PROPOSAL

Development and Demonstration of a Prototype Nuclear Reactor Using Direct Conversion Technology (DCT) Based on HLEC and TPV

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1. INTRODUCTION

The increasing need for efficient and reliable nuclear energy production necessitates exploring new technologies for converting the heat produced in the core of nuclear reactors. Traditional nuclear power systems rely on complex power trains involving steam generators, turbines, and electric generators with multiple components requiring extensive maintenance and operational oversight.

This project aims to develop and demonstrate a **conceptually new system with no moving parts**, leveraging **Heat-to-Light-to-Electricity Conversion (HLEC) and Thermophotovoltaic (TPV) technologies**. While HLEC and TPV have been successfully tested in laboratory environments, the primary challenge lies in **scaling the power output of Direct Conversion Technology (DCT) to MW-level electricity production**. Overcoming this challenge could pave the way for a **new generation of highly efficient and compact electric power production systems** that revolutionize nuclear energy conversion.

2. PROJECT SCOPE AND OBJECTIVES

The present proposal seeks funding for development and demonstration of **HLEC and TPV** based Direct Conversion Technologies capable of producing **MW-level electric power** from nuclear reactors. Scope of work will include the following:

- **Develop and validate fundamental physics and material properties** needed for DCT.
- **Construct and operate a lab-scale prototype** demonstrating power generation using HLEC and TPV.
- **Evaluate scalability and performance** in extended operational conditions.
- **Deliver a conceptual reactor design** that incorporates DCT into an SMR framework.

3. COLLABORATIVE DEVELOPMENT TEAM

This project is envisioned as a collaborative effort between a **US-based team of nuclear scientists and advanced material specialists** and **a team of scientists and engineers from Technion – Israel Institute of Technology**.

Technion's Role in the Collaboration

Technion is a world-leading Israeli hi-tech research institution with extensive expertise in:

- **Advanced materials science**, particularly high-temperature-resistant materials.
- **Photonics and nanotechnology**, which are critical for optimizing HLEC and TPV systems.
- **Nuclear and energy conversion research**, contributing theoretical and experimental insights into non-mechanical heat-to-electricity conversion.

The collaboration will enable an **international exchange of expertise**, leveraging Technion's specialization in **optical engineering and materials science** alongside **US-based nuclear engineering and reactor physics knowledge**.

4. SCOPE OF WORK, TIMELINE, AND BUDGET

Scope of Work

The project will be divided into the following key work packages:

Phase 1: Technology Development & Validation (Year 1-2)

- **Refine HLEC and TPV Designs**: Optimize efficiency and stability of heat-to-electricity conversion.
- **Material Selection & Testing**: Identify and test radiation-resistant materials for high-temperature emitters and PV cells.
- **Computational Modeling**: Simulate and refine energy conversion mechanisms.
- **Initial Prototype Fabrication**: Develop small-scale experimental systems to validate core concepts.

Phase 2: Lab-Scale Prototype Demonstration (Years 2-3)

- **Prototype Construction**: Build a lab-scale demonstrator of DCT.
- **Experimental Testing**: Conduct extended tests under nuclear-relevant conditions.
- **Performance Benchmarking**: Validate system efficiency, durability, and power output.

Phase 3: SMR Conceptual Design & System Optimization (Years 3-5)

- **System Integration Modeling**: Simulate a full nuclear reactor using DCT.
- **Conceptual SMR Design**: Develop an initial design blueprint incorporating DCT.
- **Technical & Economic Feasibility Analysis**: Assess the cost-benefit potential for commercial deployment.

5. PROJECT TEAM & REQUIRED EXPERTISE

Each team (US and Israeli) will consist of 4-5 members, including:

- **Nuclear Engineer (1)** – Reactor core thermal analysis and safety considerations.
- **Materials Scientist (1-2)** – High-temperature material selection and degradation studies.
- **Optical Physicist (1)** – Optimization of thermal emitters and photon transport.
- **Photonics Engineer (1)** – Development of advanced spectral filtering and optical coatings.
- **PV Specialist (1)** – Optimization of TPV cells for radiation capture efficiency.
- **Experimental Researcher (1)** – Overseeing laboratory testing of emitter-PV interactions.

6. TIMELINE, DELIVERABLES, BUDGET (4-5 YEARS)

Phase	**Duration**	**Budget Estimate (USD)**
Phase 1: Technology Development & Validation	24 months	$6M - $8M
Phase 2: Lab-Scale Prototype Demonstration	12-18 months	$7M - $9M
Phase 3: SMR Conceptual Design & System Optimization	18-24 months	$7M - $8M
Total Estimated Budget	**4-5 years**	**$20M - $25M**

7. POTENTIAL FUNDING SOURCES

This project aligns with multiple US and international funding opportunities, including:

US-Based Funding Sources

- **Department of Energy (DOE) Advanced Research Projects Agency-Energy (ARPA-E)** – Supports high-risk, high-reward energy innovations.
- **DOE Office of Nuclear Energy** – Provides grants for next-generation nuclear technologies.
- **National Science Foundation (NSF) Engineering Directorate** – Funds nuclear materials and energy conversion research.
- **Private Sector Investment** – Venture capital from energy technology funds and corporate partners in nuclear and semiconductor industries.

International Funding Sources

- **Israel Innovation Authority** – Provides funding for Israeli-led technology collaborations.
- **Horizon Europe (EU Program for Research & Innovation)** – Supports transnational nuclear and energy innovation.
- **Bilateral US-Israel Energy Center (BIRD Foundation)** – Facilitates joint US-Israeli R&D initiatives.
- **International Atomic Energy Agency (IAEA) Research Grants** – Supports innovative nuclear power research.

8. CONCLUSION

The project aims to **develop and demonstrate** a viable Direct Conversion Technology (DCT) that can replace conventional steam-cycle power conversion in nuclear reactors. If successful, this project will deliver a **patented and demonstrable DCT, a lab-scale prototype, and a conceptual SMR design**.

The collaborative effort between **US and Israeli scientists** ensures access to world-class expertise, and the project's **measured scope and budget ($20M-$25M over 4-5 years)** make it an attractive investment for government and private funding entities.

The success of this project will be a crucial milestone in advancing nuclear energy technology, providing the necessary groundwork for the commercialization of next-generation nuclear power systems based on Direct Conversion Technology (DCT).