Journey to the West

Paul Grant goes to China seeking wisdom...
Epiphanies Undergone...

“I have seen the future...and it works!”

Lincoln Steffens, 1920

“A wise Communist will not be afraid of learning from a capitalist.”

V. I. Lenin, 1922
www.w2agz.com
## China-USA Electricity Statistics (2001)

Source (CIA & EIA)

<table>
<thead>
<tr>
<th>Production Source (%)</th>
<th>China</th>
<th>USA (NA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil</td>
<td>80.2</td>
<td>71.4 (15% NG)</td>
</tr>
<tr>
<td>Hydro</td>
<td>18.5</td>
<td>5.6</td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1.2</td>
<td>20.0</td>
</tr>
<tr>
<td><strong>Annual Production (TkWh)</strong></td>
<td><strong>1.42</strong></td>
<td><strong>3.72</strong></td>
</tr>
</tbody>
</table>
China – Installed Generation Capacity

7%/year increasing (now > 380 GW)

根据预测，2010年将达到6.5亿千瓦左右，2020年达到9.5亿千瓦左右。

USA: ~ 1050 GW

Power Generation Installed Capacity (10MW)

400 GW

USA: ~ 1050 GW
Present & Prospect

• Total installed capacity, China ranks second only after U.S.A.

• In 2000, capacity/population in China < 1/3 of world.

• Capacity / population will be 1kW in 2050, the middle level of current developed country.

• Power consumption increased 15% past half year; 8 GW in Beijing and 15GW in Shanghai this summer.
電荒, 2004年中国仲夏夜之恶梦

Electrical power shortage (30GW),
the midsummer nightmare of 2004.
February national发电量 1581.77 billion kWh (average发电量 54.54 billion kWh) ，比上年同期增长 31.36%。

全国发电装机容量已达 3.85 billion kWh，在建电力项目 1.3 billion kWh。

**Capacity 385GW,**

**Shortage 30GW,**

线损率 line losses 7% (Three Gorges Project: 18 GW)

130GW under construction

It is said that 2006 could be better

**Could be worse**
China “Factoid”

• Current Population: 1.3 Billion Souls
• All want to live like Americans
• Chinese Family Priorities:
  – (1) TV, (2) Washer, (3) Fridge…
  – Next an Air Conditioner (200 USD, 1 kW)
• Assume an average family size of three, then…

An extra 500 GW of generation capacity must be added just to keep them cool!
## China-USA Recoverable Coal Reserves (2002)

<table>
<thead>
<tr>
<th></th>
<th>Million Short Tons</th>
<th>Years Left*</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>126,215</td>
<td>273</td>
</tr>
<tr>
<td>USA (NA)</td>
<td>280,464</td>
<td>309</td>
</tr>
</tbody>
</table>

*One Short Ton = 6150 kWh

Efficiency Conversion – 40%
Applied Superconductivity Research Center (ASRC), Tsinghua University

Established in 2000,
A multidisciplinary research center,
11 full-time staff (4 Postdoc) and 14 graduate students.

- PIT BSCCO wires,
- Coated Conductors,
- Characterization,
- New methods, new applicatio
Close relation with InnoST and Innopower
Innova Superconductor Technology Co., Ltd. (InnoST) 英纳超导公司

- THE FIRST SUPERCONDUCTOR COMPANY IN CHINA
- Founded in September, 2000
- Located in Beijing Economy and Technology Development Area, China
- >30 employees,
InnoST Production Unit

200 km/year
Innopower Superconductor Cable Co., Ltd. 云电英纳超导电缆公司

- Invested by YEPG and InnoST.
- Short term objective to develop the first HST power cable in China.
- The cable will be installed in YUNNAN power network in the beginning of year 2004.
Government Sponsorship

Applied Superconductivity Program

2002-2005, (863 超导专项)

Department of High and New Technology and Industrialization,
THE MINISTRY OF SCIENCE AND TECHNOLOGY OF CHINA (MOST)
Open to European 6th Frame Programme

Executive group members: 专家组成员

Dr. Z. Han, group leader, Tsinghua University,
Dr. H. Wen, vice group leader, CAS Institute of Physics,
Dr. P. Zhang, vice group leader, Northwest Institute for Non-ferrous Metal Research
Dr. H. Gu, General Research Institute for Nonferrous Metals
Dr. L. Xiao, CAS Institute of Electrical Engineering
Dr. Y. Tang, Huazhong University of Science and Technology
Dr. F. Wang, Peking University
Funding

Three areas:

- Superconducting materials.
- Power applications.
- Electronic applications.

- 31 projects, 31个项目
- RMB 100 millions for 3 years supported by MOST.
- > RMB 300 millions supported by local governments and Industries.
Superconducting Materials Projects

- Long BSCCO tape,
- MgB$_2$ wires,
- Low $T_c$ wires,
- Large Area YBCO Thin Film,
- Coated Conductor.
Puji Cable

33.5 m Cable

Former ID/OD(with Braiding): 30/35 mm
Layers of HTS tape: 4
Number of HTS tape: 90(21,24,24,21)
Ic of HTS tape: 60-80 A (77K, self field)
ID/OD of cryostat: 43/70 mm
Dielectric material: XLPE
Thickness of dielectric: 11.9mm
Overall linear specific weight: 9.2kg/m
Puji Substation
# Puji Cable Specs

<table>
<thead>
<tr>
<th>Subject</th>
<th>Specification</th>
<th>Subject</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of Cable</td>
<td>Three single phase, Outdoor</td>
<td>Operation Altitude</td>
<td>1,900m</td>
</tr>
<tr>
<td>Length</td>
<td>33.5m (flange to flange)</td>
<td>Outer Diameter of Cable</td>
<td>112mm</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>35kV</td>
<td>Cooling Fluid</td>
<td>LN₂</td>
</tr>
<tr>
<td>Rated Current</td>
<td>2kA(rms)</td>
<td>Cooling Capacity</td>
<td>2,000W at 75K</td>
</tr>
<tr>
<td>Shortcut Current</td>
<td>20kA/2S</td>
<td>Inlet Temperature</td>
<td>70~72K</td>
</tr>
<tr>
<td>Dielectric Type</td>
<td>Warm</td>
<td>Outlet Temperature</td>
<td>74~76K</td>
</tr>
<tr>
<td>Installation Bending Angle</td>
<td>90°</td>
<td>Reliability Requirement</td>
<td>&gt;20000 hours</td>
</tr>
</tbody>
</table>
Accessories

Terminations

Resistance at 300K:
47 \mu\Omega

Resistance at working:
40 \mu\Omega
Cryogenics

Cooling System

Purge (dry N\textsubscript{2} gas): \textit{20-24 hours}

Pre-cooling: \textit{15-20 hours}

Number of Cryorefrigerators working at normal load (800-1500A): \textit{4-5}

LN\textsubscript{2} flow rate: \textit{600-900 L/h}
Power Station

Monitoring & Control

Parameters monitored

Temperatures:
In/out of each phase;
out of pump tank;
In/out of subcooling tank;
Coldhead of each cooler;
Cooling water

Pressure:
In/out of Pump tank;
In/out of each phase;
Subcooling tank
LN2 tank

LN2 flow rate:
Each phase;
Water

LN2 level:
Pump tank
Subcooling tank
LN2 tank

Current:
Each phase

Voltage:
Each phase
Future Directions

Near Future Applications of HTS Cable

From substation to large capacity refineries and plants

Replacing old cables in existing tunnels and trenches to increase capacity
Future Cable Applications

Near Future Applications of HTS Cable

From generator to transformer, typically, 24kV/20-30kA, 20-200m
HTS Cable?
Postcard from China

Helping to Promote US – Chinese Relations

Glad you’re not here, Dr. Grant & Friend

Stone Forest
Yunan Province, PRC
June, 2004
Recipe for a Room Temperature Superconductor