



Grid of the Future - 2022

New HTS Cooling Method Can Help with Transmission Line Siting

Stephen Conant – VP Commercial - VEIR

November 9, 2022

Dutch physicist

Heike Kamerlingh Onnes

- Discovered Superconductivity in 1911 in Mercury at 4 Kelvin during the search for Absolute Zero
- Temperature of liquid Helium – 4.19K
- Availability of Helium was limited

“On the Sudden Rate at Which Resistance of Mercury Disappears” 1911 Paper

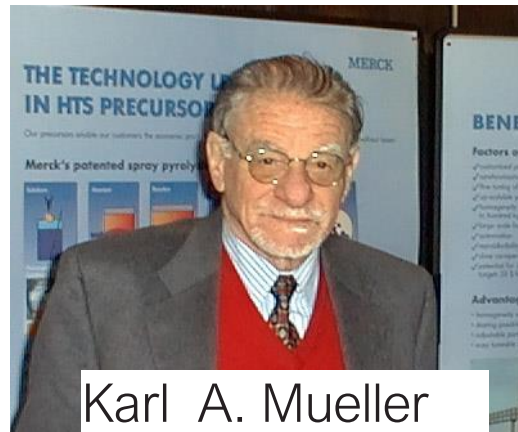


The Woodstock of Physics

New York 1987



George Bednorz



Karl A. Mueller



Congressional and Administrative Action 1988

PUBLIC LAW 100-697-NOV. 19, 1988

102 STAT. 4613

Public Law 100-697
100th Congress

An Act

To establish a national Federal program effort in close collaboration with the private sector to develop as rapidly as possible the applications of superconductivity to enhance the Nation's economic competitiveness and strategic well-being, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "National Superconductivity and Competitiveness Act of 1988".

SECTION 2. FINDING AND PURPOSES.

(a) FINDINGS.—The Congress finds that—

(1) recent discoveries of high-temperature superconducting materials could result in significant new applications of these materials in such areas as microelectronics, computers, power systems, transportation, medical imaging, and nuclear fusion, yet most potential applications may well lie beyond our ability to predict them;

(2) full application of the new superconductors is expected to require 10 to 20 years, thus calling for long-term commitments by the public and private sector to appropriate research and development programs;

(3) the Nation's economic competitiveness and strategic well-being depend greatly on the development and application of critical advanced technologies such as those anticipated to evolve from the new superconducting materials;

(4) the United States manufacturing industries confront strong

Nov. 19, 1988
[H.R. 8048]

National
Superconductivity
and
Competitiveness
Act of 1988.
16 USC 5201
note.
15 USC 5201.

Executive Order 12661--Implementing the Omnibus Trade and Competitiveness Act of 1988 and related international trade matters

Source: The provisions of Executive Order 12661 of Dec. 27, 1988, appear at 54 FR 779, 3 CFR, 1988 Comp., p. 618, unless otherwise noted.

By virtue of the authority vested in me as President by the Constitution and laws of the United States of America, including the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418, 102 Stat. 1107) ("Omnibus Trade Act"), the Tariff Act of 1930 (Chapter 497, 46 Stat. 590, June 17, 1930), as amended ("Tariff Act"), the National Defense Authorization Act, Fiscal Year 1989 (P.L. 100-456, 102 Stat. 1918) ("Defense Authorization Act"), section 301 of Title 3 of the United States Code, and, in general, to ensure that the international trade policy of the United States shall be conducted and administered in a way that achieves the economic, foreign policy, and national security objectives of the United States and in a coordinated manner under the direction of the President, it is hereby ordered as follows:

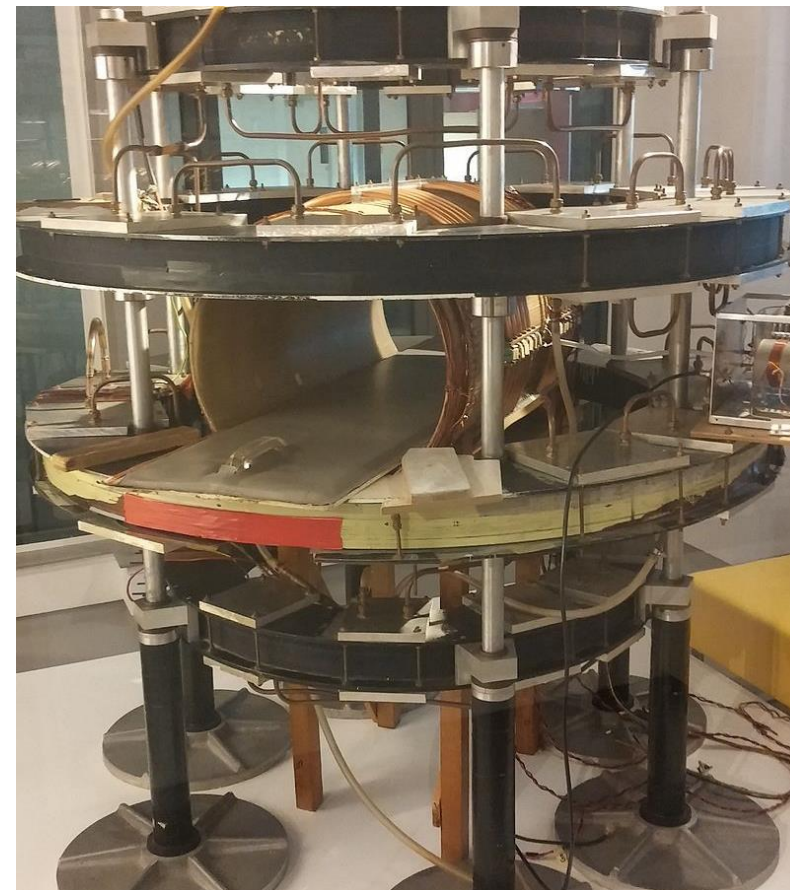
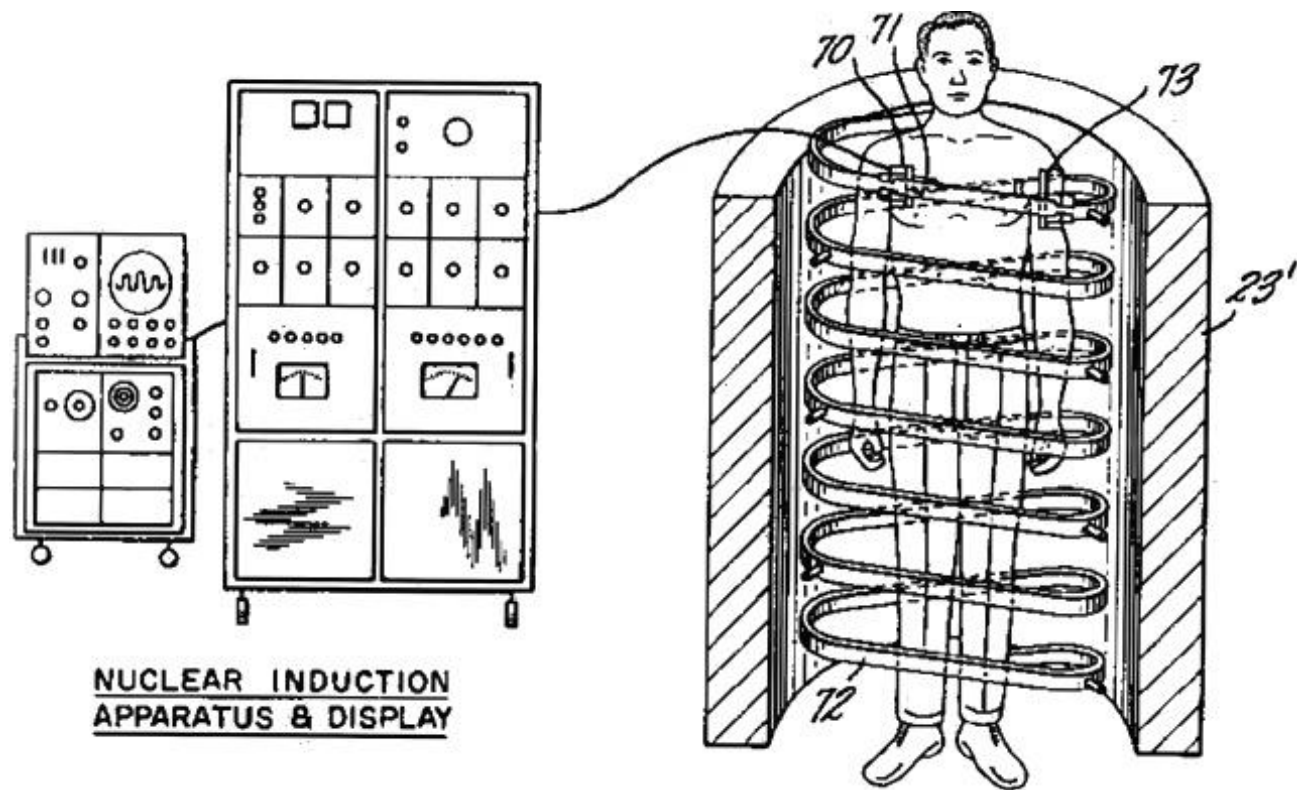
Sec. 3-401. A National Commission on Superconductivity.

(1) **Establishment.** There is established a National Commission on Superconductivity ("Commission"). The Commission shall consider major policy issues regarding United States applications of recent research advances in superconductors including research and development priorities, the development of which will assure United States leadership in the development and application of superconducting technologies.

(2) **Membership.** The membership of the Commission shall be not more than 24 individuals appointed by the President and include representatives of:

“... most potential applications may well lie beyond our ability to predict them...”

What do we do with it?

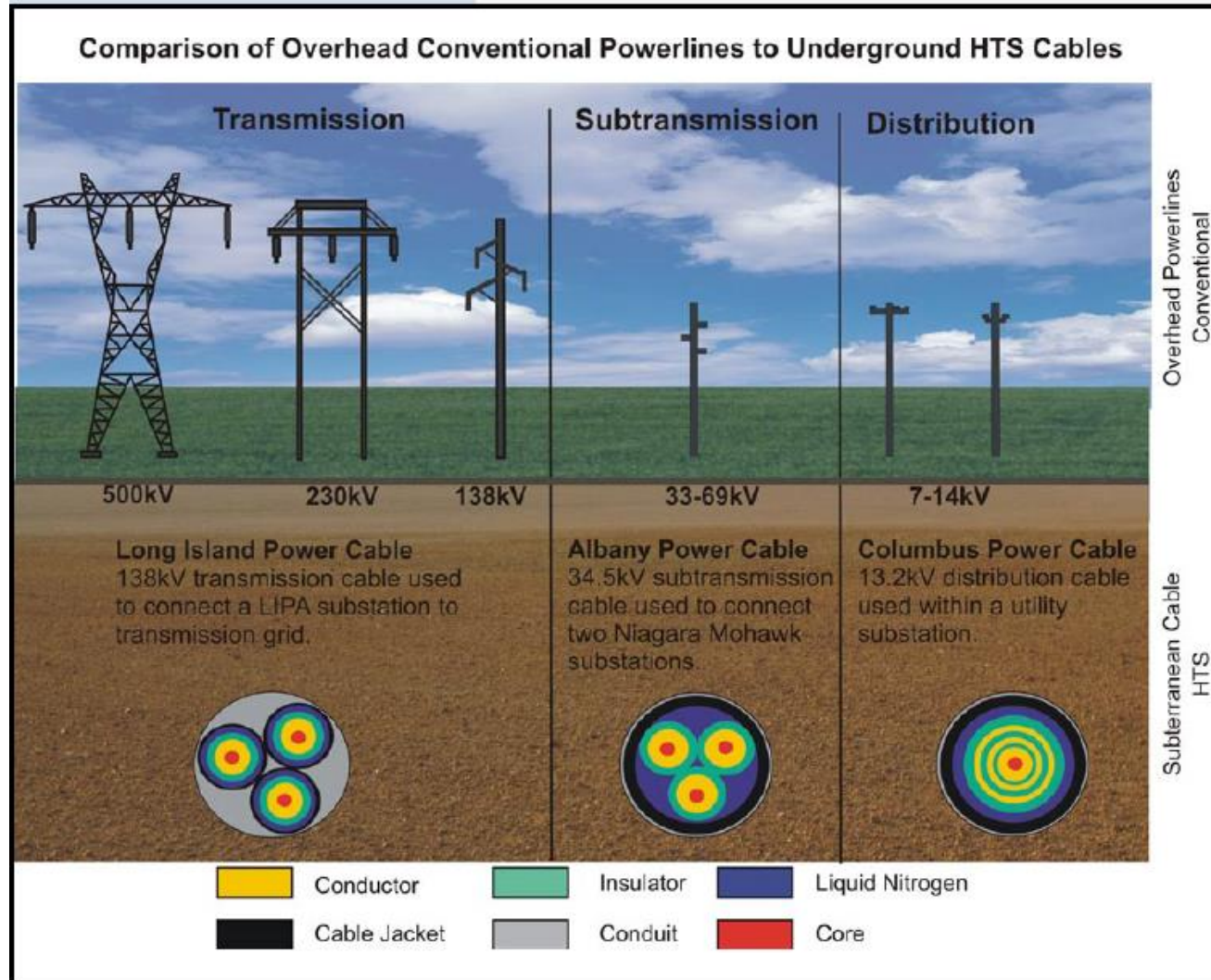


Applications in the *electric power industry* were seen as more than *15 years in the future* “if... feasible at all.” Office of Technology Assessment – 1990

2005 -2008 – The HTS Hay Days for electric power



Benefits of Superconductors for the Grid



- “Eliminate the need for new rights of way
- “Enable power flow as low voltages, significantly reducing permitting requirements
- “Enhance overall system efficiency as a result of exceptionally low losses
- “Increase utility system operating capacity and flexibility”*

Image from “A National Effort to Introduce New Technology into the Power Delivery Infrastructure” DOE Office of Electricity Delivery and Energy Reliability - 2/16/2007

*“Basic Research Needs for Superconductivity”, DOE Office of Science, May 2006

Closed Loop Superconducting Grid Projects



Columbus, OH (2006)

Utility: *AEP*
Cable: *Southwire/AMSC*
Distance: *200m (0.1 miles)*
Capacity: *51 MVA @ 13.2kV*



Albany, NY (2006-2008)

Utility: *National Grid*
Cable: *Sumitomo/SuperPower*
Distance: *350m (0.2 miles)*
Capacity: *48 MVA @ 35kV*



Long Island, NY (2008)

Utility: *LIPA*
Cable: *Nexans/AMSC*
Distance: *600m (0.4 miles)*
Capacity: *574 MVA @ 138kV*



Utility: *KEPCO (South Korea)*
Cable: *LS Cable/AMSC*
Distance: *700m (0.5 miles)*
Capacity: *50 MVA @ 23kV*



Yokohama, JP (2012)

Utility: *TEPCO (Japan)*
Cable: *Sumitomo (SEI)*
Distance: *250m (0.2 miles)*
Capacity: *200 MVA @ 66kV*



Essen, DE (2014)

Utility: *RWE (Germany)*
Cable: *Nexans*
Distance: *1km (0.6 miles)*
Capacity: *40 MVA @ 10kV*



Jeju Island, KR (2014)

Utility: *KEPCO (South Korea)*
Cable: *Nexans*
Distance: *1000m (0.6 miles)*
Capacity: *600 MVA @ 154kV*

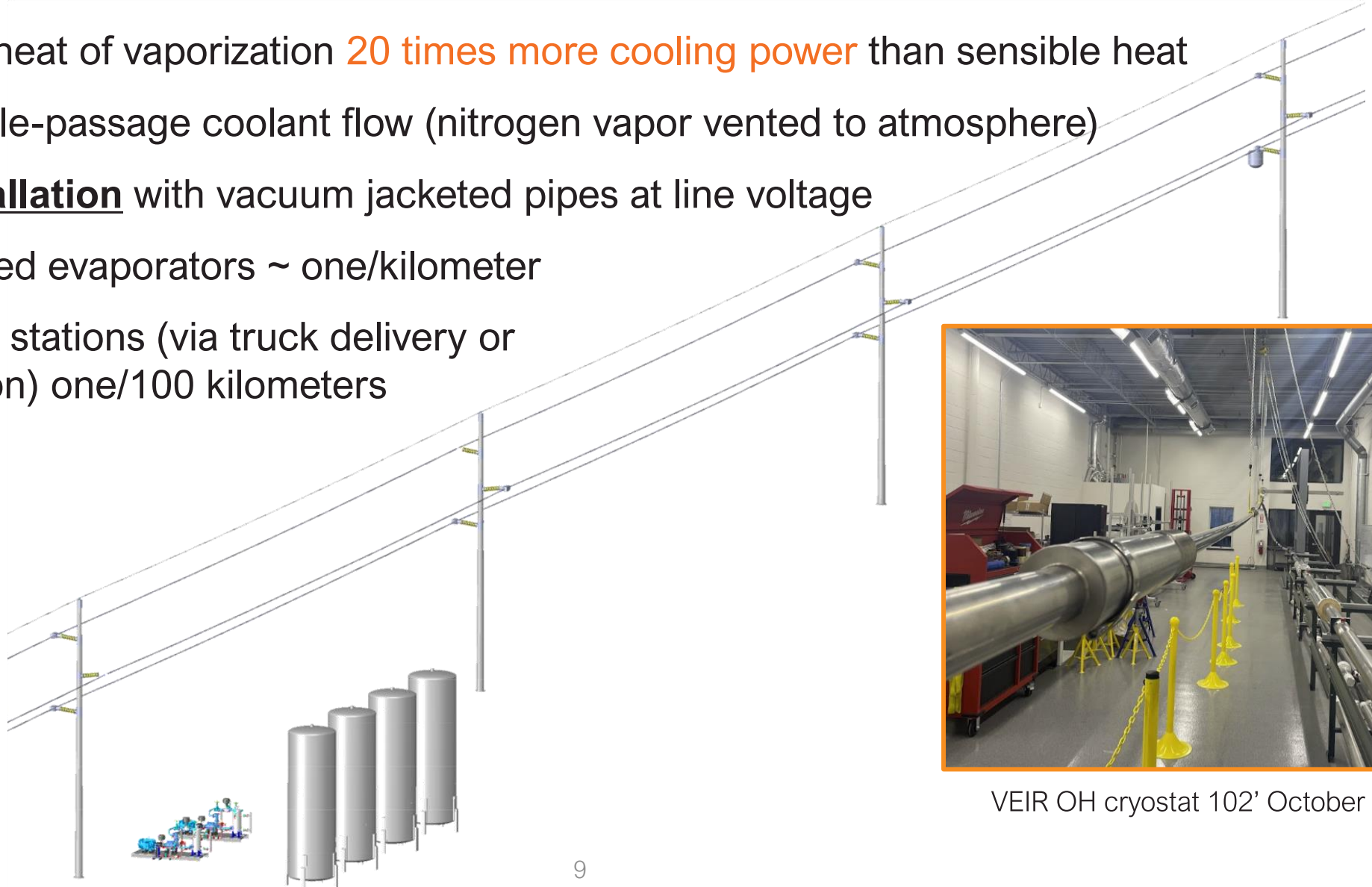


Chicago, IL (2021)

Utility: *ComEd*
Cable: *AMSC*
Distance: *200m (0.1 miles)*
Capacity: *62 MVA @ 12kV*

Distributed evaporative cooling unlocks long distance HTS

- Nitrogen latent heat of vaporization **20 times more cooling power** than sensible heat
- Open loop, single-passage coolant flow (nitrogen vapor vented to atmosphere)
- **Overhead installation** with vacuum jacketed pipes at line voltage
- Pole-top mounted evaporators ~ one/kilometer
- Nitrogen supply stations (via truck delivery or onsite generation) one/100 kilometers



VEIR OH cryostat 102' October 2022

Superconductors – Higher Power. Lower Voltage.

Conventional Transmission

Versus

Superconducting Transmission



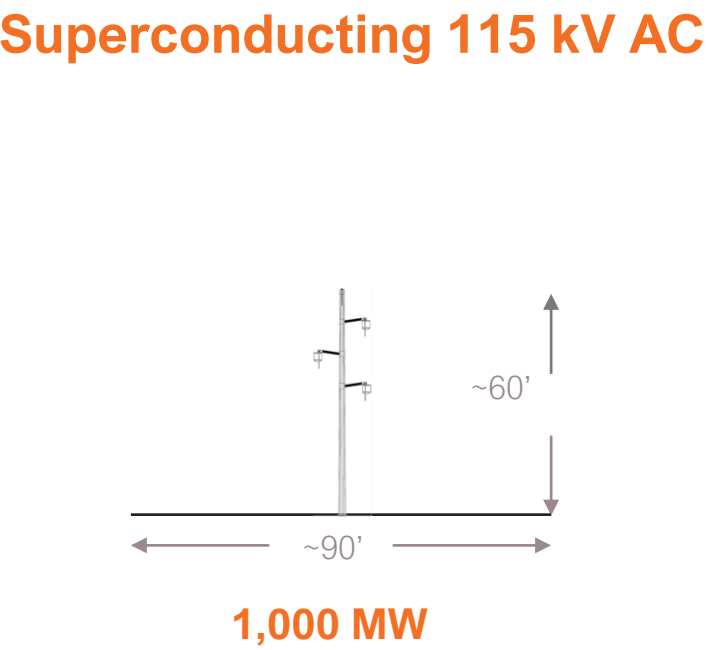
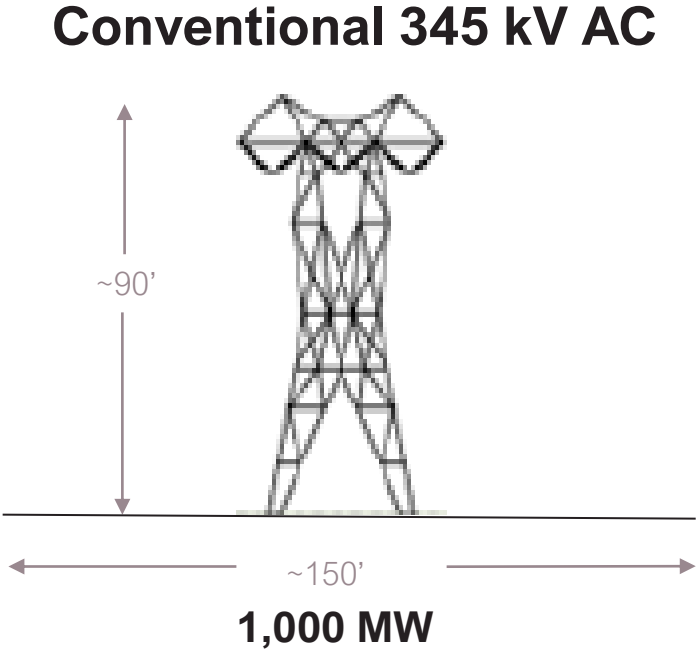
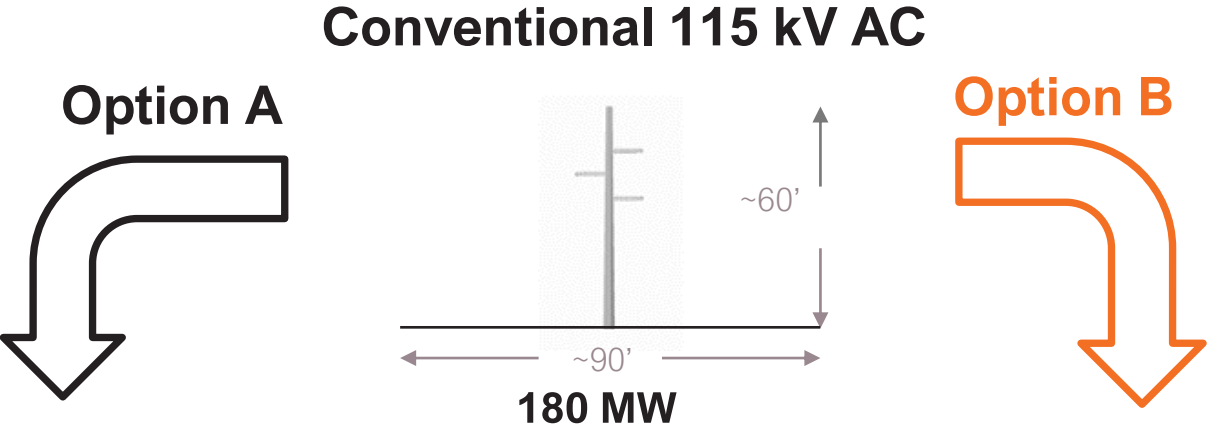
1200 MVA
345 kV



Same Capacity
Lower Voltage

1200 MVA
138 kV

Capacity Increase Options



Conclusion

**Distributed evaporative cooling
can move more power with less
tower over long distances.**