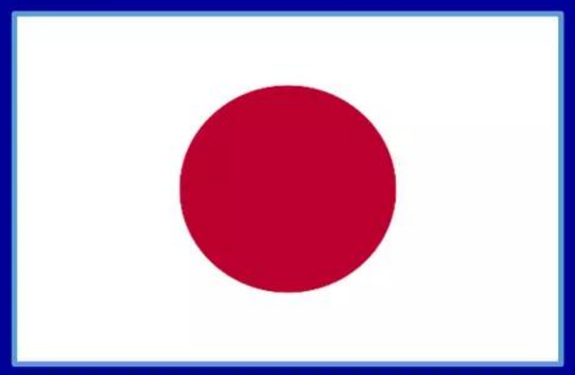
Lattice Energy LLC

Commercializing a next-generation source of safe CO_2-free nuclear energy

New Energy Times reports Japan funding R&D in LENRs

After hiatus of ~20 years government issued RFP that includes LENRs

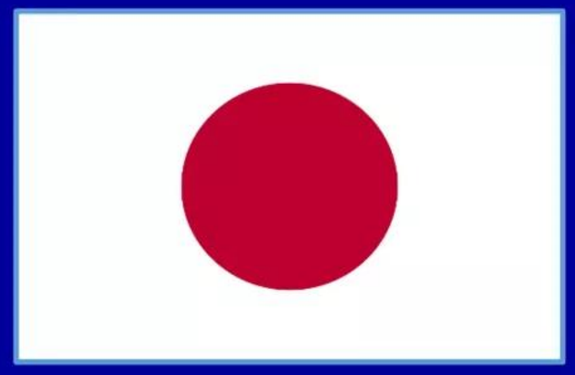
Ultralow energy neutron reactions could be strategic to Japan's energy security



Lewis Larsen

President and CEO

August 25, 2015



"Japan has little domestic fossil fuel which plays a center role of energy source, and has the vulnerability to depend on import from abroad. It causes Japan to have the energy structure which is easily affected from domestic/international situation of energy. It is essential for security of states to secure stable supply of energy as blood vessel, and this always remains a big issue for Japan. Besides … under … situation where international geopolitical structure faces a big change … circumstance surrounding Japan's energy security becomes severer."

Japan's National Strategic Energy Plan (English translation - April 2014)

Contact: 1-312-861-0115 Chicago, Illinois USA lewisglarsen@gmail.com

http://www.slideshare.net/lewisglarsen/presentations

Japan is extraordinarily dependent on imported energy

Country imports >80% of primary energy supply; most vulnerable on oil

FEPC | The Federation of Electric Power Companies of Japan.

http://www.fepc.or.jp/english/energy_electricity/supply_situation/

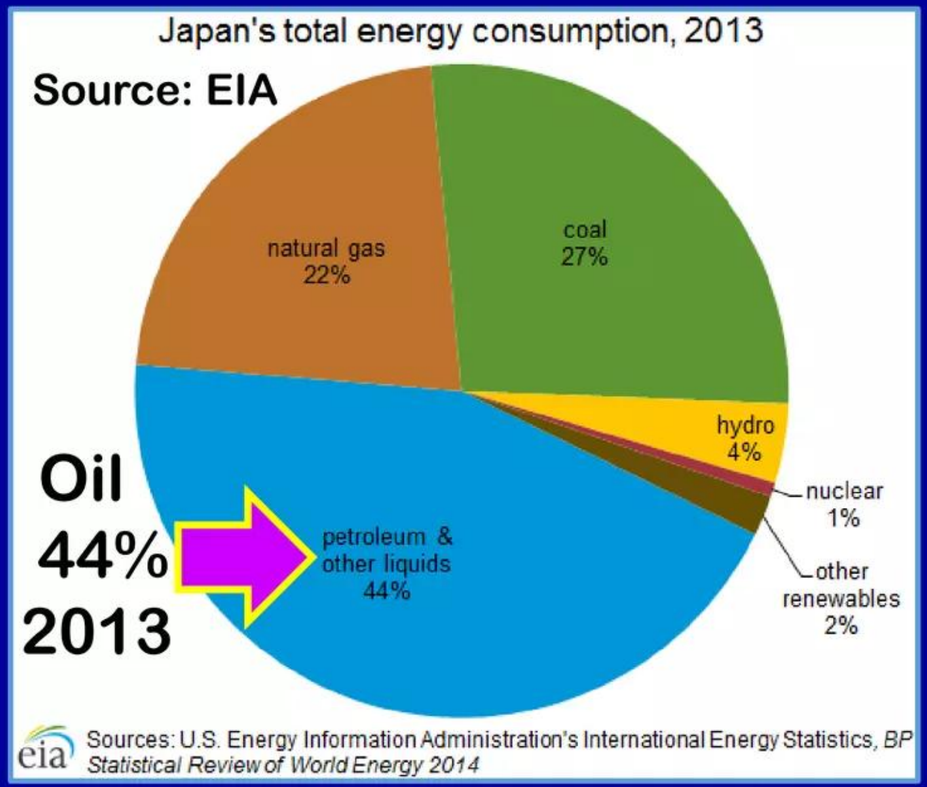
"Resource-poor Japan is dependent on imports for 96% of its primary energy supply; even if nuclear energy is included in domestic energy, dependency is still at 82%. Thus, Japan's energy supply structure is extremely vulnerable. Following the two oil crises in the 1970s, Japan has diversified its energy sources through increased use of nuclear energy, natural gas and coal, as well as the promotion of energy efficiency and conservation."

"Despite these improvements, oil still accounts for about 50% of Japan's primary energy supply, and nearly 90% of imported oil comes from the politically unstable Middle East. Moreover, prospects for importing electricity from neighboring countries are very poor because Japan is an island nation. In addition, there is an urgent need for global warming countermeasures such as reduction of carbon dioxide emissions from the use of energy."

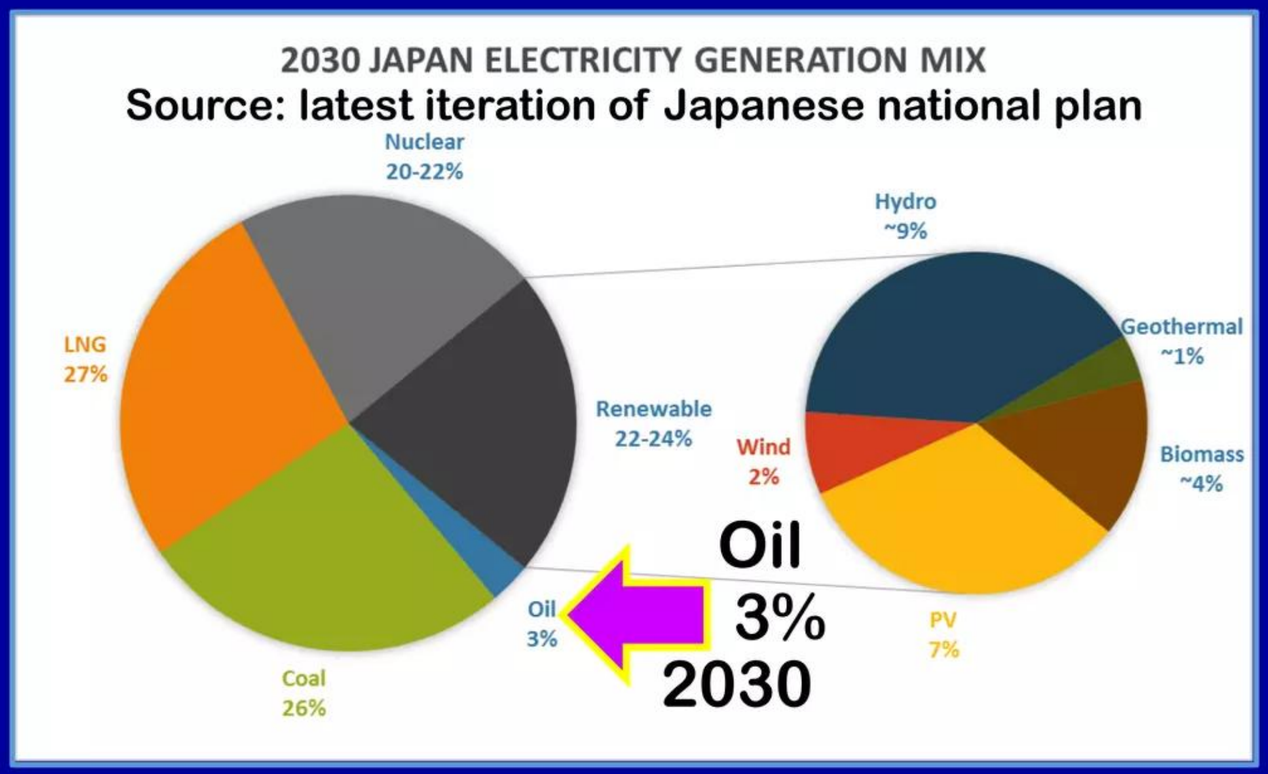
Source website: Federation of Electric Power Companies of Japan as of August 25, 2015

Japan planning to reduce usage of oil substantially by 2030

Source: Wikipedia	Energy in Japan[8]					
	Capita	Prim. energy	Production	Import	Electricity	CO_2-emission
	Million	TWh	TWh	TWh	TWh	Mt
2004	127.7	6,201	1,125	5,126	1,031	1,215
2007	127.8	5,972	1,052	5,055	1,083	1,236
2008	127.7	5,767	1,031	4,872	1,031	1,151
2009	127.3	5,489	1,091	4,471	997	1,093
2010	127.4	5,778	1,126	4,759	1,070	1,143
2012 (Japan)	126.7	6,034	1,013	5,532	851 [9]	1,207 [10]
2012 (IEA)	127.8	5,367	601	4,897	1,003	1,186
Change 2004-10	-0.2 %	-6.8 %	0.0 %	-7.2 %	3.7 %	-5.9 %
Mtoe = 11.63 TWh, Prim. energy includes energy losses that are approximately 2/3 for thermal power stations [11]						



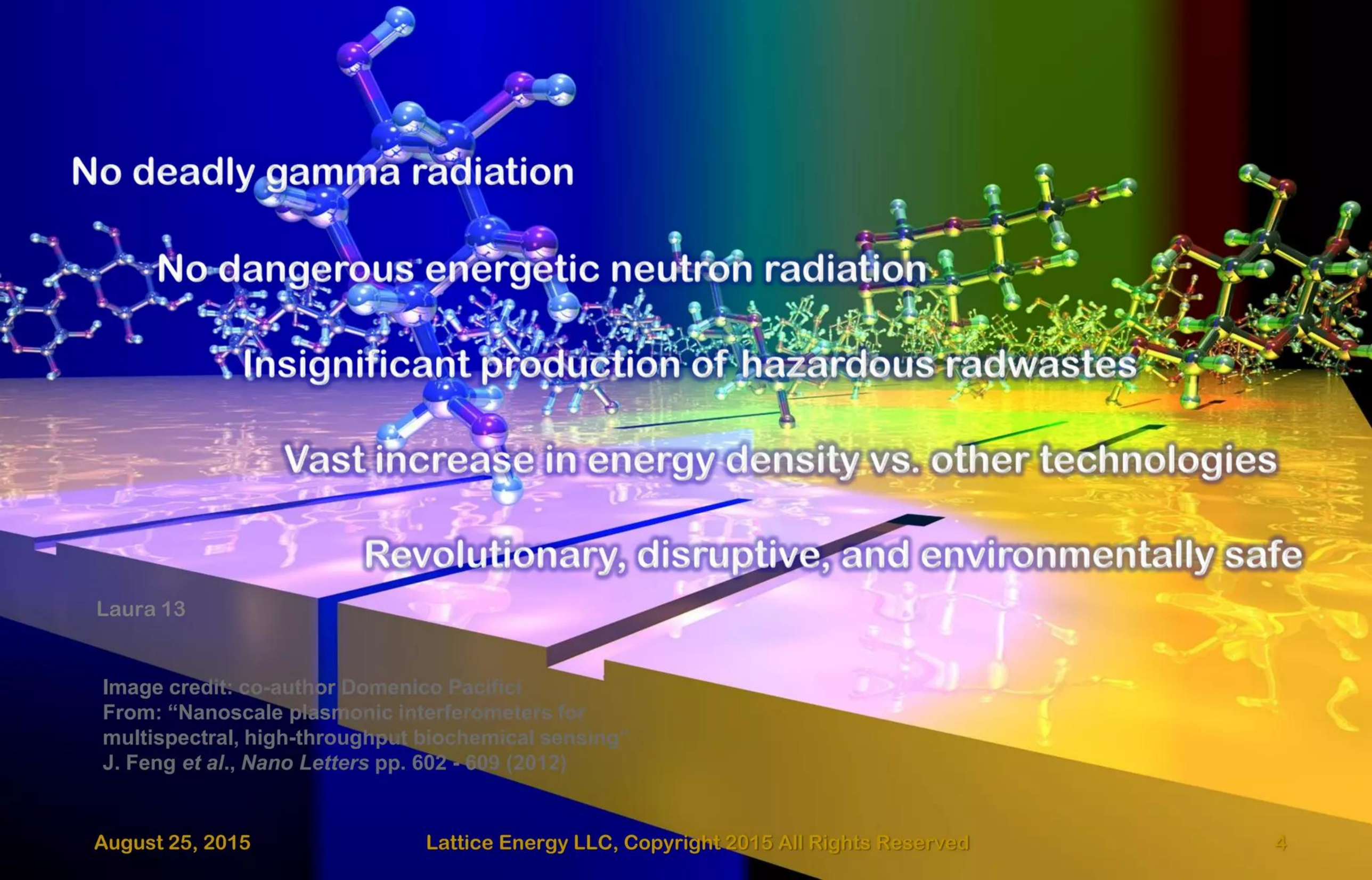
Under latest national energy plan, hydro and other types of renewables go up from 6% in 2013 to 22 - 24% in 2030



Percentage of nuclear was abnormally low in 2013 because of total plant shutdowns prompted by Fukushima disaster

Revolutionary new type of safe nuclear energy technology

Unique advantages of ultralow energy neutron reactions (LENRs)



Laura 13

Image credit: co-author Domenico Pacifici
From: "Nanoscale plasmonic interferometers for multispectral, high-throughput biochemical sensing"
J. Feng *et al.*, *Nano Letters* pp. 602 - 609 (2012)

New Energy Times reports NEDO issued RFP on LENRs

NEDO: New Energy and Industrial Technology Development Association

Arm of Government of Japan - its mission is to develop new energy technologies

Japanese Government Will Fund LENR Research Again

http://news.newenergytimes.net/2015/08/24/japanese-government-will-fund-lenr-research-again/

Selected excerpts quoted directly from Steven Krivit's news story:

For the first time in two decades, the Japanese government has issued a request for proposals [RFP] for low-energy nuclear reaction (LENR) research, according to information recently obtained by *New Energy Times*.The request for proposals was published by the New Energy and Industrial Technology Development Organization (NEDO), a national research and development agency.

The request for proposals, "Energy and the Environment New Leading Technology Program," was released in July. The line item for the LENR research is on PDF Page 16, item D4. The item translates to "Metal which becomes new energy source and analysis and control of the technology of heat reactions between metals and hydrogen."

In a response to an e-mail from *New Energy Times*, long-time LENR researcher Tadahiko Mizuno confirmed that item D4 is for LENRs. Some Japanese LENR researchers, according to Mizuno, are filing a joint application to NEDO, with the assistance of Akito Takahashi, a former professor at Osaka University.

In 1994, the Japanese government, through the Ministry of Trade and Industry [MITI], sponsored an earlier research program called the New Hydrogen Energy Agency. It ran for several years at a cost of several million dollars. It terminated after researchers reported lackluster results.

Japanese government is again funding R&D in LENRs

NEDO: organizational instrument that promotes energy tech development

NEDO New Energy and Industrial Technology Development Organization

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

Excerpts quoted from NEDO website in Japan as of August 25, 2015:

"NEDO actively undertakes the development of new energy (e.g., photovoltaic, wind power, biomass and waste, geothermal power, thermal utilization and full cells) and energy conservation technologies, verification of technical results, and introduction and dissemination of new technologies (e.g., support for introduction). Through these efforts, NEDO promotes greater utilization of new energy and improved energy conservation. NEDO also contributes to a stable energy supply and the resolution of global environmental problems by promoting the demonstration of new energy, energy conservation and environmental technologies abroad based on knowledge obtained from domestic projects."

"With the aim of raising the level of industrial technology, NEDO pursues research and development of advanced new technology. Drawing on its considerable management know-how, NEDO carries out projects to explore future technology seeds as well as mid- to long-term projects that form the basis of industrial development. It also supports research related to practical application."

Japanese government is again funding R&D in LENRs

Orchestrates key relationships between academia and private industry

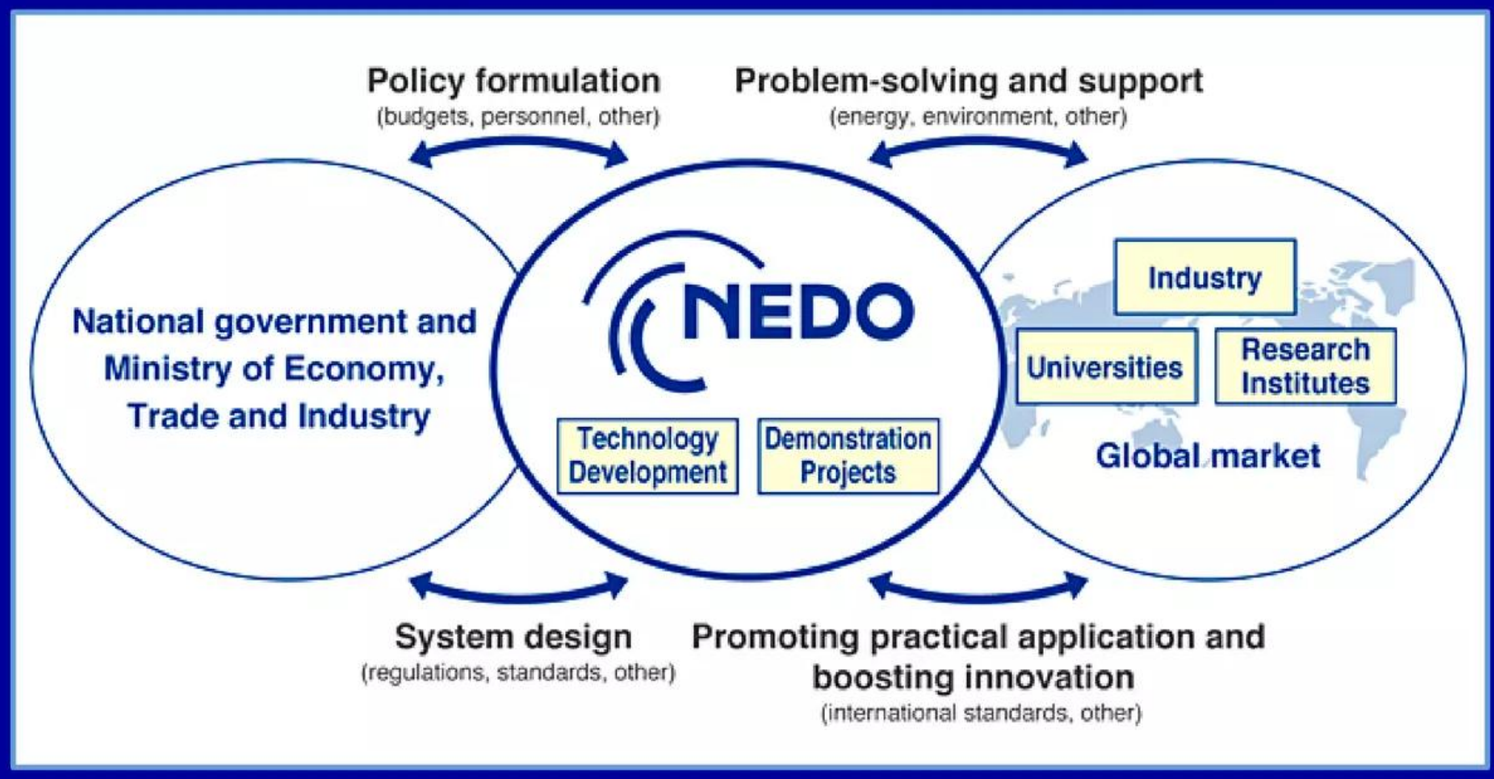
NEDO New Energy and Industrial Technology Development Organization

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/

Mode of operation – graphic is copied from home page of NEDO website

経済産業省 Ministry of Economy, Trade and Industry



TOYOTA

MITSUBISHI

Japanese government is again funding R&D in LENRs

Will engage keiretsu to help execute national plan for energy security

Mitsubishi, Toyota, and other groups will become linchpins in technology strategy

- ✓ Mitsubishi Heavy Industries and Toyota have been funding R&D in LENRs out of their own budgets since 1989; minimal help from their government
- ✓ Keiretsu - Japanese term that describes a loose association of different companies that share one or more common interests and work closely together to achieve mutually agreed-upon key business and technological objectives. They may or may not have some degree of mutual ownership and are tied to banks. Mitsubishi and Toyota are members of respective keiretsu; Toyota considered largest vertical conglomeration now in Japan
- ✓ Mitsubishi Heavy Industries and Toyota have been conducting and reporting important experimental basic science results on LENR transmutation measurements for many years; heretofore did not focus on trying to produce substantial amounts of excess heat to generate power
- ✓ Key details of NEDO RFP reveal an important strategic shift in R&D goals; instead emphasizes generation of excess heat as implied in description of goal: "… technology of heat reactions between metals and hydrogen"
- ✓ RFP signals a shift from pursuit of basic science to engineering-oriented programs that develop revolutionary new power generation technologies

Japanese scientific work in LENRs goes back to 1925

Japanese scientists and companies have made many important contributions to our understanding of LENRs extending over the past 90 years

- ✓ Prof. Hantaro Nagaoka (*Nature*, 1925) was the first-ever to successfully demonstrate in over 200 experiments that Tungsten can be transmuted into Gold and Platinum with high-current electric discharges in oil. While his experiments were not effectively repeated until Mitsubishi did so in 2012, the passage of time has not diminished the importance of his still-astounding experimental discoveries that were reported in *Nature* some 90 years ago
- ✓ Minoru Toyoda himself personally supported LENR R&D conducted in Nice, France, at the very height of the intensely acrimonious public controversy about LENRs back in the 1990s
- ✓ Mitsubishi Heavy Industries and Toyota have both reported many important experimental results dating back to 1989; Mitsubishi pioneered development of a laboratory permeation method which resulted in the publication of a seminal *JJAP* paper in 2002; Toyota finally confirmed their Cesium-target results in a *JJAP* paper that was published in October 2013
- ✓ Tadahiko Mizuno, formerly of Hokkaido Univ. and now at Tōhoku Univ., has made many fine experimental contributions over the years, including brilliant first-ever experiments with Phenanthrene in 2008 which demonstrated that W-L neutron production could be triggered on aromatic rings. He has also published many excellent transmutation measurements
- ✓ On the theory side: in a book published in 1997, Mizuno informally speculated without using mathematics that the $e + p$ weak interaction created neutrons during LENR experiments which explained the transmutation products that he had observed. In 1998, Iwamura *et al.* published their EINR theory of LENRs which is really a phenomenological version of the neutron-based Widom-Larsen theory without any detailed physics or mathematics. The Widom-Larsen theory provides detailed physics of LENRs in a rigorous mathematical form

Widom-Larsen LENR theory is extremely multidisciplinary

Theoretical breakthrough achieved by combining multiple disciplines

Analogous to J. C. Maxwell: explains all LENR effects as a coherent whole

Fully explains all previously inexplicable characteristic features:

- ✓ Absence of deadly energetic neutron and gamma radiation
- ✓ No appreciable production of long-lived radioactive isotopes
- ✓ Large array of different Japanese experimental data on nuclear transmutations that extends from present day back to the 1920s
- ✓ Plus collection of other anomalous LENR-related effects that have been observed and reported by scientists for over 100 years

Widom-Larsen enables commercialization of LENRs

Applied nanotechnology and LENRs are mutually joined at the hip

Development risks can be reasonable thanks to Widom-Larsen and nanotech

Guided by physics of the Widom-Larsen theory, an opportunity to commercialize LENRs as truly green CO_2-free nuclear energy source has been enabled by a unique juxtaposition of very recent parallel advances in certain very vibrant areas of nanotechnology (esp. plasmonics), quantum entanglement, new innovations in nanoparticle fabrication techniques, as well as an array of new discoveries in advanced materials science.

Visualization of plasmon electric fields on a substrate surface

Lattice's commercialization strategy akin to computer chips

Scale-up LENR system power outputs and integrate energy conversion

Use existing nanotech and power conversion to cut development time/risks

- ✓ **LENRs can presently reach temperatures of 4,000 - 6,000° K and boil refractory metals in limited numbers of microscopic LENR-active hot spot sites on laboratory device surfaces.** Lattice plans to use its unique proprietary knowledge of LENR engineering physics and key operating parameters (e.g., achieving and maintaining very high local surface electric fields) to first get heat production working well microscopically. That is: reproducibly trigger LENRs on specific, purpose-designed nanoparticulate structures with dimensions ranging from nanometers to microns that are fabricated using existing, off-the-shelf nanotech processes and then deliberately emplaced at what will become LENR-active sites located on Hydrogen-loaded substrate or nanoparticle surfaces
- ✓ **In principle, output of such LENR heat sources could be readily scaled-up:** either by fabricating larger area-densities of affixed nanostructures that facilitate formation of LENR-active hot spots on device surfaces, or by injecting larger quantities of specially designed fuel nanoparticles into volumetrically larger reaction chambers containing turbulent dusty plasmas, with or without spatially organized magnetic fields present
- ✓ **A variety of off-the-shelf energy conversion subsystems could potentially be integrated with commercial versions of LENR-based heat sources. These include thermoelectric; thermophotovoltaic cells; steam engines; Rankine cycle steam turbines; Brayton cycle gas turbines, boilers, etc.** Other speculative possibilities involve new types of direct energy conversion technologies that are still under development, e.g. harvesting of β^-

LENRs are green: no energetic radiation or radwastes

Lack of hard radiation obviates need for shielding and containment

Major opportunity to develop safe, battery-like portable LENR power sources

Fission and fusion processes both emit deadly MeV-energy neutron and gamma radiation

Fission reactors need 1 foot of steel and 3 feet of concrete to protect humans from hard radiation and wastes emitted by reactor; makes systems intrinsically large and heavy

LENRs enable devices something like this: small, portable battery-like power sources that are safe and disposable

Revolution in green nuclear technology

Much larger LENR devices based on dusty plasma embodiments can potentially scale-up to megawatts; akin to today's power plants

Electroweak reaction in Widom-Larsen theory is simple

Protons or deuterons react directly with electrons to make neutrons

Need input energy source such as electricity to drive LENR neutron production

electrons + protons (Hydrogen) → neutrons + neutrinos (benign photons, fly into space)

Require source(s) of input energy

Input energy creates electric fields > 2.5 x10^{11} V/m

Collective many-body quantum effects: many electrons each transfer little bits of energy to a much smaller number of electrons also bathed in the very same extremely high local electric field

Many-body collective electroweak neutron production

Heavy-mass e^{-}* electrons react directly with protons

Quantum electrodynamics (QED): smaller number of electrons that absorb energy directly from local electric field will increase their effective masses ($m = E/c^2$) above key thresholds β_0 where they can react directly with a proton (or deuteron) → neutron and neutrino

$$\text{Energy}_{\text{E-field}} + e^-_{sp} \rightarrow e^{-*}_{sp} + p^+ \rightarrow n^0 + \nu_e$$

ν_e neutrinos: ghostly unreactive photons that fly-off into space; n^0 neutrons capture on nearby atoms

Radiation-free LENR transmutation

Neutrons + fuel elements → heavier elements + decay products

Neutrons induce nuclear transmutations that release enormous amounts of clean, CO_2-free heat

Fossil Carbon can be transmuted rather than combusted

Heavy oil and coal could be processed to produce CO_2-free LENR fuels

Carbon atoms found on aromatic rings good fuel for radiation-free transmutation

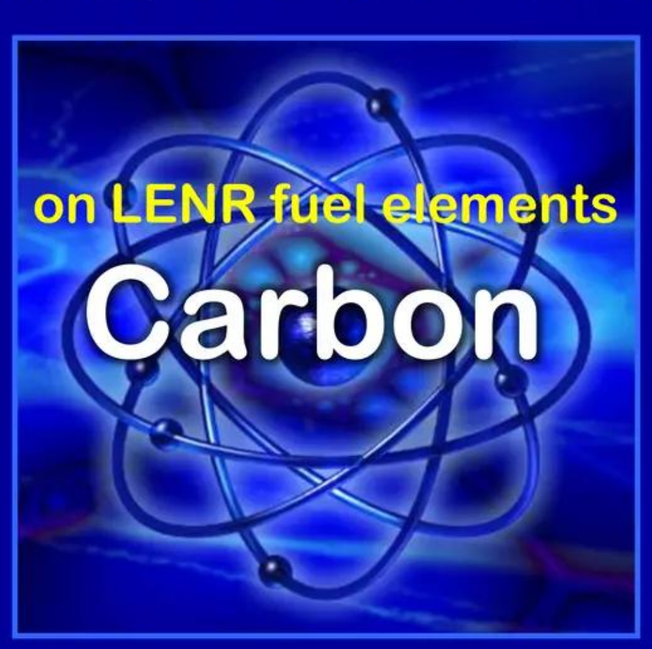
Radiation-free LENR transmutation

Neutrons + LENR fuel elements → heavier elements + decay products + heat

Catalytic neutron 'match'

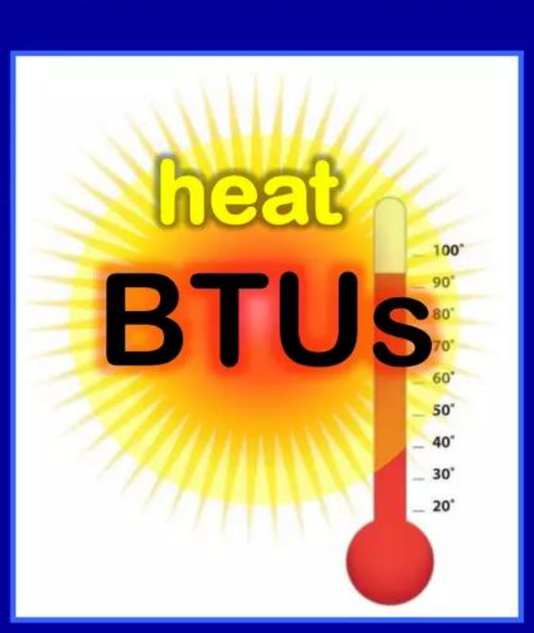
capture +

Neutrons are readily absorbed by LENR fuels such as inexpensive Nickel, Titanium, Lithium, or Carbon atoms



produces →

Direct conversion of neutron capture and decay-related gammas to IR and beta/alpha particles create heat



Process does not emit any deadly radiation or produce troublesome radwastes

Fossil fuels could be converted into green LENR fuels

Breakthroughs in physics and nanotechnology make this possible

Bitumen, heavy oil, and coal may be much more valuable as CO_2-free LENR fuels

In 2009 Larsen discovered that aromatic molecules can potentially be extracted and processed to be converted into green LENR fuels in which there would be no hard radiation emissions, no production of any long-lived radioactive wastes or emission of gaseous CO_2 into the atmosphere; would instead release **> 5,000 times more thermal energy versus combustion of Carbon-based molecules with Oxygen**

All of these fossil hydrocarbons contain aromatic ring molecules that can be extracted

Canadian bitumen

Heavy viscous oil

Anthracite coal

Fossil fuels and biomass can be converted to aromatics

Converting Carbon into aromatic molecules produces green LENR fuels

Technological advance in 2015 creates Carbon nanofibers from atmospheric CO_2

Contain aromatic molecules

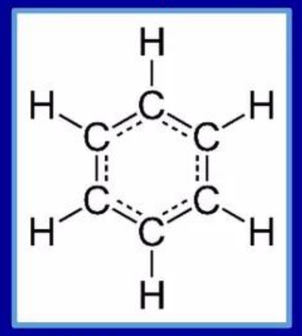
Examples:

- Heavy oils and natural bitumen — Extract
- Coal — Extract
- Lignin and other plant biomass — Extract
- Natural gas — Mo catalyst
- CO_2 → C nanofibers — Processing

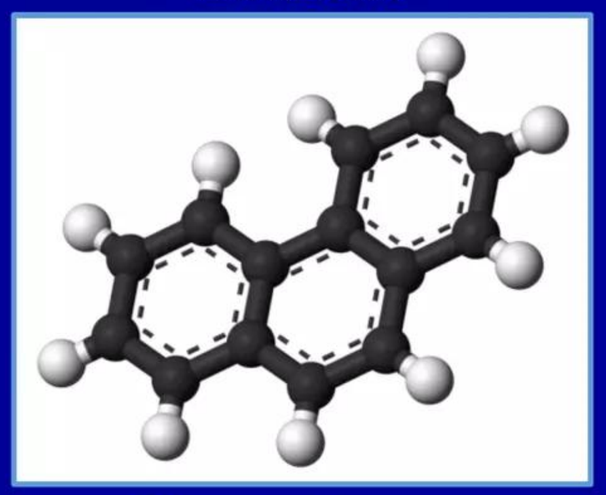
Chemical process

Variety of simple and complex aromatic molecules

Examples:



Benzene



Phenanthrene

Enormous gain in energy density makes these conversions economic

Chemical processing

Process into

Green CO_2-free LENR fuels

plus nanotech

5,000x greater energy density

NANO LETTERS

"One-pot synthesis of Carbon nanofibers from CO_2"
J. Ren *et al.*
NANOLetters August 3, 2015
http://tinyurl.com/og25w4u

LENR technology could enable energy security for Japan

Could utilize indigenous coal resources to help replace oil in vehicles

Japanese government taking new steps to facilitate commercialization of LENRs

- ✓ Japanese government and companies have long reputation for business foresight and excellence in long-range strategic planning and execution
- ✓ Mitsubishi keiretsu has great technological depth in nuclear fission technology for power generation and aerospace; Toyota keiretsu has enormous market presence and technological depth in motor vehicles
- ✓ While no members of either group will admit it publicly, it is very likely that one objective in commercializing LENRs would be to replace the internal combustion engine. Propelling future vehicles with LENR power technologies could slash Japan's present dependence on foreign oil and help achieve energy security goals specified in the current national plan
- ✓ NEDO RFP involving LENRs recently disappeared from website; not at all believable that they suddenly changed their minds about LENRs; more likely bureaucrats decided to get crafty with gaijin competitors collecting business and technological intelligence; ARPA-E did similar thing in 2014
- ✓ China presently appears to be way behind Japan in developing science & technology of LENRs; only limited R&D at just a handful of universities is apparent. Government of China would be well-advised to watch carefully

Widom-Larsen theory of ultralow energy neutron reactions

Documents below provide more info on theory and LENR technology

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen
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

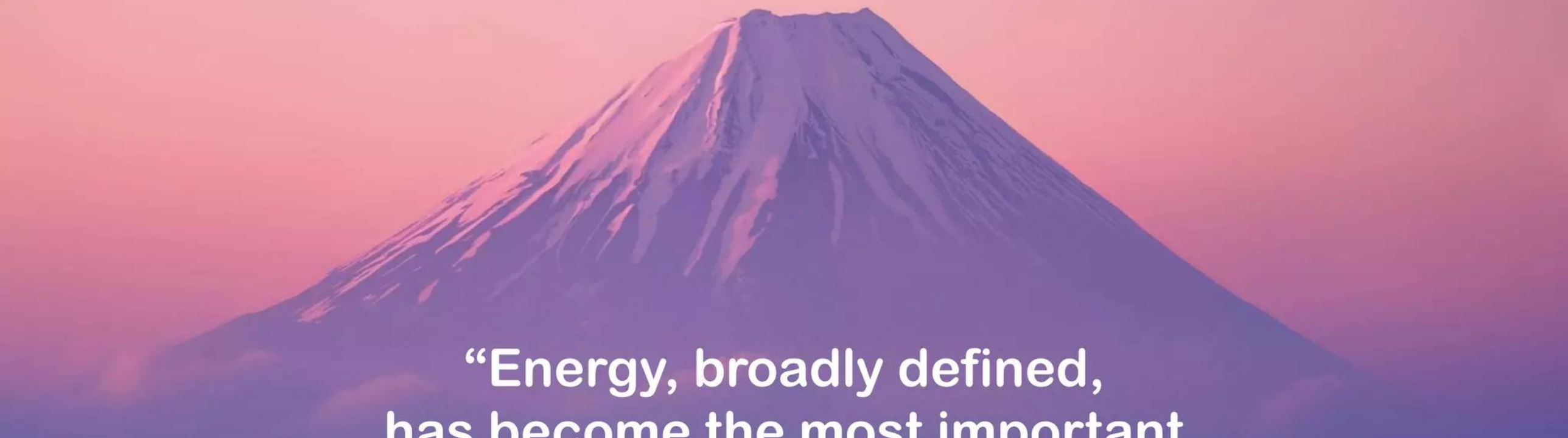
"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen
Pramana - Journal of Physics 75 pp. 617 - 637 (2010)
http://www.ias.ac.in/pramana/v75/p617/fulltext.pdf

"Compelling economics of transmutation vs. combustion of carbonaceous energy sources" January 14, 2015 [44 PowerPoint slides]
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-compelling-economics-of-transmutation-vs-combustion-of-carbonaceous-energy-sources-jan-14-2015

"Green low energy neutron reactions (LENRs) could enable a Moore's Law for energy" November 19, 2014 [101 PowerPoint slides]
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenrs-could-enable-a-moores-law-for-energy-nov-19-2014

Lattice Energy LLC

Commercializing a next-generation source of safe CO_2-free nuclear energy



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

Thomas Friedman
New York Times, April 28, 2006

Japan's beloved Mt. Fuji