# Custom Armored Cable

## *Assembly for Hydrokinetic Energy System in Alaskan Village*

**By Amy Brown**

The mighty Kvichak River rushes past the village of Igiugig, located at the mouth of Lake Iliamna on the Alaskan Peninsula. With a year-round population of 70, primarily Yup'iks, Aleuts and Athabascans, Igiugig depends on the Kvichak for fresh drinking water, and for subsistence and sports fishing of enormous sockeye salmon and rainbow trout.

In 2019, the river began providing electrical power for the village as well, thanks to a unique renewable power system by Ocean Renewable Power Co. (ORPC Inc.) from Portland, Maine. The new RivGen 2.0 Power System delivered a clean, sustainable hydrokinetic power solution, powered by two submerged, cross-flow river current turbines. Igiugig had been relying primarily on a 40-kW diesel-fuel power plant since the 1970s for its electrical needs, but ORPC's RivGen technology has supplied approximately one-third of the community's electrical requirements and may reduce its diesel usage by 90 percent once a second RivGen device, expected in 2021, is added.

Igiugig is one of 250 Alaskan communities generating electricity from diesel-powered, small-scale, autonomous microgrids. The community's power plant costs in 2018 were $255,708, and the plan was for the RivGen project to significantly reduce heating and electrical bills for the village, and decrease reliance on diesel fuel that is incrementally flown or barged in at approximately 4,000-lb. batches at up to $7 per gallon.

*BIRNS developed a custom cable assembly with a BIRNS Millennium 3O-4F-CP, a 3M-13-CP, as well as a BIRNS Primum MSSL-3-4 connector, terminated in a "Y" split and overmolded to a single junction cable.*

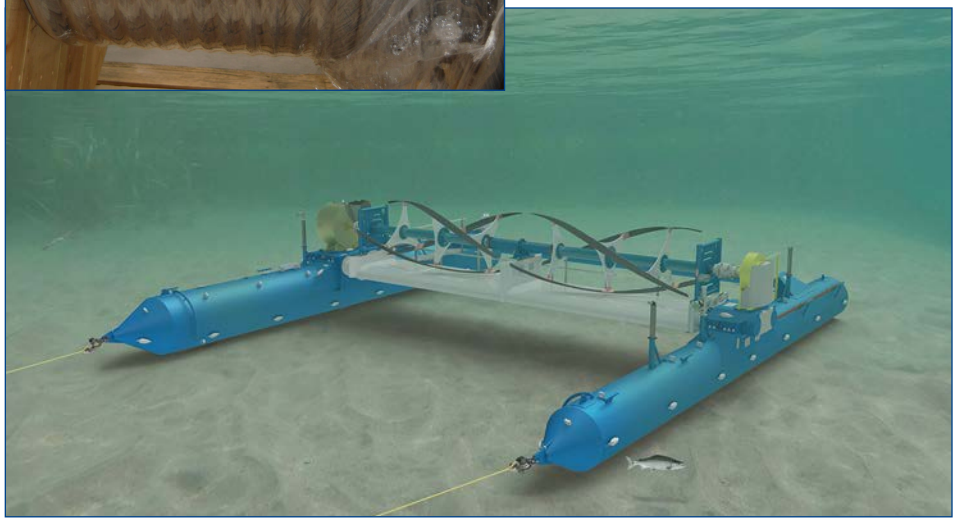
**System Features**

This custom standalone power-generating system operates completely underwater, powered only by the kinetic energy of the Kvichak River currents at a 15-ft.-deep installation.

The RivGen Power System has a rated power output of 40 kW in a resource with 2.25 m/s current speed, and 80 kW in a 3.5 m/s current speed, with power output dependent on resource speed. The speed of the river current fluctuates somewhat over the course of a year.

The system's turbine generator unit (TGU) is mounted on two pontoons at a low profile and at a river flow velocity of approximately 2.5 m/s.

The entire system is 15.7 m (51.5 ft.) by 14.3 m (46.9 ft.), 3.5 m (11.5 ft.) in height, and weighs 65,036 lb. It's constructed of composite materials optimized for performance and long life underwater.



*(Clockwise) RivGen's application required the cable assembly terminated to a 675-ft.-long underwater armored cable, connecting the turbine generator unit (TGU) installed to the junction box. BIRNS technician performs continuity and IR testing on the final cable assembly. Graphic of RivGen device deployed. (Credit: ORPC)*

The RivGen System can operate 24/7, and as it functions while completely submerged, it's safe from storms, wind and ice interference.

The RivGen device was transported from Maine to Alaska on two flatbed trucks across the lower 48, barged from Seattle to Anchorage, over ground from Anchorage to Homer, barged across Cook Inlet, overland a short distance, and finally barged down Lake Iliamna to the setup area at Igiugig.

It was then assembled and deployed by ORPC engineers who worked with local contractors, vessels and equipment.

**System Connectivity**

The RivGen System needed a robust armored cable assembly for several of its key operating components, and according to ORPC, a primary driver was the ability to house all of the connectivity in a single assembly that was also rugged enough to rest on a riverbed for weeks at a time during maintenance intervals. BIRNS Inc. of Oxnard, California, was called upon to develop a bespoke complex cable assembly terminated to the armored underwater power cable, which is used to connect the system and transfer power to the community grid. The solution includes a large assembly with three different cable plug (CP) connectors: a BIRNS Millennium 3O-4F-CP and a 3M-13-CP, as well as a BIRNS Primum MSSL-3-4 connector, in an assembly terminated in a "Y" split and overmolded to a single junction cable.

The robust BIRNS Primum MSSL-3-4CP was made specifically for high power loads and features three 4AWG sockets and a rugged coupling ring. The MSSL-3-4 is used for the three-phase power for RivGen's underwater permanent magnet generator. Three-phase power provides three alternating currents with greater power density while making it easier to balance loads, along with consistency in power delivery.

The RivGen's cross-flow turbines are designed with a helical twist and spin in one direction, eliminating gears and lubricants. The device is placed perpendicular to the river's flow to capture energy from it. These rotating turbines feed into a direct-drive permanent magnet generator. This generator does not use a gearbox and includes a fully encapsulated rotor and stator, making it a robust electrical system for extended operating periods, without requiring maintenance.

The BIRNS 3M-13-CP is a high-density electrical connector with five 16AWG sockets and eight 20AWG sockets. It is used for control power for the RivGen's underwater supervisory control and data acquisition (SCADA) components, which provide real-time remote monitoring and oversight of the TGU. Sensors on the SCADA system monitor a range of functions, including water speed, direction and the speed of the individual turbines, as well as temperature, oil pressure and other

*(Top) RivGen device deployed in Kvichak River, Igiugig, Alaska, 2019. (Credit: ORPC) (Bottom) RivGen device deploying to riverbed, Igiugig, Alaska, 2019. (Credit: ORPC)*

systemic functions, all fed to shore-station monitoring. The BIRNS Millennium 3O-4F-CP connector in the cable assembly provides four optical-fiber ferrules supporting the system's fiber-optic data communication lines going to shore from the RivGen device.

The 3M-13 and the MSSL 3-4 electrical connectors in the assembly were both terminated and inspected per J-STD-001, Class 3 IPC/WHMA-A-620, Class 3. Testing of both individual electrical connectors and the final assembly included continuity and insulation resistance (IR) testing—IR required to be greater than 300 megohms at 500 VDC. The 3O-4F optical-fiber connector was tested in accordance with EIA-455-A at dual wavelengths (1,310 and 1,550 nm). The entire assembly was overmolded in BIRNS's NAVSEA PRO-020 certified lab.

The application required an armored 675-ft.-long underwater cable, connecting the installed TGU to the junction box onshore. BIRNS delivered the specialized armored cable—with a total reel weight of 2,500 lb.—consisting of six single-mode fibers inside stainless-steel tubing, with three 2AWG conductors, and two twisted shielded pairs of 22AWG conductors, and one 16AWG twisted quad. It had polypropylene insulation, a polyurethane jacket and two layers of galvanized improved plow steel (GIPS) armor.

## Results

According to ORPC, the RivGen System has been operating continuously, other than pauses for maintenance events, since the summer of 2019, and is functioning extremely well. There were intensive environmental studies done prior to the launch to ensure that the system would not create harmful interactions with either smolt (young salmon) that migrate to the ocean and return to spawn or resident young trout, or have issues with ice interference in the winter. There has been no impact on fish to date, it has caused no known environmental harm, and it continues to generate a meaningful amount of electricity—and is expected to deliver a total annual generation of 404 MWh delivered to the shore station. It is predicted that $CO_2$ will be down 230 metric tons per year, Igiugig's diesel costs will decrease by $170,000 per year, and operating and maintenance costs will also decrease by $50,000 per year once both RivGen devices are installed in 2021.

During her presentation at the 2020 Northern Lights conference, Village Council President AlexAnna Salmon reported that this unique hydrokinetic system and Igiugig's partnership with ORPC is expected to contribute to the citizens of Igiugig's strategy to live sustainably, in perpetuity, in their homeland—where their ancestors have lived for the last 9,000 years.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## References

For a list of references, you may contact the author: abrown@birns.com. **ST**


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