change Emissions Management Fund /ERA [4]	197,000,000
2010–2016	AB Innovates–Energy and Environment Solutions [5]	42,400,000
2010–2016	AB Innovates-Technology Futures [6]	540,000,000
2011–2015	Fossil-fuels-related CAIP Chairs (four at ~ $450,000 per yr)	9,000,000
2016–	Petrochemicals Diversification Program (royalty credits)	1,000,000,000
2016–	provincial contribution to FESRI (UAlberta)	unknown
2016–	provincial contribution to GRI (UCalgary)	unknown
2017	ERA Fund announced July 2017 for SAGD R&D [7]	50,000,000
2017–	Oil Sands Innovation Fund	440,000,000
2018	Alberta Carbon Conversion Technology Centre (ERA funding only)	35,000,000
	Total	**6,401,564,000**

Sources: Data tables in the report, and [1] Adkin/Cabral research on ASRIP project spending from 1997/98 to 2014/15. $35.3M is 72% of ASRIP energy-related funding for projects related to fossil fuels (including remediation). [2] Figures for Alberta Ingenuity Fund centres from 2010-2014 from the Director of Information Services, Economic Trade and Development, June 26, 2017. [3] Federal lobbyist registry 2006-2007, https://lobbycanada.gc.ca/app/secure/ocl/lrs/do/vwRg?cno=13645&regId=505263#regStart. [4] Adkin/Cabral research on CCEMC/ERA spending from 2009/10 to 2016/17. [5] Figures from the FOIP Officer for Alberta Innovates, July 17, 2017. [6] Ibid. [7] Emissions Reduction Alberta, http://www.eralberta.ca/news/media-releases/emissions-reduction-alberta-era-offers-50-million-funding-technologies-help-oilsands-meet-greenhouse-gas-emissions-limit-2030/

Turning to provincial investment in renewable energies, energy efficiency and conservation, fuel cells, and biofuels research, we identified the following funding sources and amounts for the 1997–2018 period.[54]

Table 6.4 Provincial Government Investments in Renewable Energies, Energy Efficiency and Conservation, Fuel Cells, and Biofuels Research, 1997–2018

Funding Period	Provincial Investments in Alternative Energy Technologies and Energy Conservation Research	Amount (nominal $)
1997–2015	ASRIP/RCP	
	EECons	270,941
	RenEN	7,197,590
	Fuel cells	5,601,089
	Biofuels	488,595
	Subtotal	**13,558,215**
2010–2016	AI-EES "renewable and emerging resources"	5,860,000
2011–2015	CAIP Chairs (one in biofuels)	900,000
2009–2017	CCEMC/ERA [1]	
	RenEN	119,000,000
	EECons	8,200,000
	Biofuels	93,100,000
	Subtotal	**220,300,000**
2011–	Advanced Energy Research Facility (biofuels) (support from AI-EES)	Unknown
2016	provincial contribution to FESRI (UAlberta) in these areas of research	Unknown
	Total	**240,618,215**

[1] CCEMC/ERA data from Adkin 2019.

Lastly, searching our data for provincial investment in environmental research or sustainable development, and using generous definitions of these, we were able to identify the amounts (in some cases, estimates) reported in Table 6.5.

Table 6.5 Provincial Government Investments in Environmental and Sustainable Development Research, 1997–2018

Funding period	Funder and Investment	Amount (nominal $)
1997–2015	ASRIP/RCP investment in environmental research	26,000,000
1997–2015	ASRIP spending on SustDev (two projects)	1,190,624
2010–2016	AI-EES investment in water research	8,300,000
2010–2018	Provincial contribution to ABMI	unknown
2010–2016	Provincial contribution to AWRC	16,824,000
2011–2015	CAIP Chairs @ estimated $450,000 per year	
	CAIPS in water	12,600,000
	Other env CAIP	2,250,000
2009–2017	CCEMC/ERA investments in climate change mitigation or adaptation research	8,280,360
2018–	Climate Change Innovation and Technology Framework Fund (for GHG emission reductions)	145,000,000
	Total	**189,944,984**

In a nutshell, then, since 1997 the governments of Alberta have spent at least $6.4 billion on technology development related to fossil fuels (excluding the estimated $1.4 billion for AOSTRA that ended in 2000), compared to about $241 million on R&D related to renewable energies, energy conservation, and biofuels, and about $190 million on research related to environmental science, water quality and management, and climate change. In percentage terms, this means that what governments of Alberta have invested in alternative energies adds up to only 4 per cent of what they have invested in FFR R&D. What they have invested in environmental research and climate science adds up to only 3 per cent of the amount invested in FFR R&D. As for investment in research for sustainable food production, this is hardly traceable (we found only two projects funded by ASRIP between 1997 and 2015 that could be classified in this category). Overall, ASRIP funding for research in any area of agriculture has severely decreased, while its funding for energy research has tripled.

Further revealing the importance attached to FFR R&D compared to research that will lay the groundwork for a future post-carbon society are the choices surrounding the creation of research chairs—made by senior university administrators, government agencies, and corporations. Recall that of 25 Canada Research Chairs in energy R&D created between 2000 and 2017 at the universities of Alberta and Calgary, 16 were in the fossil-fuels area. (By comparison, 11 CRCs were created in the environment domain.) Of the 36 energy-related IRCs created over the same period, 35 were in fossil-fuels-related research. (Only three IRCs were created in the environment domain.) Between 2005 and 2013—while oil prices were still

incentivizing oil sands expansion—corporations in the fossil fuels sector sponsored the establishment of an additional 16 research chairs. Research chairs in areas such as biodiversity, agriculture, water, or fisheries have had some NSERC (CRC) and CAIP support, but little corporate funding. An exception is the ABMI, which receives funding from COSIA and monitors the effects of surface mining in the oil sands on wildlife. Going back as far as 1990 we found only nine centres in Alberta universities with a focus on the Arctic, biodiversity, rural sustainability, environmental law, or related issues, almost all of which have relied primarily on university support for their existence; only six of these are in operation today. On the other hand, we found at least 26 centres whose central focus is on energy—primarily, development of the oil sands; about 22 of these are operating today.

In recent years there has been some increase in investment in renewable energy technologies on the part of Emissions Reduction Alberta and ASRIP, although these investments are still greatly outweighed by those in the oil and gas sectors. The award by the federal TriCouncil-administered Canada First Research Excellence Fund (CFREF) to the University of Alberta in 2016 may point to a shift in federal funding priorities, but it will not be known for some time how FESRI's $75 million budget will be allocated between fossil-fuels-related, renewable energy, and other areas of research (including in the social sciences and humanities).[55] The $75 million Calgary CFREF appears to remain committed to the project of making fossil-fuels extraction and processing less carbon intensive. By 2017, water issues were beginning to receive more support from Alberta Innovates, as evidenced by the Campus Alberta Innovation Program. Sustainable agriculture, on the other hand, appeared to be not yet on the radar for NSERC, CFI, or the provincial innovation agencies. In light of the former NDP provincial government's concerns to diversify the economy and generate employment, and the food security problems intensified by climate change, one would expect a far greater investment in research related to sustainable agriculture and rural communities.[56]

The funding patterns that are revealed by our research are mirrored in the changes over time in the numbers of researchers working in different areas. Recall the findings that the number of NSERC-funded researchers in FFR-areas at the universities of Alberta and Calgary grew from 50 in 1999/00 to 138 in 2015/16, while during the same period the number working on renewable energies grew from zero to 23 and the number of environmental researchers increased from 47 to 105. We also discovered that a growing percentage of environment researchers in the science and ALES faculties have been obtaining NSERC funding for projects related to fossil fuels. In 2015/16 we found 151 NSERC-funded researchers at the two universities working on technologies or environmental remediation related to fossil-fuels, but only 19 working in areas related to sustainable development such as

water systems, sustainable forestry, or agriculture. Meanwhile, the percentage of environment researchers working on climate change has declined since 1999/00.

It is evident from these findings that the priorities of the fossil fuel industries have been transcribed to government roadmaps for economic development and are over-represented in the allocation of research funding to Alberta's universities. Yet continuing heavy investment in R&D related to the extraction, processing, and transportation of fossil fuels is clearly in conflict with the urgent need to prevent further climate destabilization. It is, moreover, in conflict with the growing recognition that Alberta must develop a post-carbon-extractive economy as global demand for its bitumen exports shrinks. So, we must ask how these investment priorities are justified by university, government, and corporate actors as being in the public interest. How are these decisions about the directions of university research and teaching being made? Whose interests are being served, and whose interests ignored or marginalized?

6.2 New Climate Denialism

Oil sands producers have responded to global economic and political developments with strategies to lower their costs of production and secure market access for bitumen products. Since they can neither accept the only strategy that is consistent with a substantial and rapid reduction of Canada's greenhouse gas emissions, i.e., the phasing-out of oil sands production, nor outright deny the existence of the climate crisis, corporations and governments have adopted a response that some political analysts characterize as a new form of climate denialism (Klein and Daub 2016).[57] This strategy involves acknowledging the reality of climate change while denying its urgency and downplaying the responsibility of Canadians to reduce global GHG emissions. This response asserts that global demand for fossil fuels will continue to grow in coming decades, and that energy corporations aim to meet this demand in the most environmentally sustainable fashion possible, given existing technologies and environmental regulations. Phasing out fossil fuel extraction, it is claimed, would cause losses of jobs and government revenues while making little difference to global GHG emission levels. In this view, fossil fuel extraction in Canada should continue, and even expand, while corporations work to reduce the GHG-intensity of extractive processes. Incrementalism and aversion to regulatory approaches or to radical social or economic change are key elements of the new climate denialism. In addition, multiple strategies have been adopted by governments and corporations to minimize opposition to oil sands and pipeline projects from Indigenous peoples. To some extent, these strategies, too, involve the promise of environmental mitigation and remediation technologies.

The new framework of climate denialism relies heavily upon promises of both economic benefits (for Albertans and Canadians), and technological success in reducing GHG emissions and other environmental harms. As then-provincial Minister of Environment Rob Renner put it in March 2009: "In Alberta, our greatest opportunity to truly reduce emissions and continue as a global energy producer will come from innovation and technology. By supporting innovation and advancing technology, we are increasing our potential … to improve efficiency, reduce or even stop emissions and ultimately improve environmental performance" (Alberta Environment 2009, 10).

For oil sands producers, the innovation priorities are to reduce the carbon footprint of production, demonstrate the effectiveness of remediation technologies, bring down production and transportation costs, and secure social license for their operations. For these reasons, we have seen a shift in funding priorities in the direction of technologies to replace water/steam used in SAGD, extend the life of machinery used in the oil sands, replace human labour, capture CO2, and so on. However, it bears repeating that these technologies aim not to *phase out* fossil fuel production in Canada, but rather, to *prolong* the extraction of oil and gas well into the future. Albertan and Canadian governments implausibly assert that the conflict between fossil fuel extraction and combustion, on the one hand, and timely action to prevent extreme climate destabilization, on the other hand, can be made to disappear by their investments in new technologies.

Because the fiscal regime implemented by the Klein government in the 1990s makes the province excessively dependent for revenue on resource rent (Adkin and Miller 2016), and because successive governments have been unwilling to substantially reform this regime, the oil and gas industry continues to exercise enormous leverage in the shaping of provincial energy, environmental, and climate policy and regulation (Adkin 2016, Carter 2016, Taft 2018).[58] Governments in the oil-extracting provinces, along with the federal government, have accommodated the industry's demands—including for various forms of cost subsidization such as public funding of fossil-fuels-related technology research and development (either through innovation agencies or tax credits).[59] As a result, enormous sums of money are announced in a seemingly endless stream to incentivize "innovation" in the fossil fuels sectors.

To deal with the conflict between fossil fuels extraction and the growing climate crisis, the former NDP government of Alberta adopted a "two-track" strategy of expanding bitumen or upgraded oil exports while seeking to diversify the economy and reduce GHG emissions from other sectors (Adkin 2017b). Indeed, the Notley government made the expansion of bitumen exports via new pipeline capacity a condition for provincial cooperation in the federal government's Pan-Canadian Framework on Clean Growth and

Climate Change (PCF). Like its predecessors, the NDP government argued that Alberta could increase both bitumen exports and provincial resource revenue while reducing the carbon footprint of oil and gas extraction over time (Adkin and Stares 2016).[60] The government's "climate change" policy relied heavily upon the same promise of technological innovations that would reduce emissions from the oil sands sector (Adkin 2019).

Meanwhile, the giant ships that are research universities sail in the direction of government-determined research priorities in order to position themselves to capture external research funding. The "Promethean"[61] emphasis on market-driven "human ingenuity," and "technological innovation" solutions to ecological problems has been reproduced frequently in the discourse of university administrators seeking to attract corporate and government revenue for new buildings, labs, researcher salaries, graduate scholarships, research chairs, and institutional prestige. When it comes to fossil-fuels-related research, the new forms of denial of the climate crisis come into play, as in this speech by Elizabeth Cannon, President of the University of Calgary, to the Canadian Science Policy Conference in September 2016:

> At the University of Calgary, we've identified energy innovation as one of our top research priorities. We want to harness our capacity for discovery to develop and share the next great energy innovations that the world needs. This includes advancing cleaner, more cost-effective ways of extracting energy from unconventional hydrocarbon resources … Thanks in part to this work, we've become a magnet for researchers who want to work at a world-class institution dedicated to solving energy challenges. Today more than 270 faculty members and more than 1,500 graduate students and 110 postdoctoral scholars are engaged in energy research. In addition to oil sands projects, our people are conducting research into reducing the environmental impacts of hydraulic fracturing techniques. They're inventing dramatically more efficient processes to capture CO2 and convert it into useful products. They're contributing to the science behind low emissions fuel cells. They're investigating ways to integrate more renewable power into the energy system. And they're studying public policy and regulatory frameworks. All of these elements will be needed as the world moves to a low carbon energy system (Cannon 2016).

In 2011, the Dean of UAlberta's Engineering Faculty, David Lynch, made a number of promotional videos for the Canadian Association of Petroleum Producers (CAPP), highlighting the work of industry and the university to make oil sands exploitation more environmentally benign.[62] In 2012, on the occasion of the announcement of the Xstrata Corporation-endowed Chair in Mining and Mineral Process Engineering, Lynch said, "Our vision is to become a world-class research centre and innovation hub in clean coal/carbon and mineral processing technologies. By providing the basic research

foundation, we can promote the development and upgrading of Alberta's natural resources in an environmentally-responsible manner."[63] Again in 2016, Lynch stated on his faculty's website that university researchers were "working with industry and government to enhance the social, environmental, and economic sustainability of the oil sands."[64]

Such statements dovetail perfectly with the messages of corporate donors to the university. The President and CEO of Encana, for example, making a $7.5 million donation to the university in 2008, said: "Our world is continually demanding more energy and Alberta is in a unique position to help. At the same time, developing our natural gas and oil resources in an environmentally sound manner is essential. That's why we need the collaboration of great institutions like the University of Alberta to find new and better ways to efficiently develop our resources in a sustainable way."[65] Some researchers see such statements and donations as forms of "greenwashing" the fossil fuel industry, that is, lending the credibility of university-based research and expertise to the industry's claims that its operations are environmentally sustainable (Hashimoto Schaff 2016; Lander 2013; Muttitt 2003).

The commitment of provincial and federal governments in Canada to "clean energy" innovation as the ticket to sustaining economic growth while reducing greenhouse gas emissions has meant continuing heavy investment in fossil-fuels-related technologies. Yet, as we have seen, capital and research capacity directed to the fossil fuels sectors are diverted from the development of renewable sources of energy, of energy-conserving and environmentally benign building materials and other products, and from the advancement of sustainable agriculture, food security, water conservation, biodiversity protection, zero-carbon emitting transportation, and many other critical areas for investment. Perhaps even more pernicious than the misuse of scarce public investment and human capital, however, is the illusion perpetuated by many government, university, and industry leaders that these "clean energy" technologies will miraculously dissolve the ecological limits of fossil-fuelled economic growth or the local and global crises of justice rooted in the global economy.

6.3 Petro-Universities

A University of Alberta media release in 2008 stated, "For more than six decades, the University of Alberta has been instrumental in developing Alberta's renowned oil and gas industry, from the education of its work force and leaders to geological discovery to technological innovation."[66] This relationship was expressed in even blunter terms by the chair of the University's board of governors, Doug Goss, in 2014, who said, "The oilsands industry would not exist without this university."[67] While Alberta's university spokespersons often speak of their institutions' contributions to oil sands

development, the province's political economy has also deeply structured the universities.

As Dr. Lynch,[68] former University of Alberta president Indira Samarasekera,[69] and various university public affairs statements have repeated over the years, the University of Alberta has become a globally recognized powerhouse of R&D related to heavy oil and other unconventional oil production. In May 2016, the Engineering faculty proclaimed on its website that the University of Alberta ranked number one in the world in oil sands research publications (467 papers between 2006 and 2015) and number six in energy research publications. Moreover, more than 80 engineering faculty members and 800 graduate students and other researchers were said to be employed in R&D related to the oil sands.[71]

Constituencies and physical infrastructure linked to fossil-fuels research have become entrenched at both the universities of Alberta and Calgary (and, increasingly, in the technical institutes, due the creation of research facilities and chairs in this area). These interests give rise to conflicts with other constituencies in these institutions whose research tends not to be funded by, or otherwise linked to the R&D priorities of the fossil fuel industries.

We saw conflicting views about what the oil sands represent in the responses of some faculty members and administrators in 2018 to the University of Alberta Senate's decision to award an honorary doctorate to Dr. David Suzuki, a leading critic of the expansion of bitumen extraction.[72] While the deans of Engineering and Business publicly condemned the award, faculty members from other parts of the university viewed the decision as a rare acknowledgement of the importance of critical environmental perspectives. Such conflicts go to the heart of the question of the university's fundamental purposes and obligations, but it must be emphasized that the answers are not reducible to the political views of individual deans or university presidents, nor to differences of values between such homogenized groups as "engineers" and "liberal arts" scholars. Rather, these trenches are dug and maintained by the interests and ideologies that governments make central in the mandates of the innovation institutions.

More generally, the Promethean and market-driven approach to innovation for sustainable development has enormous implications for the kind of research that is funded and promoted within the universities, and for the skills and knowledge that we are providing to our students. The universities have moved further away from a "universal" approach to knowledge, i.e., from curriculum design that values multi-disciplinarity. Instead, the innovation ideology and its corresponding funding priorities make quite clear which kinds of knowledge are to be privileged within post-secondary education institutions, and which are to be fed a subsistence diet.

The consequence is a heavily lopsided response by our institutions to the socio-ecological crises that confront us. The response is lopsided first because, as indicated above, fossil-fuels-related R&D is massively advantaged in comparison to R&D that lays the foundation for ecologically sustainable development. Second, the much larger pool of funding available for natural sciences and engineering disciplines (as compared to the social sciences and humanities) privileges technical knowledge that is largely disconnected from social, political, and cultural knowledge.[73] Concomitantly, as Guppy et al. (2013, 13) note in regard to the CFI, innovation funding has disproportionately rewarded research conducted by men (male researchers received 86 per cent of CFI funding from 1998–2009). We should add to this observation that Indigenous knowledge has been marginalized in this model of innovation. These imbalances matter, because the solutions needed for the crises we face are not and cannot be solely technological.

The influence of the fossil fuel corporations and their associated interests (e.g., in construction, manufacturing, petrochemicals, corporate law, and other service industries) regarding the direction of university research and teaching is sometimes visible—as, for example, when industry representatives sit on the boards of research institutes or on the boards of governors, or when corporations provide endowments or scholarships. Alberta governments have repeatedly appointed individuals with such industry connections to the boards of governors of the universities of Alberta and Calgary (Carroll et al. 2018, CAUT 2013). A University of Alberta ad for positions on its board of governors, issued in September 2013, clearly stated the kinds of qualifications sought: "Preference will also be given to those who have demonstrated expertise in financial management, experience with human resources; and/or information technology, as well as those with experience working with Alberta's energy and/or natural resource sector."[74]

However, our research suggests that less visible forms of influence on the production of knowledge in our universities are equally (if not more) important. Corporations have a privileged role in determining what will be funded by governmental agencies like NSERC, NRC, NRCan, CFI, and Alberta Innovates by virtue of their economic power and relationship to the state. For governments that equate the strategic interests of these corporate actors with the public interest (an association manifested, for example, in the rationale offered by Prime Minister Trudeau for the federal government's purchase of the Trans Mountain Pipeline from Kinder Morgan, and in Alberta premiers' characterizations of the importance of the oil and gas industry to Albertans), it is only a short step to matching "innovation" priorities to the needs of private sector actors. Corporations do not have to be represented on the decision-making bodies of the funding agencies (although they sometimes are) to exercise the influence that comes with their structural, economic power. They are viewed by politicians and civil servants

as being the "principal stakeholders" of funding decisions, whether or not they are at the table (see, e.g., Adkin et al. 2017).

In the case of Alberta's universities, the dominance of the fossil fuel industry in the provincial economy, the influence of the industry vis-à-vis provincial and federal governments, and the neoliberal ideological orientation of our governments since the early 1990s have combined to structure knowledge production in ways that privilege the interests associated with oil and gas extraction. In 2020, with world prices for oil and gas severely (and perhaps permanently) depressed, and the climate crisis growing ever more urgent, the structural power of the fossil fuel industry may be entering a period of decline, with implications for the universities' research and teaching priorities.

6.4 Steering in a New Direction?

There is room for manoeuvre regarding the setting of research priorities, but it requires vocal, principled leadership on the part of academics and administrators. University leaders can choose to "follow the money," trying to position their institutions to profit from the latest shift in government funding direction. Or, they can try to mobilize public and political support for an independent vision, generated from the bottom-up, through consultation with academic staff, support staff, students, and our surrounding communities about how the university can best serve the public interest.

Governments and university leaders that express support for processes of truth and reconciliation with Indigenous peoples, and, in some cases, claim to respect the United Nations Declaration of the Rights of Indigenous Peoples, must confront the conflict between the worldviews of the dominant innovation ideology and Indigenous cultures.[75] Universities are called upon not only to be environmental citizens, but to be participants in decolonization, and this means opening all our disciplines to self-reflection about the implications of our teaching and research for settler-indigenous relationships.

Lastly, the interests and ideologies that structure knowledge production within the universities serve either to widen or constrict the vision and lifeways of our young people. If we are not providing an educational experience that introduces students to multiple ways of seeing problems like ecologically and socially sustainable development, but we are instead competing to recruit them into specialized fields that communicate very little with one another, then we are not serving them well as citizens who will be called upon to shape—and who will live with the consequences of—the future we are building today. Funding agencies should be encouraging the building of interdisciplinary bridges and adopting a far more holistic understanding of "innovation" that includes social, cultural, and political—

as well as technological—change. We would then be better positioned to provide leadership for our society's urgently needed transition to a just and ecologically sustainable future.

Endnotes

1 NSERC's Awards Database, using fiscal years and results displayed by program, http://www.nserc-crsng.gc.ca/ase-oro/index_eng.asp?new; SSHRC Awards Search Engine, http://www.sshrc-crsh.gc.ca/results-resultats/award_search-recherche_attributions/index-eng.aspx.

2 CCS is widely regarded to be far too costly an option to be implemented on the scale needed to stop global warming (even if the risks associated with the technologies could be made acceptable). See Thomson 2009 and 2015.

3 Mark Jacobson, for example, rejects biofuels and biomass energy as alternatives to wind, water, solar, and storage energy technologies on six grounds: "(1) nearly all biofuels are combusted to generate energy, resulting in air pollution similar to or greater than that from fossil fuels; (2) liquid biofuels do not reduce CO2e emissions nearly to the extent as WWS-powered battery electric or hydrogen fuel cell vehicles do; (3) some liquid biofuels increase CO2e emissions relative to fossil fuels; (4) many biofuels require rapacious amounts of land; (5) many biofuels require excessive quantities of water; and (6) many biofuels are derived from food sources, increasing food shortages, food prices and starvation … Because liquid biofuels cause greater climate, pollution, land, and water problems than do WWS technologies, biofuels represent opportunity costs." See "Why not liquid biofuels for transportation as part of a 100% wind-water-solar (WWS) and storage solution to global warming, air pollution, and energy security," excerpt from a forthcoming textbook, published online December 13, 2018, https://web.stanford.edu/group/efmh/jacobson/Articles/I/BiofuelVsWWS.pdf.

4 The literature on fossil fuel interests and Canadian universities is still limited to a handful of studies. See Adkin 2020 (forthcoming); Carroll, Graham, and Yunker 2018; CAUT 2013; Gray and Carroll 2018. For studies on cases in the USA and UK, see: Gustafson 2012; Lander 2013; Lockwood 2015; Muttitt 2003; Russ 2010; Washburn 2010. On the corporatization of Canadian universities more generally, see: Buchbinder 1993; Newson 1994, 1998; Polster and Newson 2009; Turk 2000.

5 The granting programs we included in the NSERC database search were: Automotive Partnership Canada Project, Canada Excellence Research Chairs, Canadian Forest Service Research Partnership, Canada Research Chairs, Collaborative Research and Development Grants (university-industry selection committee), Cooperative Activities, Discovery Frontiers—Northern Earth System Research, Discovery Grants—Individual, Discovery Grants—Accelerator Supplements, Discovery Grants—Northern Research Supplement, Engage Grants, Engage Plus Grants Program, Idea to Innovation, Industrially Oriented Research Grants, Industrial Research Chairs, Interaction Grants, Major Facilities Access Grants, Northern Research Chair, NSERC/Energy Sector/NRCan, Regional Office Discretionary Funds, Research Tools and Instruments—Category 1, NSERC/NRCan/AECL Generation IV Energy Technologies Program, Sector/NSERC Research Partnership—Project, Program for International Polar Year, Special Research Opportunity—Northern Research, Strategic Network Grants, Strategic Projects—Group.

6 See, for example, the account of the NSERC's "Strategy for Partnerships and Innovation" in NSERC/CRSNG, "Partners in R&D," December 2014, http://www.nserc-crsng.gc.ca/_doc/business/SPI-Partner_e.pdf. Sixteen of the NSERC award programs included in our search listed industry partners for university-based research.

7 In a first stage of our research, we tracked all the federal agencies' budgetary funding by program and year from 2000 to 2016 to identify trends in their funding for researcher-determined, government-determined, industry-university partnerships, university/government-determined "strategic," and other programs.

8 National Research Council, "Open for Business: Refocused NRC will benefit Canadian industries," 7 May 2013, http://www.nrc-cnrc.gc.ca/eng/news/releases/2013/nrc_business.html.

9 Mandate letter from the Minister for Innovation, Science and Economic Development, Navdeep Bains, and the Minister of Science, Kirsty Duncan, to Mr. Iain Stewart, President of the NRC, dated October 18, 2016, https://nrc.canada.ca/en/corporate/about-nrc/archived-mandate-letter-mr-iain-stewart-october-18-2016.

10 Note that these figures do not add up to 356 because some award recipients work in more than one area of research and so were counted in more than one category

11 Canadian Association of Petroleum Producers, "Canada Oil Sands Expenditures," Table 4-14, Statistical Handbook (accessed September 2018).

12 The CFI funds infrastructure requests up to 40 per cent of the budgeted cost; it is expected that the remainder of the funding will come from provincial government departments or funding agencies, or from the private sector.

13 For details of CFI funding criteria and programs see CFI 2013.

14 Only one award was made to ULethbridge (June 2012) that had applications to oil sands, petrochemical, and coal by-products, among other areas of research. The amount of the award in 2015 dollars was $424,309.

15 The REE was created to help universities attract and retain new faculty members. See Brochu 1998, 5.

16 Our sources for ASRIP project funding include 40 reports published between 1991 and 2015, with the titles *Sponsored Research Funding at Alberta Universities* (six reports, 1990/91 to 1995/96); *Research Funding at Alberta Universities* (11 reports, 1996/97 to 2006/07); *Alberta Science and Research Investments Program Research Outcomes* (three reports, 2003, 2005, 2006); *Catalyst for Success: Alberta Science and Research Investments Program 2000–2006* (two reports, 2007, 2008); *Research Funding at Alberta Universities* (2006/07); *Research Capacity Impacts* (three annual reports: 2009, 2014, 2015); *Research Funding at Alberta's Comprehensive Academic and Research Institutions* (five reports, 2007/08 to 2011/12); *Sponsored Research Revenue: Research Funding at Alberta's*

Comprehensive Academic and Research Institutions (three reports, 2012/13 to 2014/15), and; *Small Equipment Grants Program: Research Outcomes/Impacts* (two reports, 2006, 2007).

17 See Government of Alberta, "Alberta researchers equipped for innovation," news release, 7 December 2009, https://www.alberta.ca/release.cfm?xID=274746A16ABA4-92AF-5D3F-20C5CE2A662B206E.

18 Data in this section provided by the FOIP Officer for Alberta Innovates, 17 July 2017 unless otherwise indicated.

19 The Ministry of Economic Development and Trade reported in 2016 that 47 per cent of provincial funding for research at the CARI institutions for 2014/15 had been channelled through Alberta Innovates (Government of Alberta 2016, 9). We were unable to analyze Alberta Innovate agencies' funding of university-based research by category of research (as we did for NSERC, CFI, and ASRIP), because detailed information about the projects funded was not provided in the annual reports and was not available from Alberta Innovates in 2017. It does not appear that databases of projects funded were maintained by the four AI agencies.

20 The report of the International Board of Review on the Fund stated that, in 2006/07, AIF made $13.5 million in research training awards to 378 natural science and engineering students in Alberta universities, and supported 58 new faculty with start-up funding in the amount of $7 million (Alberta Ingenuity 2008a, 15). AI's 2007/08 Annual Report states that it had provided funding for almost 500 students since 2001 (Alberta Ingenuity 2008b, 11).

21 This figure is from the Director of Information Services, Economic Trade and Development, 26 June 2017. No data have yet been located for the AICML's funding from 2007-2009.

22 This centre became an "institute" in 2007, with a $30 million investment from the Government of Alberta (Alberta Ingenuity 2008b, 20).

23 Ministry of Energy, http://www.energy.alberta.ca/Oil/RI/Pages/IETPAR.aspx.

24 Government of Alberta, "New Energy Innovation Fund supports energy development and environmental protection," media release dated 30 August 2006, https://www.alberta.ca/release.cfm?xID=204275FD97AC6-F63D-DE63-202C2D4F30BFD6C9.

25 The Titanium Corporation proposal and reports are available on the Ministry of Energy's website (http://www.energy.alberta.ca/AU/Publications/Pages/SandI.aspx).

26 Titanium Corporation [N. Erasumus], "Research Grant Proposal to Alberta Department of Energy," 22 October 2007, updated 7 February 2008, http://www.energy.alberta.ca/AU/Publications/Documents/2008TitaniumEIFResearchProposal.pdf, p. 26.

27 Links to the funding agreements are available on the website of the Ministry of Energy: https://www.alberta.ca/carbon-capture-and-storage.aspx.

28 ERA, "New Chair for Emissions Reduction Alberta," 28 August 2018, https://www.eralberta.ca/news/media-releases/new-chair-for-emissions-reduction-alberta/.

29 "CAPP mulling AOSTRA-style project using solvent-based bitumen recovery," *Daily Oil Bulletin*, 17 April 2017. Deborah Jaremko, "CAPP pitching an AOSTRA for oilsands solvents," JWN, 21 April 2017, http://www.jwnenergy.com/article/2017/4/capp-pitching-aostra-oilsands-solvents-weeks-best-quotes/. CAPP, "A competitive policy and regulatory framework for Alberta's upstream oil and natural gas industry," July 2017, https://www.capp.ca/publications-and-statistics/publications/304673. Former Premier, Alison Redford, had promised an "AOSTRA 2" in March 2012, funded to the tune of $3 billion. See "Redford pledges $3 billion in oil-sands environmental research," *Globe and Mail,* 28 March 2012.

30 Government of Alberta, "Petrochemicals Diversification Program," March 2018, https://www.alberta.ca/assets/documents/energy-petrochemical-diversification-factsheet.pdf.

31 IOSI's website stated in March 2020 that the Institute had 161 "participants worldwide."

32 In a 2009 blog, Taylor referred to a $15 million "public/private partnership" between the AWRI and GE Water & Process Technologies to improve the treatment of water used in oil sands operations, and to an AWRI-funded project involving researchers at the University of Alberta that was studying the potential of micro-organisms to break down chemical compounds in the tailings ponds and convert them to methane gas. Lorne Taylor, "Water challenges in oil sands country: Alberta's Water for Life Strategy," Guest Blog on the Alberta Government Water Portal, September 12, 2009, https://albertawater.com/alberta-water-blog/12-guest-columnist-lorne-taylor.

33 Annual reports going back to 2003 may be found on ABMI's website: https://www.abmi.ca/home/publications/551-600/562.

34 CERC program, https://www.cerc.gc.ca/news_room-salle_de_presse/releases-communiques/nr-co-20121108-eng.aspx.

35 In the first CERC competition, 20 awards were made in the science, engineering, and medical fields. None of these went to women.

36 "First Canada Excellence Research Chair created at University of Calgary," *UToday,* 17 October 2014, https://www.ucalgary.ca/utoday/issue/2014-10-17/first-canada-excellence-research-chair-created-university-calgary.

37 UAlberta has also secured a CERC in Arctic Resources (related to diamond mining), held by D. Graham Pearson, a CERC in Glycomics (3rd competition), held by Lara Mahal, and a CERC in Virology, held by Michael Houghton. It should be noted that the University of Alberta submitted a proposal in the third competition for a CERC in Smart Electrical Energy Systems which was, however, not successful. See CERC Program, https://www.cerc.gc.ca/phase1/alberta-eng.aspx.

38 As of May 2016, UAlberta claimed to have 49 Tier I and 35 Tier II CRCs, whose funding totalled $13.3 million annually. See https://uofa.ualberta.ca/news-and-events/newsarticles/2016/february/crcs#sthash.6A81ppIo.dpuf (accessed 7 May 2016). There were also two SSHRC CRCs in areas of environmental research at the UAlberta: Gavin Renwick (Design for Arctic Environment) and Brenda Parlee (Social Responses to Ecological Change).

39 Summary of Campus Alberta Innovation Program Chair appointments provided to the author by Mr. Neil Sulakhe, Director, Research Capacity Planning, Alberta Economic Development and Trade, 15 May 2017.

40 Undergraduate students, too, are encouraged to think of careers in the oil and gas corporations, through the faculties' close relationships with these corporations as sources of scholarships, summer schools, and internships, their endowments to faculty buildings, lecture theatres, and other facilities, as well as their participation in recruiting fairs. The "About Us" page of the website of the Faculty of Engineering at the University of Alberta stated, in March 2020, that it had placements for almost half of its undergraduate students ("more than 2,000 students") in its co-op program, and that "Our partnerships with industry are part of our education and research culture." https://www.ualberta.ca/engineering/about-us. The UAlberta Engineering Faculty also offers the only accredited BSc in Petroleum Engineering in Canada (https://www.ualberta.ca/civil-environmental-engineering/research/petroleum), and it has its own employment centre (https://www.ualberta.ca/engineering/student-services/employment).

41 An article on the incorporation of EnergyINet describes its purpose in this way: "The creation of EnergyINet is the result of more than three years of consultation and discussions involving industry, government and research leaders, who have come together to develop a coherent energy production and environmental technology plan for Canada. Operating as a virtual network of more than 200 energy, environmental and technical experts, EnergyINet recognizes that no single source of energy will be enough to meet the continued growth in energy demand. Accordingly, the group will pursue an integrated energy production strategy that promotes innovation and the development of new technologies, in addition to research and development." See "EnergyINet pursues plan for environmentally responsible energy production," *Ecoweek* 17 October 2005, http://www.ecoweek.ca/issues/ISarticle.asp?aid=1000198355.

42 Office of the Commissioner of Lobbying of Canada, lobbyist database, https://lobbycanada.gc.ca/app/secure/ocl/lrs/do/vwRg?cno=13418&regId=501293#regStart.

43 A list of such groups may be found in "Ecosystems and Society," a joint proposal for a Signature Area at the University of Alberta from the Faculties of Arts, ALES, and Science, January 2017, https://drive.google.com/file/d/0B8g5PWMGyfxPZmZKSERaRWlmTXM/view. This proposal was co-authored by Laurie Adkin, James Cahill, and Nadir Erbilgin, representing the Faculties of Arts, Science, and ALES, respectively, with input from other members of those faculties.

44 See "UCCities—Global Urban Research Group at UCalgary: About," University of Calgary, 2020, https://arts.ucalgary.ca/labs/global-urban-research/about.

45 The unit producing these reports was called Research and Information Support from 1990-1996, University Research Branch from 1997–2000, University Research and Strategic Investments Branch from 2001–c. 2006, and Research Capacity Planning Branch from 2007–2015. See note 16 for a list of the reports.

46 COSIA is an alliance of 13 corporations engaged in developing and sharing technologies to reduce production costs and minimize environmental harms associated with bitumen extraction and processing. COSIA claims to have contributed to 936 technologies as of 2016, at a cost of $1.33 billion. The industry alliance is a co-funder of the Alberta Biodiversity Conservation Chairs at the University of Alberta. See COSIA, 2016 Project Portfolio, http://www.cosia.ca/uploads/files/performance-goals/COSIA-2016-Project-Portfolio.pdf.

47 This list was culled from the NSERC and CFI databases (awards made to researchers at Alberta universities) and from searches of corporate websites.

48 Statistics Canada, "Study: Industrial contributions to research and development spending in Canada," *The Daily*, 15 February 2017, http://www.statcan.gc.ca/daily-quotidien/170215/dq170215f-eng.htm. A fuller report of the findings from the 2013 survey of companies is provided by Richards et al. 2017.

49 Statistics Canada, 2017, op cit. In this report, Statistics Canada also notes that "foreign-controlled firms" accounted for 39 per cent of industrial R&D spending in resource industries in 2013.

50 Statistics Canada. Table 27-10-0347-01 Industrial energy research and development expenditures by area of technology, by industry group based on the North American Industry Classification System (NAICS) and country of control (x 1,000,000). https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2710034701. DOI: https://doi.org/10.25318/2710034701-eng.

51 This finding regarding the heavy weighting of corporate R&D budgets toward in-house research was also found in studies of fossil fuel companies' R&D investments in the British and American cases. See Lander (2013), Muttitt (2003), and Washburn (2010).

52 Statistics Canada, Table 27-10-0347-01 Industrial energy research and development expenditures by area of technology, by industry group based on the North American Industry Classification System (NAICS) and country of control (x 1,000,000), https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2710034701.

53 The negligible investment by Canadian energy companies in renewable energy R&D appears to be the case at the global level, as well. A recent report from the International Energy Association shows no oil and gas company investment in onshore wind or solar PV technologies from 2015 to 2018, and very little investment in offshore wind technology (about 2 per cent of global investment) ("Share of global capital investment in selected low-carbon technologies 2015-2018" table, IEA 2020). On the other hand, about 38% of all investment in carbon capture and storage or utilisation technologies has come from oil and gas companies during the same period (Ibid.).

54 In 2016 the NDP government created the Energy Efficiency Agency, and in 2018 it announced the creation of the Bioenergy Producer Program and the Industrial Energy Efficiency Fund. These entities are not included in Table 6.4 because they do not fund research and development.

55 The CFREF applications and business plans have not been made available to the public.

56 There are, regrettably, no signs that the UCP government elected in April 2019 plans to reverse this trend. In December 2019, the government cut the budget of the Ministry of Agriculture and Forestry by 9.1 per cent and laid off 50 employees, many of whom were engaged in research. The government said that it was "transitioning to a framework of producer and industry-led research" (French 2019).

57 Others view government-subsidized technology innovation for the fossil fuels industry as a central element of fossil capitalism's medium-range accumulation strategy, or "climate capitalism" (Adkin 2017b, Sapinski 2016).

58 The NDP government made some moderate reforms to income and corporate tax rates during its term in office but did not modify the royalty regime or bring in a sales tax to raise government revenue. It should be noted, however, that the NDP government did bring in a tax on combustible fuels whose revenue was partially directed to energy efficiency programs and public transportation financing.

59 The Canadian Centre for Policy Alternatives—BC Office and the Corporate Mapping Project have published numerous reports in the past five years documenting the political influence of the oil and gas corporations and their industry associations.

60 The NDP government allocated $31 million to a campaign to win public support for the Trans Mountain Pipeline expansion project. In January 2019, the government estimated that it had spent about $23 million of this amount (Carney 2019). The government's so-called "cap" on oil sands sector GHG emissions of 100 Mt was set at a level which permitted emissions to grow by 25-30 Mt. The Premier, the Minister for Energy, and the Minister for Environment and Parks made statements on numerous occasions to the effect that Alberta could increase oil sands production while reducing the carbon footprint of the sector's operations. See for example, Environment and Parks Minister Shannon Philips' preface to the 2016/17 Annual Report of the Climate Change Emissions Management Corporation (ERA 2017, 7). In a November 2018 interview, Energy Minister Marg McCuaig said: "We know that there's (going to) be a demand for a long time, with fossil fuels, but we also know that we can ... work our way to a low carbon transition, you know, to innovation, and get clean and sustainably produced resources from Alberta" (Audette-Longo and de Souza 2018). See, too, Premier Notley's address to Albertans of August 30, 2018 (Notley 2018).

61 This is a reference to the Titan of Greek mythology who brought fire to humans, thereby invoking the wrath of the gods. The general association is between technology and human progress, equated with human power to manipulate and control the elements. See Dryzek 1997.

62 See, for example, https://www.facebook.com/OilGasCanada/videos/702204435727/ (last accessed 14 October 2018). Another video highlighting research to make oil sands mining less environmentally harmful—made by the government of Alberta—features Murray Gray, former Chair of the Department of Chemical and Materials Engineering at the University of Alberta, Dean of Graduate Studies, and Director of the Institute for Oil Sands Innovation. See http://www.youtube.com/watch?v=XrCPKKN35LQ&NR=1 (last accessed 25 May 2016). Gray retired from the UAlberta in 2014 to become VP Research at Hamad bin Khalifa University in Qatar, and then the Senior VP Academics and Provost of the Petroleum Institute in Abu Dhabi, UAE.

63 Nicole Basaraba, "Xstrata Chair in Mining and Mineral Process Engineering for C5MPT," University of Alberta website, 1 October 2012. https://www.ualberta.ca/engineering/news/2012/October/XstrataChairinMiningandMineralProcessEngineeringforC5MPT.aspx.

64 Statement by Dean David Lynch, Faculty of Engineering website: http://research.engineering.ualberta.ca/research-specializations/research-leaders/WorldsTopOilSandsResearch.aspx (accessed 9 May 2016).

65 Encana, "EnCana donation advances energy and environmental research," 19 March 2008, https://www.encana.com/news-stories/news-releases/details.html?release=609375.

66 University of Alberta media release, 19 March 2008, author's archives.

67 Doug Goss, quoted in Sheila Pratt, "U of A top brass insulted by U of C's

claim to be 'Canada's energy university'," *Edmonton Journal* 24 October 2014, http://edmontonjournal.com/news/local-news/u-of-a-top-brass-insulted-by-u-of-cs-claim-to-be-canadas-energy-university.

68 On his LinkedIn site, David Lynch claims that, during his tenure as dean, the Faculty doubled its undergraduate and graduate student enrolments (to over 6,000 students), hired more than 270 new professors, secured over 50 Chair positions (endowed, industrial, and government funded), and obtained capital funding for the construction of five new engineering buildings (130,000 square metres of space). He further claims that the faculty secured over $900 million in donations and grants to finance this expansion. "David Thomas Lynch," LinkedIn, n.d., accessed September 30, 2019, https://www.linkedin.com/in/david-thomas-lynch-79b09022/.

69 Dr. Samarasekera, whose term as President of the University of Alberta ended 1 July 2015, is now a Senior Advisor at Bennett Jones Vancouver, where she "advises clients on mining, oil and gas, and environmental matters" (http://www.bennettjones.com/SamarasekeraIndiraV/). In April 2016 she became a member of the board of directors of TransCanada Pipelines (https://www.transcanada.com/globalassets/pdfs/about/governance/transcanada-board-of-directors-indira-samarasekera.pdf).

70 Faculty of Engineering website: http://research.engineering.ualberta.ca/research-specializations/research-leaders/WorldsTopOilSandsResearch.aspx (accessed 9 May 2016). The top five universities for energy research publications, in descending order, were ranked by the ISI Web of Science in 2016 as: Tshingua University (China), IIT (India), Zhehjiang University (China), UC Berkeley, and Shangai Jiao Tong University. The Imperial College of London was number 7.

71 The 2019-2020 Calendar of the University of Alberta lists 270 continuing faculty members (assistant, associate, or full professors) in the Faculty of Engineering. Eighty faculty members would constitute 30 per cent of the professoriate.

72 Providing the flavour of this conflict are: Fraser Forbes (Dean of Engineering), message to the "Engineering Community," 23 April 2018, published on the website of the Engineering Faculty, https://www.ualberta.ca/engineering/news/2018/april/message-from-fraser-forbes, and; Laurie Adkin et al., "Energy industry must not be allowed to bully universities," *Edmonton Journal,* 3 May 2018, http://edmontonjournal.com/opinion/columnists/opinion-energy-industry-must-not-be-allowed-to-bully-universities.

73 The privileging of natural sciences and engineering research by granting agencies is a world-wide phenomenon. Recently published research that analyzed 4.3 million grants from 333 agencies to researchers in 37 countries for climate change research found that only 0.12 per cent of all research funding from 1990 to 2018 went to social science work (Overland and Sovacool 2020).

74 Excerpts from the ad are quoted in Sheila Pratt, "University of Alberta looks for oil and gas expertise for board of governors," *Edmonton Journal* 16 September 2013.

75 Such statements have been forthcoming from officials at the Universities of Lethbridge (https://www.uleth.ca/unews/article/mike-mahon-statement-truth-and-reconciliation-commission#.Xi5LUehKhP4), Alberta (https://www.ualberta.ca/provost/our-initiatives/indigenous-initiatives/index.html), and Calgary (https://www.ucalgary.ca/indigenous), and from the Government of Alberta (https://www.alberta.ca/education-for-reconciliation.aspx). In July 2015, Premier Notley directed her cabinet ministers to review ways of implementing the UNDRIP principles within their portfolios. The web address for this document is no longer active (http://indigenous.alberta.ca/documents/premier-notley-letter-cabinet-ministers.pdf) but the letter is referred to in the government's submission to the National Inquiry into Missing and Murdered Indigenous Women and Girls (March 2019), https://www.mmiwg-ffada.ca/wp-content/uploads/2019/03/Govt-Alberta-Final-Written-Submission.pdf, as well as in other sources, e.g., https://www.oktlaw.com/walking-talk-albertas-new-government-moves-implement-un-declaration-rights-indigenous-peoples/. The Liberal government of Canada says that it will introduce legislation to ratify the UNDRIP by the end of 2020 (https://www.cbc.ca/news/indigenous/trudeau-undrip-bill-1.5383755) and the NDP government of British Columbia passed a bill to implement UNDRIP in November 2019 (https://www2.gov.bc.ca/gov/content/governments/indigenous-people/new-relationship/united-nations-declaration-on-the-rights-of-indigenous-peoples).

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