Heat Transfer Characteristics of a Scalable Antarctic Thermoelectric Generator for Harvesting Ocean Thermal Energy to Generate Electricity During the Polar Night

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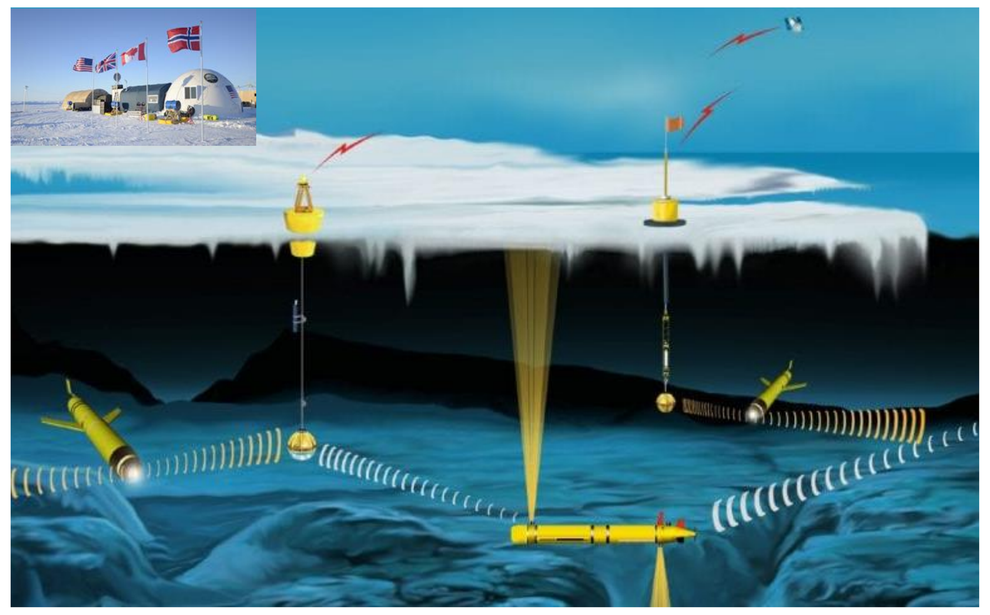
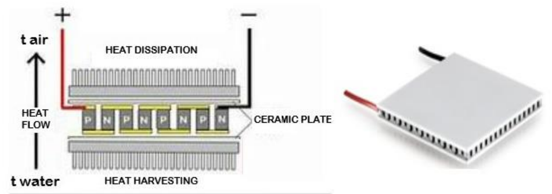
SATEG CORP
SATEG POWER MODULE
Clean Power for Polar Buoys & Autonomous Underwater Vehicles

The Future of Polar Power

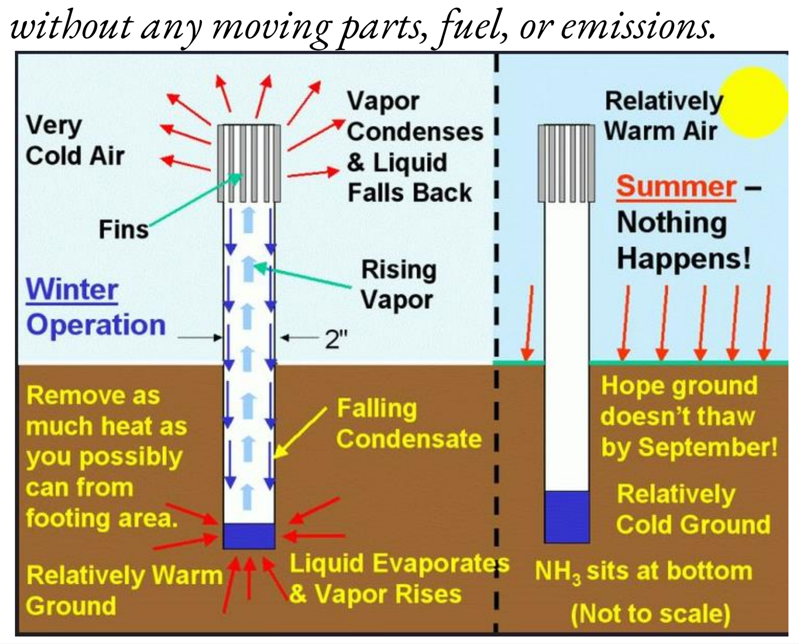
The SATEG was designed to supply continuous power above and below the ice during the polar night in pursuit of an interconnected polar region with an abundance of reliable data.

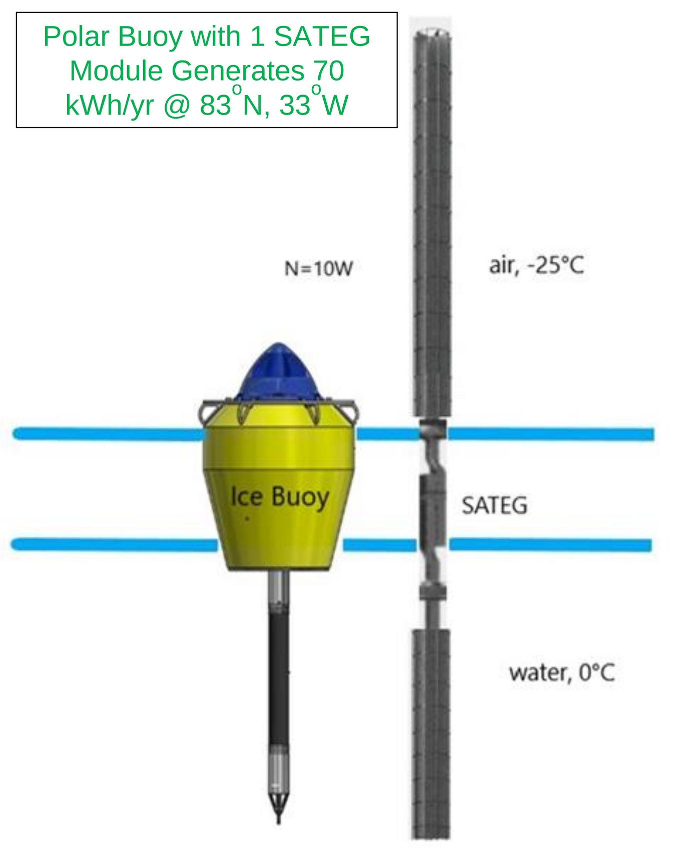


Embedded in ice floes and permafrost, a distributed network of SATEG units can act as beacons for monitoring movement of the ice and as utility providers to continuously power sensors and transmitters. Thermoelectric generators enable these functions.



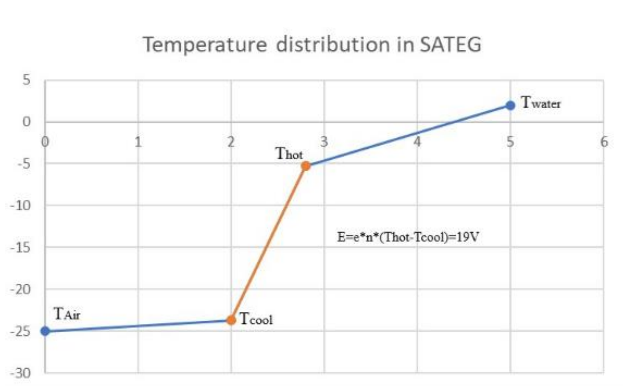
SATEG is an innovation for removing heat from the sea and land to produce renewable energy that extends the longevity of power supplies, reduces servicing expenses, and provides electricity at night without any moving parts, fuel, or emissions.



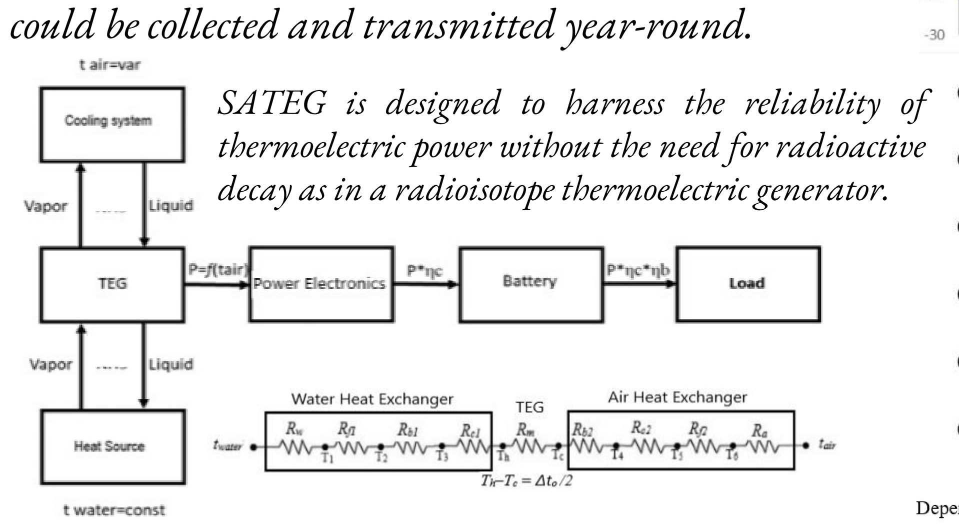


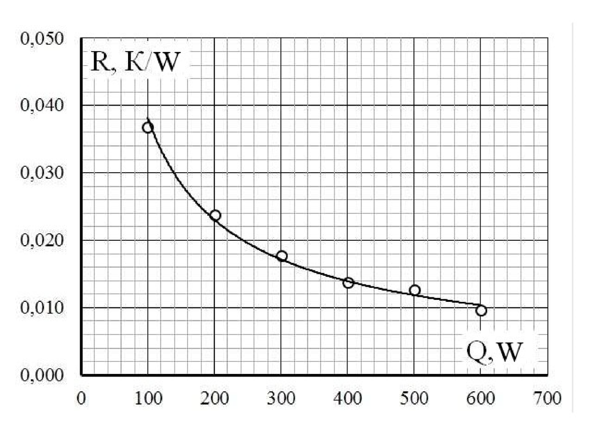
Technology for Reliable Continuous Data

As the temperature difference between finned heat exchangers at either end of a SATEG increases, the thermoelectric modules experience lower resistive losses. Thus, a SATEG unit's performance increases as the air gets colder. When paired with solar panels for daytime power generation and a small secondary battery, data could be collected and transmitted year-round.



SATEG is designed to harness the reliability of thermoelectric power without the need for radioactive decay as in a radioisotope thermoelectric generator.





Dependence of the thermal resistance of the thermosiphon R on the heat flow Q

Assessment of Value for Polar Regions

A key focus of the novel design is taking green initiatives that are transferable between polar regions. The following assessment conducted for the Arctic demonstrated that an Arctic communications buoy that consumes an average of 7W requires over 300 kWh of battery storage to support a 5-year mission, but it only needs 25 kWh of battery storage when integrated with a single SATEG module.

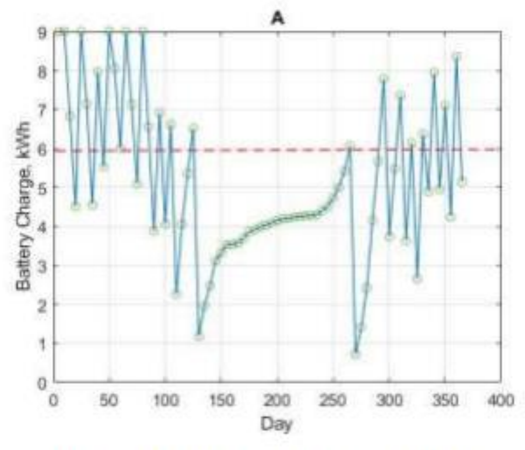


Figure 13A. Charge Cycle for LRAUV Docking Buoy & 1 SATEG Module

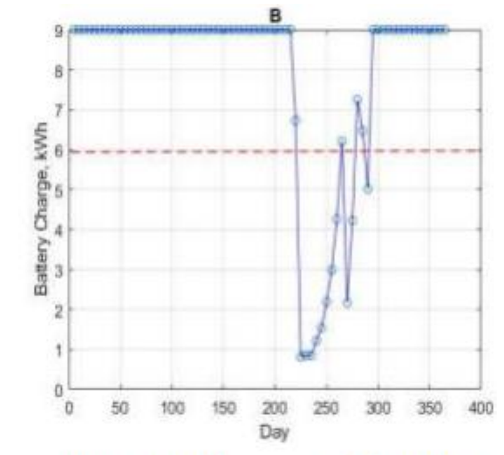


Figure 13B. Charge Cycle for LRAUV Docking Buoy & 3 SATEG Modules

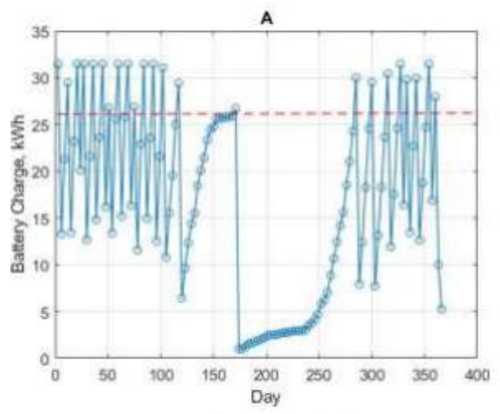


Figure 14A. Charge Cycle for REMUS 600 Docking Buoy & 5 SATEG Modules

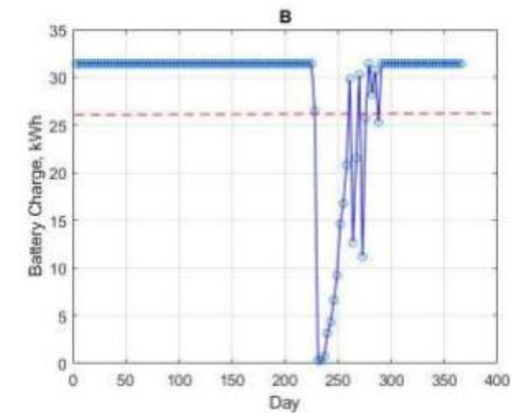
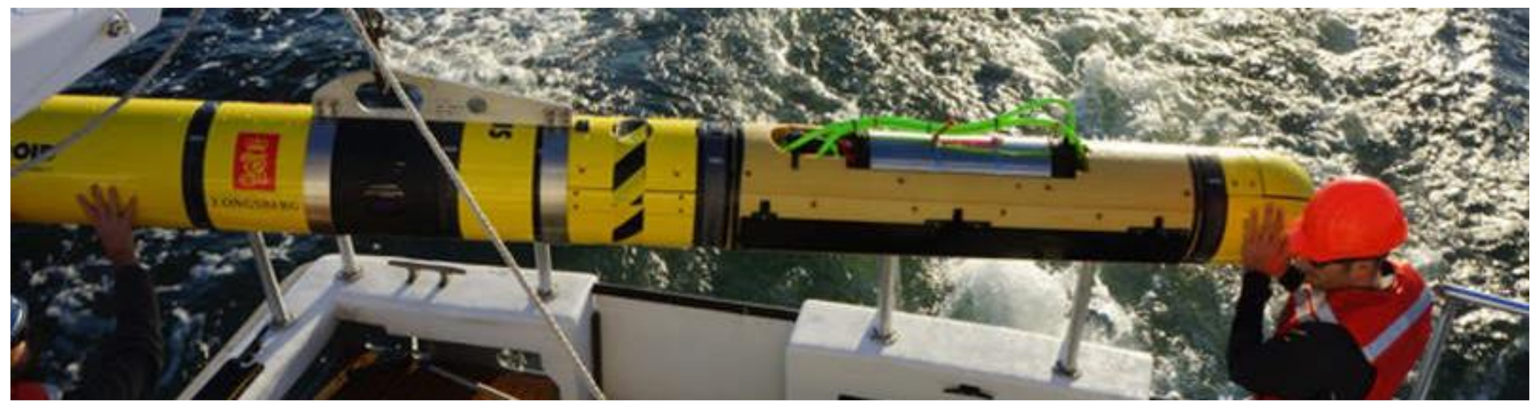
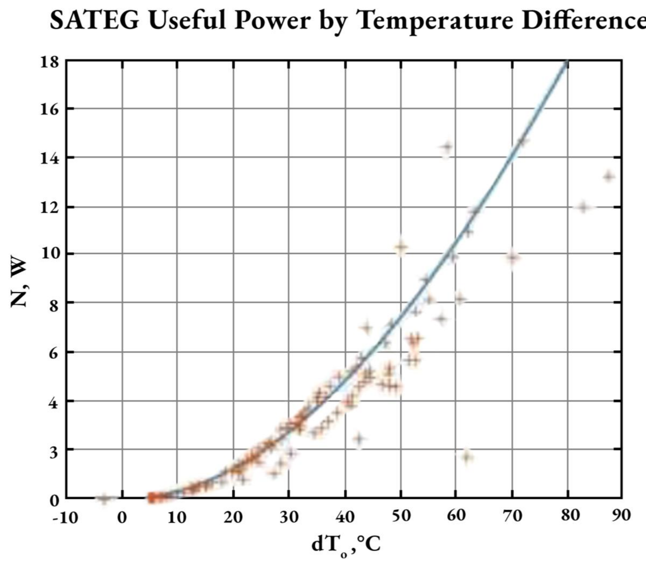


Figure 14B. Charge Cycle for REMUS 600 Docking Buoy & 25 SATEG Modules

Laboratory testing of a prototype SATEG conducted at Solid Cell (Rochester, NY)



Above charts simulate charging a docking buoy for the REMUS 600 UAV depicted



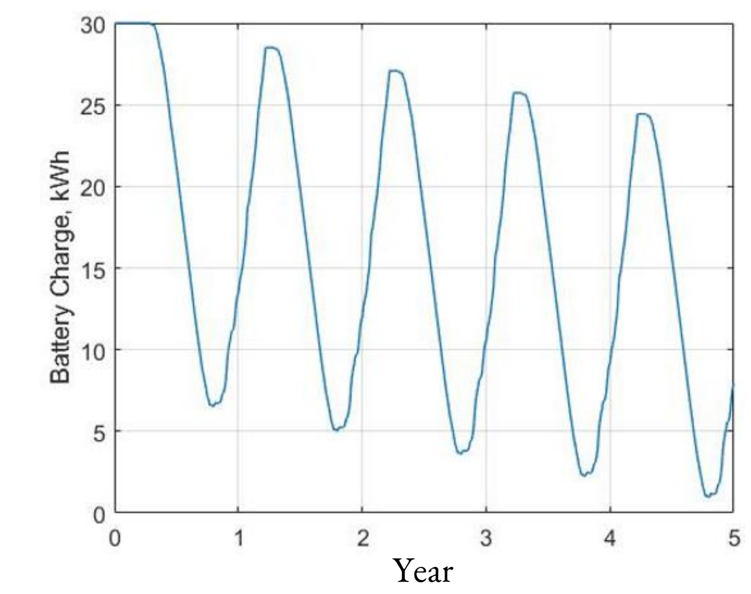
Experimental power generation fit the model most closely with hot and cold side temperature differences between 5 and 45 °C.

Having demonstrated feasibility for the Arctic region, testing in Antarctic conditions is highly desirable to truly investigate the potential of a SATEG network to provide power across a range of polar conditions.

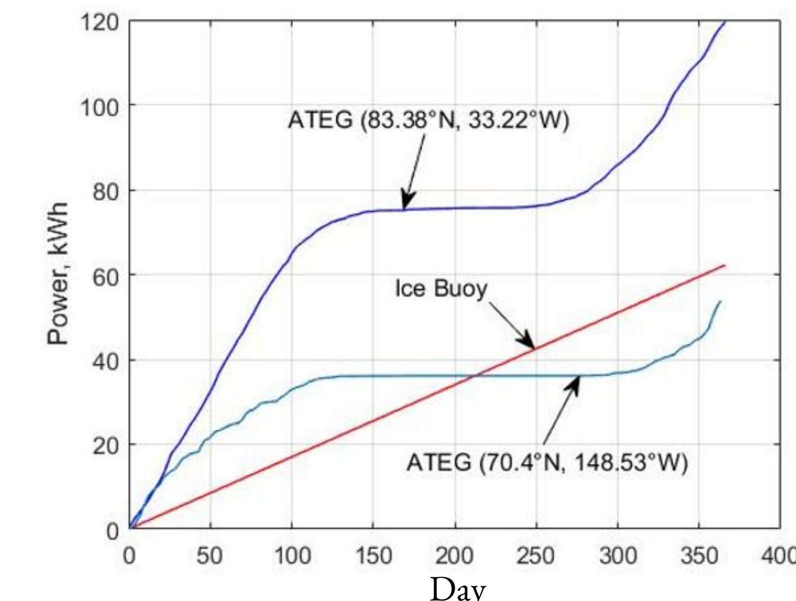
Next Steps and Continued Challenges

A U.S. university partner actively involved in research in Antarctica is desired to apply for an identified NSF grant as the primary investigator. Prototype SATEG units could be fabricated to support hardware deployment that will facilitate data acquisition and demonstrate SATEG's usefulness in-situ.

Modeled for Technical & Economic Viability



Battery Charge Cycle for Ice Buoy & SATEG System



Energy Demand/Supply for Ice Buoy & SATEG

Initial thermodynamic modeling and experimental data collection suggest that a SATEG supported ice buoy can sustain operations 5 times longer than the same buoy deployed alone.

Test Development for SATEG Construction

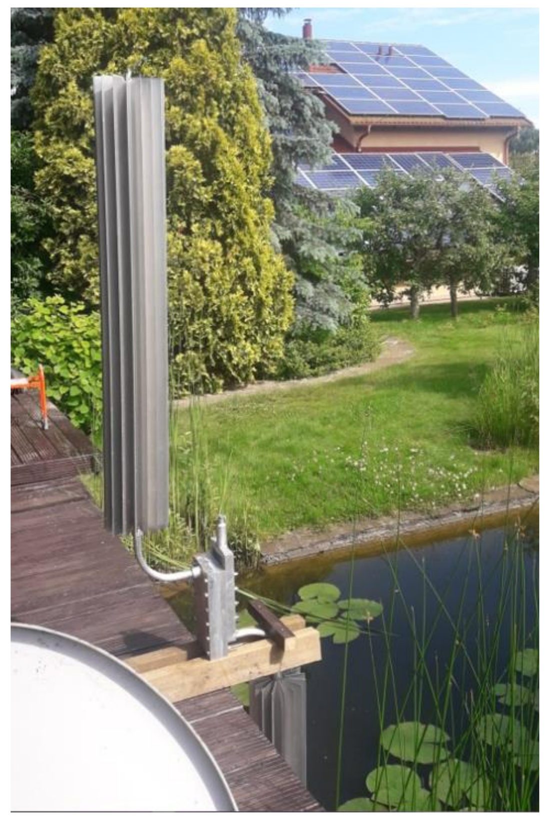
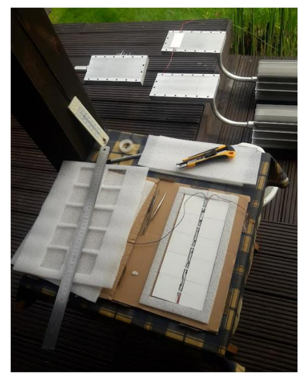
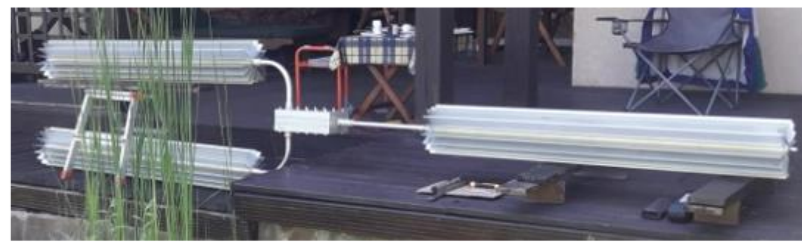


Table I. Heat transfer rate for different mechanism of heat exchange. [20,21]

Heat transfer mechanism	α_i, W/m²K
Free convection of gases	2 ... 20
Free convection of liquids	50 ... 1000
Forced convection of gases	25 ... 300
Forced convection of liquids	100 ... 40,000
Boiling or condensation	2500 ... 100,000





Liquid nitrogen cooling was used for benchtop testing in Rochester, NY. Another 40kg prototype SATEG was tested by submergence outdoors near Kyiv, Ukraine. Internals are gastight to allow for evaporative heat transfer.

Acknowledgement of Key Supporters:

The original modeling for SATEG was funded by the Office of Naval Research with project partner Woods Hole Oceanographic Institution. Woods Hole provided key insights on arctic temperature profiles and REMUS 600 UAV power loads as well as additional funding for prototyping, and conference travel was sponsored by the School of Individualized Studies at the Rochester Institute of Technology. The laboratory and prototype fabrication resources provided by Solid Cell were essential in acquiring experimental thermodynamic data. SATEG Corp.

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