

# “Cold Fusion” Poised to Become an Industrial Reality!

*Recent announcements of breakthroughs in the arena of cold fusion have caught the physics community worldwide by surprise. Should cold fusion research in India, dumped in the 90s following worldwide skepticism, be revived?*

“**C**OLD Fusion” is the popular term used to describe the occurrence of nuclear reactions in a metallic lattice such as Palladium, Nickel, Titanium etc when they are heavily infused with deuterium or hydrogen. The phenomenon was first revealed 22 years ago by chemistry professors Martin Fleischmann and Stanley Pons of the University of Utah at a press conference held in Salt Lake City on 23 March 1989.

They claimed that during a simple test tube electrolysis experiment wherein a few centimetres long thin palladium rod was used as cathode and a platinum wire coil surrounding it as anode and which were immersed in an electrolytic solution composed of lithium deuterioxide (LiOD), nuclear “fusion” reactions took place within the rod, generating anomalous “excess heat”.

They postulated that during electrolysis deuterons impregnate the palladium rod forming Palladium deuteride (PdD) and in course of time “when the right conditions are attained”, nuclear reactions involving deuterons occur in/on the Pd rod. Temperature

sensors (such as thermocouples, thermistors etc) located inside the test tube detected the onset of production of large amounts of anomalous heat, which they proposed could only be attributed to the occurrence of nuclear reactions.

## Opposition to Cold Fusion

Suffice it to say that this simple announcement ignited one of the fiercest debates in the history of Physics! When most attempts to replicate the experiment failed and majority of researchers could not find any evidence for nuclear reactions taking place, the two professors were vehemently criticized, abused, insulted and ridiculed for daring to suggest that fusion reactions occur at room temperatures inside a solid matrix!

The primary reason for the concerted criticism and non-acceptance of the claim was that according to the prevalent understanding of nuclear physics it is absolutely impossible for two deuterons, which are positively charged, to overcome the repulsive electrostatic repulsion between them before any nuclear reaction can occur. Fusion reactions are known to occur for example in the sun and the stars (and indeed also in a hydrogen bomb) when hydrogenous isotopes are raised to a temperature of over 100 million degrees, becoming an

intensely hot plasma. Hence, the term “thermo-nuclear fusion” was coined to describe such reactions. So where is the question of nuclear reactions occurring at room (or “cold”) temperature inside a deuterated Palladium rod?

All this is now old story. The Internet contains enough discussion on the cold fusion “confusion”. Any “reputed” physicist will be happy and indeed enjoy explaining to the confused reader why the “cold fusion” claim is “utter nonsense” and indeed an “embarrassment” to science!

## Worldwide Progress

Unfortunately for the physics pundits, the story is not over. Unexpected breakthroughs do happen in science upsetting the established “old order”! A small minority of a few hundred persistent scientists from about 10 countries have been carrying forward the flag of “cold fusion” for the past two decades. The site [www.lenr.org](http://www.lenr.org) catalogs over 2000 scientific papers that chronicle evidence for the occurrence of a variety of nuclear reactions inside metallic lattices when they are loaded with deuterium and in some cases even with hydrogen. Such reactions are now preferably referred to as “Low Energy Nuclear Reactions” (LENR) and the field as a whole as “Condensed Matter Nuclear Science” (CMNS).

## *There is no reason why India should not jump on this 21<sup>st</sup> century “energy bandwagon” and strive to exploit it to feed an energy-hungry nation.*

### “LENR TRANSMUTATIONS”

When Fleischmann & Pons announced the discovery of the cold fusion phenomenon in 1989, the general understanding was that nuclear fusion reactions presumably occur between the deuterons loaded in the Pd lattice. It was presumed that the “host metal” nuclei themselves were merely spectators, serving only as a catalyst or facilitator. Viewed from the perspective of the generally accepted understanding of nuclear physics, the occurrence of nuclear fusion reactions between a pair of deuterons at room temperature as proposed by the discoverers was and still is considered “impossible”. The basic issue is the strong repulsion between two positively charged deuterons referred to as the “Coulomb barrier”, which has to be overcome before a nuclear reaction can take place.

However, there were some Physicists who even at that time speculated that the host metal atoms, in this case Pd, might be participating in the nuclear processes in the metal. Given the disbelief of the Nuclear Physics community of even the simple (d,d) fusion reactions implied in the cold fusion phenomenon, any suggestion or speculation of the possible occurrence of nuclear reactions between the deuterons and the nuclei of the host metal such as palladium, titanium, or nickel (or others), resulting in the transmutation of the host metal nucleus would be considered as preposterous and totally unthinkable! Obviously the magnitude of the repulsive Coulomb barrier between deuterons and the nuclei of the host metal atom is if at all enormously larger than that between a pair of deuterons!

However, over the past two decades experimental evidence has slowly been piling up, confirming the occurrence of precisely such “unbelievable” elemental transmutation reactions in a variety of simple LENR experiments. A comprehensive review paper on such LENR Transmutations is currently under publication in Chapter 43 in the forthcoming “Wiley Nuclear Energy Encyclopedia: Science, Technology, and Applications”, 2011 Edition\*, Edited by Steven B. Krivit, Jay H. Lehr, and Thomas B. Kingery. (See [www.newenergytimes.com](http://www.newenergytimes.com) for details.) However, the quantum of such transmutations observed so far in the experiments reviewed in the Wiley paper is relatively small.

But the recent experimental demonstration of the 10 KW Ni-H Rossi reactor, described in the accompanying article, has established the massive scale of occurrence of elemental transmutations, in this case conversion of Nickel to Copper, mediated by protons! Preliminary analysis of the post run Nickel samples appears to indicate that one or more protons have been able to successfully invade the nucleus of the Nickel atom in a very simple experimental configuration, and succeed in altering its nucleonic composition, resulting in its isotopic composition changing as well as transmuting its elemental nature.

It is almost as if the age-old claim of Alchemy has been effectively validated, and assuming that all this stands up to in-depth scrutiny in the months to come, it would have to be admitted that nuclear science is witnessing a silent revolution of unprecedented proportions with deep scientific implications!

#### \*Low Energy Nuclear Reactions: Transmutations

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During 1989-90, a dozen groups from BARC had entered the fray and indeed confirmed observing both neutrons and tritium, telltale signatures of the occurrence of nuclear fusion reactions. These results were first published in 1989 as *BARC-1500 Report*, which is now available online (see [www.lenr.org](http://www.lenr.org)). A comprehensive review paper on the early BARC work has been republished by the American Chemical Society [M. Srinivasan, “Wide-Ranging Studies on the Emission of Neutrons and Tritium by LENR Configurations: An Historical Review of the Early BARC Results”, in *Low Energy Nuclear Reactions and New Energy Technologies Sourcebook*, Ed. S. Krivit and J. Marwan, Amer. Chemical Society, Oxford University Press, Washington, D.C., Vol. 2 (2009)]. But sadly Cold Fusion research at BARC too was shutdown in the early 90s following global skepticism.

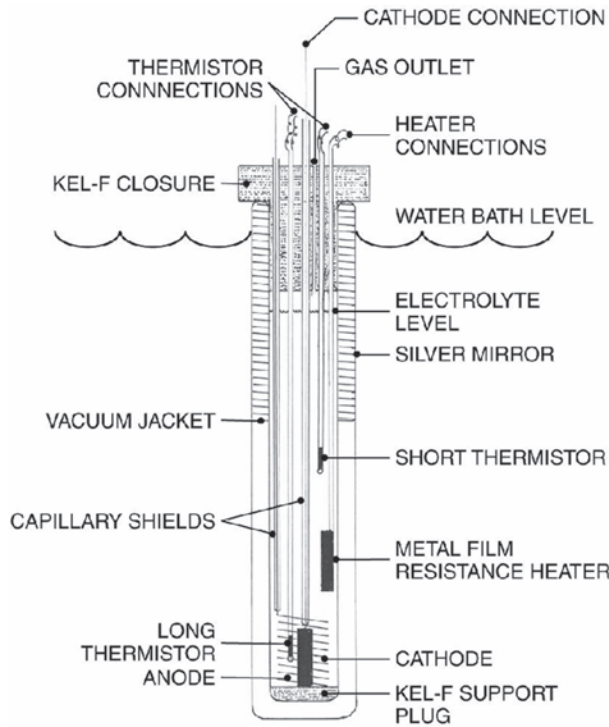
It must however be conceded that the theoretical aspects of the exact mechanism underlying the nuclear phenomena going on inside deuterated/hydrogenated metallic matrixes is not yet fully understood. It is apparent that the physics of nuclear reactions taking place inside a solid matrix is very different from what happens in plasma or a low-density gas. Clearly the “host metal matrix” somehow catalyzes nuclear reactions, something that was totally unexpected by physicists.

### International Conference in Chennai

The city of Chennai played host to the 16<sup>th</sup> International Conference on Condensed Matter Nuclear Science (ICCF 16) as well as three associated satellite meetings that were held during February 2011 (see [www.iscmns.org/iccf16](http://www.iscmns.org/iccf16)). About 60 foreign “cold fusioners” and 25 Indian observers participated in this conference.

One of the hot topics on which there were many papers was the near reproducible generation of nuclear heat in deuterium gas loaded Pd and Pd-Ni nano powders dispersed in a zirconium oxide matrix, a technique pioneered by the winner of the prestigious Imperial Prize of Japan, Prof. Arata of Osaka University. Other groups, notably from Kobe University and the Naval Research Laboratory of Washington D.C. in the USA, reported their findings in such gas-loaded systems.

There were also over a dozen papers on the theoretical approaches to understanding the LENR puzzle. The



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interested reader can get more information on these developments from the following websites: [www.infinite-energy.com](http://www.infinite-energy.com); [www.newenergytimes.com](http://www.newenergytimes.com) and [www.coldfusionnow.org](http://www.coldfusionnow.org) besides [www.lenr.org](http://www.lenr.org).

### Breakthrough Announcement

Those of us who have been following the development of the emerging new field of Condensed Matter Nuclear Science closely, were pleasantly surprised to learn of the public demonstration of a 10 KW "cold fusion" reactor on 14 January 2011, by Andrea Rossi and his collaborators in Italy, just weeks prior to the Chennai conference. Rossi's web sites (<http://www.journal-of-nuclear-physics.com> and <http://rossiportal.com/>) give details of this development.

Rossi's patent application filed in August 2008, claims that "a practical embodiment of the inventive apparatus, installed on 16 October 2007, is at present perfectly operating 24 hours every day, and provides an amount of heat sufficient to heat his small factory." Rossi was granted an Italian patent for his "Energy Catalyzer" on 6 April 2011. The full text of this patent is available at <http://www.wipo.int/pctdb/en/wo.jsp?IA=IT2008000532&DISPLAY=DESC>.

Industrialist and inventor Andrea Rossi and his mentor Physics professor Sergei Focardi of the University of Bologna have disclosed details of their invention in an article dated 22 March 2010 and titled "A new energy source from nuclear fusion" published in their website. They have indicated that in their device nuclear energy is released following proton capture in Nickel isotopes leading to the formation of various nuclides of Cu.

Rossi states: "At the end of the operations in the reactor, the percentage of copper was integrally bound to the amount of energy produced. A charge that has worked for 6 months, 24 hours per day, at the end had a percentage of Cu superior to 30%." The Cu<sup>63</sup> to Cu<sup>65</sup> isotopic ratio was found to be substantially different from its natural abundance values. Likewise, the isotopic composition of Ni too was significantly different from natural.

This Rossi announcement dominated the discussions in the lobby during the ICCF-16 conference in Chennai; Clearly Rossi seems to have stolen a march over the majority of the LENR researchers worldwide who are mostly following the deuterated Pd route to cold fusion, originally propounded by Fleischmann and Pons. The "Energy Catalyzer" or "E-Cat boiler", as Rossi prefers to call it, is based on the less expensive and less studied Ni-H route.

LENR literature indeed contains many scientific papers published since the mid-90s that describe the occurrence of a variety of nuclear transmutation reactions in Nickel-hydrogen systems. For example, the earlier studies of Piantelli and his collaborators of the University of Bologna as also that of Patterson and Miley at the University of Illinois with thin-film Ni-coated plastic beads are noteworthy. (This writer himself had coauthored papers in 1995-96 describing generation of low levels of Tritium in both Ni light water electrolytic cells as well as thin self heated Ni wires exposed to hydrogen gas, and has thus personally confirmed that nuclear reactions do take place in Ni-H systems.)

What caught the ICCF-16 participants by surprise was however the magnitude of the power output, namely the 10 to 15 KW region, during the Rossi-Focardi reactor demonstration, as against the input heating power which was about 400 watts only. Two of the witnesses of the January 14 demo who were present at the Chennai conference shared their observations at a specially convened session on the inaugural day of the ICCF-6 conference.

### Rossi-Focardi 10 KW Reactor

A hundred grams of Ni nano powder is charged into a hydrogen filled horizontally mounted stainless steel container, about a litre in volume. (The entire reactor chamber was wrapped in Al foil to prevent revelation of the "trade secrets" of his invention to visitors, until grant of patent to him.) A 2-cm thick lead jacket placed around the reactor vessel helps attenuate the radiation fields caused by X-rays in the 300 Kev energy band generated during reactor operation. According to Rossi, when the reactor is switched off what little remnant residual radioactivity is present in the core decays within minutes. Rossi has however revealed that there is a "secret" additive (approximately 3 gm in weight) incorporated in the Ni powder, whose nature will not be disclosed for now.

During the 14 January 2011 demo conducted in the presence of a specially invited audience of about 50 eminent persons, the thermal output measurements were carried out by Prof. Giuseppe Levi of the University of Bologna, an independent Physicist not associated with Rossi's invention. Levi was authorized to establish the E-cat's performance as a "black box". Dr. Rossi turned on the 400 W electrical





1 MWth  
Prototype  
Reactor under  
installation in  
Greece

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Andrea Rossi  
with Sergio  
Focardi standing  
near their  
apparatus

resistance heater from its Controller to start heating the Nickel powder and consequently the temperature of the output water began to climb during this transient phase of operation. For about an hour and a half thereafter the generator produced 10 KW of net power. From the decrement in the weight of the hydrogen gas cylinder during this period, it was surmised that the mass of hydrogen consumed was less than a gram. The total integrated energy output during the 1.5 hr test translated to an energy equivalent of 517 kg of oil. Rossi claims that one gram of nickel powder can produce as much energy as 500 barrels of oil before it is fully consumed.

In a follow-up test conducted during 10-11 February 2011, the reactor generated 15 KW continuously for 18 hours (touching 20 KW at times) during which only about 80 watts of input power required by the power supplies of the measuring instruments was consumed. In other words

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the reactor itself operated on a self-sustaining self generation mode, heat being produced only by the Ni “nuclear fuel”. However in general for ease of control Rossi prefers not to operate the device in a self mode; by having the ability to shut off heating power to the resistance heater he has better capability to shut down the nuclear reaction rate.

One of the safety concerns is whether there could be any possibility that the reaction rate could go out of control and increase beyond safe limits. Rossi has, in fact, stated that in a recent experiment the reactor power did increase to 130 KW and had to be throttled down to 15 KW. They are therefore installing elaborate electronic control systems to automatically maintain power at preset levels as in most nuclear power reactors. Another precaution required is to guard against chemical explosions caused by hydrogen combustion; Rossi himself has experienced several hydrogen leakage explosion incidents during his experimental campaigns.

The radiation fields generated around the 10 KW reactor was reportedly much less than that produced around a medical X-ray machine in a hospital diagnostic centre. Notwithstanding this, however, installation of the Rossi cold fusion reactor would likely need approval of appropriate regulatory authorities in most countries.

A yearlong R&D program has been initiated at the Physics Department of the University of Bologna, the “oldest University in the world”, to address unanswered questions and safety issues. They are also preparing a campaign of detailed analysis of the spent Nickel fuel with a Secondary Ion Mass Spectrometer (SIMS) at the University of Padua.

Two additional tests were carried out with a single Rossi module in Bologna on 19 and 28 April 2011 for the benefit of representatives of the Swedish Newspaper NyTechnik who personally carried out heat output measurements. The Swedes wanted to independently verify the claims by measuring the net energy that the device generates as accurately as possible. The results of the two tests showed a net power output of between 2.3 and 2.6 kilowatts, of the order of a large stove plate. Input electric power was in the order of 300 watts. The tests lasted for two and three hours respectively and the total net energy developed was calculated to be 5.6 and 6.9 kWh.

A new company called *Defkalion Green Technologies* set up in Greece to exploit this breakthrough technology has acquired the world rights (except the Americas) for the invention. The first prototype 1 MWth reactor plant is to be installed at Athens and is scheduled for commissioning in October 2011 subject to obtaining the requisite clearances. This



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The modules for the Greek power plant have already been manufactured at the Florida based plant of Rossi's Learnado Corporation ([www.learnadocorp1996.com](http://www.learnadocorp1996.com)) that has been in the business of manufacturing electric gensets fueled by vegetable oils and animal fats. The 1 MWth plant will first be assembled and tested for a few days at the Florida factory premises before being shipped out to Athens. So the big question is how is the US Govt Nuclear Regulatory Commission going to react to the test in Florida? Objecting to the test and requiring Rossi to apply for permits will imply they acknowledge the reality of Cold Fusion, which in itself would be a big boost to Rossi and his team.

It was announced on 16 May 2011 by the Swedish Newspaper *NyTeknik*, which keeps a close watch of global technology developments, that Leonardo Corporation has concluded an agreement with a company called "Ampergo" formed in April 2009 and located in New Hampshire, Ohio, USA for the manufacture and marketing of Rossi Reactor modules in the Americas. (It is significant that one of the co-founders of this company, Robert Gentile, was earlier Assistant Secretary of Energy for Fossil Energy at the US Department of Energy during the early 1990's.)

1 MWth reactor will comprise of 300 modules of 4KW each arranged in a series – parallel fashion (as per their April 2011 announcement) – and will be used to power a factory building that is to be used for manufacturing 300,000 numbers of multi kilowatt Rossi reactor modules a year.

Rossi has indicated that he is averse to increasing the power capacity of each individual module beyond the 10 KW level as he has been playing around with this size for many years and is very comfortable with it. He does not want to risk making it bigger for fear of unexpected new problems and safety issues cropping up.

### Waking up to the Reality

March 2011 marked the Centenary of the discovery of the Atomic Nucleus by Ernst Rutherford who was awarded the Nobel Prize for it. It is a fortuitous coincidence that a "third route" to tapping Nuclear Energy (besides Fission and Thermo-nuclear Fusion) has now emerged and is showing prospects of reaching the market place by the end of this year.

Obviously much more research needs to be done before this breakthrough science can make a dent on the global energy scene. Young Indian scientists have a great opportunity to enter the fray and play an exciting role in unraveling the physics behind these atomic lattice catalyzed nuclear reactions. The curious researcher is recommended to watch the fascinating video titled "The Magic of Mr. Rossi", available on Youtube (<http://www.youtube.com/watch?v=NzL3RllcwbY>).

The Rossi Reactor breakthrough could not have come at a more opportune moment in the affairs of the world, at a time when fossil fuel as a source of energy has given rise to global warming concerns and Fukushima has awakened the ghost of Chernobyl. "Cold Fusion" or "Condensed Matter Nuclear Science (CMNS)" or "Low Energy Nuclear Reactions (LENR)" or whatever else you may like to call it, has clearly attained maturity 21 years after its discovery. This "Revolution in Nuclear Science" warrants being welcomed and embraced as a legitimate branch of science, in this centenary year of the discovery of the nucleus.

The powers that be in India who direct the course of scientific research need to wake up to its reality. There is no reason why India should not jump on this 21<sup>st</sup> century "energy bandwagon" and strive to exploit it to feed an energy-hungry nation, unless of course, the authorities prefer that we import "cold fusion" reactors from Greece, Korea or China!

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