Lattice Energy LLC

Commercializing a Next-Generation Source of Safe Nuclear Energy

Low Energy Nuclear Reactions (LENRs)

Company Vision

What key milestones remain and why are we doing this?

Lewis G. Larsen

President and CEO

September 11, 2011

"Energy, broadly defined, has become the most important geostrategic and geoeconomic challenge of our time."

Thomas Friedman

New York Times, April 28, 2006

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Where are we at with LENR device technology today?

Understanding of the physics is vastly better than in 1989

- ✓ Back In 1989, many thought LENRs were some form of "cold fusion"
- ✓ They were wrong: thanks to Widom-Larsen (WLT) theory we now know that unique features of LENRs involve "weak interaction," <u>not</u> "strong interaction" fusion (hot, cold, warm, or otherwise) or fission
- ✓ WLT explains exactly how LENRs are clean and 'green,' i.e., why there are no deadly emissions of 'hard' gamma photon radiation, fluxes of dangerous energetic neutrons, or long-lived radioisotopes
- ✓ As of today, we have published the non-proprietary, basic physics of LENR devices in two mainstream peer-reviewed journals (2006, 2010)
- ✓ While competitors may still be struggling to understand basic science issues in LENRs, after 10 years of effort Lattice is finally ready to apply its proprietary knowledge of LENRs and initiate a device engineering program to build high performance heat sources

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What milestones remain for commercialization of LENRs?

There are several: include capital, hard work, and partners

- ✓ **Lattice needs at least US$25 million to begin prototype device engineering program; establish secure R&D facility in Chicago area**
- ✓ **Two-track parallel development of device embodiments suitable for small heat sources (engineered 'target' nanoparticles affixed to substrate surfaces) and extraordinarily scalable large heat sources (injection of 'fuel' nanoparticles into highly organized dusty plasmas)**
- ✓ **After that, cost-effective, long lived LENR-based power generation systems must be engineered, scaled-up in power output, manufactured in high unit volumes at reasonable cost, and sold at prices that equate to at least 10x better price/performance vs. competing energy sources**
- ✓ **Large strategic corporate partners will also be needed to leverage LENR-based systems into large array of important market applications**

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Is commercialization of LENRs a certainty yet?

No, and it won't necessarily be easy - but
We will never know whether it is possible if we don't try

Quoting from a speech given by U.S. President John F. Kennedy at Rice University back in 1962,

"We choose to go to the Moon in this decade and do the other things, not because they are easy - but because they are hard. Because that challenge is one we are willing to accept, one we are unwilling to postpone and one we intend to win."

Science of LENRs is real: somebody, somewhere, will do this

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How long to commercialize LENRs; for what applications?

Our thinking on this subject as of today

- ✓ Goal of planned US$25M engineering program is to produce system-level prototype LENR heat sources within 2-3 years of full funding
- ✓ Results achieved with two different types of device prototype embodiments ('target' nanoparticles affixed to substrate surfaces vs. nanoparticle injection into dusty plasmas) will determine next set of engineering goals. If both approaches deemed successful, will continue on two tracks toward both small- and large-scale commercial systems
- ✓ Upon successfully reaching this milestone, final time-to-market will be determined by: availability of needed capital; whether any surprises have arisen in scale-up engineering or product safety; and Lattice's ability to secure large strategic corporate R&D and marketing partners who can further accelerate product development and market penetration
- ✓ Possible first products include 3-5 kW standalone stationary electrical power generation systems and bore-hole heaters for oil & gas industry

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Potential market applications for LENRs; first targets

Applications	Description	Target Markets
LENRs enable safe, 'green' carbon-free nuclear energy production and power generation at reasonable cost - Vastly greater energy densities and longevity at a lower price per kWh compared to chemical power sources	Scale-up and integrate LENR heat sources w. different energy conversion technologies: e.g., develop portable battery-like devices using thermoelectrics that can convert raw heat directly to DC electricity; or, use heat to rotate a shaft for propulsion (e.g., Stirling or modern steam engines in motor vehicles)	SAFE - no radiation shielding or nuclear waste issues; could also eventually enter portable power markets and compete directly against chemical batteries, small fuel cells, and microgenerators
Bitumen extraction, heavy oil recovery, and/or oil shale processing According to Prof. K. Deffeyes of Princeton University, about 2/3 of oil remaining in the ground worldwide is classified as 'heavy'	Use bore-hole LENR thermal sources to heat-up bitumen or heavy oil underground: reduce production costs, enhance recovery; could use LENR heaters for in-situ underground upgrading and downstream process heat	Major benefit to large oil producers – can help increase long-term supplies of oil and reduce total production costs as well as CO_2 'footprint'
Develop much cleaner fission power generation technologies Use LENRs and ultra low momentum neutrons (ULMs) for triggering fission	Design new types of LENR-based subcritical fission reactors that can burn existing fissionable fuels down to stable isotopes – little or no long-lived radioactive wastes	Retrofit new ULM-neutron reactors into existing nuclear fission power systems; much better safety and lower costs
Nuclear waste treatment Transmute dangerous radioactive nuclear waste using LENRs; generate additional power from waste burn-up	Develop turnkey systems for on-site clean-up of existing worldwide inventories of fission wastes from nuclear power plants	Nuclear waste remediation and clean-up – opportunities in many countries, e.g., US, France, Japan, China, etc.
Transmutation of stable elements Produce almost any very valuable element or isotope in the periodic table at competitive costs compared to present mining and refining operations	Use LENRs to transmute less expensive elements into much more valuable ones – first do it abiologically; later migrate to methods using various species of genetically engineered bacteria	Mostly target precious and rare metals production, e.g., platinum, gold, rhodium, rare earth elements, etc

First Targets

Potential Long-term Opportunities

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What is market strategy once LENRs are commercialized?

Could potentially have immense impact on energy markets

- ✓ Over time, plan to ride down manufacturing experience cost curve; similar to build-cost reduction and market penetration strategies used by electronics manufacturers; e.g., microprocessors, memory chips, PCs, and cellphones
- ✓ As product manufacturing experience accumulates and internal build costs are progressively reduced, leverage enormous energy density/longevity advantages of LENRs (>million times larger than chemical); price LENR-based systems to drastically undercut price/performance provided by competing thermal sources and chemically-based power generation systems --- this strategy can be applied to portable, distributed stationary, mobile, and central station power markets
- ✓ Potential to gradually replace internal combustion engines over 30 - 60 years; enable reduction of CO_2 emissions and "energy independence" from petroleum
- ✓ Widespread global deployment of LENR technologies, together with synergistic large- and small-scale photovoltaic and wind-power systems, could create a less expensive, greener energy future for humanity. LENRs and a portfolio of other types of carbon-free energy technologies have the potential to democratize access to affordable energy for every inhabitant of the planet

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Why are we doing this? It's not just about money

Because it is important - it transcends countries

"No single solution will defuse more of the Energy-Climate Era's problems at once than the invention of a source of abundant, clean, reliable, and cheap electrons. Give me abundant clean, reliable, and cheap electrons, and I will give you a world that can continue to grow without triggering unmanageable climate change. Give me abundant clean, reliable, and cheap electrons, and I will give you water in the desert from a deep generator-powered well. Give me abundant clean, reliable, and cheap electrons, and I will put every petrodictator out of business. Give me abundant clean, reliable, and cheap electrons, and I will end deforestation from communities desperate for fuel and I will eliminate any reason to drill in Mother Nature's environmental cathedrals. Give me abundant clean, reliable, and cheap electrons, and I will enable millions of the earth's poor to get connected, to refrigerate their medicines, to educate their women, and to light up their nights."

Thomas Friedman in "Hot, Flat, and Crowded" 2008 page 186

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Six articles about LENRs written for a general audience

Published by Institute of Science in Society (London, UK)

"Low energy nuclear reactions for green energy - how weak interactions can provide sustainable nuclear energy and revolutionize the energy industry" November 13, 2008 http://www.i-sis.org.uk/LENRGE.php
"Widom-Larsen theory explains low energy nuclear reactions & why they are safe and green - all down to collective effects and weak interactions" December 4, 2008 http://www.i-sis.org.uk/Widom-Larsen.php
"Portable and distributed power generation from LENRs - power output of LENR-based systems could be scaled up to address many different commercial applications" December 10, 2008 http://www.i-sis.org.uk/PortableDistributedPowerFromLENRs.php
"LENRs for nuclear waste disposal - how weak interactions can transform radioactive isotopes into more benign elements" December 11, 2008 http://www.i-sis.org.uk/LENR_Nuclear_Waste_Disposal.php
"Safe, less costly nuclear reactor decommissioning and more - how weak interaction LENRs can take us out of the nuclear safety and economic black hole" January 26, 2009 http://www.i-sis.org.uk/safeNuclearDecommissioning.php
"LENRs replacing coal for distributed democratized power - low energy nuclear reactions have the potential to provide distributed power generation with zero carbon emission and cheaper than coal" January 27, 2009 http://www.i-sis.org.uk/LENRsReplacingCoal.php

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Technical papers on Widom-Larsen theory of LENRs

"***Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces***" Eur. Phys. J. C **46**, pp. 107 (March 2006) Widom and Larsen – initially placed on arXiv in May 2005 at http://arxiv.org/PS_cache/cond-mat/pdf/0505/0505026v1.pdf; a copy of the final *EPJC* article can be found at: http://www.newenergytimes.com/v2/library/2006/2006Widom-UltraLowMomentumNeutronCatalyzed.pdf
"***Absorption of nuclear gamma radiation by heavy electrons on metallic hydride surfaces***" http://arxiv.org/PS_cache/cond-mat/pdf/0509/0509269v1.pdf (Sept 2005) Widom and Larsen
"***Nuclear abundances in metallic hydride electrodes of electrolytic chemical cells***" http://arxiv.org/PS_cache/cond-mat/pdf/0602/0602472v1.pdf (Feb 2006) Widom and Larsen
"***Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces***" http://arxiv.org/PS_cache/nucl-th/pdf/0608/0608059v2.pdf (v2. Sep 2007) Widom and Larsen
"***Energetic electrons and nuclear transmutations in exploding wires***" http://arxiv.org/PS_cache/arxiv/pdf/0709/0709.1222v1.pdf (Sept 2007) Widom, Srivastava, and Larsen
"***Errors in the quantum electrodynamic mass analysis of Hagelstein and Chaudhary***" http://arxiv.org/PS_cache/arxiv/pdf/0802/0802.0466v2.pdf (Feb 2008) Widom, Srivastava, and Larsen
"***High energy particles in the solar corona***" http://arxiv.org/PS_cache/arxiv/pdf/0804/0804.2647v1.pdf (April 2008) Widom, Srivastava, and Larsen
"***A primer for electro-weak induced low energy nuclear reactions***" Srivastava, Widom, and Larsen Pramana – Journal of Physics **75** pp. 617 (October 2010) http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

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Our final thoughts

The Gordian knot facing humanity is not that our world will ever run-out of energy per se in the foreseeable future. Between global coal reserves and electromagnetic energy in the form of endless photons streaming from the sun there is more than enough energy to be had for whatever purpose. Energy availability, in the broadest possible sense, is not the Gordian knot.

The Gordian knot is that worldwide consumers of energy need to have technologically usable, reasonably priced energy delivered to the right place at exactly the right time in forms that are environmentally benign and readily compatible with sustainable, long-term global economic growth.