Powering the world to a green future

Vast disparity in cumulative R&D investments

Green LENRs for power generation vs. nuclear weapons technology

Commercializing LENRs could potentially reduce global price of energy

Present situation is problematic given possible societal benefits of LENRs

Commentary

A contrast of paradigms

Lewis Larsen

President and CEO
Lattice Energy LLC

August 12, 2013

"Our children will enjoy in their homes electrical energy too cheap to meter."

Robert Strauss (1954)

Then Chairman, US Atomic Energy Commission
Speech to National Association of Science Writers

Contact: 1-312-861-0115
lewisglarsen@gmail.com
http://www.slideshare.net/lewisglarsen

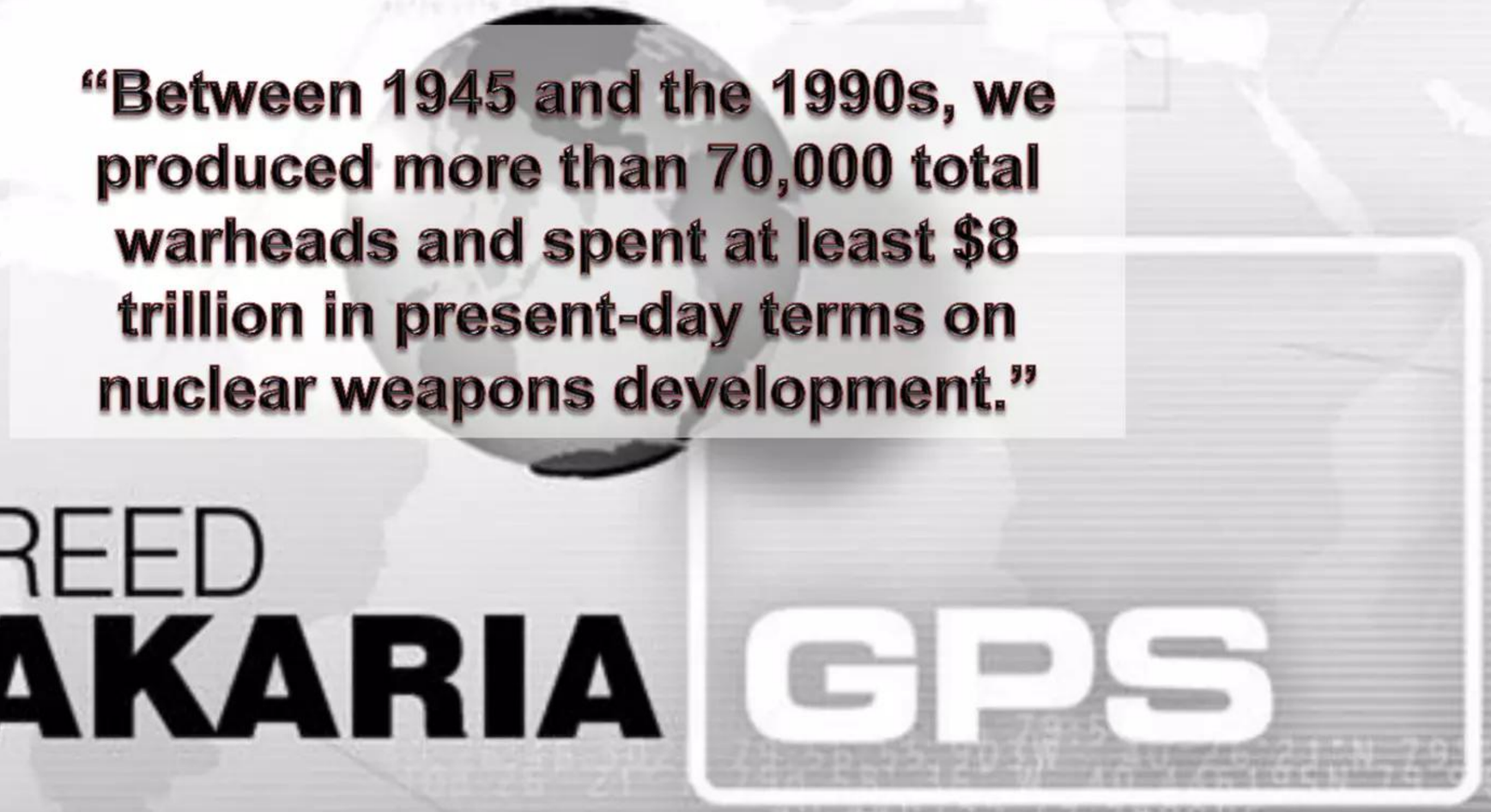
Trinity test shot
first nuclear explosion (1945)

Fukushima Daiichi
nuclear plant melt-down (2011)

Powering the world to a green future

Since 1940s U.S. has spent >$8 trillion on nuclear weapons

Fareed Zakaria, GPS program - CNN broadcast on August 11, 2013:



http://transcripts.cnn.com/TRANSCRIPTS/1308/11/fzgps.01.html
David Krieger (1997): http://www.wagingpeace.org/articles/1997/06/00_krieger_nuclearism-asia.htm

Powering the world to a green future

Fission and fusion technologies

Paradigm Changing

LENR technology

Powering the world to a green future

Alternative dense energy sources

LENRs provide opportunity to develop vastly 'greener' new energy source

Combustion of fossil fuels (strictly chemical processes involving outer valence electrons of nuclei):

Comments: emits copious quantities of CO_2, a greenhouse gas; comprises vast majority of mankind's energy production today

Scale of energy release: eVs (chemical regime)

Alternate natural sources of fuel: primarily oil, coal, and biomass; basic reaction: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ + energy

Controlled release of nuclear binding energy (fission and fusion; mainly involve strong interaction):

Comments: no CO_2 emission; emit dangerous *energetic* radiation (γ, neutron); today <10% of global energy production

Scale of energy release: MeVs (nuclear regime) > 1,000,000x all chemical energy sources

Heavy-element fission (involves shattering heavy nuclei to release stored nuclear binding energy):

Comments: requires massive shielding and containment structures to handle radiation; major rad-waste clean-up

Alternate natural 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 isotopes) + energetic gamma radiation + energetic neutron radiation + energy

Fusion of light nuclei: (involves smashing light nuclei together to release stored nuclear binding energy):

Comments: present multi-billion $ development efforts (e.g., ITER, NIF, Tokamaks) focusing mainly on D+T fusion reaction; requires massive shielding/containment structures to handle 14 MeV neutron radiation; minor rad-waste clean-up $ vs. fission

Natural sources of fuel: Deuterium and Tritium (two heavy isotopes of hydrogen)

Most likely commercial fusion reaction involves: D + T → He-4 (helium) + neutron + energy (total 17.6 MeV; ~14.1 MeV in neutron)

Low energy neutron reactions (LENRs - key distinguishing feature is neutron production via weak interaction; neutron capture + gamma conversion to IR + decays [α, β] release nuclear binding energy):

Comments: early-stage technology; no emission of energetic neutron or gamma radiation; no long lived rad-waste products; LENR systems do not require massive and expensive radiation shielding and containment structures → much lower $ cost

Natural sources of fuel: *any* element/isotope that can capture LE neutrons and release >0.78 MeV in nuclear binding energy

Involves complex, branching LENR nucleosynthetic transmutation networks that begin with neutron captures on seed nuclei then proceed from lower to higher values of atomic mass (A); very similar to what happens in stars, only at low temps/pressures

Powering the world to a green future

Paradigm shift: green radiation-free nuclear processes

Absence of hard MeV radiation: LENRs were hidden in plain sight for 100 years

- ✓ **Fusion (1929) and fission (1938) mainly rely on strong interaction and emit readily detectable fluxes of deadly hard MeV gamma and/or energetic neutron radiation; consequently, those two types of nuclear processes were discovered experimentally and well-accepted by the physics and astronomy communities long before most recent public controversy about scientists claiming to have observed LENR transmutations in a prosaic electrolytic chemical cell (1989)**

- ✓ **In fact, observations of what we now know were actually LENRs have been episodically reported and published by experimentalists for nearly 100 years; however, given an absence of obvious hard radiation signatures, they had no Idea they were encountering a very green, energetic nuclear process that occurs on microscopic length-scales in condensed matter systems under a very particular set of conditions that only rarely line-up perfectly in Nature**

- ✓ **No radiological health risks are known to be associated with LENRs because they don't emit hard radiation and typically don't produce biologically significant amounts of environmentally hazardous, long-lived radioactive isotopes. That being the case, very subtle telltale signs of LENR activity can only be readily detected and measured through the use of extraordinarily sensitive, modern mass spectroscopy techniques on stable isotopes. Such analytical techniques have only been readily affordable and reasonably easy-to-use by a broad range of scientists in different disciplines for less than two decades. Consequently, LENR processes have effectively been hidden in plain sight and unappreciated by the vast majority of the world scientific community for the better part of the last 100 years**

Powering the world to a green future

Lopsided public/private investments in fission for 71 years

Rough estimates of cumulative R&D investment by nuclear technology

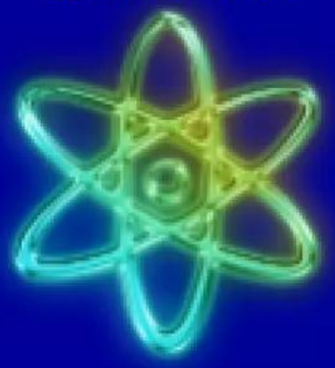
- ✓ **Fission/fusion – mostly Uranium/Plutonium fuels (>US$8 trillion; in US alone since 1942):**
  Began with U.S. nuclear weapons programs starting in 1942; commercial fission power generation technologies were direct outgrowth from these longstanding programs. World's first commercial fission power plant went operational in 1957 at Shippingport, PA, USA. In civilian non-military sector, fission power generation technology hasn't achieved extremely broad deployment that was previously hoped-for because of public's issues with perceived safety, unsolved radioactive waste disposal problems, and very serious weapons proliferation issues involving rogue states and terrorist non-state actors ("vital risks")

- ✓ **Fusion power only - Deuterium and/or Tritium fuels (~US$250 billion worldwide since 1950):**
  Promising D-T fusion power generation process researched mainly by governments since 1950s; still without working commercial fusion reactors after investing many billions of $ and vast numbers of man-hours by a myriad of scientists; mainly ITER and NIF (US) to show for all that effort. Will commercialization of fusion power require yet another 20 - 30 years?

- ✓ **LENRs - many stable elements can serve as fuels (<$200 million worldwide since 1989):**
  Inexplicable anomalous experimental effects seen in labs for almost 100 years; initially not ascribed to any nuclear processes because strong radiation signatures are absent; finally theoretically understood by Widom & Larsen papers published over the past 8 years; now there is an outstanding business opportunity to develop truly green forms of nuclear power

Fission and fusion

Green LENRs



Comment: nuclear power technologies are finally evolving into safer, greener types of processes that can release nuclear binding energy (>1 million times chemical processes such as burning fossil fuels) without injecting gaseous CO_2 into biosphere

Powering the world to a green future

LENRs potentially much better than fission or fusion

Stars, fission reactors, tokamaks, and thermonuclear explosions: not required

LENRs do not have Velikhov's "vital risks" yet release comparable amounts of energy

Less Energy Per Reaction

Reaction Type	Typical "Average" Energy Release		Relative Index of Energy Release	
U-235 Conventional Fission (1938)	220 MeV	Nuclear: Strong Interaction	1000	Taekwondo
H+H Fusion in Stars (1939)	27 MeV		123	
D+T Fusion Reactors (1950s)	17. 6 MeV		80	
Light and Heavy Water LENRs (1989)	~ 22 MeV (high side)	Nuclear: Weak Interaction	91	Aikido
	~ 0.1 MeV (low side)		0.45	
Blacklight Power's "Hydrinos" (1991)	max 0.02 MeV	?	0.09	Chemical
Hydrogen Fuel Cells (1838)	0.0002 MeV	Chemical	0.0001	
Combustion of Gasoline (1876)	0.0001 MeV		0.00005	

Evolution of nuclear technology

Powering the world to a green future

LENRs potentially much better than fission or fusion

Stars, fission reactors, tokamaks, and thermonuclear explosions: not required

Chart ranks competing nuclear energy technologies by eco-greenness

"Greener"

Reactants/Fuel	Reaction Type	Main End Products of Reactions	
Very Heavy Uranium or Plutonium metal atoms + neutrons (chain reaction)	Conventional Fission in Nuclear Power Plants; Strong Interaction	Unstable long-lived radioactive isotopes, hard gamma/ X-ray radiation, energetic neutrons, heat	
Starts With Lightest Atoms Hydrogen + Hydrogen	Fusion in Stars; Strong Interaction	Stable Helium-3/4 isotopes, Mainly fluxes of energetic neutrons, heat	Taekwondo
Starts With Slightly Heavier Isotopes of Hydrogen Deuterium + Tritium	Fusion in Proposed Commercial Reactors; Strong Interaction	Stable Helium-3/4 isotopes, Mainly fluxes of energetic neutrons, heat	
Lighter to Medium-Heavy Atoms + H or D + Electrons + ULMN Neutrons	Heavy and Light Water LENRs; Mainly Weak Interaction	Primarily stable isotopes, no hard radiation, beta and alpha particles, no externally released neutrons, heat	Aikido

Powering the world to a green future

LENR systems: energy-dense and readily scale-up

Green: no deadly energetic neutrons or gamma emissions and no radwastes

Unique features eliminate need for any heavy, expensive containment and shielding

- ✓ **LENRs are revolutionary green nuclear technology; fully explained by Widom-Larsen theory breakthrough published in peer-reviewed journals**
- ✓ **Have none of the safety and environmental problems or proliferation issues associated with fission and fusion power generation technologies**
- ✓ **Absence of any requirements for shielding and containment subsystems opens-up the possibility of developing revolutionary battery-like portable nuclear power sources that are safe and low-cost; no onerous clean-up $**
- ✓ **Commercial LENR systems would incorporate substantial amounts of nanotechnology; manufacturing techniques would resemble computer chips much more than internal combustion engines or wind turbines**
- ✓ **Output of LENR power sources would be inherently upwardly scalable, either by increasing active working surface area and/or volumetrically**
- ✓ **Could be vastly less expensive than fission or fusion for power generation**

Powering the world to a green future

LENR systems: energy-dense and readily scale-up

LENRs potentially enable revolutionary safe portable nuclear power sources

- ✓ Advanced batteries are just beginning to approach their technological limits in terms of achievable energy densities; >100x increase in energy density is not possible chemically
- ✓ Lithium-based batteries could unknowingly be encountering LENRs already; subset of "field failure" thermal runaways could potentially be triggered by rare LENR hotspots inside batteries
- ✓ Lithium-based batteries effectively store electrical energy in electrons in ions at only eV energies; a LENR Lithium fuel cycle releases ~27 MeV per nuclear reaction cycle (~27 million x more)
- ✓ Since they are radiation-free and do not produce long-lived radioactive isotopes, battery-like LENR power generation devices would not require any radiation shielding or containment subsystems, dramatically reducing their weight, size, and cost; enable development of revolutionary portable, battery-like nuclear power systems for compact electronics
- ✓ With energy densities >1 million x those of chemical systems, compact, portable LENR-based generators could eventually compete directly with batteries and fuel cells in key applications

? perhaps in some thermal runaways

Powering the world to a green future

Breakthroughs in nuclear technology

Widom-Larsen theory provides knowledge needed to start commercialization

In peer-reviewed *Pramana* W-L theory review paper (2010) we concluded by saying that:

"The analysis presented in this paper leads us to conclude that realistic possibilities exist for designing LENR devices capable of producing 'green energy', that is, production of excess heat at low cost without lethal nuclear waste, dangerous γ-rays or unwanted neutrons. The necessary tools and the essential theoretical know-how to manufacture such devices appear to be well within the reach of the technology available now. Vigorous efforts must now be made to develop such devices whose functionality requires all three interactions of the Standard Model acting in concert."

2013 Hiroshima-Nagasaki Remembered
68th Anniversary, Tuesday, August 6, 2013
Annual lantern ceremony
Victoria, B.C., Canada

Powering the world to a green future

Fission and fusion technologies

Paradigm  Changing

LENR technology

Powering the world to a green future

LENRs could reduce real price of energy over time

Economically important target market applications

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 well-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 nuclear waste clean-up** of existing worldwide inventories of stored 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

Time

First targets

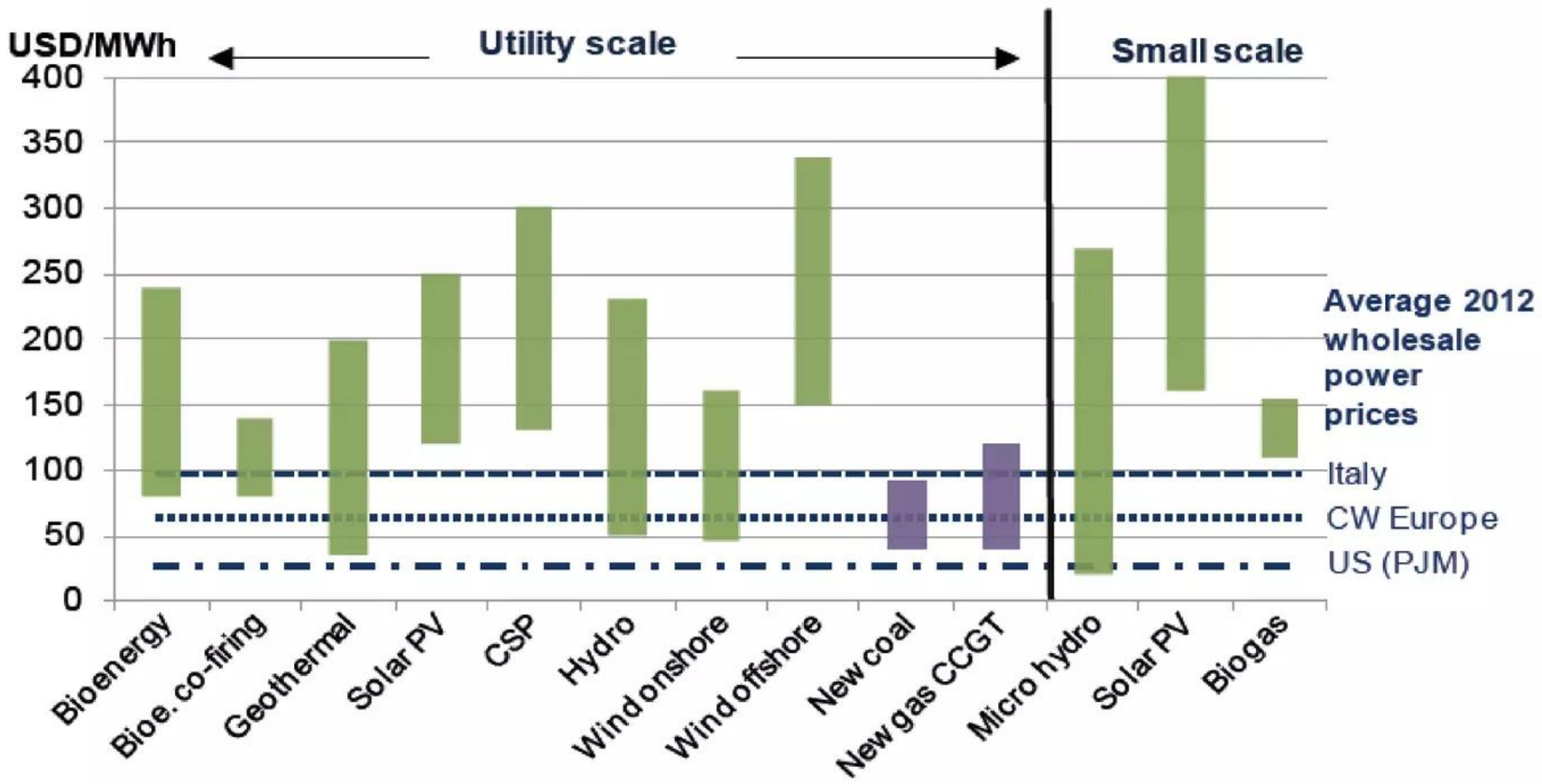
Potential long-term opportunities

Powering the world to a green future

Future global energy demand will be very strong

Need new clean energy technology that makes small scale <<< less expensive

Figure 3 Global levelised costs of power generation ranges, first quarter of 2013



Notes: costs are indicative and ranges reflect differences in resources, local conditions and the choice of sub-technology. CCGT = combined-cycle gas turbine. Central-Western (CW) Europe = Austria, France, Germany, Switzerland. United States (US). PJM = regional transmission organisation covering 13 states and the District of Columbia (DC).

Source: IEA analysis with power price data from Bloomberg LP, 2013.

Source: International Energy Agency (IEA) http://www.iea.org/Textbase/npsum/MTrenew2013SUM.pdf

Powering the world to a green future

LENRs enable small-scale distributed generation

Cost-effective, small-scale LENR-based systems could change the world

- ✓ At system power outputs of just 5 - 10 kW, cost-effective green LENR-based distributed power generation systems could provide enough heat and electricity to potentially satisfy the stationary energy requirements of a majority of urban and rural households and smaller businesses worldwide
- ✓ At system power outputs of just 50 - 200 kW, LENR-based systems could begin to power steam or all-electric vehicles, breaking oil's stranglehold on transportation; could also provide high-quality heat for industrial processes
- ✓ Although they could very likely be designed and built, megawatt LENR systems are not mandatory to change the world of energy for the better
- ✓ If widespread deployment of small-scale distributed generation could be achieved, nowhere near as many new, large fossil-fired and/or fission power generation systems would have to be built to supply competitively priced electricity to regional grids serving urban and many rural areas. In that case, grid-based centralized power generation would be gradually displaced by vast numbers of smaller, lower-cost distributed systems in smarter grids

Powering the world to a green future

LENRs enable small-scale distributed generation

Smaller LENR mammals could someday displace fossil fueled dinosaurs

- ✓ **Small-scale LENR systems might seem to be light years away from being able to compete head-on with enormous 500 - 1,000 MW coal-fired and Uranium-fission power plant dinosaurs. But please recall the history of personal computers versus mainframes. When PCs were first introduced 35 years ago, mainframe computer manufacturers regarded them as little toys; information processing jokes of no real consequence. Less than 10 years later, mainframe companies weren't laughing any more. Today, except for a small handful of survivor companies like IBM, most mainframe and minicomputer dinosaurs have disappeared. In fact, most of today's mainframes contain internal arrays of commodity PC microprocessors**

- ✓ **Using a similar market penetration and expansion strategy that combines high-volume manufacturing, aggressive pricing and distributed generation, relative costs of electric power generation with coal vs. LENRs could potentially converge in not-too-distant future. Commercial versions of LENR technologies could someday begin competing directly with "king coal," oil, and natural gas as yet another cost-effective primary energy source**

Powering the world to a green future

Commercialized LENRs could reduce real price of energy

To achieve goal need higher levels of R&D investment by private/public sectors

From older problematic energy sources

To a greener less expensive tomorrow

Evolution of nuclear technology

Fossil fuels + fission + fusion → LENRs + renewables

Powering the world to a green future

Fission and fusion technologies

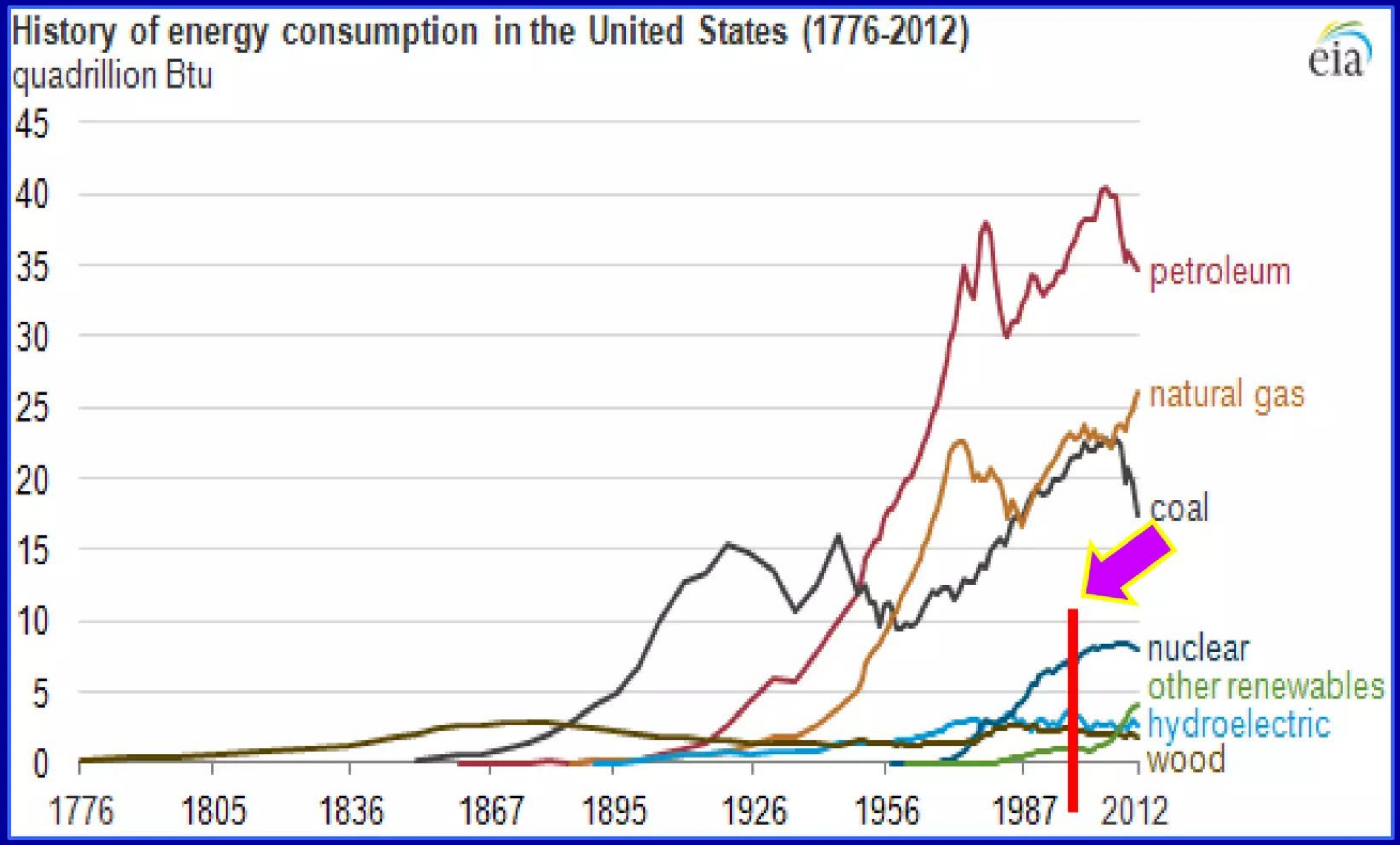
Paradigm  Changing

LENR technology

Powering the world to a green future

Fission power generation topped-out during 1986 - 2007

Petroleum also seems to have hit plateau; gas increasing; coal declining

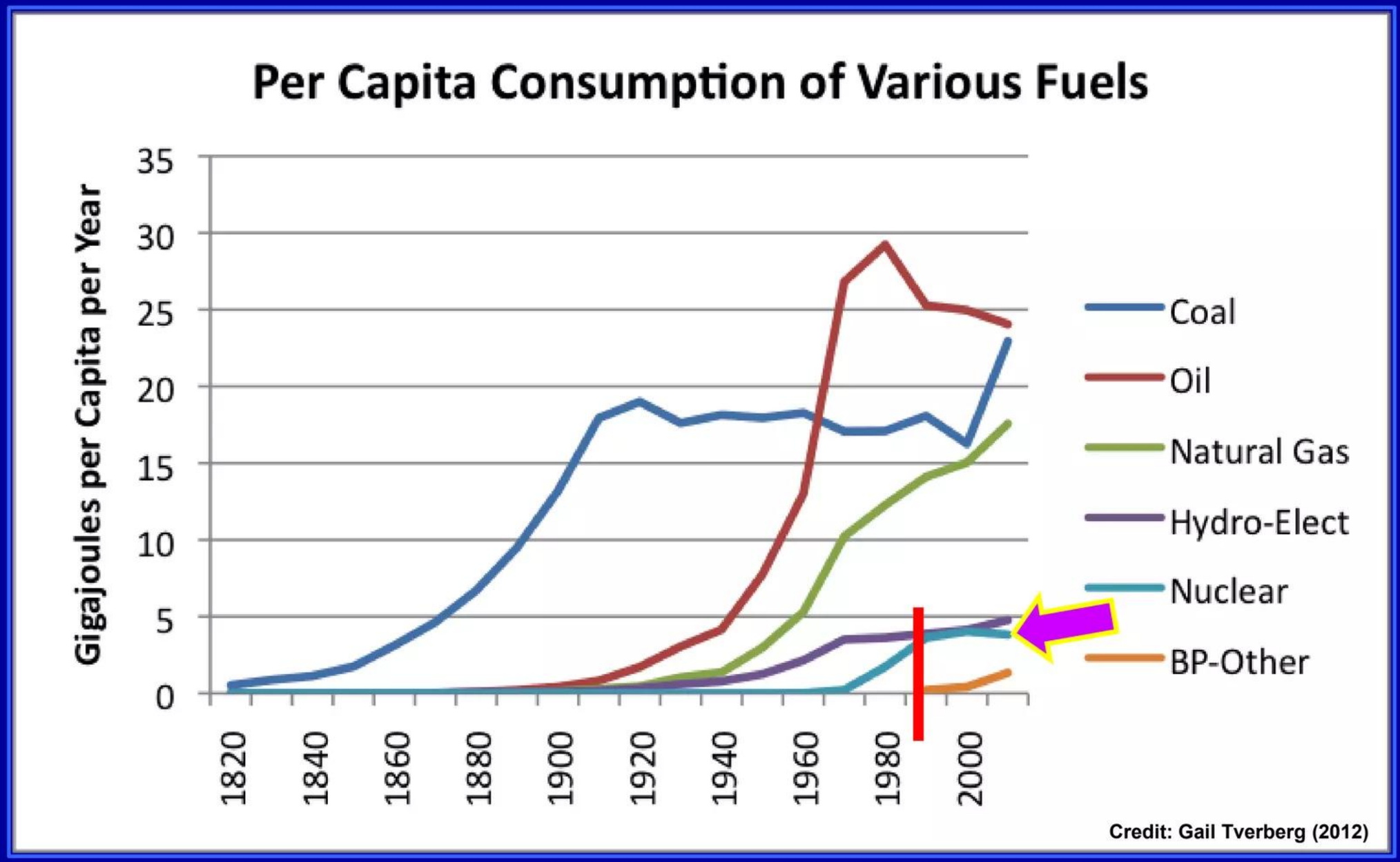


Source: U.S. Energy Information Administration (EIA)

Powering the world to a green future

Fission power generation topped-out during 1986 - 2007

Existing nuclear technology is minor player due to safety and other issues



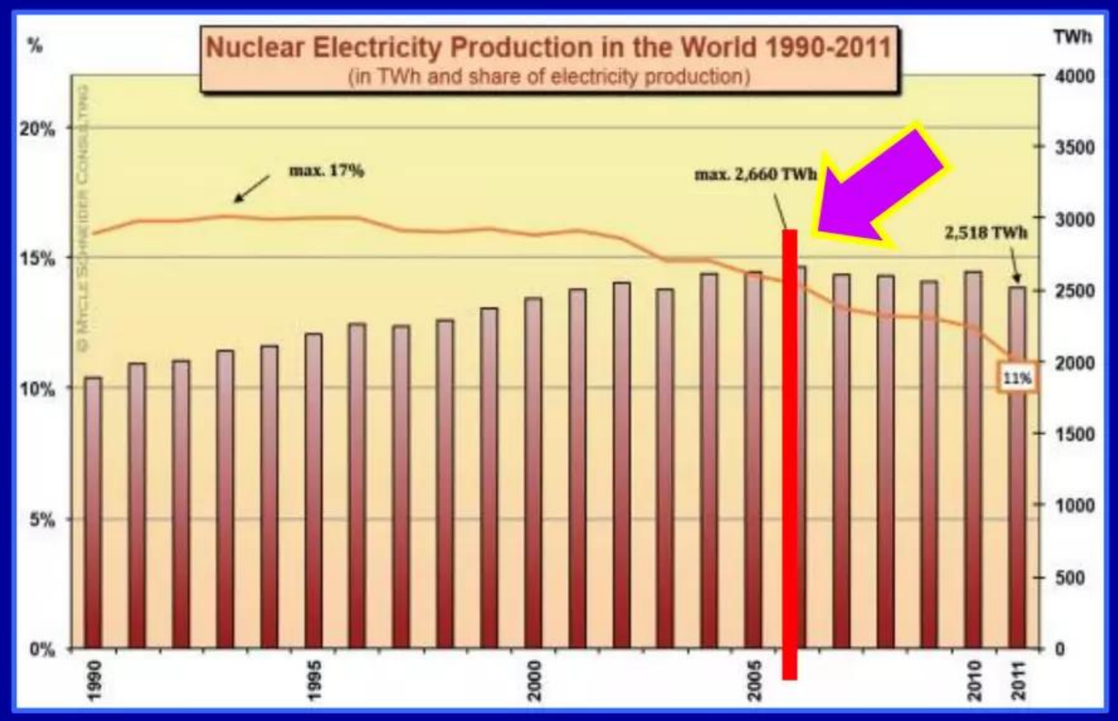
Source: http://ourfiniteworld.com/2012/03/12/world-energy-consumption-since-1820-in-charts/

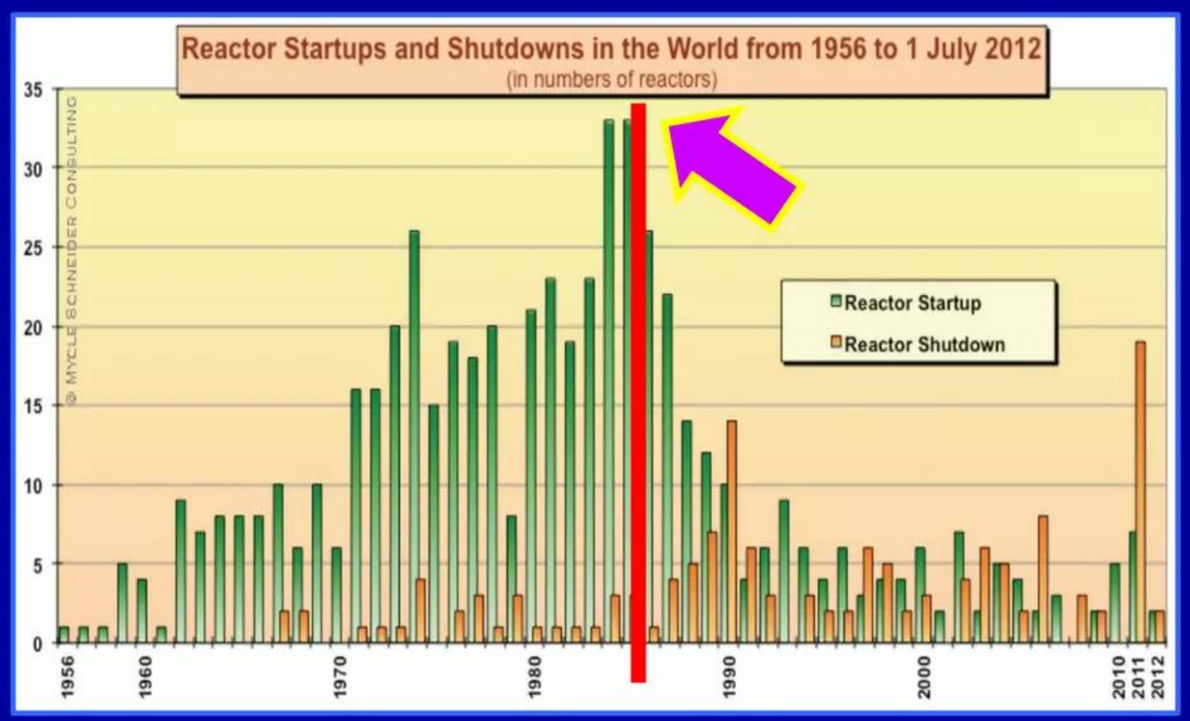
Powering the world to a green future

Fission power generation topped-out during 1986 - 2007

Technological performance over time often follows an S-curve

Has fission technology finally reached the flat, gently sloped top of its S-curve?





Source: IAEA-PRIS, BP, MSC (2012)

Powering the world to a green future

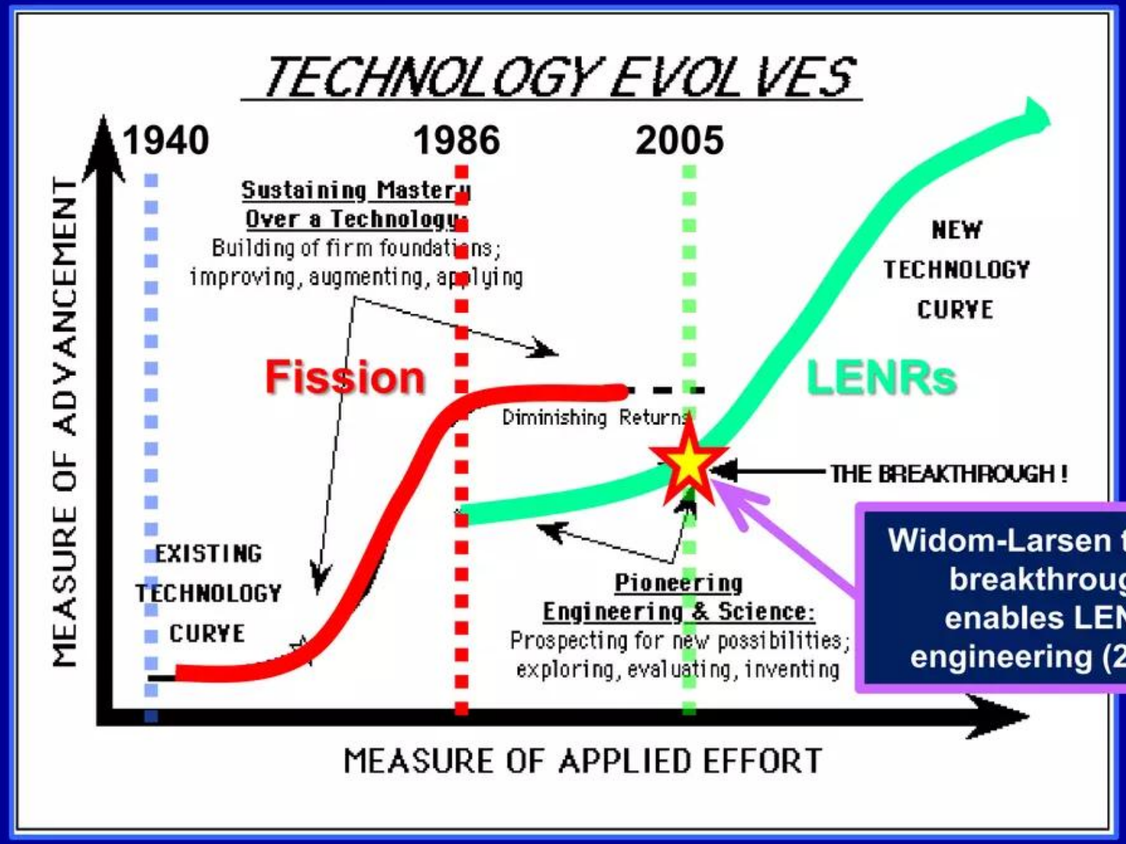
LENRs can create new S-curve for nuclear technology

S-curve of product performance tends to improve with cumulative R&D $

Similar to the experience curve concept but not as rigorously delineated or measured

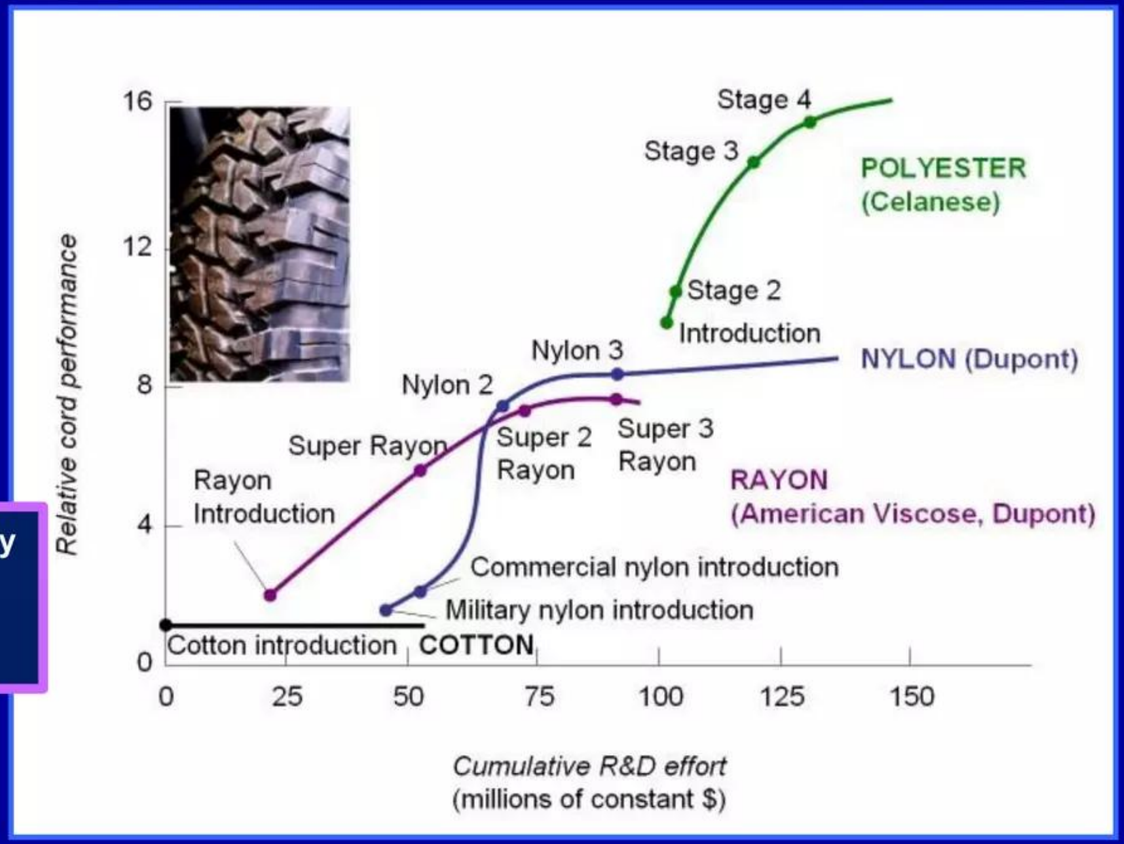
To reduce real price of energy need new breakthrough nuclear technology: LENRs

Technology S-curve for fission vs. LENRs:



Widom-Larsen theory breakthrough enables LENR engineering (2005)

S-curve concept and tire cord technology:



Powering the world to a green future

Fission and fusion technologies

Paradigm Changing

LENR technology

Powering the world to a green future

Fossil fuels still dominate grid power generation

Wide-area electric grids now dominate electricity production and distribution

Limited numbers of large central station power plants generate 90+% of grids' electricity

- ✓ In 2012: United States generated about 4,054 billion kilowatt hours of electricity; about 68% of the electricity generated was from fossil fuels (coal, natural gas, and petroleum). Detailed breakdown is: coal 37%; natural gas 30%; nuclear (Uranium-235 fission) 19%, hydropower 7%, other renewables 5%; biomass 1.42%; geothermal 0.41%; solar 0.11%; wind 3.46%; petroleum 1%; and "other gases" < 1% (source: EIA, May 2013)
- ✓ Centralized grid system architecture was well-established by 1900 in US, Europe, and Japan; has since spread worldwide
- ✓ In recent years, coal and nuclear fission have come under increasing attack by green activists and governments worldwide; changes in regulatory environments are causing accelerated retirement of many older coal plants and making financing of new, modern coal-fired power plants much more problematic – same issues for fission plants, especially in U.S.
- ✓ While use of renewable energy sources is increasing, in absence of carbon taxes, they are still more expensive than fossil fuels; don't fit as easily in a centralized grid architecture

Source: http://www.ucsusa.org/assets/documents/clean_energy/Water-Smart-Power-Executive-Summary.pdf

Powering the world to a green future

Economics of power plants: coal, gas, fission, and LENRs

Recent fracking boom has reduced natural gas prices in the U.S.

White paper:

"Will low natural gas prices eliminate the nuclear option in the US?"
R. Graber and T. Retson (released July 2013)

Abstract: "A probabilistic comparison of the investment risks of nuclear power and natural gas-based electricity generating plants has been carried out using a total life cycle power plant model. Although the cost of the gas plant (with carbon tax) is found to be slightly cheaper, that choice of fuel carries a far greater cost uncertainty, suggesting a greater long-term investment risk than nuclear power." [10 pages]

http://www.nuclearenergyinsider.com/nuclear-construction-summit/content-neireport.php

This white paper was produced by EnergyPath Corporation who will be revealing further findings at the 5th Annual Nuclear Construction Summit (22-23 October, Charlotte, NC) – for further information on this event please see:
www: www.nuclearenergyinsider.com | 7-9 Fashion Street I London E1 6PX

Powering the world to a green future

Economics of LENR power plants and retrofitting boilers

Admittedly speculative future cost scenarios; underlying assumptions noted

See white paper cited on previous slide: "Will low natural gas prices eliminate the nuclear option in the US?", R. Graber and T. Retson (released July 2013)

Discussion of Lattice's assumptions regarding different cost parameters:

Parameter	Assumptions made about each parameter and comments thereon
Capital	Capital costs substantially lower than fission plants since no radiation shielding or containment subsystems are required; > gas-fired; so assume 33% > gas = $16.92; retrofit is 20% of gas = $2.54
O&M	Operation and maintenance costs would likely be higher than combustion-based natural gas plants but substantially less expensive than fission power plants; thus assume O&M is 50% of nuclear = $5.02
Fuel	LENRs have vastly lower fuel costs (can use almost any 'target' nano-fuel that can capture neutrons) compared to either fission or natural gas; in 2012, Uranium price averaged $54.99/lb; 2013 nickel price = $6/lb; titanium = $10/lb; avg. of Ni/Ti = $8.00/lb + $2/lb (processing) = $10/lb = 18% of nuclear = $1.00
Taxes	Taxes for LENR power plants would be exactly = natural gas, which is > nuclear; so assume = $10.39
Decommissioning	Unlike fission and hoped-for D-T fusion power plants, LENRs do not induce any appreciable amounts of radioactivity in reactor components; decommissioning costs should thus be ~same as gas = $0.00
Waste disposal	Unlike fission plants, LENRs do not produce any long-lived radioactive wastes. However, depending on target fuels used (e.g. nickel, titanium) can create stable heavy metals: assume 10% of nuclear = $0.10
Environmental compliance	Cost for compliance is = $0.00, since LENRs do not emit gaseous CO_2 into atmosphere; carbon taxes would not be applicable to LENR systems (presumably they would only apply to fossil-fueled plants)
Summary remarks	Using simple, relatively conservative assumptions about parameters, and based on Graber & Retson's model, purpose-built or retrofitted LENR plants could perhaps be 54 - 75% less costly than natural gas

Powering the world to a green future

Economics of LENR plants and retrofitting boilers

Future scenario compares nuclear and natural gas vs. retrofitted fossil plants

Purpose-built LENR plant cost might be ~54% less than natural gas with no Carbon tax

Table 2: Cost Components of Levelized Costs ($/MWh) ($2012)				Lattice estimates
Cost Component ($/MWh)	Nuclear	Natural Gas (No Environmental cost)	Natural Gas (With $25/Ton CO_2)	Purpose-built LENR plants
Capital	$ 57.78	$ 12.72	$ 12.72	**$ 16.92**
O&M	$ 10.03	$ 3.46	$ 3.46	**$ 5.02**
Fuel	$ 5.55	$ 46.99	$ 46.99	**$ 1.00**
Taxes[1]	$ 9.79	$ 10.39	$ 10.39	**$ 10.39**
Decommissioning	$ 1.46	-	-	**-0-**
Waste Disposal	$ 1.00	-	-	**$ .10**
Environmental Compliance	-	-	$ 9.80	**-0-**
TOTAL	**$ 85.61**	**$ 73.55**	**$ 82.35**	**$ 33.43**

Source: http://www.nuclearenergyinsider.com/nuclear-construction-summit/content-neireport.php

Powering the world to a green future

Economics of LENR plants and retrofitting boilers

Future scenario compares nuclear and natural gas vs. retrofitted fossil plants

Retrofitted plant cost might be ~74% less than natural gas plant with no Carbon tax

Table 2: Cost Components of Levelized Costs ($/MWh) ($2012)				Lattice estimates
Cost Component ($/MWh)	Nuclear	Natural Gas (No Environmental cost)	Natural Gas (With $25/Ton CO_2)	Retrofit nat. gas or coal plants
Capital	$ 57.78	$ 12.72	$ 12.72	**$ 2.54**
O&M	$ 10.03	$ 3.46	$ 3.46	**$ 5.02**
Fuel	$ 5.55	$ 46.99	$ 46.99	**$ 1.00**
Taxes[1]	$ 9.79	$ 10.39	$ 10.39	**$ 10.39**
Decommissioning	$ 1.46	-	-	**-0-**
Waste Disposal	$ 1.00	-	-	**$ .10**
Environmental Compliance	-	-	$ 9.80	**-0-**
TOTAL	**$ 85.61**	**$ 73.55**	**$ 82.35**	**$ 19.05**

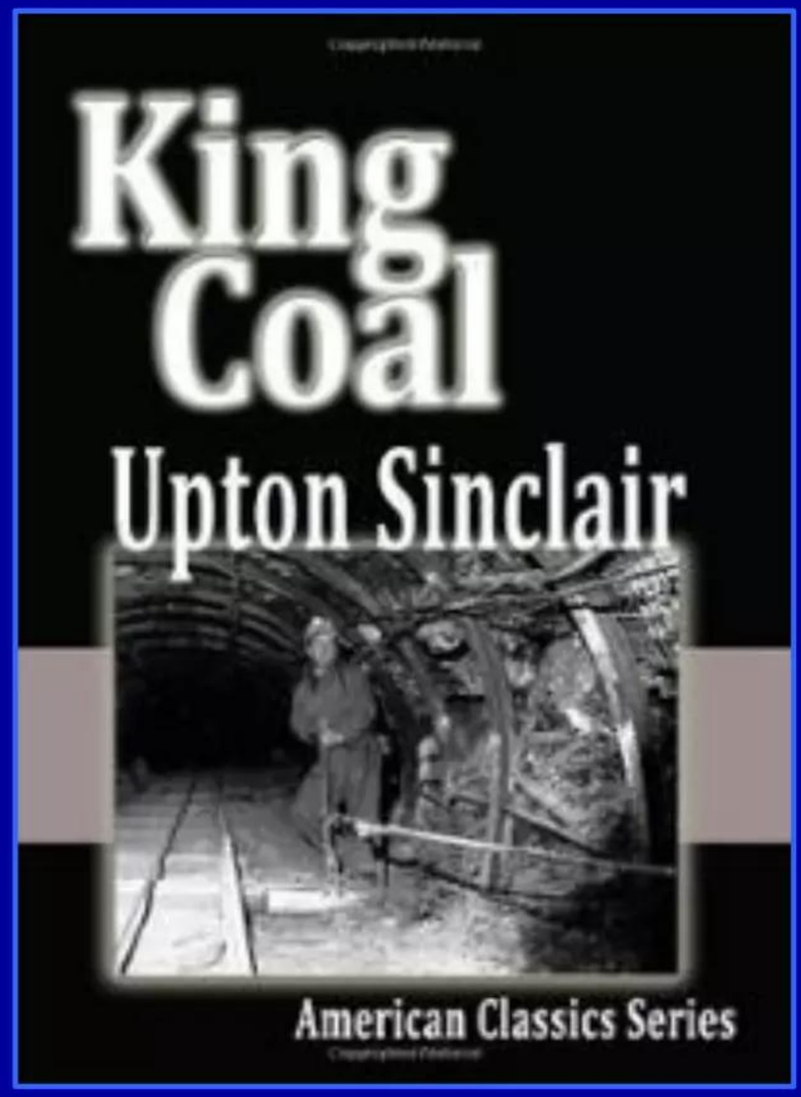
Source: http://www.nuclearenergyinsider.com/nuclear-construction-summit/content-neireport.php

Powering the world to a green future

LENRs could greatly reduce real price of electricity

If commercialized, LENR power generation technology could change the world

- ✓ Potentially very disruptive to portable power markets
- ✓ Synergistic with oil and coal industries in the near-future
- ✓ Assuming that they can be successfully built, multi-megawatt output, grid-scale LENR power plants could potentially be 54 - 74% less costly vs. natural gas plants
- ✓ Potential to gradually replace internal combustion engines over the next 30 - 60 years; enable substantial reduction of man-made CO_2 emissions and someday energy independence from petroleum in transportation
- ✓ 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 portfolio of other types of carbon-free renewable energy technologies together have the potential to substantially reduce the real price of electricity and thus democratize access to affordable energy for every inhabitant of the planet**



"King Coal" by Upton Sinclair (1878 - 1968)
First self-published in Pasadena, CA (1917)
http://www2.hn.psu.edu/faculty/jmanis/u-sinclair/KingCoal.pdf

Powering the world to a green future

LENRs could likely reduce energy costs vs. fossil fuels

Distributed power generation all by itself would be able to do the trick

While it won't make electricity "too cheap to meter" as Robert Strauss had hoped back in 1954, LENRs could potentially enable a substantial decrease in the real price of energy over time

Powering the world to a green future

Fission and fusion technologies

Paradigm  Changing

LENR technology

Powering the world to a green future

Key take-aways from this presentation

Perhaps more major corporations/governments should increase R&D in LENRs

- ✓ R&D investments by governments and corporations have disproportionately favored nuclear fission and fusion technologies, especially weapons, for 71 years
- ✓ Virtually everyone agrees that development of lower-risk, ecologically clean, low cost sources of energy is crucial to future world economic growth and overall quality of life, especially for people now living in rural areas without any electricity
- ✓ Over the past 63 years, enormous financial investments have been made in D-T fusion technology, yet today there are still no operating commercial power plants
- ✓ In last 24 years, tens of billions of dollars, euros, rubles, yuan, yen, and rupees were spent on fusion R&D; by contrast, less than ~US$200 million has gone into LENRs during that time; vast majority of that money came from the private sector
- ✓ Maybe it's time for both corporations and governments to start making greater parallel R&D investments in LENRs in addition to fusion and fission technologies
- ✓ By pursuing multiple synergistic paths toward the same common goal we could, collectively all "hedge our bets" on the development of new, non-polluting, inexpensive energy sources that can ultimately supplant fossil fuels

Powering the world to a green future

Relevant documents

Peer-reviewed paper - overview of expanse of Widom-Larsen theory of LENRs:

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

Lattice document concerning LENR-based power generation systems vs. fission and fusion:

"Truly green nuclear energy exists – an overview for everybody: no deadly gammas … no energetic neutrons … and no radioactive waste"
L. Larsen, Lattice Energy LLC, updated and revised through June 23, 2013 [108 slides]

http://www.slideshare.net/lewisglarsen/powering-the-world-to-a-green-lenr-future-lattice-energy-llcapril-11-2013

Index to large collection of documents re LENR theory, experimental data, and the technology:

"Index to key concepts and documents" v. #14 at this URL is updated through Sept. 12, 2013
L. Larsen, Lattice Energy LLC, May 28, 2013 [82 slides]

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-index-to-documents-re-widomlarsen-theory-of-lenrsmay-28-2013

Powering the world to a green future

"No single solution will defuse more of the Energy-Climate Era's problems at once than the invention of a source of single solution 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, "Hot, Flat, and Crowded" pp. 186 (2008)