Cleantech.org Webinar Series

NEW NEW ENERGY

September 20, 2012

Dr. Edward Beardsworth

Why we are here

- Current energy sources all have drawbacks and limitations:
  (fossil, solar, geothermal, nuclear, biomass, wind, oceans)
- We're always looking for something new & better.
- We need and want (new) sources (aka "holy grails") which are:

  1. Cheap, 2. Clean and 3. Inexhaustible.

- Today -- an overview of what's being looked at for:

  NEW NEW Sources of Energy

Outline

NEW NEW ENERGY

I. Breakthroughs -- ”Accepted Science”

II. Breakthroughs -- "Not Accepted Science”
-- The fun stuff

Goal 1: Greater awareness of the range of stuff being worked on.
Goal 2: Provide a deeper understanding of underlying science.

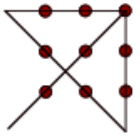
The Presenter's Background

Dr. Edward Beardsworth Energy Technology Advisors

PhD in Physics from Rutgers University

Brookhaven National Lab -- interdisciplinary analyses of energy systems during the first energy crisis of the 1970s.

Electric Power Research Institute (EPRI)



Jane Capital Partners LLC,

Advisor to Nth Power, Garage Technology Ventures, the Cleantech Group, Cleantech Open, and many startups.

UFTO program, providing technology scouting to 30 of the top utility R&D and corporate venture arms.

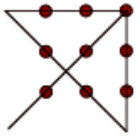
Technical Director, **The Hub Lab**, a stealth R&D program funding revolutionary energy technologies.

The Presenter's Background

The Hub Lab

a stealth grant program funding R&D in *revolutionary* energy technologies.

- Two years of operation 2008-2010
- 7 small grants (the "Patron" model)
- Specific (and restrictive) criteria:
  - Primary energy sources
  - New Science, not incremental.
  - "Scientific method" / "rigor" / "people"
  - Non-establishment actors more than welcome



Grants made:

- Anomalies in Energetics of a Magnetostrictive Alloy (2nd Law)
- Semiconductor MEMS device (2nd Law)
- Non-Semiconductor PV (2 projects...both raised further funds)
- Fluid Dynamics without Numerical Simulation

Successful. And so many more opportunities we wanted to pursue.

Energy Now

We need energy which is:

1. Cheap, 2. Clean*, 3. Inexhaustible.

(*i.e., externalities really actually dealt with)

-- Nothing we have now hits all three.
(fossil, solar, geothermal, nuclear, biomass, wind, oceans)

-- For starters, we'd settle for Cheap and Clean

-- With hard work, good luck, resources, and *time*, we may get closer with one or more of our current sources.
[and R&D, science & technology, engineering, money...]

Energy Now

Not Today's Topic:

Improvements for existing sources.

(e.g. clean(er) fossil, 4th gen PV, wind, wave, fuel cells, etc.)

Today's Topic:

New Energy Sources that could be a big deal:

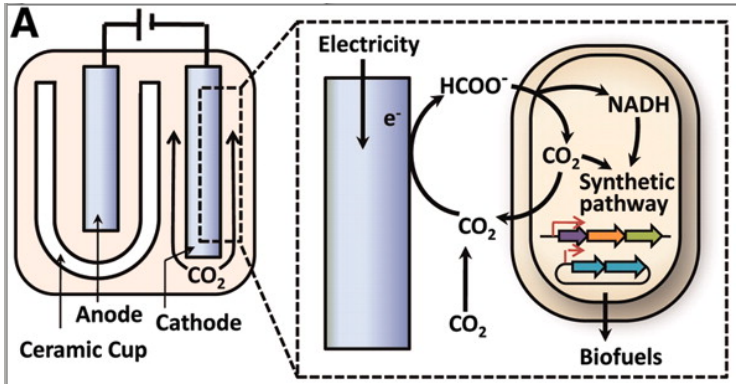
First, In the realm of "Accepted Science",

- "Electro Fuels" (briefly - otherwise not tackling biology)
- New Nuclear Fission (most of it isn't really new)
- Nuclear Fusion

Accepted Science ... ElectroFuels

Microbial Electrosynthesis

Electricity is fed **to** Microorganisms which uses CO2 to produce useful chemicals, including liquid fuels.



NOT same as Microbial fuel cell,
NOT same as Microbial electrolysis

BYPASSES photosynthesis.
No Sunlight required.
No growing plant biomass required.
10 X more energy efficient

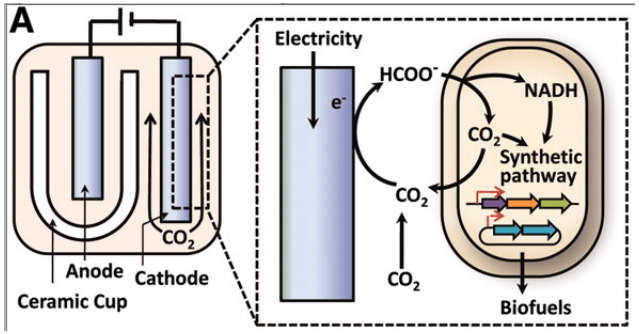
Accepted Science ... ElectroFuels

Microbial Electrosynthesis

Not a “primary” energy source. (consumes electricity)

A “conversion” capability, with immense potential,

A solution for CO2 !



ARPA-E $44M funding
A dozen projects underway at labs, universities and private companies

http://arpa-e.energy.gov/ProgramsProjects/Electrofuels.asp

Accepted Science ... Nuclear

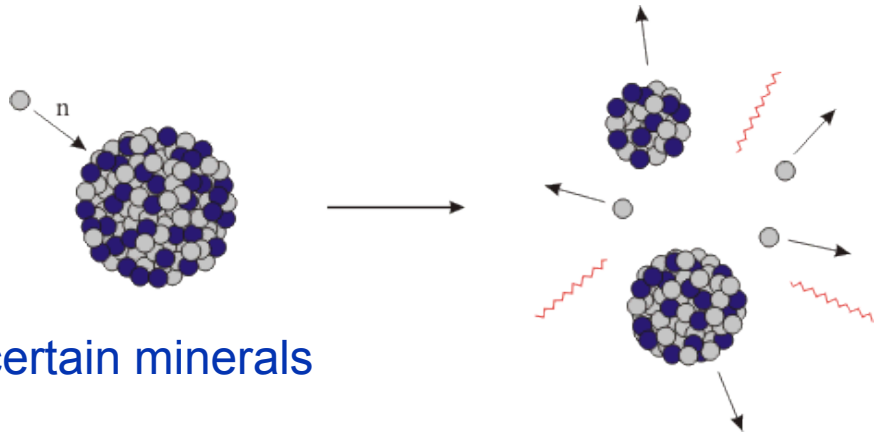
New Nuclear Fission -- a quick survey:
-- alternative reactor concepts and fuel cycles.
-- small modular reactors (SMR)

Fusion
-- Mainstream R&D programs with huge devices (ITER, NIF)
-- Alternate approaches - smaller systems may have a chance
-- some are venture backed
-- Aneutronic uses different "fuels".
-- much less radiation, but much harder to do (higher energy)

Nuclear Fission

What is Fission?

.... atoms splitting apart, making other atoms, and releasing energy



Radioactivity naturally occurring
-- mysterious emanations from certain minerals
-- transmutation of elements

Stimulated radioactivity
-- triggering emission

Chain reaction—self sustaining

.....and, by the way, $E = M C^2$
-- converting mass into energy

After that, nuclear power (and the bomb) was “just engineering”.

Nuclear Fission

Historical choice of LWRs was largely dictated by politics and policy
-- Rickover, atomic submarines
-- Make plutonium for bombs

"It was a **VHS** victory over several superior **BetaMax** alternatives"

Many alternatives that were thought of -- and tried –
in the '50s and '60s are getting a second look.

Nuclear Fission

happily borrowing from:

KACHAN
& Co.

Emerging Nuclear Innovations

Picking global winners in a race to reinvent nuclear energy
A report by Kachan & Co., 64 pages, Nov. 2011.

Which companies & technologies stand a chance to re-invigorate nuclear power?

- Improvements in conventional light water reactors (LWRs -- BWRs and PWRs),
- Thorium as a fuel, in molten salt and solid fuel reactors,
- Molten salt reactors,
- Fast neutron reactors,
- Pebble bed reactors,
- Modular reactors,
- and Fusion, neutronic and aneutronic

Special discount code for webinar participants:

http://www.kachan.com/research/emerging-nuclear-innovations-report
X98GH7P1 -- expires Oct 31. $495 to webinar attendees, from $1295

Nuclear Fission

Improvements in conventional light water reactors
(LWRs -- BWRs and PWRs),

The major incumbent suppliers of conventional systems have developed Gen III designs:

- Areva (PWR)
- Westinghouse Electric Co. (PWR)
- GE Hitachi Nuclear Energy (ABWR)

The main challenge... loss of coolant accidents

The main response... passive cooling systems
Not much else is changed, and
All the other issues remain, especially the fuel cycle.

Still a long way from Cheap and Clean, but it is big, and no-carbon.

Nuclear Fission

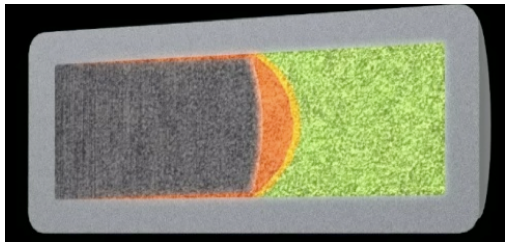
TERRAPOWER

Fast Neutron Reactor (FNR) -- not a Fast Breeder (FBR)

Uses spent fuel, i.e., depleted uranium (from LWRs)
- Can also run on thorium

"Travelling Wave" concept dating to 1950's "breeding its own fuel"
- Long slow burning process avoids refueling, enrichment and reprocessing

2030 at the earliest



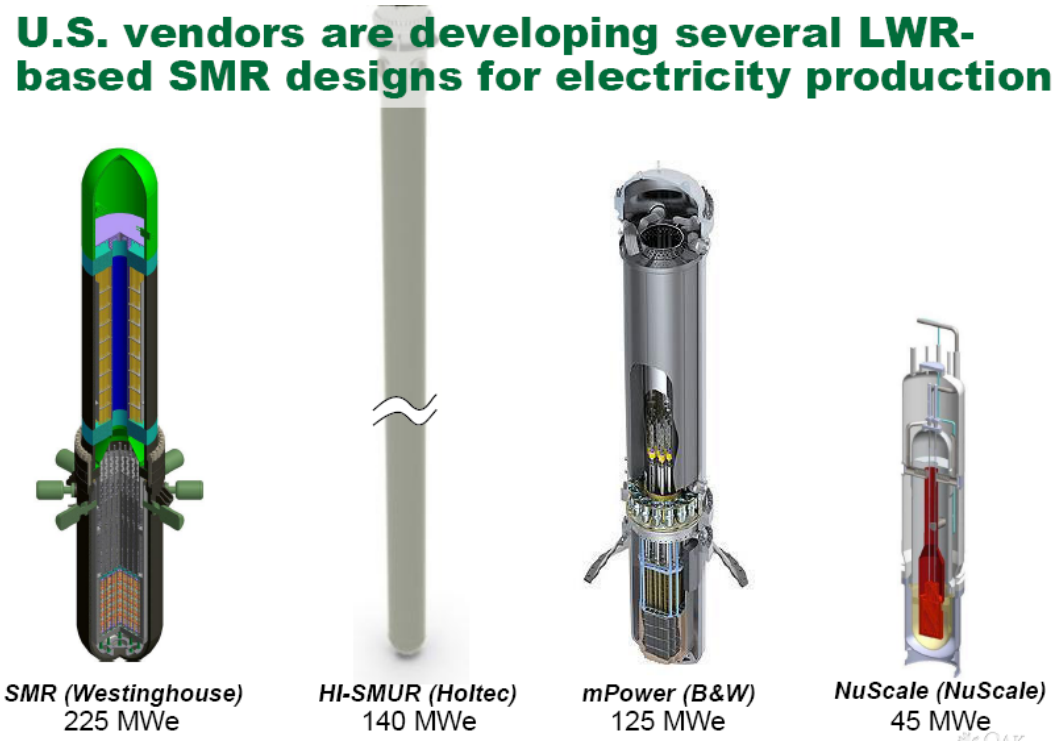
Bill Gates, Khosla Ventures, Charles River Ventures,
also Los Alamos Nat'l Lab, and Reliance Industries

www.terrapower.com

Nuclear Fission

Modular Reactors, aka Small Modular Reactors (SMR)

- Strong interest around the world
- Lower capital cost – total and unit (vs. dis-economies of scale)
- Manufactured in a factory, some are sealed units; to be buried underground
- Very diverse technologies
- Diverse applications (off grid, heat only)



Nuclear Fission

Small Modular Reactors (SMR)

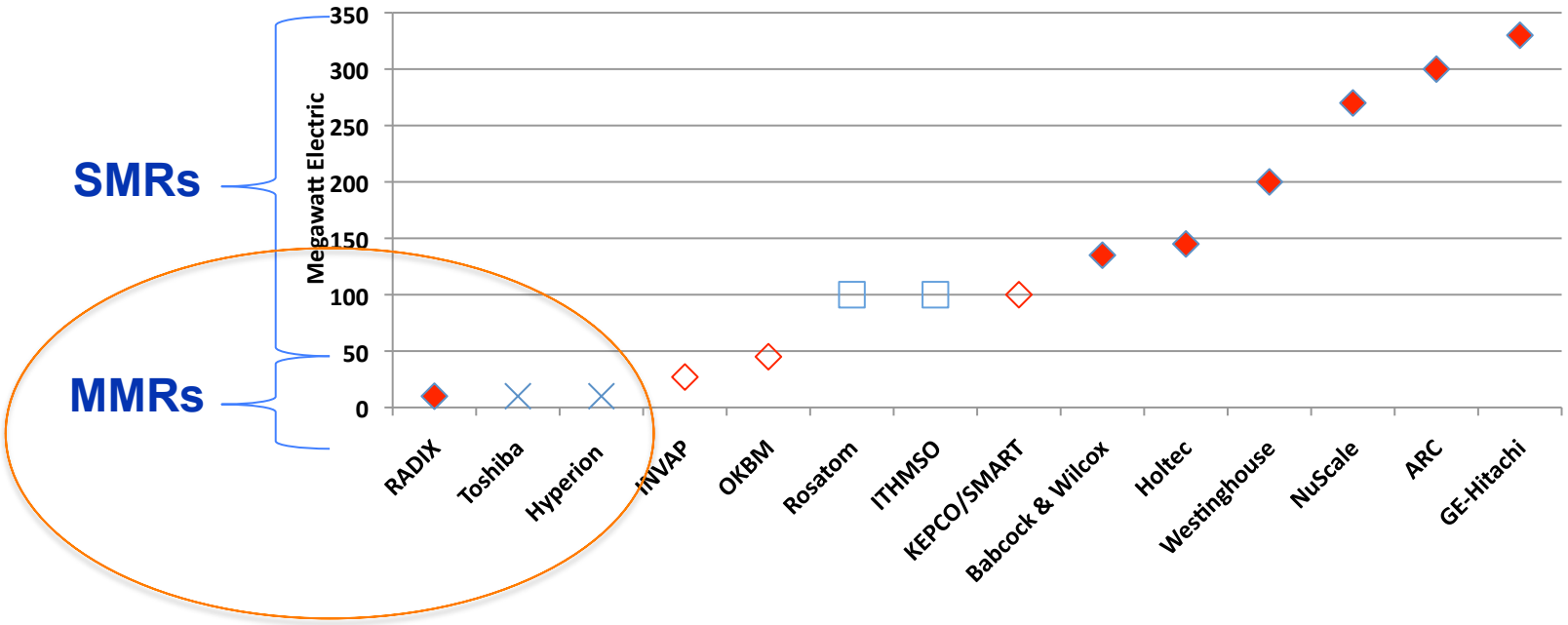
Medium and Small (25 MWe up) reactors with development well advanced

Name	Capacity MWe	Type	Developer
KLT-40S	35	PWR	OKBM, Russia
VK-300	300	BWR	Atomenergoproekt, Russia
CAREM	27-100	PWR	CNEA & INVAP, Argentina
IRIS	100-335	PWR	Westinghouse-led, international
Westinghouse SMR	200	PWR	Westinghouse, USA
mPower	150-180	PWR	Babcock & Wilcox + Bechtel, USA
SMR-160	160	PWR	Holtec, USA
SMART	100	PWR	KAERI, South Korea
NuScale	45	PWR	NuScale Power + Fluor, USA
ACP100	100	PWR	CNNC & Guodian, China
HTR-PM	2x105	HTR	INET & Huaneng, China
EM2	240	HTR	General Atomics (USA)
SC-HTGR (Antares)	250	HTR	Areva
BREST	300	FNR	RDIPE, Russia
SVBR-100	100	FNR	AKME-engineering (Rosatom/En+), Russia
Gen4 module	25	FNR	Gen4 (Hyperion), USA
Prism	311	FNR	GE-Hitachi, USA
FUJI	100	MSR	ITHMSO, Japan-Russia-USA

http://www.world-nuclear.org/info/inf33.html

Nuclear Fission

-- Small Modular Reactors (SMR) & Micro Modular Reactors (MMR)

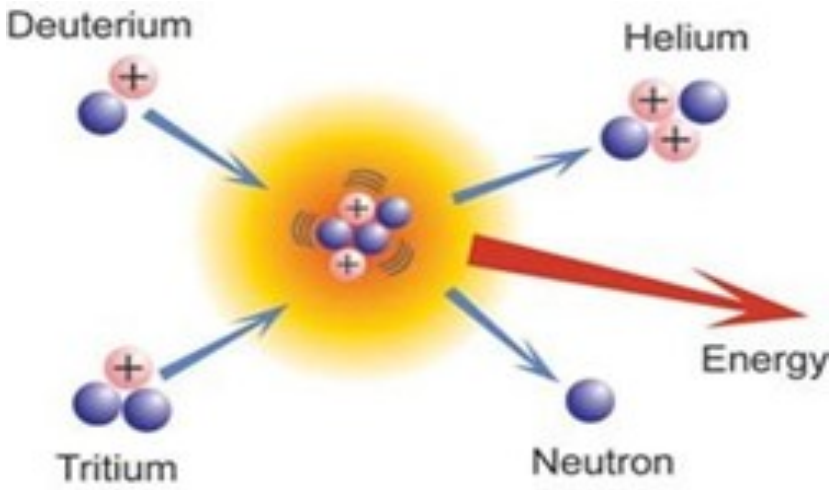


Not a complete answer, and will take a very long time.

Nuclear Fusion

What is Fusion?

Bring two (small) atoms together,
producing different atoms, plus energy. . Again, $E = M C^2$



-- Need to overcome electrostatic repulsion – the Coulomb Barrier.
-- Easy to do in small numbers, with an accelerator.
-- Very hard to do in large numbers required to produce power.
(confinement, temperature, density)

Nuclear Fusion

Three broad categories

-- Mainstream R&D programs with huge devices (ITER, NIF)

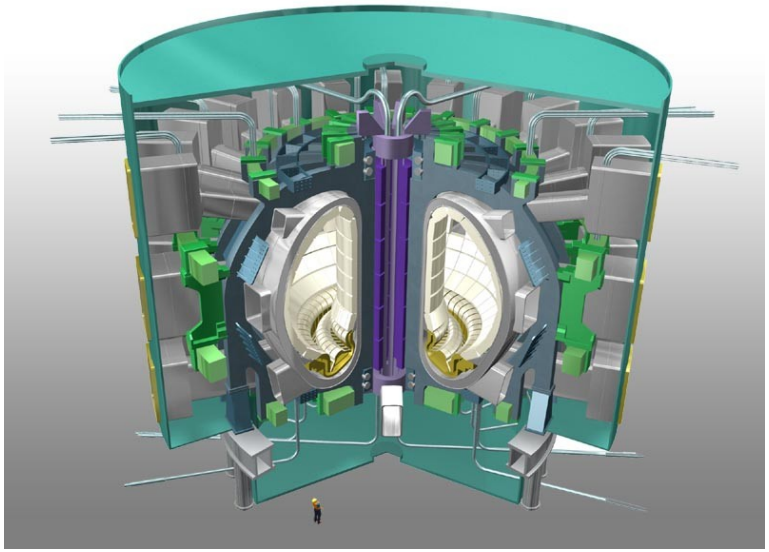
-- Alternate approaches - smaller systems may have a chance
    -- Some venture backed

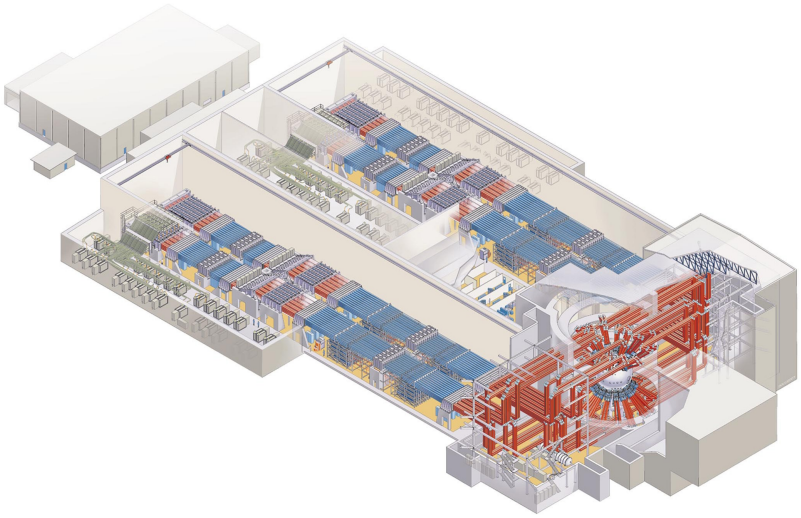
-- Aneutronic uses different "fuels".
    -- Much less radiation, but even harder to do

Nuclear Fusion

The Mainstream programs with huge devices -- unlikely to deliver, ever.

ITER
Int'l Thermonuclear
Experimental Reactor



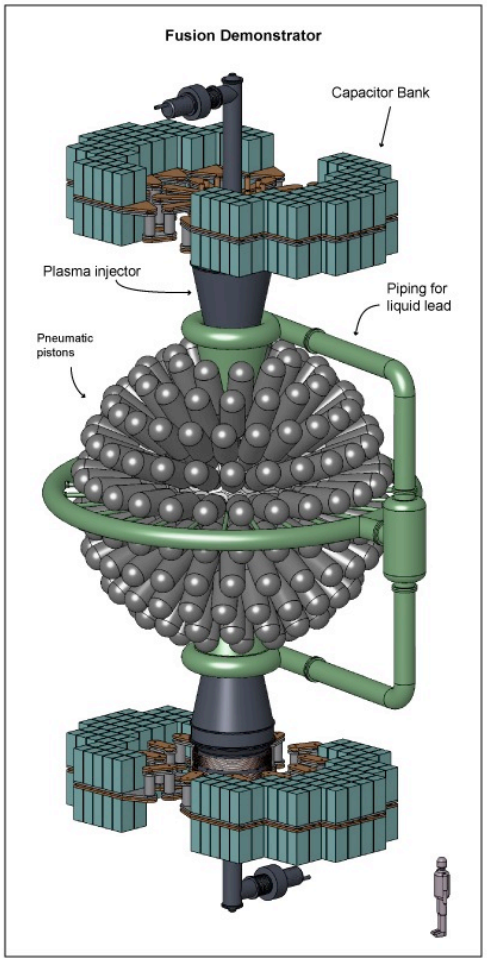


NIF
National Ignition Facility
Livermore National Lab

They don't have a path to ever become a commercial power plant.

Nuclear Fusion

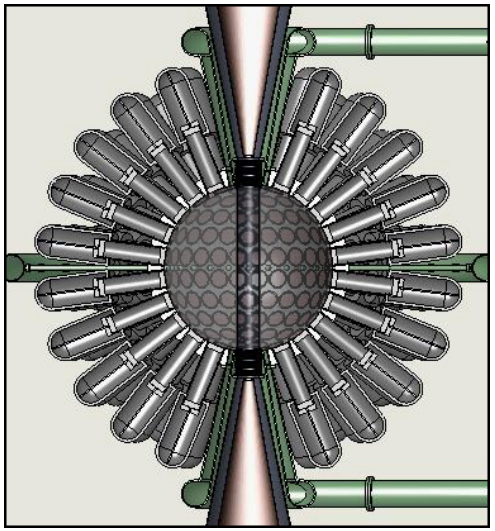
-- alternate smaller systems may have a chance
-- some are venture backed!



General Fusion

magnetized target

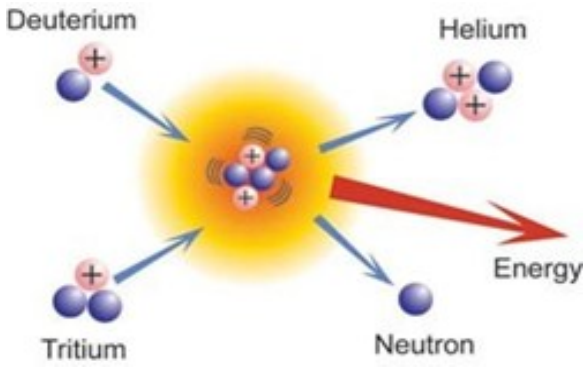
acoustically driven
uses physical rams that transmit shock waves to compress the material



VENTURE BACKED:
Cenovus Energy, Jeff Bezos, Chrysalix, GrowthWorks, Braemar, Entrepreneurs Fund, Business Development Bank of Canada (BDC), and SET Venture Partners.

www.generalfusion.com

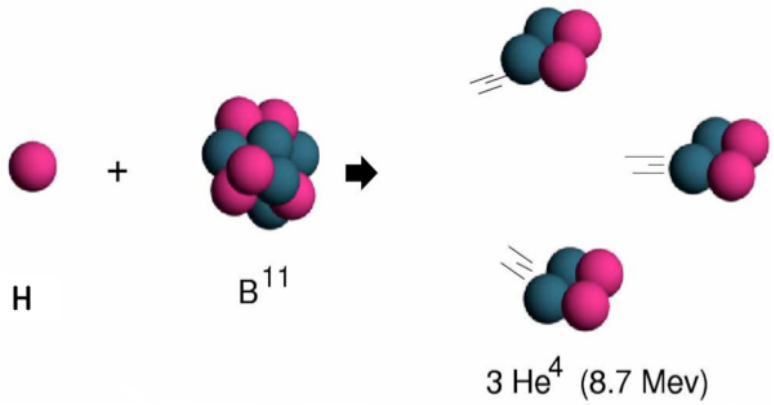
ANEUTRONIC Nuclear Fusion



D-T fusion: the problem of Neutrons.

ANEUTRONIC FUSION

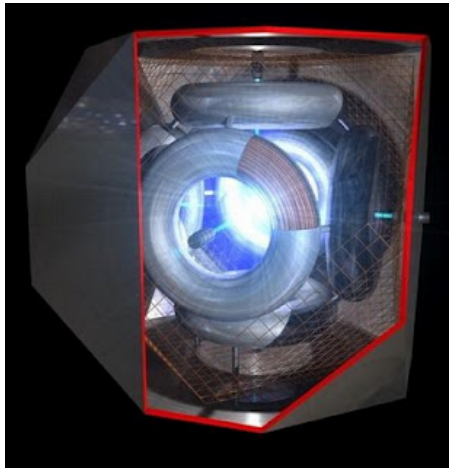
-- No Neutrons.
-- Uses different "fuels".
-- Much less radiation, but
-- Much harder to do.
(requires higher energy)



P + Boron → 3 alphas

ANEUTRONIC

Nuclear Fusion



EMC2 Fusion Development Corp (nonprofit)
"Polywell" "Wiffleball 1 through 8"
Inertial electrostatic confinement (IEC)
Robert Bussard (died 2007)
US Navy Funding

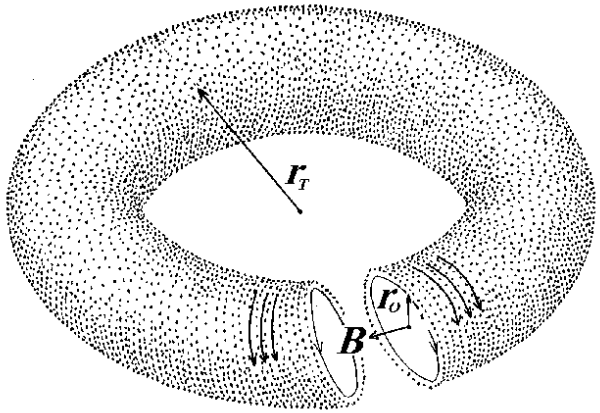
www.emc2fusion.org

FOCUS FUSION -- Lawrenceville Plasma Physics, Inc
"Dense Plasma Focus" -- As small as 5MW
JPL, Private investors, Abell Foundation

www.lawrencevilleplasmaphysics.com

ANEUTRONIC Nuclear Fusion

Electron Power Systems, Inc.



"Electron Spiral Toroid Spheromak"
... improves on a known colliding plasma toroid process

As small as 10 KW

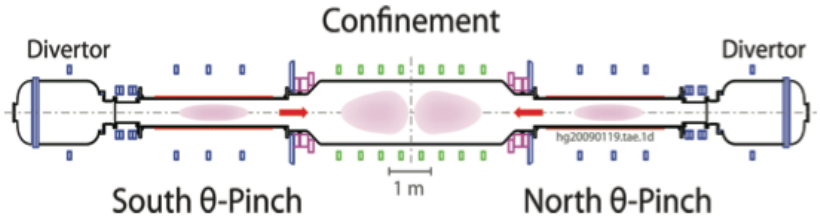
These small aneutronic programs are woefully underfunded.

ANEUTRONIC Nuclear Fusion

TRI ALPHA ENERGY Colliding Beam Fusion Reactor (CBFR), using Field Reversed Configuration (FRC)

1997 Leading fusion researchers at UC Irvine publishing openly,
Covered by NPR and The Economist.
2003 had formed the company, raised $4-5M, and gone a bit quiet.
2007 Raised $40M, and went super stealth.
(Venrock, Vulcan, Enel, Goldman Sachs)
2007 Patents began appearing.
2009 Big 2nd round $27M
2010 Big 3rd round $50M
2012 Major research papers published.

"The FRC could lead to an economic fusion reactor with high fusion power density, possibly using aneutronic fuels such as D-He3 and p-B11."



PHYSICS OF PLASMAS 19, 056108 (2012)

New New Energy

Now to the main event.... **“Not Accepted Science”**

Starting with: **COLD FUSION**

But first, what do we mean by:
-- “Accepted” vs. “Not Accepted” Science

Accepted Science vs. Not Accepted Science

Accepted Science

- The standard "Canon". What we all were taught and what is generally regarded as true, valid, proven and useful.
- What the members of the establishment ("Canonistas") currently bless with funding, publication, attention, and more or less open-minded discussion.

Not Accepted Science

- Pathological, fringe, crazy, quasi-science, unconventional, non-mainstream, outsider, unorthodox, junk,
.... and undertaken only at great risk to one's career.

"PC vs. Non-PC"

The terminology preferred by one distinguished scientist who lives in both worlds.*

* ("A Tale of Two Sciences", Peter Sturrock, 2009)

"Not Accepted" Science

- Large subcultures with devoted followers. An extensive 'literature'.
- A great deal of it can be dismissed, but ***not all of it***.
- More than a few established and well trained scientists take (parts of) it quite seriously (in spite of career risks).
- They ascribe to the point of view that there will be new science in 10, 20 or 50 years that we don't know now.
- The "fringe" is a good place to look... because people are struggling with anomalies and exceptions to existing frameworks.
- The history of science shows progress is often controversial and difficult.
  (can't go without citing: "The Structure of Scientific Revolutions", T. Kuhn)

Imagine it's 1920, and someone describes a nuclear power plant.

“Not Accepted” Science

Spoiler Alert:
This presentation won’t be presenting any NEW NEW Energy technologies that in our opinion are ready to change the world. That, however, could change quickly.

There are many experimental results and hypotheses that are at an advanced stage of development, and which deserve a great deal more attention and resources.

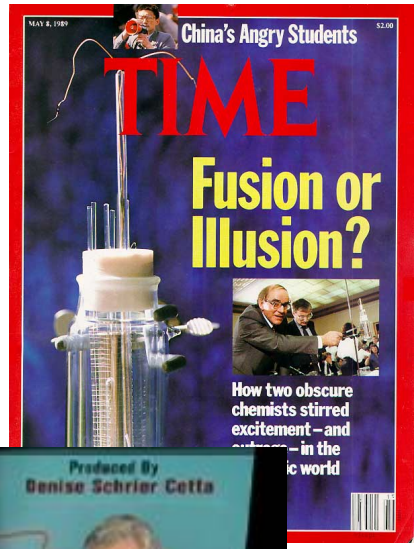
Next up: COLD FUSION

"Not Accepted" Science

COLD FUSION

from **1989** Pons & Fleischman
to **2009** "60 Minutes", ... it is **HOT AGAIN** (pun!)

Not a 1st or 2nd Law problem. Not "perpetual motion".
More of a PR problem.
If only they hadn't called it fusion.
Led to a battle over turf and $$$.
Canonistas behaved badly (imho)



- No access to publication
- No government funding
- No patents.

aka:
Low Energy Nuclear Reactions (LENR)
Chemically Assisted Nuclear Reactions (CANR)
Lattice Assisted Nuclear Reactions (LANR)
Condensed Matter Nuclear Science (CMNS)
Lattice Enabled Nuclear Reactions

COLD FUSION

The Basic Idea:

• Certain light elements interact with surrounding matter (lattice),
Deuterium in Palladium - or - Hydrogen in Nickel

• Plus a shock to the system.

• "Fusion" – of some kind – happens,

... by somehow overcoming the Coulomb Barrier,
-- or making an "end run" on it.

• Resulting in:
- "Excess Heat" (too much to be of chemical origin),
- Reaction products (notably helium)... aka "ash"
- But no "dead graduate students"

COLD FUSION

The SCOPE of the effort:

1000's of experiments, worldwide.
100 conferences, many books.
(1000 papers available for download at lenr-canr.org)
US Navy* and NASA programs.
Controversial headlines (especially from Italy) (not in mainstream media)
Theories advancing – now focused on weak interaction.
(experimenters and theorists need each other!)
Increasing corporate and investor interest.

Robert Duncan, Vice Chancellor for Research, University of Missouri
... after 60 Minutes experience, established the Kimmel Institute

Last month, Naval Research Lab went public at ICCF17 (Korea),
... "excess heat" definitively seen.

Key Players & Products

- **Leonardo Corp. -** Andrea Rossi – E-Cat (several versions)
- **Defkalion** – Hyperion OEM – new product coming
- **Brillouin** – Godes - Hot Tube Boiler
- **Black Light Power** –Mills - Catalyst Induced **Hydrino** Transition
- **Nichenergy** (Piantelli) – Ni-H **technology** vs. product ?
- **Energetics** – new focus - moving to US
- **Othe**r – Coolescence - Nanor - AUS tech. – Japan, others ?

http://pesn.com/2012/07/07/9602127_Jim_Dunns_Report_on_LENR_conference_in_Williamsburg/

New New Energy

Now, for some really ... **“Not Accepted Science”**

- "Free Energy"
- "Over-unity"
- Perpetual Motion

More energy out than energy in,
..or energy out with no energy in,
... for “free”.

But first,
-- What is Energy? (a short and painless physics lesson)

What is Energy?

Scientific Definitions

ENERGY: The work that a physical system is capable of doing in changing from its actual state to a specified reference state, the total including, in general, contributions of potential energy, kinetic energy, and rest energy.

POWER: The rate at which work is done, mathematically expressed as the first derivative of work with respect to time…

WORK: The transfer of energy from one physical system to another; especially, the transfer of energy to a body by the application of a force, calculated as the line integral between any two points of the scalar product of the force and the body's displacement along the path over which the integral is taken.

Ooops..Sorry! That wasn't painless.

What is Energy?

"...in physics today, we have no knowledge of what energy *is.*"

The Feynman Lectures on Physics.

..an abstract thing, which has only one really important property.

If we add up all the values before and after something happens, then the two values will be exactly the same. (must be sure to include every object affected.)

$$(E_1 + E_2 + E_3 ..) = (E_a + E_b + E_c ..)$$

before after

This is the **Law of Conservation of Energy**

aka **"The First Law of Thermodynamics"**

What is Energy?

Forms of Energy:

- **Kinetic (e.g. wind)**
- **Potential (hydro)**
- **Thermal**
- **Electromagnetic**
- **Chemical (e.g. burning gas or oil)**
- **Nuclear**
- **Other?**

"Energy can neither be created or destroyed."

We don't "consume" energy. We can only convert it from one form to another.

IF: There is more energy after than before,

THEN: We have a "*Perpetual Motion Machine of the First Kind*"

-- OR –

There's a missing term -- a source of energy we don't know about yet.

What is Energy?

You might ask:

What do Perpetual Motion and Conservation of Energy
have to do with each other?

The fuss about “perpetual” can be misleading.
(Can you build a machine that never wears out? What is “forever”?)

Any machine will have to slow down sooner or later,
-- There is always be some kind of dissipation,
like friction or air resistance.
-- There has to be source of input energy to compensate.

Impossible to run forever without input energy. That would be:
-- a “perpetual motion machine”.

What is Energy?

Energy is never "consumed",
... but it does become less useful.

For example ..burn a log to heat a room. chemical reactions.... hot flame...
increase temp in room... heat gradually leaks out, very slightly warming the air outside.

What does get consumed is the ability to do useful work.

Or, what get consumed is "order".

ENTROPY, a measure of "disorder", always increases.

The SECOND LAW of THERMODYNAMICS

What is Energy?

The SECOND LAW of THERMODYNAMICS

Consider.... all the Water in San Francisco Bay.

If we **add** a stupendous amount of energy, we could increase Temp. by 1°C.
[actually, about ½ of all energy consumed in one day in USA]

========

Q. So, could we **get** that much energy **from** SF Bay,
by lowering the temperature by 1° C.?

========

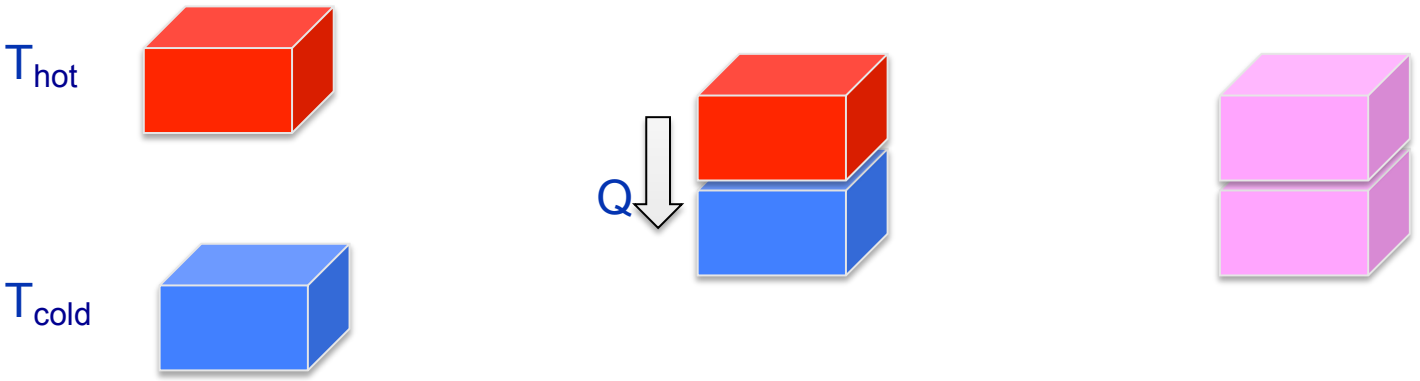
A. **No.** We can't get that energy in any "useful" form.
The 2nd Law won't let us.

========

The only way to "get" that energy
... mix the warm water with some colder water,
and end up with a temperature in between the two,
(i.e., "use" energy from the warm water to heat up the colder water.)

What is Energy?

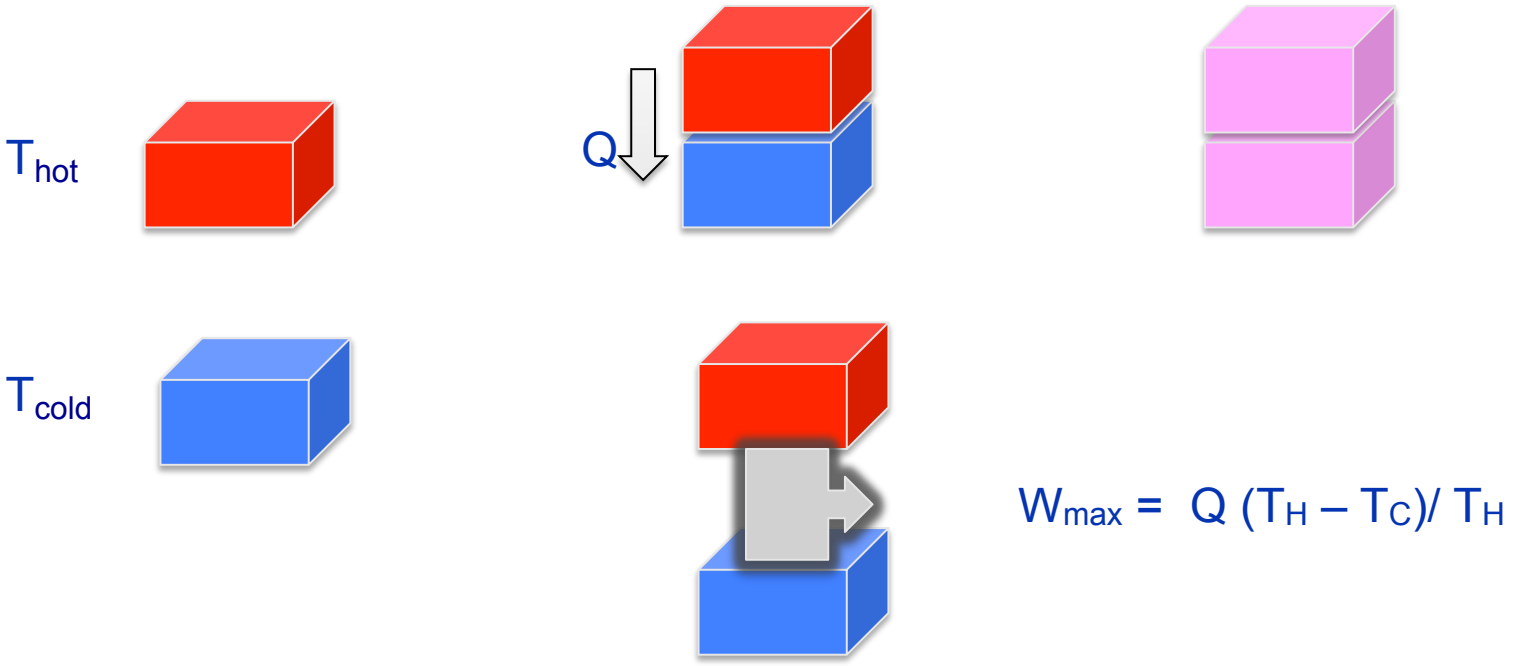
The SECOND LAW of THERMODYNAMICS



What is Energy?

The SECOND LAW of THERMODYNAMICS

Carnot's Theorem (1824) says that we need a temperature DIFFERENCE to get useful work.



$$W_{max} = Q\,(T_H - T_C)/\,T_H$$

What is Energy?

The SECOND LAW of THERMODYNAMICS

- **Entropy always increases.**
- **Heat flows from hot to cold.**
- **Messes expand to fill the space available.**
- **Perpetual motion machines are impossible.**
- **Murphy's laws and corollaries**
- **The world's running down (heat death).**
- **We're all gonna die.**

What is Energy?

The SECOND LAW of THERMODYNAMICS

- **Has not yet been violated experimentally.**
- **Is held to be absolutely true by just about everyone.**
- **Stops conversations dead in their tracks.**

BUT, it:

- **Is <u>not</u> actually on firm theoretical ground, and is <u>not</u> well defined.**
  (Dozens of formulations over last 150 years)*

-- Over 25 challenges, 60 refereed articles, by serious people, in last 15 years.
-- A number of promising concepts and experiments.
-- But "Ignored to death", unfortunately.

Keep in mind, Physical Laws do get updated and made more precise.

*(V. Čápek, D.P. Sheehan, *Challenges to the Second Law of Thermodynamics: Theory and Experiment*. Vol. 146, Fundamental Theories of Physics Series (Spring 2005).

"Not Accepted" Science

An Inventor Brings You a Radical New Source of Energy!
..a device making "free" electricity, heat, or mechanical motion...

Where could the Energy be coming from?

- If there is no apparent Source,
  Then: 1st Law violation !
  or.. is it tapping something new?

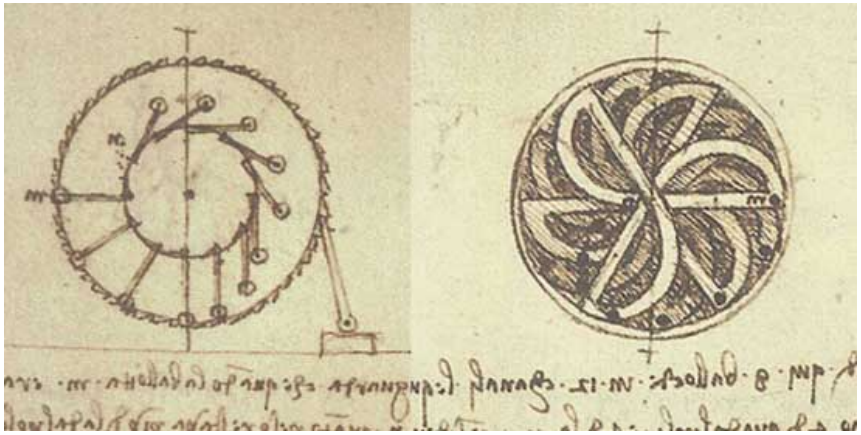
- If 'harvesting' heat from surroundings, but without a delta T,
  (i.e., cooling stuff nearby),
  Then: 2nd Law violation !

1st and 2nd Laws are very good at separating wheat from chaff,
but sometimes they can be too good at it.

“Not Accepted” Science

Gravity gadgets

.. Even Leonardo da Vinci tried,
and countless more since then.

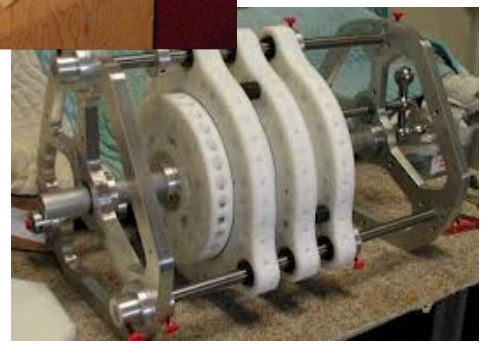


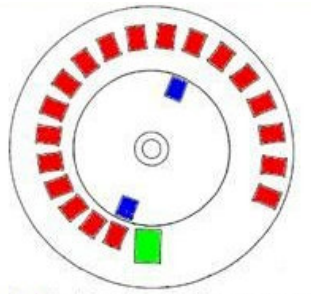
Newton’s laws do pretty well here.
No indications of a new energy source.

“Not Accepted” Science

“Over-Unity” Magnet Motors

Are Maxwell's Equations incomplete?
Do Magnets “Store” Energy?
Basic Measurement issues. (P = I • V)

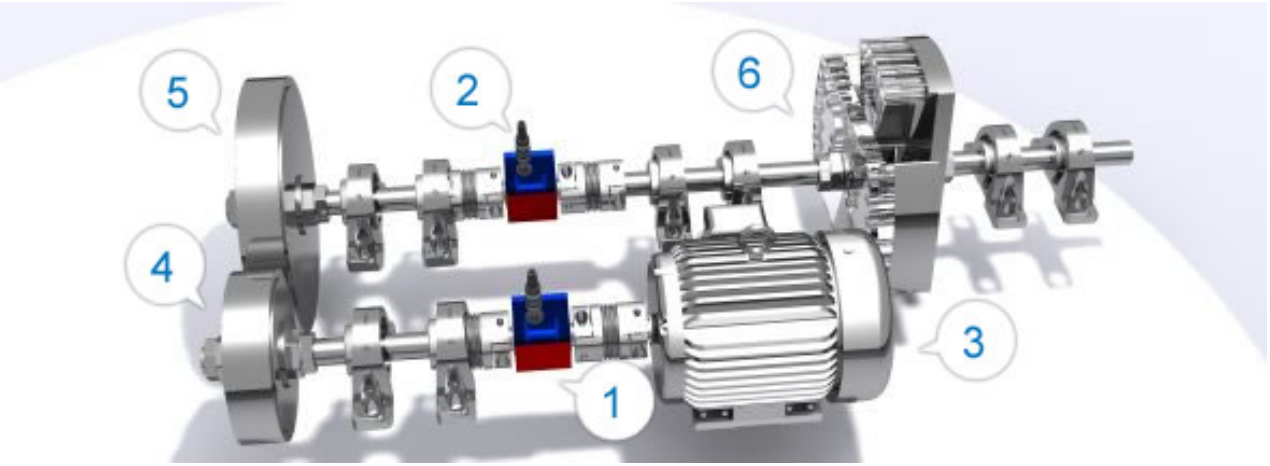




Note: uses Kawai Spiral

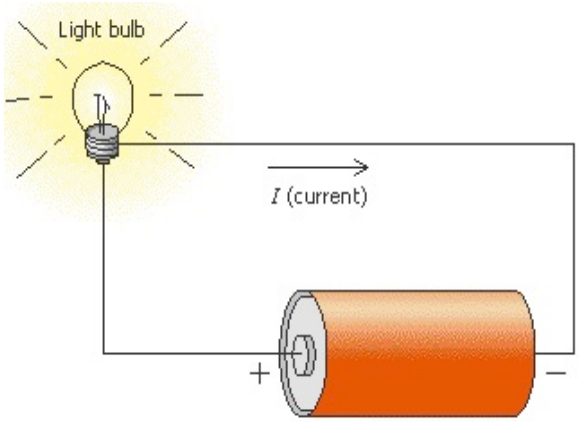
"Over-Unity" Magnet Motors

Terawatt Research, LLC
Irvine CA



www.terawatt.com

What to make of this ?????



["..and the light stays on!"]

Power = I • V

Energy = P • time

Mystery Cells

What if it's not a battery?

Is there some way for it to have stored energy?
There can be, e.g. some kind of chemical reaction, especially if the power level is very low.

If the cell cools itself, then it's a 2nd Law violation.

If not, then it's a 1st Law question.

Seen several recently, of both kinds.
-- One claims a light on for 12 years!

And, they come with theoretical explanations.

"Not Accepted" Science

Two Hub Lab projects involved mechanisms to 'challenge' the 2nd Law.

- Anomalies in Energetics of a Magnetostrictive Alloy
- Semiconductor MEMS device

The experiments are difficult, take time, and cost money.

Results are "ignored to death", despite solid data.

It continues to be hard to make progress.

“Not Accepted” Science

Back to the 1st Law...

Where could energy be coming from?

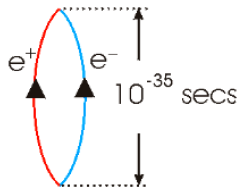
Most often suggested..

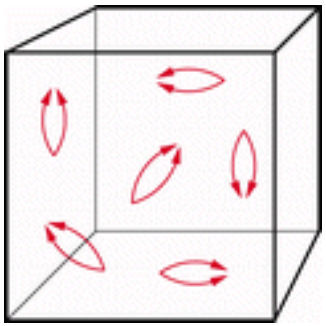
From Empty Space

Vacuum Energy, Zero Point Energy

Empty Space (Vacuum) is not Empty.
Virtual particle/antiparticle pairs pop into and out of existence.

Empty Space contains Energy (says the Uncertainty Principle)
in the form of quantum field oscillations.





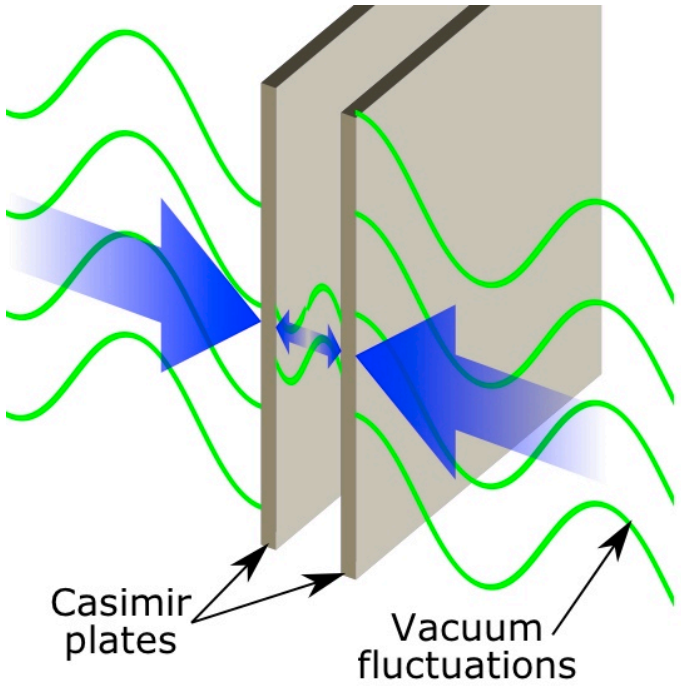
$$E = \tfrac{1}{2}\hbar\omega \ .$$

This is all pretty much "accepted"!

"Not Accepted" Science

The Casimir Force has been measured extensively and known for decades.

- Two metal plates, very close together. (a few micrometers)
- Longer wavelengths of "quantum fluctuations" are excluded.
- Net force pushes the plates together.



Accepted Science !
Known to affect nano devices

But, no known way to harvest energy,
...though many ideas and attempts.

(One intriguing detailed plan for an energy storage device.

What's "Not Accepted"?
Vacuum energy as the handy explanation for breakthrough claims.

“Not Accepted” Science

Other things we haven’t talked about

Brown’s Gas (HHO)

Ball Lightning

Sonofusion

Tesla (Nikola, not the car)

Noble Gas Engine (Papp)

Aether

"Not Accepted" Science

Where are DOD and NASA and DOE?

DOD has been known push the envelope:
-- Quietly, a mainstay of LENR work
-- Back in the cold war, DARPA/CIA, SRI, Rand Corp., tried
pyschokinesis, remote viewing, telepathy, etc. ("Men Who Stare at Goats")

NASA
-- Very active in LENR
-- Breakthrough Propulsion Physics Project ('96-'02)
Warp Drive, Anti Gravity, Quantum Vacuum, Wormhole

DOE
-- ARPA-E modeled on DARPA, but being very cautious.
-- Office of Science supposed to do the frontier stuff, but do they?

NSF -- thanks to peer review, MIA; canonista territory.

....and, of course, who knows what top secret programs.

“Not Accepted” Science

Are there any Holy Grails on the way? Cheap, Clean, and Inexhaustible?

There is a lot of very tantalizing stuff out there.

Wide range of players...from brave scientists, governments, all the way to naive wishful thinkers and fraudsters.

Difficult to separate wheat from chaff, but important and doable.

It’s “random” who gets money ...
Potential breakthrough endeavors need resources.
Only a small underground of wealthy individuals,
some institutional money (and rumored top-secret “black” programs)

New Science Patrons, a proposal to continue the work of The Hub Lab, to uncover, evaluate, and support promising new new energy science. Looking for support.

"Not Accepted" Science

Our key message:

When you're shown an "over-unity" claim, don't dismiss it by asking:

"Isn't that Perpetual Motion?"

That is the wrong question.

EITHER: the measurement is wrong. -- very high probability but not 100 %

OR: tapping a new source of energy. -- very low probability but not 0 %

Those are the only choices.

... and don't be so sure about the Second Law either.