Lattice Energy LLC

LENRs are disruptive new source of safe, radiation-free nuclear energy

Nanocomposite LENR devices in Japanese
NEDO industry-academia-government R&D project
produced enough cumulative excess heat to boil a cup of tea

Ultralow energy neutron reactions (LENRs)

Under the radar technology: little mentioned in media or science press

Could potentially replace internal combustion engine if it can be commercialized

- New type of very disruptive green nuclear power generation technology
- Radically different from fission and fusion nuclear energy technologies:
  - No emission of deadly energetic neutron or gamma radiation
  - No production of dangerous long-lived radioactive wastes
  - No necessity for $$$ radiation shielding or containment systems
  - Many-body reactions instead of simple 2-body nuclear reactions
  - Key steps rely on electroweak force rather than strong force
  - Reactions triggered at moderate temperatures and pressures
  - Spent LENR devices could be disposed of in ordinary landfills
- Cost of producing energy could be vastly lower versus fission or fusion
- LENR devices could someday be mass-produced --- much like batteries
- Physics of processes fully explained by Widom-Larsen theory of LENRs

Comparison of LENRs to fission and fusion

Fission, fusion, and LENRs all involve controlled release of nuclear binding energy (heat) for power generation: no CO_2 emissions; scale of energy release is MeVs (nuclear regime) > 1,000,000x energy density of chemical energy power sources

Heavy element fission: involves shattering heavy nuclei to release stored nuclear binding energy; requires massive shielding and containment structures to handle radiation; major radioactive waste clean-up issues and costs; limited sources of fuel: today, almost entirely Uranium; Thorium-based fuel cycles now under development; heavy element U-235 (fissile isotope fuel) + neutrons → complex array of lower-mass fission products (some are very long-lived radioisotopes) + energetic gamma radiation + energetic neutron radiation + heat

Fusion of light nuclei: involves smashing light nuclei together to release stored nuclear binding energy; present multi-billion $ development efforts (e.g., ITER, NIF, other Tokamaks) focusing mainly on D+T fusion reaction; requires massive shielding/containment structures to handle 14 MeV neutron radiation; minor radioactive waste clean-up $ costs vs. fission

Two key sources of fuel: Deuterium and Tritium (both are heavy isotopes of Hydrogen)

Most likely to be developed commercial fusion reaction involves the following:

D + T → He-4 (helium) + neutron + heat (total energy yield 17.6 MeV; ~14.1 MeV in neutron)

Ultralow energy neutron reactions (LENRs): distinguishing feature is neutron production via electroweak reaction; neutron capture on fuel + gamma conversion to IR + decays [β^-, α] releases nuclear binding energy; early-stage technology; no emission of energetic neutron or gamma radiation and no long-lived radioactive waste products; LENR systems would not require massive, expensive radiation shielding or containment structures → much lower $$$ cost; many possible fuels --- any element/isotope that can capture LENR neutrons; involves neutron-catalyzed transmutation of fuels into heavier stable elements; process creates heat

Until very recently LENR experiments couldn't boil cup of tea

NEDO project greatly improved excess heat performance vs. prior work

- LENR phenomena have controversial history dating back nearly 100 years
- At time of most recent rediscovery (1989), milliwatt-level reproducibility of excess heat was poor and after 2-year debacle, R&D interest in LENRs waned. This occurred because: (1) there was no theoretical explanation for anomalous effects observed experimentally, especially transmutation of chemical elements; and (2) nanotech required to reproducibly fabricate Watt-level heat producing LENR devices simply did not exist at that time
- Between then and now, R&D in LENRs continued at low rates with limited funding in number of countries scattered around world, including Japan and USA. Experimentation and measurements of final reaction products with mass spectroscopy demonstrated microscopic transmutation occurs reproducibly in both Hydrogen- and Deuterium-loaded LENR systems. Reproducible production of Watt-level excess heat remained very elusive
- Since 1989, production of calorimetrically measured excess heat during vast majority of experiments with purpose-fabricated LENR devices was a hit-or-miss proposition. When excess heat produced, was typically < 1 Watt for periods ranging from few hours to several days. NEDO greatly improved device fabrication, reproducibility, longevity, and excess heat performance

For years skeptics summarily dismissed LENRs as a potential new energy source because experiments were unable to produce enough excess heat to even "boil a cup of tea"

Thanks to NEDO project, not any more

Image credit: Gregory Johnston

Japan's government targeting commercialization of LENRs

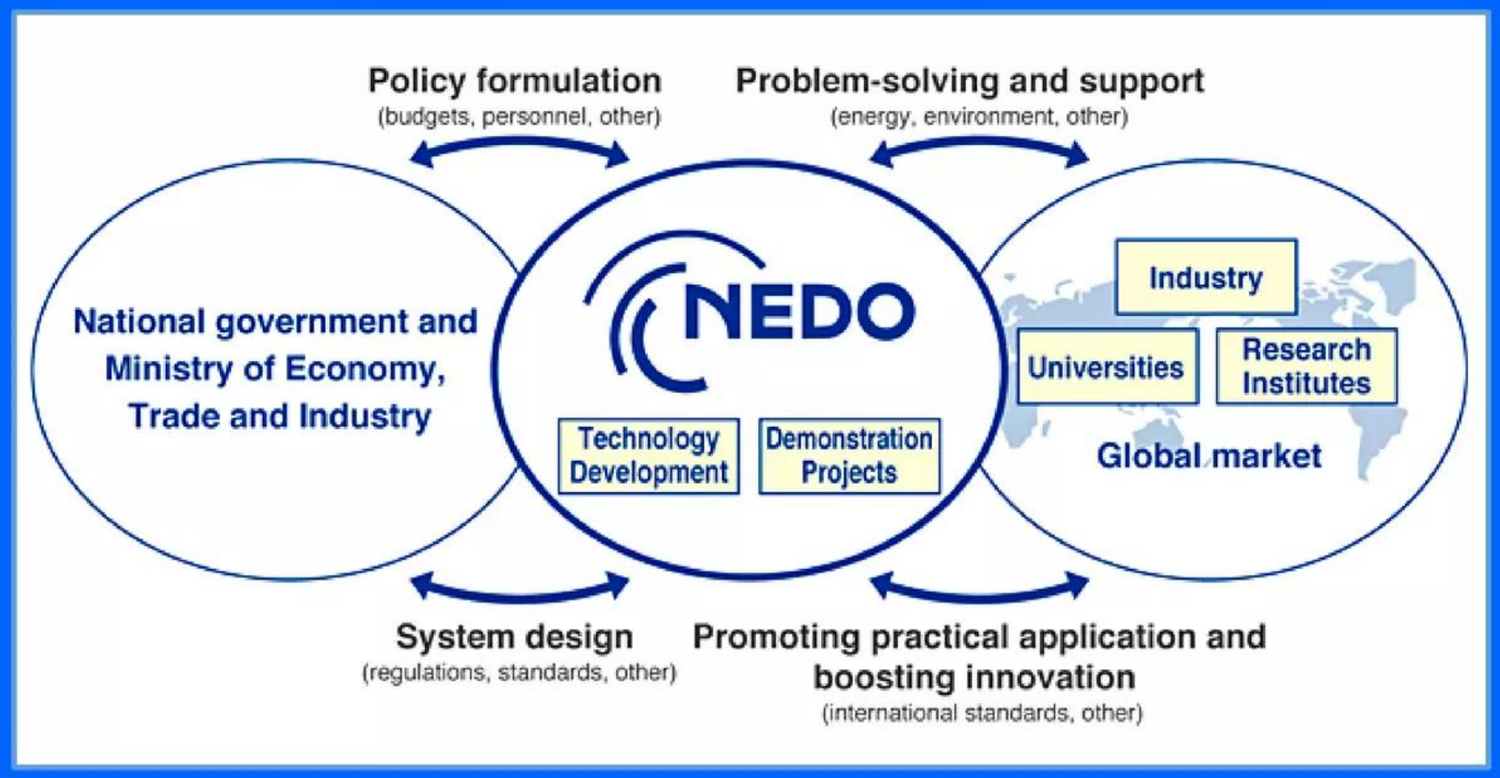
NEDO organized and funded LENR project with industry and academia

NEDO New Energy and Industrial Technology Development Organization

Combining the efforts of industry, government and academia and leveraging established international research networks, NEDO is committed to contributing to the resolution of energy and global environmental problems and further enhancing Japan's industrial competitiveness

http://www.nedo.go.jp/english/

NEDO's mode of operation – graphic copied from home page of NEDO website



経済産業省 Ministry of Economy, Trade and Industry

MITSUBISHI

TOYOTA

NISSAN

Japanese automakers working on NEDO LENR R&D project

Technova Inc. (Toyota principal shareholder) manages NEDO project

NEDO

Technova | Inc.

MITSUBISHI

TOYOTA

NISSAN

TOHOKU UNIVERSITY

NAGOYA UNIVERSITY

KOBE UNIVERSITY

KYUSHU UNIVERSITY

24 Watt heat source can boil a cup of tea in about an hour

Excess heat in certain NEDO experiments was enough to boil a cup of tea

0.0826 megajoules (MJ) of thermal energy is required to boil a single cup of tea

Typical tea or coffee cup holds ~ 250 ml of water. Starting with cup of water at room temperature (~ 21° C), it must be heated-up by 79° to reach water's boiling point of 100° C. Total amount of thermal input energy required to heat one cup of water up to its boiling point in order to make tea is calculated as follows:

Water specific heat = 4.184 Joules/gram °C **Watt** = 1 Joule/sec

1 ml water weight = 1 gram … so 250 ml weighs 250 grams

4.184 x 250 x 79 = 82,634 joules (82.6 kJ = 0.0826 MJ)

24 Watt heat source can provide ~ 83 kJ of thermal energy by operating for 3,443 seconds (57.4 minutes or ~ 1 hour)

Excess heat in certain NEDO experiments enough to boil tea

Some PNZ-type LENR devices had outstanding excess heat performance

Brief Summary Report of MHE Project Japan for 2015 October - 2017 October ResearchGate

Phenomenology and Controllability of New Exothermic Reaction between Metal and Hydrogen

Akito Takahashi[1], Akira Kitamura[1], Koh Takahashi[1], Reiko Seto[1], Yuki Matsuda[1],
Yasuhiro Iwamura[4], Takehiko Itoh[4], Jirohta Kasagi[4],
Masanori Nakamura[2], Masanobu Uchimura[2], Shunsuke Sumitomo[2], Hidekazu Takahashi[2],
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Yuichi Furuyama[6],
Masahiro Kishida[3], Hideki Matsune[3]

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Excess heat in certain NEDO experiments enough to boil tea

PNZ6: "excess power level of 10 - 24 W for more than one month period"

Quoting directly from page 3 and 4 in English version of Jan. 2018 project summary:

"Results for elevated-temperature condition: **Significant level excess-heat evolution data were obtained for PNZ-type, CNZ-type CNS-type samples at 200-400°C of RC (reaction chamber) temperature,** while no excess heat power data were obtained for single nano-metal samples as PS-type and NZ-type. By using binary-nano-metal/ceramics-supported samples as melt-span **PNZ-type** and CNZ-type and wet-fabricated CNS-type, **we observed excess heat data of maximum 26,000 MJ per mol-H(D)-transferred or 85 MJ per mol-D of total absorption in sample, which cleared much over the aimed target value of 2 MJ per mol-H(D) required by NEDO.** Excess heat generation with **PNZ-type** samples has been also confirmed by DSC experiments, at Kyushu University, using very small (0.04 to 0.1 g) samples at 200 to 500°C condition. Optimum conditions for running temperature (around 400 degree C) and Pd/Ni ratio (around 1/7-1/10) were obtained by the DSC experiments at Kyushu University to get highest heat flow (power). **We also observed that the excess power generation was sustainable with power level of 10 - 24 W for more than one month period, using PNZ6 (Pd_1Ni_{10}/ZrO_2) sample of 120 g at around 300°C."**

"Reproducibility at different laboratories: Providing two divided sample powders of **PNZ-type** from same-batch fabricated powder, independent parallel test runs were carried out at Kobe University and Tohoku University. **Results of excess heat generation data from both laboratories were very reproducible for room-temperature and elevated-temperature conditions.** Thus, the existence and reproducibility of new exothermic phenomenon by interaction of nano-metal composite samples and H(D)-gas have been confirmed."

Excess heat in certain NEDO experiments enough to boil tea

"Excess power of 3 - 24 W at … 200 - 300° C continued for several weeks"

Summary

Hydrogen isotope absorption and heat evolution have been examined for three kinds of ZrO_2-supported Pd·Ni nanocomposites, PNZ6, PNZ6r, and PNZ7k

- Excess power of 3~24W at elevated temperature of 200~300°C continued for several weeks.
- PNZ6 and PNZ6r samples with Pd/Ni=1/10 generated much higher excess power than PNZ7k with Pd/Ni=1/7
  : Pd/Ni ratio is one of the keys to increase the excess power.
- Maximum specific energy η_{av} > 16 keV/D (1.6 GJ/mol-D), Integrated excess energy = 1 keV/Ni (100 MJ/mol-Ni)
- Impossible to attribute to any chemical reaction, possibly radiation-free nuclear process

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https://www.researchgate.net/publication/321295906_Comparison_of_excess_heat_evolution_from_zirconia-supported_Pd-Ni_nanocomposite_samples_with_different_PdNi_ratio_under_exposure_to_hydrogen_isotope_gases

Excess heat in certain NEDO experiments enough to boil tea

Note involvement of Nissan Motor Co. with Technova and universities

Effect of Supporter Material on Heat Evolution from Ni-based Nano-Composite Samples under Exposure to Hydrogen Isotope Gas

Akira Kitamura[1,5], Akito Takahashi[1], Koh Takahashi[1], Reiko Seto[1], Takeshi Hatano[1], Yasuhiro Iwamura[2], Takehiko Itoh[2,7], Jirohta Kasagi[2], Masanori Nakamura[3], Masanobu Uchimura[3], Hidekazu Takahashi[3], Shunsuke Sumitomo[3], Tatsumi Hioki[4], Tomoyoshi Motohiro[4], Yuichi Furuyama[5], Masahiro Kishida[6], Hideki Matsune[6]

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IWAHLM12 (5-9 Jun. 2017)

Technova Inc.

https://www.researchgate.net/publication/317339283_Effect_of_Supporter_Material_on_Heat_Evolution_from_Ni-based_Nano-Composite_Samples_under_Exposure_to_Hydrogen_Isotope_Gas

Excess heat in certain NEDO experiments enough to boil tea

Quoting: "Excess power of 3 - 10 W for weeks at 200 - 300° C"

Summary of cooperative exp. at Kobe, 2016~2017

ZrO_2-supported

(a) $Pd_{0.044}Ni_{0.31}Zr_{0.65}$; PNZ3, PNZ4, PNZ5

(b) $Cu_{0.044}Ni_{0.31}Zr_{0.65}$; CNZ5

SiO_2-supported

(c) $Cu_{0.008}Ni_{0.079}$ (mesoporous silica supported); CNS3

(d) Pd nanoparticles (mesoscopic SiO_2 supported); PSf1

- AHE at elevated temperatures around 300 °C were observed only for binary-metal nanoparticle samples ; no AHE for single-element-metal nanoparticles
- Observed both in D-Pd system and H-Ni system
- Excess power of 3 ~ 10 W for weeks at 200 ~ 300 °C
- Integrated released energy of 3 ~ 30 MJ/mol-Ni, or 4 ~ 90 MJ/mol-H
- ZrO_2 is advantageous as the supporter material, when compared in terms of excess energy per sample mass.
- Anyway, unexplainable by any known chemical reaction.

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https://www.researchgate.net/publication/317339283_Effect_of_Supporter_Material_on_Heat_Evolution_from_Ni-based_Nano-Composite_Samples_under_Exposure_to_Hydrogen_Isotope_Gas

Excess heat in certain NEDO experiments enough to boil tea

Project scientists greatly improved reproducibility of excess heat output

Supplement

Summary of the results in the past 3 years

Sample ID	(Ni or Pd) content	H (D or H)	RT						ET (> 250°C)								Remarks			
			L_M		$E_t \equiv \int W dt$		η_{av}		L_M		W		η_{av}		$E_{ex} \equiv \int W dt / L_M$		RC	ref	α	
	(g)				(kJ/m-M)		(eV/H)				(W)		(keV/H)		(MJ/m-H)		old /new	fitting func	variable	
(NEDO)			#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2	#1	#2				
PNZt	6.4	D(H)	(1.1)	2.2	220	81	(2.1)	0.39	1.5	0.15	5.9	2.6	(0.29)	0.77	(7.8)	4.3	o			leak
PNZ3	20.0	D	3.4	1.6	200	62	0.61	0.43	2.8	1.1	8.0	10	6.5	16	3.7	5.7	o			RTDav
PNZ3r	18.8	H	0.11	(5.3)	6.0	0	0.62	0	2.1	(7.4	8.0	---	0.19	---	2.0	---	o			RTDav,leak reoxid. 200 h
PNZ4	23.0	D	3.5	1.8	180	73	0.56	0.43	3.1	1.1	---	4.5	---	4.4	---	3.0	o		v	malf. (#1)
PNZ5	41.1	D	3.5	1.1	210	43	0.63	0.4	3.1	0.55	3.5	4.2	0.4	1.3	1.1	7.6		f	v	
PNZ5r	40.7	D	0.32	0.085	16	1.4	0.53	0.17	0.7	0.2	3.7	4.5	0.025	1.0	2.5	9.0		f	v	reoxid. 100 h
CNZt	9.1	H(D)	0.19	0.19	6.7	3.7	0.37	0.2	1.7	0.2	4.0	2.2	1.7	0.83	11	150	o			
CNZ5	22.0	H	0.2	==	9.8	==	0.5	==	1.9	==	3.3	==	3.4	==	3.6	==	o		v	RTDav
CNS2	12.1	H	0.01	==	0	==	0	==	1.1	0.15	11	7.2	11	20	23	190	o			
CNS3	11.4	H	0.03	0.02	1.5	1.5	0.57	0.65	0.8	0.16	2.4	4.4	1.4	4.7	6.0	90		f	v	
PSf1	8.4	D	2.6	1.6	130	29	0.51	0.19	1.6	0.7	< 1	< 2.2	0	0	0	0		f	v	

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Supplement

https://www.researchgate.net/publication/317339283_Effect_of_Supporter_Material_on_Heat_Evolution_from_Ni-based_Nano-Composite_Samples_under_Exposure_to_Hydrogen_Isotope_Gas

NEDO project has demonstrated that LENRs can produce non-trivial amounts of excess heat from nanocomposite multi-metal devices without emission of deadly fluxes of energetic neutron or gamma radiation --- safe nuclear technology

Next steps: further nanotech engineering, optimization of device materials, and scale-up of excess heat output and useful operating lifetimes

Credit: Getty Images

Further info re Japanese NEDO project and LENR technology

Purplish hyperlinks below are 'live' as well as in SlideShare PowerPoints

"Japan's NEDO industry-academia-government R&D program's recent experimental results technically validated potential for LENRs to become major future energy source"
https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-nedo-lenr-project-reported-reasonably-reproducible-wattlevel-excess-heat-production-feb-4-2018

"January 2018: project report released - summarized progress in Japanese government-funded NEDO R&D in LENRs for Oct. 2015 thru Oct. 2017. Project scientists reported good progress in developing nanocomposite LENR devices for use as powerful heat sources"
https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-nedo-lenr-project-reported-good-progress-in-excess-heat-production-and-device-fabrication-jan-27-2018

"Scalability of LENR power generation systems"
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-scalability-of-lenr-power-generation-systems-nov-29-2015

"Japanese confirm importance of high electric fields and mobile protons in chemical catalysis" **Causal connections between LENRs & chemical catalysis**
https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-confirm-lattice-hypotheses-re-importance-of-adsorbed-protons-and-high-local-electric-fields-in-chemical-catalysis-june-27-2017

Key publications about Widom-Larsen theory of LENRs

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen (author's copy)
European Physical Journal C - Particles and Fields 46 pp. 107 - 112 (2006)
http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen (author's copy)
Pramana - Journal of Physics 75 pp. 617 - 637 (March 2010)
http://www.slideshare.net/lewisglarsen/srivastava-widom-and-larsenprimer-for-electroweak-induced-low-energy-nuclear-reactionspramana-oct-2010

"Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces"
A. Widom and L. Larsen
Cornell physics preprint arXiv:nucl-th/0608059v2 12 pages (2007)
http://arxiv.org/pdf/nucl-th/0608059v2.pdf

"Hacking the Atom" (Volume 1 - 484 pages) popular science book
Steven B. Krivit, Pacific Oaks Press, San Rafael, CA, September 11, 2016
Paperback US$16.00; hardcover US$48.00; Kindle US$3.99
https://www.amazon.com/dp/0996886451

Working with Lattice Energy LLC, Chicago, Illinois USA

Partnering on LENR commercialization and consulting on other subjects

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L. Larsen c.v.: http://www.slideshare.net/lewisglarsen/lewis-g-larsen-cv-june-2013

- We believe Lattice is the world-leader in proprietary knowledge about LENR device engineering required to develop high-performance, long lived, scalable power sources. Our published peer-reviewed theoretical papers rigorously explain the breakthrough device physics of LENR processes, including the absence of dangerous energetic neutron or gamma radiation and lack of long-lived radioactive waste production
- Lattice welcomes inquiries from large, established organizations that have an interest in discussing the possibility of becoming Lattice's strategic capital and/or technology development partner
- Lewis Larsen also independently engages in consulting on variety of subject areas that include: Lithium-ion battery safety issues; long-term electricity grid reliability and resilience; and evaluating potential future impact of LENRs from a long-term investment risk management perspective for large CAPEX projects in the oil & gas, petrochemicals, transportation, utility, and aerospace industries

“Nothing is too wonderful to be true,
if it be consistent with the laws of Nature;
and in such things as these experiments
is the best test of such consistency.”

Michael Faraday
Laboratory journal entry #10,040
March 19, 1849

Credit: Getty Images