Electrical Breakeven from LANR Phusor Device Systems: Relative Limitations of Thermal Loss in Feedback Loop

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Abstract - The final goal of LANR is net electricity, a self sustaining electricity generator. This paper discusses the preliminary efforts to do this, including wasted energy dissipation in the electrical feedback system. Adding to poor energy conversion (heat to electricity) efficiencies, and low Carnot efficiencies, in the electrical feedback loop the waste heat dissipation losses have been found to be considerable. In electrical circuits used, the first and second stages had heat dissipations of 4% and 15%, of the total energy in the loop. Energy storage by fuel cells was also found to be incredibly inefficient. LANR fuel cells have two types waste heat loss, one in gas generation and then a second when water is generated to make electricity. We measured these waste energy (dissipation) losses at 13-20% and 54-69%, respectively. These are formidable losses in the feedback loop. The net result is that of the energy which went into the feedback loop, only ~18% is available for the useful output, to drive a self sustaining LANR system to make net electricity.

Index Terms – Electricity production, Electrical breakeven, renewable electricity, feedback, energy production, LANR electricity

1. Introduction - Electricity Generation by LANR: Final Frontier

The generation of electricity by "lattice assisted nuclear reactions" (LANR, or "cold fusion") is the "home run" of both hot and cold fusion - a self sustaining electricity generator (SSEG). Of the two methods, cold fusion leads at the moment having surfaced during hot fusion's third "just twenty years away" quarter. One goal of this paper is to describe the state of affairs in the race for safe, electrical LANR breakeven. Cold fusion has exceeded hot fusion in energy output (Arata 1999 2008; Fleischmann 1989, 1992, 1993; Miles 1993, 1994; Srinivasan 1992; Szpak 2004; Swartz 2006a, 1998, 2006b, 2005, 1997a; 2002a; 2000) and the number of carefully monitored, repeated experiments. It will dominate in the future because LANR enables production of energy, from loss of nuclear mass, without clinically-significant ionizing penetrating radiation or neutron emission. The term "clinically-significant" is used for two reasons. First, because the very low energy penetrating emissions, even though meticulously investigated (Szpak 1998, 1996, 2005; Mosier-Boss 2009, 2007), are easily shielded unlike the emissions from hot fusion and nuclear reactors. Second, unlike in hot fusion, the cold fusion reactors, and the building in which they are conducted, can be reused because of the absence of residual radioactivity.

Successful SSEG can only be done using high power and high power gain with electrical feedback so that the output of an LANR device can drive the input [Figure 1] giving what is termed “electrical breakeven” or “renewable electricity”. Figure 1 shows the LANR heat/electricity generation subsystem and the feedback subsystem, which in this case has several components that evolved over time. Importantly, our effort has collected a significant amount of unexpected scientific data regarding the construction of this type of self-sustaining LANR system. It has also revealed a number of major limitations to achieving a SSEG using LANR. These results have also corroborated our previously published estimate of the requisite LANR power gain required for successful electrical breakeven (Swartz 2002).

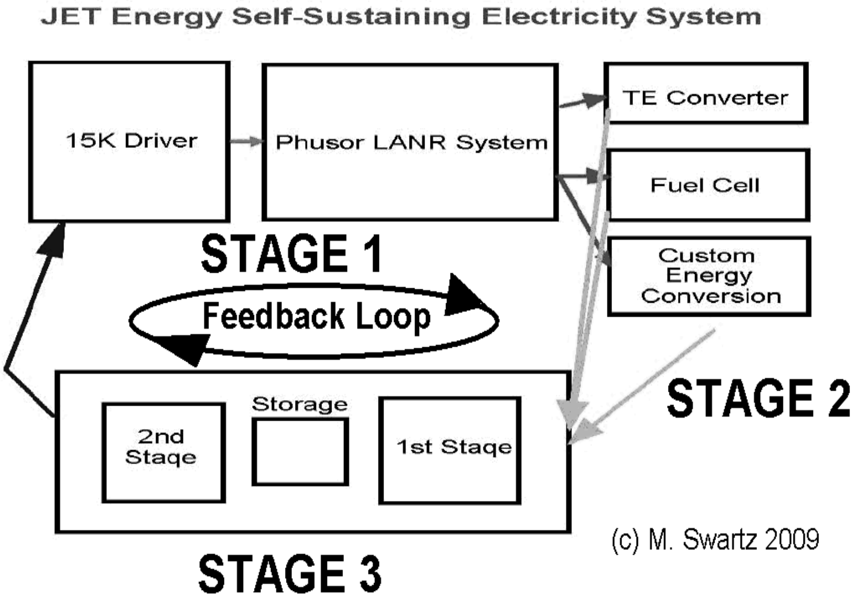

Figure 1. JET Energy Self Sustaining Electricity System

2. Experimental - LANR Devices and Generation of Electricity

STAGE 1 - For SSEG development, our research has led to a new kind of Pd/D_2O/Pt, Pd/D_2O/Au and other engineered Phusor®-type LANR structures which exhibited improved energy gain and fairly good reproducibility (Swartz 2006a, 1998, 1997a, 2002a 2006b, 2005). To develop the peak outputs, devices were run at their optimal operating point (OOP). All thermal, electrical and motor outputs were normalized to input electrical power, and calibrated by ohmic (thermal) controls, noise measurement, waveform reconstruction, adequate Nyquist sampling, time-integration, thermal ohmic control, and thermal power spectrograms.

STAGE 2 - The road to electrical breakeven first began with simple energy conversion of heat through thermoelectric. In 1996, 'Fusion Facts' reported that one of our early Phusor®-type LANR devices, during generation of over-unity energy performance, was used to also generate low level electricity, and lit up a red LED. These were early very low power, intermittent, and non-feedback experiments, where the LANR-generated electricity was not returned back to the LANR device. Instead, the electrical energy was delivered to low intensity light emitting diode radiators. Later, once the LANR devices could be driven at their optimal operating point (Swartz 1994a, 1992, 1999a, 1997b), we focused on several available conversion devices, including thermoelectric converters, fuel cells, and custom energy conversion systems (Figure 1). We developed ways of improving the power conversion; its success progressed to, for a short time, lighting up a low-power fluorescent light. By 2003, we reported at ICCF10 that thermoelectric conversion, with LANR compared to an ohmic control receiving the same input power, was used to confirm over-unity performance (Swartz 2006).

This portion of our SSEG investigations into generating electricity centered on qualifying several heat-to-energy conversion systems, such as thermoelectric converters and fuel cells. At the present time, all of the heat conversion technologies tested have had poor energy conversion efficiencies, generally in the range of 13-19%, with further significant limitations secondary to Carnot efficiency among other reasons. Although there have been reports of heat conversion efficiencies ~45%, we either have not been able to obtain the devices or their peak performance require temperatures exceeding our present peak; which have been limited for engineering reasons (<160 degree Centigrade). Generally, for the palladium heavy water LANR systems, the maximum temperatures are limited to 90 to 95 degrees Centigrade.

STAGE 3 - Attacking the physical limitations of Carnot efficiency, poor thermoelectric conversion efficiencies (we examined a variety of devices, during Phase 1 over the last decade and half), and the inherent difficulty of LANR, we have attempted to drive LANR devices into self-sustaining mode. This is the real goal of LANR - the self-sustaining generation of electricity. We focused on nickel and palladium high electrical impedance Phusor®-type [$Pd/D_2O/Pt$, $Pd/D_2O/Au$, $Ni/H_2O_{1-x},D_2O_x/Pt$, $Ni/H_2O_{1-x},D_2O_x/Au$] LANR devices. We have used several types, calibrated by ohmic controls, and time integration, to determine how close we could come to self-sustaining operation at this time, with these limited heat conversion systems. A typical system used a binary alloy palladium (heavy water) or nickel (light water) cathode opposite a platinum or gold anode - controlled at the optimal operating point, using a metamaterial design, in a high impedance system. Such a Pd Phusor®-type LANR system was demonstrated at ICCF-10. Thereafter, we have built LANR systems to drive model electric cars, to heat a model home (Swartz 2009), and to generate electricity, as described here. In this group of experiments, we also used a single fuel cell to store the energy derived from the LANR heat to electricity conversion.

Actual feedback loops are complicated from a circuit point of view. To prepare the energy in the feedback loop from the LANR output back into the LANR input requires a considerable increase in voltage. In these systems, where the initial electrical output from the LANR system has an electrical potential of value from a fraction of volt to a volt or so, that electrical potential must be increased to several hundred to a thousand volts. That takes several circuits and proprietary systems which we have investigated for years to improve their efficiency. The present JET Energy LANR system with full electrical feedback for electrical self-sustaining behavior has more than two stages of voltage multipliers and additional components and circuit elements for maintaining the electrically-tapped LANR system.

Actual feedback loops are also complicated from a materials point of view. They have connections, leads, contact potentials, losses from measurement devices, and heat losses everywhere. We have examined them, including analysis of the heat loss (energy dissipation wasted) at various portions of the feedback control "arm" to examine the nature of possible limitations of the feedback in LANR for achieving a self sustaining electricity generator (SSEG). We then adapted some of the calorimetry (with ohmic controls) which was developed for examining the LANR system to determine the etiology of the energy losses in the feedback loop to create a self-sustaining electric source from LANR. Because of the importance of energy storage in the feedback loop, we also examined the Faradic losses of fuel cells during both cycles of energy storage and electricity (and water) regeneration.

The best, maximum total feedback energy deliverable through the feedback loop to the input of the LANR device achieved has been 23.6% $^{(+/-7.1\%)}$. We have found that the effective feedback power efficiency achieved was also a function of power input to the feedback loop: input power of 1 to 3 watts yielded 28% $^{(+/-5\%)}$, whereas input powers of 12 watts achieved only 17% $^{(+/-7\%)}$.

3.0 RESULTS - LANR Electrical Feedback – Total Dissipation Losses

Analysis of the Heat (Energy Dissipation and Loss) in the Feedback Control Arm

We analyzed the heat loss (energy dissipation wasted) at various portions of the feedback control arm in one specific experiment to examine that by distributed calorimetry. Figure 2 is a pie chart which shows the actually dissipative energy losses (heat, light, losses from gas generation and recombination). Only 18% of the energy which entered the feedback loop was found to be available for the useful input to drive a self sustaining electricity generating (SSEG) LANR system. Figure 2 shows the energy losses (dissipation) associated with fuel cell energy storage, fuel cell energy recombination, and other energy (dissipative heat) losses within the feedback loop.

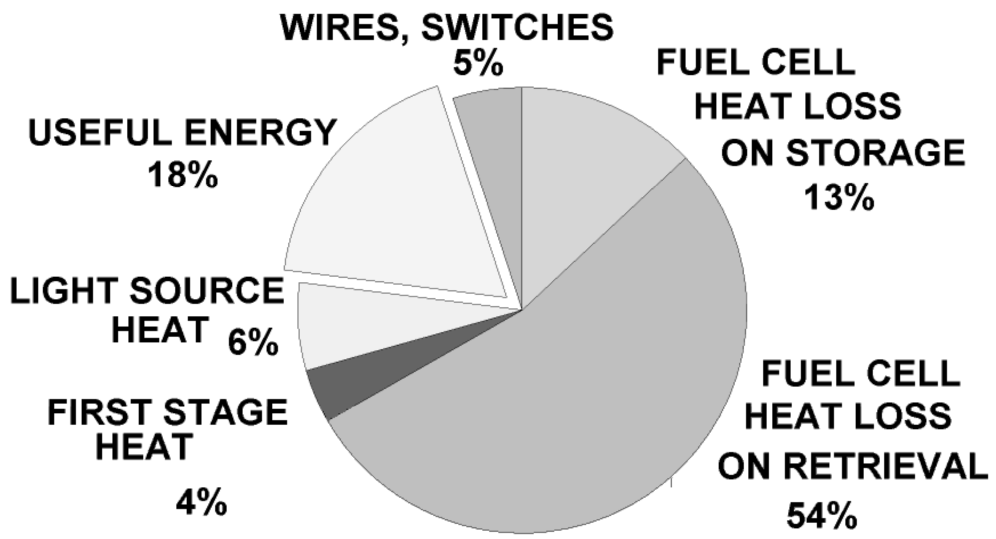

Figure 2 - Losses in the Feedback Loop of the JET Energy Self-sustaining LANR Electricity System

As Figure 2 shows, only a small fraction of the energy which enters the feedback loop actually ends up being available at the end of the feedback loop, where it should have been available for the input to the LANR device. The energetic (heat dissipation) losses in the circuits used to reconstruct input to the LANR, based upon regional on-board calorimetry, can be split into two portions in this multistage system. The first stage had a dissipation of 4%, consistent with the data sheet of one the circuit components. The second stage energy (heat dissipation loss) was several times greater [circa 15%].

3.1 RESULTS - LANR Electrical Feedback - Dissipation in Fuel Cell

Analysis of the Heat (Energy Dissipation and Loss) in Fuel Cell Storage Systems

Storage of energy in the feedback loop had the most major losses. The largest loss of energy within the feedback loop was, surprisingly, due to the fuel cell. The heat loss (energy dissipation) in the fuel cell, based on the calorimetry, was split into two portions. The first heat loss resulted from the generation of diatomic hydrogen and oxygen for energy storage. The second heat loss resulted from the recombination of diatomic hydrogen and diatomic oxygen, which were in storage, to make electricity. In the earliest group of experiments, we examined the Faradic losses of fuel cells during both cycles of energy storage and electricity (and water) regeneration.

By 2003, we found these Faradic losses in the fuel cell portion of the LANR circuit were as great as 20.3% $^{(+/-3.4\%)}$) and 69.8% $^{(+/-4.9\%)}$ of the total energy consumed in the feedback loop. In more recent (and more efficient) feedback experiments, these Faradic energy (heat dissipation) losses in the fuel cell, based on the calorimetry, were still 13% and 54% of the energy into the feedback loop, respectively. Both are formidable --and very wasteful-- losses of energy.

4.0 Implication for LANR Electricity Generation

There are many important points of these studies regarding the generation of electricity by LANR. They relate to the circuits used, and the issue of using a fuel cell within the feed back loop. First, the most important point is that the ultimate energy available for feedback in a LANR system may be on the order of only 18%. The estimates of required LANR amplification (Swartz 2002b) have been corroborated.

Second, a fuel cell is wasteful in the feedback loop. This is an incredible waste of energy. Surprisingly, of the energy losses in a fuel cell in a feedback loop, that from regenerating the water is about 3 to 4 times greater than the loss from generating the gases (for storage) in the first place. Despite the hype generally of the great efficiency of fuel cells for energy storage and conversion, their practical use is limited by their energetic and Faradic losses. The energy and Faradic efficiencies of dual-cycled fuel cells in LANR systems (storage and subsequent release) are so low as to make energy loss (dissipation) in hydrogen storage simply too lossy for any practical use. Improved materials, techniques, or shorter storage or LANR runs, would make this less, but probably not by much. The fuel cell wastage in storage, electrolysis and then recombination for electricity, is an incredible waste of useful energy. It is fortunate that there are better means of storing energy on the horizon, such as nanocapacitors.

The R&D in self-sustaining electrical generation (SSEG) continues toward increasing LANR power gain, excess energy densities, and energy conversion efficiencies and to minimizing losses in the feedback loop. At the present time, the ultimate efficiency of actual power available to drive an LANR device in a feedback loop is less than one, and will be even smaller if a fuel cell energy storage system is employed.

Acknowledgments

The author thanks Gayle Verner for her meticulous help in manuscript and idea development, and Jeffrey Tolleson, Alex Frank, Charles Entenmann, Hal Fox, Michael Beigel, Isidor Straus, Ray Kurzweil, Aaron Kleiner, Larry Forsley, Pamela Mosier-Boss, George Miley, Scott Chubb, and Peter Hagelstein for their helpful conversations and encouragement, along with JET Energy and New Energy Foundation for their additional support. PHUSOR® is a registered trademark of JET Energy, Incorporated. Hyperdrive™ and PHUSOR®-technology are protected by U.S. Patents D596724, D413659 and U.S. Patents pending.

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