SLAC NATIONAL ACCELERATOR LABORATORY

100 Years of Superconductivity: Perspective on Energy Applications

Paul M. Grant
W2AGZ Technologies
www.w2agz.com

AGING IBM PENSIONER

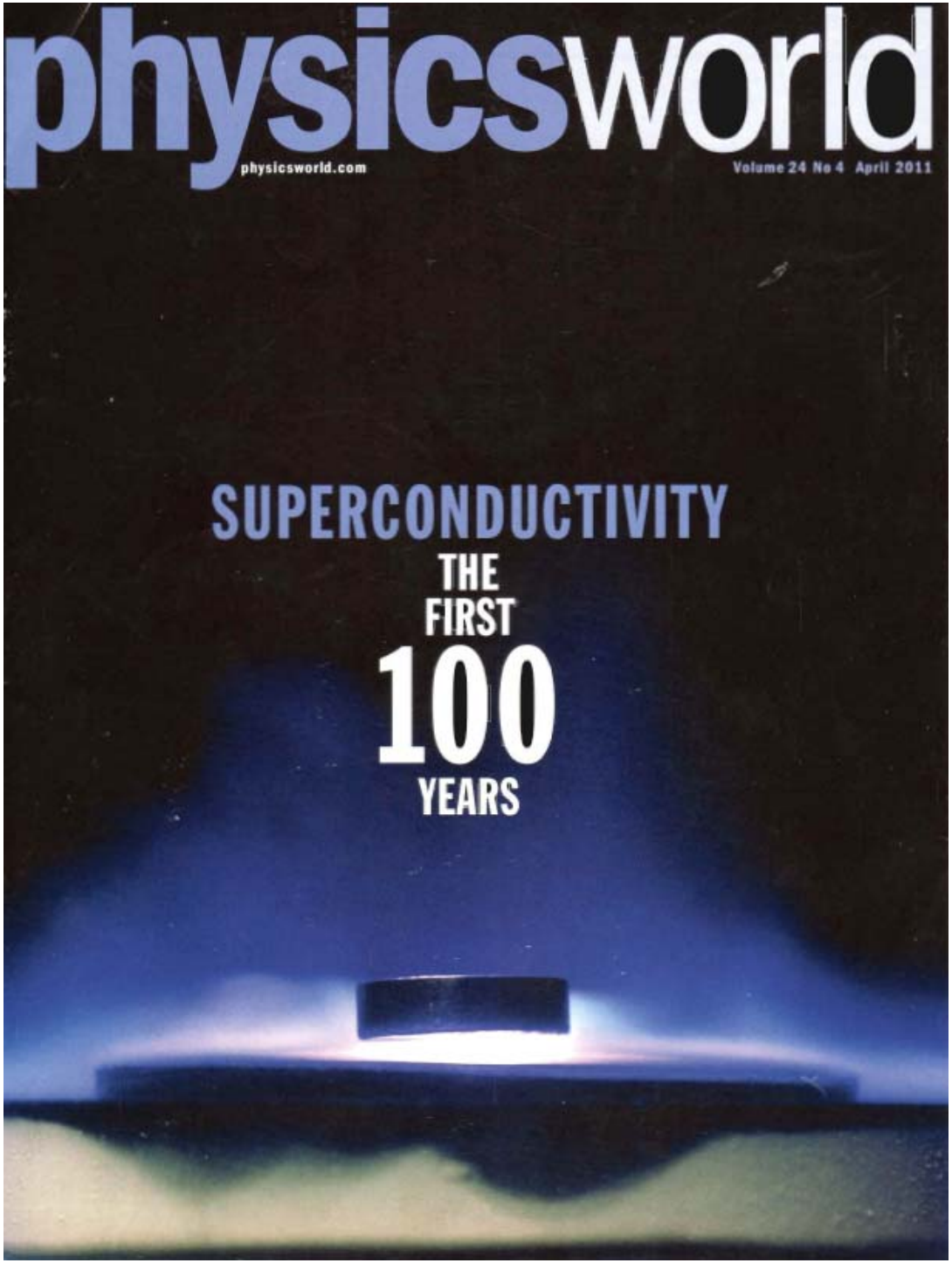
SLAC
2575 Sand Hill Road
Menlo Park, CA 94025 USA

Session B4:07 Applied Physics
Friday 11/11/11 = 2:42-2:54 PM
Kavli 3rd Floor CR

physicsworld

physicsworld.com

Volume 24 No 4 April 2011



SUPERCONDUCTIVITY

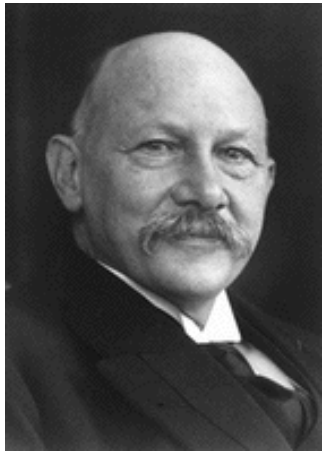
THE FIRST 100 YEARS

Discovery Anniversaries

100

1911 (4.2 K)

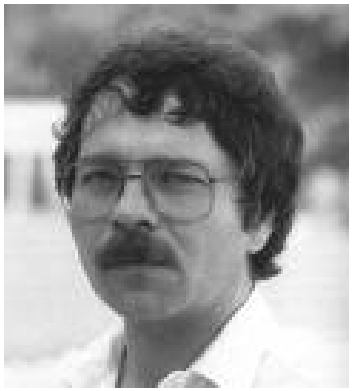
Gilles Holst



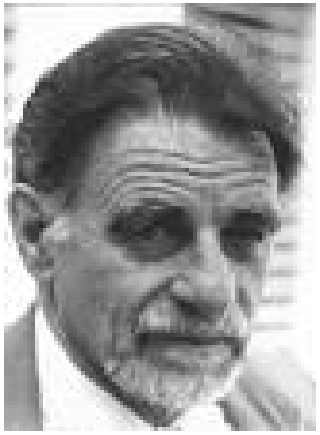
H. Kammerlingh-Onnes

25

1986 (20-40 K)



Georg Bednorz



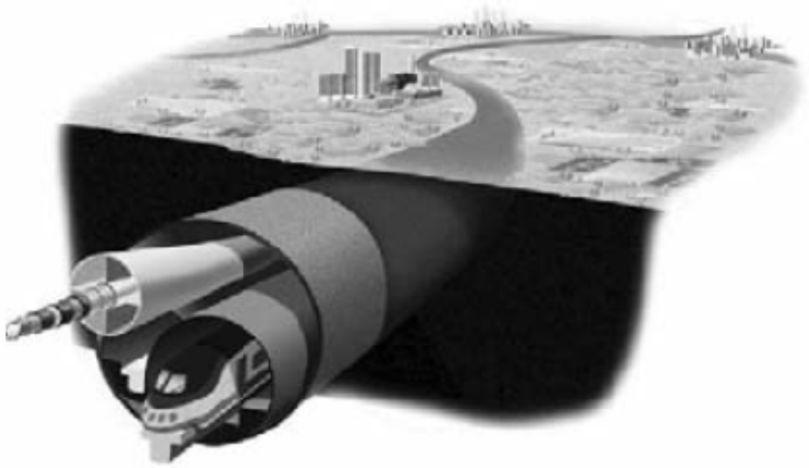
Alex Mueller

Superconductivity: 100 Years and Counting

First in a year-long series of editorial pieces celebrating the history and progress of superconductivity

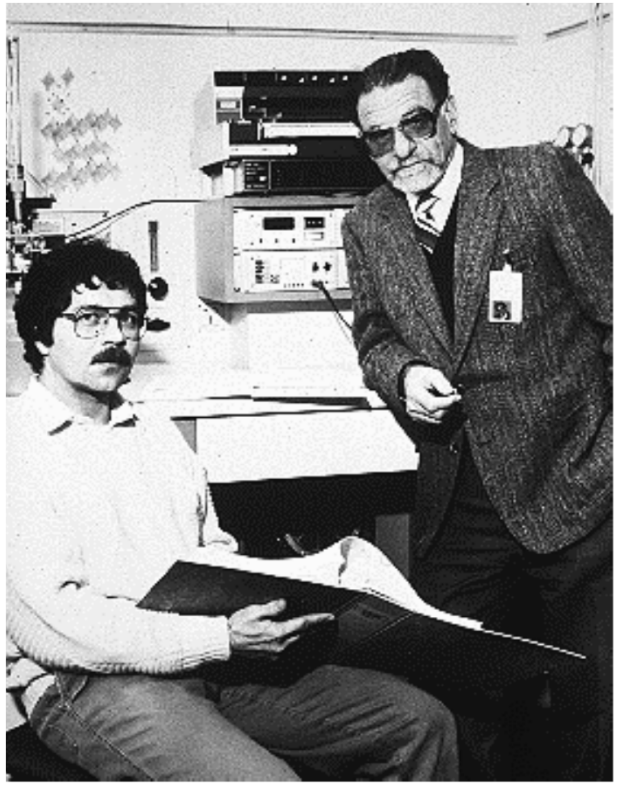
by Dr. Paul Michael Grant, W2AGZ Technologies, w2agz@w2agz.com, www.w2agz.com

The following invited article is based on a presentation by Dr. Paul Grant at the July 2010 ICEC/ICMC in Wroclaw, Poland. It is the first in a year-long series of articles in which Cold Facts will be celebrating the 100th anniversary of the discovery of superconductivity.

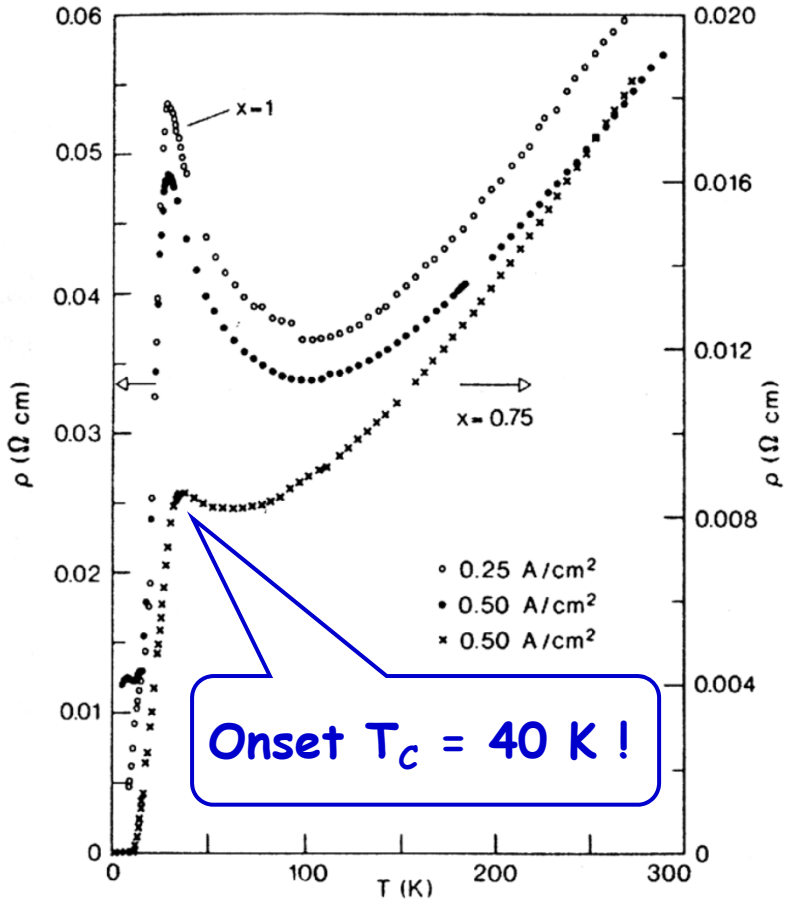


To read this article, click here. To visit a nauseatingly long list of other popular presentations and publications by the author, click here.

1986
Another Big Surprise!



Bednorz and Mueller
IBM Zuerich, 1986

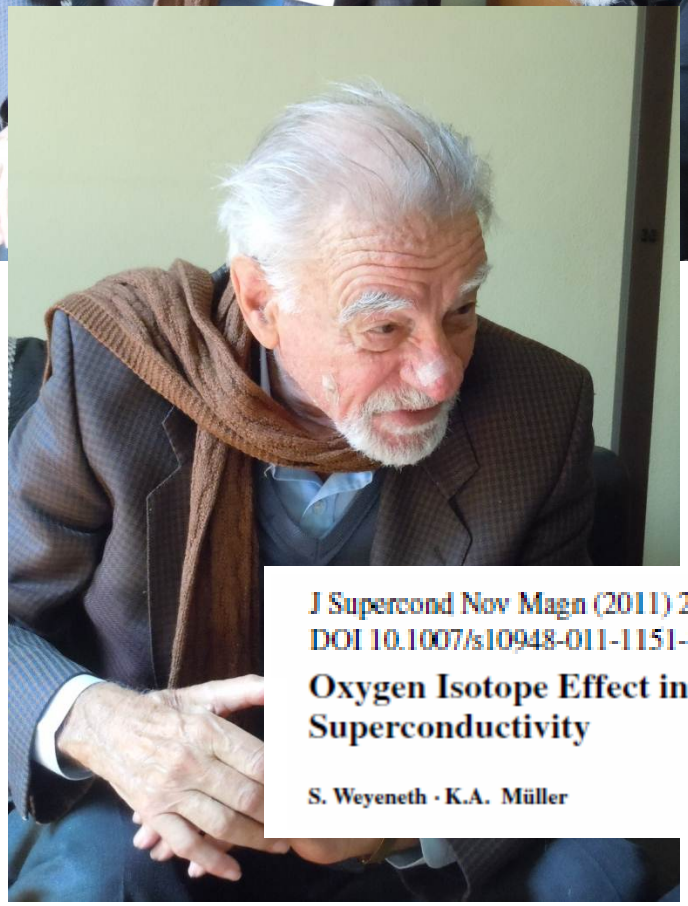


1987
“The Prize!”

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



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

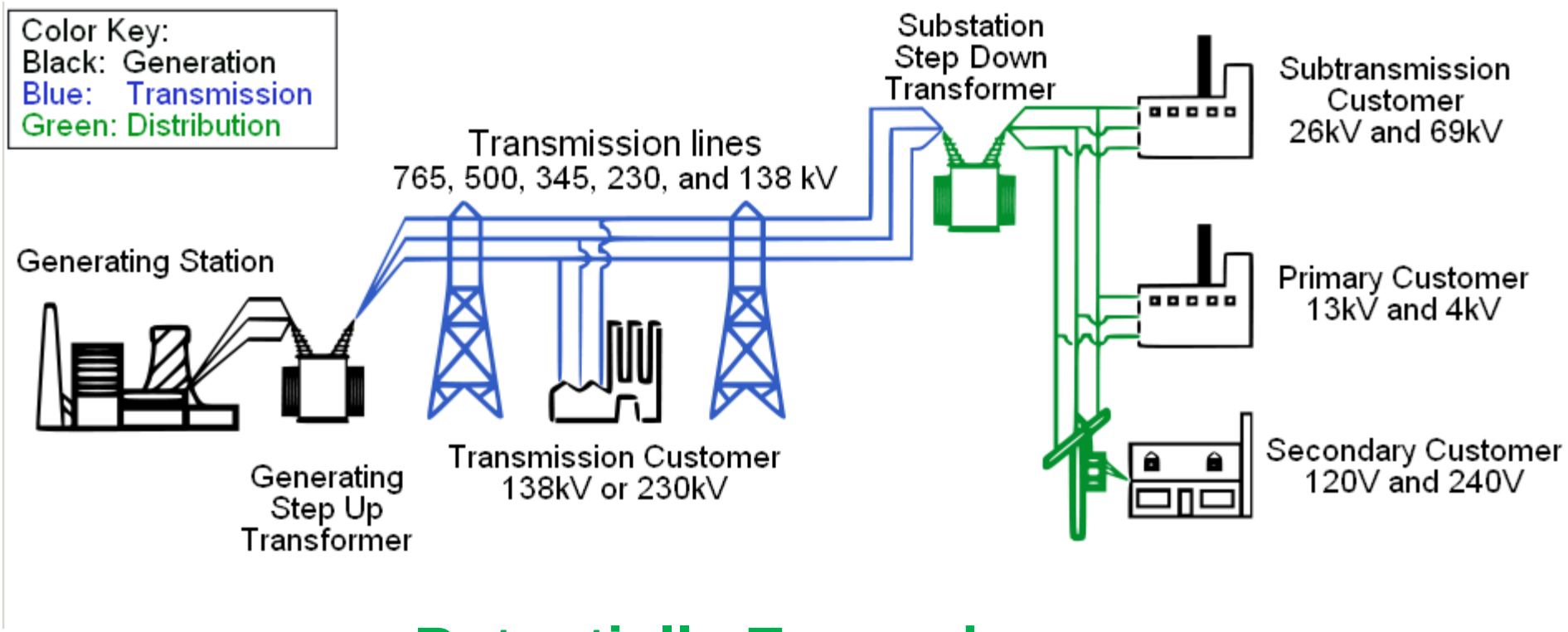
S. Weyeneth · K.A. Müller

“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.

To view a video of Reagan’s talk and other selected “outakes” from the Woodstock of Physics Era, go to http://www.w2agz.com/Video%20Content/Superconductivity/ or click here.
NB! Some of these wmv files are huge, so deploy a good, fast “streamer.”

Where Can We Apply Superconductivity to Electric Power?



Potentially Everywhere

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

(pdf)

R. L. GARWIN AND J. MATISOO

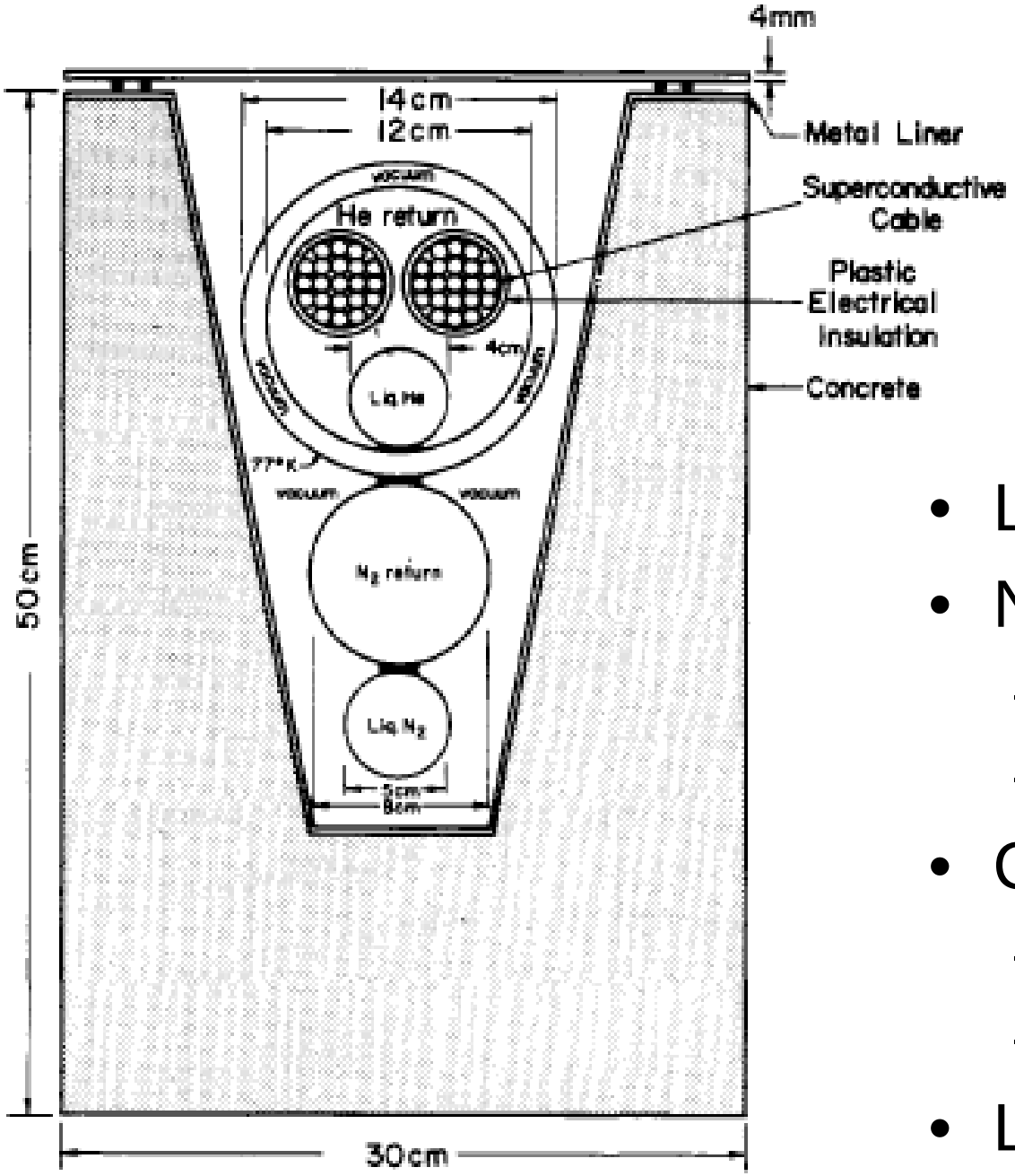
Submitted 24 June 1966

PROCEEDINGS OF THE IEEE, VOL. 55, NO. 4, APRIL 1967

"What's past is prologue" (Bill S.)

Rationale: Huge growth in generation and consumption in the 1950s; cost of transportation of coal; necessity to locate coal and nuke plants far from load centers.

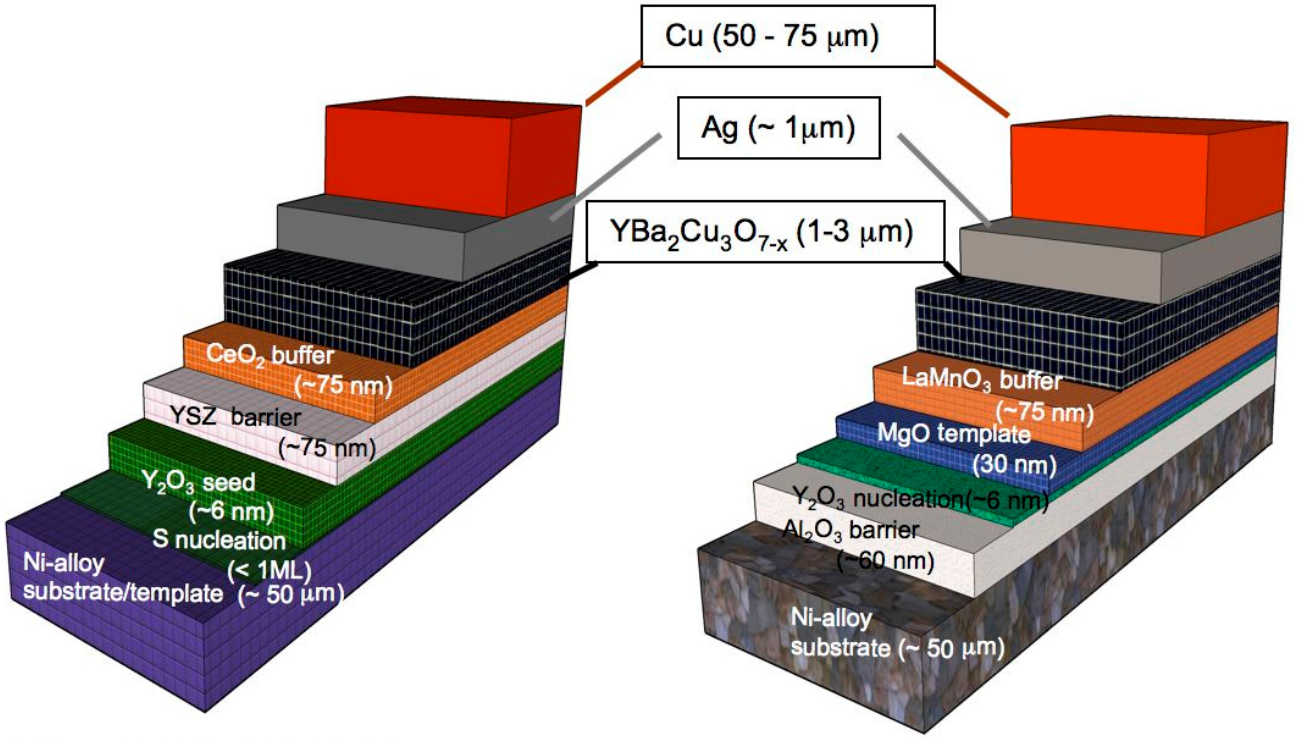
Furthermore, the utilities have recently become aware of the advantages of power pooling. By tying together formerly independent power systems they can save in reserve capacity (particularly if the systems are in different regions of the country), because peak loads, for example, occur at different times of day, or in different seasons. To take advantage of these possible economies, facilities must exist for the transmission of very large blocks of electrical energy over long distances at reasonable cost.



Specs

- 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

Gen II Coated Conductor



Rolling-Assisted Biaxially Textured Substrates (RABiTS)

Ion-Beam-Assisted Deposition (IBAD)

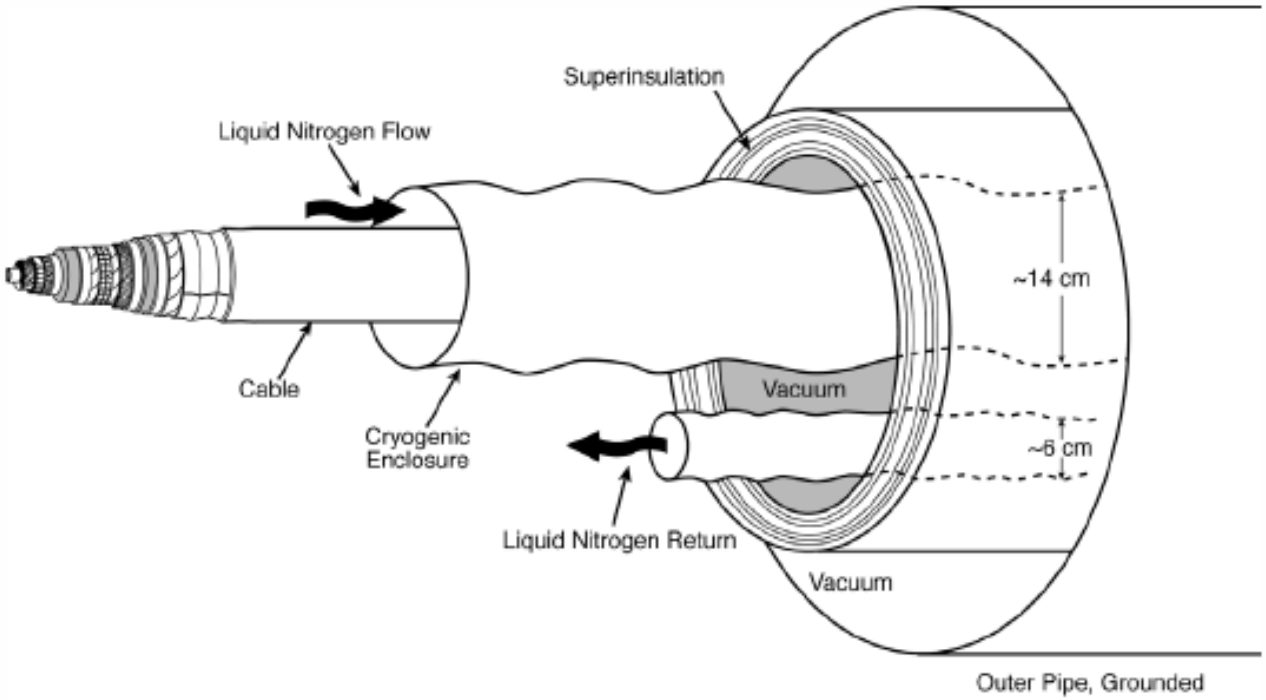
American Superconductor

SuperPower

A Superconducting dc Cable

EPRI Report 1020458 (2009)

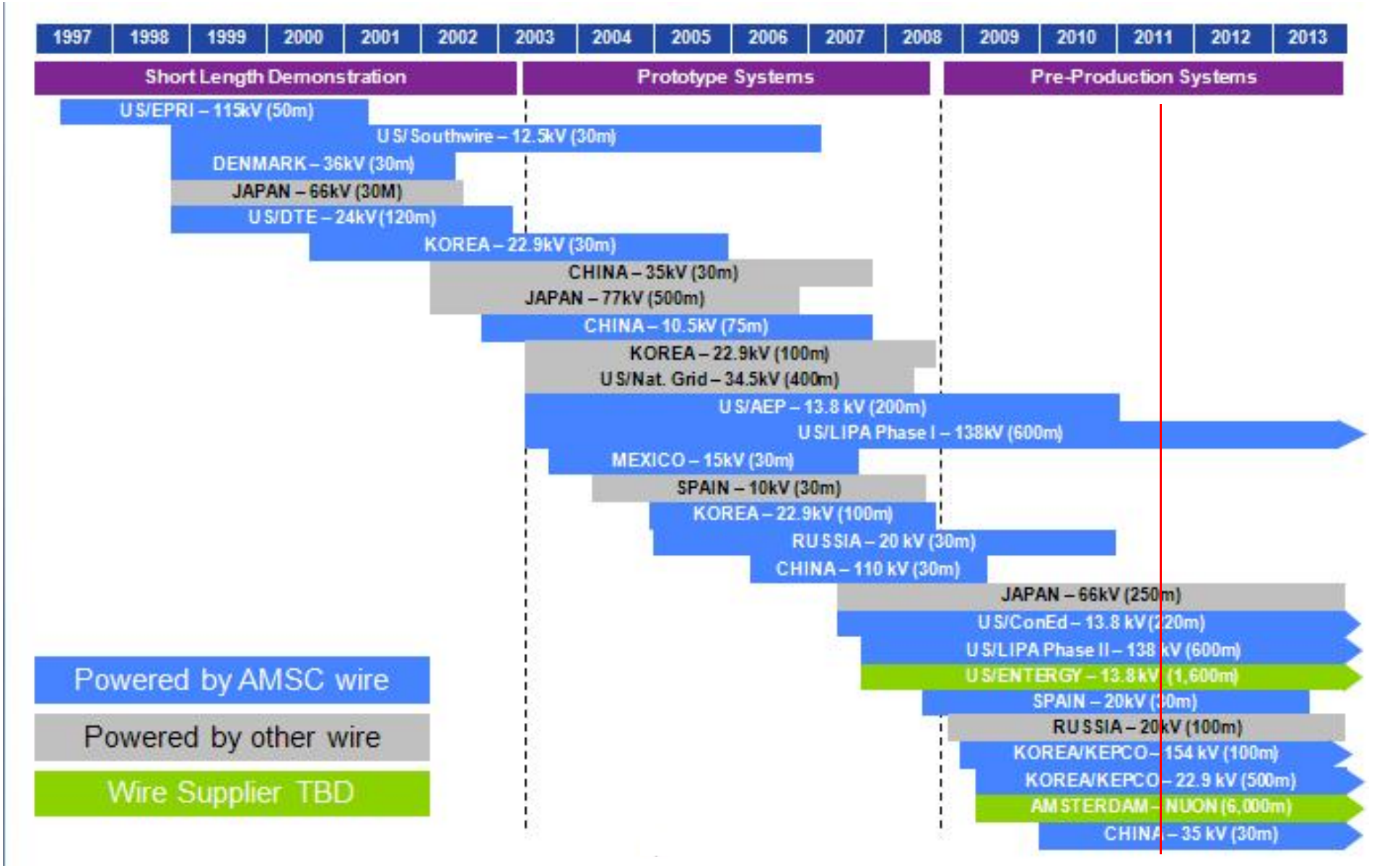
Hassenzahl, Gregory, Eckroad, Nilsson, Daneshpooy, Grant



Monopole Specs

100-kV, 100-kA, 10-GW
66 K < T< 69 K

HTSC Cable Projects Worldwide
Past, Present…Future?



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"

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?

Questions for US HTSC Wire Manufacturers

- American Superconductor
  - Estimated gross revenue from wire sales (and actual delivery) for FY2011?
  - Note: 3Q10 gross revenue from wire sales was 1.8% of total quarter
  - *Flash: On 10/17/11 American Superconductor becomes AMSC!*
- SuperPower
  - Same as AMSC #1 above
  - Estimated employee/manpower growth in CY2011
- Ultera/Southwire
  - Is Carrolton plant cable (Gen 1) still in operation?
  - Plans to replace/extend?
- Nexans/AMSC/LIPA
  - Status of Gen II wire/cable upgrade
- AMSC/ConEd/DHS
  - Status/funding of Project Hydra

A Canadian's View of the World

The Mackenzie Valley Pipeline

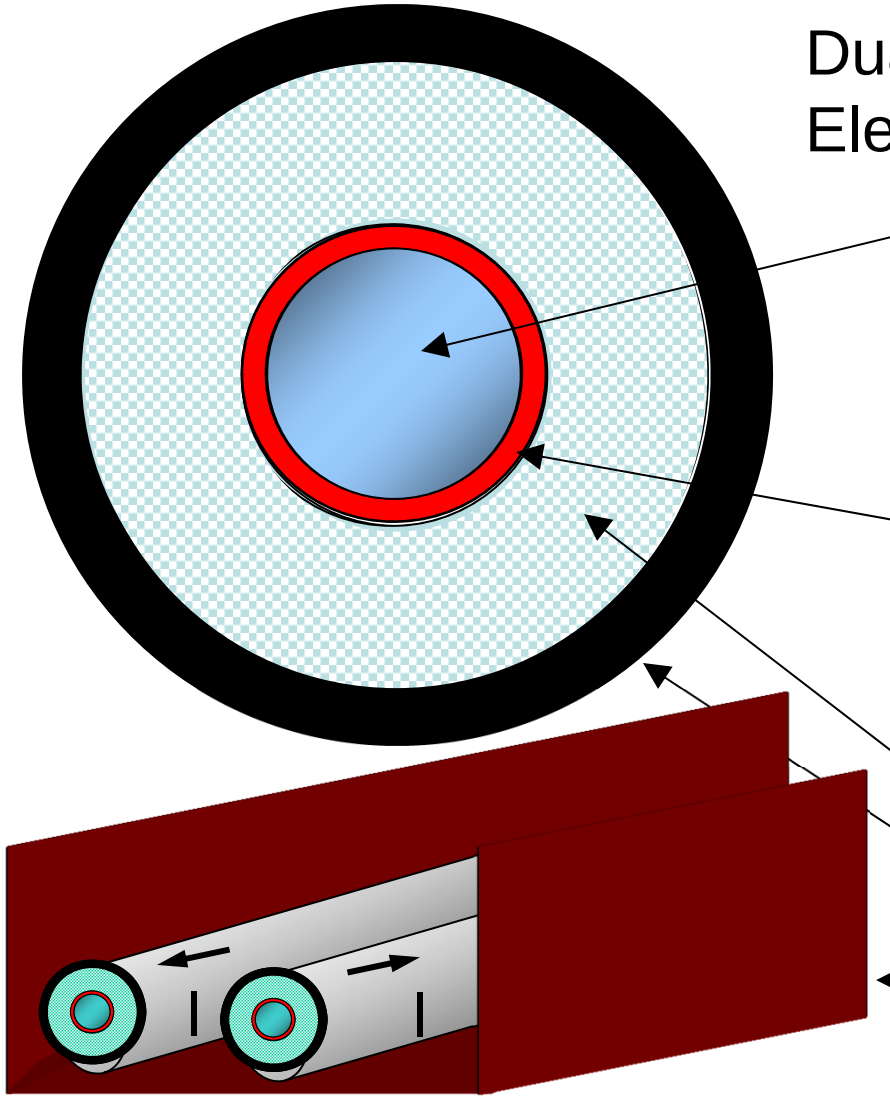
Mackenzie Valley Pipeline

1220 km
18 GW-thermal
2006 - 2010

It's 2030

- *The Gas runs out!*
- We have built the LNG SuperCable years before
- Put HTCGR Nukes on the now empty gas fields to make hydrogen and electricity (some of the electricity infrastructure, e.g., I/C stations, already in place)
- Enable the pre-engineered hydrogen capabilities of the LNG SuperCable to now transport protons and electrons.

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

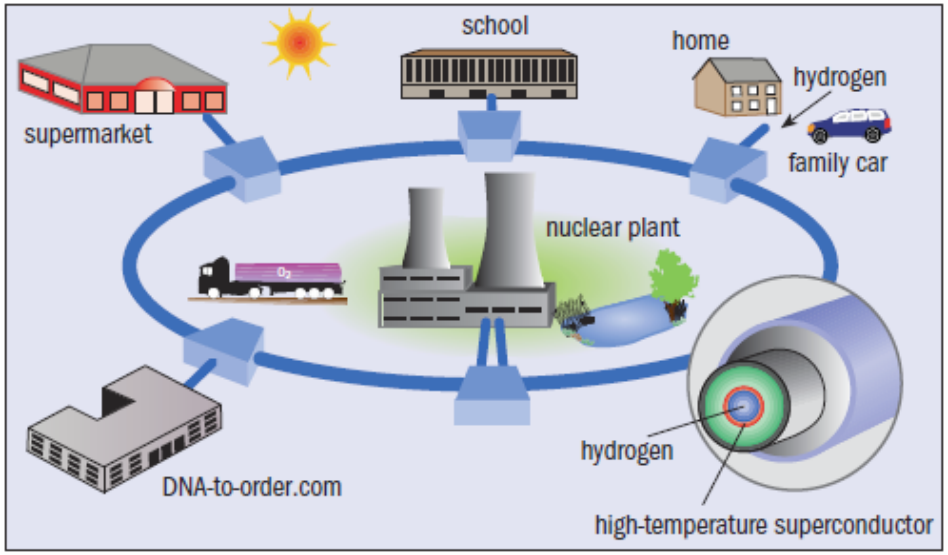
Thermal Insulation

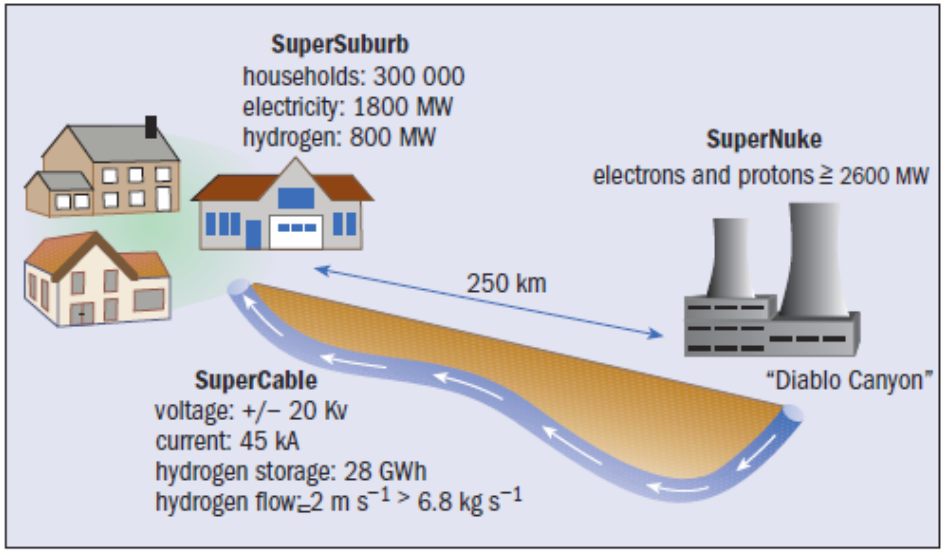
Electrical Insulation

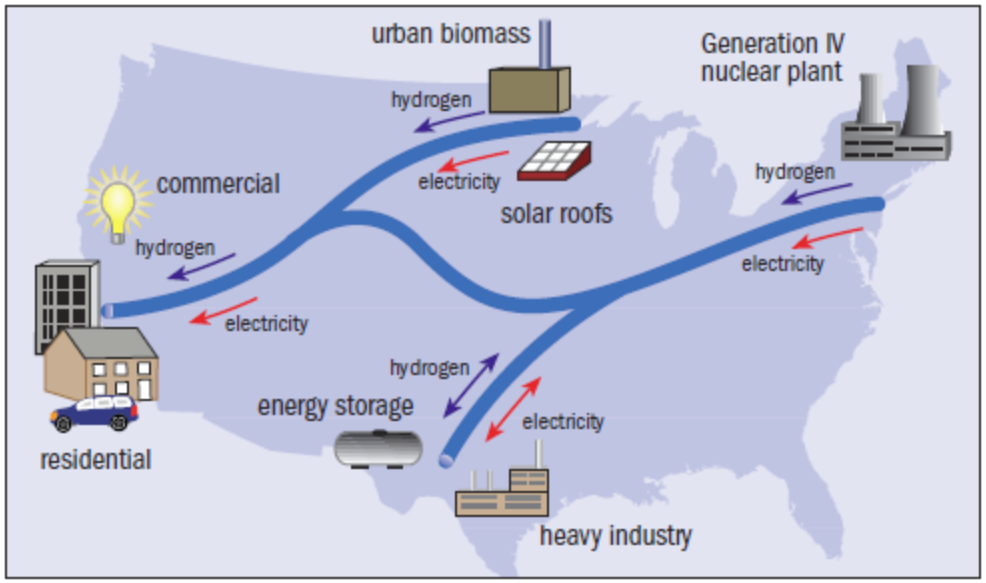
Enclosed in underground tunnel or trench

SuperCities - SuperSuburbs – SuperGrids

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

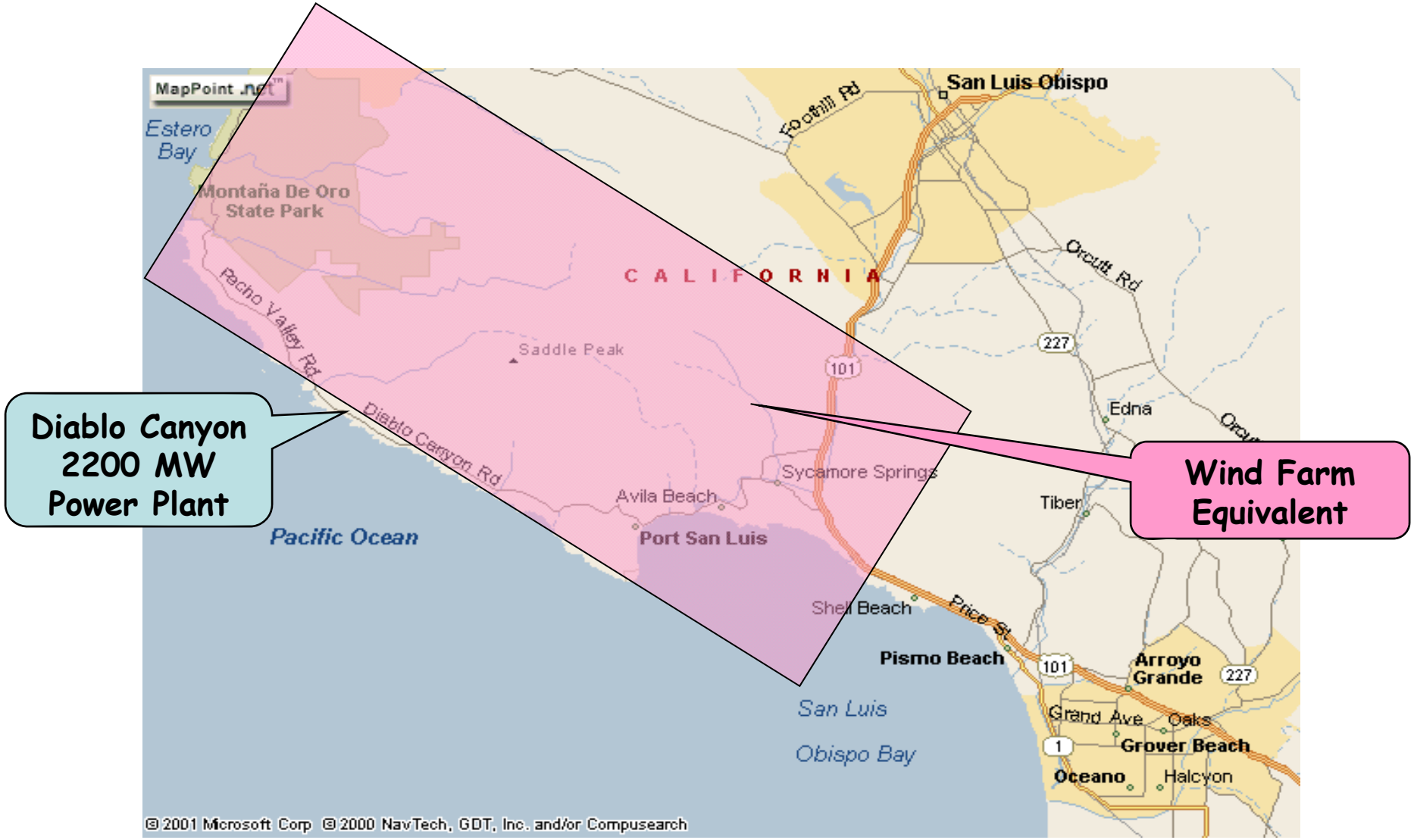






Diablo Canyon

California Coast Power



Powering Europe with Sahara Solar

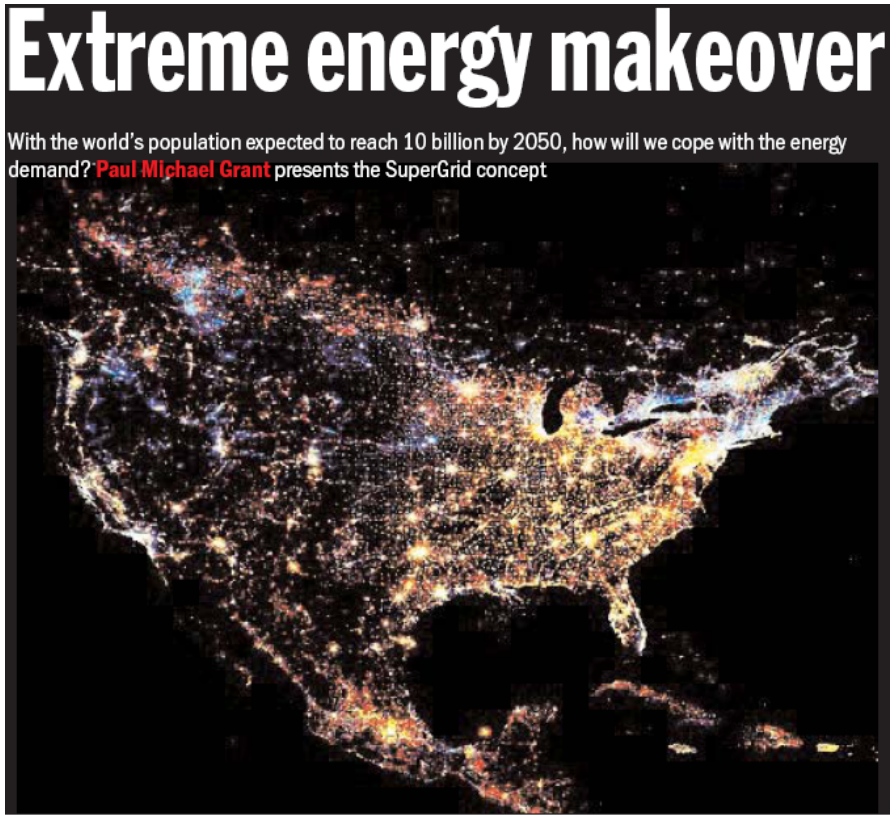
IASS Workshop, May 2011

Go Where the Sun Shines

Solar – PV & Thermal

Superconducting SolarPipe

Physics World, October 2009



From The Times

October 3, 2009

Science: Stand by for the Supergrid

Why the world needs an 'extreme energy makeover'

Anjana Ahuja

Go here for pdf of Times piece

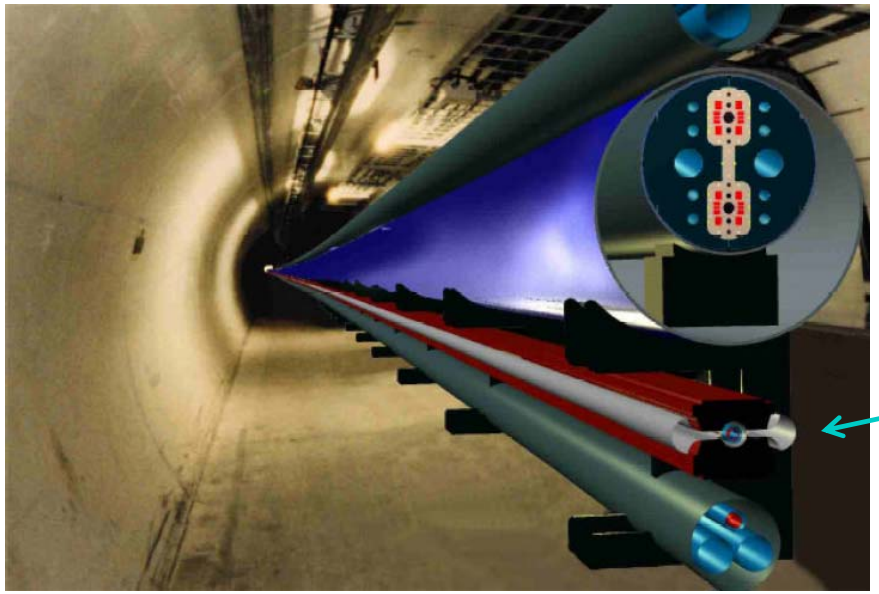
…a future editor of Nature…?

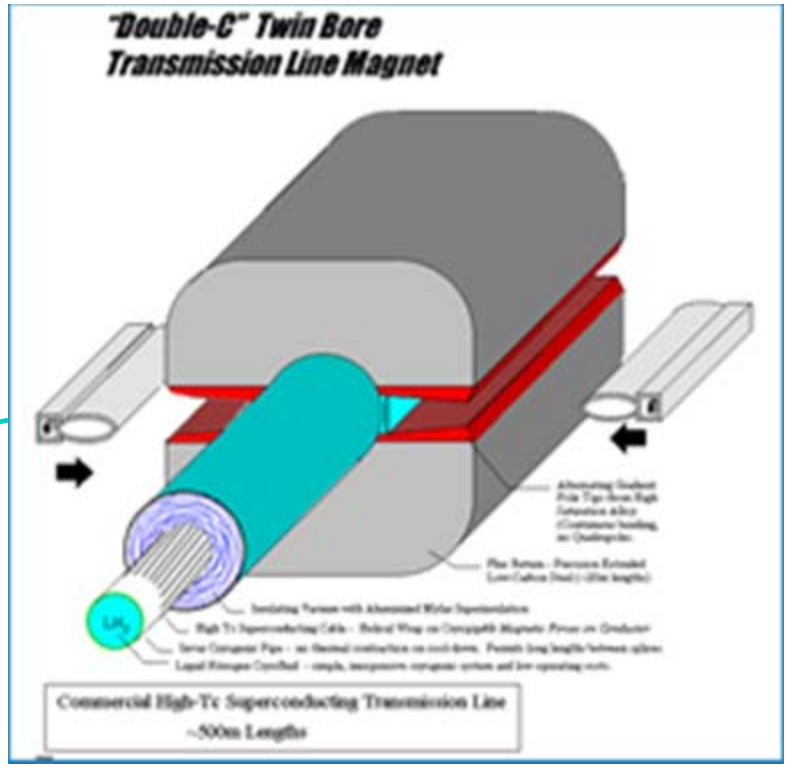
Superconductors
- The Long Road Ahead -
Foner & Orlando (1988)

"Widespread use of these
[high temperature] superconducting
technologies will have far more to do with
questions of public policy and economics
than with the nature of the new materials."

The Next American Big-Bang-a-Tron
("The Pipetron" or "Beyond Higgs")

See Lance Cooley's IASS Talk





Bob Wilson
Bill Foster
Peter Limon
Ernie Malamud
...*Limon Report*

150 TeV COM Hadron Collider
based on superferric magnets energized by a 50 kA superconducting dc cable –
Tunnel enclosure ~ 2.5 m dia, 800 km circumference.

Some Obscure Axioms of History

- There is nothing new under the sun

  Ecclesiastes 1:9-14

- What's past is prologue

  The Tempest, by Bill S.

- Those who cannot remember the past are bound to repeat it

  George Santayana

- History is more or less bunk

  Henry Ford

- I can't think about tomorrow...I'm as lost as yesterday

  Tomorrow, by Bob Seger (mp3)

- If I'm not smart enough to solve it (any problem...social or scientific), neither is anyone else!

  Anon. (hint: initials PMPG)

“You can’t always get what you want…”

“…you get what you need!”

(*mp3*)

1.
Paul, let me tell you why the t-J crowd has got it all wrong.

2.
You see, there's an isotope effect...and the lattice has gotta be involved.

3.
Hmm...I guess you're not getting it. So...OK...

4.
...I'll write it down for you. Go here...DOI 10.1007/s10948-011-1151-3