Energy Travel Efficiency and Potential High Temperature Superconductor Applications

Choose Ohio First

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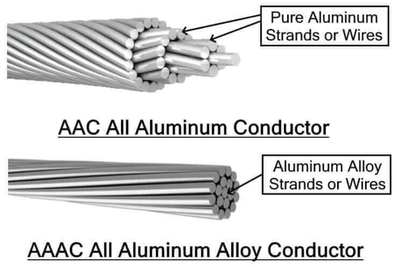
ABSTRACT:

Electricity transmission is one of the most crucial services utilized in everyday, modern life. We acknowledge this presence of electricity through the copper and aluminum power lines we see outside, providing power to our homes, schools, and other facilities. However, our electrical resources are limited by the way it is currently transmitted. Due to the resistance of electron flow in materials, energy is lost through current flow in our present-day electrical conductors. Superconductors, on the other hand, are unique materials that achieve a state of matter with no electrical resistance. If existing power lines were to be replaced with these superconducting materials, our new lines of transmission would be capable of conveying electricity more efficiently. In addition, with the upcoming research investigating the ability to propagate superconductors at room temperature and with liquid infusion, the possibility of this application is more achievable than ever. The research conducted in this project explores the prospects of implementing these superconductors into everyday electricity and power transmission, what it could mean for energy and money savings across the nation, and future ideas concerning this application of superconductors in the Cleveland area.



INTRODUCTION:

Electricity is a crucial aspect of modern life and is essential for powering homes, businesses, and industries. In 2023, the United States generated over four billion kilowatt-hours of electricity nationwide. However, this large amount of generation failed to be transmitted efficiently through traditional methods such as overhead power cables. The challenges faced with this medium include energy loss due to the joule heating effect, high costs, and environmental concerns. Superconductors offer a potential solution to these issues. Superconductors are materials that conduct electricity with zero resistance at specific critical temperatures. This property allows them to carry large amounts of electricity with minimal energy loss. Moreover, they can also carry electricity over long distances without the need for costly infrastructure and are environmentally friendly. As a result, superconductors have the potential to revolutionize the way we transmit and distribute electricity.

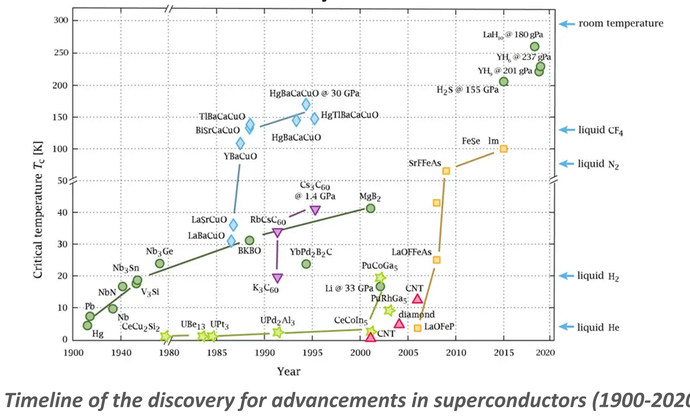


Figure 1. Timeline of the discovery for advancements in superconductors (1900-2020)

OBJECTIVES:

Through research, this project aims to quantify energy loss due to the joule heating effect in modern power delivery and apply the potential use of high temperature and pressure superconductors to yield a more energy and cost-efficient alternative.

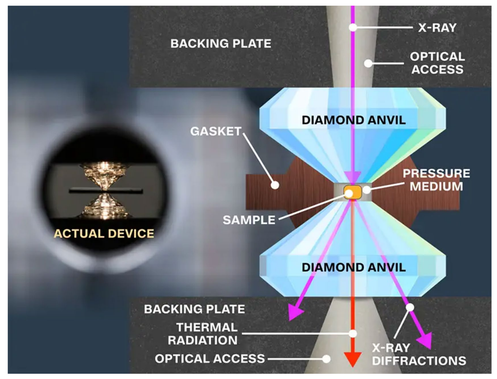


Figure 2. Model of creation of room temperature superconductor (Rochester Lab)

RESULTS:

- 360,000 miles of transmission lines, including approximately 180,000 miles of high voltage lines
- Energy loss from powerplant to consumer ranges from 8% to 15%
- Superconductor cables are 99.875% more efficient than standard overhead cables
- $25 to $70 billion worth of possible annual savings on weather-related repairs if cables were run underground and not exposed to harsh climate conditions

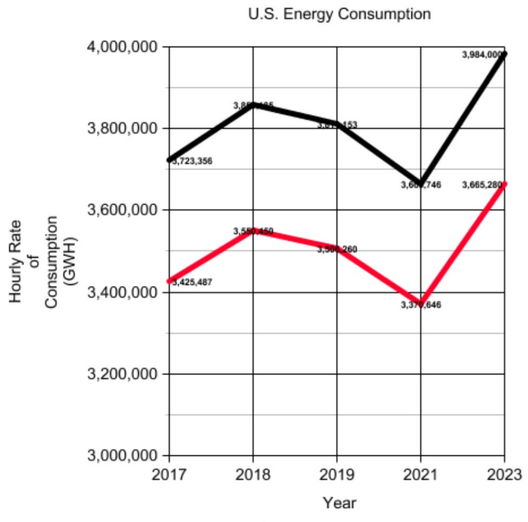


Figure 3. Projected Ideal Graph (red is energy needed without energy loss of 8%)

EXAMPLE:

A type of High Temperature Superconducting (HTS) Cable, the 'cold dielectric' design, is a tape layered arrangement infused with liquid nitrogen. This design is ambitious and is worthy technology of the future market.

Figure 4. Cold dielectric superconducting coaxial cable.

A Comparison of Power Transmission Technologies		
Technology	*Resistance (Ω/km)*	*Inductance (mH/km)*
Overhead Line	0.08	1.26
Cold Dielectric HTS	0.0001	0.06

DISCUSSION/FUTURE WORK:

There have been numerous endeavors relating to the development and implementation of high-temperature superconductors and optimizing their efficiencies in real-world practices. While Cleveland, Ohio, has yet to engage in such efforts, a notable, local attempt occurred in Columbus in August 2006. Despite facing setbacks, including a fabrication error in 2007 relating to a cooling system valve, the endeavor persists with relentless dedication to refine and conquer this revolutionizing concept. Through years of meticulous modifications and rectifications, there exists the possibility of unveiling the latest and most optimized iteration for testing in Cleveland. Successful testing has the potential to lead Cleveland in the direction of implementing superconductors into its energy landscape. More specifically, the city's power grid. By replacing traditional power lines with superconducting cables, the grid could become more efficient and less prone to blackouts. This could lead to significant cost savings for both consumers and the city government.

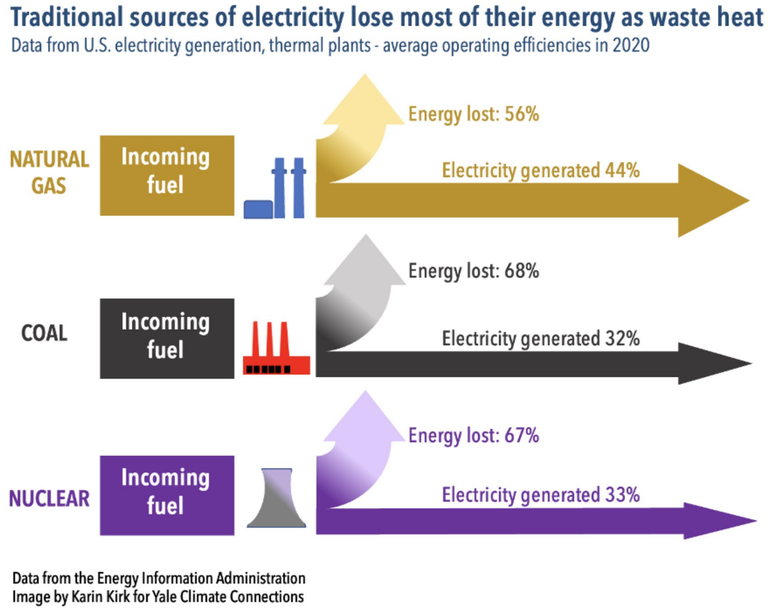


Figure 5. Efficiency data on current energy production methods.

CONCLUSIONS:

By replacing conventional power lines with superconducting cables, there is a clear opportunity to enhance the efficiency and resilience of traditional electricity mediation. These ideas provide an insight into the transformative potential of superconductors in revolutionizing electricity transmission and paves the way for a more sustainable and efficient energy future.

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