TERRESTRIAL
ENERGY

18 June 2022

Standing Committee on Science and Research
Sixth Floor, 131 Queen Street
House of Commons
Ottawa ON
K1A 0A6
Via email: SRSR@parl.gc.ca

Dear Chair and Committee Members,

I am writing with regard to your study on small modular reactors (SMRs), which you have undertaken "*to better understand this emerging technology and how it can benefit both the environment and economy in Canadian society.*"

By way of background, Terrestrial Energy is an industry-leading, Generation IV nuclear technology company based in Oakville, Ontario. We are committed to delivering reliable, safe, emission-free and cost-competitive nuclear fission energy with a set of fission technology and plant design choices that deliver a truly transformative power plant. Central to this transformative power plant is an innovative advanced reactor of the Generation IV class.

Generation IV fission technologies were defined by the Generation IV International Forum in 2001, to which Canada was a founding signatory (https://www.gen-4.org).

The GIF states that….

"Generation IV [fission] technologies will use fuel more efficiently, reduce waste production, be economically competitive, and meet stringent standards of safety and proliferation resistance."[1]

GIF leads the international collaborative efforts to develop these next-generation fission energy systems that have potential to be powerful tools to help meet the world's future energy needs.

In May 2019, Terrestrial Energy was admitted to the Generation IV International Forum (GIF) at the invitation of the Canadian government and is currently the only private sector company with this status.

In May 2022, Terrestrial Energy hosted the GIF Molten Salt Reactor (MSR) steering committee meeting at its offices in Oakville, Ontario. Twenty-one international experts attended the meeting in person and remotely, representing 12 national MSR programs.

With their potential, Generation IV nuclear technologies are attracting wide international public and private attention including an enormous grant program support from the US Federal Government, which has committed many billions of dollars to support these next-generation nuclear technologies and has done so preferentially over conventional (water-cooled-water-moderated) technologies.

Terrestrial Energy is developing for near-term commercial operation a zero-emissions cogeneration plant for industry using its proprietary technology Generation IV – Integral Molten Salt Reactor (IMSR) technology. This is the heart of the Company's commercially innovative, small and modular plant design. The IMSR, being a non-Light/Heavy Water Reactor of the Generation IV class, operates at the much higher temperatures that are required to give nuclear energy broad

[1] Source: https://www.gen-4.org/gif/jcms/c_59461/generation-iv-systems

industrial relevance in an energy transition, and required for transformative economic potential, particularly for electric power generation. The IMSR plant is capable of grid-based electric power generation and industrial cogeneration, which makes it relevant for many energy-intensive industries, including petrochemical and chemical synthesis of hydrogen and ammonia and natural resource extraction. With its valuable 585 ^{o}C heat supply, a key feature, the IMSR plant delivers a near 50 percent improvement in the operating and economic efficiency of electric power generation compared to conventional nuclear plants (water-cooled and water moderated reactor technologies).

The IMSR plant's industrial cogeneration capability delivers to today's markets industrial competitiveness, security of energy, and zero-emissions industrial production. Its use of existing industrial materials, components, and fuels supports its near-term deployment, setting the stage for a rapid global decarbonization of the primary energy system.

In this submission, Terrestrial Energy wishes to provide the Committee testimony on three key considerations related to the development of SMRs:

- Economics and importance of the Generation IV fission technology class
- Decreased Waste
- Industrial Heat Applications
- Regulatory Progress

Economics and the importance of the Generation IV fission technology class

The role of nuclear energy as a global energy supply is currently severely constrained by the costs of new plant and electric power generation. In the past, these economic challenges have been ameliorated in part by the use of the economies of unit-scale – big reactors and big plants. With the commercial failure of this approach, the industry's paradigm has changed to use the economies of

production-scale – standardized smaller reactors and smaller plants built repeatedly. It is this new paradigm that is most often referenced in the context of "SMR", yet it is not clear that the switch from the economies of unit-scale to the economies of scale-production will solve the cost limitation. What is unambiguous is that the cost of electric power from smaller plant will be more expensive than from large unless there are positive economic factors that overwhelm.

Terrestrial Energy believes that those overwhelming positive factors are in the "R" of SMR, rather than in the S or the M, i.e. they accrue from the technology choice used by the SMR power plant design. It is a fission technology choice that is at the heart of the industry's multi-decade economic malaise, and it will be a different technology choice that will be at the heat of its future economic success. Terrestrial Energy strongly encourages a discussion in the public square of the relative commercial and social advantages and disadvantages of fission technology choices – the "R" in the SMR – and in particular those of Generation IV technologies.

Terrestrial Energy is developing a Generation IV technology and continues to be dismayed by the lack of discussion in the public square concerning fission technology choice, a choice foundational to economic performance and social acceptance. We need to get past taking about a plant being "small and modular". Without competitive economic performance, nuclear power will not escape a requirement for public subsidy and will severely underplay its potential to accelerate the energy transition required over the next 25 years.

Decreased Waste

Canadians have a general understanding that a responsible industry must take full responsibility for all its waste streams to avoid the "tragedy of the commons," a concept which clearly captures the dumping from fossil fuel combustion of 34,000,000,000 tonnes of CO2 per year into our atmosphere, an atmosphere common to all.

The nuclear energy industry agrees with the Canadian public and wholeheartedly so.

Nuclear power generation emits virtually no CO2 and no other industry takes full responsibility for its waste streams, nor pays for its management and care. Even so, Terrestrial Energy has selected a Generation IV fission technology and developed its IMSR Plant with waste minimization and management in mind – the current IMSR Plant design produces 30% to 50% ***less*** radioactive waste per unit electric energy. This can be increased to 90% plus should Canada support the development of nuclear waste fuel reprocessing technology. Terrestrial Energy notes that many nuclear industrial nations have chosen in recent years to avoid the further development of such reprocessing technologies due to their immense public cost and onerous compliance requirements to meet the standards of international treaty.

Terrestrial Energy's IMSR Plant is revolutionary not because the technology is new, but because it is the product of a private sector technology innovation cycle focused intensively on today's social, market and commercial needs. Such a focus typifies private and entrepreneur-led technology innovation. With this focus, the IMSR plant delivers efficiencies in construction and operation that are transformative, and does so in a compelling time frame.

Conventional reactors (water-cooled-water-moderated reactors) operate at about 300°C, and generally generate electric power at roughly 30% thermal efficiency. By contract, a coal or gas fired electric power plant operates at between 45% and 50% thermal efficiency, an efficiency that defines the competitive commercial advantages of such systems in electric power markets today, and by extension, defines the weak commercial position of new nuclear plants using conventional reactors (water-cooled-water-moderated reactors). Terrestrial Energy's Plant using IMSR fission technology supplies heat for commercial use at 585°C to achieve 45% thermal efficiency, an impressive 50% improvement, and on par with fossil fuel plants, which it seeks to displace from markets, based on cost and price

performance. A major focus of Terrestrial Energy's IMSR innovation program is its short deployment schedule – Terrestrial Energy is capable of playing its part in the commissioning of a first plant in Canada before the end this decade. Foundational to this objective is the IMSR's use of uranium nuclear fuel of a standard grade (standard-assay low enriched uranium, "SA-LEU"). All other Generation IV reactors in development today are designed/required to use (high-assay low enriched uranium, "HA-LEU"). Outside Russia there is no commercial grade supply for HA-LEU. Such supply will cost many billions and many years to bring online in Western markets for long-term commercial supply. Furthermore, the proliferation and security of a HA-LEU fuel form remains the subject of careful policy deliberation and consideration. Terrestrial Energy's IMSR ensures that its IMSR Plant can be deployed without the need for the international community to resolve this highly vexed fuel supply problem, and commit the billions in public funds to effect its commercial supply.

Industrial applications

The pillars of our modern industrial world sit on a foundation of four essential materials – cement, steel, plastics and ammonia. These materials are produced by processes that are highly energy intensive, and particularly heat intensive. These processes represent the hardest challenges of the energy transaction for today there is virtually no alternative to fossil fuel energy use in their production. Conventional nuclear technologies (water-cooled-water-moderated reactors) are not relevant to their production needs. Terrestrial Energy's IMSR Plant changes that with its use of Generation IV technology and a highly efficient system to transport heat for 585 C industrial supply. This changes the use-case of nuclear technology and extends it deeply into the industrial sector to support its energy needs, and notably in the chemical, petrochemical, oil and gas and natural resource sectors. More explicitly, IMSR cogeneration of heat and electric power enables the lowest cost and most energy efficient methods of zero-carbon ammonia and hydrogen production at industrial scale.

On this point, Terrestrial energy has recently partnered with international engineering company, KBR, to explore and develop this. KBR has 50%+ market share of the Western markets' ammonia plant technology.

Regulatory Progress

The commercial use of nuclear technology is carefully regulated for good social reason. Early in the development of IMSR technology, Terrestrial Energy commenced the critical commercial step of nuclear regulatory engagement, and particularly with the CNSC, the US NRC and the IAEA.

Terrestrial Energy recognized these requirements, and commenced regulatory engagement with the CNSC in early 2016. By 2017, the Company had successfully completed Phase 1 of the Canadian Nuclear Safety Commission (CNSC) vendor design review and commenced Phase 2 in 2018, the first SMR developer to do so. In 2018, Terrestrial Energy started a pre-licensing engagement with the US Nuclear Regulatory Commission, and began its engagement with the IAEA in 2020.

In 2018, Terrestrial Energy participated with the CNSC and US NRC in a joint technical review of Terrestrial Energy's IMSR technology design, which was concluded in May 2022. This review was conducted as part of a cross-border regulatory program established in August 2019 by a Memorandum of Cooperation between the CNSC and the NRC. Its scope is foundational for further regulatory safety reviews and supports Terrestrial Energy's regulatory program to prepare license applications required to operate IMSR plants in other markets. Its successful completion represents a leading example of successful cross-border regulatory cooperation supporting the licensing of Generation IV fission technologies for commercial use.

***

Terrestrial's IMSR technology is well positioned to become an integral part of Canada's green economy operating in partnership with other energy supply

sources to provide Canadians with clean, affordable power on a timeline that will assist Canada in meeting its global climate commitments. With broader regulatory approvals undertaken on the international stage, IMSR technology is also in a strong position to show how IMSR technology can help the world reduce its emissions as well.

The scale of economic impacts from successful IMSR deployment outcomes attracts attention. An economic report commissioned in 2021 by Hatch Ltd, estimates Canadian suppliers in Terrestrial Energy's supply chain supporting IMSR deployment worldwide would lead to Canadian firms capturing up to $6.1 billion of revenue annually for engineering services, up to $6.4 billion annually from manufacturing and supply of components and $14.8 billion annually for fuel supply. This would increase Canada's GDP by $25.8 billion per year and support 170,600 total jobs.

In closing, thank you for the opportunity to provide this briefing to the Standing Committee on Science and Research. I trust it will be of value as you consider your report to the House of Commons.

Your sincerely,

Simon

SIMON IRISH
CEO
T +1 (905) 766-3770 x323
M +1 (646) 236-4735
F +1 (905) 823-4677
E sirish@terrestrialenergy.com

TERRESTRIAL ENERGY
"Carbon-free energy for global industry"

terrestrialenergy.com

To stay up to date with news, please sign up for our newsletter at the bottom of our home page.