Powerful Dreams

Crown Hill Farm's Hydro-Electric Plant

Juliette & Lucien Gunderman

Most Photos by Greg Wheeler

The big lake (6.1 acres) supplies the larger of the two hydro-electric turbines located 170 vertical feet below.

Several people who have heard about our hydro plant have all had the same questions! Where on earth did you come up with the idea to build a hydro-electric plant on your farm? They also wonder what it takes to design and build a hydro system.

Well, it takes an idea first and foremost. Actually, it takes a lot of ideas. It takes frequently waking up in the middle of the night with many ideas, and writing them down. It takes water, optimism, more water, diligence, more water, patience, water, practical common sense, and the will to succeed.

The idea came twenty years ago while Lucien was attending his high school's ten-year reunion at the Von farm in Carlton, Oregon. Dick Von, a logger and farmer, had always wanted to build a hydro-electric system on the farm. The Vons were just getting started with their project at the time of the reunion, so Lucien got to see the beginning phases of the system. Pipelines had been laid, and the powerhouse had been started.

The gears in Lucien's head started turning. Soon after the reunion, and every three or four years, Lucien contacted the local utility to see what they thought of the idea of a small hydro plant being built and intertied with the utility. Each time the question was asked, the same answer was given: "It's a great idea, but with the low rates that McMinnville Water & Light currently has, it's simply not an

Lucien Gunderman and the twin Canyon Industries turbines.

economical thing to build, and the payback would be too many years to count." McMinnville Water & Light still has one of the lowest electricity rates in the nation.

Eighteen years went by. The year was 2000, and an energy crunch was upon us. This energy crisis prompted us to hire an engineer and pursue the hydro project in earnest. The engineer saw promise in the project.

Lucien again contacted the Vons, and arranged for a personal visit and tour of their system, which had been in operation for nearly two decades by then. Juliette, Lucien's mother, and Lucien were both hooked after seeing the Vons' system. We both knew that Crown Hill Farm had the potential for a hydro system if Lucien's ideas could be put together into a finished package.

McMinnville Water & Light

Lucien again made a trip to the local utility, and this time got a much different response. Rates were increasing and were expected to keep increasing, and electricity was now in short supply. Amazing how a few years and an energy crisis can change a situation.

However, no one in the utility's service area had ever built a grid-tied microhydro project in its 113 year history. They were reluctant to be more accommodating than they were legally required to be. And they were completely unfamiliar with the interface and the induction generation system that we were proposing.

Photo by Dave Dillon

Juliette and Lucien Gunderman in their watershed.

Hydro History—Full Circle

When Crown Hill Farm was started, Juliette's parents were the first rural electric customers of the utility on Baker Creek Road. They also supplied cordwood to the utility to operate a steam turbine that was used to power the electric plant for the city of McMinnville in the early years. This power plant was located just one mile above the farm's entrance.

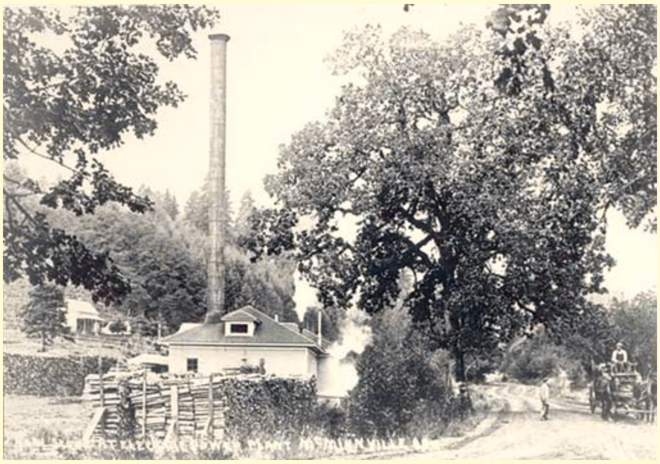
It was a combination hydro/steam turbine. When water was not available in sufficient supply from Baker Creek to turn the Pelton wheel turbine, steam was generated by a wood-fired boiler.

This plant was a 200 KW system that was the only source of electricity for the city of McMinnville in the early days. It was built in 1907. The vertical head was 237 feet (72 m), only 50 feet (15 m) more than we have on our system. The water was carried via a 24 inch pipeline approximately 1 mile (1.6 km). A dam was installed, complete with fish ladder and a large vertical slide gate for flushing the dam.

As a child, I played at the dam on countless occasions, and was always intrigued with it, the fish ladder, and all parts of the system. Recently I got to see the remains of the original turbine that was decommissioned in 1952. When McMinnville Water & Light came on-line with Bonneville Power, it was required that they shut down their own power plant.

Lately there's been talk of recommissioning this plant. The Crown Hill Farm project is a demonstration of the viability of hydro-electricity. "Things have come full circle with the completion of Crown Hill Farm's hydro project," said Juliette.

Juliette's father delivers wood to the Baker Creek power plant.



The two Canyon Industries turbines flank the 30 KW, three-phase generator.

After several meetings with us, the McMinnville Water & Light Commission and the staff of the utility saw the value that local renewable energy would provide to the community. They offered to be more flexible and to install a pole and dual meters for the project. One meter was for incoming electricity and one for generated electricity flowing back into the grid.

Crown Hill Farm Hydro

Our farm was started in 1920 by Damien and Zephirine Mochettaz, Juliette's parents. It encompasses nearly 800 acres. Crown Hill Farm is aptly named—it sits in the rolling hills west of McMinnville, and actually has a crown of high hills around the south and west ends of the property above our main farm buildings and residences. We recently put a conservation easement on the farm to protect its natural beauty and open space in perpetuity.

Once we got started on the hydro project, a hydrologist was hired. He determined that approximately 175 acres could be used as the watershed for the project. There were already two lakes on the farm. The large one was built in 1954 and is used for irrigation; it holds roughly 22 acre feet (2,700 m^3; just over 7,000,000 gallons) of water. The second lake was quite small, but could act as a collector for the new lake that would be built at a slightly lower elevation. It was in a more beneficial location for collecting and regulating water for this project.

We verified rainfall for the last 50 years, which showed that adequate water would be available, at least in the winter months, to run the system. The farm, located 6 miles (9.6 km) west of McMinnville, gets 46 to 50 inches (117–127 cm) of rain per year. After doing this research, we decided to go ahead with the project, so we started to make arrangements and plans. Various sources were used to research the project, from the Internet to Oregon State University.

We dug several small collection ponds and nearly 5,500 feet (1,700 m) of ditches. This included ditches to divert water to two reservoir ponds that supply water to the project, as well as for the main lines to the turbines.

Water for this power plant is from upland sources, including several artesian springs that run year-round, and from collected rain runoff. The head (vertical distance the water falls) from the little lake diversion is 85 feet (26 m), and the head from the large lake is 170 feet (52 m). The water leaving the powerhouse runs into Baker Creek, which borders our property, and eventually into the Yamhill, Willamette, and Columbia Rivers.

Intake & Pipe

The penstock system includes two main pipes. The 10 inch pipeline from the big lake runs 1,850 feet (564 m) and feeds the larger of the two turbines. The 8 inch pipeline from the little lake runs 950 feet (290 m) and feeds the smaller turbine. Both pipelines are buried 5 feet (1.5 m) deep. Both lines are straight runs except one 45 degree elbow in each line, where there are thrust blocks—large concrete blocks attached to the pipe. The thrust blocks anchor the pipe and absorb the force of the water on the fittings and pipe. There are also thrust blocks on the 10 inch line where it comes up and into the filter, which is adjacent to the powerhouse.

At the little lake, a blue intake pipe is drilled with hundreds of 1/4 inch holes. The galvanized shroud prevents debris from clogging the intake.

We did a lot of the manual work, and used our backhoe and dozer for much of the excavation. All four small diversion ponds and the second lake were built by Lucien and a friend, Jim Modaffari, who does excavation work. Pipelines were laid by a professional who deals with high pressure irrigation lines all of the time. All pipeline ditches were backfilled by Lucien. We also designed and helped build all portions of the tailrace and powerhouse.

The big lake has a filter screen on the end of a pipe in the lake. The stainless steel screen box is approximately 5 feet tall by 2 feet wide by 2 feet deep (1.5 x 0.6 x 0.6 m), and is clamped to the pipe with a steel clamp. It will not allow any particles or debris larger than 3/4 inch (19 mm) in diameter to enter the penstock. The penstock is the pipe that delivers the water from the intake to the turbine.

We installed a 2,000 gpm in-line filter that removes any debris that might get through the main screen in the bottom of the lake. This filter has a built-in brush and blow-off valve so that it can be cleaned and flushed even while in operation.

Canyon Industries manufactured our two Pelton turbines. They did not want any particles larger than 1/4 inch (6 mm) passing through the turbines. When we ordered the filter, the manufacturer opted to use 1/16 inch (1.5 mm) stainless steel mesh for the screen. They felt that we would have little or no trouble with organic material getting hung up on this size mesh. We've flushed the filter four times since it was installed eight months ago. The filter has two pressure gauges mounted on the body, and it is recommended that it be flushed when there is a 5 psi difference between source, and output ports on the filter. When we did flush the filter, it had never reached the 5 psi difference. We just wanted the system to work at optimum efficiency. The filter has worked very well.

The little lake intake screen is a combination screen and filter. It was made from a piece of schedule 40, 8 inch PVC pipe that is vertical in the lake. Lucien drilled 1/4 inch (6 mm) holes for seven hours one day to make this intake filter/screen. It works perfectly. We used some 24 inch (61 cm) galvanized heat duct to make a shield that surrounds the intake pipe. Water must enter at the bottom of the shield, so a very limited amount of debris is pulled up to the actual screen pipe. We plan to build a catwalk this summer so we can run a brush up and down the pipe to dislodge small particles that are sucked against the pipe during operation.

Latest Technology

The system is designed to run with water from one or both lakes in combination, and uses two, twin nozzle, Canyon Industries Pelton wheel turbines that are synchronized via a belt drive to operate in unison. The turbines are a fixed-nozzle design, and nozzles can easily be changed depending on the available water. The low-end output of the system is approximately 500 watts, and the high-end rating is 30 KW. The turbines will run efficiently with a volume as low as 65 gallons per minute or as high as 1,850 gallons per minute.

Technical Specifications

System type: Batteryless grid intertie, three-phase, 240 volt, open delta wiring configuration

Static head: Little lake, 85 feet; big lake, 170 feet

Flow rate: 65 to1,850 gallons per minute

Large turbine: Canyon 1215-2, twin nozzle Pelton, 12 inch (30.5 cm) pitch diameter

Small turbine: Canyon 9513-2, twin nozzle Pelton, 9.5 inch (24 cm) pitch diameter

Both have manganese bronze runners.

Our system is unique in that two turbines actually run one generator. Either turbine can run the generator with one nozzle or two, or both turbines with one, two, three, or four nozzles. Valves are automatically opened and closed through the secondary control panel according to lake levels. We have two on/off setpoints in both lakes according to levels that we can select at the powerhouse. The system can operate completely unattended, with a variety of weather conditions and available flows.

Nozzles: Minimum nozzle size for both turbines is 0.63 inches (16 mm). Maximum nozzle size for the large turbine is 1.6 inches (40 mm). Maximum nozzle size for the small turbine is 1.4 inches (36 mm). Nozzles are fixed-jet type nozzles that are easily changed for seasonal water fluctuations.

Generator: Marathon, M/N 324TTDP7071, 240 VAC, three-phase, induction, 60 Hz, 0.5 to 30 KW, 1,800 rpm, belt driven

Main disconnect fuse/breaker: 100 A at 240 V, three-phase

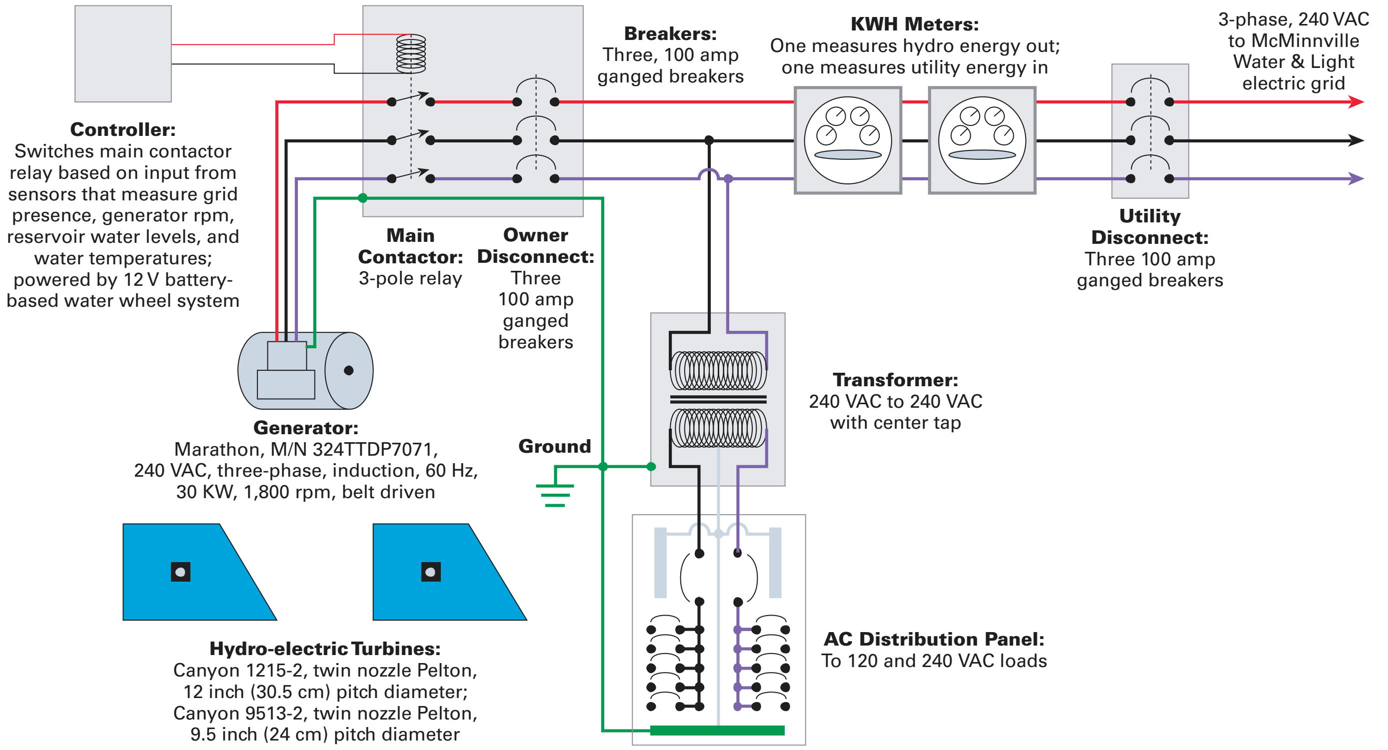
System performance metering: PQM, Multilynn. Shows voltage, amperage, instantaneous power output, and approximate KWH

Average KWH per month: 3,000 KWH January–April 2003

Utility residential KWH cost: 3.8 cents for the first 1,000 KWH; 4.1 cents over 1,000 KWH

Percentage offset by system: 50 percent in first six months of operation

Crown Hill Farm's Dual-Turbine Hydro System



Since we have a net metering contract with McMinnville Water & Light, we cannot exceed 25 KW at any time during the year. Oregon law for net metering limits the output to 25 KW. This system is a three-phase, 240 V grid interface system that is wired directly into McMinnville Water & Light transmission lines. Electricity generated is credited by the utility through a net metering agreement signed earlier this year.

This hydro plant incorporates the latest technology, and has automated features that monitor lake levels and temperature, as well as generator function, frequency, KW output, power quality, etc. It has automated controls that open and close valves on the turbines according to lake levels. Level options are programmed on a keypad on a secondary control panel, and a digital readout gives water levels in both lakes, as well as a temperature reading of the lakes and Baker Creek.

This control panel governs shutdown and startup of the turbines based on input from several sensors. The batteries below power the control system even if the utility grid fails.

The system also has a dual timer option for turbine operation, and a manual override for select situations. It has six fail-safe controls that will automatically shut down the generation system when necessary. These controls protect the equipment, and ensure that no electricity will flow into the local utility lines when they are being repaired by utility workers during a grid outage.

An automatic water shut-off feature will turn off all water to the turbines in the event of a utility failure, or any other system malfunction. Lucien designed this feature so that a valuable resource—water—will not be wasted.

Taking Care of the Fish

The system monitors the temperature of the water and the levels of each lake, to protect the fish. If the levels get too low or the water is too warm, it can't be run through the turbines and introduced into Baker Creek. Each lake has a two-stage setting with level controls to maximize resource usage, and allow for automatic control of generator output.

Water leaving the turbines through the concrete tailrace is slowed, to alleviate erosion and eliminate water turbulence when it merges with Baker Creek. The water is aerated thru a series of diversion bars of expanded metal, oxygenating the water to facilitate fish habitat in Baker Creek. The creek is listed as a fish bearing stream, which includes such species as dace, sculpin, cutthroat trout, lamprey, crayfish, winter steelhead, and coho salmon.

The main contactor enclosure contains the overcurrent protection, manual disconnect, and main relay.

Two KWH meters measure grid energy to the farm and hydro energy to the utility grid.
Below is the disconnect required by McMinnville Water & Light.
The shed that houses the turbines and controls is in the background.

The temperature standard for cutthroat trout, steelhead, and salmon is quite cold. Technically, the temperature is not to exceed 55°F (13°C) May 1 through July 15, 65°F (18°C) July 16 through October 15, and 55°F (13°C) October 16 through 31. We did a lot of talking about these temperature criteria with state and federal agencies, and ended up having to install the temperature monitoring equipment, and setting it up for auto shutdown if we exceed the creek

Induction Generation

When we looked at what type of generating system to use, the most economical and easily grid-intertied system was an induction generation system. With an induction system, you use a regular induction motor. When the turbine spins the motor shaft, the motor becomes a generator, and generates instead of consuming electricity.

Synchronization. One beauty of this system is the simple controls required to connect to the grid. There is an electronic tachometer that monitors the system speed. When the induction motor/generator hits generating speed, the control panel connects it to the grid. After the phases line up, the grid locks the generator at 60 Hz and it is generating. Induction generators are easily obtained, although ours, because of the double turbine drive, had to be special ordered.

Safety. Within the intertie panel are relays that will sense a grid failure and automatically shut down our system. So the system cannot endanger utility crews with an unanticipated electrical feed. Electrical codes are very specific as to auto shutdown in the event of a grid failure. The utility was very concerned about the intertie, since we are the first nonutility hydro plant to come on-line in their history. If the utility needs to work on main transmission lines, they can shut off our system with a manual disconnect switch, which in turn shuts down the generating system in a matter of seconds.

Induction or Asynchronous? We did also consider using an asynchronous generator. With an asynchronous system, we would have had the option of complete stand-alone power, even if the grid went down or failed. But it also would have meant more wiring, a grid-interactive inverter, batteries, and a high voltage utility disconnect. The additional cost would have been approximately US$20,000 to $25,000. We decided that since we already had backup generators, this additional investment really made little sense.

Transmission. Our transmission lines to tie in with the grid are only about 450 feet of overhead run, and we were able to tie into our existing 240 volt, three-phase, open delta irrigation service. This kept the cost down and is working very well.

Water Wheels

A small, 4 foot (1.2 m) water wheel is incorporated into the design of this hydro project, just for fun. The water wheel was constructed from an antique steel wheel that was 36 inches (91 cm) across, and the 1/2 gallon buckets were from a dismantled feed mill, the old Albers Mill on Front Street in Portland.

For the time being, it is just a functioning, aesthetic addition to the project. The dry seasons during these last two years have also limited the possibilities for the water wheel. Water for the water wheel comes from a third source of water so it does not take water away from the main turbines.

A new small water wheel, made from an old squirrel cage fan, mounted on a frame on roller bearings has been constructed, and direct coupled to a permanent magnet motor from a computer drive. This small water wheel, is mounted on top of the original tailrace, and is supplying a continuous output of between 1/2 to 1 1/2 amps at 12 VDC to two automobile batteries. A 700 watt inverter supplies emergency lighting, runs a battery charger for the DC portion of the main project, and runs some decorative lighting on the exterior of the hydro building.

A small, 4 foot diameter water wheel was built using parts from an old feed mill.

This portion of the project was just a brainstorm, and a fun part of the overall project. It uses the same water that is fed to the larger water wheel, so it does not take away from the main turbines. The inspiration for this project was a similar pico-hydro system at www.otherpower.com/otherpower_experiments_waterwheel.html.

temperature. Temperature monitoring is required from May 1 through October 31 of each year.

Alarms & Controls

Lucien installed signal lighting that is visible from our home to show when the system is operational. An audible and visual alarm were also designed and installed to alert us of a grid failure or system shutdown.

A low voltage power supply and low voltage actuators are used for the auto valve control that is run from the head level sensors in each lake. The actuators were purchased from Burden's Surplus Center in Minnesota. A 24 VDC battery charger charges two small 12 volt batteries in series, which allows the system to close valves in the event of a grid failure. If the grid goes down, a relay simply tells the panel to close all valves and shut off the water.

Even though Lucien thought up many of the details in this system, the turbines, panels, and most of the control mechanisms were not manufactured on site. There were countless phone calls and e-mail messages, as well as continuing research into many of the details of this project. It would not have come together without the help of Canyon Industries, Bat Electric, and Inertia Controls. The equipment used for the project has a long life and is expected to perform for a century or more with little maintenance.

Determination

This 30 KW capacity microhydro plant is the first newly licensed hydro plant in the state of Oregon in the last twenty years. Several people have told us that they would not have had the determination, persistence, and patience to deal with all of the agencies and their rules, regulations, restrictions, and timetables.

Local, state, and federal agencies that had jurisdiction or commented on the project included: Yamhill County Planning, Oregon Department of Fish and Game, Oregon Department of Environmental Quality, Oregon Division of State Lands, Oregon Department of Forestry, Oregon Department of Agriculture, Oregon Office of Energy, State Historic Preservation Office, Oregon Department of Water Resources (the lead agency), Northwest Power Planning Council, Oregon Parks and Recreation Department, Oregon Land Conservation and Development Department, Oregon Public Utilities Commission, U.S. Department of Fish and Wildlife, and the National Marine Fisheries Service. Our commitment was tested when dealing with these agencies during the licensing process, which took a year and a half.

Benefits

We see many benefits from our hydro project. The major one is supplying electrical energy. The system is expected to generate 96,000 KWH of electricity per year, enough to supply approximately eight typical Oregon homes. It should generate enough electricity to meet all of Crown Hill Farm's electricity, and about 25 percent more, which McMinnville Water & Light will buy at wholesale and resell to other consumers.

Hydro System Costs

Item	Cost (US$)
Turbines & switchgear	$40,000
Pipe & installation	22,500
Building & concrete	10,000
Excavation	7,500
Misc. unanticipated costs	7,500
Electrician, etc.	6,500
Misc. pipe & hardware	5,000
License & permits	3,000
Engineering & misc. costs	2,500
Hydrologist report	1,600
Water wheels (both) & equipment	500
Total	$106,600

Another important benefit is that our project is a renewable resource and does not deplete any natural resources. The two main lakes already existed and needed no structural changes. The diversion ponds provide additional wildlife habitat. The project adds cold, aerated water to Baker Creek, which enhances fish habitat.

"A hidden benefit is that this little hydro system is actually improving the power quality for their neighbors," said Christopher Dymond of the Oregon Office of Energy. "Lucien and Juliette's investment in local clean energy reflects both their patriotism and good stewardship."

One of the main pipelines also incorporates irrigation risers that will add efficiency to summer irrigation because of the larger supply line with more pressure. The large lake has been used for irrigation purposes since 1954.

The project better controls runoff water. It collects and diverts water to the new diversion ponds and two regulation lakes. This dramatically reduces erosion, sedimentation, and water damage to drainage ditches and Baker Creek.

Hydro Dreams

It has been said that dreams come and go. In this case, our dream has come true, especially for Lucien, who never gave up hope on the idea that our farm and its natural resources could one day be used to supply electricity to ourselves and others.

A project like this is a big undertaking, with many unexpected costs and hurdles along the way. But the feeling of satisfaction, pride, and good stewardship is well worth the time, energy, and hard work to bring it all together. It is a great feeling to see a project come together and work after dreaming and planning for many years.

Access

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Bat Electric, Inc., Dan Batdorf, 20200 Charlanne Dr., Redding, CA 96002 • 530-221-1336 • Fax: 530-221-3496 • BATELECINC@aol.com • Co-generation control panel

Inertia Controls, Inc., Darin Malcolm, 381 S. Redwood, Canby, OR 97013 • 503-266-2094 • Fax: 503-266-1152 • darinm@canby.com • www.saftronics.com/pages/INRT.htm • Temperature sensor and valve actuator panel

Familian Northwest, 2979 N. Pacific Hwy., Woodburn, OR 97071 • 866-537-7635 or 503-982-6141 • Fax: 503-982-1106 • www.familiannw.com • Pipeline, valves, plumbing

Precision Controls, Yvonne Vonderaye, 7110 SW 33rd Ave., Portland, OR 97219 • 800-441-8246 or 503-245-7062 • Fax: 503-245-4825 • yvonnev@teleport.com • www.ifmefector.com • Temperature sensors and controls

Farnham Electric, Dennis McGill, 1050 NE Lafayette Ave., McMinnville, OR 97128 • 503-472-2186 • Fax 503-472-4042 • roberto@farnhamelectric.com • Electrical contractor