Small Scale Nuclear Power:
an option for Alaska?

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Table of Acronyms & De nitions

ACEP: C E , A F

ADEC: A D E C

AEA: A E A

CHP: C

CNL: C

CNSC: C C

COL: C (C)

DOD: . D D

DOE: . D E

EBR-II: E B

ERO: E

ESP: E (C)

FHR: -

FLIBE: /

FNPP: F

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IAEA: A E A

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MNPP: M M ( )

MNR: M M ( )

MSR:

MTSPNR: M

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NEI: E

NEIMA: E M A

NGNP: G

NRC: C (.)

OFPU: F

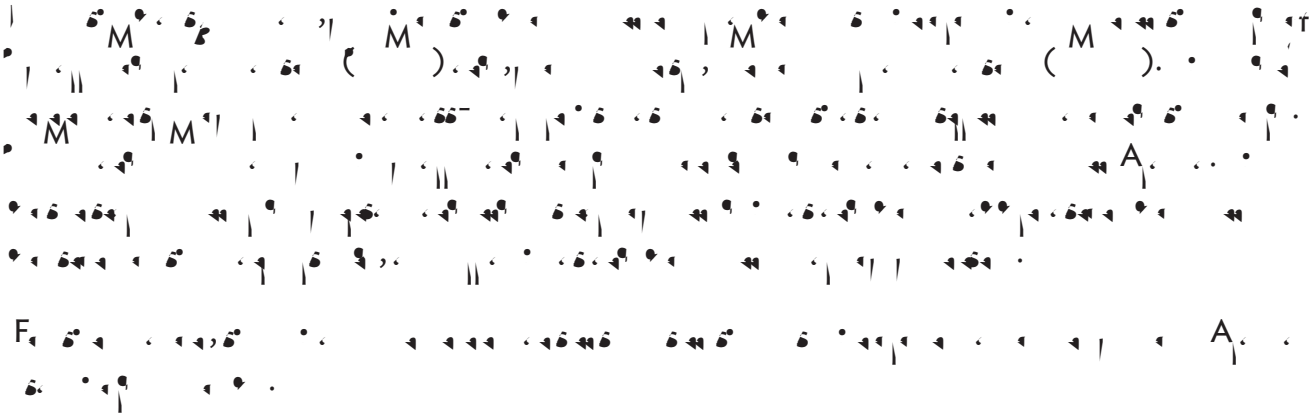
PRISM:

SFR: -

SMR: M M (-1)

TRISO:

1. Executive Summary



F . Sample non-hydroelectric communities in Alaska with su□cient heating and electric loads to match Small Modular Reactor (SMR) or Micro Nuclear Reactor (MNR) capabilities currently under development. Note that loads included in this figure represent maximum electric loads only. Industrial and military sites are not included.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2. Overview of Small Nuclear Technologies

[illegible]

[illegible]

[5] In comparison, the average size of conventional nuclear power plants is approximately 1000 MW, or 1 Gigawatt.

[6] This is an arbitrary cuto, and there are some reactors that are slightly above this size that are still considered small reactors. For example, TerraPower is a company backed heavily by Bill Gates which uses liquid sodium as a coolant and is designed to generate 345 MW of electric power.

[7] Permitting through the Nuclear Regulatory Commission (NRC) is a two-step process. Modular designs can help streamline permitting because the technology is permitted separately from the site.

[8] From "DOD Awards Contracts for Development of a Mobile Microreactor," (March 9, 2020), Retrieved December 27, 2020, from https://www.defense.gov/Newsroom/Releases/Release/Article/2105863/dod-awards-contracts-for-development-of-a-mobile-microreactor/.


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F . . Conceptual layout of a generic SMR or MNR plant. An SMR or MNR is designed to be delivered to the site with key components (or in some cases the entire system) packaged in self-contained housing that is designed to be placed below grade. Many of these reactors generate steam which is used to generate power. Heat can be delivered via a steam or hot water district heating system.

. G . A . S . N . R .

. B . F :

- *Passive cooling.* /
. E

Advanced Fuels

1. *Fuel Form Options.*

2. *Below-grade Installation.*

[16] For example, a Nuscale 12-module power plant would be capable of generating 720 MW. In comparison, the peak demand of the Golden Valley Electric Association grid is 220 MW, and the Railbelt in total is approximately 800 MW.

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T R ; ( )/ C D DC B /

[18] From “INL to provide Oklo access to recovered fuel for microreactor demonstration project,” (February 20, 2020), Retrieved December 30, 2020, from http://www.bizmojoidaho.com/2020/02/inl-to-provide-oklo-access-to-recovered.html.

[19] Information on TRISO fuel available from “TRISO particles: The most robust nuclear fuel on earth,” (July 19, 2019), by Idaho National Lab, from https://art.inl.gov/News%20Highlight%20Attachments/TRISO-particles-most-robust.pdf.

[20] The IMSR design is currently undergoing licensing in Canada of a 400MW thermal (190MW electrical) reactor design, with the first phase of a prelicensing review completed by the Canadian Nuclear Safety Commission in 2017. This first phase provided a regulatory opinion that the design features are generally safe enough to eventually obtain a license to construct the reactor. (From “Pre-Project Design Review of Terrestrial Energy Inc. Integral Molten Salt Reactor,” (November, 2017), Retrieved December 30, 2020, from http://nuclearsafety.gc.ca/eng/pdfs/Pre-Project_Design_Review/Terrestrial-Energy-Pre-Project-Design-Review-Exec-Summary-eng.pdf.)

NuScale, Oklo, USNC Research Reactor, SMR, MNRT, and Others

NuScale Power

[23] NuScale was also used for the economic model developed for ACEP's 2011 report (Holdmann et al, 2011).

[24] This project is heavily subsidized by the U.S. Department of Energy.

[25] The family of nuclear reactors known as light-water reactors (LWIu7(Looled and moderated using o(L)6tmsBT9(0r r)2(eact)2(or)2(s ked (L)

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[32] Launch Alaska website: http://www.launchalaska.com/.

[33] Information provided is derived from ACEP's nuclear educational series presentation by Wendy Simon-Pearson, General Counsel, Ultra Safe Nuclear Corporation presented December 17th, 2020.

[34] There are various reasons why a vendor would choose to license their technology in Canada rather than the U.S. Although initially having di erent approaches with the CNSC more flexible in addressing the unique needs of small reactor technology, today the CNSC and US-NRC are converging on harmonization of the licensing process, so the licensing work done for one country will be broadly applicable to the other.

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[40,41]

[37] From "Nuclear Power in Russia: Floating nuclear power plants," (Updated November 2020) by the World Nuclear

3. Licensing SMR and MNR Technologies

3.1 Licensing SMR and MNR Technologies

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[44] (C A)

C A C

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[42] Nuclear Regulatory Commission website: https://www.nrc.gov/

[43] NRC Design Certification Applications: https://www.nrc.gov/reactors/new-reactors/design-cert.html

[44] NRC Early Site Permit Applications: https://www.nrc.gov/reactors/new-reactors/esp.html

[45] Federal Register/Vol. 85, No. 32/Tuesday, February 18, 2020/Proposed Rules, available at

A E

A R G S N R

A E , C : A E .[56] A A E A (B).[57]
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E ( ) C (C)
A .[58]

A C A C B A
A .[59]
A A

[56] "Alaska Nuclear Energy Statues 2019, Section 18, Chapter 45: Atomic Energy," Retrieved December 30, 2020, from http://www.akleg.gov/basis/statutes.asp#18.45.020.

[57] "Alaska Sustainable Energy Act (SB 220)", Retrieved December 30, 2020, from http://www.akleg.gov/basis/get_documents.asp?session=26&docid=8040.

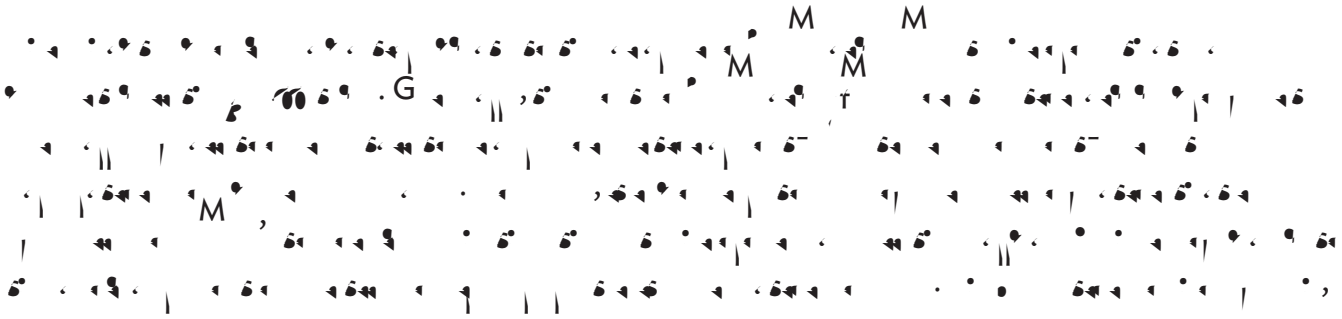
[58] From "Research in Advanced Nuclear Development and Planning," by Kuca, M., (2014), Retrieved December 30, 2020, from http://hdl.handle.net/11122/8842.

[59] "Alaska State Senate Community and Regional Affairs Committee Bill SB 194, 'An Act relating to advanced nuclear reactors'", Retrieved December 30, 2020, from http://www.akleg.gov/basis/Bill/Detail/31?Root=SB%20194

[60] “Decommissioning nuclear reactors is a long-term and costly process,” (November 17, 2017), by Gospodarczyk, M.M., & Kincer, J., Retrieved December 30, 2020, from https://www.eia.gov/todayinenergy/detail.php?id=33792.

[61] A personal discussion with a legislator involved in the original development of these statutes acknowledges they were developed in response to concerns about nuclear proliferation and waste disposal and were not intended to hinder small-scale development that was not envisioned as a possibility at the time of authorship.

5. Economics of SMR and MNR Technology in the Alaska Context

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[66] From “Cost Competitiveness of Micro-Reactors for Remote Markets,” (April, 2019), by the Nuclear Energy Institute, Retrieved December 30, 20 2.u(4.s[illegible]EMC /P [illegible]n-US)/hCID the tps://the www.nei(om .)BDC BTg/(om)5(emesou)5(emB/(om)5(emeps)5(sts-be


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[illegible] *Annual Energy Outlook* [71] [illegible] (F[illegible]).

[illegible] NRC [illegible] PROCESS [illegible]

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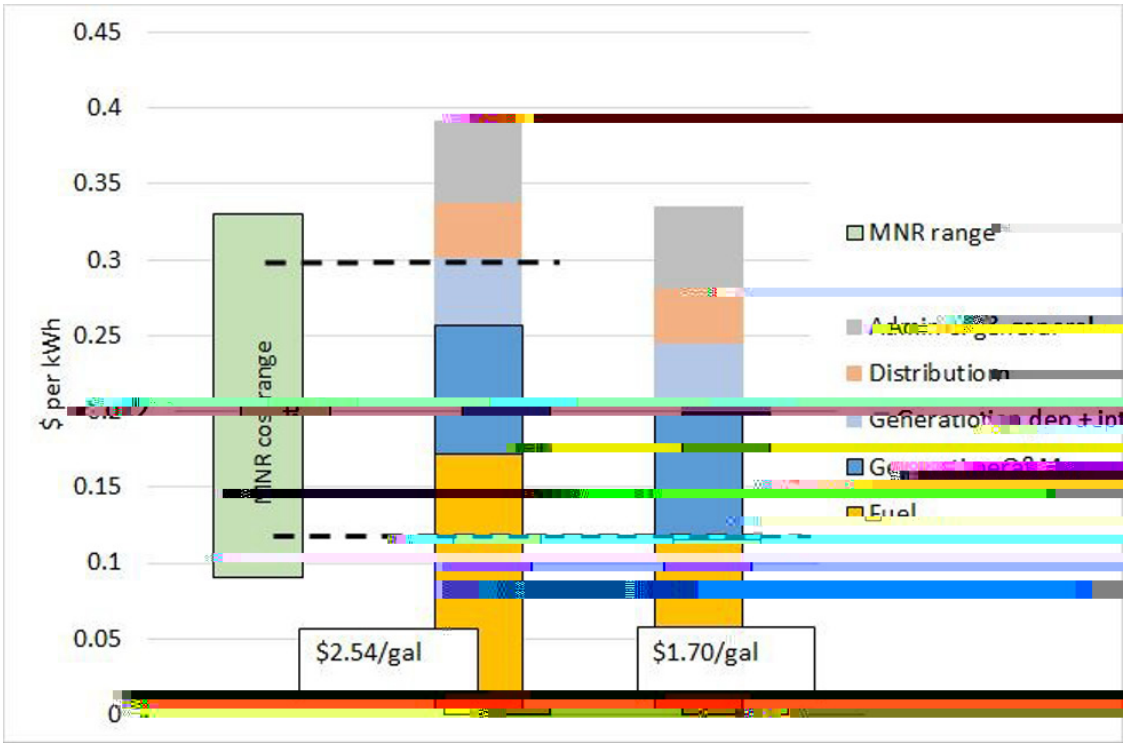

F. Comparison of the cost components of electric service in a representative Alaska hub community, under two di□erent fuel prices, to the potential range of production costs for electricity from an MNR.

6. Next Steps and Recommendations for Action

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7. Appendices

A d A:

TABLE OF REACTOR TECHNOLOGIES
(LESS THAN MW)

Advanced Reactor Concepts	MNR	MS	100	yes	no	Based on the EBR-II, a sodium-cooled fast-reactor power plant operated by Argonne National Laboratory in Idaho for 30 years. arcnuclear.com
BWX Technologies	MNPP	PWR	1-5	Project Pele	no	BWX is the prime contractor building the reactors on the U.S. Navy's nuclear-powered submarines and aircraft carriers. bwxt.com
Columbia Basin Consulting Group	SMR	LM	TBD	ANTD Path 2; GAIN	no	Received $400k in 2018 under the DOE advanced reactor development project pathway. cbcgllc.com
Elysium Industries	SMR	MS	50-1200	GAIN	no	Currently seeking approval/funding for a 10MWe pilot plant. elysiumindustries.com
Flibe Energy	SMR	MS	<5, 250	ANTD Path 2	yes	Proposes lithium fuoride/beryllium fuoride (FLiBe) salt as its primary coolant; also has been pursuing a MNR design. fibe-energy.com
Framatome	SMR	HTGR	272, 50	GAIN, DOE, ARPA-E	yes	Recently announced a partnership with General Atomics to develop a 50 MWe fast modular reactor. framatome.com
GE-Hitachi (Prism)	SMR	LM	165-311	extensive	yes	Planning a demonstration deployment at Department of Energy's (DOE) Savannah River site. nuclear.gepower.com
General Atomics	MNR	PWR	265	GAIN, ARPA-E, DOE	yes	Has historically developed many of the research reactors used in the U.S. (TRIGA). www.ga.com
Holtec	SMR	PWR	160	ANTD Path 2	yes	Completed the Vendor Design Review Phase 1 process in Canada. holtecinternational.com
HolosGen (Quad)	MNPP/ Modular	HTG	3-13	ARPA-E	no	Designed to be packaged in a standard shipping container with load following ability. holosgen.com
Hydromine	MNR	LM	200	GAIN	no	hydromineinc.com
Kairos Power	SMR	MS	140	ARPA-E GAIN	yes	Recently funded under DOE ARPA-E (GEMINA) program. kairospower.com
NuGen	MNR	HTGR	3	?	no	www.nucdev.com
NuScale	SMR	PWR	60	ANTD Path 1; GAIN	yes	Leading US manufacturer of SMRs; Current plans are to deploy in multiples of 60 MWe systems (up to 12 units); some discussion of smaller units in future. nuscalepower.com
NuScale (micro)	MNR	Heatpipe FNR	1-10	?	no	Still "paper reactor" but NuScale leading SMR company in US. nuscalepower.com
Oklo (Aurora)	MNR	Heatpipe FNR	1.5	GAIN	yes	Signifcant engagement in Alaska; has participated in Launch Alaska. oklo.com
Radiant Industries	MNPP	HTRG	~1	GAIN, ARPA-E, DOE	yes	radiantnuclear.com
Terrestrial Energy (IMSR)	SMR	MS	190	GAIN, Canadian Gov.	yes	Canadian based company; planning demonstration at Chalk River by 2026; planning to seek design approval through NRC in future. terrestrialenergy.com
Ultra Safe Nuclear (MMR-5) Corporation	MNR	HTRG	5	Canadian Gov.	yes	Plan to deploy demonstration reactor at Chalk River Laboratories (Canada) site in next few years. usnc.com
Westinghouse (eVinci)	MNPP	Heatpipe FNR	.2-5	Project Pele	yes	Los Alamos National Lab; funded through Project Pele. westinghousenuclear.com
X-energy (Xe-10)	SMR	HTR	80	ARDP, ARPA-E, GAIN	yes	Designed to be scaled as a four-pack to 320 Mwe. x-energy.com
X-energy (Xe-Mobile)	MNPP	HTR	1	Project Pele	no	x-energy.com

A d B:

RECOMMENDATION FOR MODIFICATIONS

TO ALASKA STATE STATUTES PERTAINING TO NUCLEAR ENERGY

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SUMMARY OF ACEP EDUCATIONAL SERIES ON SMALL SCALE NUCLEAR POWER

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