Jocassee Makes the Switch

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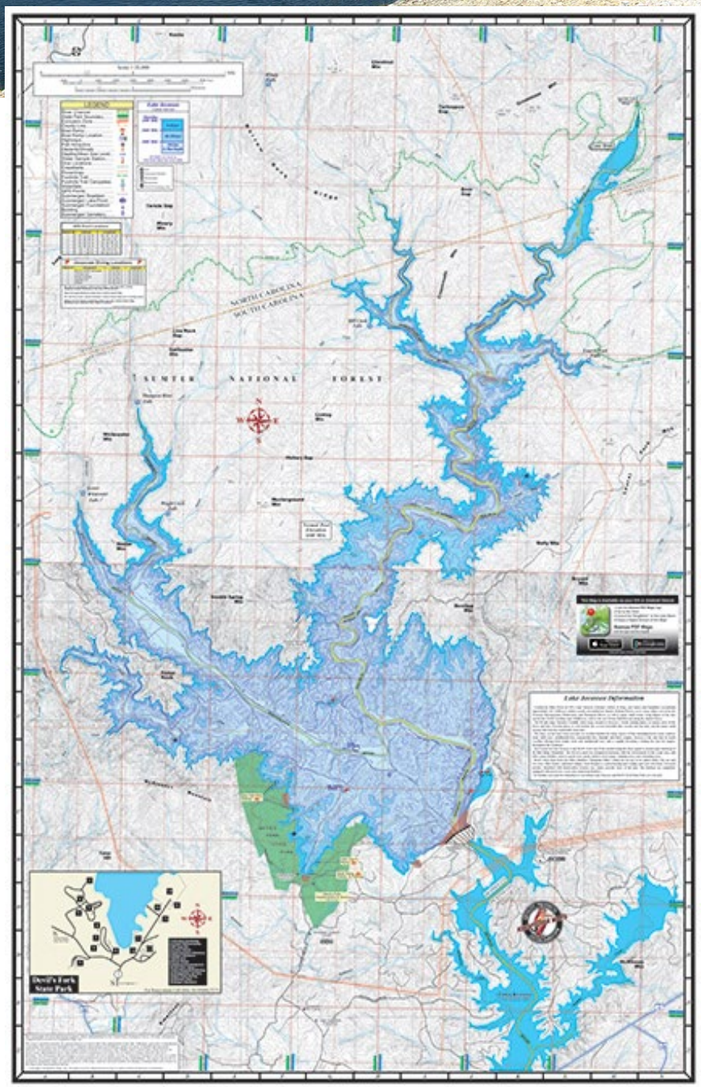


(Jocassee & Keowee Lakes)

Standing on the compacted road atop the dam that closes off the two hills creating Lake Jocassee and separating it from Lake Keowee (pronounced like the fruit but with an "O" in the middle) is an experience in beauty, magnificence and just plain awesome. The dam is a 385 foot high, 1800 foot wide, man-made wall of local earth and quarried stone. Creating this engineering feat with machines and back breaking toil in the early 1970's sealed off what used to be a small pass between these two adjacent hills.

Once upon a time the waters from a few local streams with names like Horsepasture and Toxaway ran through that open pass into what is now Lake Keowee. But by building this earthen dam – the waters of those local stream collected behind the new wall into one of the most beautiful scenes you can imagine. These waters, filling in that basin behind this newly created wall formed what is now known as Lake Jocassee.

Lake Jocassee has 13 square miles of surface area with over 75 miles of shore line. It encases the most incredibly clear, cold, pristine waters you've ever freezed a toe in. Jocassee offers recreation, first rate fishing and bone chilling diving for mile after gorgeous mile.

But; as you stand on the top of this earthen barrier, glowing at the billions upon billions of gallons spread out before you – you slowly turn around to notice, there is a near 400 foot shear drop directly behind you !

If you're not one to get woozy from heights this view is as equally breathtaking as the first.

This impressive, albeit a heck of a lot lower view, is Lake Keowee. 385 feet below the soles of your shoes and running away from the base of the dam for mile after blue green mile.

Lake Keowee seems just like Jocassee - But WAAYYYY away down there.

Pop that dam open – and you'd flood an entire quadrant of the State.

But let just a small fraction of those Jocassee waters flow to Keowee through a 33.5 foot diameter pipe into a water wheel connected to an electrical generator and there's a whole lotta power in dem dar waters!

So far this is just describing a standard hydro. But now comes the magic.

(More fun than any other type of rechargeable battery)


The Jocassee tunnel during construction

Remember when you were a kid, and you or a friend used to like to drink chocolate milk by sucking it up through a straw and then let it drop back down into the cup. Usually that would then get you a tap on the head and a -

“don’t play with your food”.

Well; Plus / Minus; that is exactly the idea behind a pumped storage facility. In this case the straw is a 33.5 foot diameter, 1,383 foot long tunnel running through the mountain. And the chocolate milk, is the waters of Lake Jocassee running through four Voith turbines. Each of those turbines is direct connected to a 34 foot diameter, 60 pole generator. And each generator is capable of pushing out about 200 megawatts of squeaky clean, carbonless, renewable electricity for the customers of Duke Energy.

Lake Jocassee is so voluminous that this power station can run full bore for over eight hours, creating nearly 800 megawatts on demand with a very short dispatch (start-up) time.
And the upper lake won’t drop more than 1.5 feet.

As Jocassee drops - - Keowee fills.

Again; If this were the end of the story – all we would be describing is a standard hydro. When Jocassee would run dry, the plant would be out of service - until the various streams filled Jocassee up again.

BUT - those turbine generators werring around – well, they have a neat little feature.

THEY CAN ALSO SPIN BACKWARDS !

Forward making megawatts-hours of power as the waters drop from Jocassee to Keowee. AND REVERSE by swapping the electrical system’s phasing on the machines electrical terminals, turning these monsters into huge motorized pumps.

Running the machines “backwards” makes these multi-megawatt motor/pump combinations capable of pumping Lake Keowee back up into Lake Jocassee “back up the straw”.

Refilling Jocassee for the next day’s needs.

At that moment you realize; you’re straddling one of the world’s largest man-made rechargeable batteries!

That gorgeous family recreation spot doubles as a reservoir for a few thousand megawatt-hours of “any time you want it” – lake water clean,

dispatchable power. And you can run it / and recharge it – more or less, as you like.

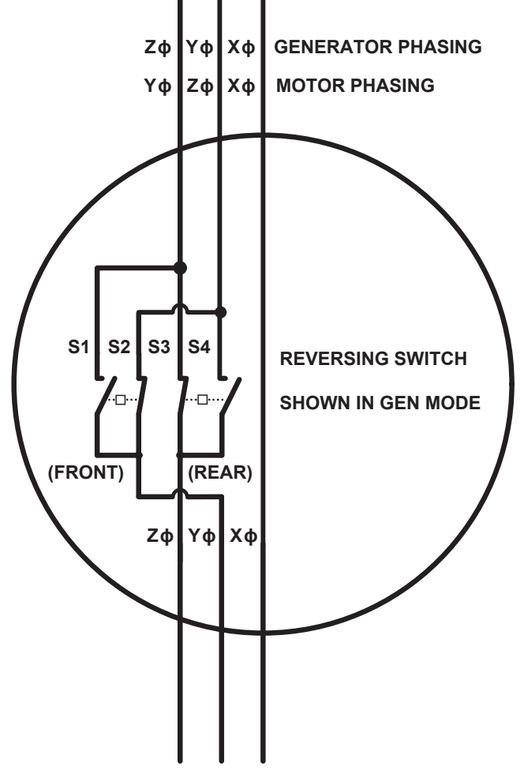
Lake Keowee has at its southern end another power station. This one is the 2,500 MW base load nuclear plant Oconee. Lake Keowee is the head waters for Oconee’s cooling water system. Even at 2,500 MW, Oconee may not be large enough to supply all of Duke’s customer’s energy needs when the demand is high. But at night and other times of lower energy use, Oconee is producing more than the local clientele is requesting. So; what better time than this, to use the extra, low cost, base load power from this 2,500 MW power station to “plug-in” your rechargeable batteries? And that’s just what the Jocassee / Oconee combination can do !

By “recharging” (i.e. refilling) Jocassee; the Oconee / Jocassee combination can produce 30 % more on demand energy for its customers as soon as the need presents itself.

Now electrically “flipping” around a 200 MW generator into a motor and back may look easy on paper – but the electrical and mechanical forces to achieve this feat means the equipment required for this task is orders of magnitude more “beefy” and rugged than your standard catalog-cut utility products. And in the case of the Jocassee system’s one-line, (see drawing attached) the quarterback of this “flipping” operation falls squarely on the medium voltage, high amperage, four-pole reversing switch. This specialized, highly customized, very high amperage reversing switch allows the electrical phase rotation present on the machines electrical terminals to either be in “Generate Mode A-B-C” or in “Pump Mode B-A-C”

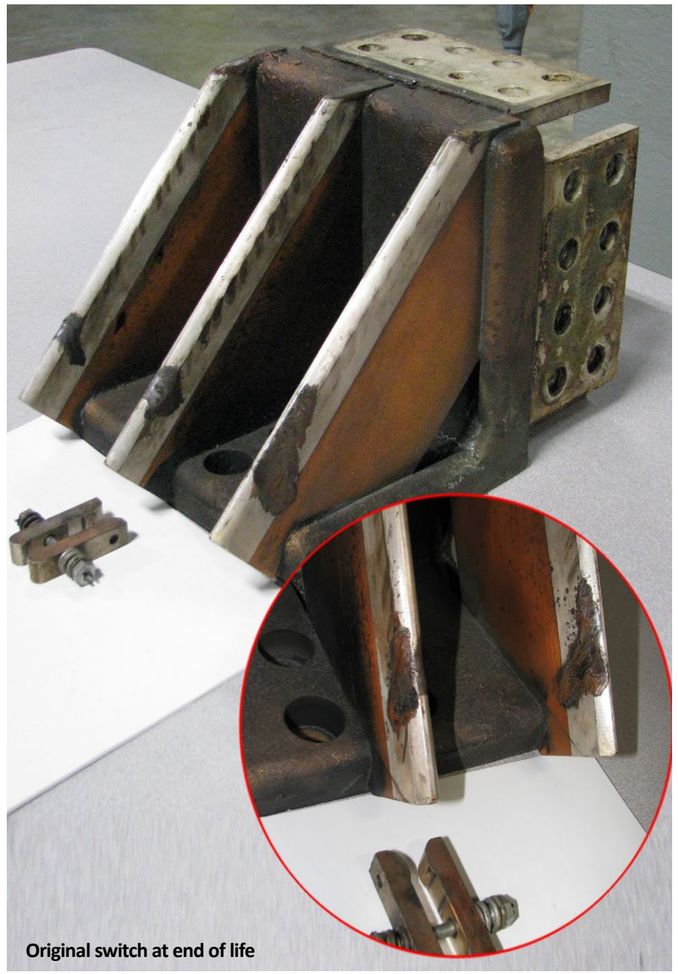
(Z-Y-X or Y-Z-X on the one-line).

Jocassee reversing switch one-line



The original General Electric reversing switch provided for this operation was a 15kV – 8,500 amp, high spring pressure knife blade design. It has served the system quite well for a number of decades. But like anything else mechanical – time takes its toll and the consistent numbers of repetitive operations wore away at moving joints, reduced spring contact pressure and ultimately created a condition of needing "a little more than a little love" or maybe major replacement.

Such 8,500 amp switching devices were for the most part either completely custom or at least VERY low production volume items. So when the station's electrical engineering / maintenance personnel sought parts from the OEM they found the availability, lead times and costing levels to be sobering.



Original switch at end of life

Fortunately Mr. Earl Brinson one of Duke's more seasoned SMEs had, over the years, worked with Mr. Jay Patel of Nimisha Inc. a consulting company located in Blue Ash, Ohio specializing in high amperage Iso Phase Bus. Prior to opening Nimisha, Mr. Patel was the Engineering Product Manager at the Westinghouse Iso Phase Bus division in Cinn. Ohio. Mr. Patel reminded Duke that Crown Electric Engineering and Mfg. of Middletown Ohio (a successor to the old Westinghouse Iso Phase Bus division) were specialists in high amperage Iso Phase Bus and related electrical apparatus. Crown Electric had a product category of SD (Super Duty) Disconnect switches specifically designed to meet the high amperage ratings for unique applications such as Jocassee.

As the parties started sharing more information – Jocassee added an additional tidbit to the discussion. During recent years, the machines were upgraded / uprated and were now putting out approximately 10% more than their original nameplate amps. Duke and Crown agreed an engineering site visit would be prudent and offer value by measuring the existing enclosures, reviewing the electrical ratings, inspect the existing bus work, verify any ventilation for thermal considerations, take a cursory look at the control scheme interfacing etc… and see if an upgrade / uprated switch employing newer technology could reasonably retrofit into the existing enclosure.

During a day when the plant would be able to de-energize and ground the exiting switch, Mr. Chad Shell, an owner and the Engineering Mgr. of Crown Electric made a return visit to Jocassee with Mr. Patel. Access was provided to the pair such that critical, limiting dimensions, locations of internal structural supports, main copper bus runs, bolt hole patterns, control wireways etc… could be gathered and compiled for an initial "sanity check" to confirm a retrofits' possibility and practicality.

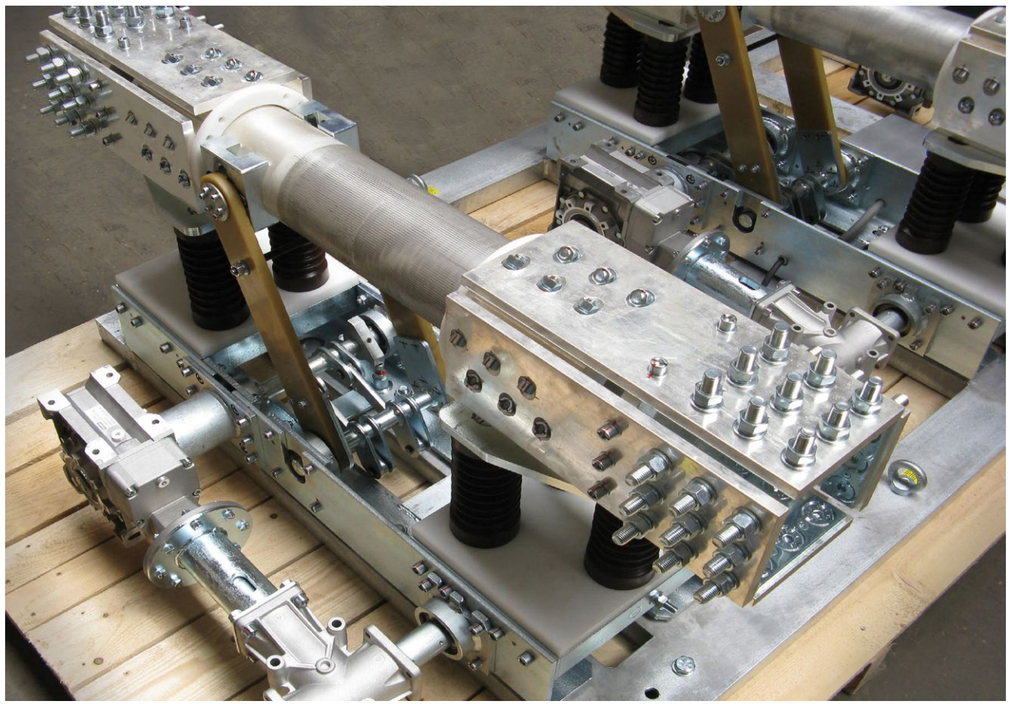
With agreement to move forward - a 3-D rendering was created. Duke appraised Crown of the sites work procedures, confirmed the dimensions of the egress / ingress paths to verify that gutting and rebuilding in place a medium voltage, four pole, 10,000 amp reversing switch could be accomplished – and all had to be done during an acceptable outage timeframe of less than four (4) weeks.

Crown Electric proposed its low profile, high-amperage, telescoping disconnect switch design.

Each pole would have its own interlocked drive mechanism with a manual emergency override. Optional integral, interlocked ground switches were discussed and decided to be unnecessary for this location in the System's one-Line.

Extremely tight access available for retrofill work

Low Profile SD (Super Duty) Disconnect Switch



New custom control panel designed for ease of retrofit & wire drops

Duke I&C personnel provided Crown Electric with a full review of existing controls, protection, interlocking and annunciation schemes. Approval of submittals for a brand new control panel set in motion the component lay-out and fabrication of a panel that could fit within the old control cabinet and allow for wire drops that would land directly onto the existing terminal blocks.

With the plant entering its outage – Crown Electric mobilized a crew of maximum size that could harmoniously access the tight work space. With laptop in hand, loaded with 3-D modeling Inventor™ software, Mr. Marc Meyer - Crown Electric's senior project design engineer supervised the on-site crew. This insured any unforeseen discoveries brought to light during the disassembly of the existing switch which might impact the installation phase of the project could be quickly addressed. Mr. Meyer could right there "on the fly" draw up critical areas of the installation with great resolution so that parts could be fabricated at Crown and shipped to Jocassee while the disassembly continued.

The total per phase material weight of the original reversing switch coming out was well over a thousand pounds. Each phase being mounted in its own very tight enclosure compartment (less than two feet in width), made laying hands on, or getting tools and torches into such sections a highly choreographed chore for execution. Impromptu specialty hoists and slinging were essential for safely finessing the larger, heavy parts that had occupied this space for decades free and clear. And this was just the disassembly !

Once the switch chambers were clear and cleaned – the process turned to remaking each enclosure such that it could receive and secure its new SD Disconnect switch phase by phase. No two sections were 100 % identical – so welding of new custom bracket positions, holes, bolting points and wire ways were each accounted for in their own assembly drawings. Each section was to be executed by a lead mechanic and overseen by the project's design engineer.

Rigging of each new phase was slow, methodical and very cautious. The crew ran practice simulations of the upcoming procedures to intercept shortcomings in the plan and to insure that each person became versed in their responsibility.

SD Switch™ poles of this amperage and having their own motor drive are close to 4 feet long and weigh approximately 750 pounds or more. They needed to fit though an original door opening of approximately 17 inches wide and line up with accuracy so as to allow a mechanic to slip a piece of 5/8" hardware into the associated mating holes.

Once in place, new custom 10,000 amp buswork was hand fitted and installed to connect each phase to the closest original bus joint's bolting points. Each switches control wiring was trained to the new custom panel and landed point to point, picking up all the functionality, interlocking and annunciation required for safe, proper operation.

Lots of amps means lots of copper

The mechanical override mechanism was ported such that loss of control power or a failed motor drive would not completely inhibit the ability to operate each of the pole assemblies.

Three weeks after the first gang boxes arrived; Crown Electric's crew performed mechanical and electrical operations checks for Jocassee I&C and Engineering.

The switch, that switches the ability to switch from generator / to motor / and back – after forty years – had been switched.

New SD disconnect retrofits