Setup

A Personal Journey in Superconductivity

(and a few other "interesting technologies!")

-- IBM, EPRI, and Beyond --

Paul M. Grant
www.w2agz.com

AGING IBM PENSIONER

Energy/SIG Presentation
1060 La Avenida
Mountain View, CA

Kelly Building
12:00N – 1:00PM
Tuesday, 7 August 2012

PMG Timeline

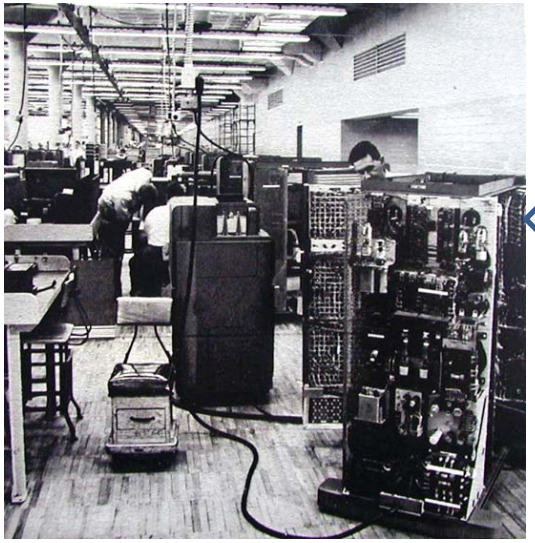
- IBM (1953-1993)
  - Project SAGE (IBM, MIT, USAF) (1953-56)
  - IBM Education Plan (1956-65)
  - San Jose/Almaden (1965-90)
  - Sabbatical @ UNAM (1990-93)
- EPRI (1993-2004)
  - Science Fellow (Superconductivity, Power Electronics Devices, Fusion, “Novel Concepts”)
  - 5-10 M$ Annual Program
- W2AGZ Technologies (2004-?)
  - Visionary Energy Societies (SuperCity, SuperSuburb, SuperGrid)
  - “Due Diligence” Consulting
  - Visiting Scholar, Stanford University
  - Staff Associate, JPL/NASA/CalTech
  - Superconductivity Committee Member, IASS, Potsdam, Germany
  - Writing Commentary for Nature, Physics World, Physics Today, Power Magazine, Cold Facts, SJ Merc-News...
  - Uncovering the Secret of HTSC !

…in their shoes…

- Paul Archibald Grant
  - W2AGZ
  - US Navy, WWII
  - IBM, 1948-1974
  - Ski Patrol, 1948-1970
- Mary Ann Whalen Grant
  - CYO BB Champ, 1921
  - NYS Bowling Champ, 1939
  - Women's Baseball, '33-'47
  - CHG&E, 1927-1965

IBM – 100 Years

1952



604 (1948)

Grant-Whalen
IBM Family
-Poughkeepsie-

701 (1952)

1953

Project Sage – IBM/MIT

Out into the Cold: Early Experiences with Superconductivity

by Dr. Paul Michael Grant, W2AGZ Technologies, w2agz@w2agz.com, www.w2agz.com

The following article is part of a year-long series celebrating the 100th anniversary of the discovery of superconductivity. Contact CSA if you have ideas for submissions: theresa@cryogenicsociety.org.

One of my earliest memories was watching my parents ice skate on frozen Wappingers Pond where they had taken me swimming for my first time only a few months before. The mid-Hudson Valley was, and still is, notorious for its temperature extremes, the river itself usually completely freezing over between its banks. In mid-winter the outside temperature could approach -50°F (-46°C, 228K). I was reminded of the rigors and discomfort of my boyhood cold climate experiences this past July at ICEC-ICMC held in Wroclaw, Poland, as one of a group of attendees who underwent a "cryotherapy" session at a nearby spa, where "room temperature" was approximately -100°C. Thomas Wolfe was wrong…You can go home again!

Ice was the base cryogenics technology of my childhood years throughout the early 1940s, delivered daily, sawdust covered, in carts drawn by horses due to the wartime rationing of gasoline for automobiles and trucks [1]. Household refrigeration didn't really arrive for working class folks until after WWII. However, while I was in grammar school, although we didn't have formal science classes, we had occasional "science demonstrations," usually conducted by engineers from the nearby IBM plant. I remember two in particular, one on something called "dry ice," really cold to the touch, which just sat there and smoked and didn't melt; the other by a gentleman who brought what looked like a large thermos bottle containing "liquid air" into which was dunked a tomato, which was then withdrawn and struck with a hammer, shattering it as if it were glass. Pretty impressive to a seventh grade male (~1948).

My next encounter with cryogenics didn't occur until I was 18. My high school grades were atrocious, to put it mildly, not good enough to get me into college, and I did not want to go anyway—I wanted a job so I could buy a car. So I did what Wappingers Falls boys usually did: I went to work at IBM, first setting pins in the employee bowling alley and then as a mail boy in the mail room of a new IBM lab in downtown Poughkeepsie. I really wanted to be a bench technician, so between delivery runs I hung out with the engineers. One day one of them called to me, "Hey, kid. Come over here and I'll show you something really cool." (He didn't actually say "cool.") His name was Jim Crowe [2].

Jim splattered some solder on his bench top, scraped it off, cut out a small rectangle with his "dikes," wired it in series with a flashlight battery and a resistor of unknown (to me) size, and also hooked up in parallel with leads to a Hewlett-Packard vacuum tube voltmeter. Next to his bench was a huge stainless steel container which Jim told me held liquid helium, saying it was the coldest substance known to man. He dropped the wired up solder chip through a small opening in the top of the "dewar" and we watched the voltage across it slowly drop…and then suddenly disappear! At the time, I knew enough about electricity and Ohm's Law to complain, "The leads must have come off!" Jim said, "No, that's 'superconductivity'. The resistance of the lead-tin in the solder goes away under liquid helium." I thought to myself, "Yeah, sure!"

That evening I had dinner at home with another IBM engineer, my dad. I told him about my experience, and he replied, "Hmm. I've heard some talk about making a superconducting computer. But I don't know…you would have to fill up a whole building with liquid helium." This was 1953.

That was my first and last experience with superconductivity for some time to come. Shortly after turning 21, IBM decided I was worth educating and sent me (as an employee!) to college and graduate school for nine years, and I wound up with a physics doctorate from Harvard (superconductivity was not taught at Harvard in the early 60s!). IBM assigned me to the San Jose, now Almaden, Research Lab, and in 1972, Rick Greene (now at UMD) and I teamed up to start working on organic metals as possible room temperature superconductors, both of us having become disciples of Bill Little's dream that properly prepared polymeric chains might exhibit really high (> 500K) superconductivity, and in 1975 the group indeed discovered the world's first 300 degree superconductor, the inorganic polymer polysulfur nitride…alas, the units were millikelvin! In 1986, 25 years ago, Bednorz and Mueller taught us we should have been spending our time looking at layered copper oxide perovskites instead.

Paul Grant at 17. This photo shows him about six months before he went to work for IBM.

Big Blue BRAT!

Nevertheless, I remain an ardent fan of the Little/Ginzburg exciton-mediated BCS-pairing proposal to enable superconductivity well above 300K. In 1998, I wrote a "sci-fi" piece for *Physics Today* predicting its fulfillment by 2028 [3]. Maybe then I can finally come in from the cold.

References

1. **A fascinating tale of pre-industrial cryogenics technology can be found in Gavin Weightman's book, "The Frozen Water Trade," (ISBN 0-7868-6740-X), the story of two New England brothers who "farmed" almost every northeastern pond and lake each winter to cool the cocktails of Caribbean resorts in the 19th century.**

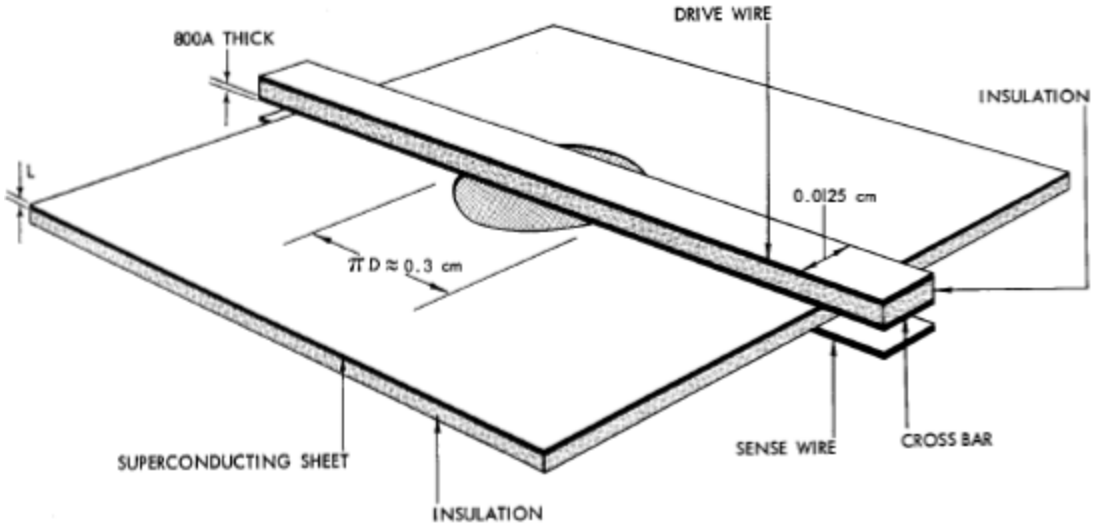
2. **Jim Crowe invented one of the very first superconducting memory elements, and arguably the first to employ trapped flux. See J. W. Crowe, "Trapped-Flux Superconducting Memory," IBM Journal, October 1957, p. 295. Jim Crowe became a good friend, mentor and my manager when I returned to work at IBM summers during my college years.**

3. **P. M. Grant, "Researchers Find Extraordinarily High Temperature Superconductivity in Bio-Inspired Nanopolymer," Physics Today, May 1998. Nineteen more years to go. http://www.w2agz.com/Publications/Popular%20Science/Bio-Inspired%20Superconductivity,%20Physics%20Today%2051,%2017%20(1998)a.pdf**

J. W. Crowe

Trapped-Flux Superconducting Memory*

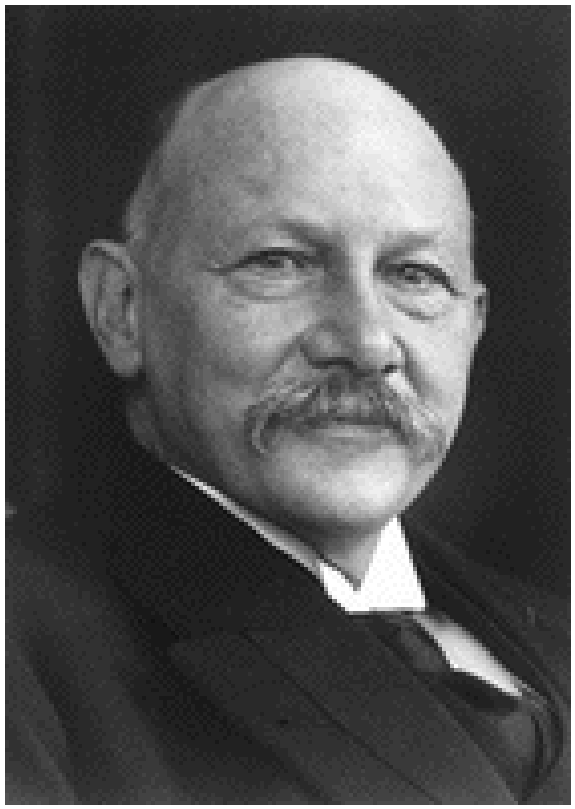
Abstract: A memory cell based on trapped flux in superconductors has been built and tested. The cell is constructed entirely by vacuum evaporation of thin films and can be selected by coincident current or by other techniques, with drive-current requirements less than 150 ma. The short transition time of the trapped-flux cell indicates its possible use in high-speed memories. The superconductive film memory does not exhibit the problems of "delta noise" in core memories resulting from the difference in half-select pulse outputs.



Fathers of Cryogenics

Dewar

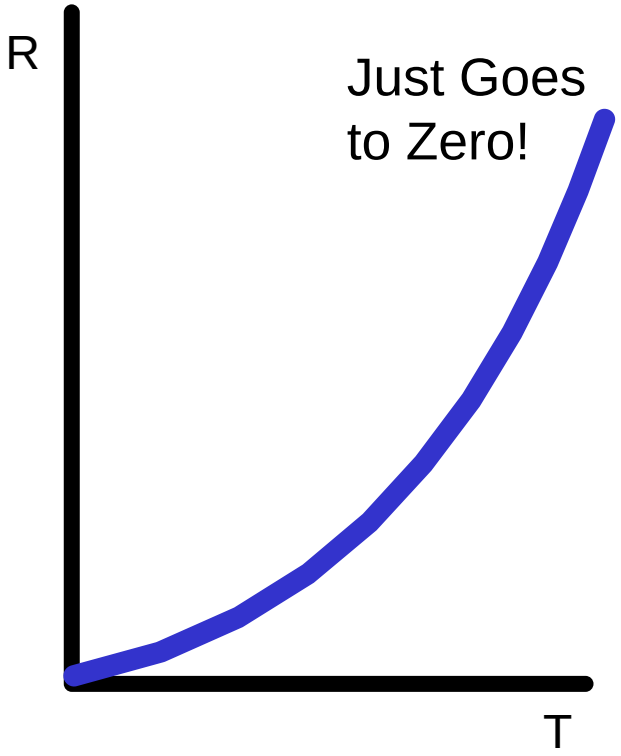
CH_4	112 K
O	90
N_2	77
Ne	27
H_2	20
He	4.2

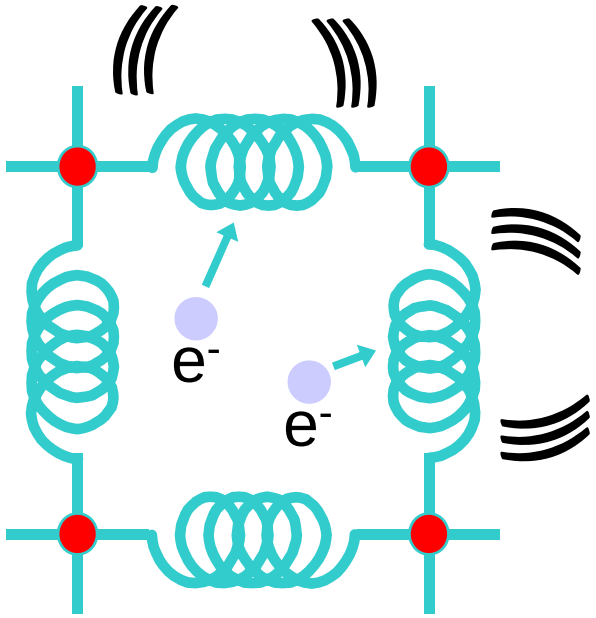


Kammerlingh-Onnes

Models of Electrical Conductivity

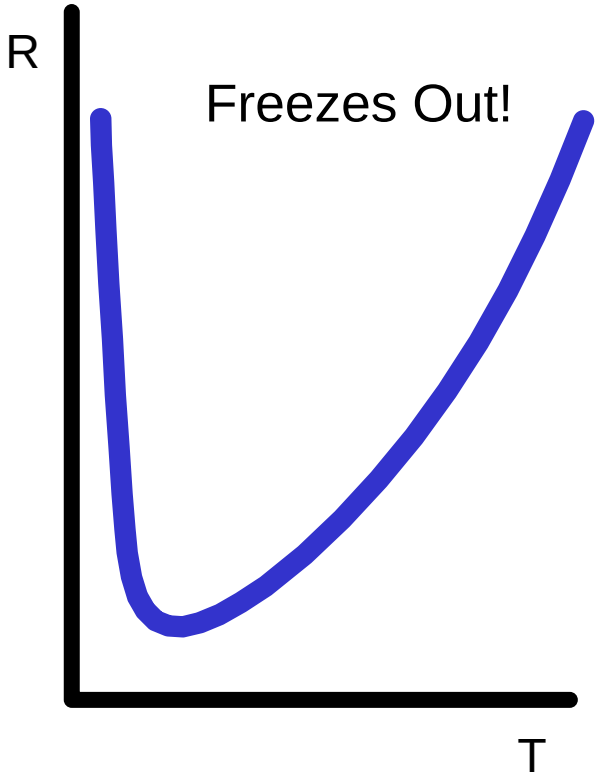
The First Idea:

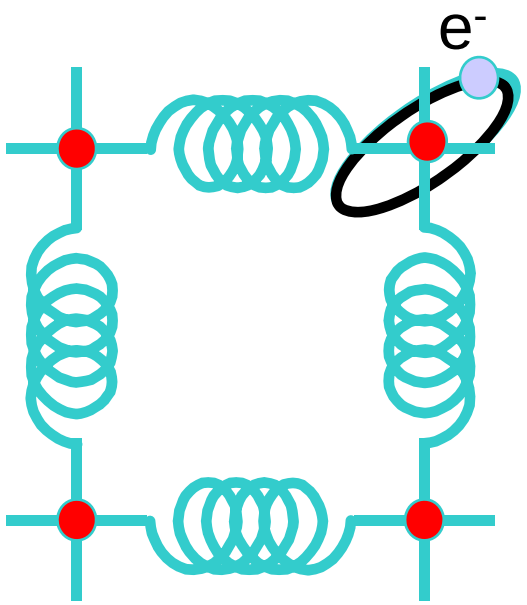




Models of Electrical Conductivity

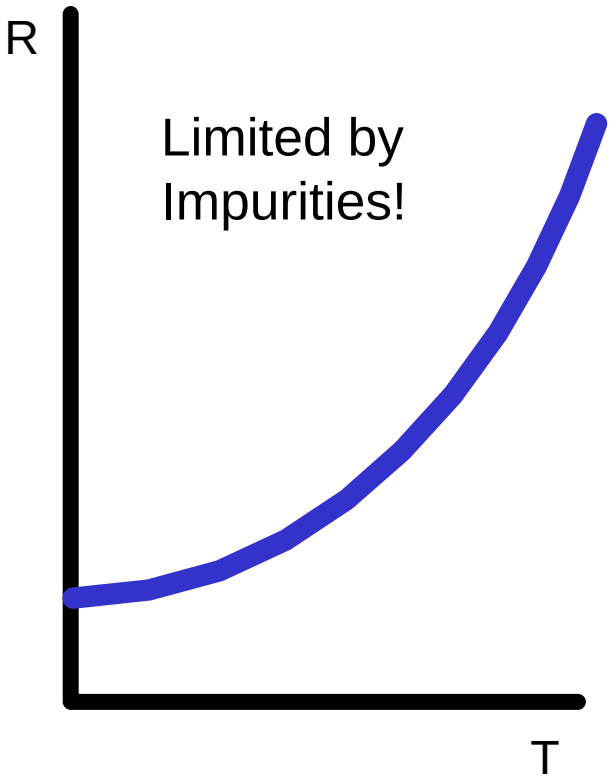
The Most Popular:

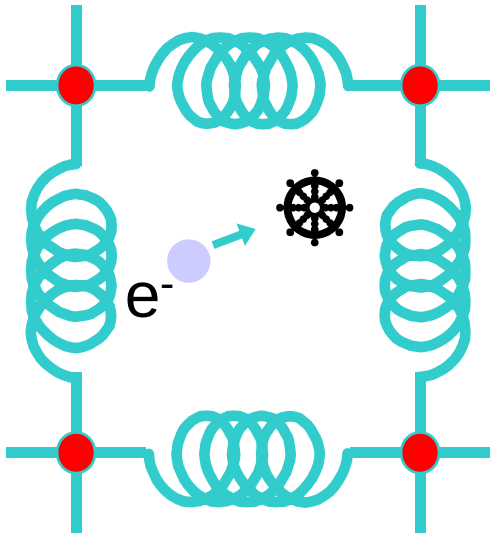




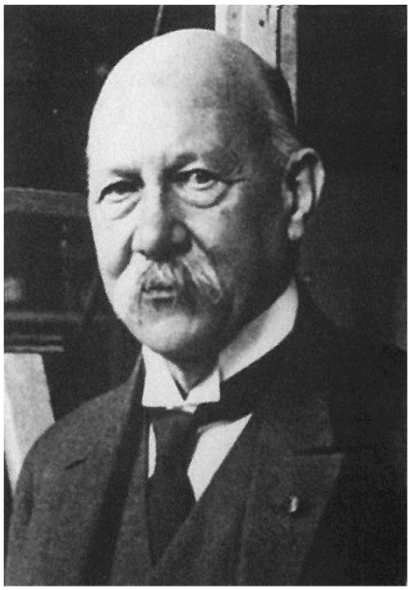
Models of Electrical Conductivity

Reality:

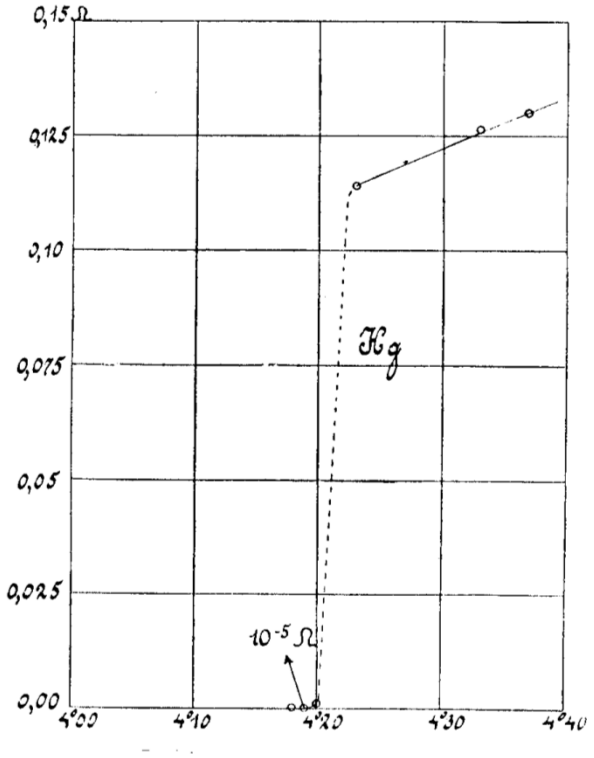




1911
A Big Surprise!



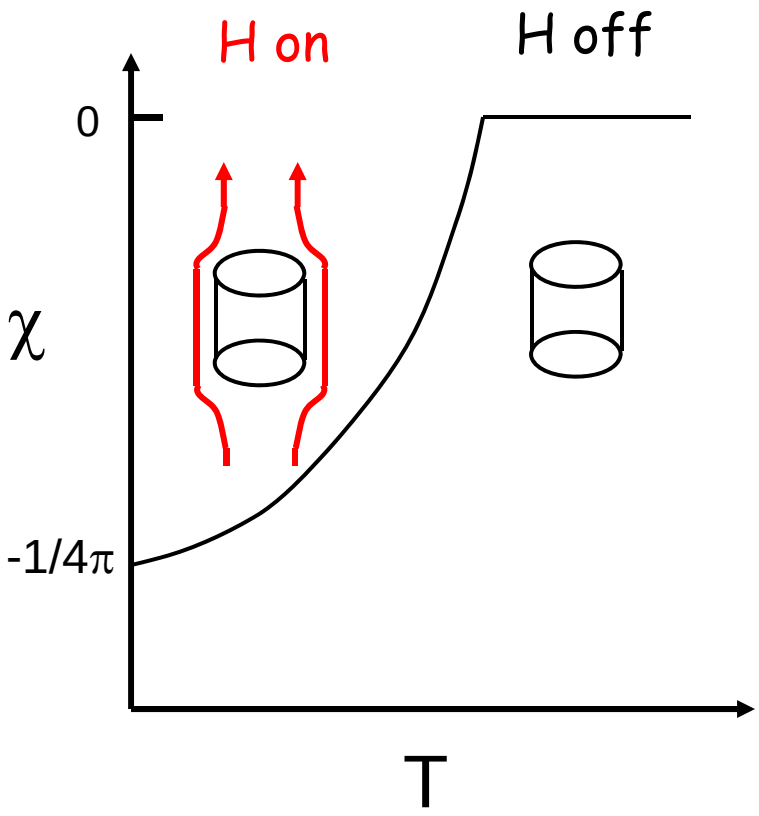
Gilles Holst



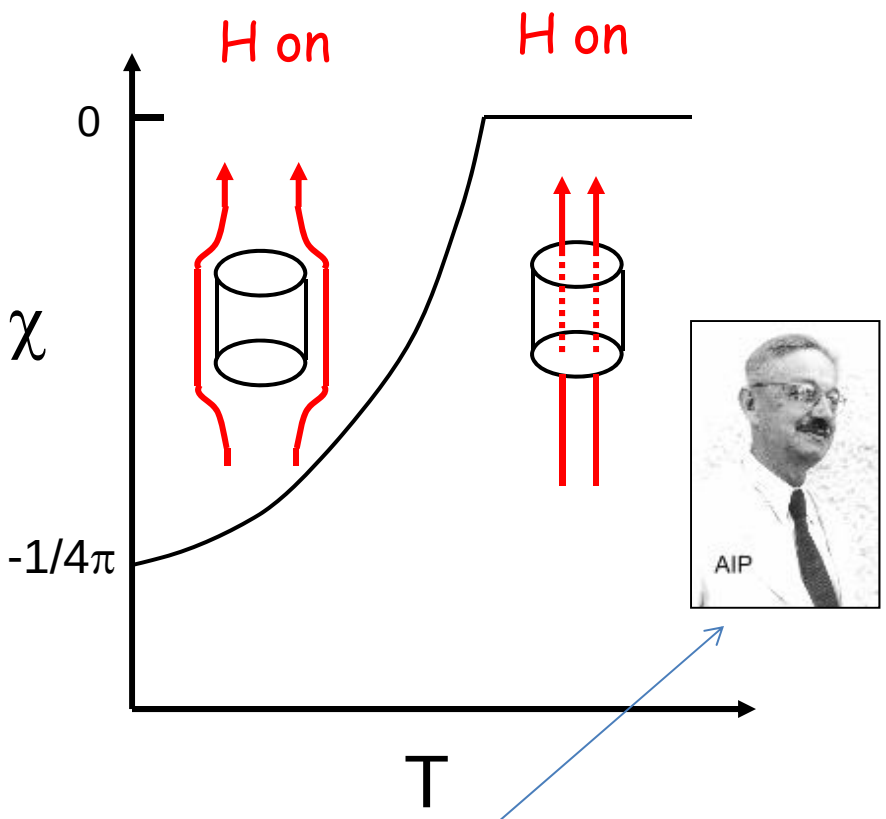
Thus the mercury at 4.2 K has entered a new state, which, owing to its particular electrical properties, can be called the state of *superconductivity*

H. Kamerlingh-Onnes (1911)

Magnetic Properties



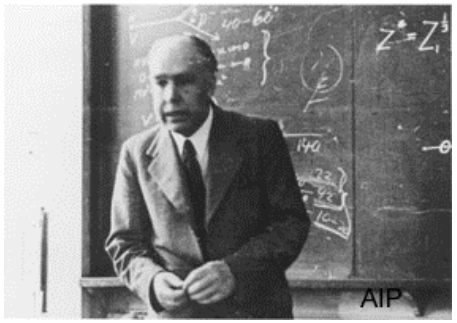
Expected (Lenz' Law)

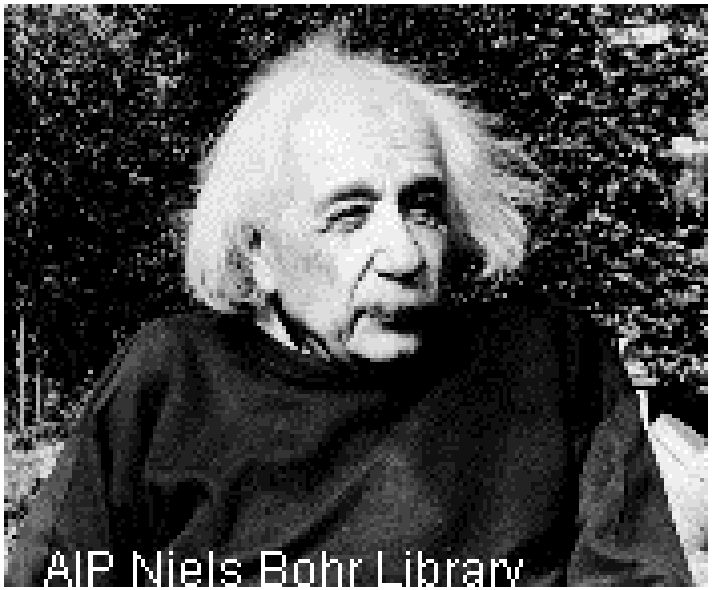


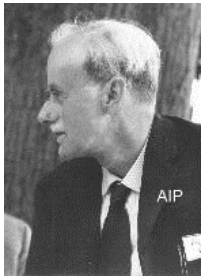
Weird ! (Meissner Effect)

Explanation ???

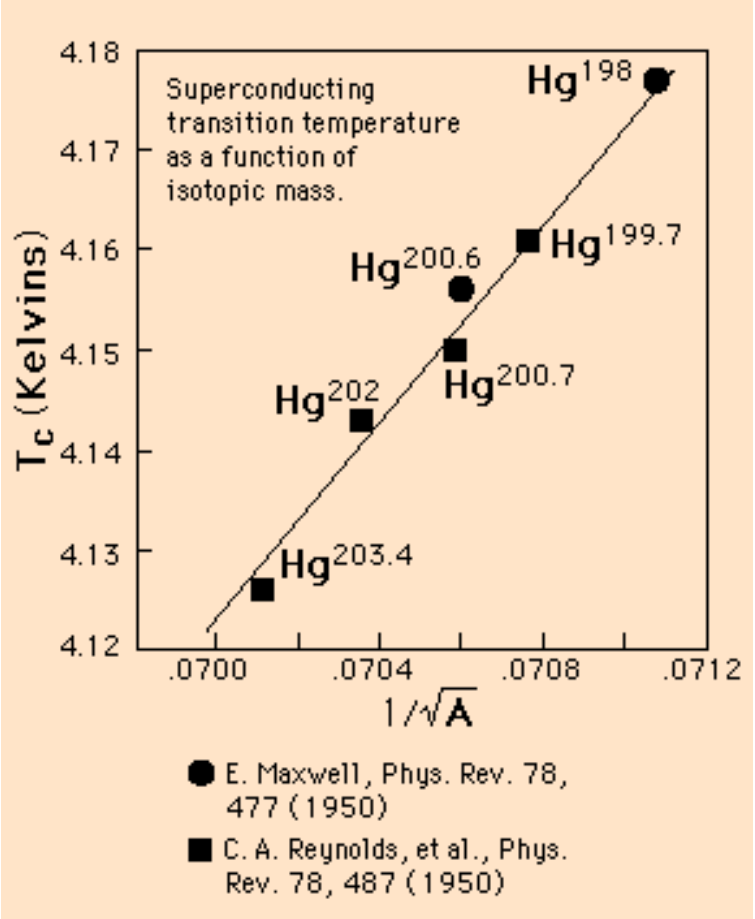
This Group Tried... **And Failed !**







Isotope Effect



Somehow the mass of the atomic nucleus is involved!

Wow...is that ever counterintuitive!

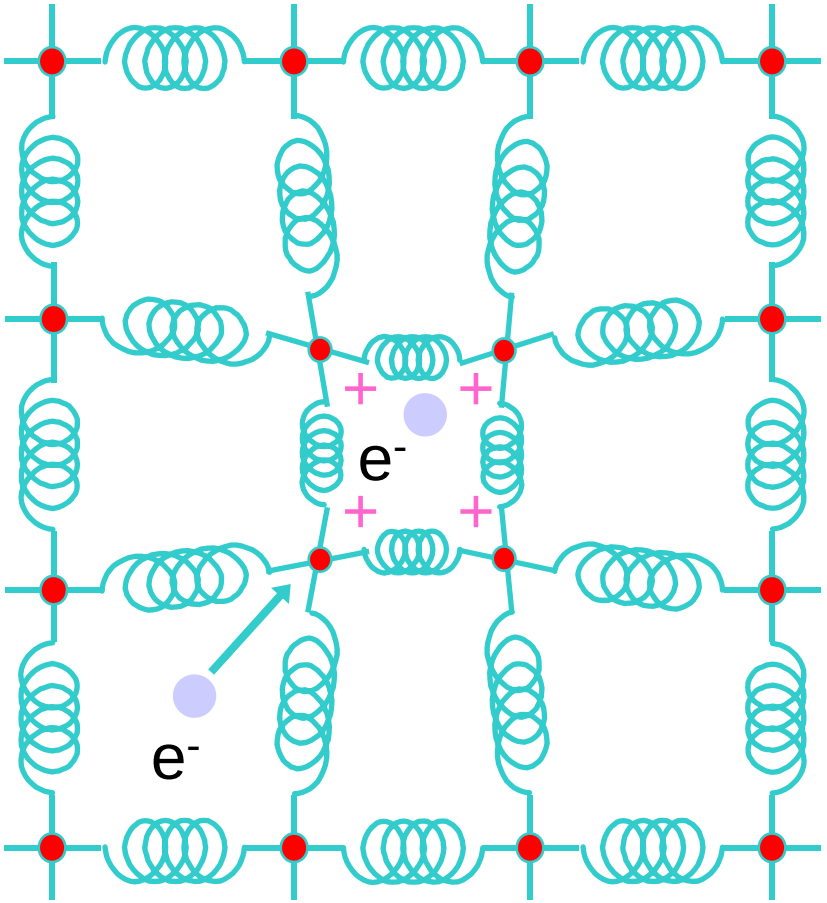
These Guys Got It Right!

B ----- C ----- S (1972 Nobel for Physics)

There has to be a regime where the lattice vibrations act to bind electrons together rather than scatter them with loss as given by Ohm's Law.

Bardeen: "It's a macroscopic quantum state"
Cooper: "It's got twice the charge you'd expect"
Schrieffer: "Ψ's a statistical wavefunction"

Physics of Superconductivity a la BCS



Electrons Pair Off!

BCS Equation

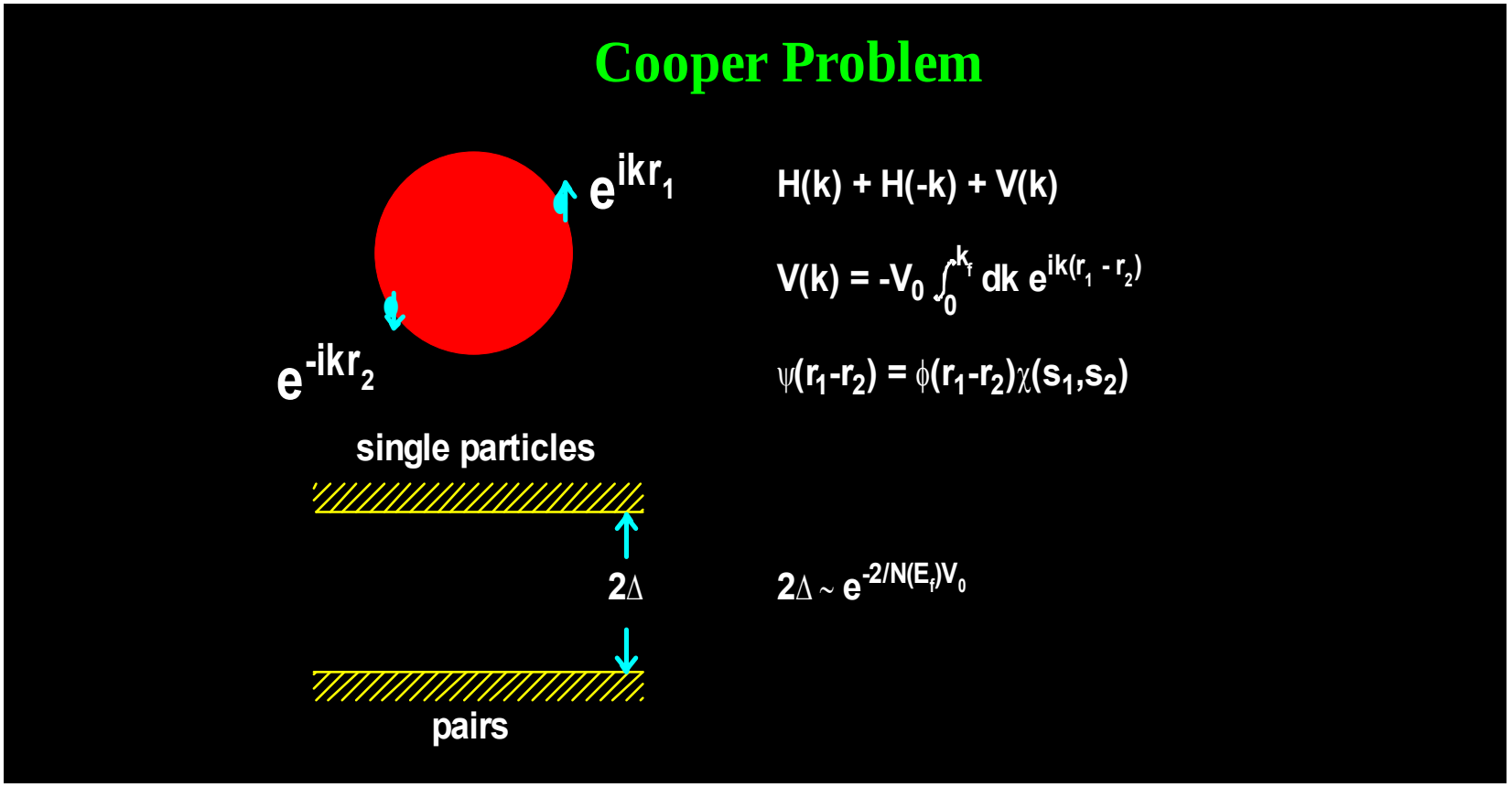
$$T_C = 1.14\,\theta_D \exp(-1/\lambda)$$

$\theta_D = 275\ \text{K}$,

$\lambda = 0.28$,

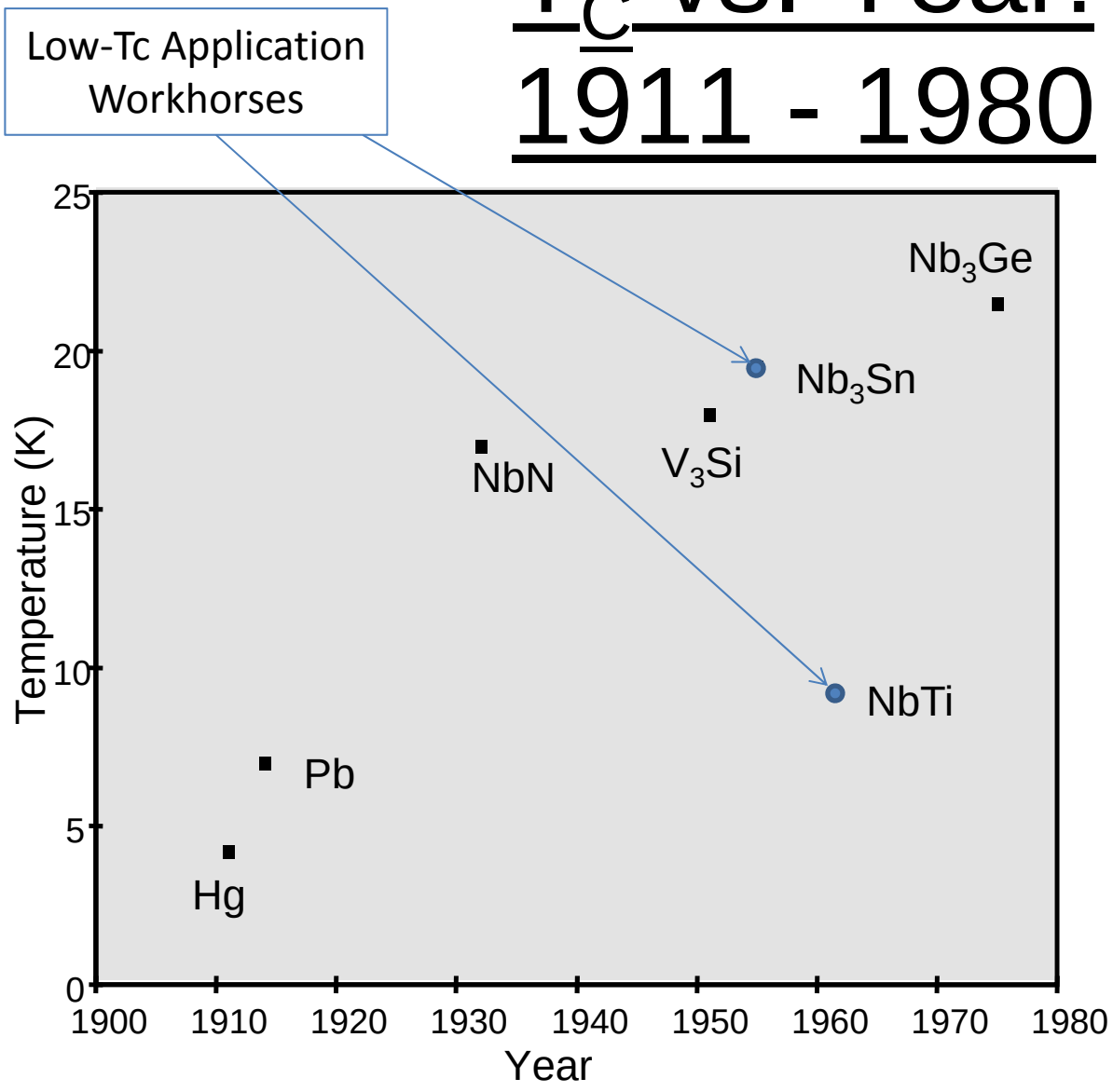
$\therefore T_C = \underline{9.5\ \text{K}}$ (Niobium)

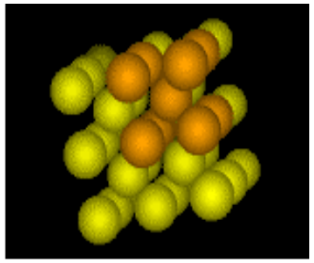
“Cooper’s Problem”

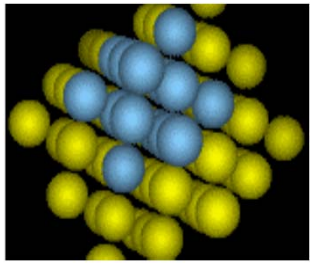


Homework Problem: Formalism Applies to any “V_0 boson”...More Later.

T_C vs. Year: 1911 - 1980







Cubic Metals

Low-Tc Applications

Yesterday (Wilkinson)

PROCEEDINGS

THE INSTITUTION OF ELECTRICAL ENGINEERS

Volume 113

Prospect of emplo
in power cables a

K. J. R. Wilkinson, D.Sc., C.Eng., M

Submitted 28 February 19

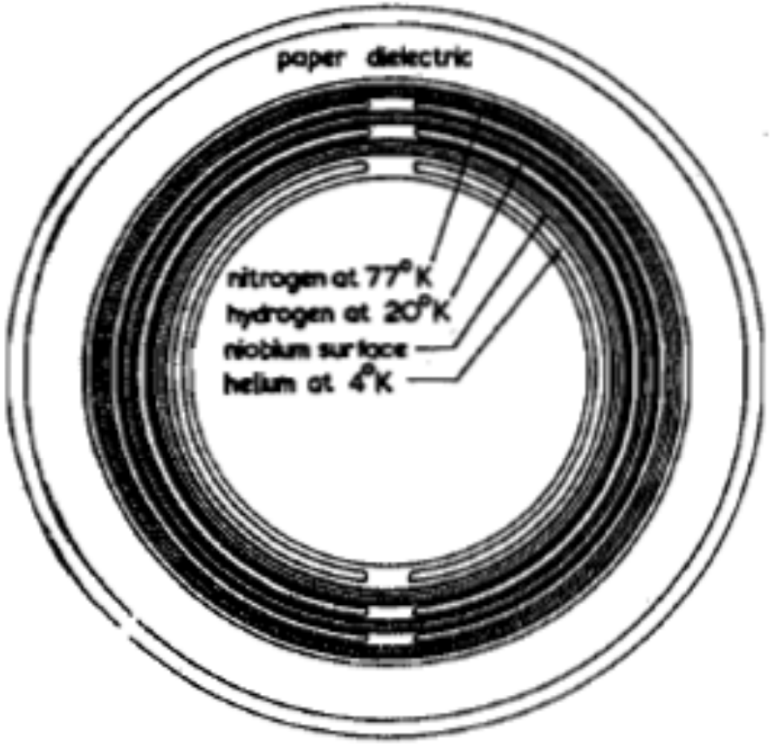


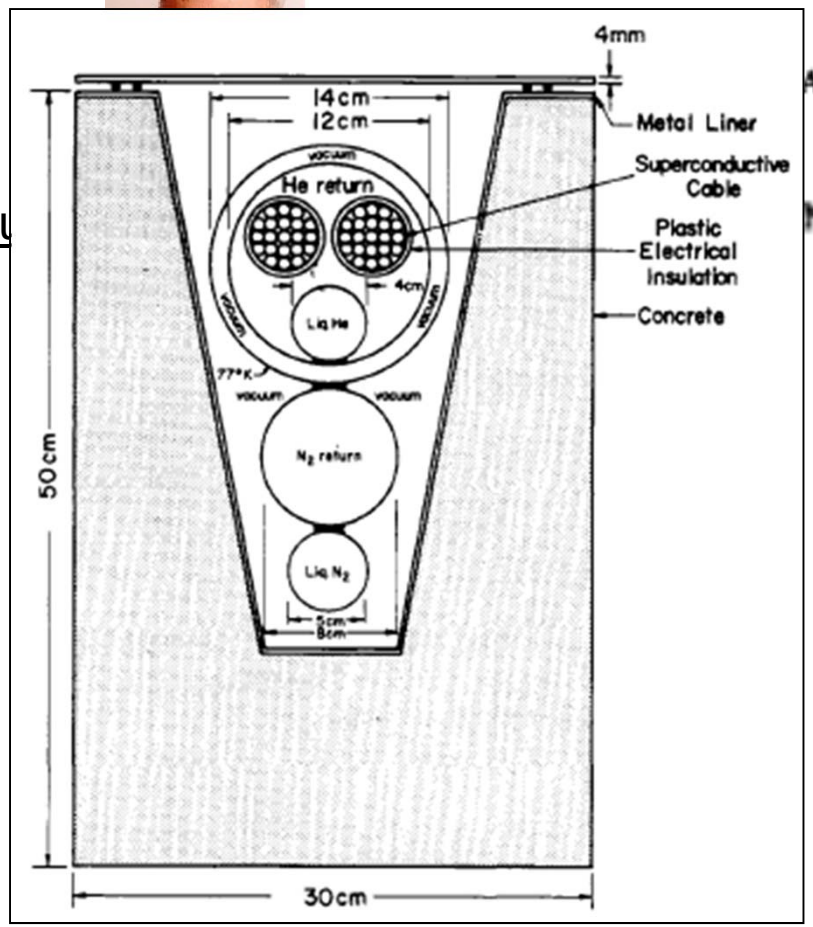
Fig. 2

Superconducting thin-walled niobium core cooled internally by liquid He and protected externally by liquid H_2 and liquid N_2

- ac Cables: 760 M
  - Be 77 K
  - Al 20 K
  - Nb 4 K (a
- *Objective: Efficiency, not increased capacity!*

Yesterday (Garwin - Matisoo)

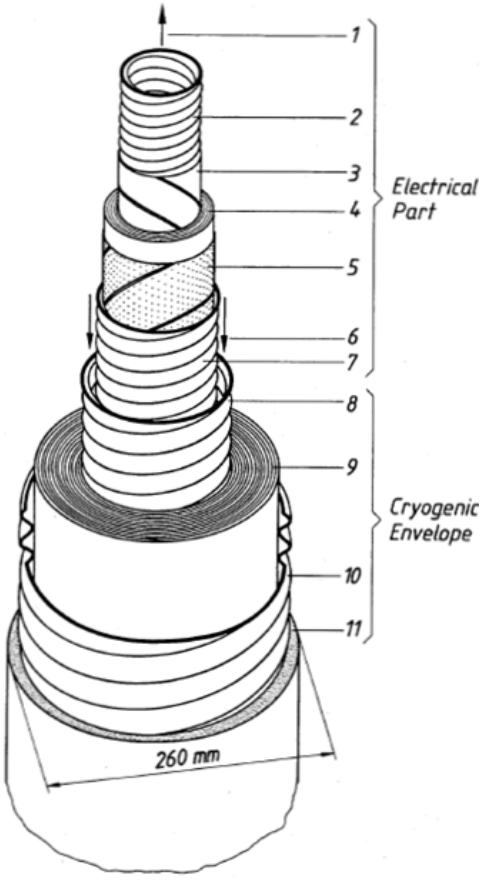
Superconducting Lines for the Transmission of Large Amounts of Electrical Power over Great Distances



- LHe cooled
- Nb_3Sn (T_C = 18 K)
  - J_C = 200 kA/cm^2
  - H* = 10 T
- Capacity = 100 GW
  - +/- 100 kV dc
  - 500 kA
- Length = 1000 km

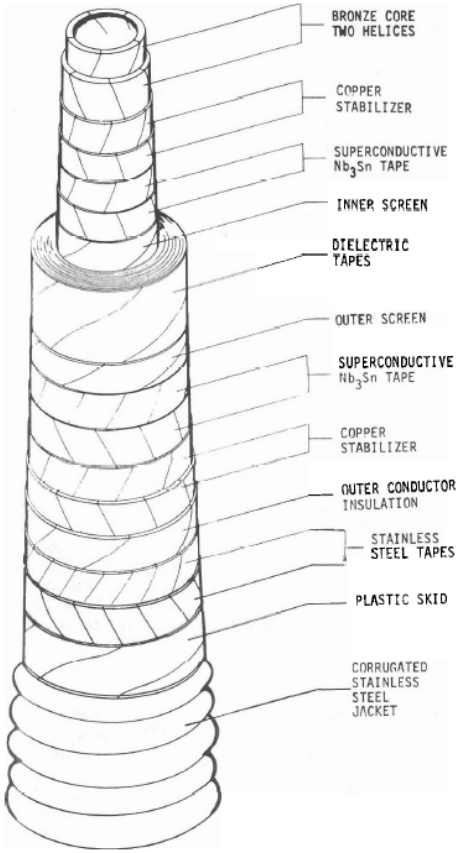
Yesterday (3 Real Cables)

Graz, Austria (Late 1970s)



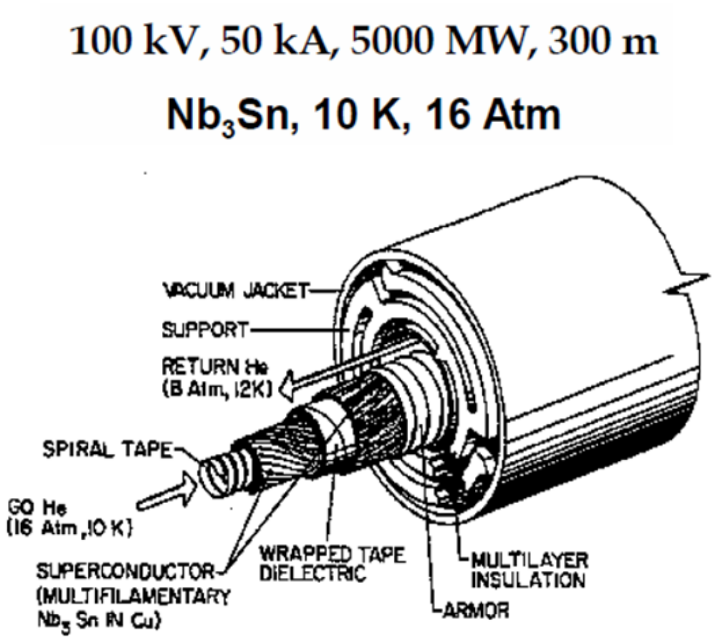
330 MW, 110 kV, 3 kA, Nb, 4.2 K, 50 m

Brookhaven (Early 1980s)



1000 MVA, 138 kV, 2.4 kA, Nb_3Sn, 7.5 K, 115 m

LANL (Early 1980s)



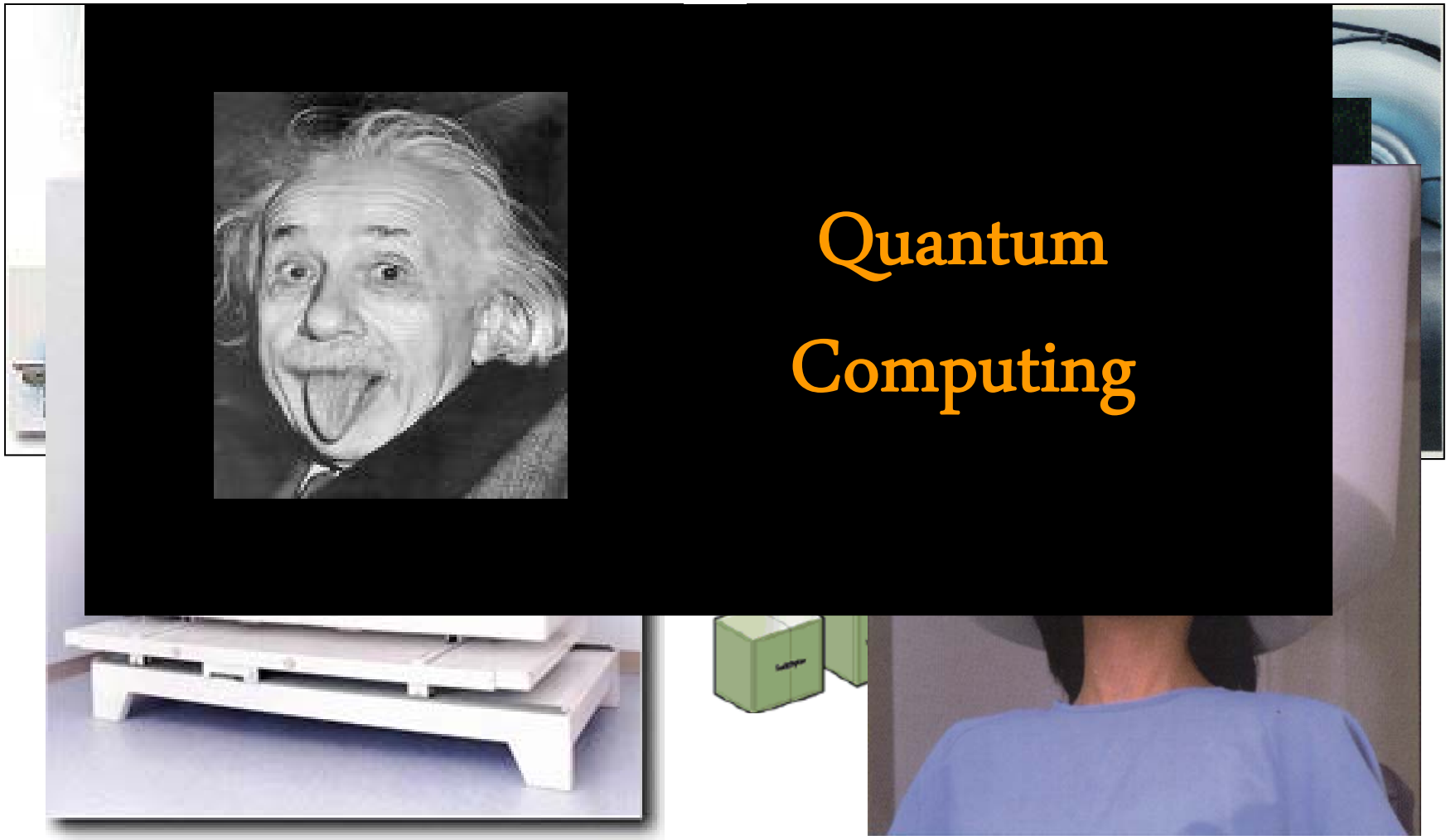
Yesterday (Japan 1975-85)

- Generators
  - "Super-GM"
- Transformers
  - For installation near hydroplants
- SMES
- Levitated Transport (Shinkansen)
- Cables (small scale demos)

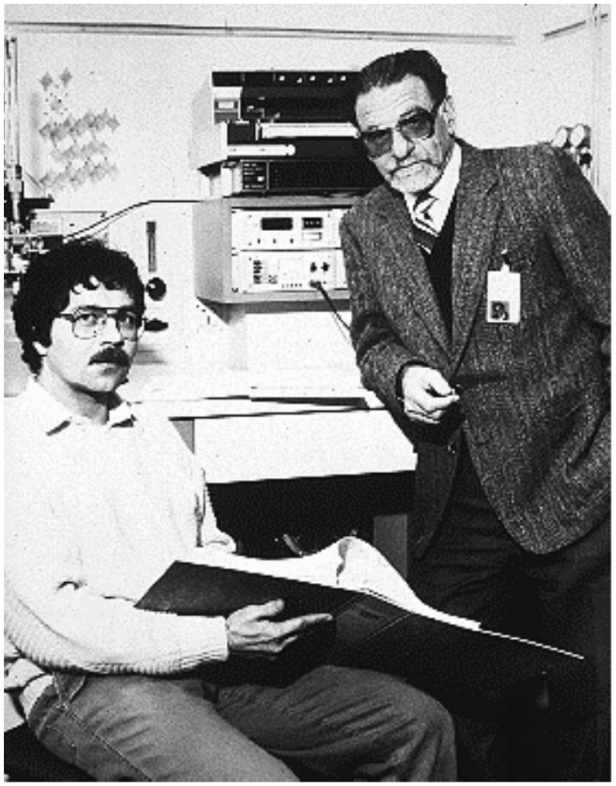
Yesterday (IBM)

- Crowe Cell
  - Replace magnetic cores
    - Cores got faster
- Josephson (a long story)
  - Speed
    - Blindsided by high-current bipolars
  - Low Power
    - Blindsided by MOSFET
  - Upside: Most sensitive SQUIDS available

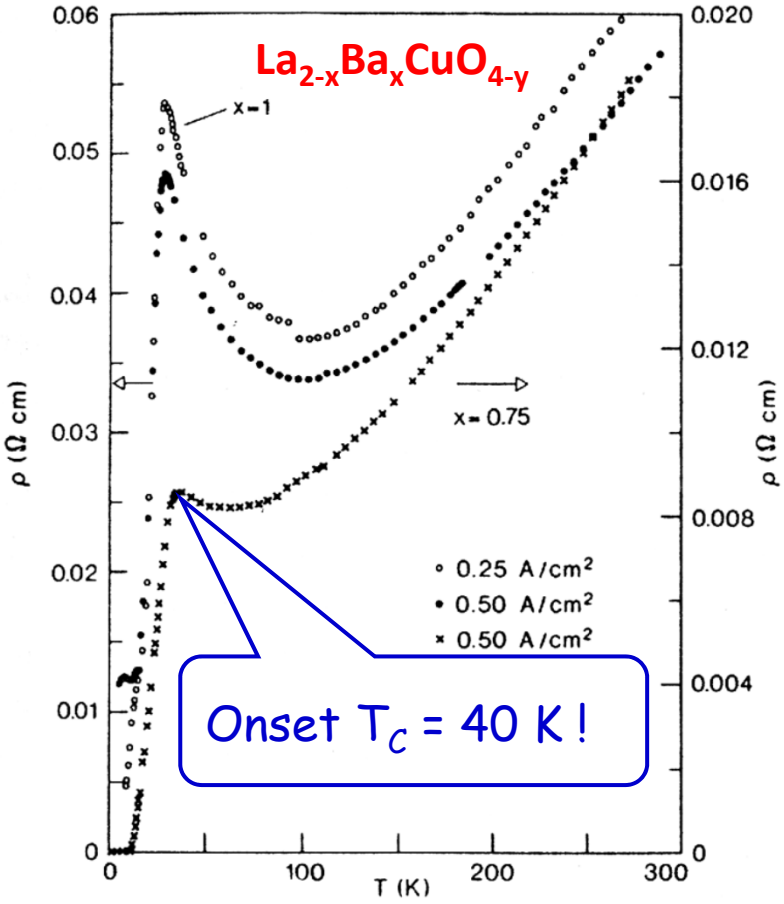
Today



1986
Another Big Surprise!



Bednorz and Mueller
IBM Zuerich, 1986



1987
“The Prize!”

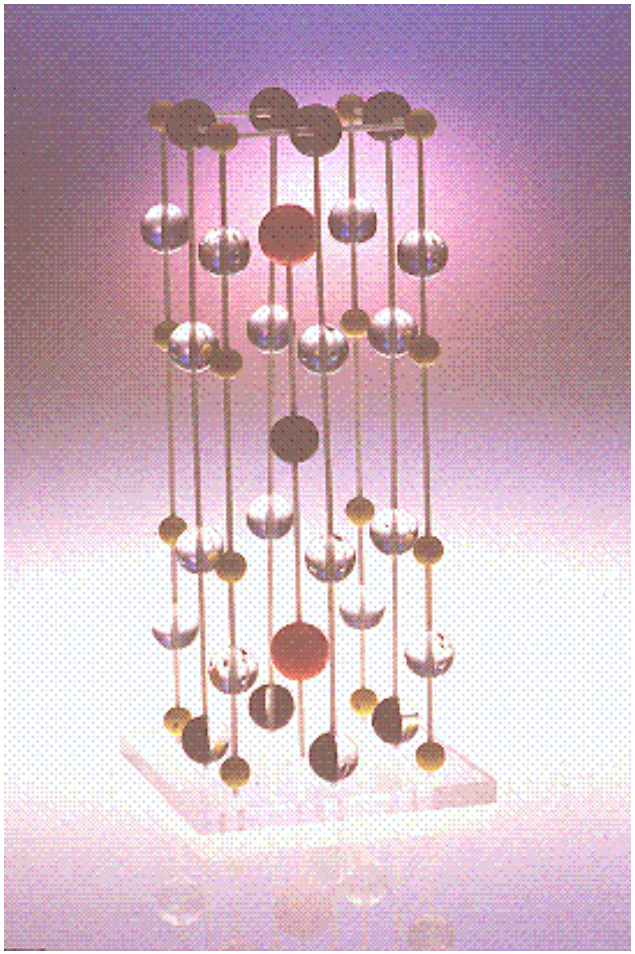
Associated Press

J. Georg Bednorz, left, and K. Alex Müller after learning they had won the Nobel Prize in physics.

2 Get Nobel for Unlocking Superconductor Secret

March 3, 1987

“123” Structure Discovered at IBM Almaden



Woodstock of Physics
NYC, 1987

Physicists' Night Out!

commentary

Woodstock of physics revisited

Ten years have passed since the now famous American Physical Society meeting that heard the first breathless accounts of high-temperature superconductivity. Now, in calmer times, practical applications are emerging.

Paul M. Grant

Snap quiz: who can tell me the winner of the 1987 Super Bowl? Not most physicists, I suspect, for whom it was certainly eclipsed by two events of far greater consequence that shared the early months of that year. One, the discovery of Supernova 1987A, perhaps portended the other: the announcement of superconductivity above liquid-nitrogen temperature on planet Earth — a dream fulfilled for many condensed-matter physicists like myself, whose careers had orbited around this elusive star.

The successful sighting[1] fell to W. K. Wu and C. W. (Paul) Chu and their teams of students and postdocs at the Universities of Alabama and Houston, following only five months after the publication in autumn 1986 by Georg Bednorz and Alex Müller[2] at IBM Zürich of their discovery of superconductivity in a previously unexplored class of compounds, the layered copper-oxide perovskites.

The 'inside' story of the hectic interval between the first week in January 1987 — when an announcement of the confirmation of Bednorz and Müller's discovery first brought 'high-temperature superconductivity' to wide public attention — and the week of the American Physical Society's March meeting, remains to be told. Suffice it to say that this period, and the last three months of 1986, were replete with incredulity, credulity, excitement, secrecy and a sense of immediacy in competition with one's peers, all of which resulted in, frankly, a substantial amount of intrigue and suspicion. All who participated surely came to understand, if they had not done so before, that physics is not only a science but, perhaps more significantly, an intensely human pursuit — something they do not teach you in graduate school.

Rising stars: Müller and Chu with Shoji Tanaka (right), whose Tokyo laboratory provided one of the first confirmations of Bednorz and Müller's discovery.

The programme of the March meeting, held each year in a different US city, is 'cast in concrete' early the preceding December; thereafter, an absolute policy of no alterations prevails. By the deadline of 5 December 1986, for the 1987 meeting at the Hilton hotel in New York City, only one abstract had been accepted on the new materials: "Specific heat of Ba–La–Cu–O superconductors" by Rick Greene and his collaborators at IBM Yorktown. But the explosion of results that appeared in the new year prompted the meeting's organizers to take an unprecedented step. Brian Maple of the University of California, San Diego, was asked to put together a special post-deadline evening session devoted entirely to the discovery.

All those wishing to report results would be granted five minutes each, in order of the arrival of their request to take part — and did the requests rain in, reaching a downpour in the two weeks before the meeting, as confirmations of the Wu–Chu measurements were made. All in all, 51 presentations were to be given throughout the evening and early morning of Wednesday and Thursday, 18 and 19 March. That memorable and riotous session was to become our "Woodstock of physics", so named in honour of the village only 50 miles north where, in an obscure farmer's muddy field in 1969, the rock concert occurred that defined a generation of youth the world over.

Fever pitch: the room filled to overflowing with physicists eager for news of superconductivity.

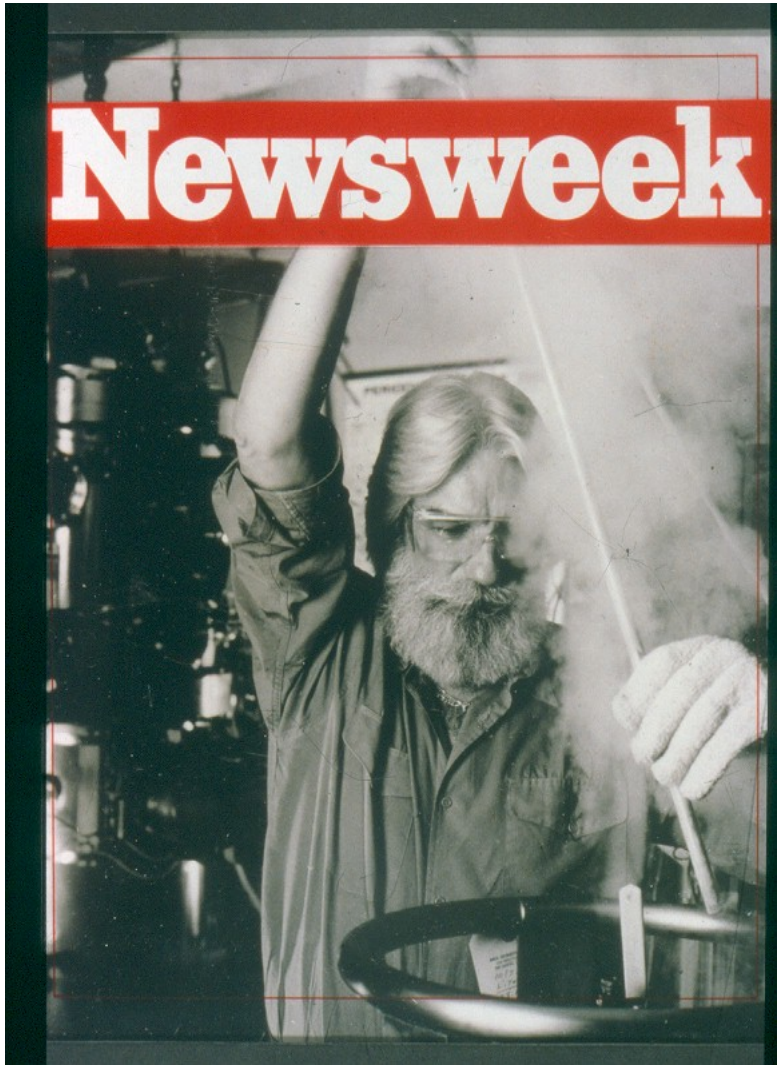
Opening act

A few personal observations and anecdotes may help to convey the colour of that week in midtown Manhattan. Excitement was running high even before Wednesday night. On Monday, the opening day, the press were already beginning to catch some of us to be interviewed. That noon my colleague Ed Engler and I went to lunch at a nearby Brew 'n' Burger and found Alex Müller sitting by himself in a corner booth, attempting to escape the turmoil at the Hilton. At the time he was not yet widely recognizable to those attending the meeting or to the press — a situation that would soon change.

“The Great Communicator”

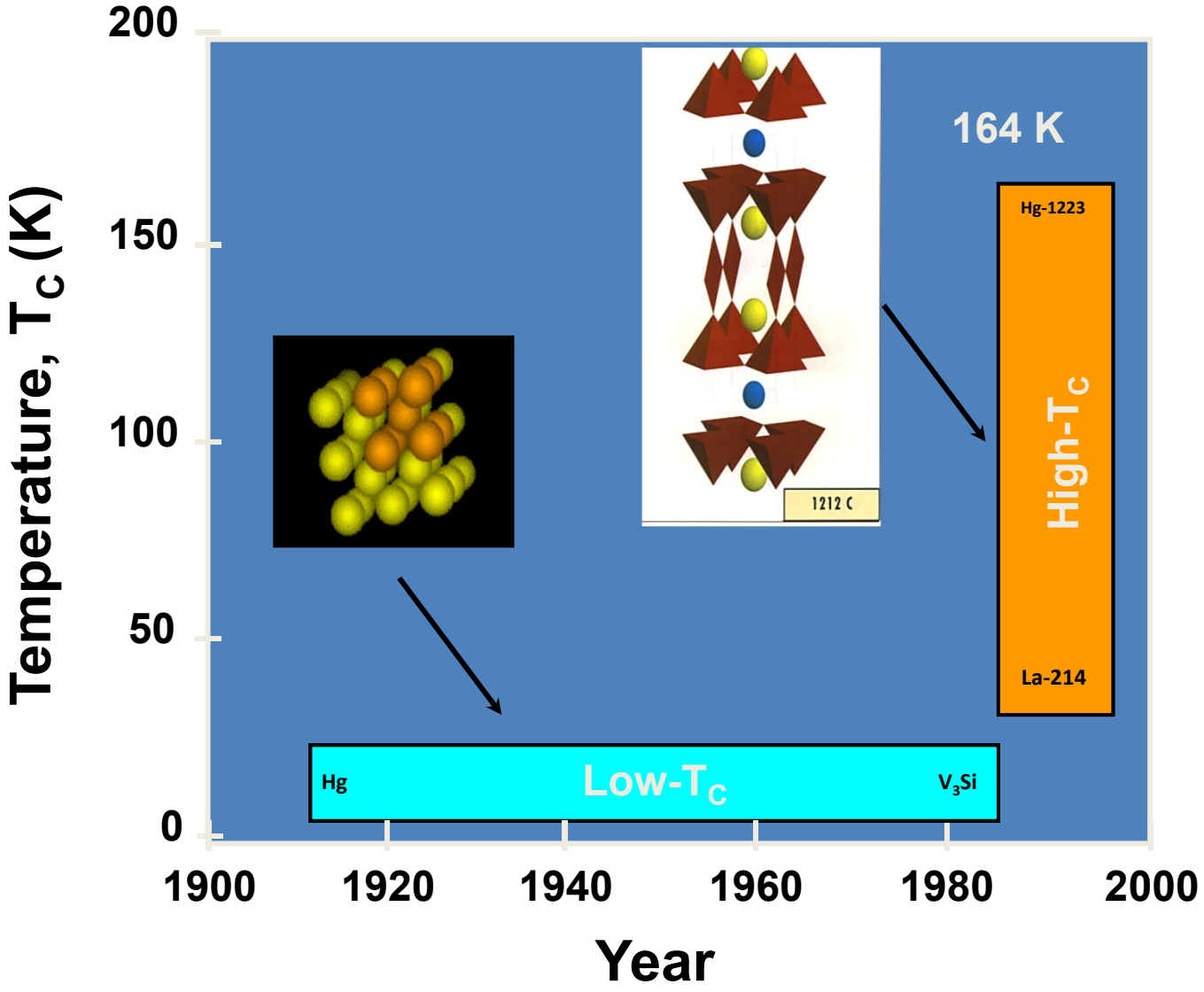
Alan Schriesheim, Director of Argonne National Laboratory, demonstrates superconductivity to the President, Chief of Staff Howard Baker, Secretary of Defense Caspar Weinberger, Secretary of State George Shultz and Secretary Herrington.

15 Nanoseconds of Fame

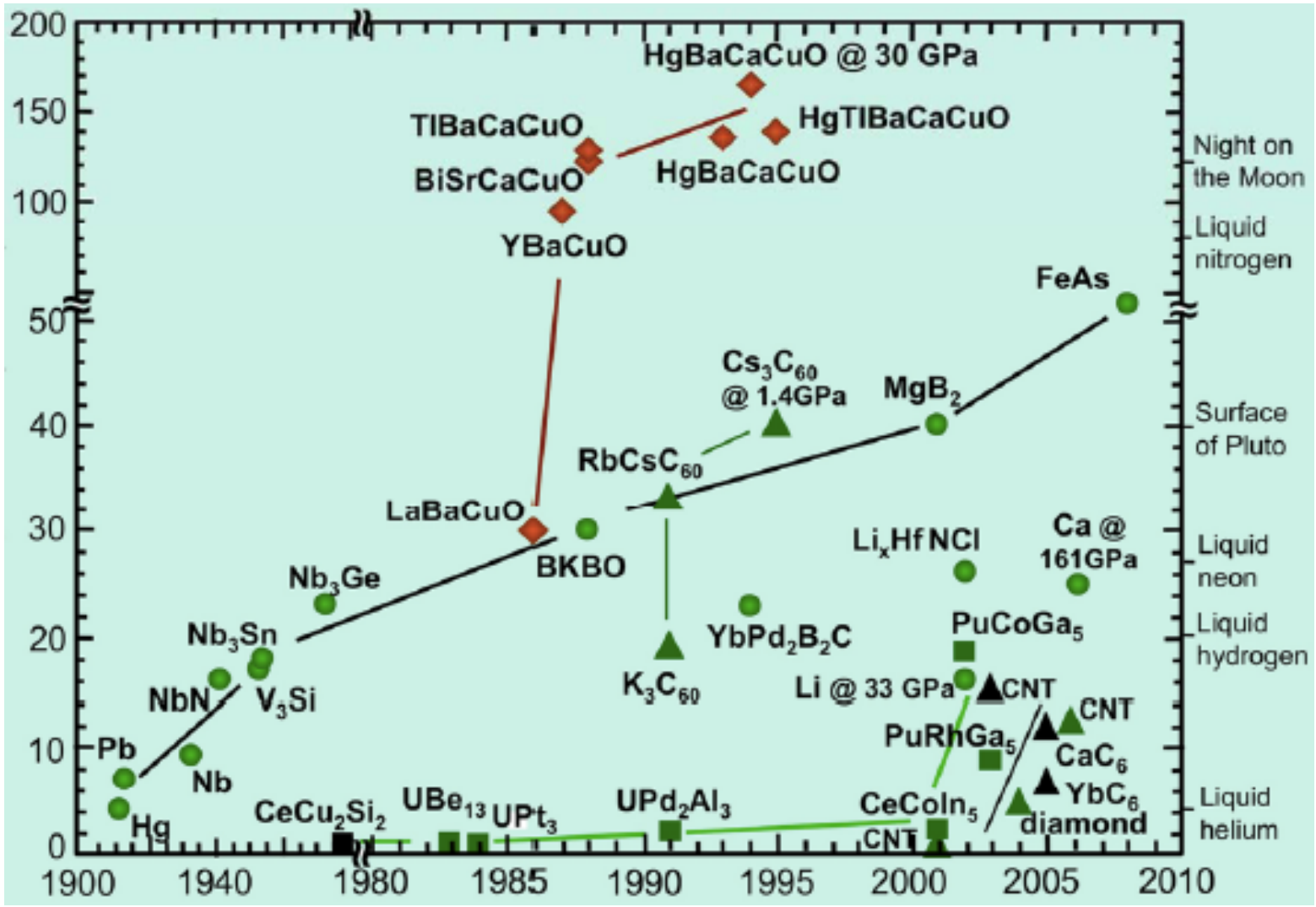


High-Tc Applications

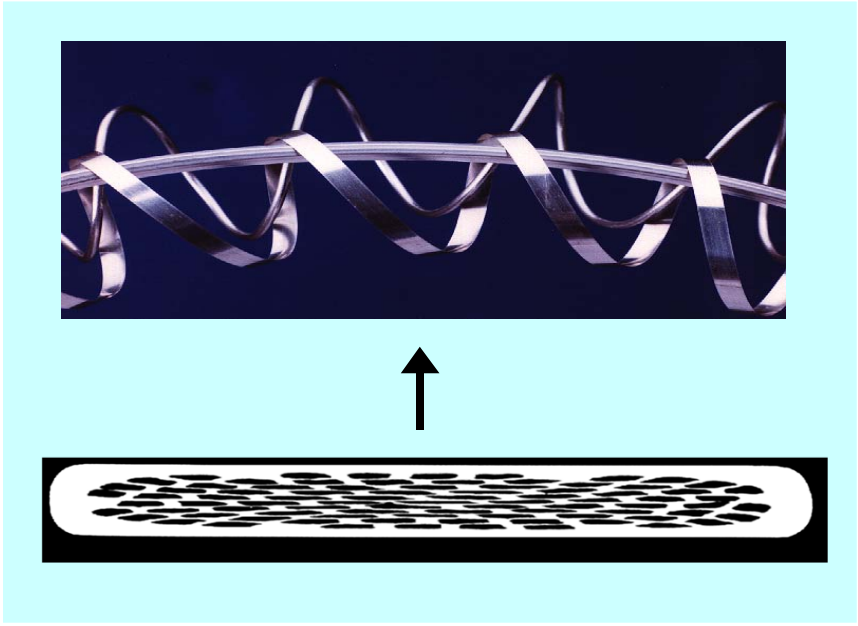
HTSC Today

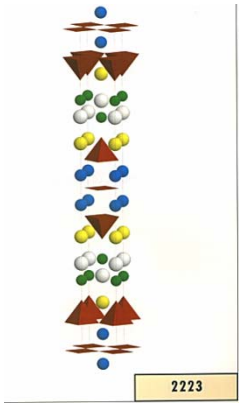

200
150
100
50
0
Temperature, T_C (K)
1900
1920
1940
1960
1980
2000
Year
164 K
Hg-1223
High-T_C
La-214
1212 C
Hg
Low-T_C
V_3Si

Today in Detail



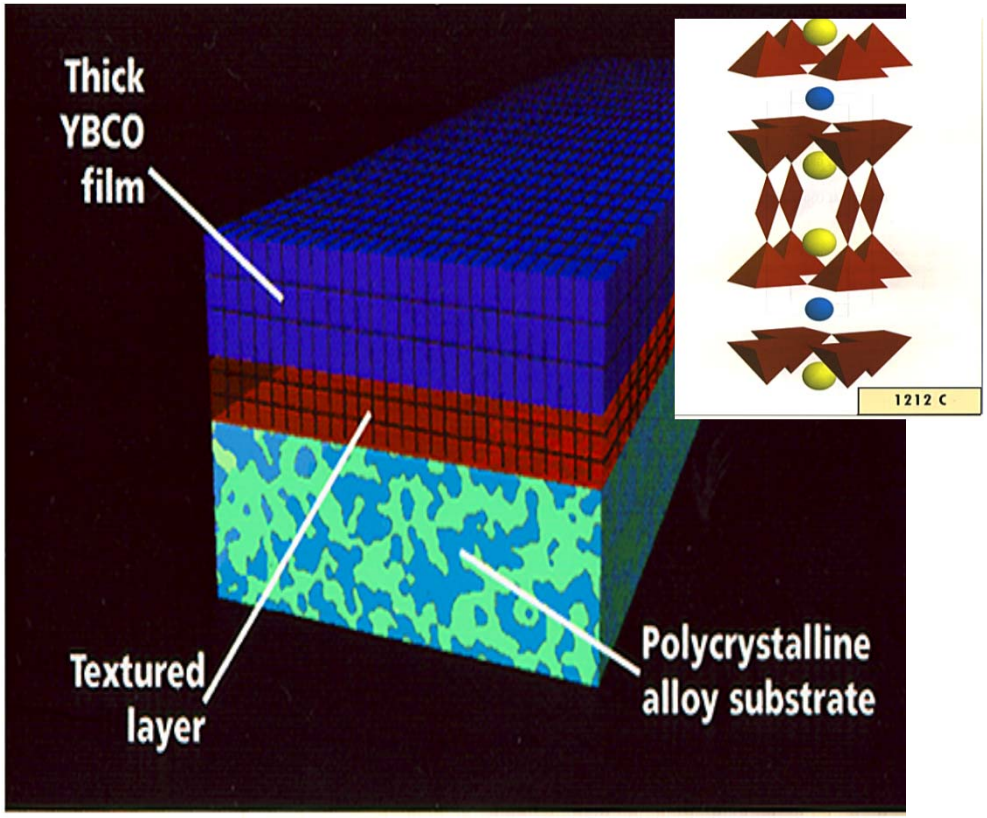
Practical HTSC Wire is Available



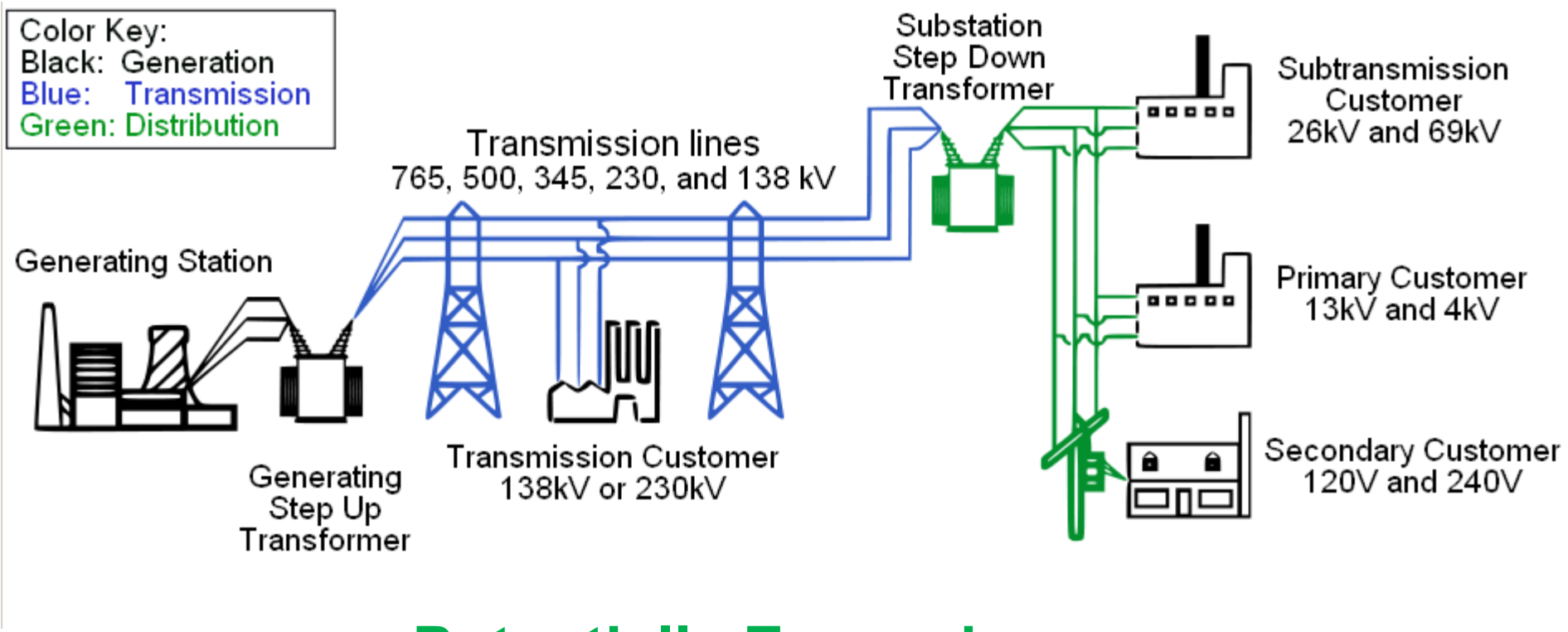


Gen 1

Gen 2



Where Can We Apply Superconductivity to Electric Power?



Potentially Everywhere

HTSC Utility Market (2006)

In the utility/energy market, the applications that appear to value performance attributes of HTS most are Fault Current Limiters and Synchronous Condensers.

10 More Years!

	Utility/Energy Market - Importance of Performance Attributes					
	Small & Light	High Power Density	Low Impedance	High Efficiency	High Field	Overall
Power Cable	●	●	●	●	○	●
Synchronous Condenser	●	●	●	●	●	●
Fault Current Limiter*	●	●	●	●	○	●
Industrial Motor	●	●	●	●	●	●
Utility Generator	○	○	●	●	●	●
Wind Generator	●	●	●	●	●	●
Transformer	●	●	●	●	○	●

Source: NCI Analysis, see Appendix: Value Propositions

* Fault current limiters also rely on the inherent quench properties of HTS.

NAVIGANT

US Department of Energy

Budget of the Office of Electricity Delivery and Energy Reliability: FY 2010-11 (10^3 USD)

	FY 2009		FY 2010	FY 2011
	Current Appropriation	ARRA Appropriation	Current Appropriation	Congressional Request
Research and Development				
High Temperature Superconductivity	23,130		?	?
Visualization and Controls	24,461			
Energy Storage and Power Electronics	6,368			
Renewable and Distributed Systems Integration	29,160			
Clean Energy Transmission and Reliability			38,450	35,000
Smart Grid Research and Development			32,450	39,293
Energy Storage			14,000	40,000
Cyber Security for Energy Delivery Systems			40,000	30,000
SUBTOTAL Research and Development	**83,119**		**124,900**	**144,293**
Permitting, Siting, and Analysis	5,271		6,400	6,400
Infrastructure Security and Energy Restoration	6,180		6,187	6,188
Program Direction	21,180		21,420	29,049
Congressionally Directed Activities	19,648		13,075	
American Recovery and Reinvestment Act, 2009		4,495,712		
Use of prior year balances	-769			
TOTAL	**134,629**	**4,495,712**	**171,982**	**185,930**

WOW ! "Obama Cash"

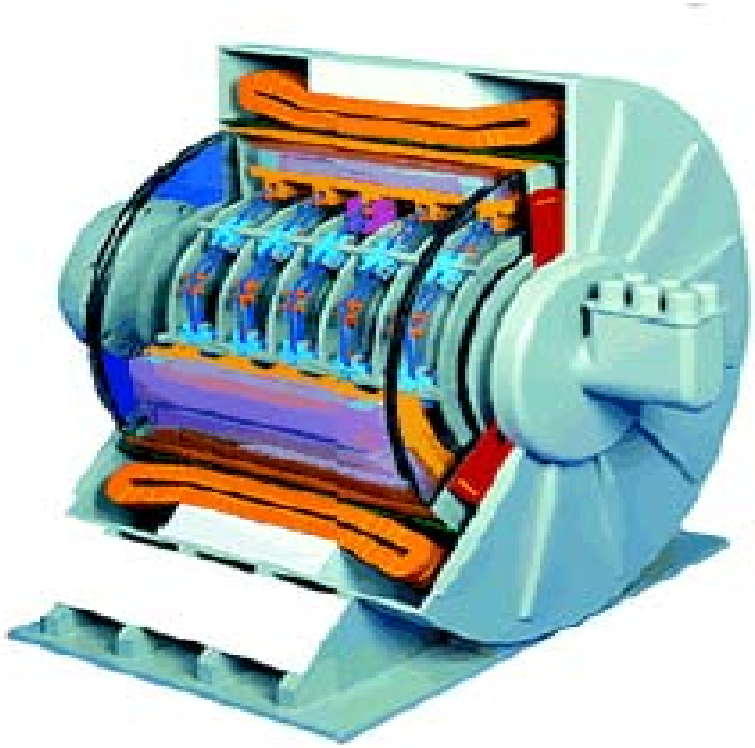
EPRI & Superconductivity

1993-2003 ($18M)

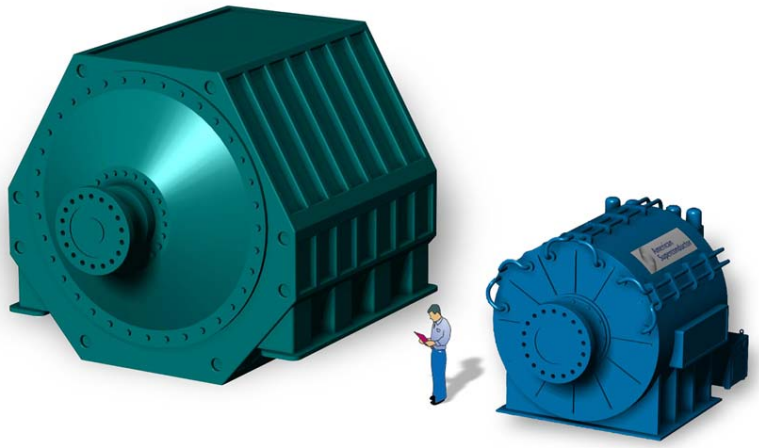
Universities	Industry	Institutions
Wisconsin	AMSC*	LANL
Stanford	Superpower	LBNL
MIT	IBM	ORNL
Houston	Pirelli	DOE (Partner)
Maryland	Westinghouse	CCAS
	Detroit Edison	

*Coated Conductor Alliance ($4M(EPRI)+$6M(AMSC))

Rotating Machinery - Motors



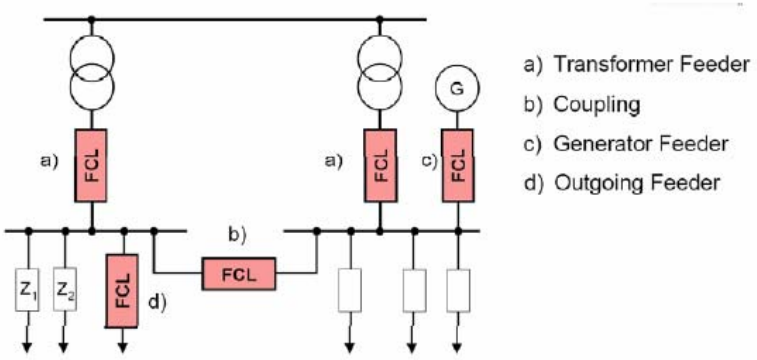
- 25,000 hp
- Small, Light (1/5 Conventional)
- High Power Density
- Quiet
- Robust



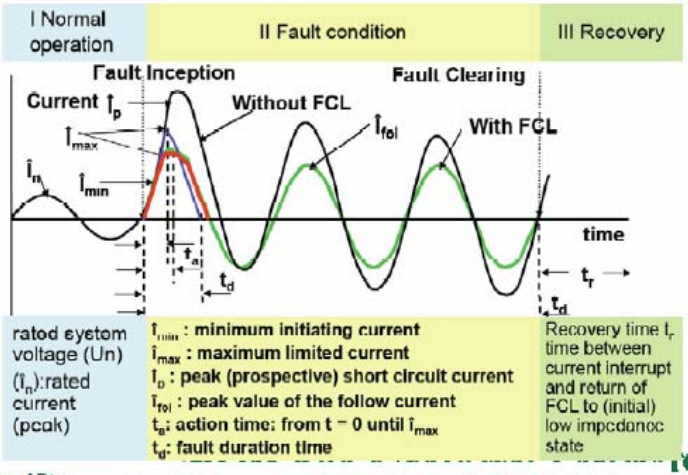
Some Current "FCL" Projects

Thanks…Robert Duckworth

- **Overview of FCL projects**
  - **Stand-alone FCL devices**
    - **Resistive**
    - **DC Iron Core**
  - **Integrated FCL devices**
    - **FCL HTS Cable**
    - **FCL HTS Transformer**



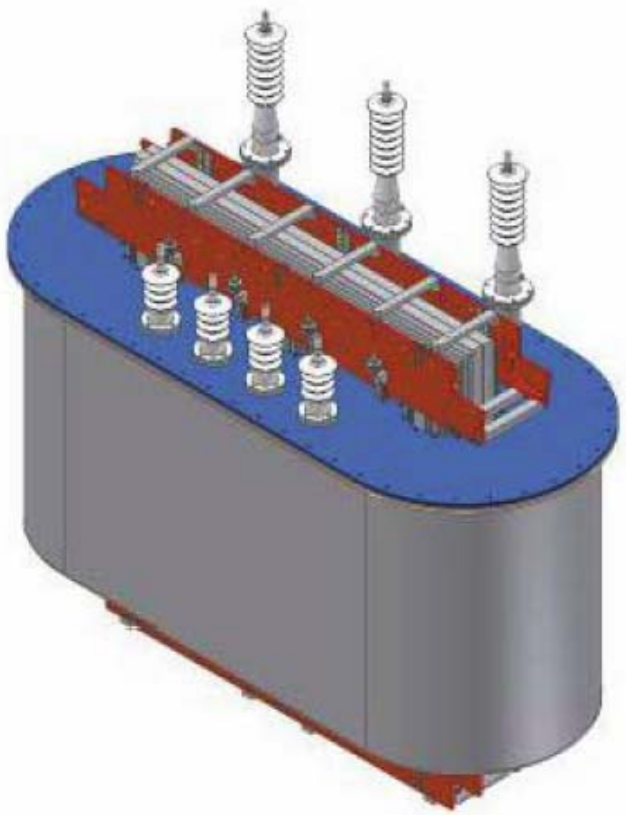
M. Noe @ CCA 2009



S. Eckroad EPRI @ CCA 2008

HTSC FCL/XFMR Combo (2009)

- **Smart Grid Demonstration Project**
  - **Waukesha Electric**
  - **SuperPower**
  - **Oak Ridge National Laboratory**
  - **University of Houston**
  - **Southern California Edison**
- **Fault current limiting transformer rated for 28 MVA**



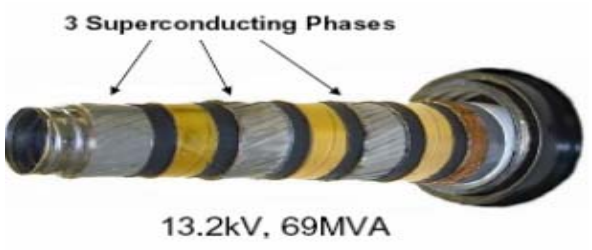
Year	HTS Cable Demonstration	Cable Manufacturer

Nexans

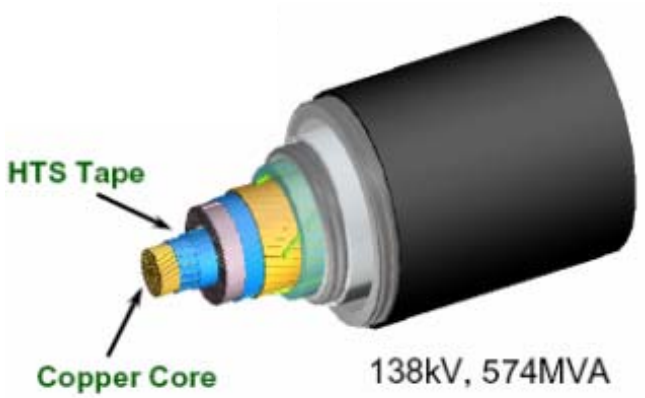
AMSC/Nexans
Long Island Power Authority

Various ac HTSC Cable Designs

Sumitomo



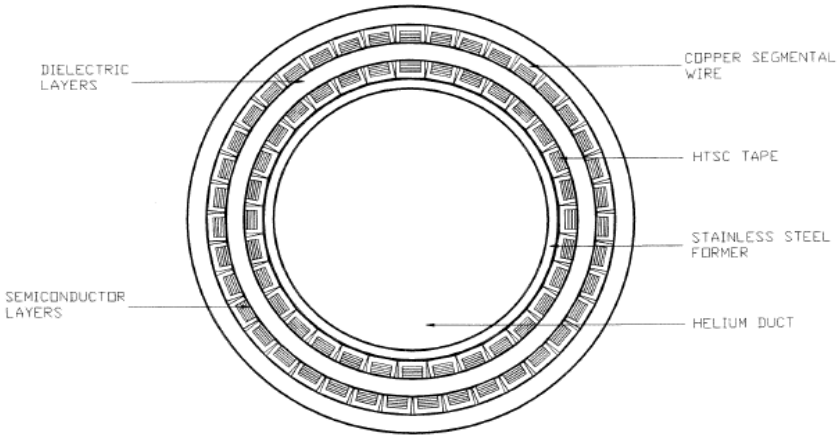
Ultera-ORNL



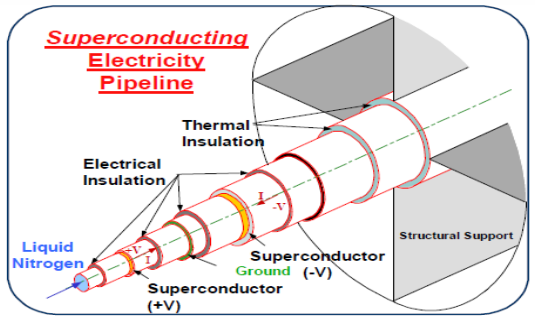
Nexans-AMSC

Pirelli

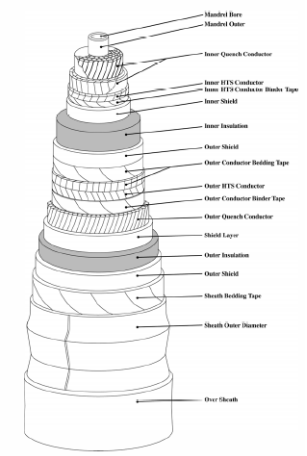
Various dc HTSC Cable Designs

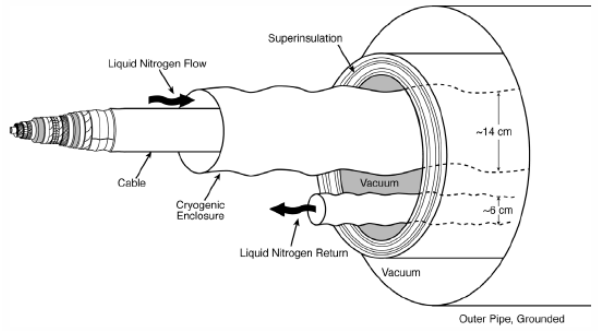


BICC: Beales, et. al, (1995)
40 K, +/- 20 kV, 10 kA, 400 MW



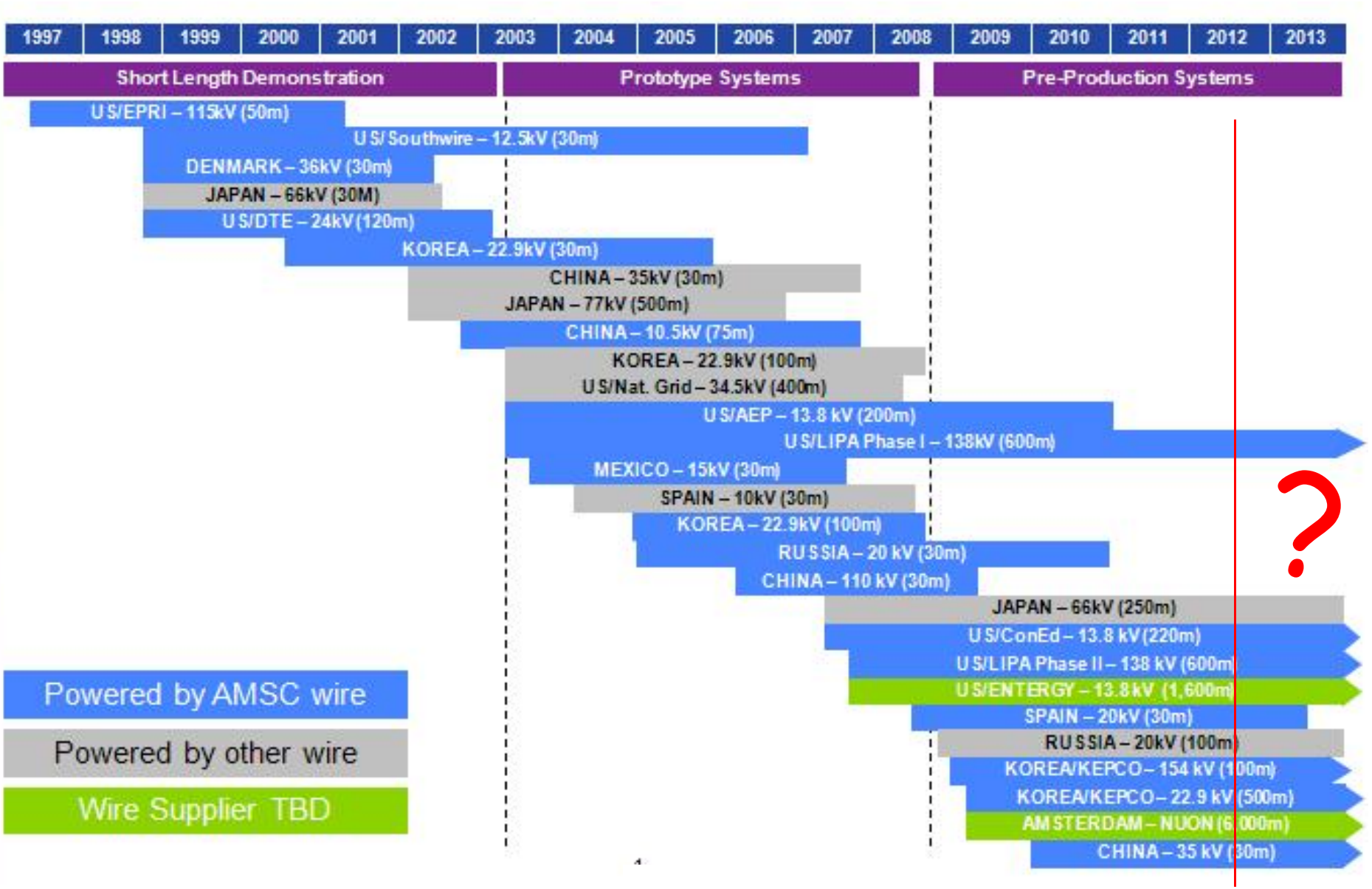
EPRI: Schoenung, Hassenzahl, Grant (1997)
+/- 50 kV, 50 kA, 5 GW





EPRI: Hassenzahl, Gregory, Eckroad, Nilsson, Daneshpooy, Grant (2009)
+/- 50 kV, 100 kA, 10 GW

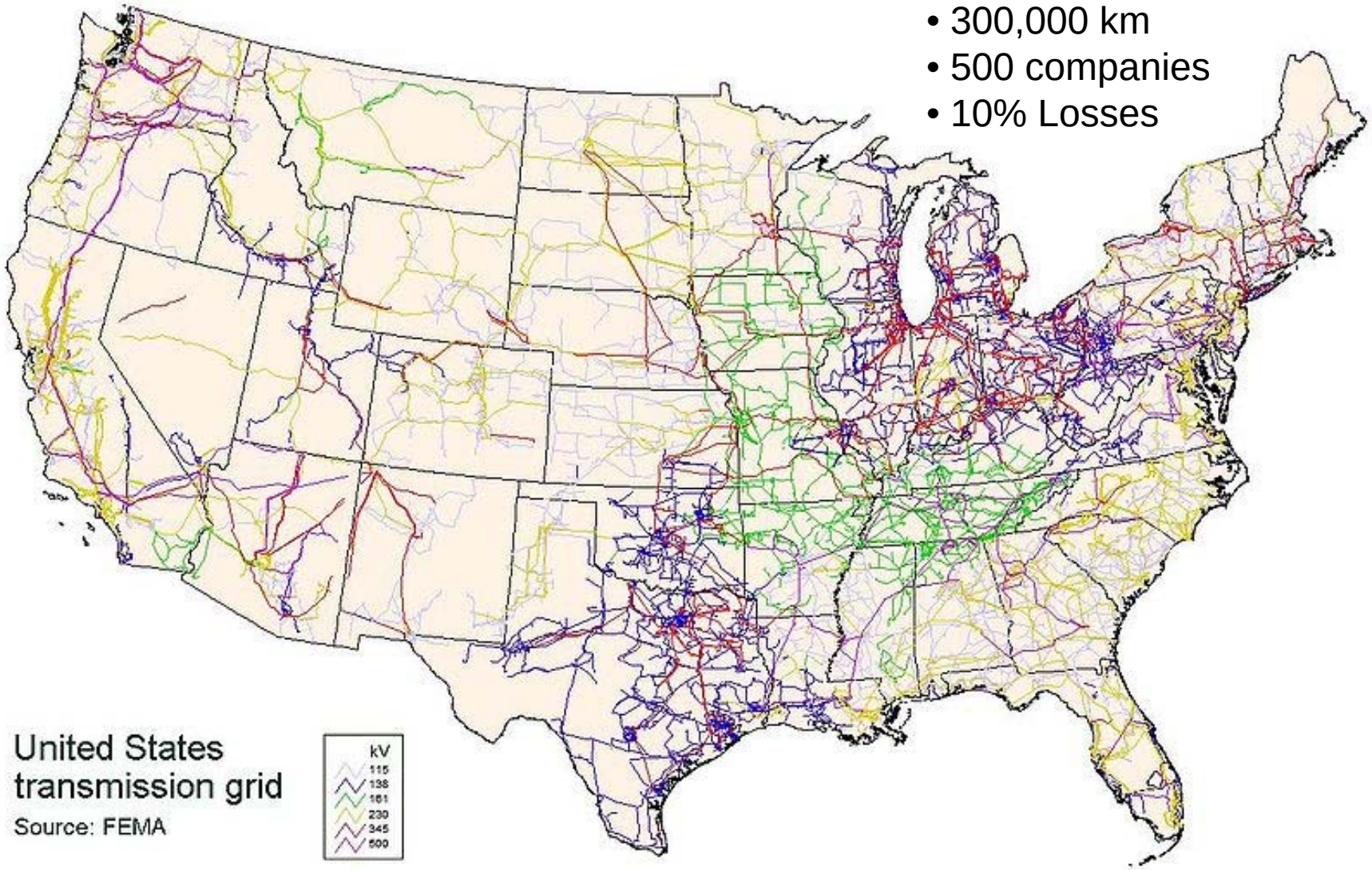
HTSC Cable Demonstration Projects Worldwide Past, Present…Future?



Is There a Future for HTSC Superconductivity?

The US Transmission Grid(s)

- 300,000 km
- 500 companies
- 10% Losses



Pacific Intertie

- HVDC, +/- 500 kV, 3.1 kA, 3.1 GW
- 1,362 km
- ~50% of LA Power Consumption
- T&D Losses ~ 10%

Celilo I/C Station
“A Mountain of Silicon”

Fathers of Electricity

Edison

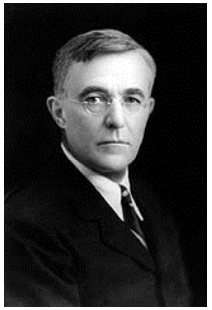
Practitioners

Insull

Tesla

Coolidge

Langmuir



Thomson
&
Sprague

Steinmetz

Can “New” Transmission Technology Help?

- Yes, but probably not superconductivity in a big way, at least for a while.
- More likely, “smart” grid stuff will come first
  - HVDC cables and lines
  - FACTS to increase present corridor capacity by 30%
  - IT and communications plus an “OS/360” to more effectively and efficiently management power flows

A Modest Proposal
-Upbraiding the Utilities-

- More than a half-century of successful demonstrations/prototyping power applications of superconductivity (1950s - >2000, in Japan and US)…low- and high-Tc…now sitting "on the shelf."
- Why aren't they "in the field" today?
- Is their absence due to…
  - Cost?
  - Hassle?
  - or "lack of compelling" need?
  - or "all of the above?"

- US utilities have long claimed to “want”…
  - Efficient long-length cables
  - Oil-free transformers
  - Energy Storage
  - Fast fault current limiters at high voltage (FCLs)
  - Efficient rotating machinery (aka, motors and generators)
- Well, we got ‘em. Utilities claim:
  - They’re too high-cost, because,
    - The wire is too expensive.
    - They have to be kept too cold.
    - Electricity is cheap, and “in field” energy efficiency is not a “compelling” driver
  - Anyway, we can solve our needs by incrementally improving the “old” ways (<u>don’t ever underestimate the ingenuity of a utility engineer to improvise, adopt and adapt</u>)

“Then…a modest proposal…”

- If the “cost” of the wire in any given application were to be “zero,”…
- Would the utilities then “buy them?” And sign a “letter of intent” to purchase “x” number?
  - e.g., Fault Current Limiters, for which US utilities have long claimed a need
- “Zero cost” would be obtained as a Federal or State “tax credit” for the wire cost of the quantity purchased by the utility equipment vendor or the utility itself…
- Well?

“Superconduct-ress”

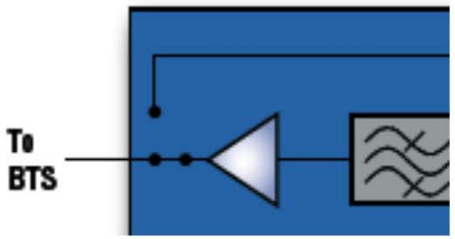
Mr. Electric Utility Good Ol' Boy

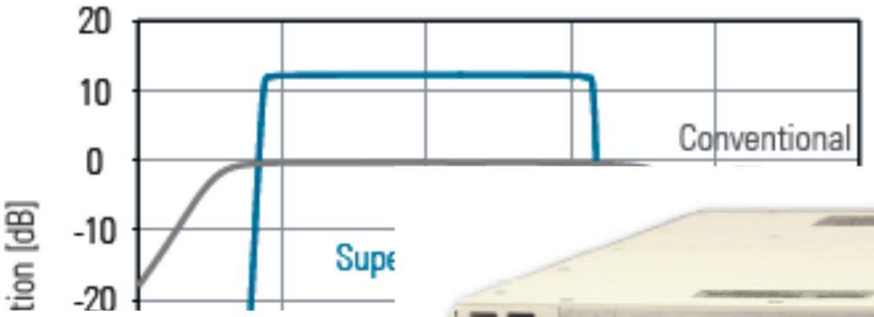
Miss Same Old Technology

Together Forever?

“Al Gore” – He’s Available !

Electronics





“A room temperature device !”

Woodstock + 25
So where are we?

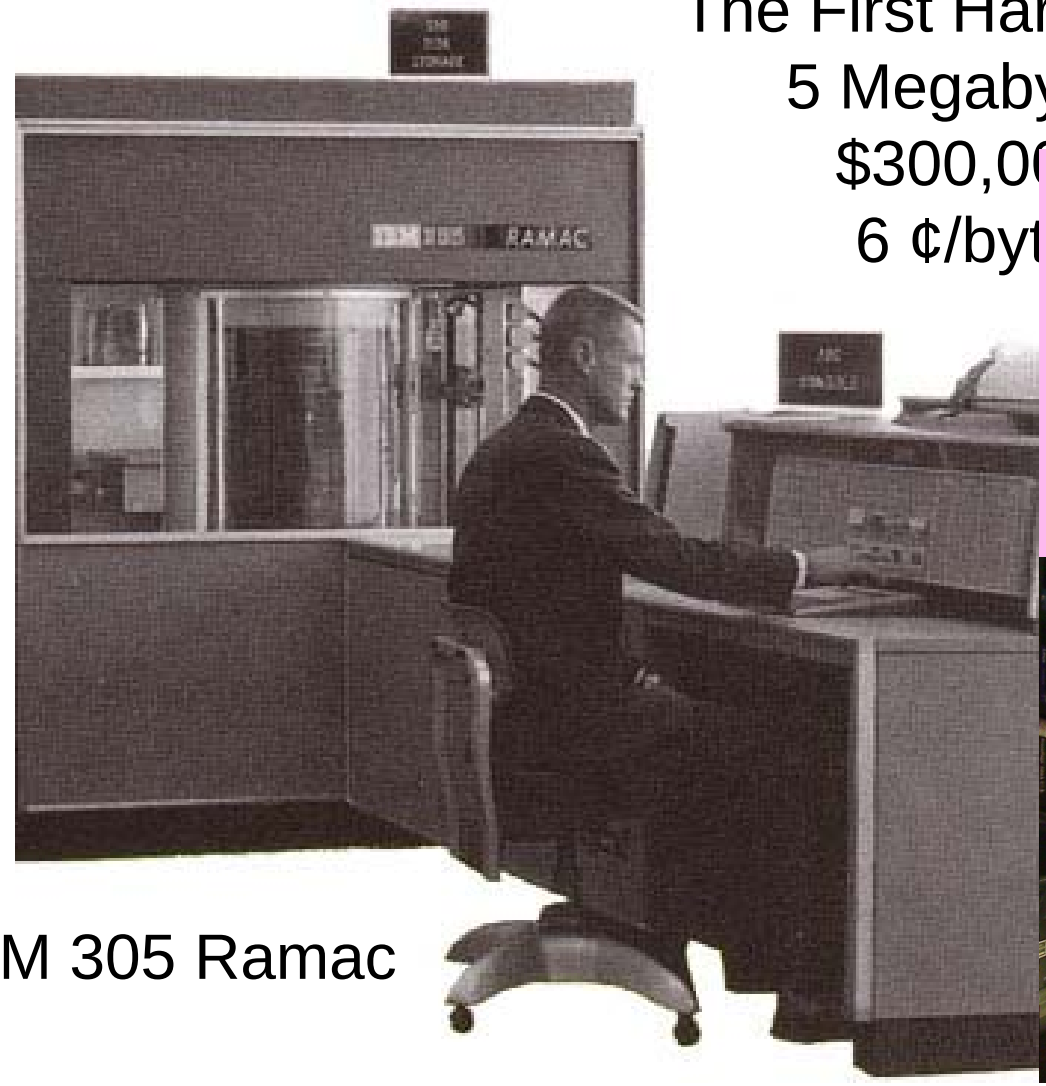
- There remains no (generally accepted) theory to explain high-Tc
- Nonetheless, we now have a high performance wire technology that works and is available in long lengths
- And there has been > 100 successful demonstrations of HTSC power equipment and applications
- Yet there exist no significant markets for HTSC applications – power or electronic
- WHY?

Because...

1) There’s not enough money to be made
2) ...and made quickly.
3) Old technologies can be improved incrementally and simultaneously achieve better performance more cheaply and increase market share
4) ...but not in the mature energy sector!

“Point 3) Example”

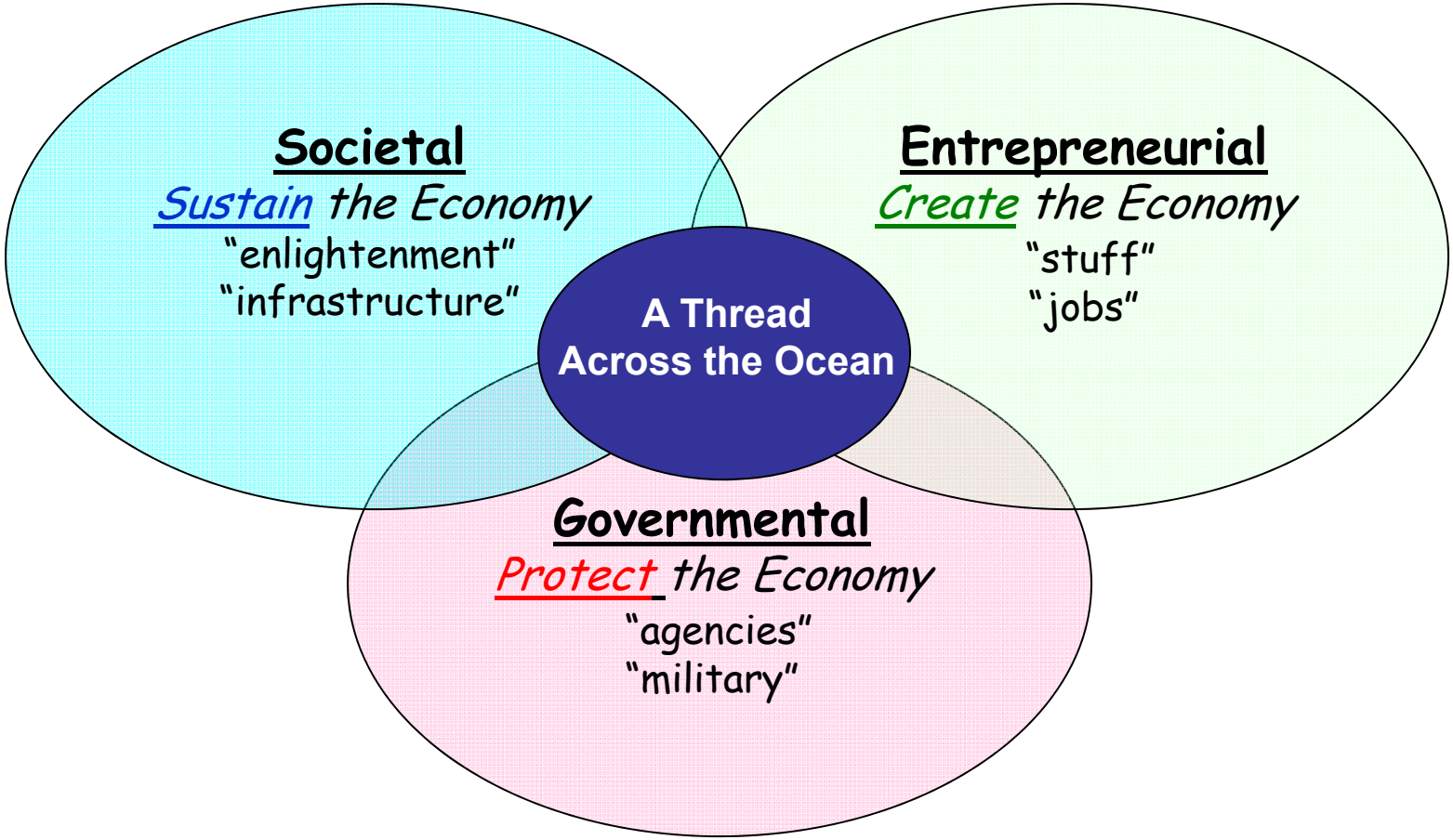
<u>1956</u>
The First Hard Drive
5 Megabytes
$300,00
6 ¢/byt



IBM 305 Ramac

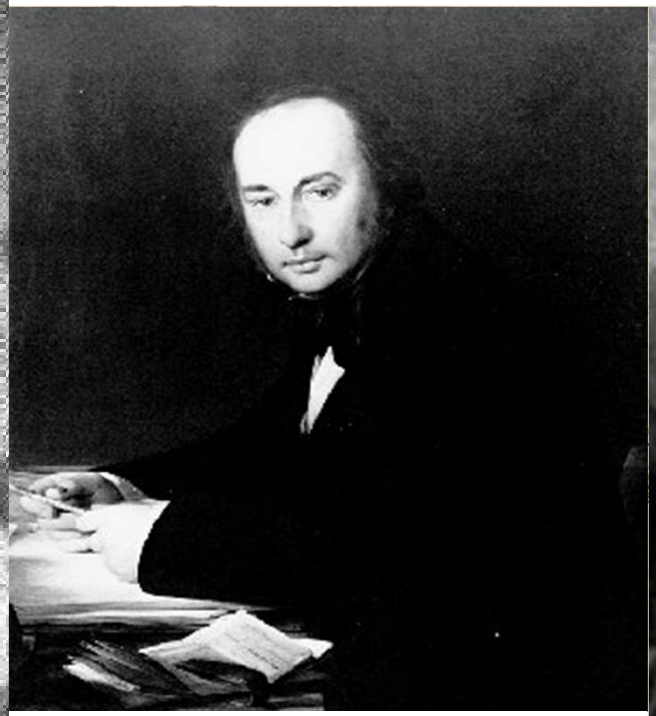
<u>2011 (+55)</u>
HP Personal Media
2 Terabytes
$100
5 nano-¢/byte

The Economic Troika That Drives and Exploits Technology Innovation



“A Thread Across the Ocean”

Cyrus Field
American Capitalist



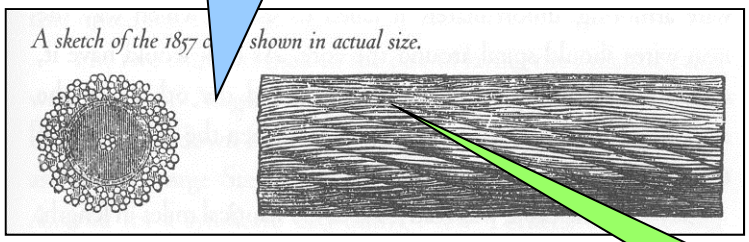
Isambard Kingdom Brunel
English Engineer

William Thomson
Irish Physicist

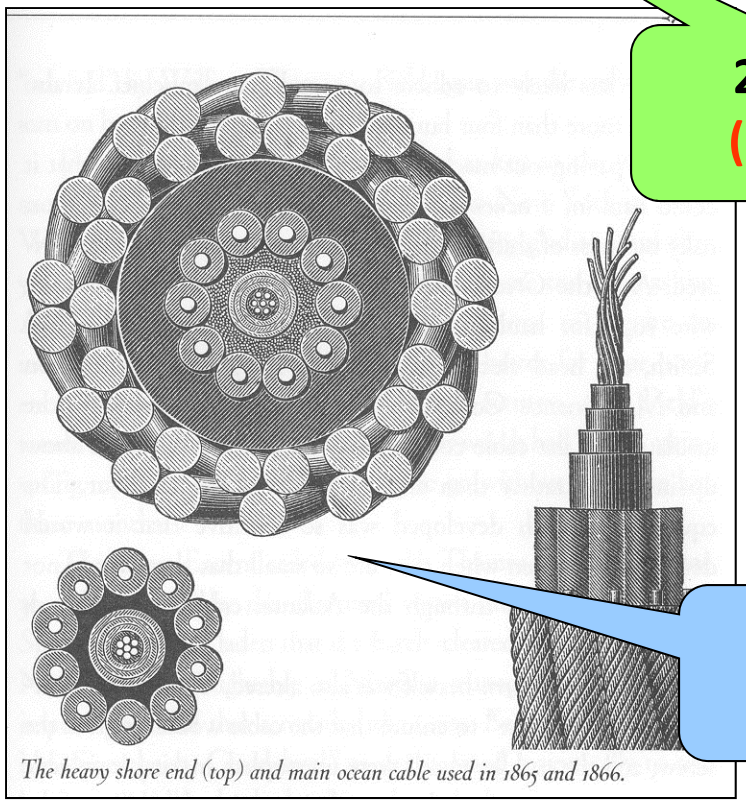
John Steele Gordon

Atlantic Cable Timeline & Designs

1857
"Broke"

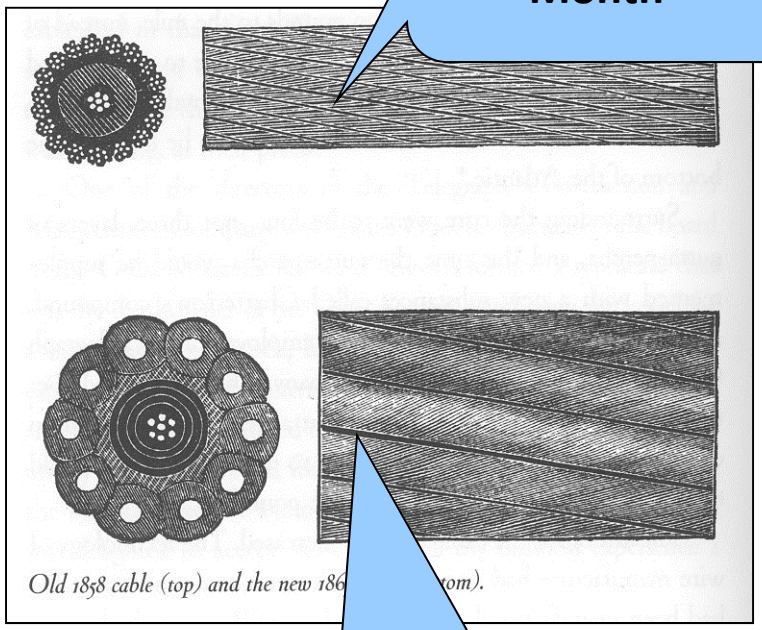


2 $/m
(2005)



1866
Success!

1858
"Worked for a Month"

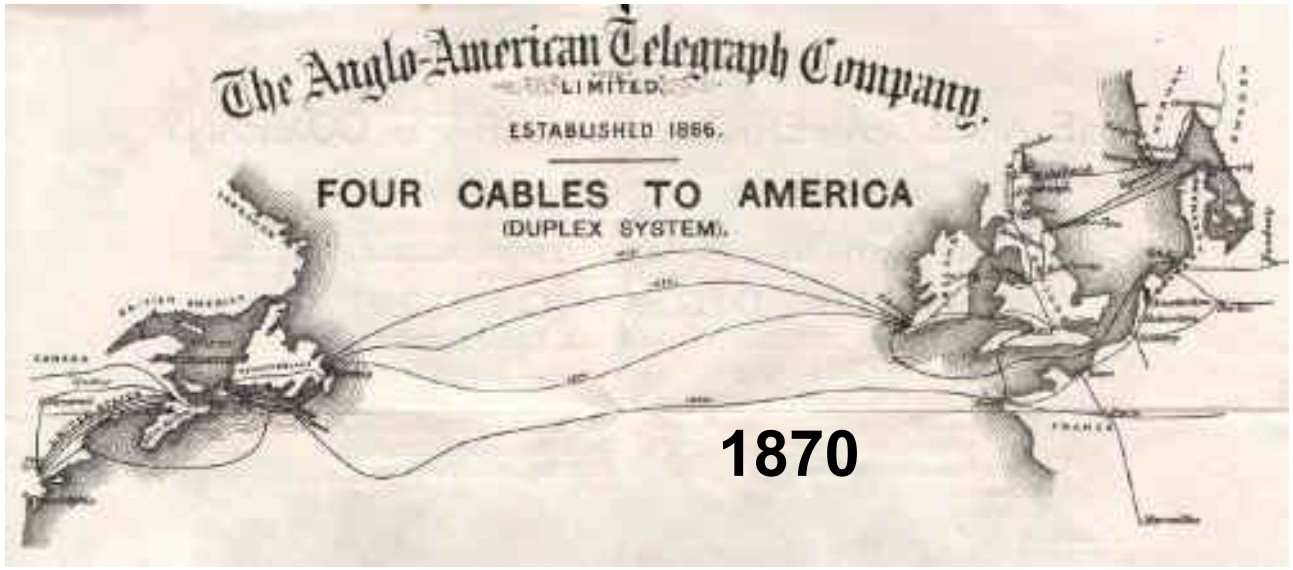


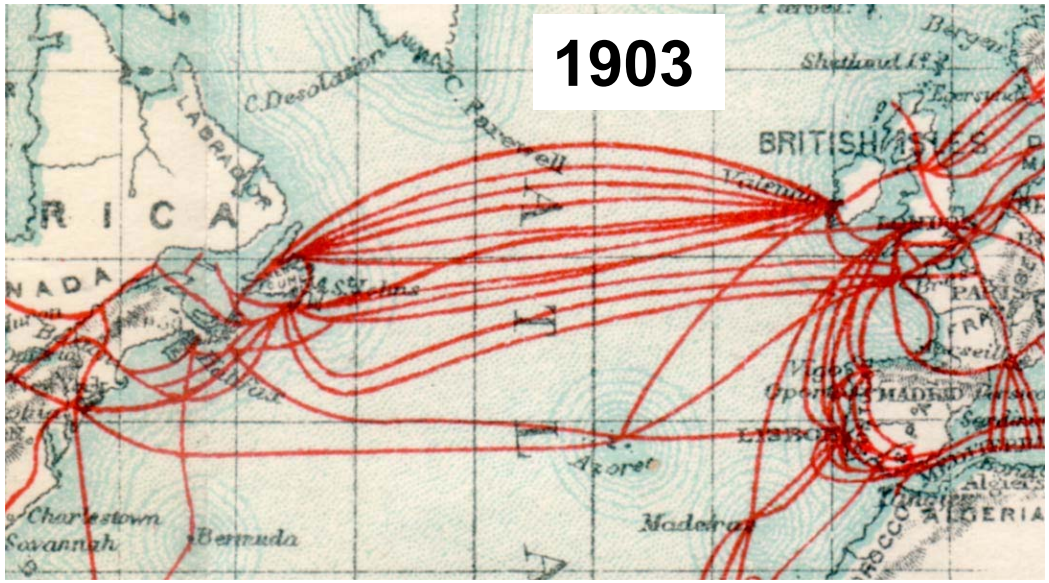
1865
"Parted"
(Recovered in 1866)

What Kept Them Going?

- The investors knew, that if communications with Europe could be cut from 2 weeks to 2 minutes, they'd all get…
- FILTHY RICH!
  - Estimates are that the total cost of the project in 2005 dollars was $100 M
  - First year 1867 revenue in 2005 dollars was $10 M !!

The After-Story





Is There a Future for Superconductivity?

-Yes-

The Ideal Energy Society

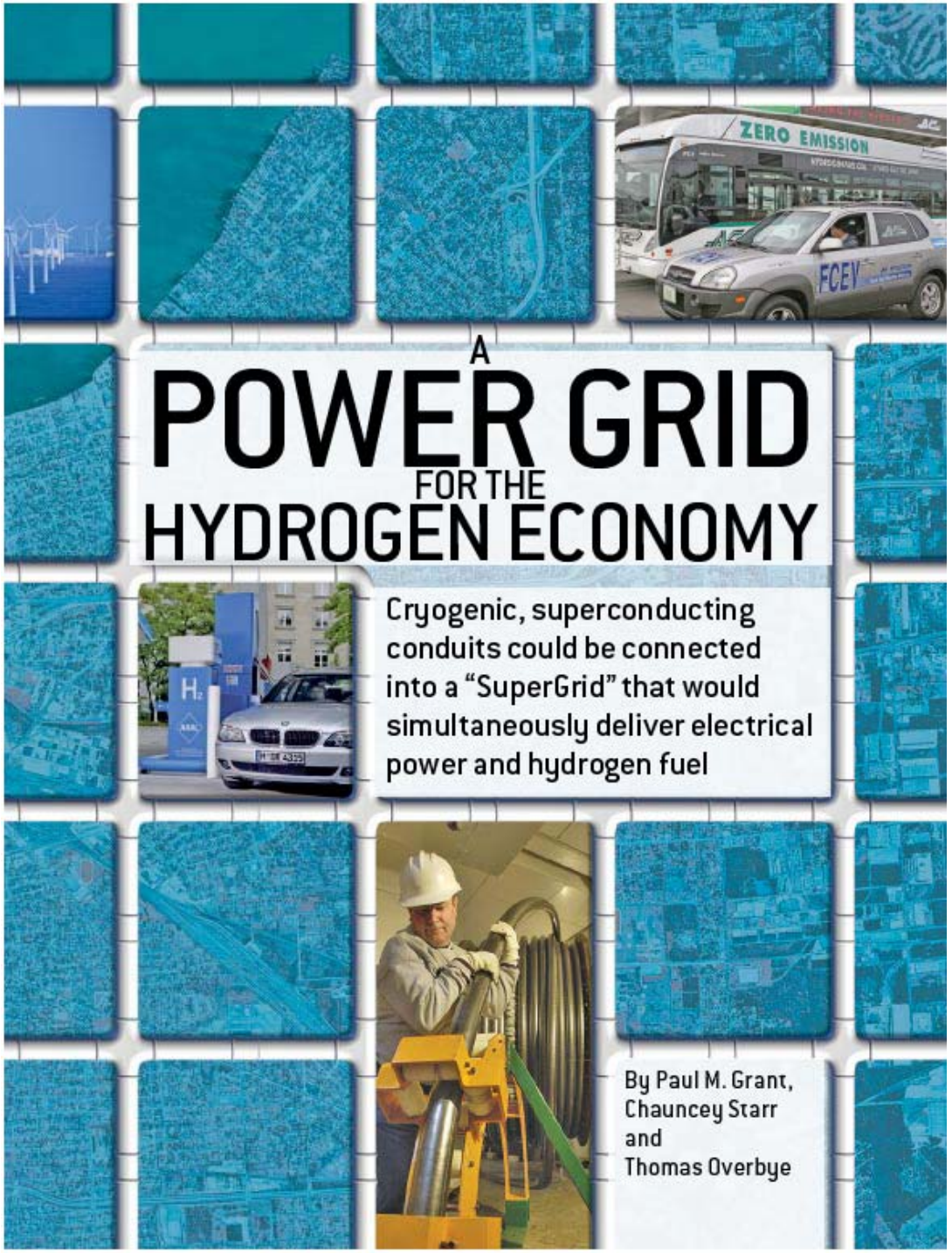
My Virtual Grandfather (@ 94)

Our Visionary Energy Society
- The Next “Thread?” -

- Carbonless
  - No CO_2
- Non-Eco-Invasive
  - Minimal land/ecology impact
- Off-the-table
  - Large scale renewables (wind, solar, bio)
  - Sequestration

Implementing Technology Menu

- Generation
  - HTGCR Nuclear (80%)
    - electrons
    - protons
  - PV Solar Roofs (20%)
- Transmission
  - Hydricity SuperCable
- Storage
  - Hydrogen + Hydricity Fuel Cell
- End Use Power
  - Electricity
  - Hydrogen



On the afternoon of August 14, 2003, electricity failed to arrive in New York City, plunging the 10 million inhabitants of the Big Apple—along with 40 million other people throughout the northeastern U.S. and Ontario—into a tense night of darkness. After one power plant in

Published in

SCIENTIFIC AMERICAN

July, 2006

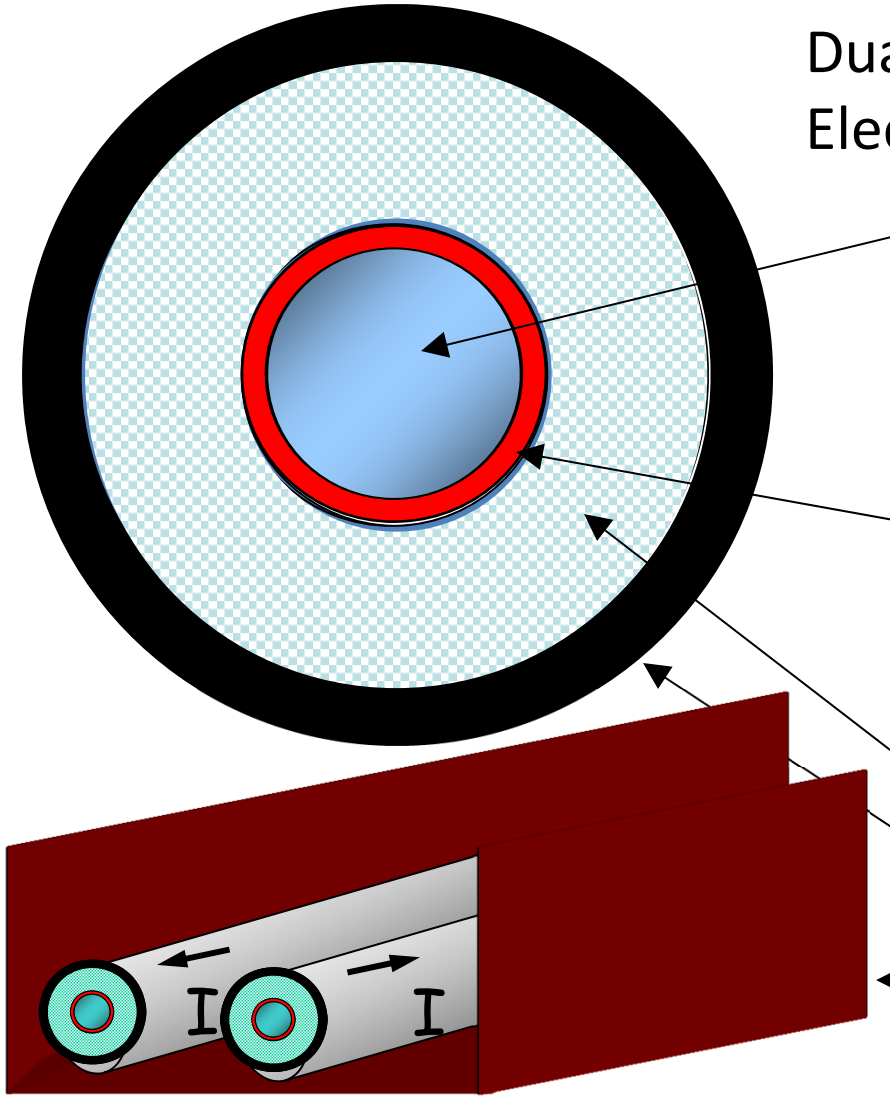
"System Crash"

Omni Productions, Vancouver, BC

CBC Broadcast October, 2008

Implementation Technology

The Hydricity SuperCable



Dual Delivery of Hydrogen and Electric Power

Flowing liquid hydrogen or cold H_2 gas under pressure delivers power and also serves as the refrigerant to …

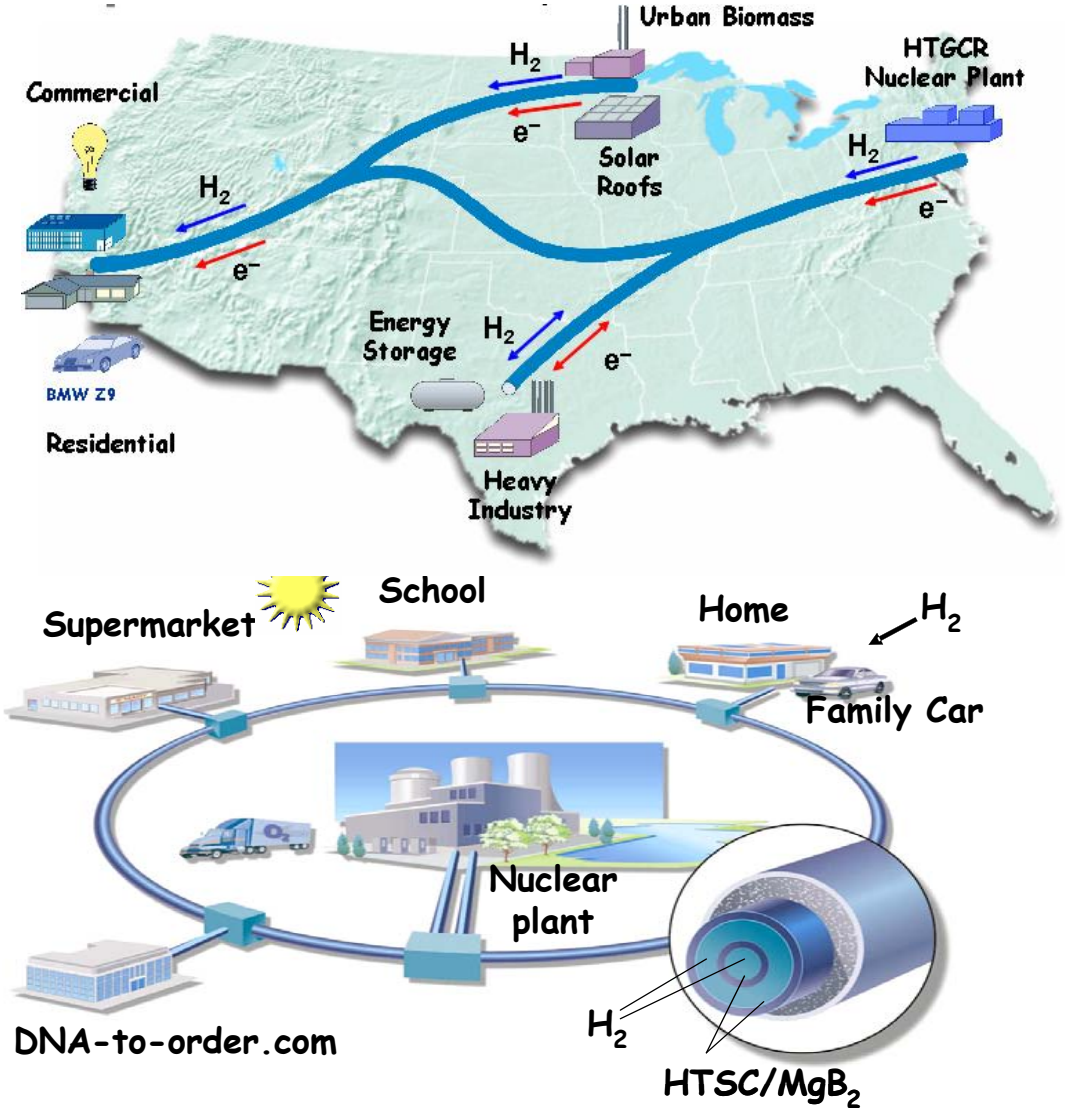
Enable the transmission of large amounts of electric power losslessly using superconductors

Thermal Insulation

Electrical Insulation

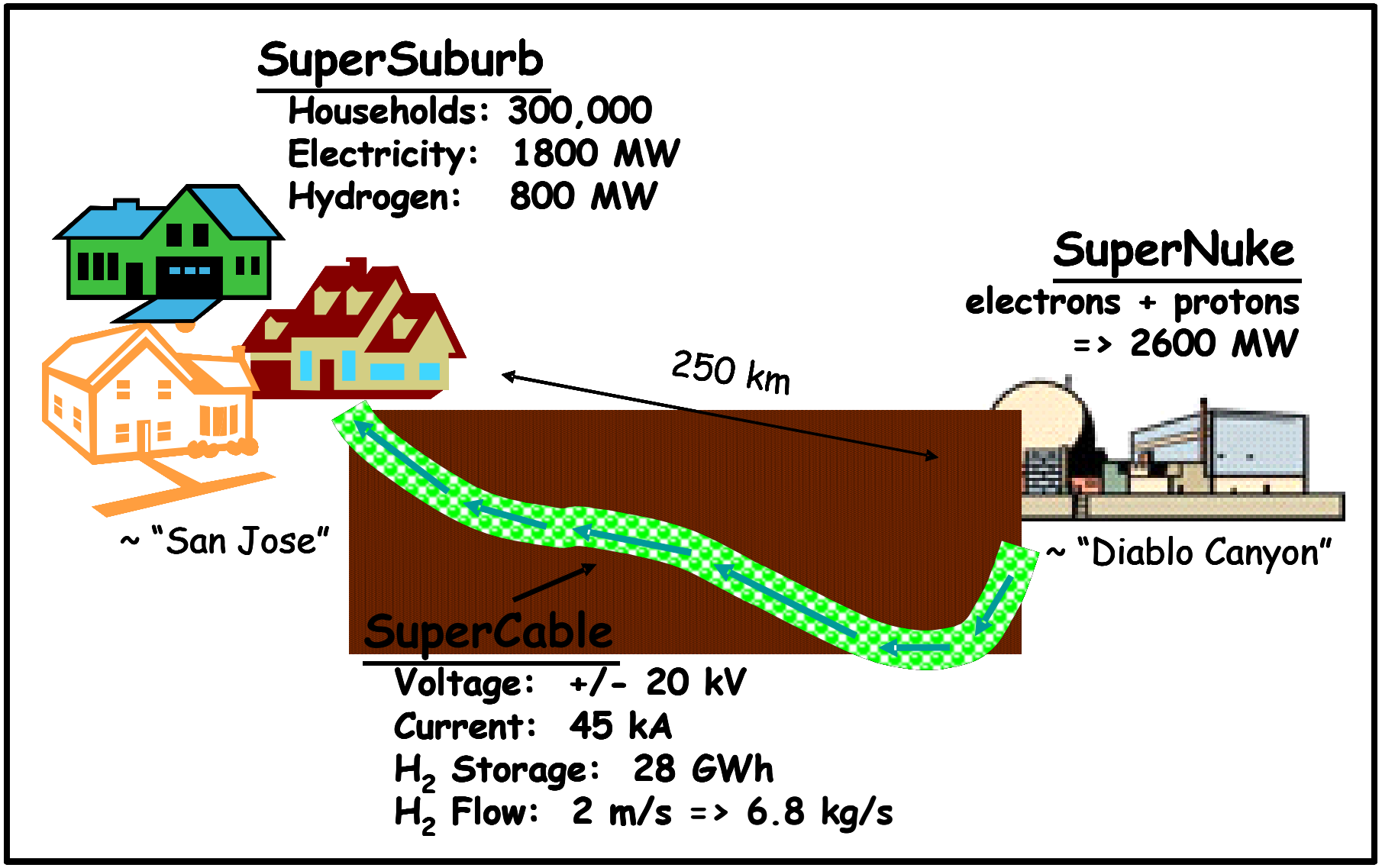
Enclosed in underground tunnel or trench

SuperCities & SuperGrids



- Nuclear Power can generate both electricity and hydrogen – "Hydricity"
- Hydricity can be distributed in underground pipelines like natural gas
- The infrastructure can take the form of a **SuperGrid**
- ...or a **SuperCity**

SuperSuburb

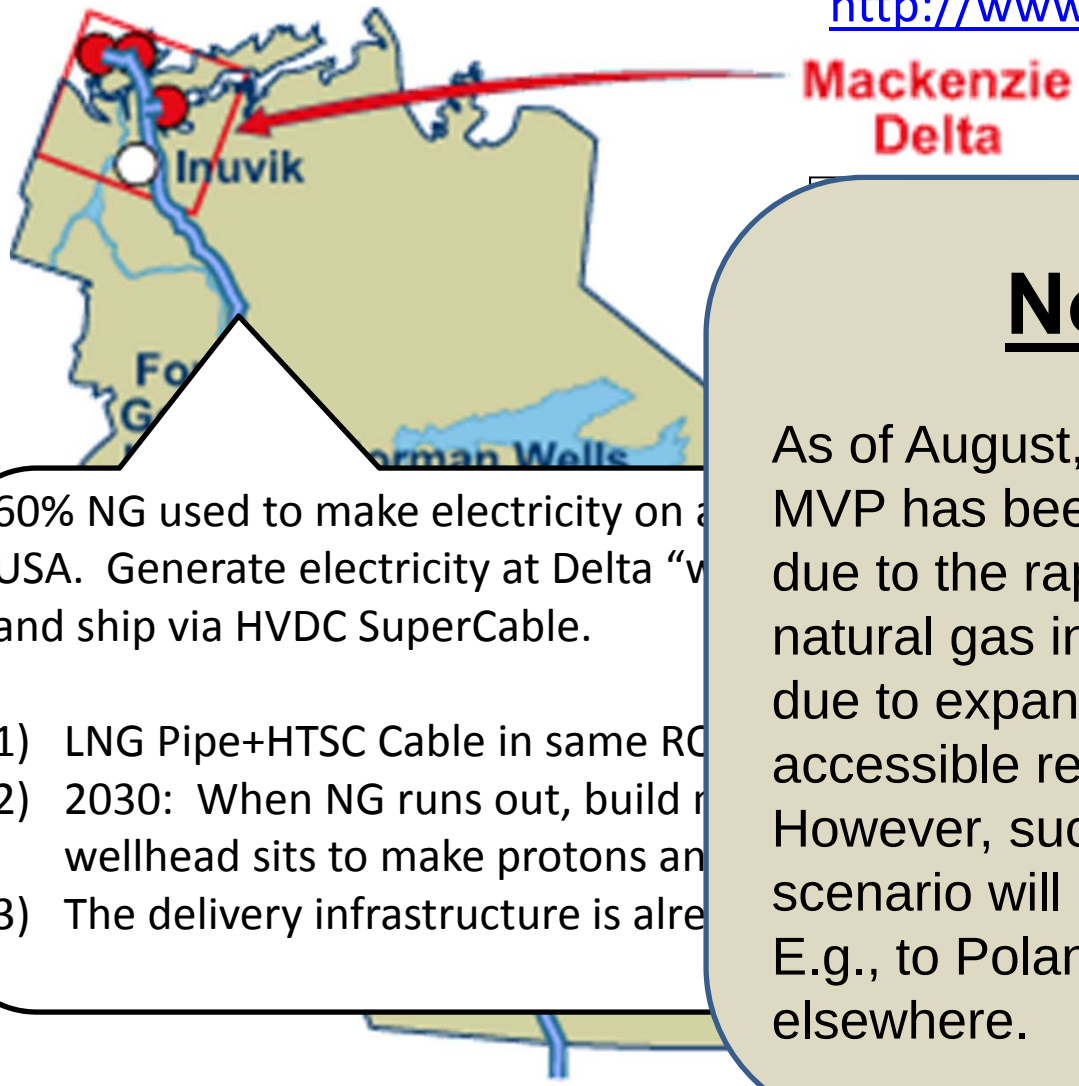


Some Other Possibilities

A Canadian's View of the World

The Mackenzie Valley Pipeline

http://www.mackenziegasproject.com



60% NG used to make electricity on a
USA. Generate electricity at Delta "w
and ship via HVDC SuperCable.

1) LNG Pipe+HTSC Cable in same RC
2) 2030: When NG runs out, build r
   wellhead sits to make protons an
3) The delivery infrastructure is alre

Nota Bene!

As of August, 2012, funding for the MVP has been reduced by about 30% due to the rapidly decreasing price of natural gas in North America, primarily due to expanding available "fracking accessible reserves" in the US. However, such means the MVP scenario will only expand globally. E.g., to Poland, Mexico, Asia and elsewhere.

Transporting Tens of Gigawatts to the Green Market

12 – 13 May 2011
Institute for Advanced Sustainability Studies
Potsdam, Germany

An American Experiment!

Powering Europe with Sahara Solar

LES TENDANCES ENERGETIQUES

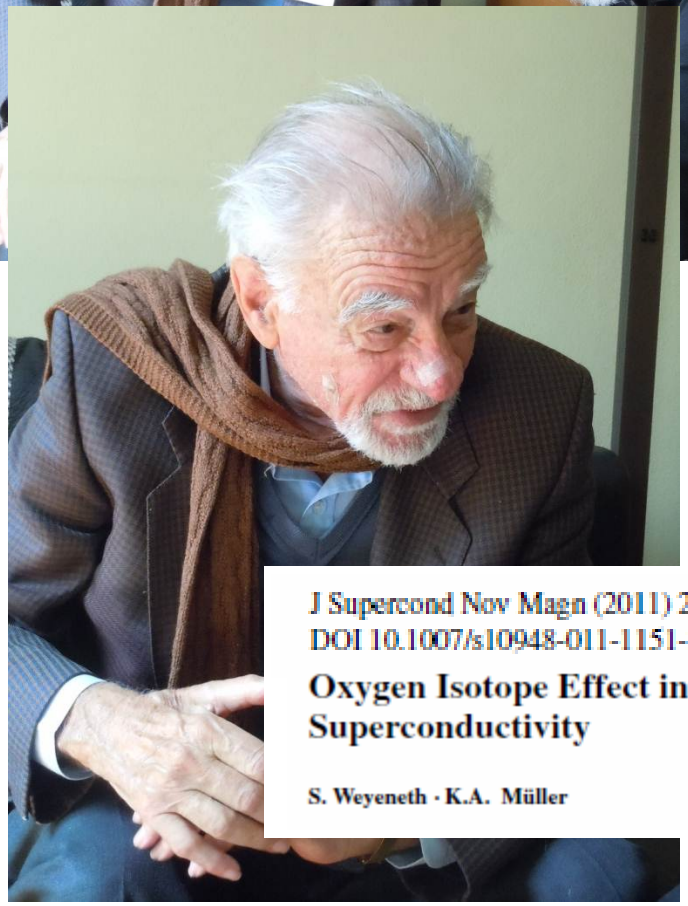
- Le modèle énergétique de l' UE

	2009	2029
-Coal	7,7%	14 %
-Oil	32,2%	10%
-Gas	28,6%	25%
-Nuclear	12,4%	13%
-Hydro	2%	2%
-Biomass	11,5%	11,5%
-Renewables	5,6%	10%+15% import

Go Where the Sun Shines

Solar – PV & Thermal

Superconducting SolarPipe



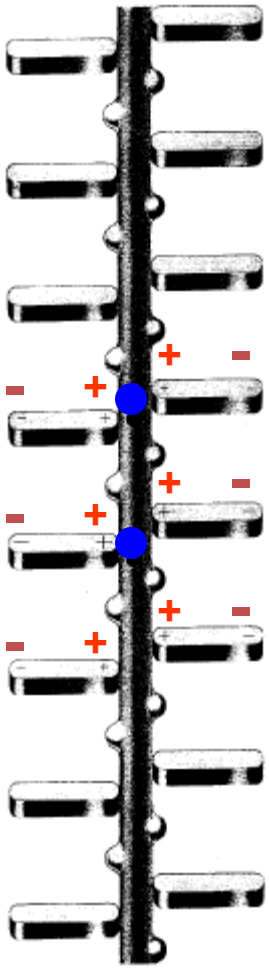
J Supercond Nov Magn (2011) 24: 1235–1239
DOI 10.1007/s10948-011-1151-3

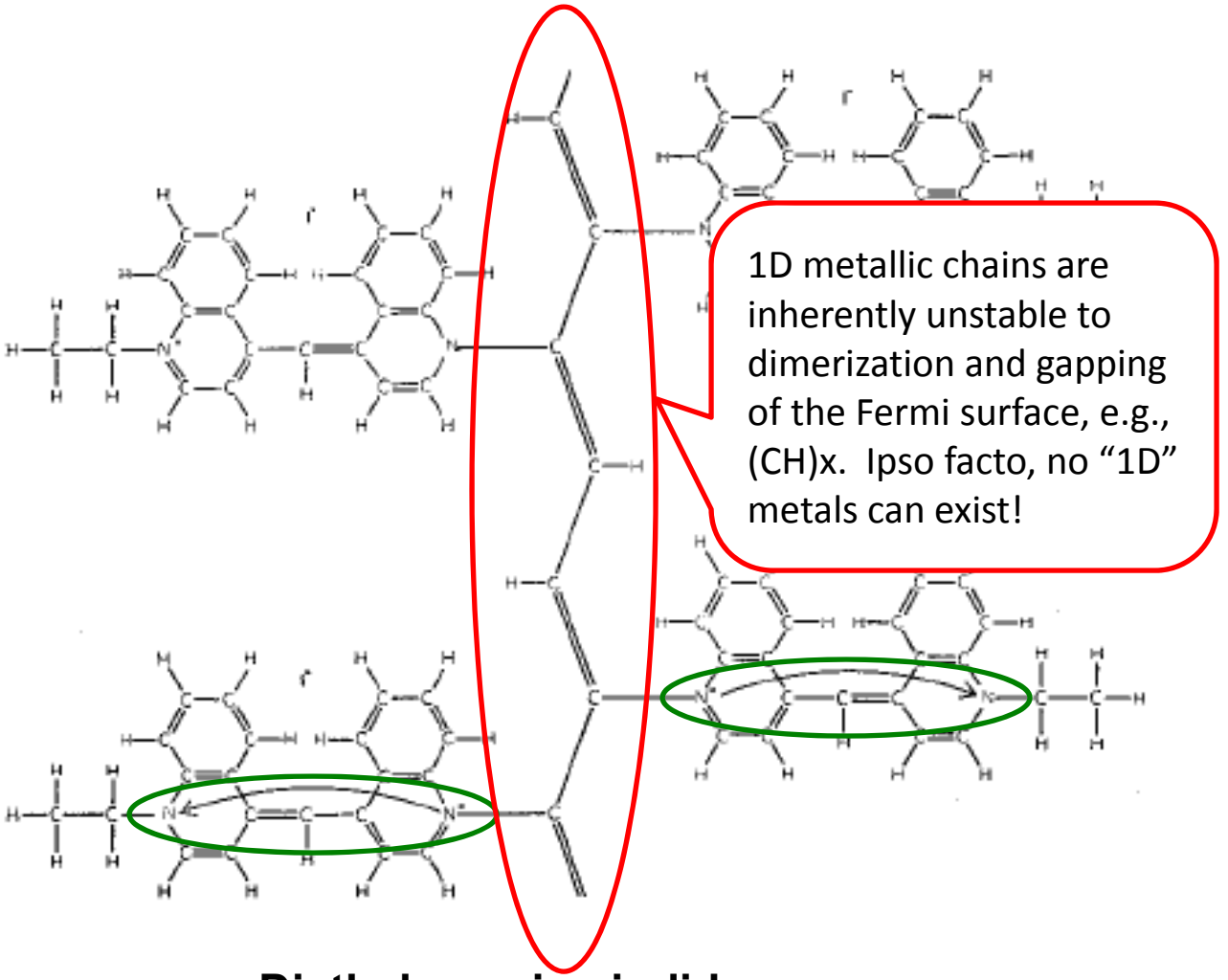
Oxygen Isotope Effect in Cuprates Results from Polaron-induced Superconductivity

S. Weyeneth · K.A. Müller

Room Temperature Superconductivity

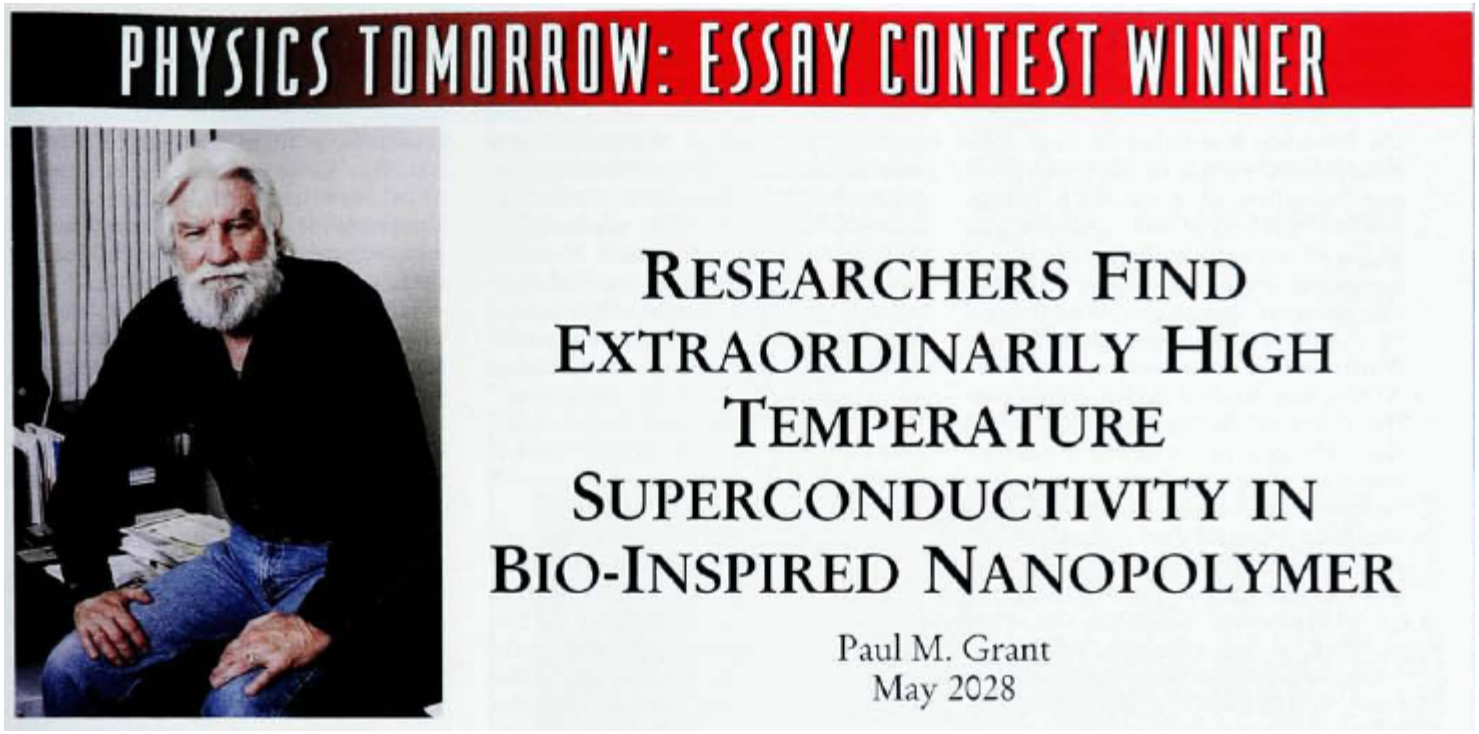
Room Temperature Superconductor
Little, Ginzburg, 1963





Diethyl-cyanine iodide

Does the DA VINCI CODE Hold the Key to Room Temperature Superconductivity?



50th Anniversary of Physics Today, May 1998

So Now We Have a Room Temperature Superconductor… So What?

(Will We Be Able to Use It?)

Paul M. Grant

Visiting Scholar, Stanford

IBM Research Staff Member Emeritus

EPRI Science Fellow (Retired)

Principal, W2AGZ Technologies

The Road to Room Temperature Superconductivity

Loen, Norway

17-22 June 2007

http://www.w2agz.com/rtsc06.htm

The Eventual Hydrogen Economy?

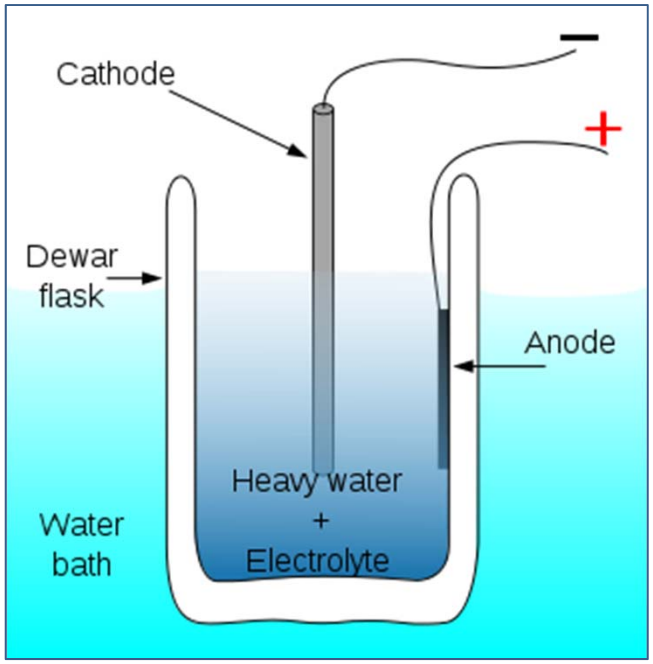
Alternative Energy Scenarios
- Too Good to be True! -

Go To: www.w2agz.com/

March,1989

- Jones, Fleischmann, Pons -

- The Energy Salvation of Mankind -



“Cold Fusion”

1) Deuterium (from “heavy water”)-loaded palladium cathode under “high electrolytic” local field “fuses” a la “hydrogen bomb.”
2) Result “boils” electrode water producing steam useable to power steam turbine and thus electricity.
3) Sure...

Is this really possible ???

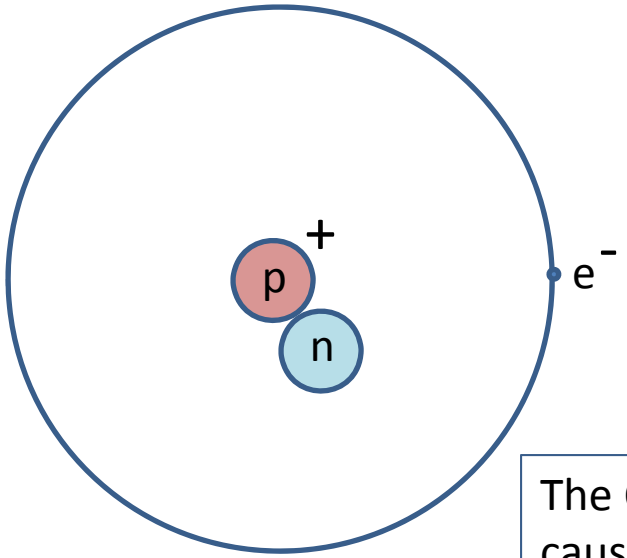
Muon-Catalyzed D_2 Fusion

Sakharov-Frank-Alvarez-Jackson-Jones

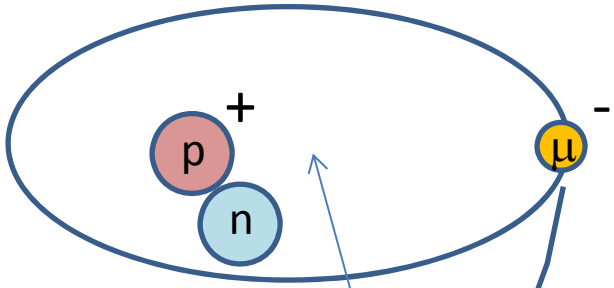
1940s – 1970s

...but not frequently enough to be a practical energy source!

Deuterium Atom



After Electron -> Muon Substitution



The C-O-M will "wobble" causing the nucleus to "fuse" with its neighbor...occasionally...

muon mass ~ 200 x electron

Excerpts from Cold Fusion Wikipedia Page...

Announcement

In mid-March 1989, both research teams were ready to publish their findings, and Fleischmann and Jones had agreed to meet at an airport on March 24 to send their papers to *Nature* via FedEx.[24] Fleischmann and Pons, however, pressured by the University of Utah, which wanted to establish priority on the discovery,[25] broke their apparent agreement, submitting their paper to the *Journal of Electroanalytical Chemistry* on March 11, and disclosing their work via a press release [26] and press conference on March 23.[23] Jones, upset, faxed in his paper to *Nature* after the press conference.[24]

Response and fallout

On May 1, 1989, the American Physical Society held a session on cold fusion in Baltimore, including many reports of experiments that failed to produce evidence of cold fusion. At the end of the session, eight of the nine leading speakers stated that they considered the initial Fleischmann and Pons claim dead with the ninth, Johann Rafelski, abstaining.[6] Steven E. Koonin of Caltech called the Utah report a result of "*the incompetence and delusion of Pons and Fleischmann,*" which was met with a standing ovation.[46] Douglas R. O. Morrison, a physicist representing CERN, was the first to call the episode an example of pathological science.[6][47]

...Continued

Subsequent research

After 1991, cold fusion research continued in relative obscurity, conducted by groups that had increasing difficulty securing public funding and keeping programs open. Research continues today in a few specific venues, but the wider scientific community has generally marginalized the research being done and researchers have had difficulty publishing in mainstream journals.[6][7][11]

Small but committed groups of cold fusion researchers have continued to conduct experiments using Fleischmann and Pons electrolysis set-ups in spite of the rejection by the mainstream community.[11][72] Often they prefer to name their field **Low Energy Nuclear Reactions** (**LENR**) or **Chemically Assisted Nuclear Reactions** (**CANR**),[73] also **Lattice Assisted Nuclear Reactions** (**LANR**), **Condensed Matter Nuclear Science** (**CMNS**) and **Lattice Enabled Nuclear Reactions**; one of the reasons being to avoid the negative connotations associated with "cold fusion".[72][74] The new names avoid making bold implications, like implying that fusion is happening on them.[75] Proponents see them as a more accurate description of the theories they put forward.[76]

Changing Power

Game-changing 'free energy' breakthroughs & what you need to know

Billionaire Sidney Kimmel helps clean-energy cause

February 12, 2012

Jeanne Manning

Sidney Kimmel,
Founder, Jones Apparel

Billionaire businessman Sidney Kimmel is putting $5.5 million toward making "cold fusion" successes more reliable. His interest in the topic had been piqued in 2009 by a television program.

Wrong! Kimmel hired one of his LA PAs to "flog" Energetics to CBS well before the the 60 M production, as well as being an early financial backer.

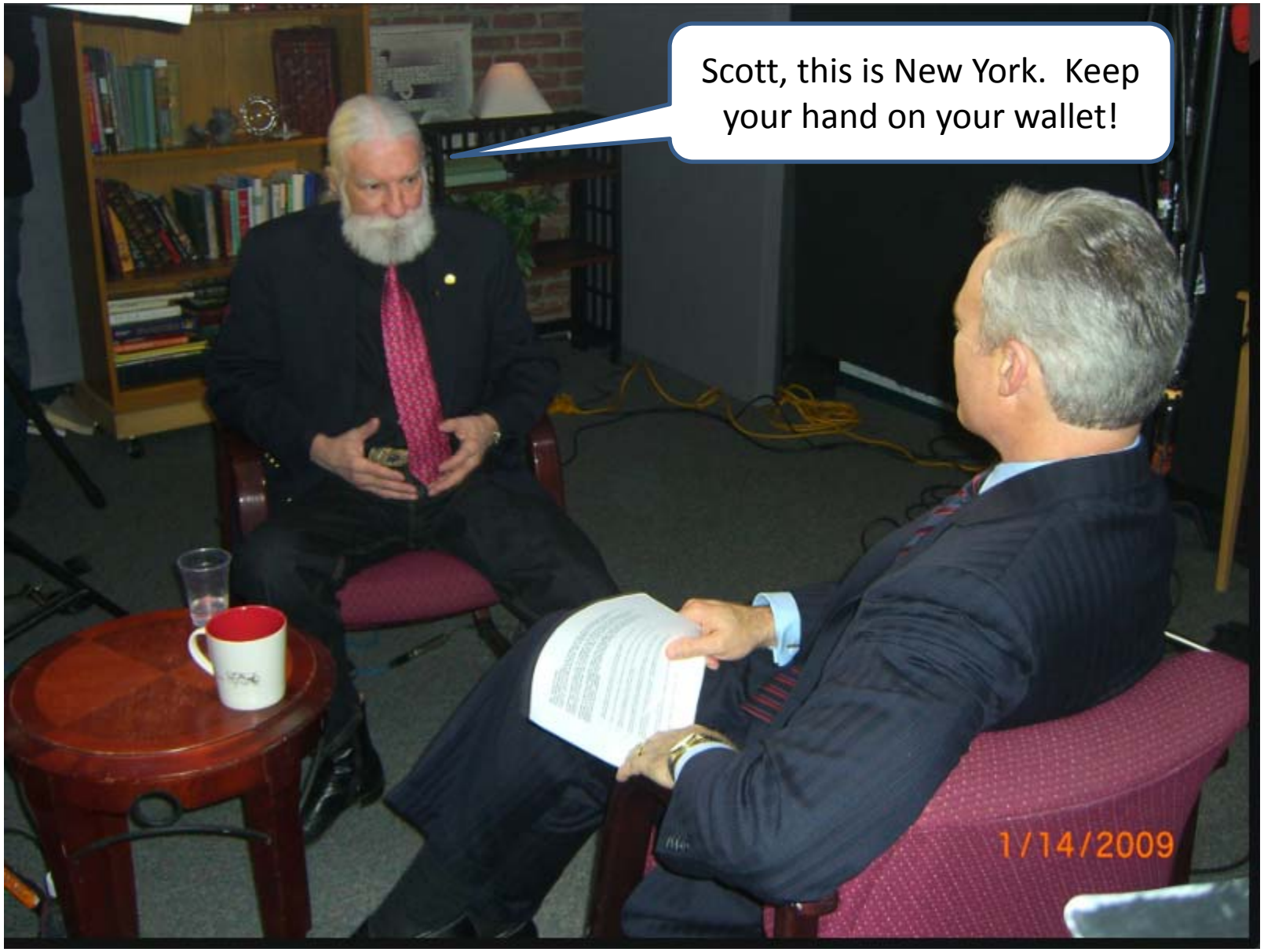
To recap that year: producers of the TV program 60 Minutes had wanted to find out whether cold fusion is real. They looked for an independent scientist to check it out and chose Rob Duncan, vice chancellor of research at Missouri University and an expert in measuring energy. He was said to have been a skeptic about cold fusion before 60 Minutes sent him to Israel to investigate the work of a company called Energetics Technologies. He came back convinced that the

Wrong! Duncan was "sympathetic" to CF prior to the 60 M segment. He became a "true believer" after his trip to Israel, even though he did not actively participate in any measurements. Think of "Saul on his way to Damascus."

It took a while for Kimmel's interest to translate into funding for the university, but recently Duncan learned about the generous gift of money and equipment. Kimmel's donation will create a Sidney Kimmel Institute for Nuclear Renaissance which will involve researchers from the Missouri University Research Reactor, and physics, engineering and chemistry departments.

Whoa! Conflict of interest ??? Hmm...

Cold Fusion After 20 Years


Scott, this is New York. Keep your hand on your wallet!
1/14/2009

Bohr Was Wrong!

"As was Schrödinger, Heisenberg, Pauli, Dirac..."

"yeah, right"

According to Quantum Mechanics, the ground state energy of the hydrogen atom is given by,

$$R_E = \frac{(k_e e^2)^2 m_e}{2\hbar^2}$$

According to Randall Mills (MD Harvard), Founder Blacklight Power, this energy should be one-half R_E because the charge density of hydrogen's electron exists (he says) only on an infinitely thin spherical shell, to wit:

$$\rho(r, \theta, \phi, t) = \frac{e}{4\pi r^2}\delta(r - r_n)Y_0^0(\theta, \phi)$$

Mills claims a catalytic process to capture the transition to this lower ground state energy from water "for free." No, this is not cold fusion revisited.

No verification has ever been published in a major recognized peer-reviewed scientific journal.

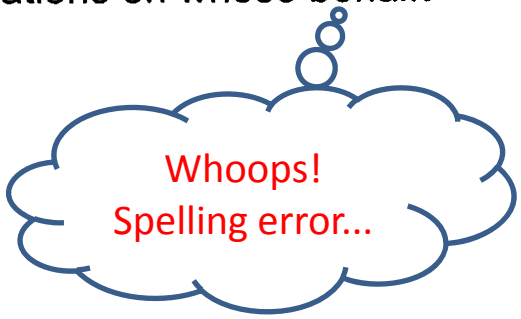
Oh, No!

Re: Public Misstatements Regarding Blacklight Power Inc.

Dear Dr. Grant:

We have been retained by Blacklight Power Inc. ("Blacklight"). Blacklight has requested that this firm investigate legal remedies for disparaging and defamatory comments made by you with reference to the work performed by Blacklight and its president Dr. Randell L. Mills.

Blacklight is currently assessing its options with regard to your behavior, which options include bringing a suit for monetary damages, requesting an injunction prohibiting further false and defamatory communications by, and other remedies. Any such action would be brought against yourself and any organizations on whose behalft you have purportedly been acting.



Probably a Harvard
Law graduate

From: Eric Hermanson <eric@alum.mit.edu>
Sent: Monday, July 23, 2012 5:53 PM
To: pmpgrant@w2agz.com
Cc: w2agz@w2agz.com
Subject: On the Hydrino

Paul --

Re: http://www.w2agz.com/TrapDoors.htm

... and your other related critical commentaries on the subject, referenced on the Internet.

I think you may be one of the most uninformed people on the planet, and in my opinion 'lazy' to boot, and that's both a shame and an irony given the greatly above average intelligence you posses. History may not treat you kindly.

- Eric

...Sigh...

Got Lots More “Bad Science” War Stories...

- Alternative Medicine
- New Tesla Society (Dennis Lee)
- Antigravity Shields (Plodkletnov)
- IAS (“Digital Wave Technology”)
- Media Fusion (“NetFlix over Powerlines”)
- NEX (“Noble Gas Power (??)”)
- Magnetostrictive 2nd Law Violations
- QuEnergy (Heat Transfer via Superconductivity)
- Joe Newman
- Schoen Imbroglio (The 2002 Shame of Bell Labs)
- Starlite (2009...Nuclear Blast Shield)

...Sorry. Outa time. Invite me back!

Where there is no vision,
the people perish…

Proverbs 29:18

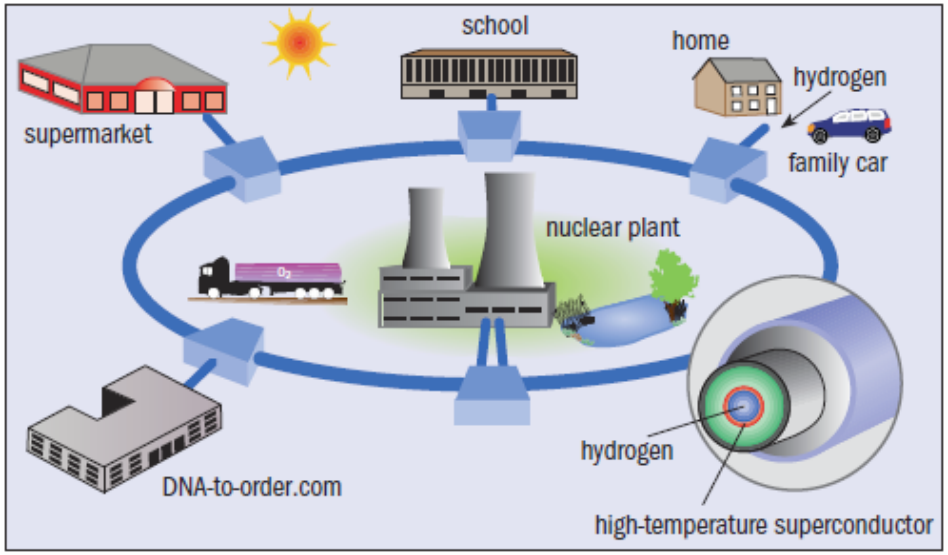
“You can’t always get what you want…”

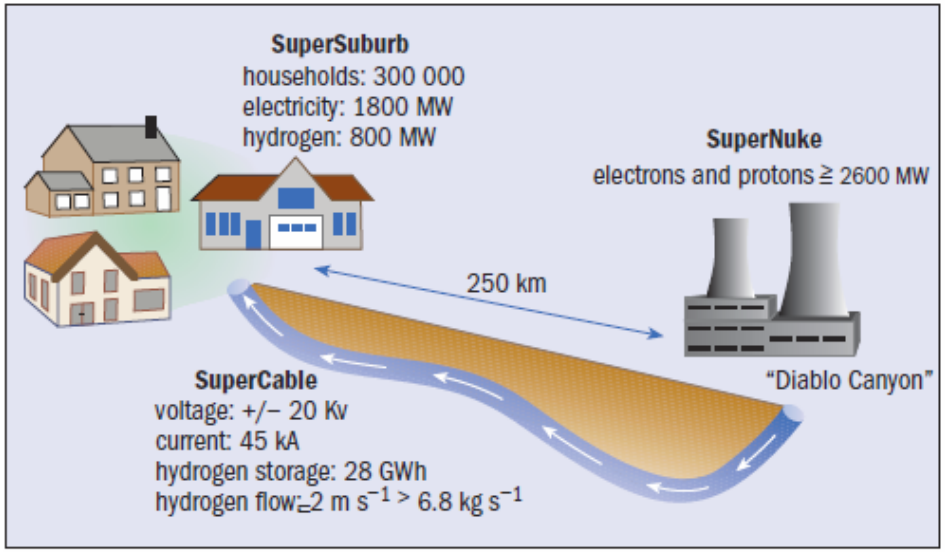
“…you get what you need!”

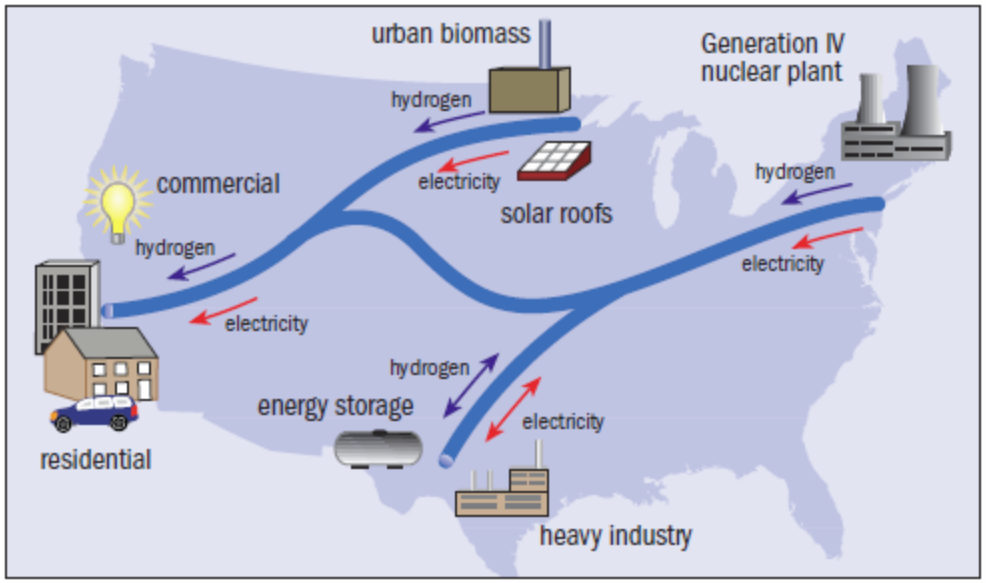
Spares & Extras

SuperCities - SuperSuburbs – SuperGrids

Grant, Overbye, Starr, SciAm 295, 76 (2006)







Caveat Emptor

(wisdom from Garwin-Matisoo, 1967)

- "…for low power levels and sufficiently short distances…it will be more economical to use conventional ac EHV transmission."
- "…the use of superconducting power lines appears feasible. Whether it is necessary or desirable is another matter entirely."

EMPIRE CONNECTION

Specifications

2-1000 MW HVDC Bipolar Circuits

- Circuit 1: 130 miles, Greene County → Bronx County
- Circuit 2: 140 miles, Albany County → New York County
- Each Circuit: +/- 500 kV, 1000 A Bipolar (2 cables ea.)

Financials

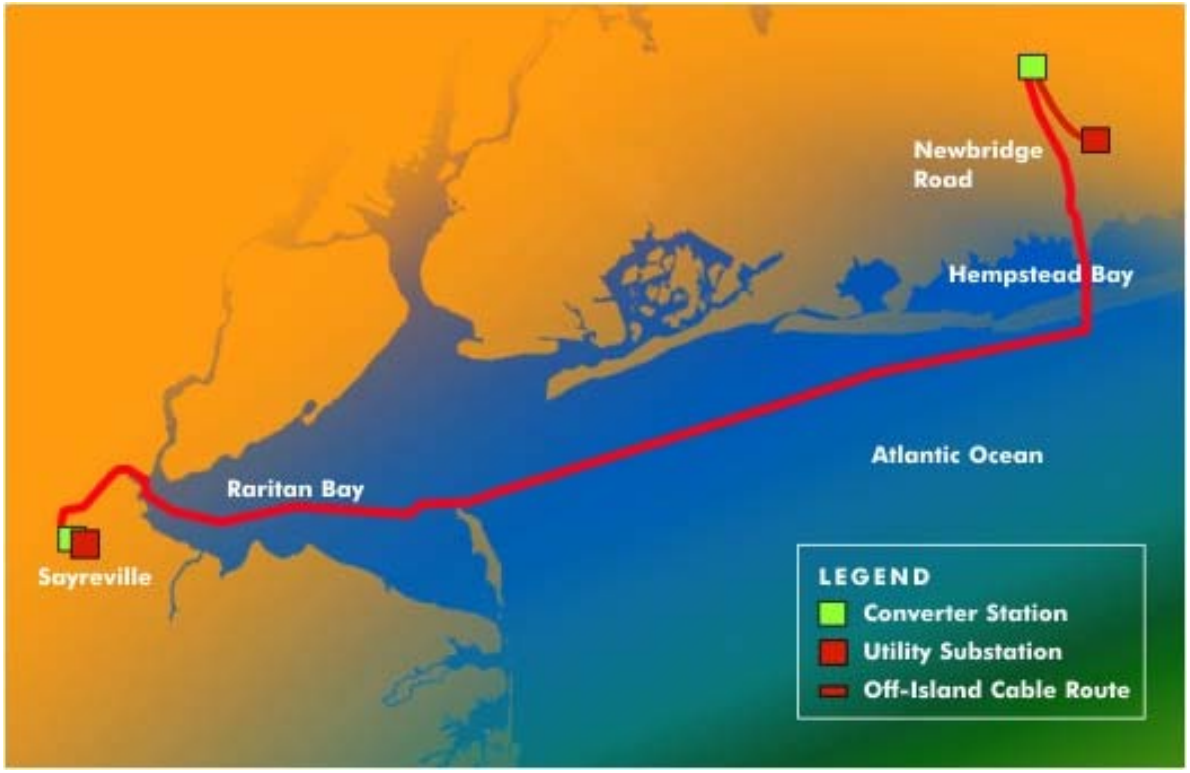
$750 M ($400 M "VC", $350 M "Futures")

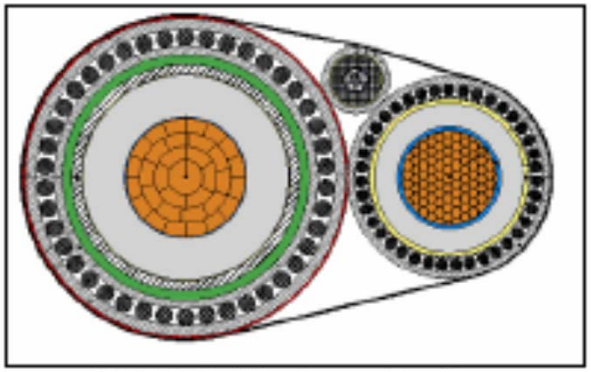
- Loan Payment (4%, 40 yrs, 750 M$) = 35 M$/yr
- Labor, Overhead, Maintenance = 5 M$/yr
- Tariff = 0.5 ¢/kWh
- Profit (NOI) @ 50% Capacity = 4 M$/yr
- Profit (NOI) @ Full Capacity = 48 M$/yr

Wire C/P = 100 $/kA×m
HTSC Cost = $87 M

Why didn't it go forward?

NEPTUNE
Regional Transmission System™





HVDC Cable Cross-Section

Pirelli (Prysmian) Energy Cables

$190 M

Sayerville, NJ → Levittown LI, NY

- 600 MW (+/- 250 kV, 1200 A)
- 65 miles (105 km)
- $400 M
- 2007

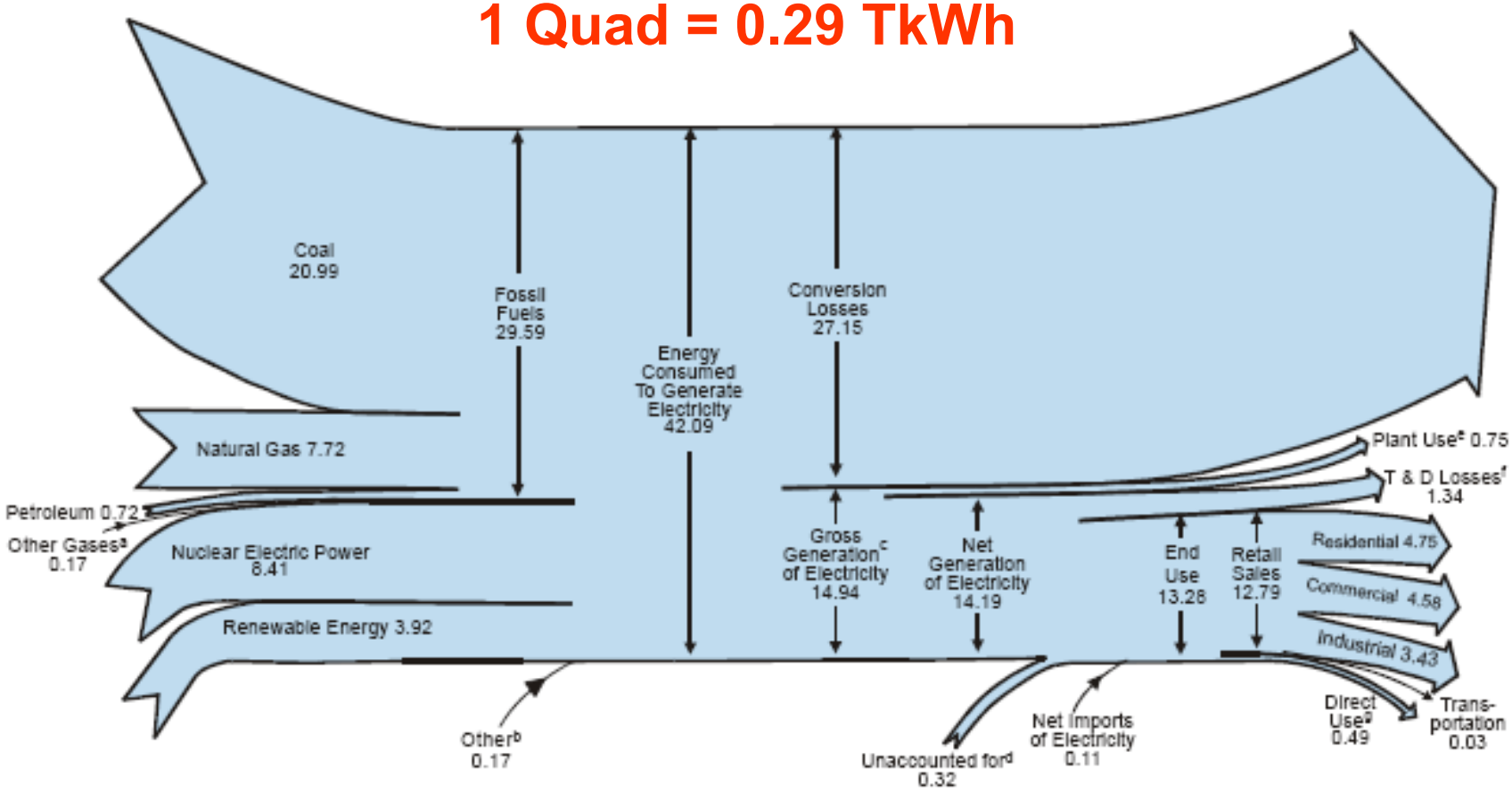
Financials

40 yrs @ 4%:	$ 20M
LOM:	1 M
NOI (100%):	5 M

T 77 K	C/P $/kA×m	Cost ($M)
Cu	7	1.8
HTSC	100	25.1

US Electricity Flow - 2007

1 Quad = 0.29 TkWh



US Generation Capacity = 1.1 TW
Gross Generation = 4.33 GWh
(T&D Losses)/(End Use) = 10%

- Electricity -

The Crown Jewel of the US Economy

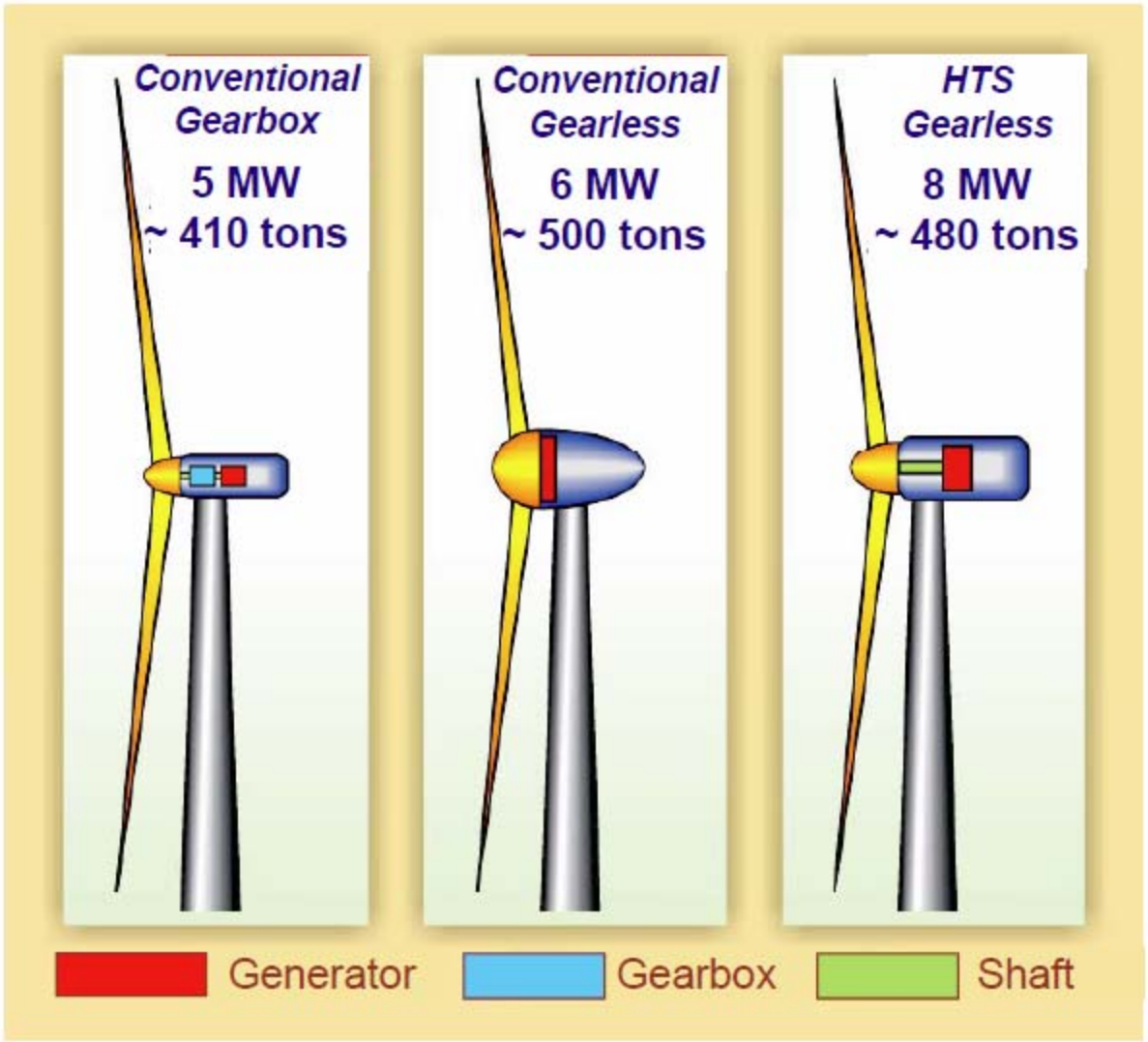
- **~$2 trillion total asset value**
- **$344 billion annual revenues**
- **142 million customers**
- **3273 utilities**

Without electric power the $14.3 trillion U.S. economy would come to a halt

Recuirs Jes' Minmal Skil Levil

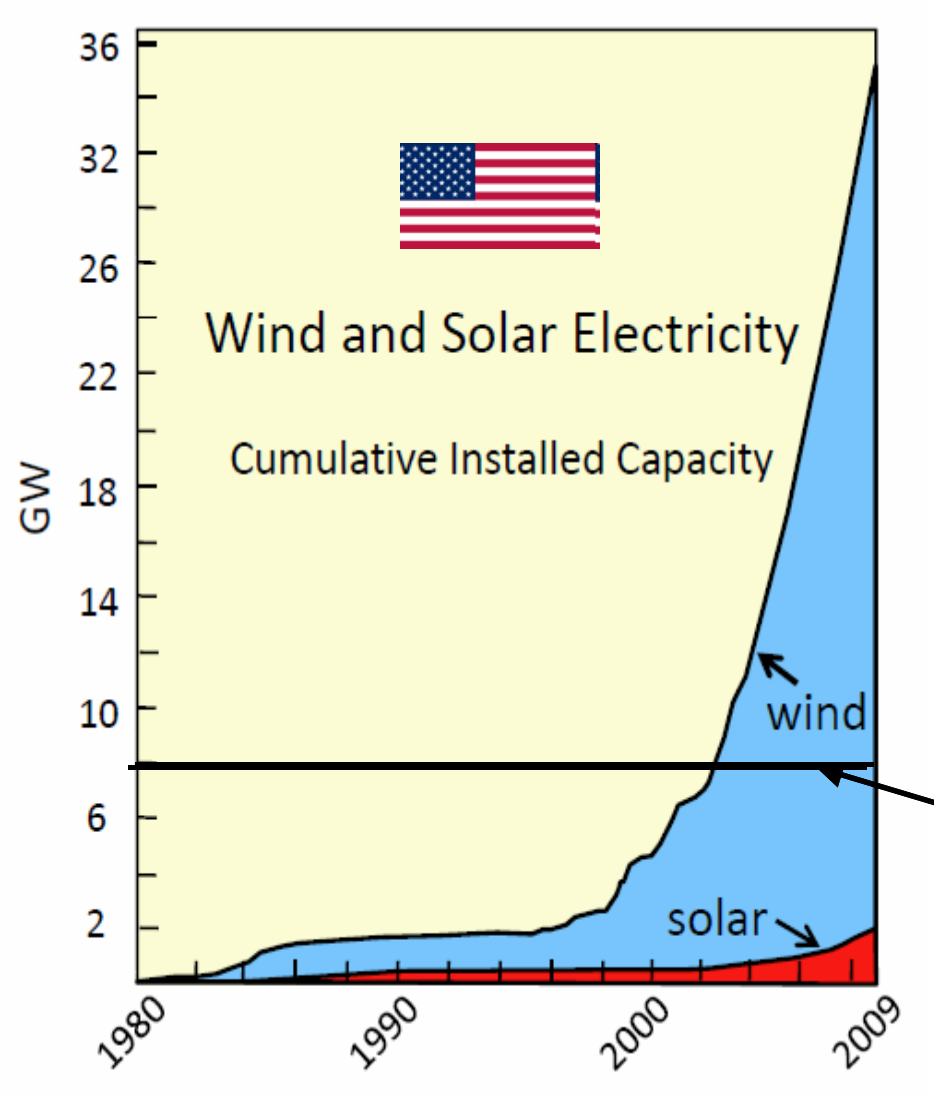
- Harvard PhD…OK
- But…
- Ya gotta pass the IBEW union apprentice exam too!

Rotating Machinery - Wind Generators



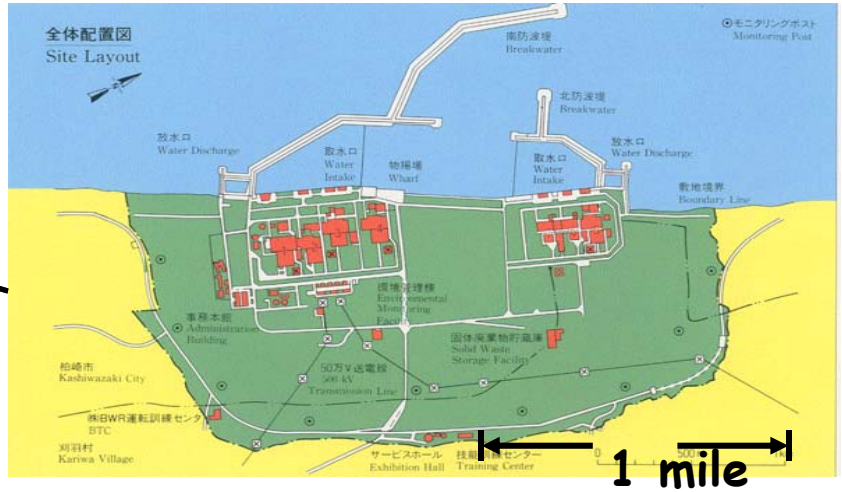
Matthews, Physics Today **62**(4), 25 (April 2009)

Wind Power Factoids



KK Wind Equivalent (8 GW)

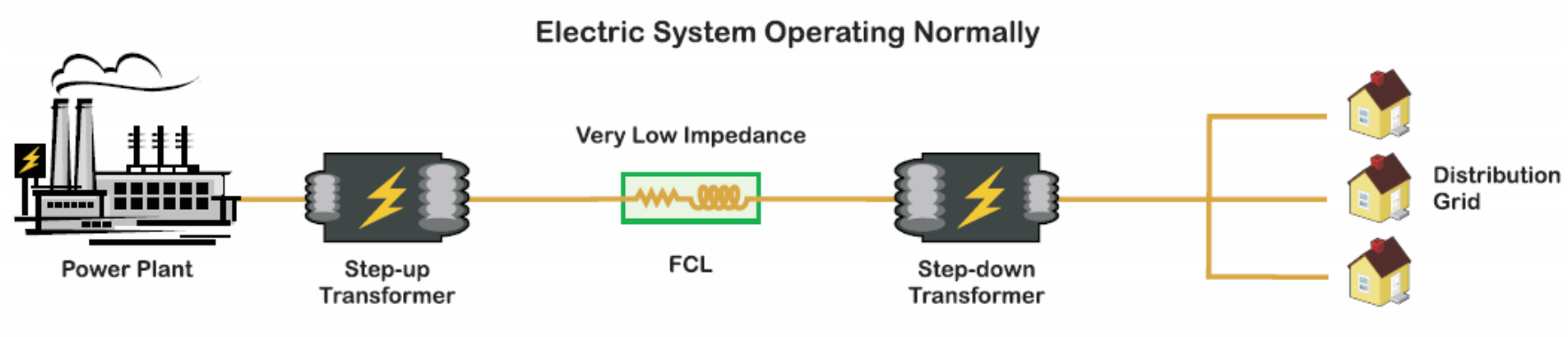
- Power per Tower 8 MW
- Number of Towers 1000
- Inter-tower Distance 1000 ft
- Total Area (miles x miles) 43.5 x 43.5

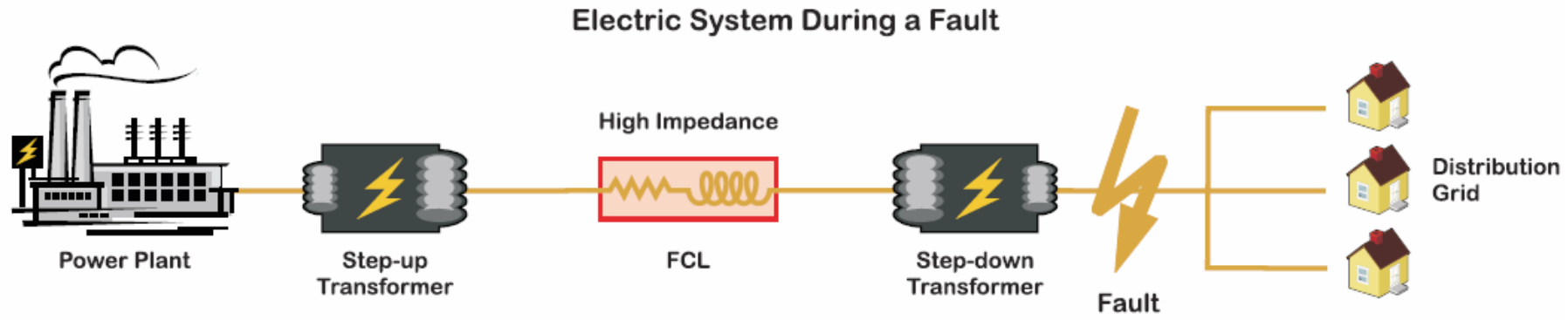


Kashiwazaki Kariwa: 8 GW !

Diablo Canyon

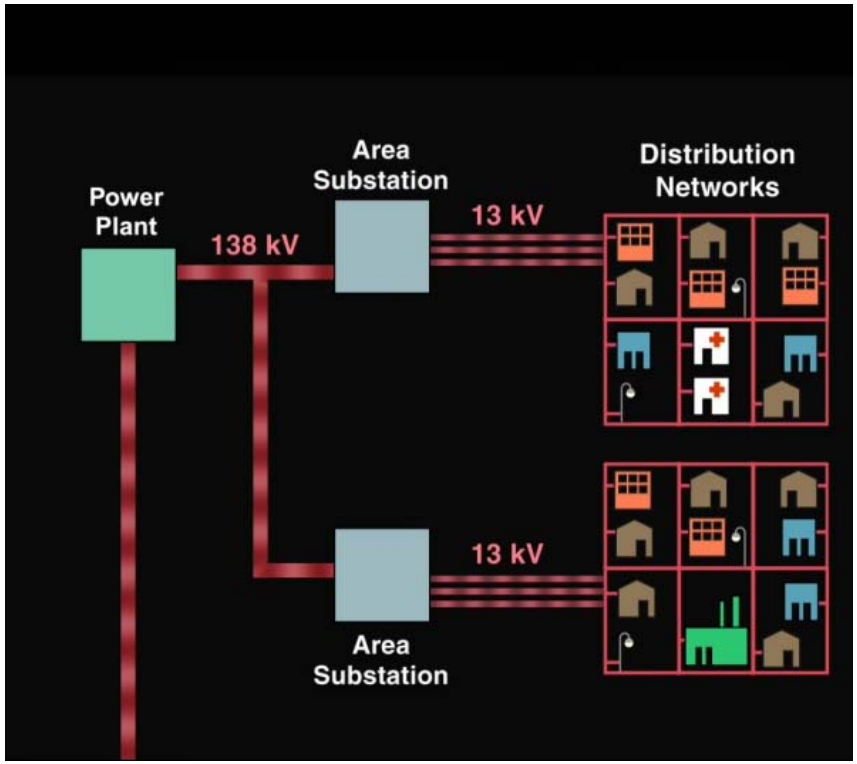
Fault Current Limiters 101

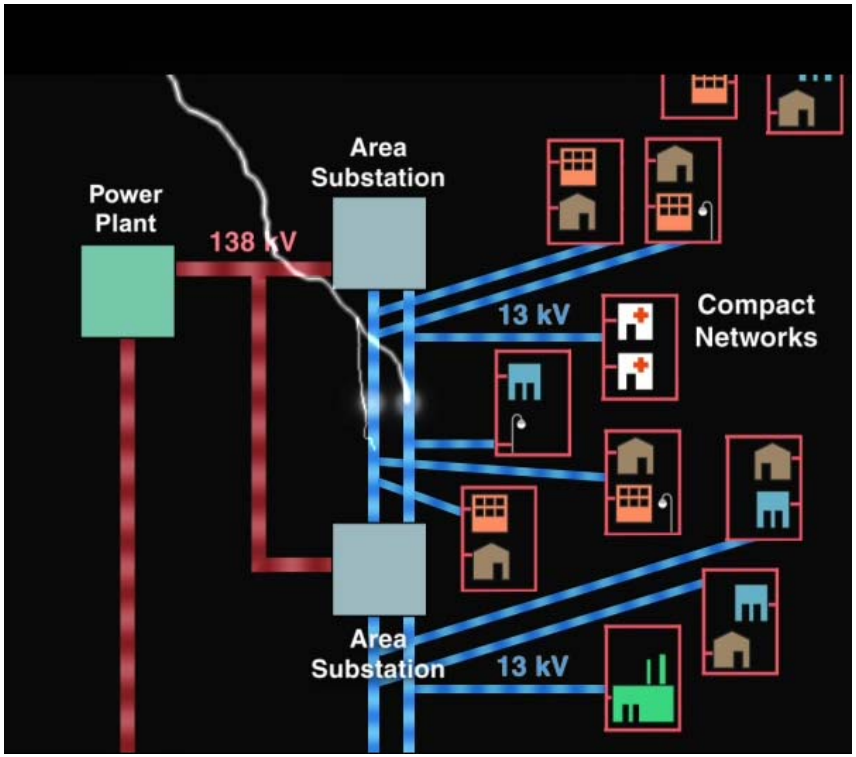




Project Hydra
DHS, NYC, ConEd, AMSC

Concept: Combine High Capacity HTSC Cables With FCL Functionality





US Department of Energy

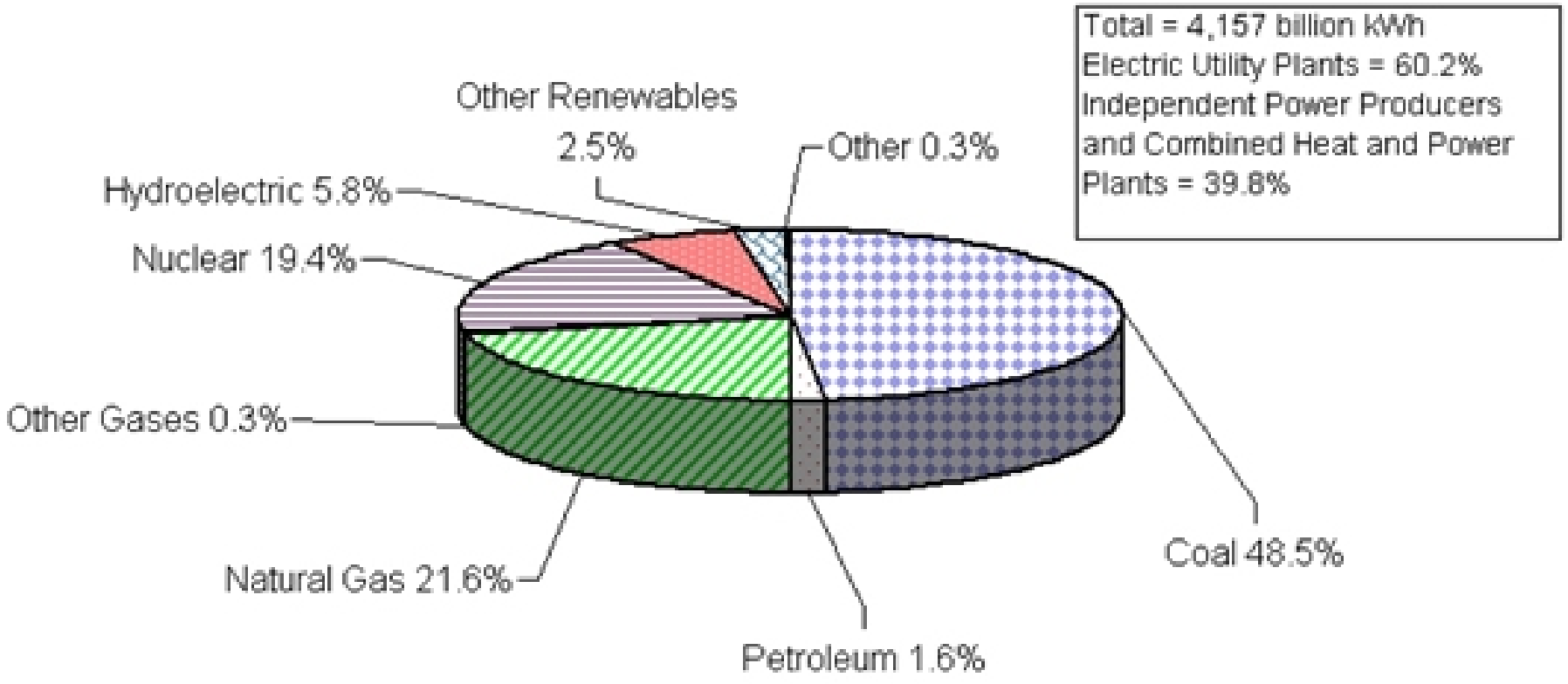
Budget of the Office of Electricity Delivery and Energy Reliability: FY 2010-11 (10^3 USD)

DOE Conclusion: HTSC Power Technology is now "on the shelf" and ready to deploy !

	FY 2009		FY 2010	FY 2011
	Current Appropriation	ARRA Appropriation	Current Appropriation	Congressional Request
Research and Development				
High Temperature Superconductivity	23,130		?	?
Visualization and Controls	24,461			
Energy Storage and Power Electronics	6,368			
Renewable and Distributed Systems Integration	29,160			
Clean Energy Transmission and Reliability			38,450	35,000
Smart Grid Research and Development			32,450	39,293
Energy Storage			14,000	40,000
Cyber Security for Energy Delivery Systems			40,000	30,000
SUBTOTAL Research and Development	**83,119**		**124,900**	**144,293**
Permitting, Siting, and Analysis	5,271		6,400	6,400
Infrastructure Security and Energy Restoration	6,180		6,187	6,188
Program Direction	21,180		21,420	29,049
Congressionally Directed Activities	19,648		13,075	
American Recovery and Reinvestment Act, 2009		4,495,712		
Use of prior year balances	-769			
TOTAL	**134,629**	**4,495,712**	**171,982**	**185,930**

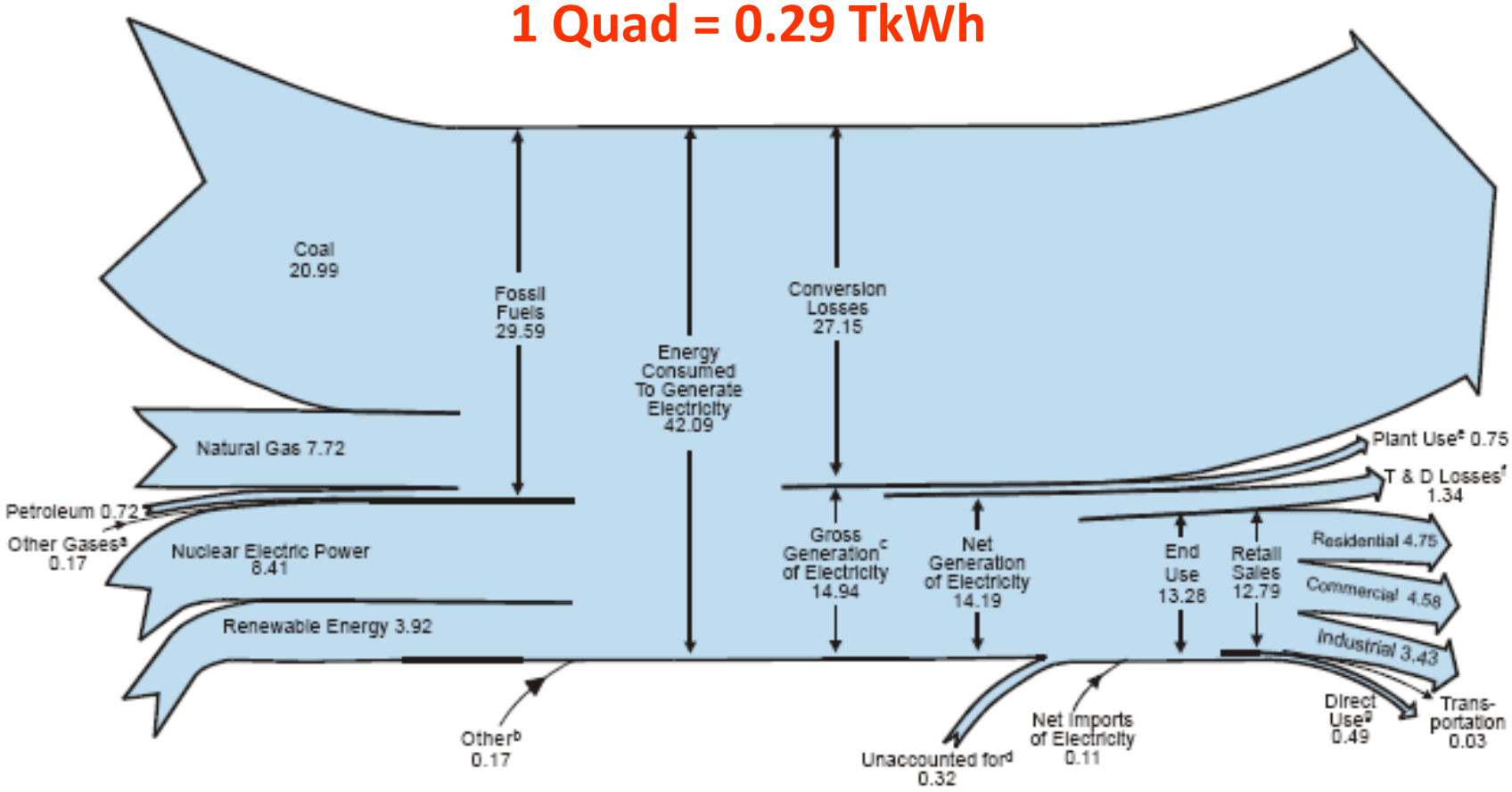
WOW ! "Obama Cash"

US Electricity Generation Sources



US Electricity Flow - 2007

1 Quad = 0.29 TkWh

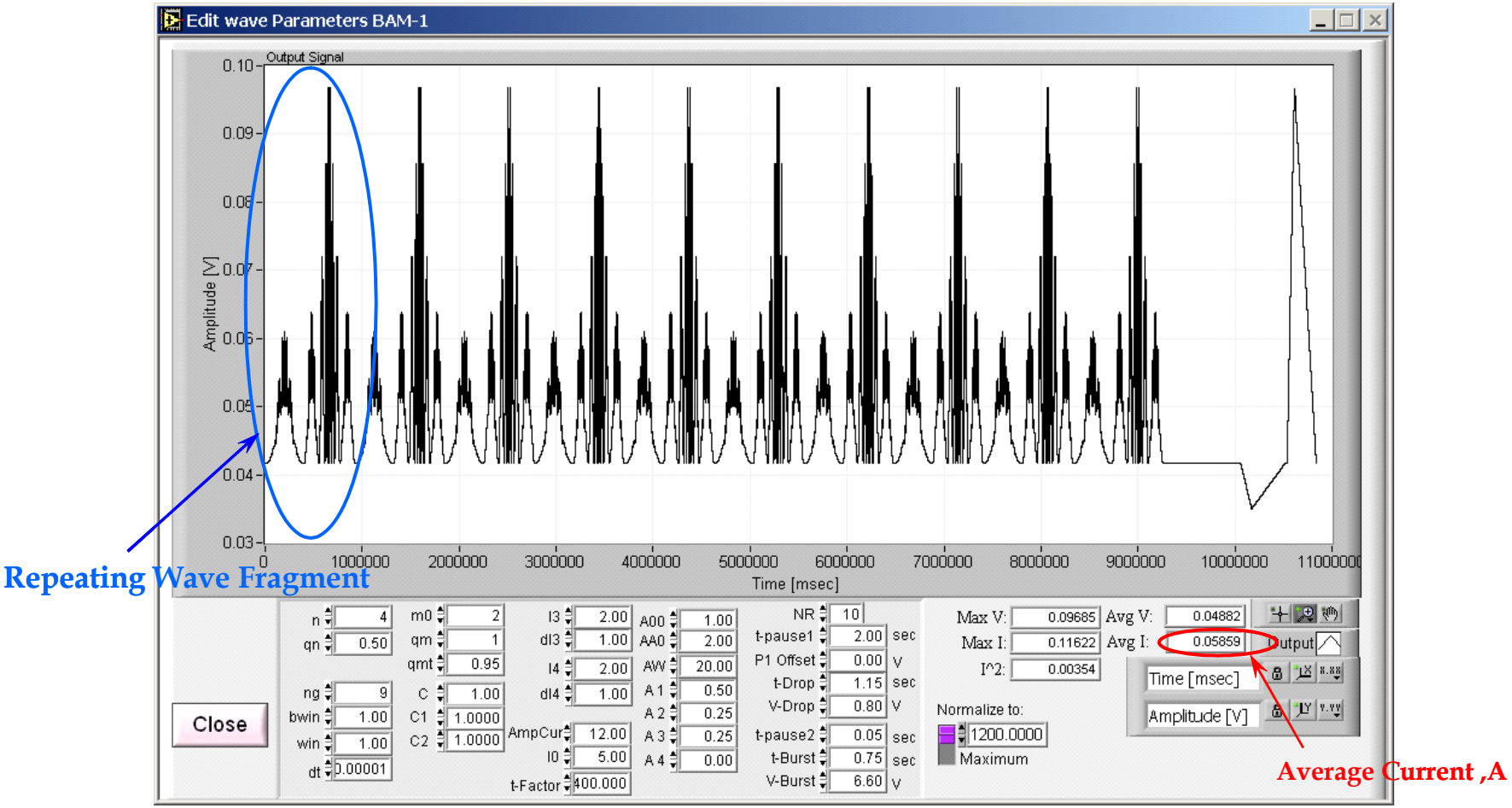


US Generation Capacity = 1.1 TW

Gross Generation = 4.33 GkWh

(T&D Losses)/(End Use) = 10%

Enfranchisement of Women


Edit wave Parameters BAM-1
Output Signal
Amplitude [V]
Time [msec]
Repeating Wave Fragment
Average Current ,A
Close
Max V: 0.09685
Avg V: 0.04882
Max I: 0.11622
Avg I: 0.05859
I^2: 0.00354
Output
Time [msec]
Amplitude [V]
Normalize to:
1200.0000
Maximum