MONWANA LODGE'S CENTRALISED, INTEGRATED HEATING AND COOLING SYSTEMS

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Monwana is located within the prestigious Thornybush Nature Reserve, which is home to the famed Big 5 and offers world-class game viewing.

In 2021, the lodge – which was initially constructed in 1993–95 – was all but demolished, and construction began on what was to become a world-class safari lodge. The project was then started and completed from January 2021 to August 2022.

Located within the greater Kruger National Park, a pristine natural environment, and garnering their revenue from wildlife tourism and conservation, a high level of emphasis was placed on energy efficiency and sustainable utilisation, without compromising on the level of service and comfort to their guests.

With regard to the heating/cooling system, the client needed a solution to meet the many luxuries required in a high-end lodge, while keeping the power draw as low as possible. The lodge is divided into two different sections: front-of-house and back-of-house. The front-of-house is host to seven free-standing guest units that sleep a total of 16 guests as well as a spa, gym, kitchen and main dining area. The back-of-house includes the plant rooms, workshops, laundry, offices and accommodation for 48 staff members.

The guest units all required the following: climate control for bedrooms and living areas (heating/cooling through fan coils), hydronic underfloor heating for bathrooms, heated towel rails as well as private heated swimming pools. This, as well as supplying the domestic water (both hot and cold), meant there were many reasons to design a centralised heating and cooling system.

The grid is only capable of supplying 50kVA. The rest of the power on site is produced with a large solar PV system backed up with batteries. The central heating and cooling systems' communication system connects with the photovoltaics (PV) system to make logical decisions.

Entrance to Monwana lodge.

Aerial view of Monwana Lodge, showing the distances between the building structures.

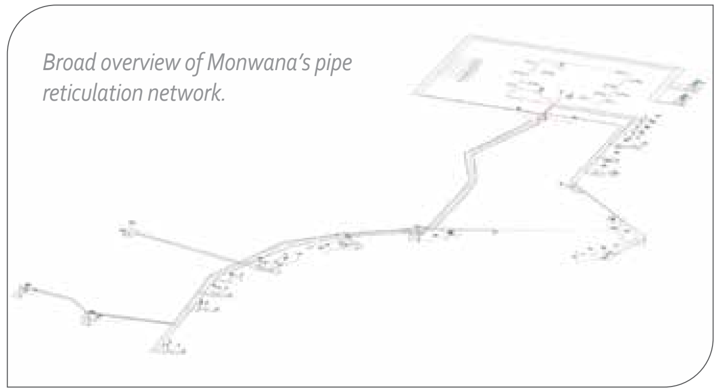
PROJECT DESIGN PHASE

The engineering team at Essensia Heating and Cooling Systems uploaded the architect's AutoCAD Design drawing onto proprietary software. This architectural drawing allows the engineer to extrapolate a detailed building design structure using a professional HVAC design programme from Poland that is used to design HVAC systems such as underfloor heating/cooling, aircon systems, heated towel rails, pool heating and domestic hot water systems. This part of the design process is crucial as all pump specifications, fan coil

Images supplied by Essensia Heating & Cooling Systems

Colin Holden from Monwana in the Photovoltaic plantroom.

sizes and pipe coil lengths are calculated by the programme, which need to be installed later into the foundational structures of the lodge buildings. This programme makes ordering all necessary equipment for the installation possible, as it provides detailed engineering results needed for every component. The broad overview of the piping reticulation can be seen in the following picture:



Broad overview of Monwana's pipe reticulation network.

We first make use of what is freely available to us in sunny South Africa: the sun. We obtain energy from the sun through the solar water heating panels adding around 1.5–2Kw of heating per panel to the system. The energy is transferred to insulated buffer tanks. The solar thermal panels can be seen in the following picture:

Sungazer solar hot water flat plate collectors

A second source of hot water is a chiller with full heat recovery. It is the main source of cooling for the server rooms and any spatial cooling demand. Any heat removed is recovered and transferred to the hot buffer tanks.

A third source of heat is heat pumps equipped with desuper heaters. They can heat the buffer tanks. These heat pumps can also assist with cooling, as about 20% of the heat rejection is recovered as high temperature hot water that is

Aerial view of PV solar panels for electricity generation on roof structures.

also transferred to the hot buffer tanks. The heat pumps with partial heat recovery can be seen in the following picture:

ANL desuper heat recovery units.

The energy stored in the hot buffer tanks is transferred to various energy-hungry elements by the distribution stations. The distribution stations can be seen in the following picture:

Boilernova hot water buffer tanks, expansion vessels and distribution stations.

In the picture above, the hot water buffer tanks can be seen on the left hand side together with expansion vessels that deal with the expansion and contraction of the system.

The distribution stations with the variable speed drive (VSD) pumps can be seen on the left, against the wall. The distribution stations, together with the insulated tanks on the right-hand side of the wall, are the chilled water buffer tanks and distribution stations. These transfer the chilled water to the spatial cooling network. The chilled water is chilled with the full heat recovery heat pump, which cools down the cold buffer tanks and dumps all its heat in the hot water buffer tanks. The heat pumps, equipped with the desuper heaters, are reversible heat pumps which means that they can make chilled water as well.

The domestic hot water is heated from the hot buffer tanks. The two systems are seperated by a heat exchanger coil inside the domestic hot water tank to ensure the treated water in the heating system doesn't mix with the potable hot water. In the picture below the insulated domestic hot water tanks can be seen as well as the backup condensing modulating gas boilers:

Domestic hot water tanks, Fondital condensing gas boilers.

The distribution stations are used to circulate the chilled water, hot water, potable hot water and potable cold water in an insulated trench. The trench is foamed with closed-cell polyurethane foam as seen in the picture below:

Before and after of foaming trenches to insulate piping to Monwana Spa, by Reliance Foam. The foam gun sprays a mixture of isocyanate and resinate through a heated gum. The mixture solidifies and expands on contact.

This is a highly efficient way of distributing hot and cold water. For example, we can circulate hot water in a ring main that is about 1.2km long, and we lose less that 1°C in the ring main. The foam is environmentally friendly and is ozone-inert.

The insulated trench runs throughout the lodge and supplies the buildings with:

- Chilled treated water
- Hot treated water
- Potable cold water
- Potable hot water

TREATED CHILLED WATER

The chilled water from the insulated trench is sent to a fan coil unit at each location that requires cooling. It is circulated through the coil of the fan coil, and air from the room is circulated over the chilled coil, thereby cooling the air down and returning it to the room.

We used fan coils from Aermec. These units are known and proven to be effective, reliable and quiet – which makes them the ideal units for our installations.

Ceiling void mounted fan coils that are ducted.

The fan coil is connected to a ducting system that is connected to linear slot diffusers.

Linear slot diffusors – black linear slot on the wall above the doors.

TREATED HOT WATER

The hot treated water from the insulated trench is used for:

- Spatial heating through the fan coils
- Hydronic underfloor heating for the bathrooms
- Heated towel rails
- Swimming pool heating

SPATIAL HEATING THROUGH FAN COILS:

The spatial heating through the fan coils work on the same principal as the spatial cooling through the fan coils. We send hot treated water through the coil of the fan coil, and air from the room is circulated over the coil of hot water, thereby heating up the room.

Hydronic underfloor heating for bathrooms:

The hot treated water from the trench is also sent to the hydronic underfloor heating of the villas, located in the bathrooms. The hot water flowing through the screed heats up the screed to a temperature of about 28°C, giving a heating output of 70 watts per square.

PEX piping laid on top of foam for the underfloor hydronic heating system in the bathrooms. The next stage of the process would be a mesh layer and screed on top of the piping system, and then the tiles.

Heated towel rails:
The hot treated water is also sent to the heated towel rails in the bathrooms to warm up and dry the towels.

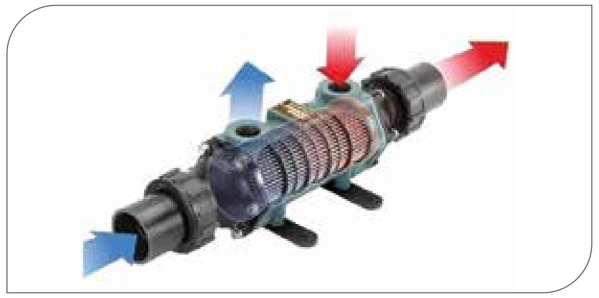
Bathroom with underfloor heating and hydronic heated towel rails.

> "The Bowman shell and tube heat exchangers are fully serviceable and have probe sockets to measure the temperature of the pool water flowing through it."

Pool heating:
The hot treated water is also utilised to heat the pools.

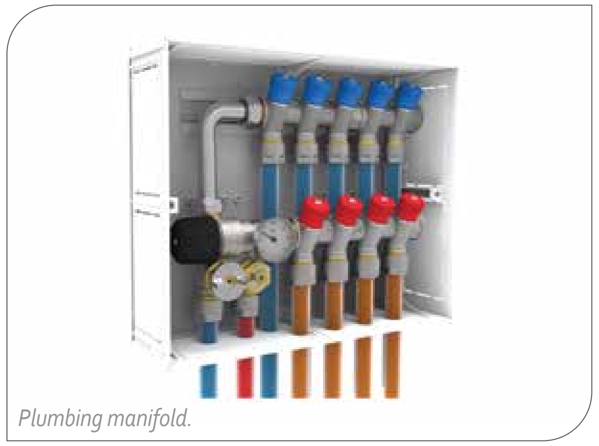
Villa pools are heated through heat exchangers.

The pool is heated up by the hot treated water sent to a Bowman shell and tube heat exchanger. The treated hot water flows over the tubes in the heat exchanger and the pool water flows through the tubes in the heat exchanger. This allows us to be able to heat up the pool water without having to mix the pool water with our treated hot water. The Bowman shell and tube heat exhangers are fully serviceable and have probe sockets to measure the temperature of the pool water flowing through it.



Bowman heat exchanger

Potable hot water:
From the insulated trench, the potable hot water is branched off the ring main to plumbing manifolds. The plumbing manifolds are located at all bathrooms and kitchens.



Plumbing manifold.

The hot water is connected to the red ports of the manifold inside the manifold box. The benefit is that each hot point has a tap that can be shut in a scenario where some fixture has a leak. This allows the maintenance team to isolate an individual tap, and the rest of the plumbing points still have hot and cold water while maintenance is done. Pre-insulated Multilayer PEX piping was used due to high durability at its high temperature and pressure.

Potable cold water:
From the insulated trench, cold potable water is tee-ed off to the cold water manifold in the manifold box. The cold water manifold can be seen in blue in the manifold box.

The benefit is that each cold point has a tap that can be shut in a scenario where some fixture has a leak. This allows the maintenance team to isolate an individual tap, and the rest of the plumbing points still have cold water while maintenance is done. Multilayer PEX piping was used due to high durability at its high temperature and pressure.

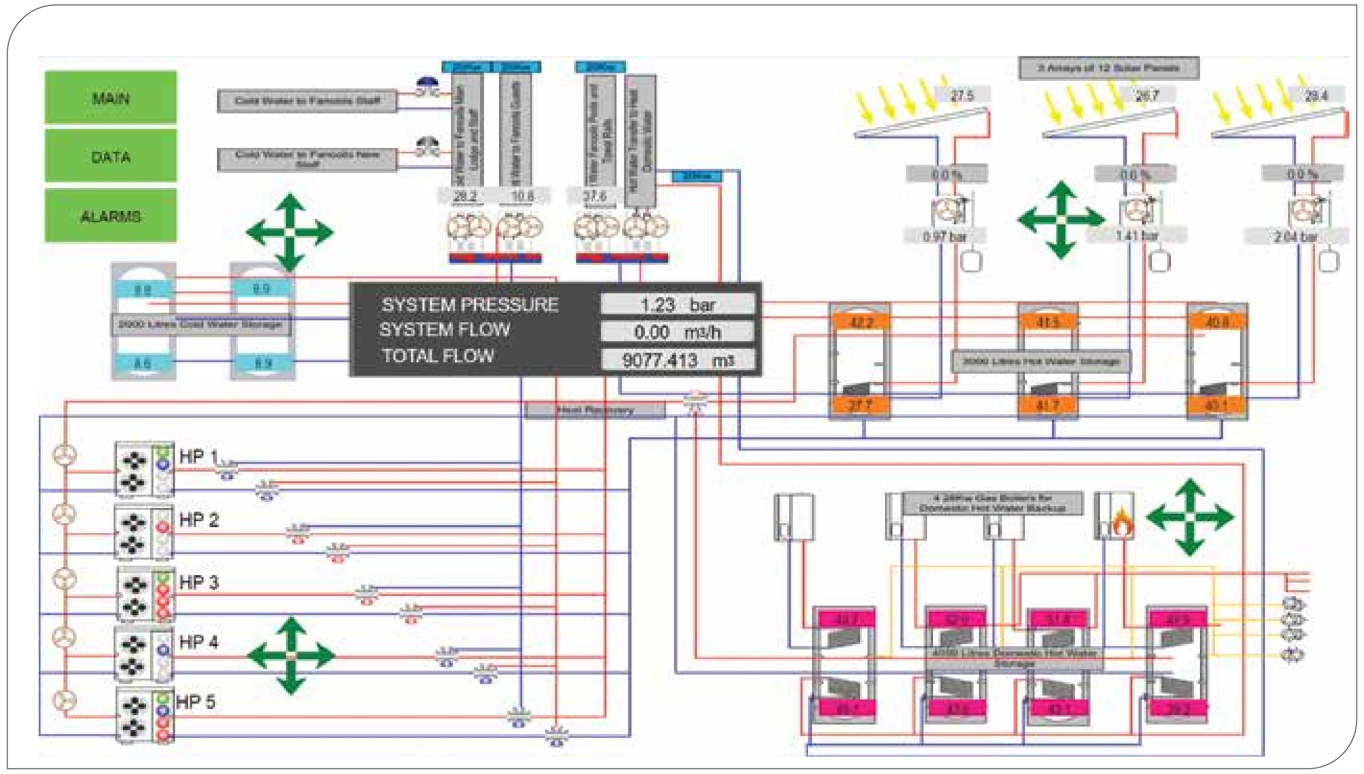
The heart of the integrated system is the PLC control system. The control system allows the system to run and make logical decisions for itself based on the requirements of the lodge. The control system controls all pumps, valves, heat pumps and gas boilers and measures all required temperatures.

The control system helps the lodge save a large amount of energy. It with the Victron PV system, and can turn off non-essential heating and cooling loads as well as heat pumps when limited energy is available, without compromising the guest experience.

The control system has remote monitoring and remote programming capabilities, allowing the maintanance team to control the system from any smart device. The engineers at Essensia Heating and Cooling Systems can also monitor the system and make adjustmants to the parameters of the system from any smart device. The control system sends alarms to all parties if there is a fault in the system, such as if gas botttles are empty for the backup gas boilers or if a heat pump has an error. This allows the maintenance team of the lodge to rectify any potential issues and ensures that guests have the ultimate experience. The physical control system, which is housed in the plantroom, can be seen in the following picture:

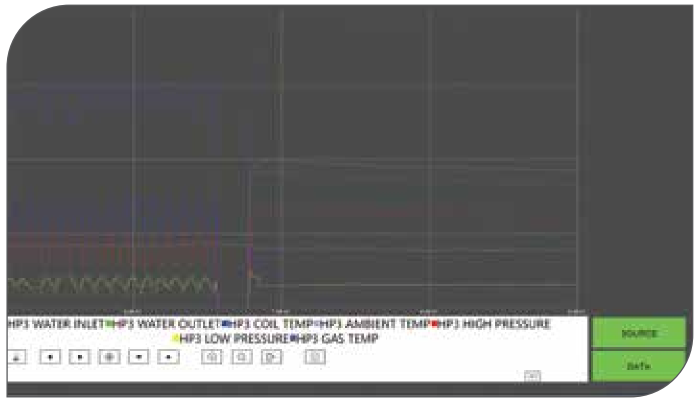
Colin Holden from Monwana viewing the PLC control system home screen.

The plant summary can be seen below:



Plant summary of the PLC control system.

The data for all heat pumps is tracked, making it possible to see how well the heat pumps run and what they have done in the past. A picture of a heat pumps trend can be seen below:



Trend line of heatpump parameters on PLC control system.

Each villa's pool, underfloor heating, fan coil heating, fan coil cooling and heated towel rails are closely monitored, as seen below:

Data screen for Luxury Villa 1 on PLC control system.

In the picture above, the pool temperature has been set to 32°C, the pool is busy heating up, the underfloor heating is turned off, and the room's temperature is set to 19°C. The actual temperature measured is 22.5°C. The fan speed is on low due to the actual temperature being close to the set point temperature. Other information, such as humidity, is also monitored to ensure ultimate comfort for guests.

DESIGN CHALLENGES AND SOLUTIONS

- To create an optimal climatic environment for the guests without making noise in the peaceful environment of the villas
- To design the most energy efficient system possible with the limited power supply
- To design the system so that it is architectually pleasing
- To integrate the system with the vast distances between buildings

Hydronic underfloor heating was the solution to heating the bathrooms in the villas as they provide:

- A uniform distribution of energy
- Less heat loss
- Greater thermal well-being

- No architectural limits
- High reliability
- Optimal hygienic conditions

Hydronic underfloor heating provides energy savings because it works with radiant heat, which is distributed throughout a room. Due to the radiant heating concept, it is generally 600% more energy efficient than electrical underfloor heating. There is also a massive advantage of being able to achieve even higher efficiency by combining it with solar thermal panels and heat recovery. Hydronic underfloor heating makes no noise while heating up the room.

The fan coils used are of high quality and the ducting is sonic lined to ensure any noise from the fan coil is not transported down the ducting. The fan coils are designed to run at lower fan settings, and therefore they are extremely quiet.

The hydronic towel rails involve hot or cold water flowing through the pipes at low velocities, so as not to make noise.

Equipment that usually makes most of the noise – such as heat pumps and pumps – are installed in the plantroom far away from the guests. This is an extremely big benefit of an integrated central system.

To design the most energy efficient system, the engineering team had a specialist consulting engineer, Q-Mech, who helped with the detailed heat load analysis. The energy model of the lodge was built to see what would happen in an hourly interval for a whole year. This information was used to see what equipment will run at the same time, and which equipment should be used to make the system as efficient as possible. Due to the heat recovery and solar thermal panels and the water-based central cooling system, the integrated system is using a fraction of the energy that conventional systems would have used altogether.

The system is architecturally pleasing as the only thing the guests can see is a black slot in a bulkhead and a thermostat on the wall. You cannot see the rest of the equipment and can only enjoy the comfort thereof. It would not be typical for guests to go the plantroom, but that is the only other component of the system that they can see. The plantroom houses all imported equipment of the highest quality and is also aesthetically pleasing.

To integrate the system to different buildings that are vast distances apart was a design challenge, and the solution was to dig a trench from the plantroom to all the villas and to use closed cell polyurethane foam to insulate the pipes. The foam is closed cell and therefore does not allow water to pass through the foam, which makes it an excellent solution for insulating pipes underground between buildings. RACA

Project name: Monwana Lodge		
List of professionals:		Name of company:
Owner	Dirk van der Lelij	Monwana
Developer	James Ord / Jefferson Wicks	Red Earth
Architect / Designer	Barnaby Steynor	Architects Incorporated
Project Manager	Jefferson Wicks	Red Earth
Consulting Engineer	Mechanical	Essensia Heating and Cooling Systems
Contractors	Main building	Red Earth
	HVAC&R	Reliance Eco
	Wet Services	Red Earth
	Electrical	Alex van Noordwyk
HVAC and associated product suppliers:		
Mechanical design		Essensia Heating and Cooling Systems
HVAC Importer and Wholesaler for Lavato, Fondital gas boiler, Boilernova puffer tank, GREENoneTEC Sungazer solar flat plate collector, Aquapress solar expansion tank, Henco multilayer PEX piping system		Essensia Heating and Cooling Systems
HVAC Installer		Reliance Eco
Closed cell Polyurethane Foam Service provider		Reliance Foam
ANL desuper heat recovery units and fan coils		Aermec
PLC Automation		EWSS Automation
Photovoltaic		Onesolar
Heat load analysis		Q-Mech consulting
Bowman		Galaxy Sustainable Solutions