House Committee on Science and Technology

"The Advanced Research Projects Agency – Energy (ARPA-E): Assessing the Agency's Progress and Promise in Transforming the U.S. Energy Innovation System"

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Introduction & Background

Good morning Chairman Gordon, Ranking Member Hall, and members of the committee, thank you for inviting me to testify on an urgent matter of national importance; commercialization of clean energy technologies. My name is Anthony Atti and I'm the Co-Founder and CEO of Phononic Devices and am deeply passionate about this issue. Originally from Buffalo, NY, I've had the uniquely American opportunity to work in clean energy across the country as a scientist and entrepreneur and am continually inspired by our entrepreneurial spirit, now very much embodied I believe in ARPA-E. I have an undergraduate degree in Biochemistry from Ithaca College and earned my Ph.D. in Organic Chemistry from the University of Southern California where I researched hydrogen and methanol fuel cells in partnership with NASA's Jet Propulsion Laboratory. During that time our research was supported by DARPA with an audacious goal…extend battery run time while significantly reducing their weight by more than 30% thus benefiting the war fighter. Here I saw the positive impact of a transformational funding approach coupled with commercial emphasis; an important template for ARPA-E. I've now spent almost a decade building early stage clean energy companies; the rewards are great but so too are the risks. First and foremost is technology readiness; few investors can quantify this variable and often misjudge time to market. Second is market risk; if you build it…the customer does not always come. And last is operating risk; start-up companies require staffing of key management and technical positions. Collectively, a chicken and egg scenario confronts entrepreneurs as they're told by investors; "come see me when you have something"…only to think "but isn't that what your money is for?"

Phononic Devices

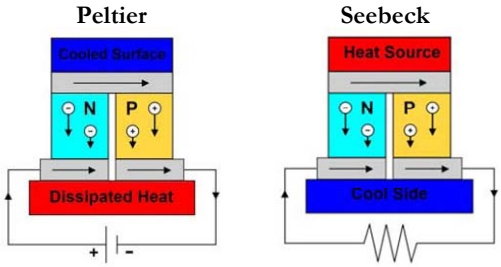
In today's energy landscape we generate most electricity by making heat, whether it's through burning coal or splitting atoms. That heat makes steam which turns a turbine and makes electricity. A somewhat antiquated process, most of the heat is wasted...a staggering 50-60% according to Department of Energy estimates. Consequently, and not without some irony, there's a more than $7B industry for technologies that deal with the damaging effects of this heat. Phononic Devices was founded to recapture this waste heat and convert it into usable electric power, or depending on the source of the heat, provide refrigeration and cooling. This 'thermoelectric' concept uses advanced semiconductor materials, similar to those found in microprocessors and solar cells, to manage heat by manipulating the direction of electrons at the nanoscale. Resembling computer chips, thermoelectric devices are quiet, have no moving parts or harmful emissions, and our design concepts are projected to dramatically improve thermoelectric efficiency from less than 10% today to more than 30%. This is expected to result in a $/W energy savings of 75% for power generation and 60% for cooling, respectively. Innumerable market opportunities for power and cooling exist…steel and aluminum manufacturers accustomed to venting heat through smoke stacks now view this as a source of power while a new generation of refrigerators and air conditioners can operate quietly and without harmful chemicals.

ARPA Impact

While our plan is sound and the rewards truly transformational, the challenge ahead is formidable; Phononic Devices' technology is still early in development, market penetration features entrenched multi-billion dollar competitors, and we are literally building the company from the ground up out of laboratories at the University of Oklahoma and North Carolina State University. Very few venture capital investors are willing to take on this level of risk…and this economy only makes it worse. However, in the process of responding to ARPA-E's program we have made great progress with investors: we signed an exclusive agreement with the University of Oklahoma accessing valuable intellectual property; partnered with best-in-class researchers at the University of California Santa Cruz and California Institute of Technology; and built a technical and business database for investors to review. Having now successfully concluded the reward process, Phononic Devices has raised more than $2M in venture capital financing from clean energy leaders Venrock and Oak Investment Partners. We have aggressive growth plans, having now added 4 full time engineers in just 6 months our business plan projects the need for more than 250 employees over the next 3 years. Already, we have received inquiries from Fortune 500 defense, industrial and electronics customers with a pressing need for innovative cooling solutions, or power generation options to mitigate their electricity costs. Our company has a very simple but important motto…"Do Good Science…Quickly" and with ARPA-E is excited to be a part of this important initiative benefiting our country at such a critical time in her history. Thank you again for your time and I look forward to answering your questions.

WRITTEN TESTIMONY

Company Background: Phononic Devices is commercializing advanced thermoelectric semiconductor materials and devices designed to convert waste heat from industrial and commercial processes into usable electric power, and conversely, highly efficient cooling and refrigeration. Despite the national security risks and pollution concerns associated with fossil fuel consumption, the Department of Energy estimates that 50-60% of all the energy consumed in the US per year is wasted as heat; recovery of which is an intense area of interest. Phononic Devices' unique approach and design concepts, developed in an exclusive licensing partnership with the University of Oklahoma, are projected to dramatically improve thermal to electric energy conversion efficiency by combining key thermoelectric properties: superior thermopower with thermally insulating thin film materials. With diverse energy harvesting applications that include powering wireless devices, hybridization with solar thermal concentrators and combustion engines, as well as the ability to displace compressors for residential and HVAC cooling, Phononic Devices' approach makes possible a more than $125B market opportunity.



Applied current removes heat

Waste heat drives current/power

Nanostructured Semiconductor Materials: despite a clean and reliable solid state platform and high value-add uses that include opto-electronic cooling and custom refrigeration, widespread thermoelectric commercial adoption has been hindered by low ZT ~1; an important gauge of Carnot Power Conversion Efficiency of only ~10%. Too low to compete with or displace incumbent power generation and refrigeration technologies, traditional thermoelectric design concepts have focused mainly on reducing lattice thermal conductivity with limited success. Emphases on material nanostructures that specifically optimize thermopower – core to Phononic Devices' approach – present a tremendous opportunity.

$$ZT = \frac{\alpha^2 T}{\lambda \rho}$$

α - Seebeck Coefficient
ρ - electrical resistivity
λ - thermal conductivity

Transformational Impact: High Efficiency Thermoelectric Devices: Phononic Devices is uniquely positioned to accelerate market penetration through direct sales, OEM licensing, and joint venture partnerships with industry and manufacturing leaders. Phononic Devices recognizes that to capture an existing share of the $300M thermoelectric market, but more importantly access a more than $125B cooling and energy harvesting opportunity, its product platform must radically change the fundamentals of thermal to electric energy conversion. Performance features

far superior to existing competitors and exceeding demanding customer requirements are enabled by Phononic Devices' thin film and high efficiency thermoelectric approach. Device features will follow a modular and scalable design approach; flexible range of operating conditions; highly efficient 'Z'T Carnot Power Conversion and COP cooling; and a thin-film manufacturing platform readily scaled and transitioned using industry-standard high volume throughput manufacturing techniques. Phononic Devices is led by an experienced entrepreneurial team, best-in-class technical collaborators, and backing from top tier Silicon Valley Cleantech investors; the company was recently recognized by the newly created ARPA-E as a leader in the emerging clean energy marketplace.

MARKET OPPORTUNITY

Cooling & Refrigeration: thermoelectric cooling is popular for luxury and recreational refrigerators and also widely used to cool and control temperature in optoelectronics and telecommunications equipment. Concerning the former, as customers increasingly incorporate aesthetics into their utility purchases, a quiet and more importantly compact option provides greater flexibility and functionality beyond the kitchen. In the latter case of opto-electronics and telecom, cooling and temperature stabilization of laser diodes, superluminescent laser diodes, and diode pumped solid state lasers is of paramount importance. In many cases thermoelectric modules are considered a standard component of laser devices as temperature control is a critical element needed to maintain laser lifetime, prevent premature failure, and enable advantageous laser emission parameters.

Opportunity	IT Server Cooling	Refrigeration	Commercial HVAC
Reduce Emissions (Conservative Estimates)	• 71% reduction in electricity vs. cooling fans • 84,000 tons of CO_2 eliminated • 70,350 tons of coal not burned	• 60% reduction in cooling power vs. compressors • 54,400 tons of CO_2 saved • 26,760 tons of coal not burned	• 33% reduction in cooling power vs. compressor • 130,000 tons of CO_2 saved • 16MM tons of coal not burned
Market Opportunity	• 35M servers worldwide by 2012, 15% CAGR	• 16M refrigerators sold annually in US; 2% CAGR • Custom refrigeration CAGR of 7%	• >15M HVAC sold per year in US; 3.2% CAGR • HVAC global equipment demand $84B; 6% CAGR

Energy Harvesting: energy harvesting is the process whereby ambient heat is captured, converted into electricity and used to drive electrical and combined devices. The use of thermoelectrics, in which a temperature difference creates an electric potential, can convert a portion of this waste heat from thermal sources into electricity thereby improving the overall efficiency of an operating system. Widely used in space propulsion for decades, recently thermoelectric generators have been targeted by military and wireless customers for sensors and remote power where battery life and access to back-up power is problematic. Hybridization with Concentrating Solar and Concentrating PV are also of great interest as waste heat from the sun's direct rays can be captured to augment the collective power and efficiency of the installation.

Opportunity	Solar Hybridization	Wireless Devices	Automotive Waste Heat Recovery
Reduce Emissions (Conservative Estimates)	• Eliminates 480,000 tons of CO_2 & 402,000 tons of coal	• Eliminates 1,900 tons of batteries from landfill • TE device reliability > 15 years	• 13% improvement over current fuel economy (28 vs. 25 mpg) • Eliminate 58MM tons of CO_2 & 166MM bbls crude
Market Opportunity	• $/Wp: 50% cheaper than current PV systems • Cost competitive w/grid	• $67BB RFID tags expected by 2014 • 50B battery market; $10B for micro power devices	• More than 8MM mid & full-size sedans purchased annually in US

Short Narrative Bio

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An experienced clean energy investor and entrepreneur, Dr. Atti has demonstrated expertise and leadership in venture financing, business development, start-up growth and operations, and negotiating joint venture relationships. As a former Director at MHI Energy Partners, a seed and early stage energy private equity fund, Dr. Atti managed deal flow networks, conducted due diligence, structured venture financing transactions, and provided direct portfolio company leadership as an Entrepreneur-in-Residence. Dr. Atti earned his Ph.D. in Organic Chemistry from the Loker Hydrocarbon Research Institute at the University of Southern California under the direction of Dr. G.K. Surya Prakash and Dr. George A. Olah; the former a world-renowned fluorine chemist and the latter a winner of the 1994 Nobel Prize in Chemistry. As a Post-Doctoral member of the Electrochemical Technologies team, he conducted research on hydrogen and methanol fuel cells at the NASA-Jet Propulsion Laboratory in Pasadena, CA. Dr. Atti also holds an MBA from New York University and a Bachelor of Arts in Biochemistry from Ithaca College.