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FOR A SUSTAINABLE BUILT ENVIRONMENT

ISSUE 21 | AUGUST - SEPTEMBER 2014

Francis Kéré's **DREAMS REALISED**

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CHARGING AHEAD

By boldly stepping where few green homes have gone before, House Rhino is a showcase of design, technology and materials that push boundaries in home innovation and energy savings.

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House Rhino – perched on the edge of a kloof in Crossways Farm Village, overlooking the Van Stadens River gorge outside Port Elizabeth – has emerged from a vision to develop a single residential unit that integrates as many sustainability and green technology options as possible.

This off-grid, zero energy, zero waste house serves as an industry example, while changing the scene for homeowners who are serious about sustainability.

"I see it as an on-going experiment," says Brian van Niekerk, House Rhino homeowner and managing director of the Rhino Group of Companies. He took responsibility for the systems design and integration, which includes several Rhino Group sustainability solutions.

House Rhino is an autonomous, functional and modern family home that Van Niekerk believes applies sustainability at a whole new level, "as opposed to building a home with some sustainability solutions". At the same time, he argues, "these systems have not made our home unaffordable."

The house's location in Crossways Farm Village – a functioning dairy farm and eco-village – allowed for it to be developed off-grid, says developer, Dr Chris Mulder of CMAI Architects. "The sustainability detail implemented in House Rhino is exceptional," he adds.

The municipality was supportive when it came to planning, architect Steff Mulder of CMAI Architects explains: "The local Kouga Municipality was not opposed to the concept of off-grid housing within the development."

NO ARCHITECTURAL COMPROMISES

While House Rhino's design had to comply with the development's overarching architectural guidelines, Steff Mulder says the client wanted to demonstrate that green technology could be applied to almost any home without "restraining or sacrificing architectural design".

House Rhino has two wings - a bedroom and living space wing linked via the kitchen, which leads out onto a courtyard. "The design benefits from a combination of active and passive design features, including a northern orientation, skylights and double-glazed facades on the northern front," says Steff

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Mulder. The link between the two wings has a green roof with recycled plastic planting boxes for growing vegetables.

INTEGRATING SUSTAINABILITY

Van Niekerk believes even at the scale of a single home, "natural resources and waste can be managed right, with nothing going to waste".

Zero waste, water conservation and energy generation were the key points of departure, corresponding to the Rhino Group's three-tiered backbone: energy, water and food.

WATER

An intricate system of rainwater harvesting, water storage and recycling – including ecologically functional aqua gardens – has been implemented. "We are harvesting rainwater, not only from the roof space as one would conventionally do, but

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01. House Rhino is located in Crossways Farm Village.
02. The design of the house maximises its location and orientation to ensure natural heating and lighting.
03. The extensive sustainability features didn't hamper the comfort or look at the house.
04. Lighting plays an important role in House Rhino's energy efficiency.
05. Heating and cooling are given a lot of attention in the design.

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NUTSHELL

Location • Crossways Farm Village, Port Elizabeth
Size of stand • 1110m²
House footprint • 450m²
Cost • R8 million
Construction period • 19 months
End construction • March 2014

- 01.** The water system includes rainwater harvesting, water storage and recycling.
- 02.** The gardens provide a passive sustainability element.
- 03.** The aqua gardens differentiate House Rhino from its counterparts while making a statement about water conservation.

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we've also implemented a drainage system below the hard-surfaced driveway, parking area and around the residence for additional harvesting," says Van Niekerk.

By using Hydromedia, a porous concrete product, the rainwater catchment area for the household is effectively amplified. Sarel Bam, water systems and treatment manager at the Rhino Group, says rainwater draining through this medium is diverted to an underground drainage system and inline filter. The water is channelled to 300 000 litre rainwater storage tanks. The medium's high permeability means rapid absorption of rainwater, increasing the volume of water captured.

From the storage tanks, the water passes through a series of filters, including ultra-filtration and UV filtration processes. "Through these filtration processes, excellent quality potable water is supplied

to the home," says Bam.

A secondary harvesting system has also been implemented, where all black and grey water, along with organic kitchen and garden waste, is fed through an Agama biogas digester. The natural gas produced from this process is used for cooking and delivers enough gas for four hours' cooking time.

Even the system's effluent by-product is put to use. The overflow from the biogas digester is routed to a small polishing plant, where it is treated through a trickling filter and collected in a water tank with a 2500 litre capacity. "Once collected, it is treated with ozone prior to use for irrigation," says Bam. Van Niekerk says their objective is "to eventually have this biogas effluent water treated well enough for household consumption purposes".

Completing the water systems loop is an aqua garden, including a reed bed system. "The reed bed system purifies water for the natural swimming pool," says Bam.

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passive heating & cooling measures

Including a carefully positioned thermal cooling tower, as well as the thermal massing of walls and foundations help to retain solar energy, slowly releasing stored heat at night to moderate temperature fluctuations. Utilising both active and passive ventilation systems, the building design encourages the natural circulation of air flow by allowing warm air to rise while drawing cooler air through a series of low level ventilator grills.

rainwater harvesting system

capable of storing more than 30,000 litres of water, ensuring that the majority of the water falling onto the roof and catchment areas of the site will be captured and stored. In addition, all grey & black water produced will be treated on site and reused for flush and irrigation services - a highly efficient and complete on site water solution.

high performance**double glazing**

with a strong focus on surpassing new energy efficient standards in building design, House Rhino will incorporate low thermal emission double glazing on all main openings, as well as high performance insulation and LED lighting throughout to ensure compliance with SANS 10400x6.

liveable courtyard spaces

special attention and consideration was given to the creation of flexible outside areas, catering for a range of climatic conditions to ensure that the occupants are protected from prevailing winds and driving rain. This will allow a variety of external spaces to be utilised throughout the year.

expansive photovoltaic array

consisting of more than 200m² of solar PV panels carefully integrated into the design of the north facing roof, the building is capable of generating enough energy to fulfil the requirements of the entire house with a progressive goal of operating autonomously from the municipal service grid. This 100% off-grid approach will enable the house to be occupied on a permanent basis before the remaining development services are in place.

local materials

dry packed stone and recycled alien timber such as bluegum are used throughout the building offsetting the building's carbon footprint by reducing the need to import certain materials to site.

innovative under-floor heating

utilising 10,000 litres of solar heated water circulated through the dense concrete floor slabs, the system will assist in regulating the thermal mass of the building.

CAPACITY AND CONSERVATION

The water system can handle up to eight permanent residents. "It can also accommodate up to 70 people at short intervals," explains Bam. This is particularly important as House Rhino will serve as a green building training centre.

Based on an average consumption of 150 litres per person per day, Bam says the water systems in place contribute to water savings of approximately 400 000 litres per year for eight residents.

Regarding supply security, Van Niekerk says they "technically cannot run out of water with the primary and secondary water harvesting, recycling and treatment processes in place".

The green building solutions featured in House Rhino are extensive and the combination is unique to this build.

SUSTAINABILITY FEATURES

- Fully reliant on sustainable solutions for energy and water provision
- Passive and active architectural design features
- Sloped roofs with 74 PV panels
- Energy generated in excess feeds back to the Crossways Farm Village grid
- Constructed mainly out of Aruba
- Smart Building Management System, which integrates, regulates and controls water and energy consumption, and can be remotely controlled
- Rainwater harvesting via roof and ground surface drainage system using porous concrete
- Aqua gardens naturally treating water on ecological basis
- Black and grey water harvesting and treatment for non-potable use around the home
- Biogas digester for the treatment of sewage, and organic kitchen and garden waste
- Biogas digester produces natural gas for cooking and water effluent for irrigation
- Every drop of water is treated, recycled and reused
- Water-based under-floor heating system
- Passive cooling via thermal tower
- Roofing insulation
- Double glazed windows

ENERGY

House Rhino is powered by 74 photovoltaic (PV) panels mounted on the building roof, each with a generating capacity of 230W.

The roof has been designed to accommodate a mini solar plant. "The northern orientation allows for maximum solar exposure," says Steff Mulder. "The slope of the roof is approximately 20 degrees. We've remained conscious of aesthetic impact while allowing the best possible opportunity for solar energy generation," he adds.

The PV system has been designed to support a daily energy consumption of 50kW and is supported by zero-maintenance batteries. "The total storage is able to run the house for one and a half to two days," explains Van Niekerk. Monitored by a building management system (BMS), non-essential

- 01. The mini solar plant is powered by 74 PV panels that each generate 230W.
- 02. The roof has been designed to incorporate solar panels.
- 03. 75% of the house was constructed with interlocking Aruba blocks, an insulated concrete form system.
- 04. The PV system is supported by zero-maintenance batteries, with a total storage to run the house for up to two days.

appliances are switched off during low energy days, which facilitates conservative energy use. The system is further specialised by separating the Grundfos pool pump from the main PV system, running it on its own 1000W PV system.

Taking into account seasonal variations, the PV system has generated in excess of 100kW, with winter generation averaging at 45kW. "The system has not run for a full year yet; data will be recorded over the next few months for more accurate energy generation determinations," says Van Niekerk. Should energy generation exceed demand, excess will feed into the development's electrical grid.

Howard Harris of Structatherm Projects undertook independent energy modelling for House Rhino. "The modelling demonstrates that despite having a 70% fenestration to floor area ratio, the building demonstrates low energy usage," says Harris. In this sense, House Rhino is setting an example. "It shows how much can be achieved across disciplines and technology use."

BUILT WITH ARUBA

About 75% of House Rhino was constructed of interlocking Aruba blocks, an insulated concrete form (ICF) system. This green building technology is widely used in the United States and Europe, but is still fairly unknown in South Africa, explains green building consultant Ian van der Westhuizen.

According to the project's structural engineer, Dave Visser of Nieuwoudt & Co, this polystyrene form filled with concrete is successful because the cavity in the block is internally reinforced, both horizontally and vertically. To meet structural standards, "engineers can choose how to reinforce the wall with the cavity filling", says Visser.

With House Rhino paying close attention to zero energy construction, Aruba added the advantage of

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“ With the primary and secondary water harvesting, recycling and treatment processes in place, House Rhino technically cannot run out of water.

– BRIAN VAN NIEKERK, HOUSE RHINO OWNER AND MD OF RHINO GROUP OF COMPANIES



insulation. “The facade is largely glazed,” says Van der Westhuizen. “We needed to increase the insulation values of the walls dramatically to curb potential heat loss.”

They chose Aruba blocks made of Neopor, which “specifically gave us a thermal resistance (R-value) of approximately 2.9, compared to the 0.9 of a conventional brick wall”, says Van Niekerk. “With an Aruba wall, the insulation factor is thus roughly three times that of a conventional wall.”

ICF is still a new technology, particularly in the Eastern Cape. “This proved to be the greatest hurdle,” says Van der Westhuizen. Main contractor John Baines of Shield Homes says it’s the first time they’ve worked with Aruba, “and it has been a learning curve for the entire team”.

Initial training by an Aruba representative familiarised the team with the blocks. “Once the team understood how the product worked, it turned out to be fairly basic to use,” says Baines. However, as with any new product, the industry is not yet convinced and there will be obstacles to overcome.

In an attempt to be energy efficient, House Rhino allows for ample natural light and ventilation.

Steff Mulder believes “Aruba is not very forgiving in the South African construction context – it necessitates a high precision level”.

INTEGRATED INSULATION

Aruba’s insulation properties were replicated in other areas of the house. “The ICF concept of integrated insulation was repeated in the flat concrete roofs,” says Van der Westhuizen, as it offers two key benefits: “It remains as permanent insulation integrated into the concrete, and in the case of the concrete roof there is no need for additional insulation as required by conventional systems.”

EFFECTIVE HEATING AND COOLING

Although underfloor heating is common, House Rhino makes use of a less common application. The water-based under-floor heating is primarily driven by solar energy and internal fire combustion. As backup, dual heat pump technology is available “for when the other two energy sources cannot deliver”, says Van Niekerk.

In keeping with House Rhino’s holistic approach to sustainability, the final indoor flooring is polished concrete. “That way, we’ve got a very good transfer

GREEN BUILDING TRAINING

House Rhino serves as an important example for the professional industry. The project team has run a course on the house for architects, giving them an opportunity to experience the sustainability solutions and green technology first hand. In collaboration with Howard Harris, author of the Handbook for the Application of the Amendments to the National Building Regulations for Energy Usage: SANS10400XA / SANS204, another course is being planned, which will focus on the design essentials and practicalities of a number of energy interventions applied in the house. Collaborations with local universities on green technologies and design are also being planned.

