The efficacy of Bio-Climatic design and Green Building materials in subsidised housing in South Africa:

A case study to rate substantial improvement the quality of life

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In order to rate the overall '*quality*' of a building and thus establish the present and future commercial value of a given real estate there are two fundamental subjective judgement criteria that can be objectified through undisputable numerical economical, engineering architectural computations

The first being an purely esthetic judgement of a given architectural design in the context of the natural surroundings or urban neighborhood metered through it's compliancy with well-established protocols of Bio-Climatic Design and Architecture and principals of Eco-Friendly Urban Planning and measured in practice in terms of greenhouse gas emissions reduction.

The second being the quality of dwelling within the building in terms of comfort, air quality and wellness of living that can be metered in terms of thermal efficiency (reference SANS 204: 2011 Energy Efficiency in Buildings) and measured in terms of savings of electricity and effective cost savings on the electricity bill.

The scope of the following study is to provide numerical evidence to express the 'qualities' of the EnviroCrete Bio-Climatic Building System and the EnviroCrete Green Construction Material.in comparison to conventional building technologies house design and urban plans that have been and still common place in South Africa

Bio-Climatic Design

In order provide a possible meter to rate an architectural design of a house or a layout of a residential neighborhood Envirocrete proposes to confront it with some key principals of Bio-Climatic Design that have a direct esthetical and environmental impact, namely

- **Surface area to volume ratio**: In buildings designed to actively impact on the environment it is important to minimise heat gains and losses through the building envelope. One way of reducing this is to minimise the surface area of the building relative to its volume. Simple compact buildings achieve the best ratio.
- **Direct Solar Gain:** Sunlight is a free heat source that can be used to reduce the requirement for heating in buildings on cold days. The simplest way of harnessing this resource is to allow sunlight to enter buildings. Proper location and orientation of the building are essential to ensure good solar access at the right times of the year. Shape and dimension of openings, glazing and shadings should be designed to direct solar access to the right area and retain heat gathered or block excess heat when required. Material color and type of finishes should be selected to provide good thermal storage.
- **Indirect Solar Gain:** More complex, but more controllable passive solar heating systems are indirect solar gain systems. These use the sun to warm high thermal mass materials such as rock or water. This heat is then stored and circulated to the building using air or water as a medium. It is advisable that the collection area of these systems be well integrated in the building and have good solar access
- **Cross ventilation** is an energy efficient way of cooling buildings in areas where there are moderate breezes. Airflow through the building is used to remove heat and bring in fresh air. When developing landscapes and buildings with cross ventilation special care should be taken to expose façades with opening windows to breezes and to avoid these being in the 'wind shadow' of other buildings and obstructions. Also the depth of the building should be no more than 12-15m. When designing the Internal spatial layout, air movement should be directed around people and the 'breeze path' between windows on opposite walls be made as direct as possible to ensure that air movement is effective

The Green Building guidelines outlined above have been implemented at the **Envirocrete Bioclimatic sample house erected in Centurion Raslouw Guateng -** designed by Prof Sergio Los Faculty of Architecture of Venice - For Better Living Challenge Context Cape Town WDC 2014 - SA Agrèment Approved 2018 in accordance with a low-income budget requirements

Building Envelope Insulation and Thermal Efficiency

In order provide a possible meter to judge the Thermal Efficiency design of a house or a proposed layout of a residential neighborhood Envirocrete proposes to confront it with the guidelines of SANS 204: 2011 Energy Efficiency in Buildings and the recommendations of the GBCSA Green Building Council South Africa namely taking into consideration:

- Local weather, ecosystems, and hydrography of the environment to maximize performance and lessen overall impact
- Leverage wind and sunlight patterns
- Utilization of locally sourced building materials and low-impact construction techniques
- Reduction of energy consumption for heating, cooling, lighting, and equipment
- Minimize overall energy balance throughout construction and during use

The thermal efficiency of a building is primarily affected by meteorological factors surrounding the building. The indoor temperature distribution is strongly affected by the outdoor weather conditions. It is estimated that without adequate ceiling insulation, 42% percent of household heat is lost through the roof. Walls account for around 24% percent of heat loss and 10 percent of heat is lost through floors. Therefore good thermal insulated walls and roof can minimize the influence of the outdoor weather condition on the indoor temperature distribution of the building according also to detailed guidance provided by SANS 204:2011 . Envirocrete has conducted a study on it's showcase bio-climatic house in Centurion to evaluated the effect of the walls and roof on the heat flow dynamics The overall building thermal efficiency findings are summarized in the following comparison table that refers to low income household end use energy intensities (GJ/annum)

Default subsidy house built in accordance with a low-income house plan as approved by the National Home Builders Registration Council (NHBRC). This is a 40 square meter housing unit comprising two bedrooms, a living area including a kitchenette, and a bathroom having a shower, a basin and a watercloset (wc). The house is to be constructed of 140 mm-wide hollow concrete blocks on conventional concrete foundations, a conventional 75 mm concrete floor slab on a damp proof course on compacted fill, steel window frames, steel door frames with timber doors internally and externally, and a roof assembly consisting of timber beams with a cranked steel roof sheet.

Data suppield by CSIR: Reference: BE13-PA-F The efficacy of innovative technologies in subsidised housing in South Africa: A case study Reference: BE13 PA-F Llewellyn van Wyk

House	Area	Wereabouts	Heating load (GJ/annum)	Cooling load (GJ/annum)	Total Laod (GJ/annum)	Total kWh/annum	Energy Savings
Typical subsidery RDP house (detached)	40 sqm	Western Cape -common	12,29	7,5	19,79	5497	
EnviroCrete Bioclimatic House (detached)	48 sqm	Centrurion JHB	8,33	0	8,33	2314	**57,9%**
EnviroCrete Bioclimatic Row Houses (attached)	48 sqm	*just simulation*	7,67	0	7,67	2131	**61,2%**

Bioclimatic house - designed by Prof Sergio Los Factulty of Arcitecture of Venice - For Better Living Challenge Context Cape Town WDC 2014 - SA Agrèment Approved 2018 in accordance with a low-income budget requirments. This is a 48 square meter housing unit orientated due south comprising two bedrooms, a living area including a kitchenette, and a bathroom having a shower, a basin and a watercloset (wc). The house is constructed with modular Envirocrete precast pannels 1200 x180 mm- on a conventional al 75 mm concrete floor slab on a damp proof course on compacted fill, steel window frames, steel door frames with timber doors internally and externally, and a composite Envirocerete slab roof assembly consisting corrugate sheetmetal/EV slab 650 x 140 mm with corrugated sheetmetal external covering

Any building in line with the above mentioned criteria and that attains the level of thermal efficiency declared is subject to be judged positively and be certified LEED (Leadership in Energy and Enviromental Design) or equivalent, and thus have a higher commercial value on the real estate market

LEED/green certified buildings are intended to use resources more efficiently when compared to conventional buildings simply built to code however when a LEED rating is pursued, the cost of initial design and construction rises. Pursuing LEED certification for a project is an added cost in itself as well.

This added cost comes in the form of USGBC correspondence, LEED design-aide consultants, and the hiring of the required Commission Authority (CxA)—all of which would not necessarily be included in an environmentally responsible project

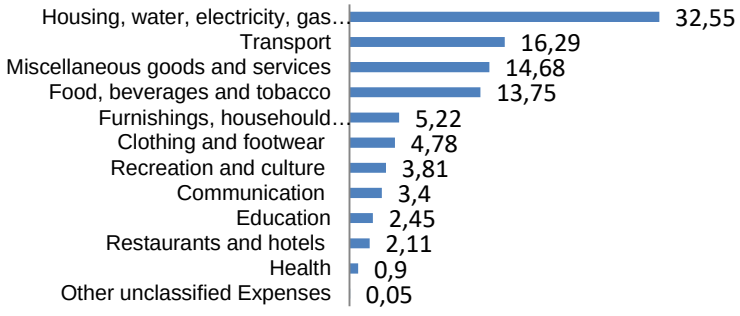
For this reason EnviroCrete has not seeked the LEED Certification as yet and can prove that simply attaining to local standards building code and conventional construction practices (no need for specially skilled workers) the construction costs are comparable and in most instances lesser than conventional costs and can be very effectively mitigated by the savings incurred over time due to the much lower-than-industry-standard operational costs typical of EnviroCrete buildings

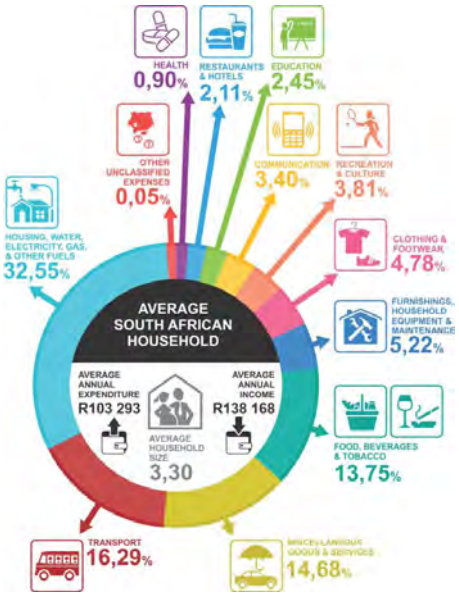
Life Cycle Costing

As part of more comprehensive study of Life Cycle Costing for assessing the total cost of ownership, taking into account all costs of acquiring, owning and operating, and the eventual disposal of a building, we here choose to exemplify the concrete and tangible savings on the electricity bill the following study was based on data acquired by Statistics South Africa's Living Conditions Survey (LCS) that provides a breakdown on how the average South African household spends its money over the course of a year.

The LCS found that in 2015, the average South African household consisted of 3 to 4 persons, with an average annual income and consumption expenditure of R138,168 and R103,293, respectively.
When looking at the total consumption expenditure of South African households, 32,55% of money spent went to housing and utilities. This was the biggest expenditure category, followed by transport at 16,29%, miscellaneous goods and services at 14,68%, and food, beverages and tobacco at 13,75%.

However additional economic payback that most certainly comes in the form of household productivity gains incurred as a result of dwelling in a healthier environment, low carbon impact over the life cycle of the building, and eco sustainable life style can only be theorized at this stage for EnviroCrete.





However a preliminary study suggests that an up front cost increase of the house (investment) of 3-5% (principally tied to the adoption of Envirocrete ecological precast wall panels system instead of conventional brick and mortar walls) yields over 20-30 times initial investment over the life cycle of the building.

More over when running the production of Envirocrete construction system at economy of scale it is likely that there shall be no cost increase but a relevant cost decrease per unit or put in other words there will be a paradigmatic change of scale of values owed to wide spread adoption of sustainable green alternative building technologies and innovations.

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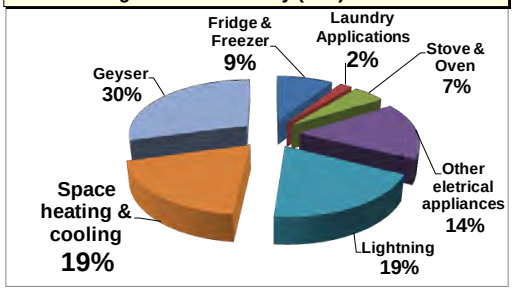
Data supplied by Eskom tarif 2018 The Inclining Block Tariff applicable to Block 1(>0-600 kWh) for Homepower has an energy charge of 135,30c/kWh (including VAT).

Description of expenditures per annum	ZAR/annum	%	GJ/annum	kWh /annum	c/kWh	ZAR/annum	% diff.
Average expenditure per year family 3,3 persones	ZAR 103.293,00						
Household operation running ALL electrical appliances	ZAR 33.621,87	32,6%		28933	ZAR 1,35	ZAR 39.146,32	
Space Heating & Cooling in 40 sqm conventional house	ZAR 6.388,16	19%	19,79	5497	ZAR 1,35	ZAR 7.421,31	19%
Savings introduced Envirocrete insulation /bioclimatic design house	ZAR 2.555,26	60%	8,33	2314	ZAR 1,35	ZAR 3.123,77	-58%

Data measured at EnviroCrete sample house (detached) 48 sqm in Raslouw Centurium JHB

Electrical Consumption breakdown according to South Africa's Living Conditions Survey (LCS)



Assumption taken from LCS study
Average consumption is
500kWh/month in summer
800 kWh/month in winter

By analysis of the significant cost savings per normal operation of the household on the basis of a coherent and realistic set of economical, statistical and physical parameters, given here as example for typical low income household, it becomes possible to elaborate some promising economic conjectures to support the perceived and actual value of the new real estate developments and more importantly to elaborate predictions of future value and savings and improvement of life style conditions that impact on national economy.

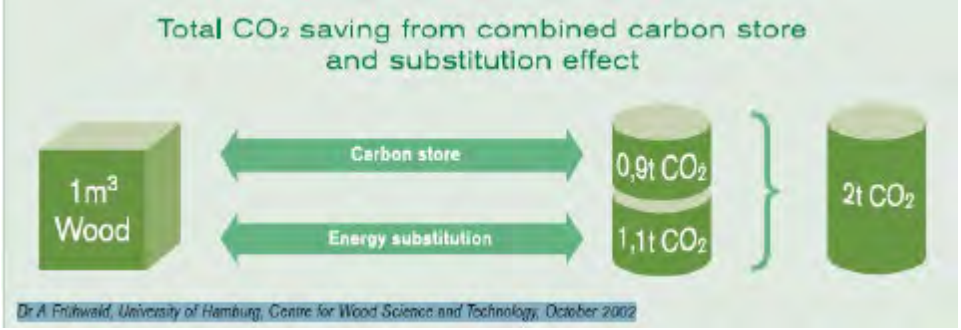
Conclusion

The study proves that the adoption EnviroCrete Alternative Building Technology actually delivers measurable performance improvements, exemplified by some simple metrics to prove substantial improvement of quality of life and economic conditions as well as contribute to green economy national goals.
It is not difficult to translate the impact of individual savings per housing unit into significant savings on national scale and to convene on a viable roadmap for developing future human settlements

In the table below there is a summary of the massive savings and efficiencies related to the national housing backlog in South Africa estimated at 2.3M in 2017 and also related to the upcoming CommuniTgrow Westcape City Project However, for these to be realised will require an inter-governmental approach aimed at coordinating the necessary resources and institutional arrangements

In particular the EnviroCrete's holistic development frame work paradigm (houses made up treated woodchips, a renewable and sustainable resource) could enable new dedicated cooperation arrangements and promote practical economic synergies between the Ministry of Human Settlements and Energy and the Ministry of Ministry of Agriculture, Forestry and Fisheries and related private industrial sectors all to the good of sustainable future developments.
Wishful thinking?
Hopefully not

National Resources Reductions						
ENVIROCRETE Bioclimatic-technology	**Per single house**			**National housing backlog (2017)**	**CommuniTgrow WestCape City Project (2019)**	
		Total houses		**2.300.000**	**200.000**	
Energy reduction heating/cooling	11,12	GJ		25576000	2224000	GJ
CO2 reduction from materials	0,685	ton		1575500	137000	ton
Material mass reduction	18,8	ton		43240000	3760000	ton
Waters from Materials	19,73	m^3		45379000	3946000	m^3
Water , through rain-water harvesting	22	m^3		50600000	4400000	m^3
Electricity savings	3183	kWh/annum		7,3209	0,6366	billion kWh/annum
CO_2 reduction by storage (sequestration)	5,4	ton/kWh/annum		12,42	1,08	million ton/annum
CO_2 reduction (material subsitution)	6,6	ton/kWh/annum		15,18	1,32	million ton/annum



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BIOCLIMATIC-BUILDING