Energy Modeling Forum
Potential Transformations Through Science
- The SuperGrid Vision -

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Energy Modeling Forum
Snowmass, CO
23 July – 3 August 2007
http://www.w2agz.com

http://www.w2agz.com/pes07.htm

W2AGZ Technologies   **Oglethorpe IEEE-PES/AEI Course**   **W2AGZ Technologies**

Plain Talk about the **Electric Power System** for the **Non-Power Engineering Professional**

23 - 25 January 2007
Oglethorpe Power Corporation, Tucker, GA
Sponsored by the IEEE Power Engineering Society and the American Education Institute ([link](#) to course home page)

Advanced Transmission Technologies ([pdf](#), [ppt](#))
Paul M. Grant
[W2AGZ Technologies](#)
(Introduction by T. R. Schneider) ([pdf](#), [ppt](#))

Links to Local Bookmarks on This Page
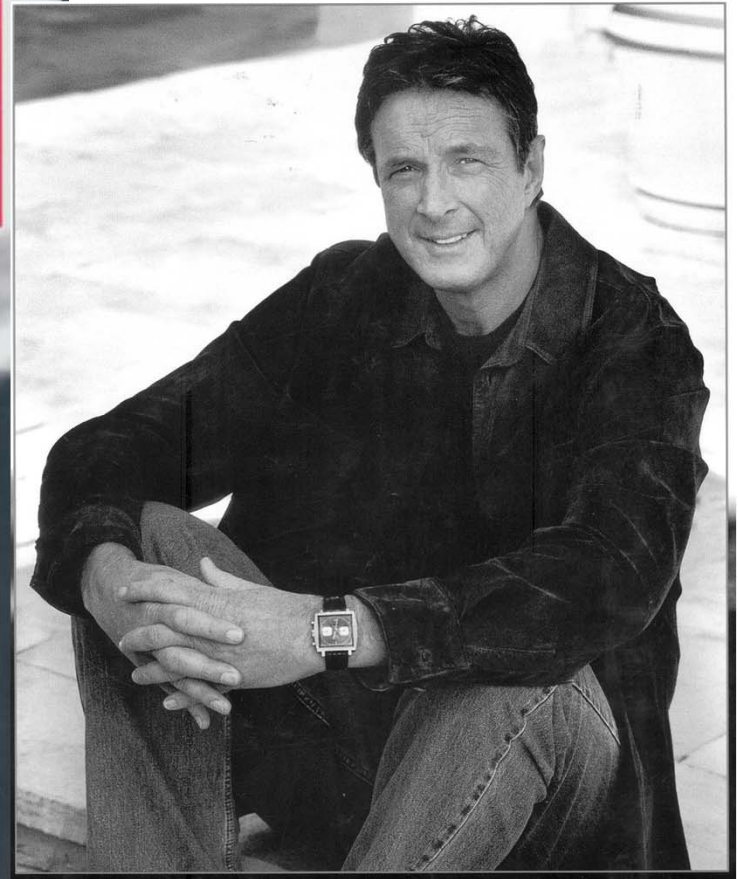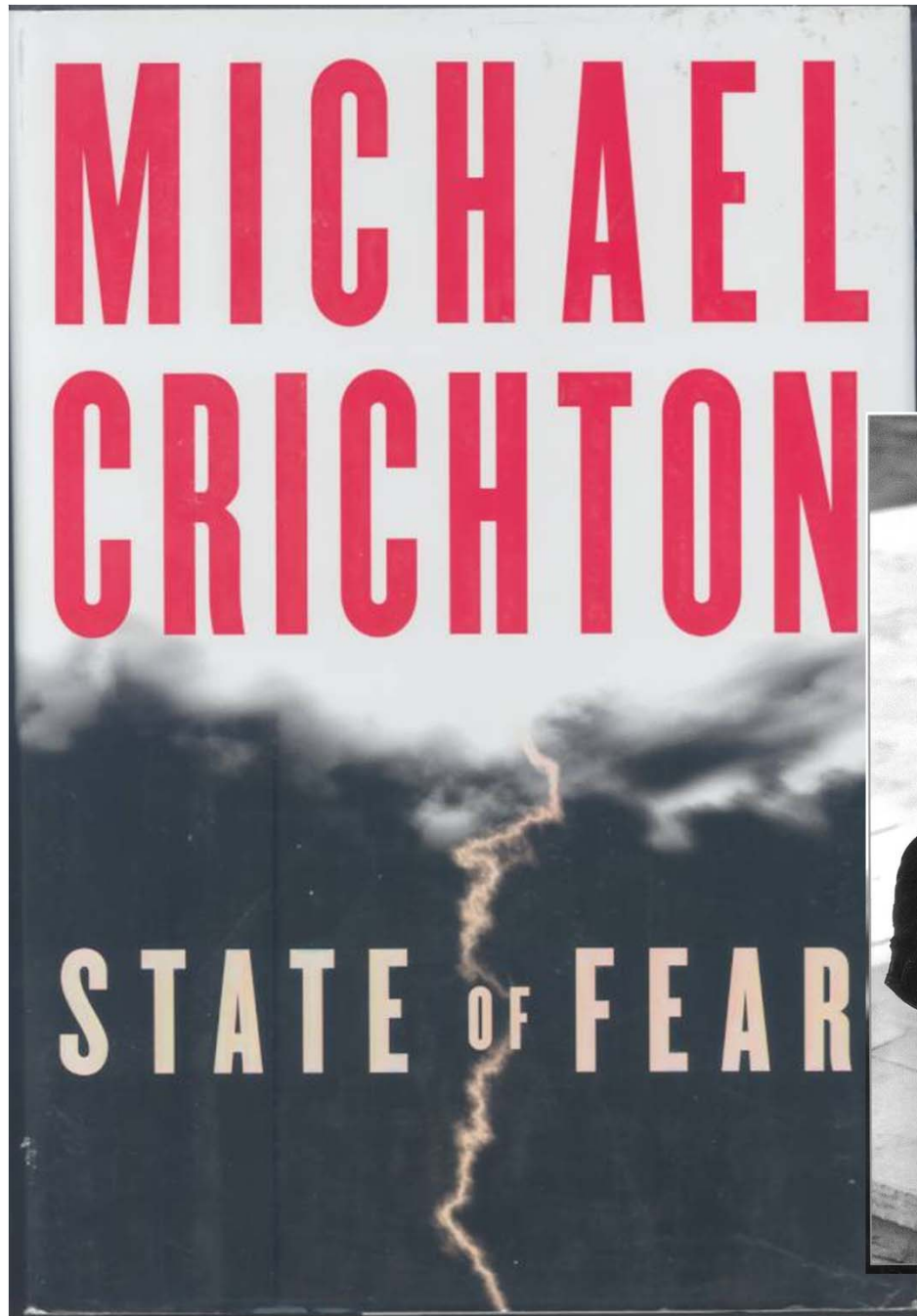[Course Background Material](#)
[Recent PMG Stuff](#) (including [SuperGrid SciAm](#) article)

An Inconvenient Truth

The Day After Tomorrow

MICHAEL CRICHTON

STATE OF FEAR

"Greenhouse Gases"

Bob Laughlin's "Theory of Everything" (that matters)

Theory of Everything

$$\mathcal{H} = -\sum_j \frac{\hbar^2}{2m} \nabla_j^2 - \sum_\alpha \frac{\hbar^2}{2M_\alpha} \nabla_\alpha^2 - \sum_{j,\alpha} \frac{Z_\alpha e^2}{|r_j - R_\alpha|} + \sum_{j<k} \frac{e^2}{|r_j - r_k|} + \sum_{\alpha<\beta} \frac{Z_\alpha Z_\beta e^2}{|R_\alpha - R_\beta|}$$

- Hydrogen atom
- Methane molecule
- Water
- Air
- Rocks
- Concrete
- Steel
- Glass
- Plastic
- Buildings
- Cities
- Continents

- Proteins
- DNA
- Viruses
- Bacteria
- Yeast
- Slime mold
- Butterflies
- Sharks
- Rats
- Lawyers
- Ebola virus
- Legislatures
- Civilizations

- Flowers
- Trees
- Cows
- Cheese
- Sauce Bernais
- Computers
- Television
- Cars
- Jets
- Lawnmowers
- Sewage
- Spotted Owls
- ...

- $3 \rightarrow 10^2$
  - Chemistry
- $10^2 \longleftrightarrow 10^3$
  - Thermodynamics
- $10^3 \longleftrightarrow 10^{10}$
  - Cooperative Phenomena
- $10^{10} \longleftrightarrow 10^{20}$
  - Emergent Behavior (Us)

- $> 10^{20}$
  - CLIMATE !
- **SIZE MATTERS !**

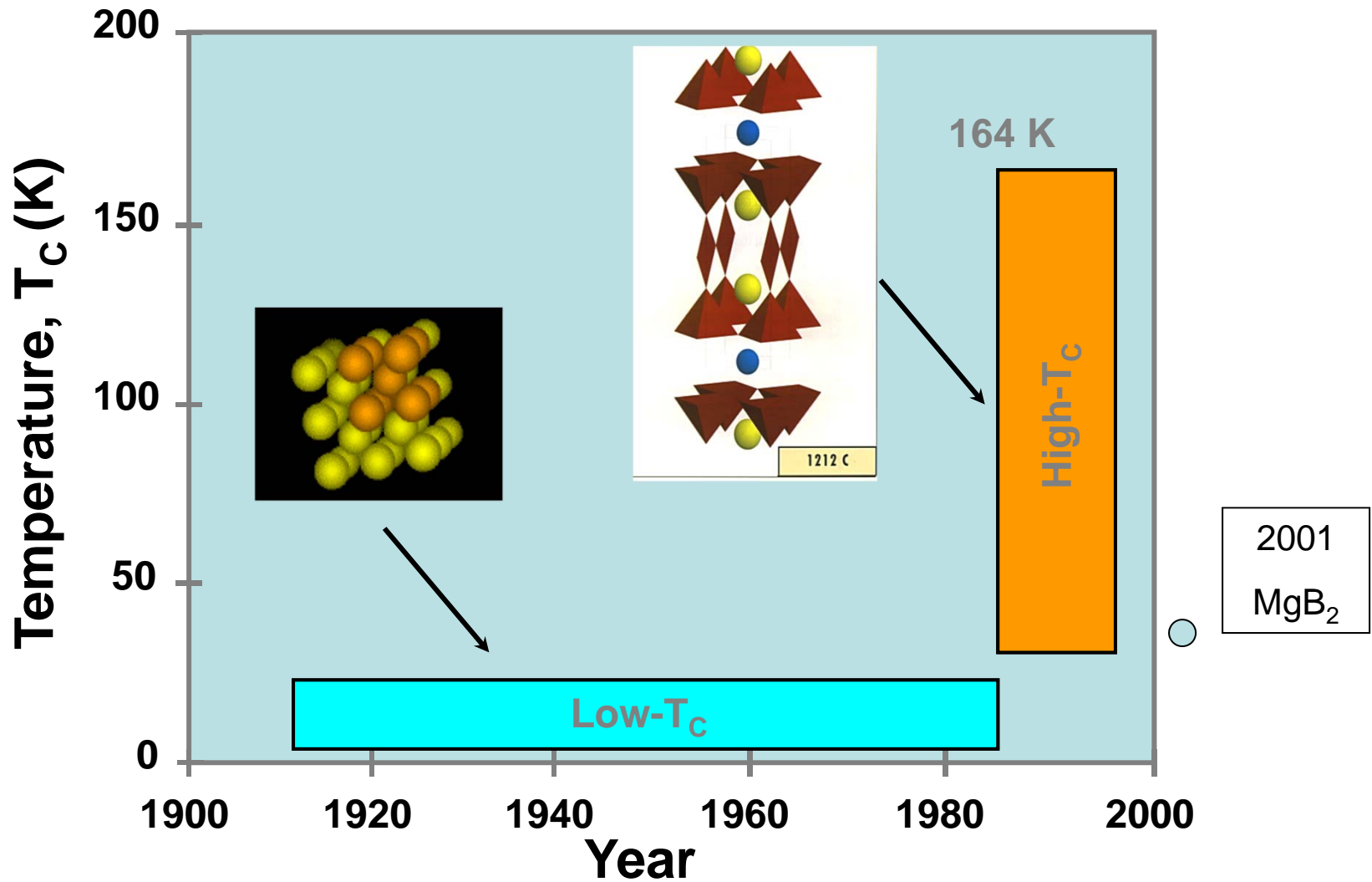# Physics of Superconductivity
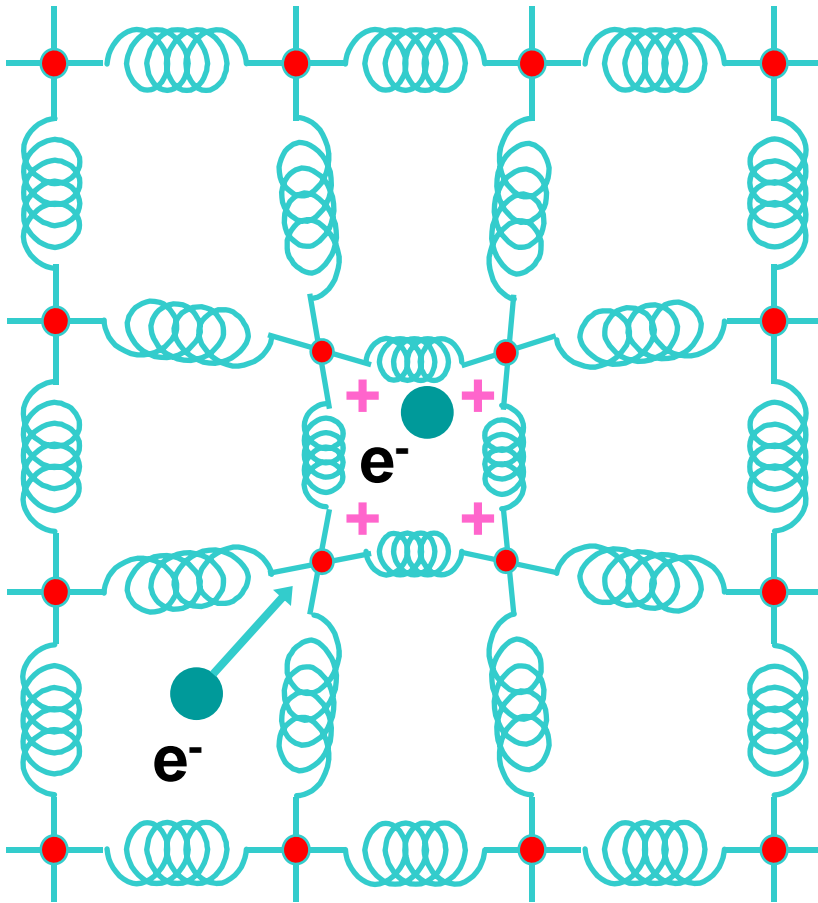
Electrons Pair Off!

BCS Equation

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

$$\theta_D = 275 \text{ K},$$
$$\lambda = 0.28,$$
$$\therefore T_C = \underline{9.5 \text{ K}} \quad (\text{Niobium})$$

T_C vs. Year: 1911 - 2007

Important Numbers
in Superconductivity

Transition Temperature, T_c Way below 300 K

Critical Current Density, J_c 10^{-2} - 10^6 A/cm^2

Critical Magnetic Field, H_c 10^{-4} - 10 T
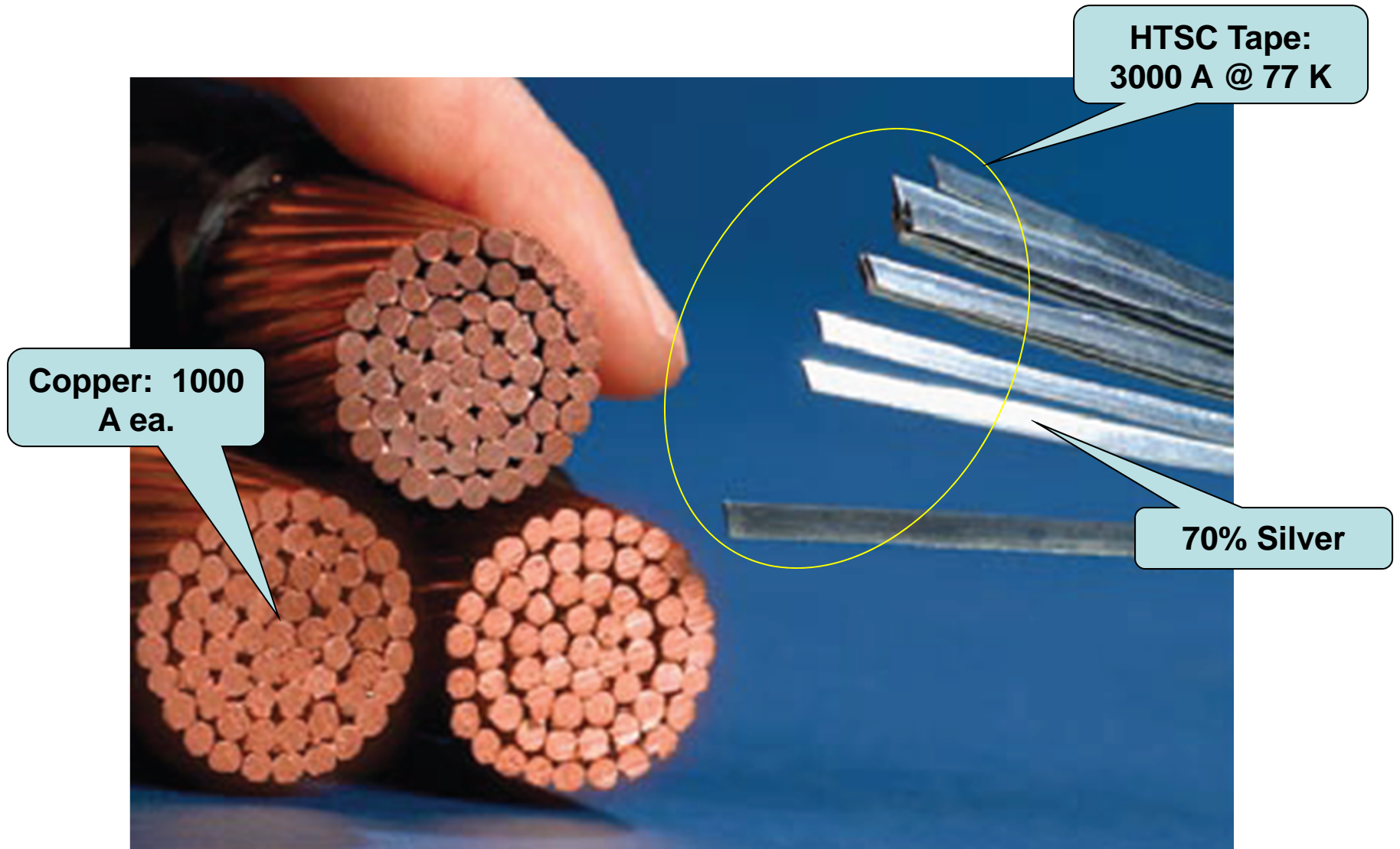
NB! All these numbers depend on each other.

Two IBM Physicists (1967)

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

R. L. GARWIN AND J. MATISOO

- Nb_3Sn (T_C = 18 K) @ 4.2 K
- 100 GW (+/- 100 kV, 500 kA)
- 1000 km
- Cost: $800 M ($8/kW) (1967)
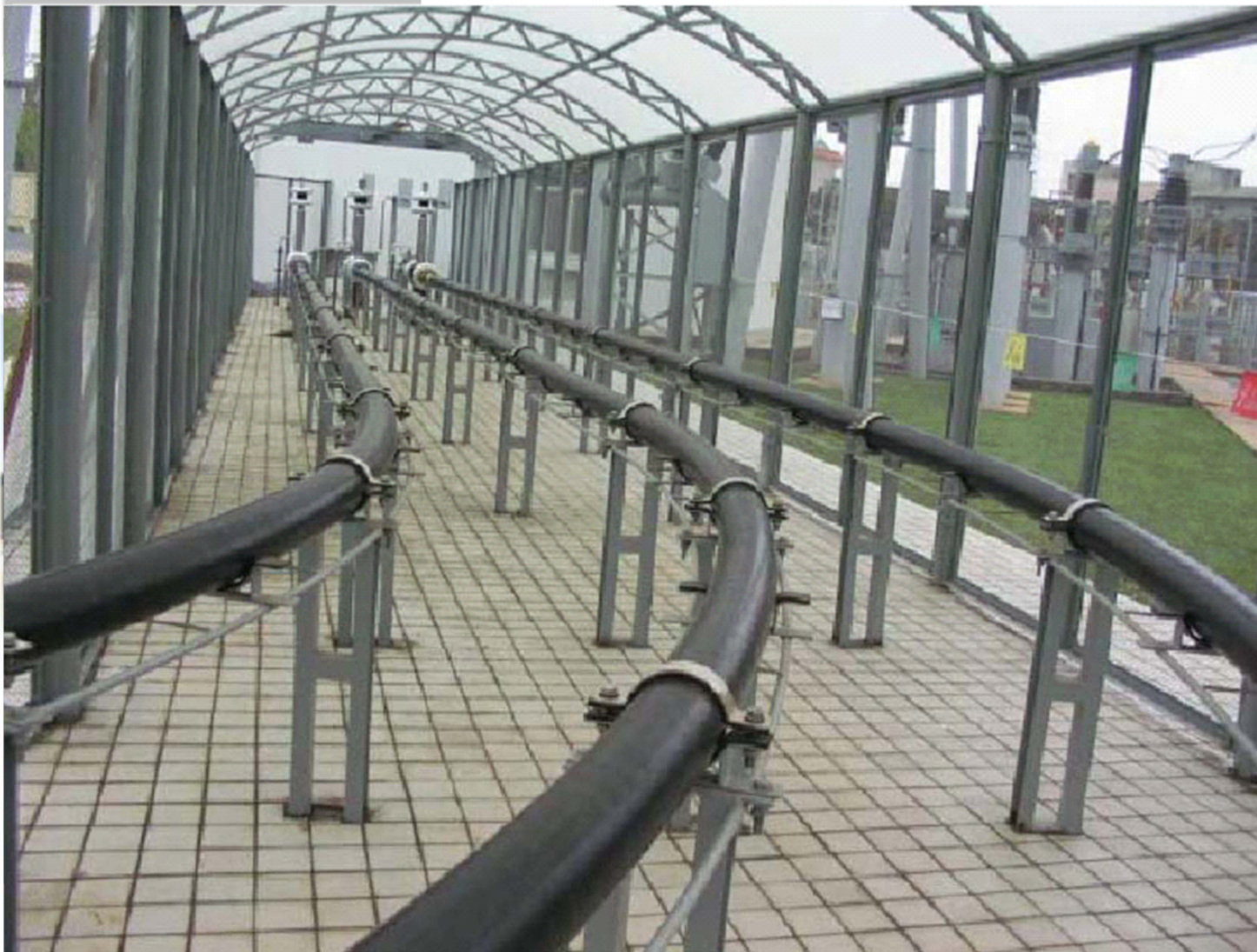
$4.7 B Today!

HTSC Tape (AMSC)

HTSC Tape: 3000 A @ 77 K

Copper: 1000 A ea.

70% Silver

Finished Cable

PIRELLI
DETROIT EDISON SPI-II
HTS CABLE 24 kV 100 MVA
2001

Cables

The 21st Century Energy Challenge

Design a communal energy economy to meet the needs of a densely populated industrialized world that reaches all corners of Planet Earth.

Accomplish this within the highest levels of environmental, esthetic, safe, reliable, efficient and secure engineering practice possible.

The Solution

A Symbiosis of

Nuclear/Hydrogen/Superconductivity

Technologies supplying Carbon-free, Non-Intrusive Energy for all Inhabitants of Planet Earth

Chauncey Starr
1912 - 2007

A POWER GRID
FOR THE
HYDROGEN ECONOMY

Cryogenic, superconducting conduits could be connected into a "SuperGrid" that would simultaneously deliver electrical power and hydrogen fuel

ZERO EMISSION

FCEV

H₂

By Paul M. Grant, Chauncey Starr and Thomas Overbye

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.
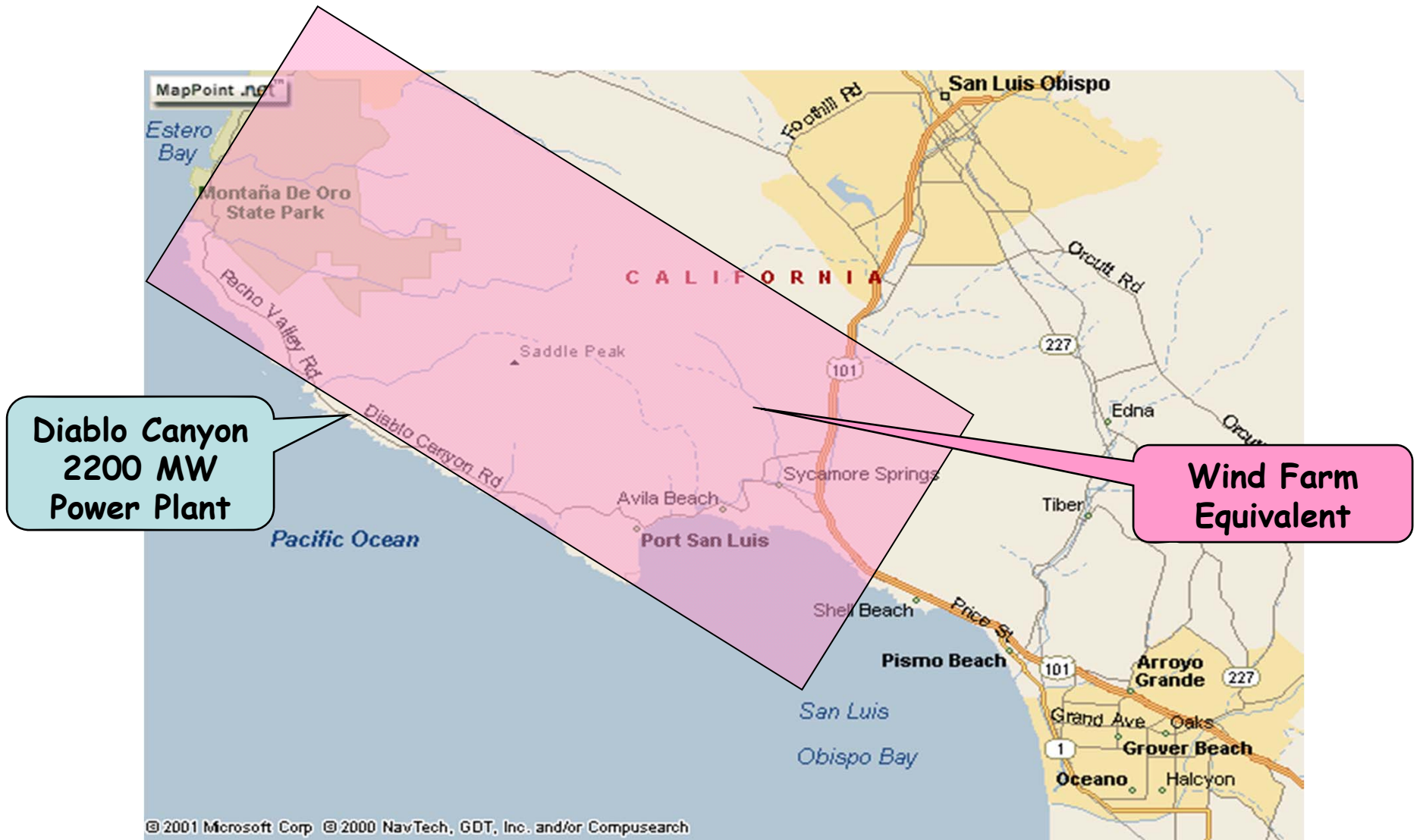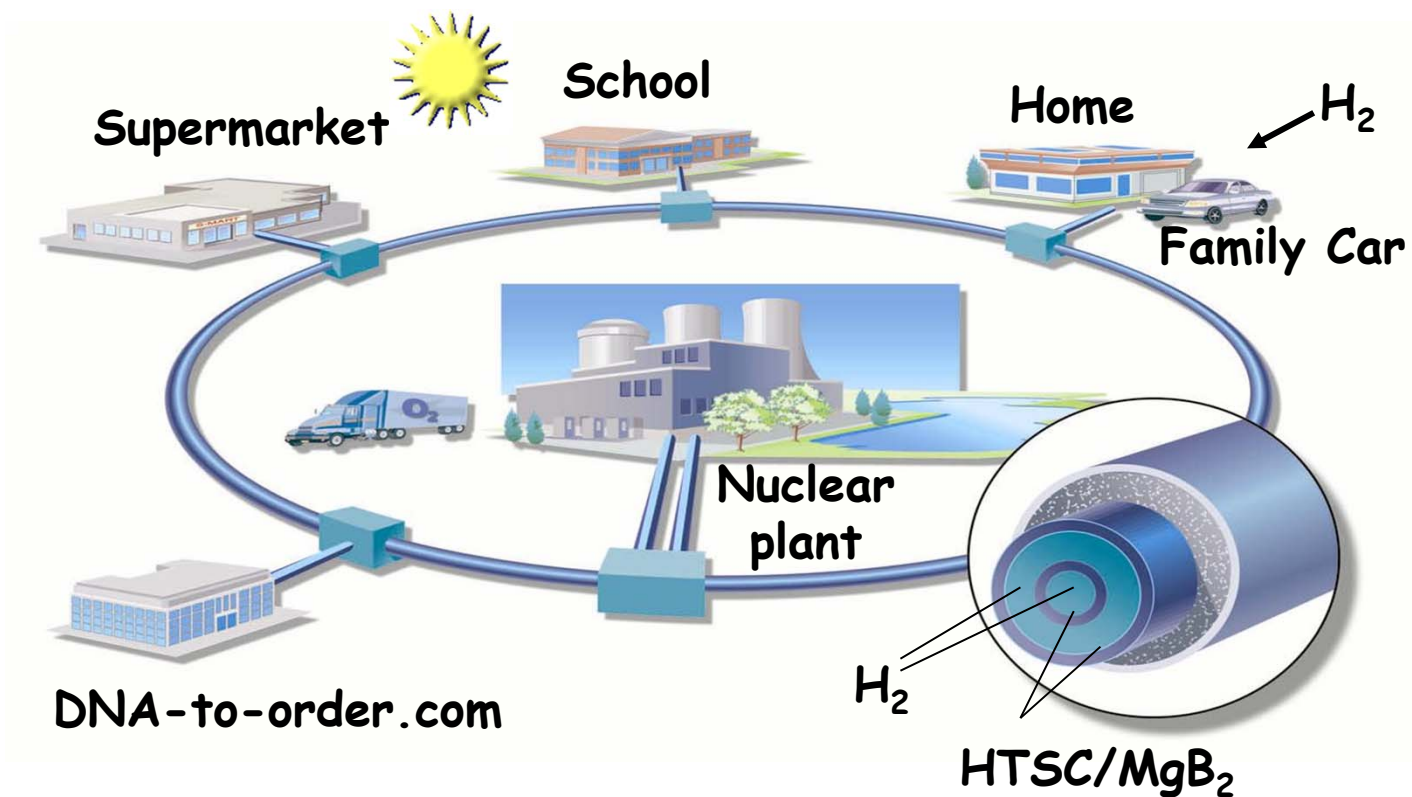
Diablo Canyon

California Coast Power

SuperCity

P.M. Grant, The Industrial Physicist, Feb/March Issue, 2002
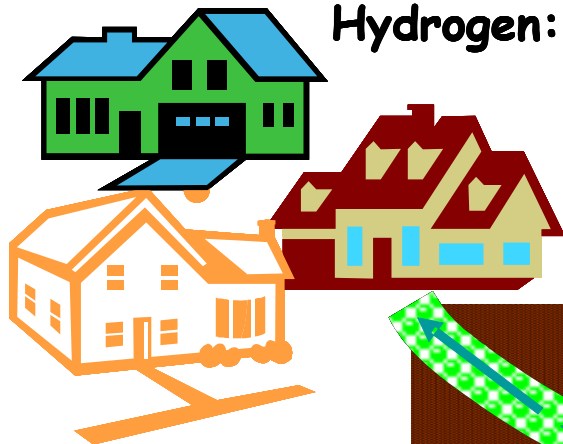
"Hydricity" SuperCables

+v

I

I

-v

H_2

H_2

Circuit #1

Multiple circuits
can be laid
in single trench

+v

I

I

-v

H_2

H_2

Circuit #2

LH$_2$ SuperCable

HV Insulation

"Super-Insulation"

t_{sc}

D_{H2}

D_O

Roughly to Scale:
• Overall 30 cm Diameter

Superconductor
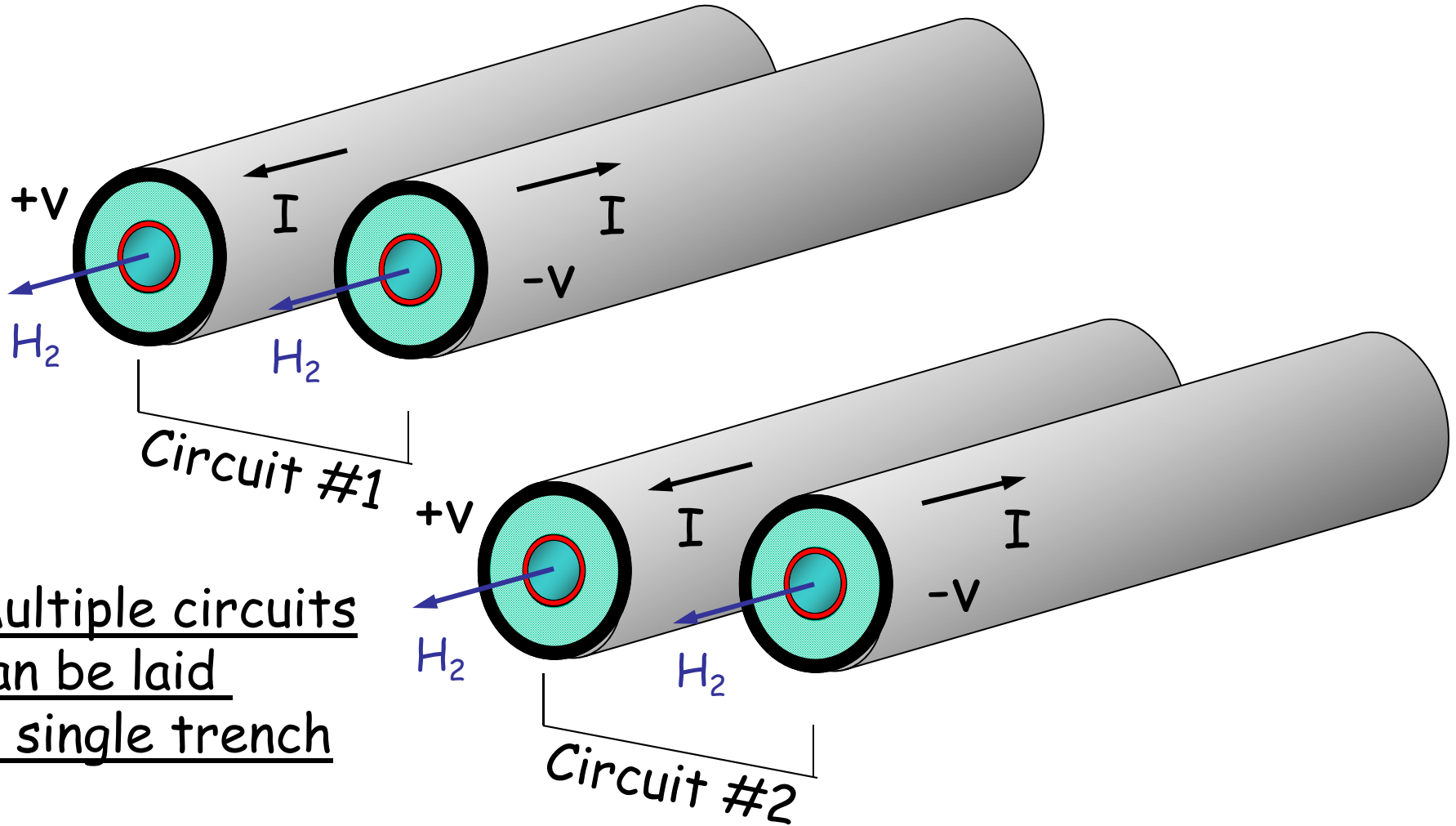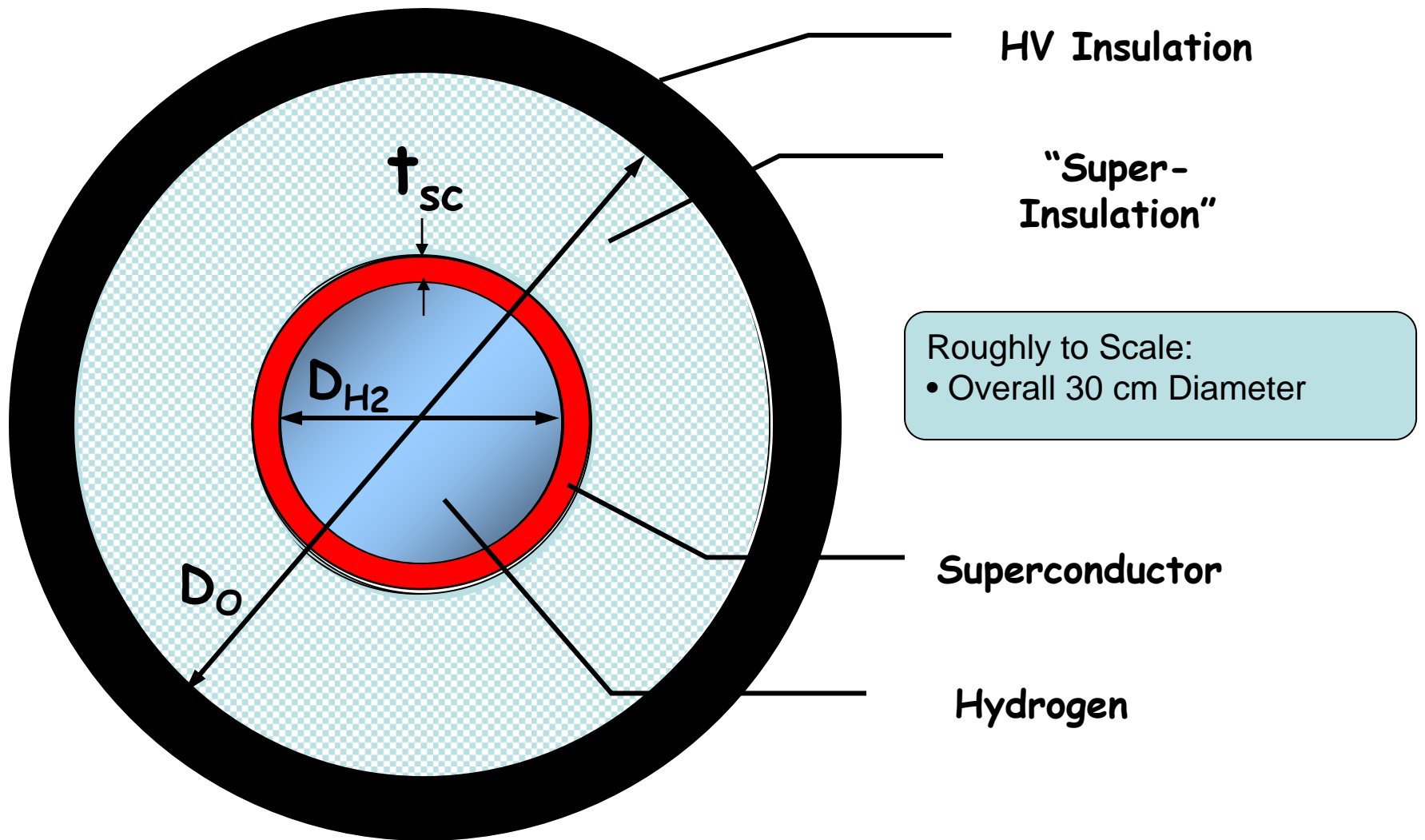
Hydrogen

SuperSuburb

SuperSuburb

Households: 300,000
Electricity: 1800 MW
Hydrogen: 800 MW

SuperNuke

electrons + protons
=> 2600 MW

250 km

~ "San Jose"
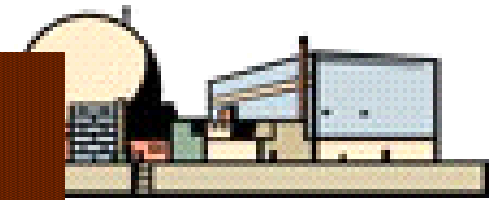
~ "Diablo Canyon"
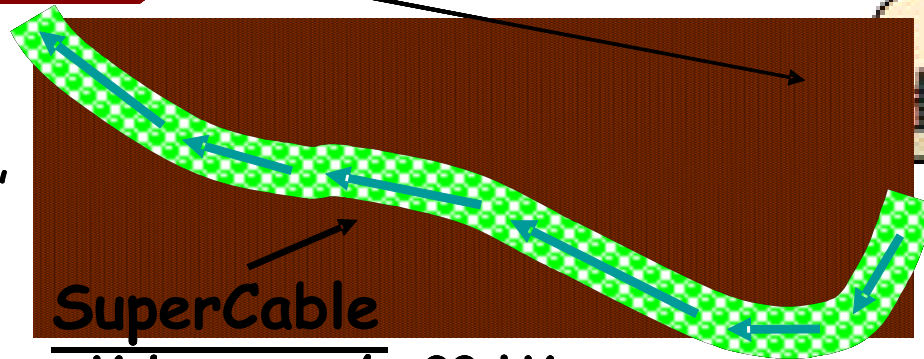
SuperCable

Voltage: +/- 20 kV
Current: 45 kA
H_2 Storage: 28 GWh
H_2 Flow: 2 m/s => 6.8 kg/s

"You can't always get what you want…"

"…you get what you need!"