Review of Building Plans for Low Cost Housing to Incorporate Renewable Energy and Energy Efficiency Technologies and Principles

1. Executive Summary

The aim of this study was to review low cost housing building plans from National Housing Enterprises (NHE), the Shack Dwellers Federation of Namibia/Namibia Housing Action Group (NHAG), and Decentralised Build Together Programme; with specific attention paid to the possibilities of improving Energy Efficiency (EE) and incorporation of Renewable Energy (RE) into designs and construction.

1.1. Building technologies & techniques investigated

The following are various options and recommendations, with advantages and disadvantages, considered to be viable solutions for implementation in energy efficient low cost housing, in terms of cost, practicality and usability for the inhabitants. For detailed costing please refer to Appendix B. For analyses on the performance of the modified buildings, refer to Appendix A.

Table 1-1 – Changes that can be implemented with little or no cost difference

Proposed Changes	Advantages	Disadvantages
– Reorientation of building to reduce east-west exposure	Increased comfort for occupants (reduced temperatures)	Orientation towards passing roads can become awkward; city and town planning do not often make reorientation possible
– Optimise north-facing window placement	Increased comfort for occupants (increased winter temperatures)	Decreased light levels in some rooms during certain times of the day
– Adding external shading using trees	Increased comfort (reduced summer temperatures); aesthetic appeal (green environment); environmentally friendly	Trees might be neglected (watering of trees might be a problem cost wise); theft or vandalism of trees; buying and planting matured trees could be expensive for some clients
– Change the standard type of light fittings to PL type CFLs	Low energy consumption; users cannot replace the lamp with a low-cost, low-efficiency type	High cost of lamps (replacements)

Table 1-2 – Changes that can be implemented with noticeable cost difference

Proposed Changes	Advantages	Disadvantages
– Change construction materials, for walls (Saving)	May offer significant cost savings; increased comfort through better isolation and higher thermal mass; may allow for owners to participate in building (due to lower skill requirements); may decrease building time; will lower embodied energy	Will affect construction plans (alternative material walls are generally wider than single brick walls – some plans have been modified already as part of this report, see Appendix C); require different skills than for conventional buildings
– Changing the type of roof covering on the buildings to a concrete-type tile (Possible Saving)	Possibly reduce costs (labour costs may vary, but material costs for CMR are cheaper); increased comfort (reduced summer temperatures and increased winter temperatures); lower embodied energy	Industry resistance to “new” technologies; needs to be accommodated in planning (increased roof pitch and different roof structure)
– Irrespective of the above, painting the roof covering,	Increased comfort (reduced summer temperatures)	Additional costs

using at least a white PVA paint (Additional cost)		
– Reduce window sizes (Saving)	Reduce costs; increased comfort (reduced summer temperatures and increased winter temperatures); lower embodied energy	Decreased light levels; decreased ventilation; socio-political issues such as occupants feeling they've been taken advantage of for cost savings
– Increase roof overhangs to keep larger parts of the house walls shaded, for longer periods of time (Additional cost)	Increased comfort (reduced summer temperatures)	Additional costs
– Alternative toilet technologies (Additional cost on building, but large savings on municipal infrastructure)	Composting toilets, gas generating toilets or dry toilets could provide cost savings in terms of infrastructure and in operational costs for the occupants, while lowering energy use in the form of embodied energy in the supply of fresh water and could even be used in providing energy	Requires a different type municipal waste collection system than current flush toilets; needs to be accommodated in planning
– Solar water heating (Additional cost, excellent mid / long term savings)	Availability of hot water off-grid and at a low cost on-grid; low performance makeshift systems can be very cheap	High cost for proper indirect systems (high performance); high maintenance requirement for homemade or cheap systems; needs to be accommodated with planning

Table 1-3 – Alternative items to be considered (not part of this review)

Proposed alternatives	Advantages	Disadvantages
– Alternative cooking technologies	Efficient charcoal or woodstoves, gasifiers, methane burners or even normal LP gas stoves provide well documented savings; solar cookers	Placement of stoves (causing dirty deposits and odours; or needing to be outside); maintenance; not as dependable as conventional electric stoves and some technologies require long cooking times; not considered part of current planning

Table 1-4 – Viable Renewable Energy technologies

Renewable energy solutions	Advantages	Disadvantages
– Solar energy (photo voltaic panels)	System can be of very small size and power lights and mobile phone chargers	Care and effort required in maintaining systems; high additional costs; theft

1.2. Results, conclusions and recommendations

Results and Conclusions

The standard designs employed by the three institutions have some scope for improvement regarding energy efficiency. It was identified that some building materials, such as clay or compressed earth could significantly reduce the cost of construction, increase "embodied energy efficiency", while providing more jobs and a better living environment inside the buildings.

It was clearly identified that the income structure of those individuals most likely to occupy these houses would not allow them to operate on a level of energy use that would rationalise large capital investments to improve energy efficiency (EE, in the conventional sense of the consumer using less energy / electricity), for the case where expensive energy efficiency measures are considered.

A compounding factor is the inability to incorporate cost saving features (for the occupants / consumers) through reduced energy consumption. If the inhabitants are most likely not going to use electricity for heating, cooking and cooling, then little or no cost savings will be incurred by efficient design. It is difficult to justify any cost-increasing changes if cost or energy savings is the sole measure of success. It would be easier if human comfort were the primary motivating factor.

Also, most of the renewable energy technologies (RETs) related to the buildings themselves would be disproportionately expensive related to the building values, or the occupants' capacity to utilise the energy. Technologies considered were small wind turbines, photo voltaic solar systems or biomass utilisation. A possible exception would be a small solar or micro wind system used to power a few energy efficient lights and charge a mobile phone or some small appliance(s). Biomass utilisation would most effectively be implemented through cooking or heating technologies.

Designing for energy efficiency in this study was assumed to reduce to designing for a desert climate, with predominantly warm conditions. The main focus was on keeping the heat out of the building as much as possible; secondly to keep heat inside (low nocturnal and winter temperatures). Clay bricks (hand made, sun dried, clay bricks) is extensively referred to in this report, for its excellent properties as well as good cost savings implied in their use, but compressed, stabilised, earth blocks (CEBs) seem to be the best choice in terms of thermal and mechanical performance, though their manufacturing costs are significantly higher than that of adobe (though still lower than conventional techniques).

Recommendations

It is recommended that the use of **clay as a building material** be promoted and implemented as soon as possible, based on the Namibian Code of Practice for Clay Based Structures (which may have to be modified to formalise it as a technical document & guidline).

Following are the designs evaluated, with recommended changes and cost implications:

		Additional Cost	% Saving of Total
	HOUSE: NHAG One Room Unit - 21.7 m2	**-3 845.25**	**7.60%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-5 225.46	10.33%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-1 064.27	2.10%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-3272.13	6.47%
	Replace light conventional fittings with PL type CFL fittings	200.00	-0.40%
	Extended roof overhang on all sides. Extend from 0.15m to 0.5m on all sides. Requires redesigned and expanded support structure.	850.08	-1.68%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	597.60	-1.18%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	796.80	-1.58%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	4322.26	-8.54%

		Additional Cost	% Saving of Total
	HOUSE: NHAG Two Room Unit - 34.8 m2	**-5 070.42**	**6.96%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-6 807.48	9.35%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-1 946.36	2.67%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-4554.04	6.25%
	Replace light conventional fittings with PL type CFL fittings	250.00	-0.34%
	Extended roof overhang on all sides. Extend from 0.15m to 0.5m on all sides. Requires redesigned and expanded support structure.	1 098.92	-1.51%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	1 083.30	-1.49%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	1 251.20	-1.72%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	5925.57	-11.71%

		Additional Cost	% Saving of Total
	HOUSE: MRLGHRD TYPE 1 - 18.1 m2	**-3 960.86**	**8.91%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-5 043.29	11.34%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-1 236.85	2.78%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-3267.14	7.35%
	Replace light conventional fittings with PL type CFL fittings	200.00	-0.45%
	Extended roof overhang on all sides. Extend from 0.15m to 0.5m on all sides. Requires redesigned and expanded support structure.	887.08	-1.99%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	621.00	-1.40%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	611.20	-1.37%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	2996.19	-5.92%

		Additional Cost	% Saving of Total
	HOUSE: MRLGHRD TYPE 2 - 34.0 m2	**-2 723.83**	**3.81%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-5 146.43	7.20%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-1 408.43	1.97%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-2 037.65	2.85%
	Replace light conventional fittings with PL type CFL fittings	250.00	-0.35%
	Extended roof overhang on all sides. Extend from 0.15m to 0.5m on all sides. Requires redesigned and expanded support structure.	1 297.52	-1.82%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	1 115.50	-1.56%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	1 168.00	-1.63%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	3275.05	-6.47%

		Additional Cost	% Saving of Total
	HOUSE: MRLGHRD TYPE 3 - 33.6 m2	**-4976.05**	**7.03%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-5 413.43	7.65%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-1 121.40	1.58%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-2 031.43	2.87%
	Replace light conventional fittings with PL type CFL fittings	300.00	-0.42%
	Extended roof overhang on all sides. Extend from 0.15m to 0.5m on N, W & E, and to 0.3m on S. Requires expanded support structure.	1 125.40	-1.59%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	1 067.20	-1.51%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	1 097.60	-1.55%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	3247.81	-6.42%

		Additional Cost	% Saving of Total
	HOUSE: MRLGHRD TYPE 4 - 44.5 m2	**-14027.91**	**15.71%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-8 744.26	9.79%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-3 557.15	3.98%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-6 399.60	7.17%
	Replace light conventional fittings with PL type CFL fittings	300.00	-0.34%
	Extended roof overhang on all sides from 0.15m to 0.5m. Requires redesigned and expanded support structure.	1 655.00	-1.85%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	1 386.90	-1.55%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	1 331.20	-1.49%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	2893.49	-5.72%

		Additional Cost	% Saving of Total
	HOUSE: NHE CORE A2 - 24.3 m2	**-5570.89**	**10.13%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-4 639.13	8.43%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-1 308.30	2.38%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-1 848.83	3.36%
	Replace light conventional fittings with PL type CFL fittings	200.00	-0.36%
	Extended roof overhang on all sides. Extend from 0.15m to 0.5m on N, W & E, and to 0.3m on S. Requires expanded support structure.	979.76	-1.78%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	828.00	-1.51%
	Insulation Option 2.1: Install bubble foil instead of sisalation, to be attached to bottom of rafters above rhino board ceiling. Install two air vents between roof and ceiling	217.60	-0.40%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	2524.32	-4.99%

		Additional Cost	% Saving of Total
	HOUSE: NHE CORE 5 - 35.8 m2	**-13432.90**	**18.03%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-6 941.71	9.32%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-4 573.48	6.14%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-5 990.59	8.04%
	Replace light conventional fittings with PL type CFL fittings	300.00	-0.40%
	Extended roof overhang on all sides from 0.15m to 0.5m. Requires redesigned and expanded support structure.	1 350.48	-1.81%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	1 177.60	-1.58%
	Insulation Option 2.2: Install bubble foil, to be attached to bottom of purlins and supported by wires, and install two air vents between roof and insulation	1 244.80	-1.67%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	1729.47	-3.42%

		Additional Cost	% Saving of Total
	HOUSE: NHE NAUTE - 64.6 m2	**-17526.57**	**14.20%**
Recommended alternative techniques	Revise plans for optimal N-S orientation and window placement	0.00	0.00%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): exterior walls	-10 671.44	8.65%
	Replace concrete bricks with sun-baked clay bricks (adobe, manufactured): interior walls	-4 065.31	3.29%
	Use Compressed Earth Bricks instead of clay (interior and exterior, 4MPa, not included in total above)	-7 666.56	6.21%
	Replace light conventional fittings with PL type CFL fittings	400.00	-0.32%
	Extended roof overhang on all sides from 0.15m to 0.5m. Requires expanded support structure.	1 866.84	-1.51%
	Wash new roof with metal conditioner, and paint roof with two coats of white heat reflective roof paint (ProMac ProRoof paint used for costing)	2 090.70	-1.69%
	Insulation Option 2.1: Install bubble foil instead of sisalation, to be attached to bottom of rafters above rhino board ceiling. Install two air vents between roof and ceiling	519.20	-0.42%
	OR replace galvanised metal-type roof with Micro Concrete Roof (MCR) tiles, including new structure and needed changes to building (not included in total above)	3193.98	-6.31%

The building costs above are based on 2006/7 average building and labour costs.

A very important consideration to keep in mind is that the above figures are **highly conservative**, since it is claimed by the Clay House Project that standard house designs (such as those forming part of this report) can be built at 50% of the normal, conventional building cost (using concrete bricks) by using clay in conjunction with micro concrete roof tiles.

Unfortunately, our [conservative] calculations show additional costs for **MCR tiles**. We do encourage the various organisations to explore this technology for themselves – if the organisations would be able to reduce the labour-cost component of these tiles, then these would be able to offer a cost saving, since it is a lower material-cost solution. It must be noted that MCR tiles require greater slopes than CIR sheeting, which in turn affects normal building costs. It is also recommended that alternative roofing materials in general be thoroughly investigated for implementation. The fact that even a small saving is shown, using conservative figures, should be motivation enough to start implementation of the recommended alternative techniques.

Renewable energy options are deemed to be very expensive at this time and should be considered by each stakeholder, on merit.

1.3. Barriers to implementation

The most noteworthy barrier to the implementation of energy efficiency measures or renewable energy technologies is cost and therefore financing.

Following is the detail information regarding the barriers to implementation collected from the stakeholders.

National Housing Enterprises

- Low cost of electricity and therefore long pay-back periods
- Lack of acceptance from financial institutions
- Absence of relevant supporting standards and a standards body

- Lack of awareness and acceptance of new ideas amongst Namibian citizens (the end users). Also a lack of awareness, acceptance and skills from building contractors who are responsible for the building of the houses.
- Poor town planning and town planning that doesn't take account of optimal layout

National Housing Action Group

- Increased costs
- Absence of local manufacturing and therefore increased transport costs

Ministry of Regional and Local Government, Housing and Rural Development

- Lack of awareness and acceptance of new ideas and technologies amongst Namibian citizens (the end users).
- Limitations in terms of finance and acceptance from financial institutions