



# U.S. Department of Energy

## Categorical Exclusion Determination Form

**Program or Field Office:** Advanced Research Projects Agency - Energy (ARPA-E)

**Project Title:** 25A5081 - Harvesting Low Quality Heat Using Economically Printed Flexible Nanostructured Stacked Thermoelectric J

**Location:** \*- Multiple States - Illinois, Massachusetts

**Proposed Action or Project Description:**

American Recovery and Reinvestment Act:

Low quality heat (< 150 oC) constitutes a 2 TW untapped source of energy in the US. High coefficient of performance thermoelectrics with a figure of merit (ZT) exceeding 1, can potentially harness approximately 4.3% of this waste heat and add 23% to the current electricity production at zero additional carbon or noise emission. Inspired by the preliminary demonstration of silicon nanowires with ZT of 0.6 at room temperature, we propose using an economic and highly scalable non-lithographic approach to fabricate size-controllable, waferscale arrays of rough-surface, one-dimensional concentric nanotubes of silicon to increase surface scattering, followed by transfer printing to manufacture flexible thermoelectric junctions. We anticipate that the multiple scattering of phonons in these nanotube waveguides will significantly enhance the room temperature ZT to beyond 1.2. The first phase of the work will involve dimensional and geometric design, ZT characterization and fine tuning repeatable fabrication. The second phase of our work will integrate the arrays onto flexible substrates using transfer printing. We will optimize the system performance of such stacked junctions. The end of phase deliverable is a 1 square inch flexible thermoelectric module with effective ZT>1.2. Such flexible modules will convert waste heat in power plants, data centers and automobiles with minimal customization of heat exchangers, and in constrained settings without requiring land resources or adding noise pollution. The proposed

**Categorical Exclusion(s) Applied:**

X - B3.6 Siting/construction/operation/decommissioning of facilities for bench-scale research, conventional laboratory operations, small-scale research and development and pilot projects

\*-For the complete DOE National Environmental Policy Act regulations regarding categorical exclusions, see Subpart D of 10 CFR10 21 [Click Here](#)

This action would not: threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, including DOE and/or Executive Orders; require siting, construction, or major expansion of waste storage, disposal, recovery, or treatment facilities, but may include such categorically excluded facilities; disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; or adversely affect environmentally sensitive resources (including but not limited to those listed in paragraph B.(4)) of Appendix B to Subpart D of 10 CFR 1021). Furthermore, there are no extraordinary circumstances related to this action that may affect the significance of the environmental effects of the action; this action is not "connected" to other actions with potentially significant impacts, is not related to other proposed actions with cumulatively significant impacts, and is not precluded by 40 CFR 1506.1 or 10 CFR 1021.211.

Based on my review of information conveyed to me and in my possession (or attached) concerning the proposed action, as NEPA Compliance Officer (as authorized under DOE Order 451.1B), I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

NEPA Compliance Officer: /s/ William J. Bierbower

Digitally signed by William J. Bierbower  
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Date Determined: 12/18/2009

Comments:

Webmaster:



## 25A5081 – Proposed Action or Project Description (Continued)

minimal customization of heat exchangers, and in constrained settings without requiring land resources or adding noise pollution. The proposed work goes beyond existing research on individual nanowires to demonstrate system level nanostructured thermoelectrics with potential savings of 21% savings in CO<sub>2</sub> emissions from electricity generation. The generation potential is equivalent to 23% of the current electricity generation and 12% of the annual crude oil consumption in the US.