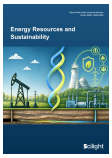
Energy Resources and Sustainability
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Editorial

Introductory Note from the Editors

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Received: 20 October 2026; Accepted: 21 October 2026; Published: 28 October 2026

How To Cite: Wilson, M.; Tontiwachwuthikul, P.; Wang, X.; et al. Introductory Note from the Editors. *Energy Resources and Sustainability* **2026**, *1*(1), 1.

It is a pleasure for us to prepare an introductory article for this new journal, Energy Resources and Sustainability. We look forward to this journal rapidly becoming a leading and impactful publication in the area of energy resource development within the broader energy transition.

It is clear from what is happening globally with climate that we are entering a period of change. Extreme events are becoming more common, and the science of climate change is putting at least a portion of the blame on the doorstep of this change in atmospheric greenhouse gas concentration. The Intergovernmental Panel on Climate Change publishes its reviews every five years and these reviews demonstrate our increasing confidence in the science and our understanding of the impacts of this change on the environment and society.

The editors listed above all live in Western Canada (this is not the editorial board in its entirety, but it will lead into the comments below), although we are joined by Xiangzeng Wang, who brings a broader geographic view from the far east. To some extent, this places us squarely at the interface between fossil fuels being part of the reason for climate change and our interest in making the use of these resources in a manner as environmentally friendly as possible, but practical. The Energy Transition, the attempt to move to energy sources with less impact on the environment, is inevitably a complex and controversial topic. How do we achieve this transition? What is the time frame within which we need to make the change and how do we accomplish this in the most cost-effective way? We cannot turn off fossil fuel production overnight and have renewables and nuclear pick up the slack. Not only is it physically impossible, but it is economically highly impractical and wasteful of current investments. The move to an electrified economy, or one dependent on hydrogen and electricity, does not preclude the use of fossil fuels, particularly natural gas as noted above. To follow any other pathway would result in significant stranding of existing energy assets.

This leads us to our purpose for writing this introduction. We hope that this will answer your most obvious question of "why start such a journal in a small city in the fossil fuel fired economy of Saskatchewan?" What has led to the creation of the International Energy Institute with its flagship journal in this location? We believe that Saskatchewan represents one viable model for what will happen globally, in terms of what has been accomplished and what remains to be undertaken for the Energy Transition.

This requires a brief history lesson. We will make this as painless as possible!

Saskatchewan has not very large, but significant, resources of fossil fuels. In addition to these, the province is a significant producer of Uranium and also the use of agriculture to produce biodiesel for the transportation sector. We bridge the divide and so see the Energy Transition happening around us. We also see the impacts of climate change in our weather patterns, many of these being quite tragic.

Saskatchewan, and particularly the University of Regina, has a long history of setting the tone and direction of research and demonstration in the areas of fossil fuel recovery and mitigation of climate change. The linkages between fossil fuel and the Energy Transition.

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Going back to 1986, the discussion about the use of CO_2 for enhanced oil recovery began. This led to a test of CO_2 capture from a coal fired electrical generating station in 1988. The latter test proved successful, although things did not progress to a capture unit at that point. The oilfield test of CO_2 recovery did proceed and was technically successful.

It was around this time that horizontal wells were moving into the mainstream of oil field development. Saskatchewan supported two tests of horizontal wells, the first for a version of Steam Assisted Gravity Drainage in the heavy oil district and the second for gravity drainage in a heavy oil field (primary recovery). Horizontal well use expanded rapidly including in Weyburn Field (more to come on Weyburn) to optimize water flood production of oil and to set the stage for tertiary recovery with CO_2.

In 1991, a few years after the CO_2 capture test at Boundary Dam (a coal fired power plant), the University hired a leading expert in CO_2 capture. This allowed the University to start a research program in post combustion chemical capture of CO_2 from flue gas, as well as teaching this discipline. Later in this decade, the extension of the pilot test of CO_2 enhanced oil recovery was expanded to full field development.

As a government, Saskatchewan was keen to see development of CO_2 capture in province. The proponent of the full field development of Weyburn field was asked to look at sources of CO_2, including from one of our coal fired generating stations. The demonstration plant at Boundary Dam had also been given to the University to undertake tests.

The interest in CO_2 capture was underway in Saskatchewan. The engineering group focused on CO_2 capture at the University moved to a new building for testing chemical systems for capture, including a versatile small demonstration plant. This was the International Test Centre for CO_2 Capture, an international program of research.

As the movement towards full field expansion at Weyburn was underway, the use of this industrial project to understand the safety of storage in the subsurface was envisaged and moved to reality. One of the mistakes made by the Nuclear Industry had been leaving questions of storage of waste till a response to the public was needed, the goal of understanding Weyburn was to answer the safety questions before they were asked.

At first glance, Weyburn Field was not a great candidate for such research according to a number of geoscience experts, in large part due to the fractured nature of the reservoir. Conventional wisdom at the time called for a more homogeneous matrix for this form of enhanced oil recovery. This was overcome by holding an international meeting in Regina to discuss moving ahead with the work at this location. The huge benefit of Saskatchewan was also the amount of geological information available. The province owns a core storage facility that collects a portion (or the complete core) of the cores taken for oil field development. This dates back to late 40s so the availability of this information, all public, is unrivaled anywhere. In addition, history has proven this to be a successful CO_2 EOR project.

The initiation of the planned research into safety of storage required significant funding and the permission of the operating company. The final aspects of this planning coincided with the creation of the Petroleum Technology Research Centre in Regina. This study became its first major project, with researchers from 6 countries. The project was able to collect field information before the first CO_2 was injected, critical for assessing the impacts on the reservoir as time progressed. While EOR has different basic expectations to pure storage, the end results still come down to the question "how much CO_2 can be safely stored in the subsurface?"

Because of the leadership of Regina in CO_2 capture and storage (CCS or CCUS), the organizing meeting that led to the Intergovernmental Panel on Climate Change (IPCC), working group 3, Special Report on CO_2 Capture and Storage was held in Regina with support from the University. The outcomes of this meeting led to acceptance of the need for the Special Report. As a result, IPCC received the 2007 Noble Peace Prize.

CO_2 was first injected into a portion of the Weyburn Field in 2000. This has been a very successful project based on two Saskatchewan led initiatives—horizontal drilling and understanding more about CO_2 as a recovery fluid. Weyburn had the reputation of being one of the most technically advanced fields globally for a number of years.

Saskatchewan's leadership in CCS/CCUS led to the provincial utility undertaking a major CO_2 capture project at Boundary Dam Power Plant—the refitting of a 150 MW unit and the addition of Sulphur capture and CO_2 capture resulted in Saskatchewan having the first major CO_2 capture facility (up to 3000 tones per day or approximately 90% of the CO_2 emitted for electrical generation) on a coal fired electricity generation station globally. This plant went on-line in 2014. The CO_2 goes primarily to the Weyburn oil field with a slip stream going to a demonstration storage project, Aquistore, owned by the utility and managed by the Petroleum Technology Research Centre. Aquistore has become a world leader in testing CO_2 storage monitoring techniques, again a globally recognized project.

The University of Regina continues to build on the success of the past with a number of relevant research initiatives. As this editorial summary started out, this has created the framework for the creation of the new journal.

As a final note, the Energy Transition will be supported by the ongoing use of fossil fuels globally for decades to come. In particular, the use of natural gas as the fuel producing the lowest greenhouse gas output. Renewables will gradually take up more importance, but CCS/CCUS will play a significant role in the reduction in environmental consequences of fossil fuel use. Saskatchewan's use of wind power, solar energy and biofuels will demonstrate its leadership on the other side of the coin of the Energy Transition.

As we speak, the province is building a 300 MW data centre, with plans to extend this to a 1.2 GW centre. This represents a huge portion of the provincial grid and will require the growth of fossil power to provide the energy for the centre. One of the ironies is that the computing power will allow us to develop a more energy efficient economy, but we must power the data centre in the interim. Natural Gas Combined Cycle with CO_2 capture looks to be the best interim alternative although we have the resources to increase renewables, provide compressed air storage of power and interlink more effectively to a broader North American grid system.

The discussion is intended to give some rationale for the importance of Regina and Saskatchewan to the broader discussion on mitigation of climate change. However, it would be remiss of us to avoid pointing out that many others have taken up the mantle of this mitigation with vigour. This includes one of our editorial leadership team who works for Shaanxi Yanchang Petroleum giving us an opportunity to look beyond the regional approach to the industrial approach to reaching the same end point.

Shaanxi Yanchang Petroleum owns chemical industrial parks and a number of oilfields in northern Shaanxi province. Since 2007, this company has placed a high priority on CCUS technological research and engineering practices to establish China's first fully integrated demonstration project taking CO_2 from the coal to chemicals base to EOR (enhanced oil recovery) in tight oil reservoirs, the use of CO_2 for reservoir fracturing and CO_2 geological storage.

Specific activities include:

- CO_2 Capture: In 2012, a 50,000 tons/year capture facility was built and was expanded to 300,000 tons/year in 2022. Currently, a new 900,000 tons/year capture unit is under construction bringing total capture capacity to more than 1 million tons/year by 2030.
- CO_2 EOR: In 2012, a 50,000 tons/year pilot test area was established in the Qiaojiawa (Jingbian) and Yougou (Wuqi) oil fields. In 2019, 100,000 tons/year CO_2 EOR and storage demonstration project was built in additional oil areas, with the goal of expanding to 360,000 tons/year by 2023. Currently, an injection capacity of 410,000 tons/year has been achieved, with cumulative CO_2 storage exceeding 500,000 tons and no geological leakage detected on-site. A new 800,000 tons/year CO_2 EOR and storage project is under construction, and total injection capacity will also exceed 1 million tons/year by 2030.
- CO_2 Storage**:** A CO_2 storage potential evaluation was undertaken, estimating Yanchang Oilfield's theoretical CO_2 storage capacity at 884 million tons. Deep saline aquifers in the basin are estimated to have a storage potential of over 100 billion tons. For the first time internationally, pressure-transient well testing technology was applied to assess dynamic CO_2 EOR storage potential, estimating Yanchang Oilfield's dynamic storage capacity at 337 million tons.
- Safety Monitoring: Understanding safety is critical to public acceptance or CO_2 storage. Tailored to the characteristics of the Loess Plateau in northern Shaanxi a program was established for an integrated "subsurface–surface–aboveground" three-in-one safety monitoring system at Hua-zi-ping (An-sai), comprehensively monitoring CO_2 storage safety.

At the First Session of COP21, President Obama made an important remark on the Climate Change issue—*"We are the first generation to feel the impact of climate change and the last generation that can do something about it."* In light of that significant remark and the adverse impact of GHG emissions from the utilization of energy and resources, we hope that this journal with your research contributions, can help transition the world to the cleaner and more sustainable future.

Please support the success of the journal and its parent Institute.

Editors

Conflicts of Interest

Given the role as editors-in-chief of this journal, Dr. Malcolm Wilson, Dr. Xiangzeng Wang and Dr. Paitoon Tontiwachwuthikul had no involvement in the peer review of this paper and had no access to information regarding its peer-review process. Full responsibility for the editorial process of this paper was delegated to another editor of the journal.