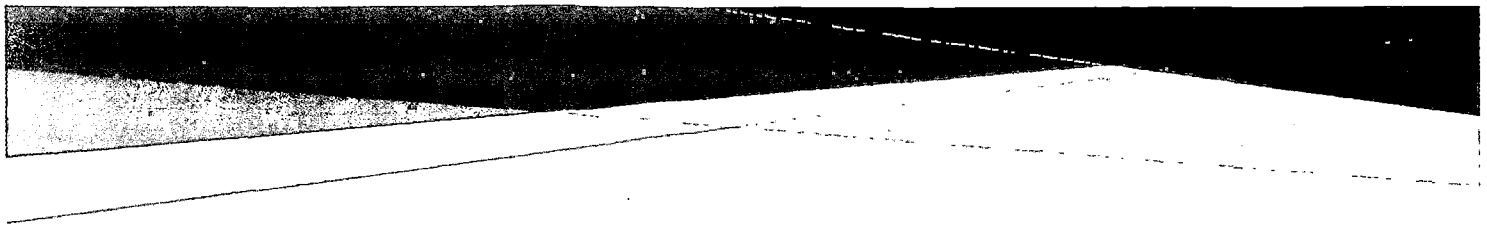

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ENERGY USA

# Examination of Regulatory Requirements to Determine Exemption Needs for the IMSR® Core-unit

**Abstract**
This white paper contains TEUSA's positions on the potential need for exemptions for the IMSR® Core-unit from the applicable technical requirements of the Nuclear Regulatory Commission (NRC) contained in Parts 50 and 52 of Title 10 of the Code of Federal Regulations (10 CFR).

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# Table of Contents





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## I. Purpose

The purpose of this white paper is to present the results of a review of the Nuclear Regulatory Commission (NRC) regulatory requirements in Title 10 of the Code of Federal Regulations (10 CFR) for applicability to the Terrestrial Energy USA, Inc. (TEUSA) Integral Molten Salt Reactor (IMSR®) Core-unit. The analysis identifies the regulations in Parts 50 and 52 that are directly relevant to the IMSR® Core-unit. TEUSA's positions are presented regarding the potential need for exemptions based on the specific design features of IMSR® technology.



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## II. Introduction

Terrestrial Energy USA, Inc. (TEUSA) is developing the Integral Molten Salt Reactor (IMSR®) design to provide electricity or process heat to U.S. industry. TEUSA is planning for the first commercial deployment of this technology in the late 2020s. The IMSR® is a Generation IV advanced reactor power plant that employs a fluoride molten salt reactor (MSR) design. The IMSR® nuclear power plant (I-NPP), consists of a nuclear island containing at least one, approximately 440 MWth IMSR® (IMSR400) Core-unit. The IMSR400 has the potential to generate up to 195 MWe of electrical power or export 600 °C of heat for industrial applications, or some combination of both. The I-NPP includes an adjacent balance-of-plant building that contains non-nuclear-grade, industry-standard power conversion and generation equipment.

The IMSR® design builds upon pioneering work carried out at Oak Ridge National Laboratory (ORNL) from the 1950s to the 1980s, where MSR technology was developed, built, and demonstrated with two experimental MSRs. The first MSR was the Aircraft Reactor Experiment (ARE) and next, the Molten Salt Reactor Experiment (MSRE). ORNL commenced a commercial power plant program for MSR technology based on the demonstrated feasibility of MSR technology. This program led to the Denatured Molten Salt Reactor (DMSR) design in the early 1980s.

TEUSA has developed and submitted a Regulatory Engagement Plan (REP) (Reference 3) to the Nuclear Regulatory Commission (NRC). The REP outlines topics and schedules for interaction with the NRC to achieve early resolution of general technical or regulatory matters related to the IMSR® design. Specifically, the REP highlights technical and regulatory topics that directly support the development and submittal of a 10 CFR 52, Subpart E application for a Standard Design Approval (SDA) of the IMSR® Core-unit. This white paper [ ] support the TEUSA SDA application development efforts.

### Company Background

TEUSA [

]. TEUSA is a Delaware C-Corp founded in August 2014 that started active business operations in 2015. TEUSA is a U. S. majority-owned company with corporate offices in Connecticut. [

].

### Licensing Strategy and Objective

The REP provided to the NRC outlines the regulatory strategy for TEUSA activities. [

] to support a commercial operation date for the first U.S. plant in the 2020s. During regulatory reviews, the NRC uses its understanding of the design and operating characteristics as well as the supporting research and engineering work to perform its review responsibilities efficiently. To support the NRC understanding, TEUSA has begun familiarizing the NRC with the IMSR® design as well as the scope of the available and planned analyses, testing, and operational experience in support of the design. By initiating the process of introducing IMSR® design information to the NRC, TEUSA expects that the NRC will be able to identify any issues that may require further testing or technical analyses. Additionally, the NRC will be more able to estimate the resource and schedule requirements necessary to conduct regulatory activities associated with IMSR® licensing.



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TEUSA's long-term licensing objective for the commercial deployment of the IMSR® design in the U.S. is to first obtain an SDA for the IMSR® Core-unit under 10 CFR Part 52, Subpart E. The IMSR® Core-unit represents a significant technical portion of the IMSR® facility and includes many systems that perform important safety functions. The systems within the Core-unit are reasonably discernible from systems outside the boundaries of the Core-unit. Subsequent sections of this white paper provide additional details about the design envelope of the IMSR® Core-unit and its safety interfaces.

The REP outlines a [

]. The first technical document that TEUSA submitted to NRC was a white paper that provides an overview of major plant buildings, structures, systems and components that make up the IMSR® facility. The next white paper that TEUSA submitted to NRC identifies the interfacing systems that provide important functions in support of the operation and safety of the IMSR® plant, and that interact directly with the IMSR® Core-unit. An additional TEUSA technical document submitted to NRC proposes a set of principal design criteria (PDC) for IMSR® SSCs that provide important functions in support of the operation and safety of the IMSR® plant.

This white paper provides a review of the NRC regulatory requirements in Title 10 of the Code of Federal Regulations (10 CFR) for applicability to the IMSR® design and its interfacing systems and structures. The analysis provided in this white paper identifies the regulations in Parts 50 and 52 that are directly relevant to the IMSR® Core-unit and its interfacing systems and structures, and presents TEUSA's positions with respect to the potential need for exemptions based on the specific design features of IMSR® technology.

The TEUSA Regulatory Engagement Plan (Reference 3) provides additional details regarding TEUSA's licensing activities and objectives.



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## III. Regulatory Envelope and Related Guidance

The regulations governing the application process for an SDA can be found in Subpart E "Standard Design Approvals," to 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The regulatory precedent for 10 CFR Part 52 Subpart E is 10 CFR Part 50 Appendix O, which was first created in January 1975. The process outlined in Appendix O of 10 CFR part 50 was used to review standard designs for nuclear steam supply systems (NSSS), balance of plant systems, a nuclear island, and a turbine island. However, there is no regulatory precedent for using an SDA process for smaller portions of a plant design. The previously approved NSSS designs were subsequently incorporated into construction permit applications for specific plant sites.

10 CFR 52.135(a), "Filing of applications," states:

> *"any person may submit a proposed standard design for a nuclear power reactor of the type described in 10 CFR 50.22 to the NRC staff for its review. The submittal may consist of either the final design for the entire facility or the final design of major portions thereof."*

The current regulations do not define what constitutes a "major portion" of a design making an applicant free to identify and justify the scope of the design for which the approval is being sought. Such freedom affords potential applicants substantial flexibility to standardize different portions of new or innovative technologies. Depending on the maturity of the design and engineering, an SDA could be developed for selected SSCs or larger integrated portions of the design at a level of detail analogous to that of a design certification application. The associated interface requirements could include significant conceptual design information for the remainder of the design.

### Exemptions

10 CFR Parts 50 and 52 specify the conditions under which exemptions may be granted from applicable technical or procedural requirements. 10 CFR 52.7 states that the NRC "may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of the regulations of this part." 10 CFR 50.12 is referenced for the criteria. As stated in 10 CFR 50.12(a):

> *"(a) The Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of the regulations of this part, which are--*
>
> *(1) Authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security.*
>
> *(2) The Commission will not consider granting an exemption unless special circumstances are present. Special circumstances are present whenever--*
>
> > *(i) Application of the regulation in the particular circumstances conflicts with other rules or requirements of the Commission; or*
> >
> > *(ii) Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule; or*



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*(iii) Compliance would result in undue hardship or other costs that are significantly in excess of those contemplated when the regulation was adopted, or that are significantly in excess of those incurred by others similarly situated; or*

*(iv) The exemption would result in benefit to the public health and safety that compensates for any decrease in safety that may result from the grant of the exemption; or*

*(v) The exemption would provide only temporary relief from the applicable regulation and the licensee or applicant has made good faith efforts to comply with the regulation; or*

*(vi) There is present any other material circumstance not considered when the regulation was adopted for which it would be in the public interest to grant an exemption. If such condition is relied on exclusively for satisfying paragraph (a)(2) of this section, the exemption may not be granted until the Executive Director for Operations has consulted with the Commission."*



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## IV. Regulatory Analysis Methodology

This section describes the process used by TEUSA to review the NRC regulations applicable to the IMSR® Core-unit. Since many of the regulations in 10 CFR Part 50 ("Domestic Licensing of Production and Utilization Facilities") and Part 52 ("Licenses, Certifications, and Approvals for Nuclear Power Plants") were written for large light water reactors (LWRs), they may not all apply directly to IMSR® systems and structures. Therefore, the first step in the methodology is to perform a complete assessment of each provision of 10 CFR 50 and 52 to determine its applicability to the IMSR® Core-unit. The licensing requirements were categorized as:

1. **Applicable** – the regulation is applicable to the TEUSA IMSR® Core-unit and its interfacing systems and structures without modification.
2. **Not Applicable** – the regulation is not directly applicable or technically relevant to the IMSR® Core-unit and its interfacing systems and structures.
3. **Exemption** – the regulation contains some requirements that are applicable to the IMSR® Core-unit and its interfacing systems and structures but also contains other requirements that are not relevant or are met using some other means to accomplish the intent of the requirements.

The full range of regulatory requirements that would need to be included as part of a complete application for either a construction permit or a combined license was not evaluated as part of this process. Examples of the additional areas that were not evaluated include, but are not limited to, physical security, emergency preparedness, material control and accounting, safeguards, decommissioning, waste storage and handling. Some of these regulatory areas are currently undergoing rulemaking to establish new or alternative requirements for advanced non-LWR designs. Prior to the submittal of a license application for construction of an IMSR® facility, TEUSA will examine the existing requirements in areas of the facility not covered by this white paper to determine if additional exemptions are potentially needed.

Since the TEUSA licensing strategy is to first focus on obtaining an SDA for the IMSR® Core-unit, the set of regulatory requirements for the entire IMSR® plant was further examined and reduced to the set of requirements that would explicitly apply to the IMSR® Core-unit. Since the interfacing systems and structures would not be a part of the future application for an SDA, potential exemptions for the interfacing systems and structures would not be included in the future SDA application. For example, the spent fuel storage tanks interface with the IMSR® Core-unit but are outside the defined boundaries of the IMSR® Core-unit. Therefore, this paper does not discuss the need for potential exemptions for the spent fuel storage tanks because they are beyond the scope of an application for an SDA for the IMSR® Core-unit.

The licensing requirements applicable only to the IMSR® Core-unit were identified and evaluated for the potential need for exemptions. A brief explanation is included, for each regulatory area identified by TEUSA that may require an exemption for the IMSR® Core-unit, and can be found in Section V.



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## V. Regulatory Analysis Results

The regulations in 10 CFR Parts 50 and 52 were reviewed by TEUSA and categorized based on their applicability to the pursuit of an SDA for the IMSR® Core-unit as described in the previous section. This section presents an overview of the results from TEUSA's review in the tables below.

### Part 50 – Domestic Licensing of Production and Utilization Facilities

The table below presents the NRC rules from 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," and their designated categorizations (applicable, not applicable, or exemption) based on TEUSA's review.

**Table 1. TEUSA Categorizations of 10 CFR Part 50 Regulations [**



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Part 52 – Licenses, Certifications, and Approvals for Nuclear Power Plants

The table below presents the NRC rules from 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," and their designated categorizations (applicable, not applicable, or exemption) based on the TEUSA review. Note that the rules are categorized based on their applicability to the pursuit of an SDA for the IMSR® Core-unit.

**Table 2. TEUSA Categorizations of 10 CFR Part 52 Regulations [**



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## VI. Conclusion

The regulations in 10 CFR Parts 50 and 52 were reviewed by TEUSA and categorized based on their applicability to the pursuit of an SDA for the IMSR® Core-unit. Within Part 50, [ ] rules will likely require exemptions and [ ] rules were found to be not applicable, either because they do not apply to IMSR® technology or because they are not relevant for an SDA for the IMSR® Core-unit. Within Part 52, [ ] are the only sections that are applicable to an SDA for the IMSR® Core-unit. Subparts [ ] are not applicable.



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## Abbreviations & Acronyms

AOO – Anticipated Operational Occurrence

ARDC – Advance Reactor Design Criteria

ARE – Aircraft Reactor Experiment

$BeF_2$ – Beryllium Fluoride

CFR – Code of Federal Regulations

CNSC – Canadian Nuclear Safety Commission

Cs – Cesium

CSA – Canadian Standards Association

DBA – Design Basis Accident

DMSR – Denatured Molten Salt Reactor

DOE – Department of Energy

GDC – General Design Criteria

HP – High Pressure

I&C – Instrumentation and Control

IFCS – Irradiated Fuel Cooling System

IFS – Irradiated Fuel System

I-NPP – IMSR Nuclear Power Plant

IMSR® – Integral Molten Salt Reactor

IRVACS – Internal Reactor Vessel Auxiliary Cooling System

KF – Potassium Fluoride

LEU – Low-Enriched Uranium

LiF – Lithium Fluoride

LP – Low Pressure

LWR – Light Water Reactor

MCR – Main Control Room

MFS – Makeup Fuel System

MHTGR – Modular High Temperature Gas Reactor

MHTGR-DC – Modular High Temperature Gas Reactor Design Criteria

MPa – Megapascal

MSR – Molten Salt Reactor

MSRE – Molten Salt Reactor Experiment

MW – Megawatt

MWe – Megawatt Electric

MWth – Megawatt Thermal



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NaF – Sodium Flouride

NPP – Nuclear Power Plant

NRC – Nuclear Regulatory Commission

ORNL – Oak Ridge National Laboratory

PDC – Principal Design Criteria

PHX – Primary Heat Exchanger

PRA – Probabilistic Risk Assessment

Pu – Plutonium

RAB – Reactor Auxiliary Building

R&D – Research and Development

RD&T – Research, Development, and Testing

REP – Regulatory Engagement Plan

RG – Regulatory Guide

RMSS – Remote Monitoring and Shutdown System

SCA – Secondary Control Area

SDA – Standard Design Approval

SDM – Shutdown Mechanism

SFR – Sodium Fast Reactor

SFR-DC – Sodium Fast Reactor Design Criteria

SHX – Secondary Heat Exchanger

Sr – Strontium

SS – Stainless Steel

SSC – Structures, Systems, and Components

TEI – Terrestrial Energy, Inc.

TEUSA – Terrestrial Energy USA, Inc.

U – Uranium

$UF_4$ – Uranium Tetrafluoride

U.S. – United States of America

VDR – Vendor Design Review

Xe – Xenon



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