LENR - what we must do to complete Martin Fleischmann's undertaking.

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Preface

❖Background:

- ➢ I have studied CF/LENR/CMNS for > 28 years
- ➢ and the deuterium palladium system for nearly 38 years

❖ Confidence:

- ➢ Effect 100 – 1000 times > sum of all possible chemical reactions
- ➢Normalized to Pd (or D/Pd) we measure 10^2 – 10^4 eV/atom
- ➢Without a working example certainty is approached asymptotically
- ➢>10,000 hours spent with my own hands in the company of extremely able individuals in my own laboratory
- ➢Systems as simple as they can be made:
  - to understand the basis of the effects hypothesized and observed by Fleischmann and Pons
  - and their extrapolated consequences.
- ➢ The results of this personal effort is reinforced by the works of numerous others:
  - – many in the audience whose skills I have come to trust
  - – results form a consistent, if not complete, pattern of understanding.

The order of my confidence in the various experimental claims:

1. Tritium (and helium-3)
2. Excess heat at levels consistent with nuclear but not chemical processes.
3. Production of helium-4 in low energy environments at levels consistent with the measured excess heat.
4. Additional range of condensed matter nuclear effects that are inconsistent with pairwise, isolated nuclear reaction.

Disclaimer

- I speak for myself alone.
- Anyone expecting me to answer the question implied in the title of this talk: *"what must we do to complete Martin Fleischmann's undertaking?"*
- May be disappointed – perhaps doubly so:
  - I don't have a clear answer for myself that can sweep all entrenched opposition aside
  - Even if I had "the secret" I would very likely not be permitted to share this knowledge publicly, or perhaps at all with any except the people who paid for my labour and contributed intellectual inputs.

SRI group has made several major contributions to the Fleischmann-Pons Heat Effect (FPHE) [1-5]:

- Postulate and demonstrate the importance of D/Pd loading in achieving the Fleischmann-Pons heat effect.
- Demonstrate and calibrate the utility and applicability of resistance ratio methods to measure D/Pd loading.
- Confirm the importance of loading and demonstrate a critical threshold of loading in producing the Fleischmann-Pons heat effect (jointly with Kunimatsu *et al* at IMRA-Japan).
- Confirm the existence of an initiation time delay in the Fleischmann-Pons heat effect (with F-P and Bockris).
- Confirm the Miles-Bush correlation of excess heat and helium production (in the Fleischmann-Pons electrochemical, Arata-Zhang double-structured cathode and Case gas loading experiments).

SRI group has made several major contributions to the Fleischmann-Pons Heat Effect (FPHE) [6-10]:

- Demonstrate the critical importance of deuterium interfacial flux in the Fleischmann-Pons heat effect (hypothesized by Hagelstein).
- With ENEA (Frascati) demonstrate the importance of metallurgical structure in achieving high D/Pd loading and surface morphology in producing the FPHE.
- With Energetics (New Jersey, USA and Omer, Israel) demonstrate the critical beneficial effects of superwave modulated electrochemical stimulus in achieving high D/Pd loading, high deuterium interfacial flux and large power and energy gains in the FPHE (hypothesized by Dardik).
- Explored high gain systems with ETI
- Exploding wire studies.

With all this "know how" what do we need to do to make progress?

"*Theory will save us*"

- Not without better experimental understanding
- Not the "normal path" of invention/innovation/product
- Subverted by the thinking and concepts of hot fusion
- Something we know "*just aint so*"

One of two things must be done

– probably and preferably both:

1. Unmistakable and irrefutable scientific proof must be provided that nuclear effects take place in condensed matter by mechanisms different from reactions in free space.
2. Demonstration must be made of a practical use of the energy so created.

Why is this so hard? Why is the bar set so high?

- Scientific proof without practical reality has not worked to convince the world of the reality/importance of "cold fusion" – the case of tritium.

- Our approach to replication has been poor. *"If the claim is made that replication is crucial to the development of our field to determine the parameters for advancement, to prove reality to critics, or to uncover systematic error, then it is astonishing that attempts to replicate the FPE have been so few, and methodologically so limited … this lack of attention to detail … is precisely the reason that the question of replicability remains on the table".*

- Our publication record does not allow easy or adequate rebuttal.

We need help.

- The “missing generation” problem.
- John Huizenga: *"It is seldom, if ever, true that it is advantageous in science to move into a new discipline without a thorough foundation in the basics of that field.”*
- The discipline of the Fleischmann Pons Heat Effect is Physical Electrochemistry and the most pertinent diagnostic tool to study heat effects is Calorimetry.
- What must we do to bring the right disciplines and skill sets to bear on the problem?
- Who do we engage to fund this?

Strategy.

- The talisman that we create for the purpose of compelling conviction must work on two levels:

1. It must be sufficiently simple and obvious that no hidden error can possibly exist to negate the result.
2. The energy produced must be sufficiently net positive that useful work can be made of it.

- We need:
  - something simple that makes power and thus energy
  - preferably in electrical form that is easily measured and
  - can be used to provide the conditions needed for control and self sustainment.

Demonstration prototype.

- Does not need to be practical, elegant, cheap or safe.
- Must be “somewhat reliable” determined by the patience of the reviewers, and
- May have no more to do with ultimate engineering practice than a shared underlying mechanism of power production.
- Purpose is to demonstrate that the effect is real and of sufficient scale potential to contribute to solution of man’s coming energy deficit.
- Engineers may use the demonstration prototype (in second generation form) to explore the parameters of control and scale-up.

Candidate constraints.

- What technology?
- What size?
- What performance characteristics?
- Our object is to make this as easy as possible for ourselves (at this stage).
- Everyone will have a personal choice based on individual experience, training, bias.
- At this stage I would like simply to describe the terrain and see if by discussion and sharing of experience and analysis we can arrive at high probability choices.

Some systems with which I am familiar.

- Two major choices and one hybrid.

1. Electrochemical PdD/LiOD at elevated temperature.
2. Metal-hydrogen gas systems at elevated temperature.
3. Metal-gas modulated plasma at elevated temperature.

1. Electrochemical PdD/LiOD.

- The progenitors of this avenue are:
  - Fleischmann and Pons,
  - F&P/Lonchampt/Biberian (elevated T)
  - Dardik/Energetics (superwave stimulus)

- Best example of success is Energetics ETI-64
  - >30W thermal output with $I_{EChem.} * V_{EChem.} < 1W$
  - integrated energy output of 1.14 MJ
  - integral energy input of 40 kJ over a 14 h period.
  - This cell boiled the coolant (H_2O at ~1 Atm.) twice (once during the 14 excursion and then again with greater energy output)
  - Not completely replicated.

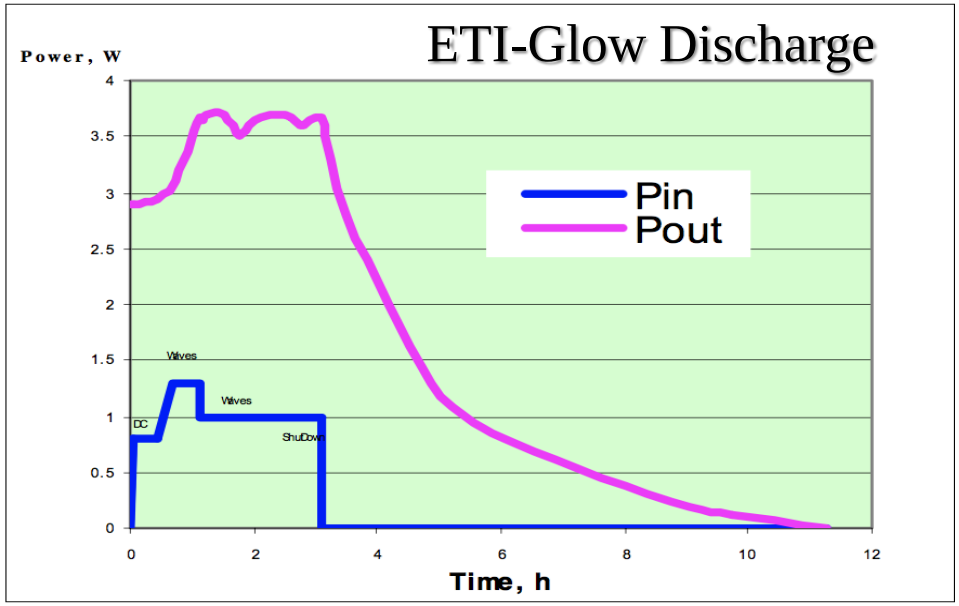
2. Metal-hydrogen gas systems.

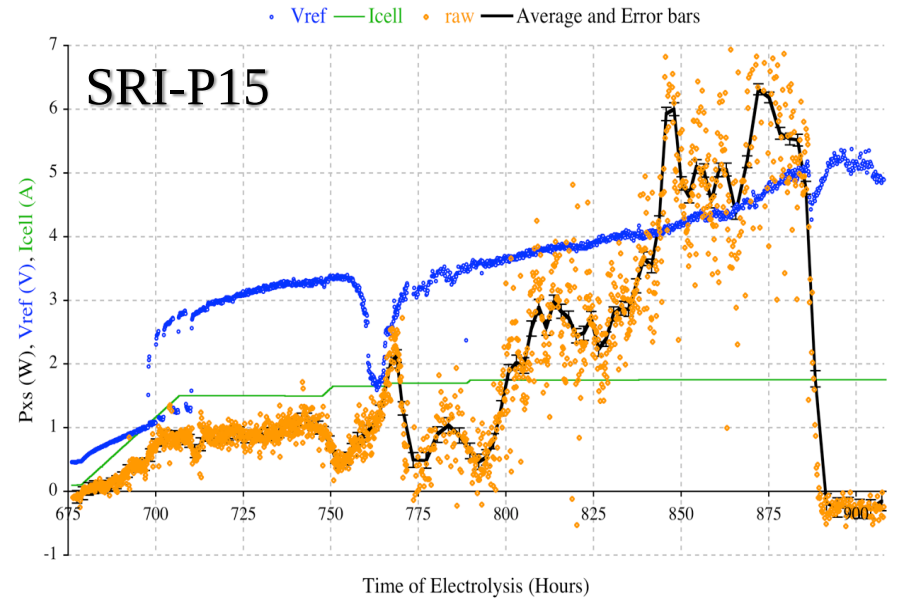
- The metal, typically in small dimension form, can be Pd, Ni, some alloy or coating of Pd on Ni, or other metal having the capacity for high hydrogen permeability.
- Gas is an isotope of hydrogen: P, D or T– or mixture.
- Some observers suggest that protium "works" with nickel, not palladium, and that deuterium is effective with palladium and not nickel.
- Ni-H gas systems
  - less experimentation than Pd-D
  - findings are more controversial
- If shown to be valid the claims are certainly satisfactory:
  - power generation of hundreds of kW
  - temperatures above 500 C,
  - sustained for meaningful periods without input power.

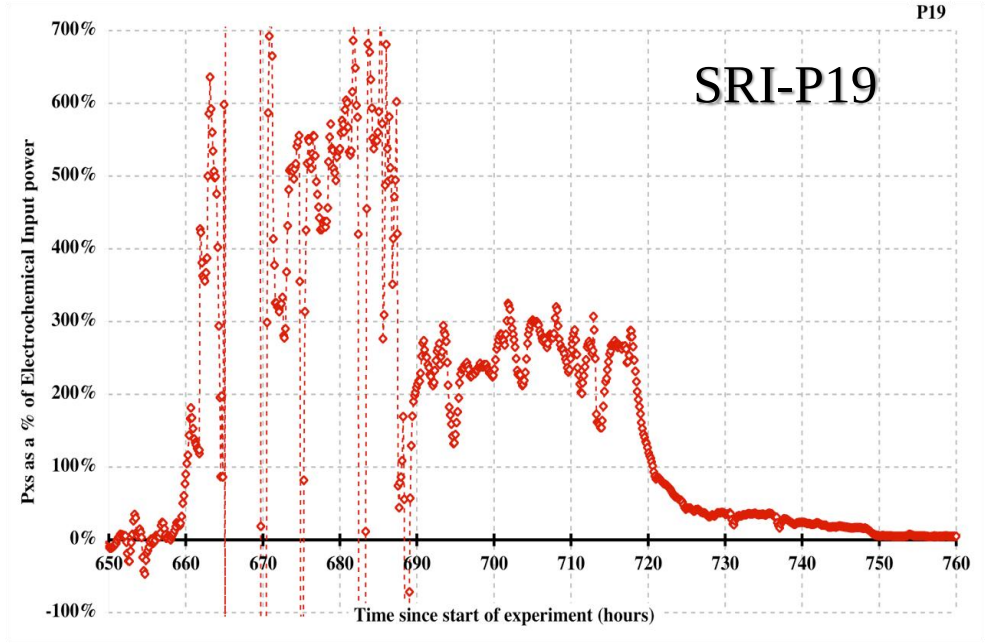
3. Metal-gas modulated plasma – Glow Discharge.

- Incorporates the advantages of electrochemistry (high chemical potential, high fluxes) and gas systems (low thermal mass and inventory of impurities).
- Arik El-Boher presented at ICCF10 what was then and remains today one of the most exciting discoveries in Pd-D heat studies:
  - Superwave modulated glow discharge between thoriated tungsten and a thin palladium coating in < 1Atm. D_2.
  - produced boiling water with a power gain of 3.88
  - energy gain of 6.72 (HAD) over a period of 10 hours.
  - T_{Plasma} high (unmeasured)
  - one can easily conceive of a demonstration prototype
  - experiment has not been replicated to my knowledge.

Electrochemical and Glow Discharge examples.







Size of demonstration prototype.

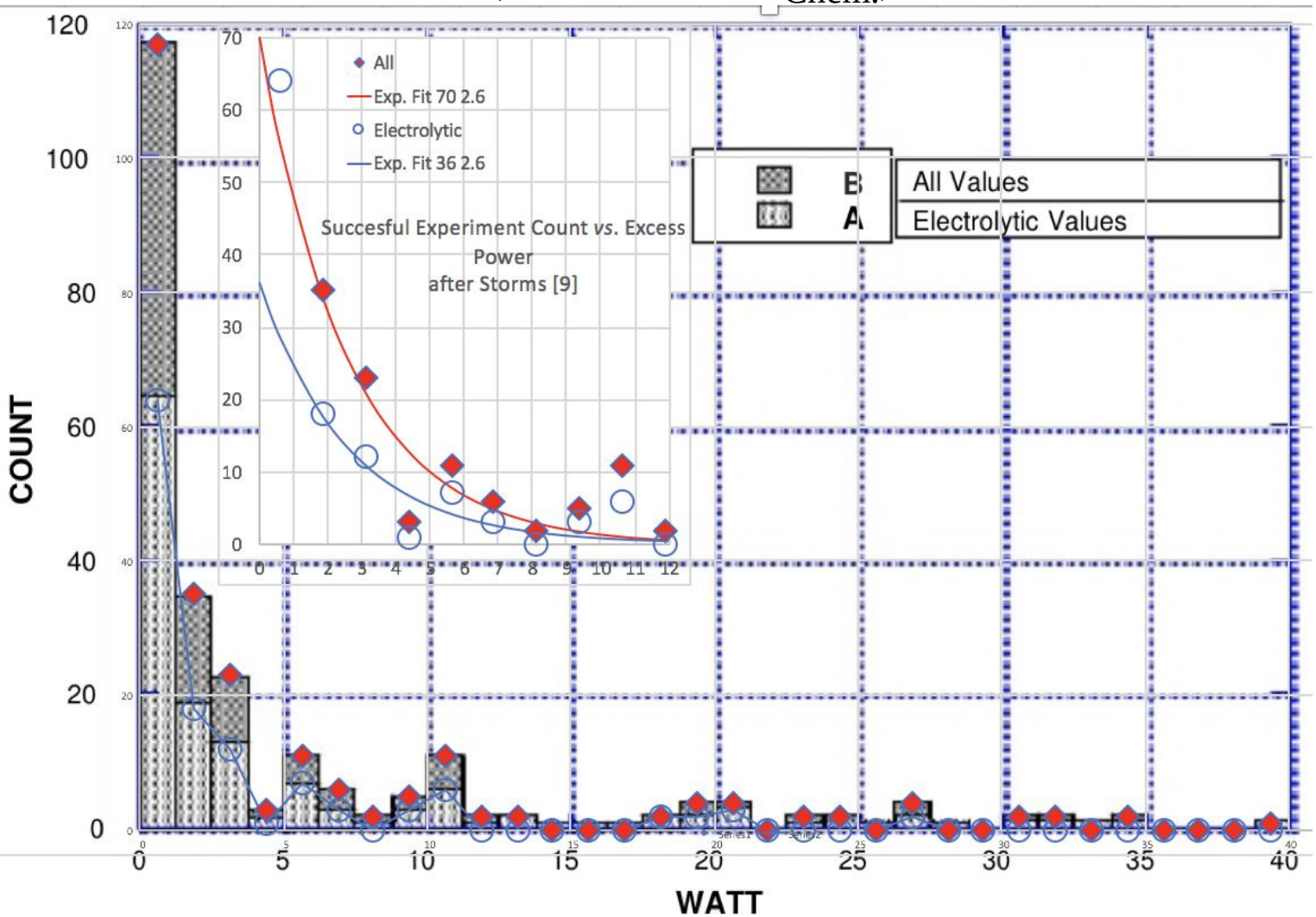
- Size. On what scale do we need to operate to convince our selected audience?
- What would it take to convince you or someone else of importance that a device is converting nuclear energy to thermal or electrical?
  - knowing nothing about CF, LENR or CMNS
  - having attended none of our conferences
  - or read (or understood) any papers on this topic
- Must observe and interrogate the demonstration object and its power production for periods sufficiently long to rule out all conceivable potential chemical or mechanical energy storage process (smaller is better).

What we have done so far has not compelled the acceptance of the FPHE – what is the problem?

- We have observed few energetic nuclear products:
  - that is good but…
  - hard to prove a nuclear effect without energetic products
- Calorimetry is an "ancient tool":
  - little taught, used, understood or respected
  - considered (by some) to be intrinsically inaccurate
- Heat is ephemeral:
  - it leaves little evidence behind (melting, phase changes)
  - need to trust the instruments and understand the numbers
- The effect is often "small"
  - relative to P_{In} and E_{In}
  - and absolute
- Important decisions are made by non-experts.

How much heat is needed to convince a non-expert?

- To be real you must be able to see it or feel it.
  - 1 W too small
  - 100 W too hard (at least for $E_{Chem.}$)



Storms Book 1
Count of heat success 1989-2006:

242 (123 EC)

<1.25 W

117 (64)

>1.25-2.5 W

35 (18)

10±1.25 W

16 (9)

>10 W

40(15=12%)

>40 W

0 (0)

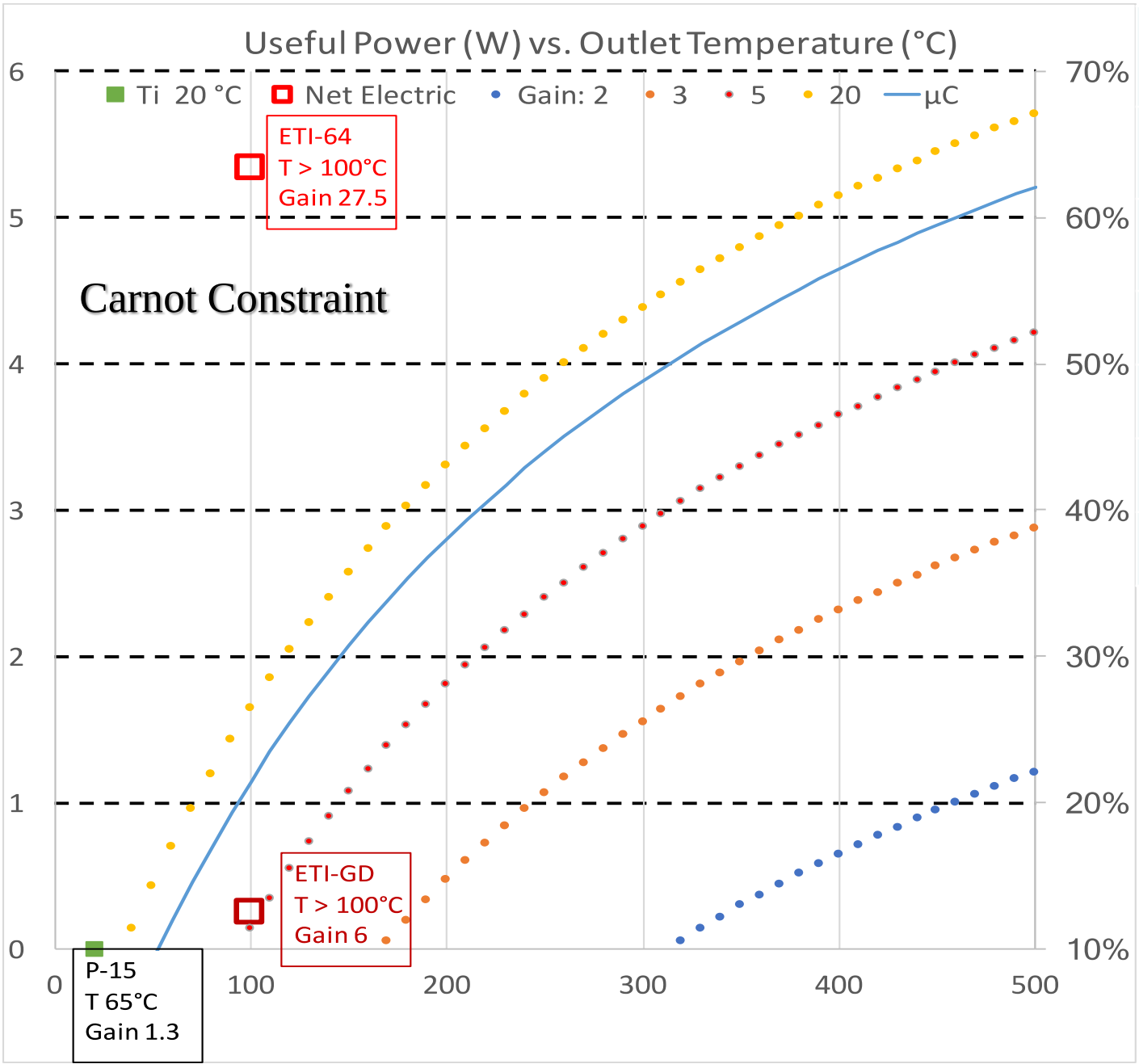
We also need to do something useful with the heat.

- If we accept 10-40 W as a "modestly robust" level of excess heat production for our demonstration prototype then this should plausibly be achievable

- Our demonstration object is required to do more than "*feel warm*"…

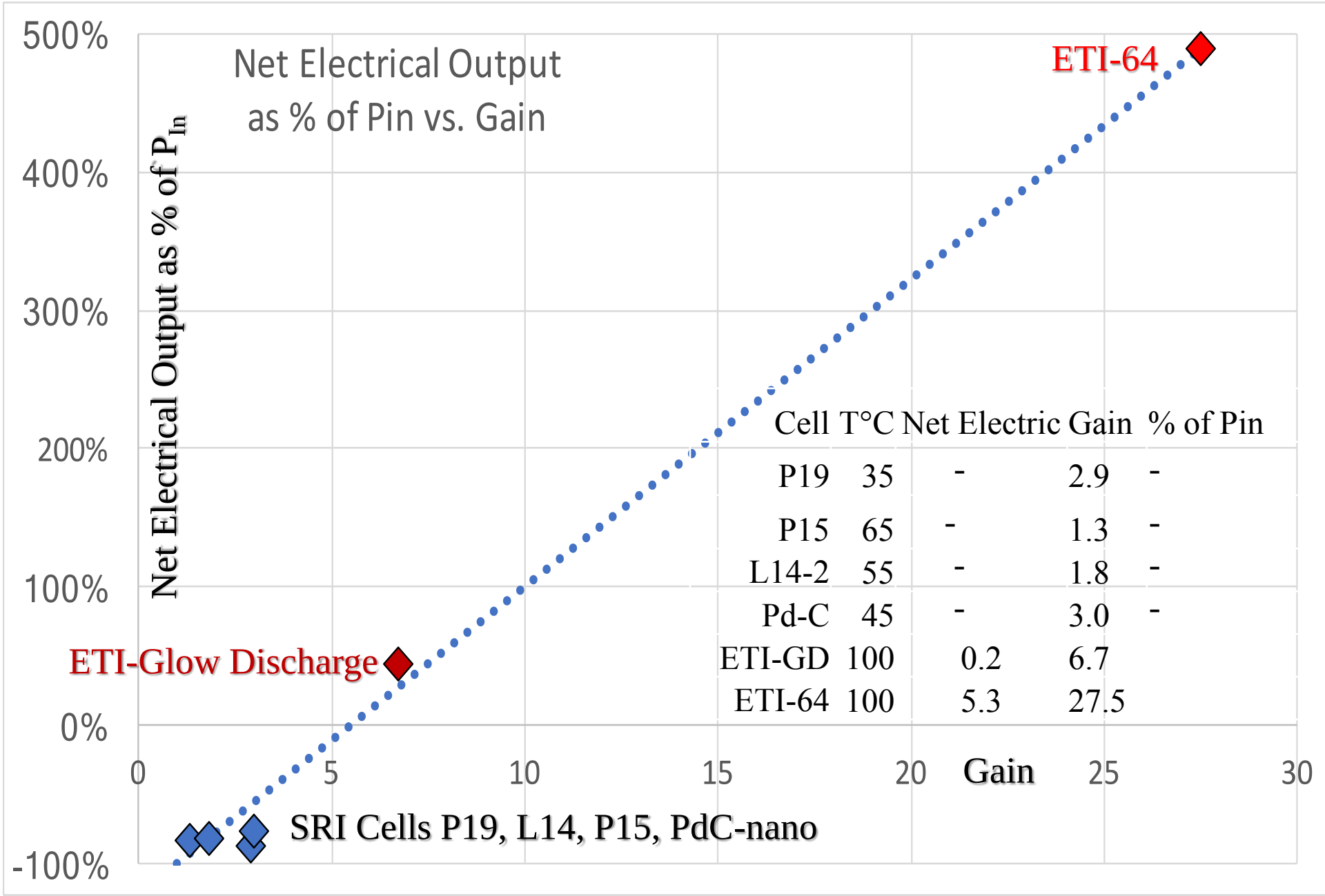
- We require it to generate sufficient electricity to self sustain for which we require energy gain and significantly elevated operating temperature to offset the strictures of Carnot.

Carnot limitations



Cell	T° C	W Net Electric	Gain
P19	35	-	2.9
P15	65	-	1.3
L14-2	55	-	1.8
Pd-C	45	-	3.0
ETI-GD	100	0.2	6.7
ETI-64	100	5.3	27.5

Gain is the key. The key to gain is reduced P_{In}.



Conclusions

- "Loading" (chemical potential) is important - flux is critical
- Theory alone will not allow us to achieve our goal
- Must prove that that novel nuclear effects take place in condensed matter and create net energy
- Demonstration must be made of a practical use of this energy
- We need the help of working scientists
- Require a Demonstration Prototype
- Operating Temperature is important but high gain is crucial to accomplish our goal
- Gain is more easily affected in the denominator than the numerator
- Our goal is to create the heat effect at low input power
- Irv Dardik is right!

Grateful acknowledgment to my esteemed colleagues…

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