Shayamoya High Density Development

Solar Water Heater Feasibility Study

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ENERGY & DEVELOPMENT GROUP

CONSULTANTS IN THE FIELD OF ENERGY AND DEVELOPMENT

EXECUTIVE SUMMARY

1. INTRODUCTION

This document outlines the case and potential for solar water heating to be implemented in the high density Shayamoya low cost rental housing project in Cato Manor.

1.1 Solar Water Heating

1.1.1 South Africa is endowed with favourable sunshine conditions, which could be used to provide energy services for space and water heating. However, very little use is made of renewable energy (RE) and energy efficiency (EE) technologies in urban developments.

1.1.2 Solar water heating (SWH) is one of the more cost effective RE technologies. It is a mature technology, offering real returns to its users. SWH offers a level of service compatible with electric water heaters, in its safety and convenience. SWH offers great potential for GHG abatement (CO_2 reduction) through the displacement of fossil fuel generated electricity. It yields great benefits to the economy as a whole.

1.1.3 However, many market barriers exist to widespread use of SWH, ranging from: lack of awareness of benefits (architects and planners), technical barriers (economy of scale issues), financial barriers (finance and overcoming the capital cost hurdle) to name a few.

1.2 Shayamoya Housing Association and Hilltop High Density

1.2.1 Hilltop High Density (Shayamoya) is a Cato Manor Development Association (CMDA) pilot project to provide secure, good quality affordable rental accommodation to low-income groups in the Durban periphery. Shayamoya is part of a massive development drive in the Cato Manor area, setting precedents for future developments.

1.2.2 The project is funded by Provincial Housing Development Board institutional subsidies, and top-up funding from the Malaysian government.

Approach

1.2.3 Shayamoya aims to demonstrate social housing as a viable delivery mechanism. While using the existing grant funding optimally, the pilot project will lobby national and local governments for increased subsidies for further development of high density rental housing targeting low income groups.

1.2.4 The approach aims to find the optimal deployment of capital expenditure in order to reduce recurrent costs to tenants.

Management

1.2.5 The Built Environment Support Group (BESG) is designing and implementing the project on behalf of CMDA. BESG will provide management support to the Shayamoya Housing Association (SHA), which will run the rental project.

1.2.6 The SHA approach is to address the needs and achieve long term social benefit by providing good housing for low income groups. SHA will operate on a not-for profit basis, with resident community participation in controlling policy making and implementation.

1.2.7 Institutional management structure has been developed for financial and maintenance tasks, which will initially be undertaken by specialised agencies with a capacity building component in the contracts managed by BESG.

Design

1.2.8 A total of 320 high density units are being constructed on a greenfields site. Flats will range from 1-3 bedroom, in single to four storey blocks. The site design is well developed and construction using local builders has begun.

1.2.9 Town planning, urban planning and architectural design criteria have been explicitly stated, though not listed here.

1.2.10 SWH has not been considered in the design at this stage. However, 75 litres electric geysers (electric water heaters, EWH) have been included.

1.2.11 The innovative and cost-saving semi-pressure water supply system is used. In its current form of integration into the building design it does not allow feedwater to reach SWH collectors in the most logical and exposed position....on the roof.

Tenants

1.2.11 Tenants are drawn from existing Cato Manor residents in over-crowded formal houses, existing Cato Manor informal settlements, de-densifying informal settlements, and from the broader Durban Metro area. 45% of households are to intended be to be women-headed.

1.2.12 The household incomes range, 65% from R 600 -R1 500 per month, 35% from R 1 500 - R 2 500 per month, for a median of R 1 400 per month.

1.2.13 Monthly rentals are according to capital costs of units and their locations, and geared to the household incomes. Rentals range from R 270 for a $27m^2$ one bed unit ,to R 750 for a 3 bed $43m^2$ ground floor unit.

1.2.14 A minimum population of 2 persons per room (including lounge) will be expected. The total minimum population is expected to be 1664 persons. In general, only one income earner will dwell in each flat. It is anticipated that there will be a high presence in the development during the working day.

2. OBJECTIVES

2.1 This study assesses the viability of SWH within this large project, where substantial economies of scale can be achieved, and where project approach is compatible with SWH economics.

2.2 Primary outputs are to:

- assess the affordability, technical, financial and economic viability of inclusion of SWH in the Shayamoya High Density housing development project, and to formulate preferred technical options,
- determine the incremental costs incurred due to SWH not being included from the start of the design,
- explore financial options for covering capital costs and for ongoing running costs within the project structure.
- determine further inputs required.

3. ANALYSIS

The financial and economic costs of SWH are compared with the costs of an EWH project at Shayamoya

3.1 Affordability to the end-user

Tenants of Shayamoya cannot afford not to have energy efficiency integrated into their development.

3.1.1 Household incomes range from R 1 000-R 2 500 per month for 4 - 8 person households. Disposable incomes after rentals range from R 750 - R 1 550 pm for 4-8 person households.

3.1.2 Expenditure on energy for some households may increase as a result of a transition from cheaper, less convenient traditional fuels (paraffin burners for cooking) to electricity, and of having access to piped water in the household, and hot water on tap. Increases may be as high as 100% or about R 90 pm.

3.1.3 Projected expenditure on energy, with EWH and incandescent lights, will range from R 166-R 287 pm for 4-8 person households,

3.1.4 Disposable income after rentals and electricity will range from R 564 - R 1 463 pm, with a median of around R 1 200 for a six person household.

3.1.5 Valuable savings are possible through use of energy efficiency and renewable energy technologies, such as SWH and compact fluorescent lights (CFL).

3.2 Financial savings possible through SWH.

SWH yields energy savings ranging from R 16 -R 26pm if full capital cost recovery for the SWH is included, to R 66-R 96 pm if no capital cost recovery is included.

3.2.1 SWH design and costing is based on bulk supply and installation, using direct close-coupled systems on north-facing roofs in Durban. System sizes proposed are (a) 2m^2 collectors with 150 litre geysers and (b) 3.3m^2 collectors with 300 litre geysers for the 4 and 8 person households respectively, with electrical back-up to provide additional hot water during inclement weather conditions. SWH system life is assumed to be 15 years, compared with 8 years for EWH. (Building structures are assumed are fully SWH compatible.)

3.2.1 Installed costs range from R 6 000 to R 8 000 per system.

3.2.2 The project will finance the SWH capital cost through bulk purchasing, and as a worst case pass finance charges to the tenant over a ten year period. This will improve user cash-flow and yield returns from the start or R 16 - R 26 per month.

3.2.2 Users will be required to pay an annual maintenance levy of R 159 per annum for SWH (which for EWH would be R 115 pa), to a joint maintenance fund administered by the SHA.

3.2.2 Savings possible as a result of SWH implementation range from R 16 - R 26 pm if full capital cost recovery for the SWH is included. This is fully financially viable, yielding an effective rate of return of 13%, which is better than the 8% yield obtainable by putting money in the bank.

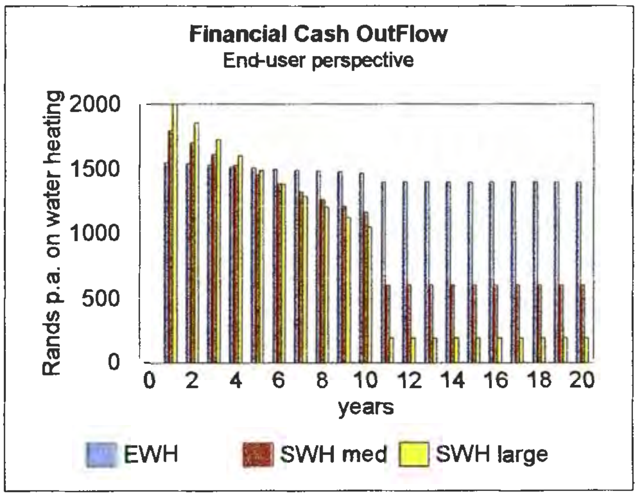


Figure i. Comparative cash flow expenditure on water heating for tenants of a 6 person flat, with 10 year capital repayment for SWH.

3.2.3 Savings to the tenant are increased if only a portion of capital cost recovery is passed on to the tenant. Savings can range from R 66-R1 00 pm, but will require co-funding for the SWH.

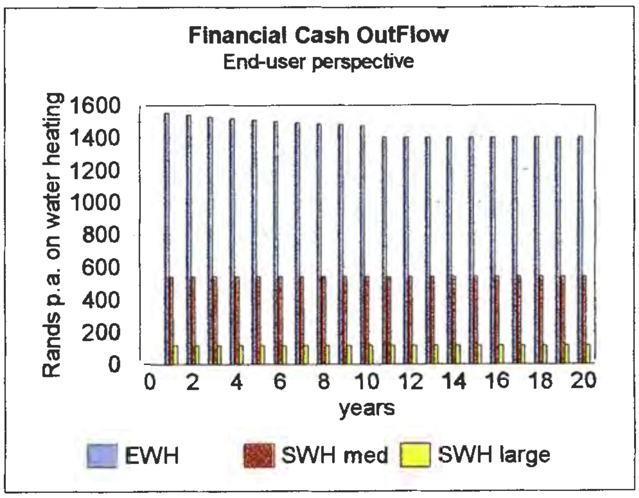


Figure ii. Comparative cashflow expenditure on water heating for tenants of a 6 person flat, with no capital recovery for SWH.

3.3 Economic viability

SWH are fully economically viable in Durban, yielding real economic rate of returns of 24%

3.3.1 SWH are economically viable under all conditions explored, and yield economic returns of R 3 531 - R 4 900 over the fifteen year life, or an IRR of 24%.

3.3.2 Economic benefits include, principally electricity savings, job creation through local construction, and GHG abatement.

3.3.3 SWH remain economically viable even if it is necessary to spend R 4 000 per system to make the building SWH compatible, although the effective returns to the economy are lowered.

3.4 Technical feasibility

In addition to the normal implementation costs for SWH, implementation at Shayamoya demands certain additional costs or building planning alterations in order to be technically feasible. This is as a result of SWH not being considered an option from the design stages.

3.4.1 Building design and orientation on site are not considered major constraints to SWH implementation at Shayamoya.

3.4.2 Water supply to Shayamoya is by innovative semi-pressure water system in each dwelling. Water pressure in each flat will be about 20kPa as cold water header tanks (CWS) are at ceiling level providing about 2m of head at taps.

3.4.3 The optimal SWH design is to locate collectors on exposed roofs to maximise solar radiation, to have close-coupled SWH with no circulating pumps, and to have natural feed to SWH rather than by feed pumps, to enable hot and cold balanced pressure at flat, and to prevent dependancy on electricity to provide water to SWH.

3.4.4 There is no possibility of supplying water to roof top SWH collectors for all flats without increasing the cold water pressure. Only a limited number if units (top floor Block Type E flats) are already SWH compatible.

Costs of options have been explored including:

- cold-water booster pumps,
- split SWH systems (physically separate geyser and collector, not close-coupled)
- relocating collectors to enable natural circulation (ie on side of building),
- relocation of CWS to the apex of roofs to increase pressure.

3.4.5 Re-introducing a full pressure water system is the simplest and cheapest approach. The cost per water connection of the semi-pressurised system is about R 405. The cost per connection for a full pressure domestic systems is R 1 484 including a 100kPa pressure regulator. The price difference is only R 1 089 to change the design if this is done prior to installation beginning. This cost differential forms the base-line against which other options can be measured.

3.4.6 It is uncertain whether the conversion to full pressure is feasible, and to what extent inclusion of the the semi-pressure system is an important criteria for this housing development.

3.4.7 Other options include a cold water booster pump, with running cost and maintenance implications. Capital costs are around R 1 000, and the hot and cold water will reach the user at different pressures. It is an unattractive option.

3.4.8 If retaining the standard semi-pressure system is a key criteria, then relocation of the CWS to a point in the apex of the roof where it can effectively feed the SWH is the best technical option. Costs of undertaking the redesign and construction have not been forthcoming, but major changes will be in the service duct and roof design.

3.4.9 It is unlikely that building modifications will be competitive with the full-pressure system costs, even when cost of changes to one 8 flat block are shared. However, it must be noted that the SWH remains economically viable even when incremental costs increase to R 4 000 per system.

4. TECHNICAL OPTIONS

The suggested technical options, on order of cost preference are:

4.1 Installation of SWH in only a limited number of flats which can already incorporate SWH without any additional costs (approx 120 out of 320 flats affected)

	Costs
Total capital cost on 120 SWH systems	120 * R 5 773 = **R 692 760**
Incremental building costs less geyser costs	R 0 **- R 228 956**
Net cost	**R 463 804**
Maintenance fund income	R 18 000 per annum
Saved electricity	120 * 2993kWh = 0.36 GWh/annum = 5.4 GWh over 15 years
CO_2 avoided	170 tons/annum = 2 560 tons over 15 years

4.2 To enable SWH at all flats, the following options are presented: (a) conversion to full pressure system, or (b) install booster pumps, or (c) relocate CWS tanks.

	a) Full-pressure system (SWH option 7.3.1)	**b) Cheapest option Booster pump (SWH option 7.3.2)**	**c) Highest cost allowed CWS relocation (SWH options 7.3.5 / 6)**
Total capital cost on 320 SWH systems	200 * R8 098 + 120 * R 5 773 = **R 2 312 360**		
Incremental building costs less geyser costs	R348 480 - R 228 956 **R 119 524**	R 320 000 - R 228 956 **R 91 044**	Maximum R 1 280 000 - R 228 956 **R 1 051 044**
Net cost	**R 2 431 884**	**R 2 403 404**	**R 3 363 404**
Maintenance fund income	R 50 880 per annum for 320 systems		
Saved electricity	120 * 2993kWh + 200 * 4480kWh = 1.25 Gwh/annum = 19.5 GWh over 15 years		
CO_2 avoided	597 tons/annum = 8 900 tons over 15 years		

(The detailed presentation of all the options explored and evaluated is in Section 7.3, together with sketches)

4.3 It can be reliably stated that the there are high costs involved by not including SWH in the design at an early stage. This investigation has highlighted these costs.

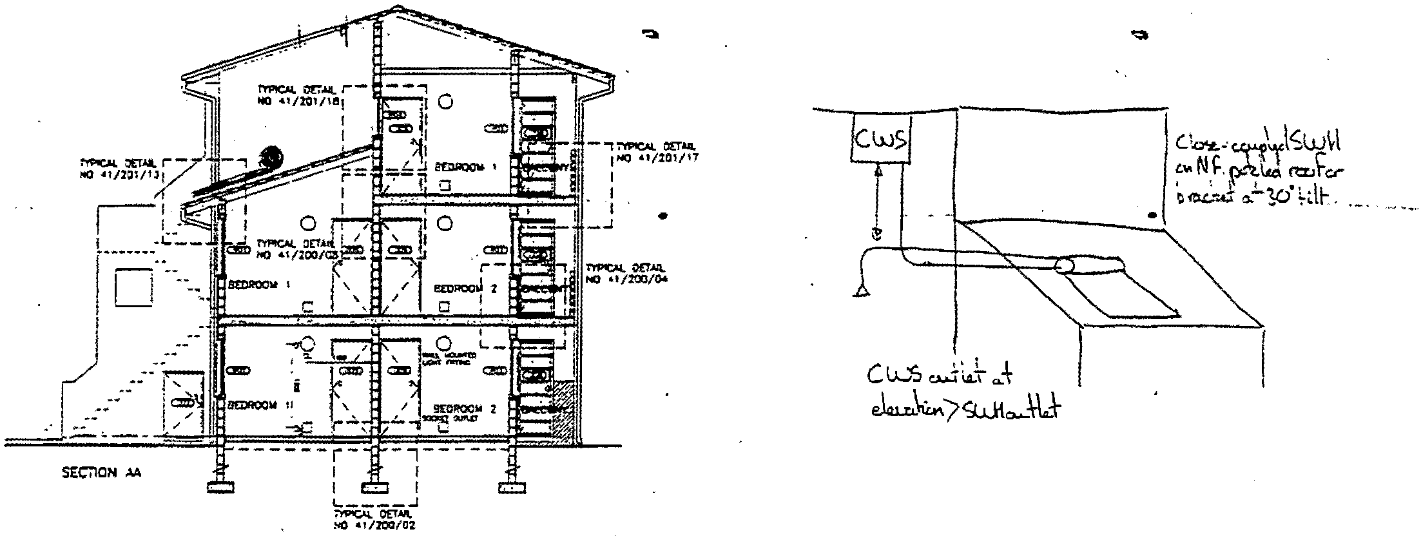


Figure iii) Section of building where SWH already viable, and SWH layout.

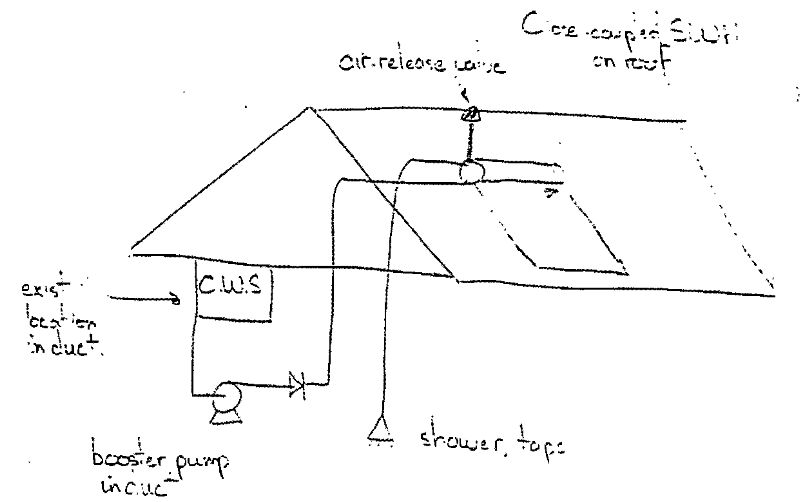


Figure iv) SWH layout for system with cold-water booster pump to close-coupled system on roof

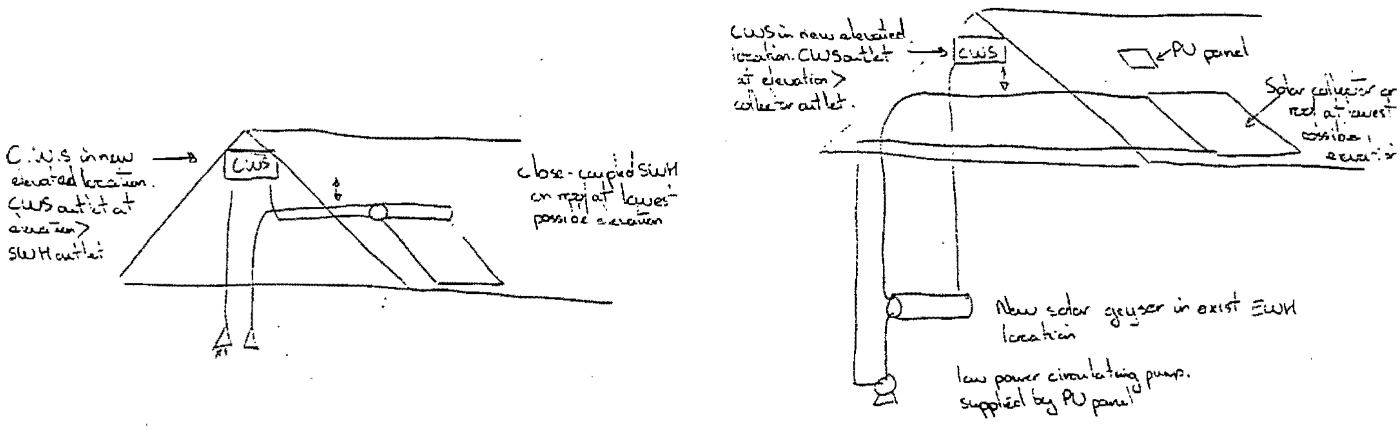


Figure v) SWH layout for CWS relocation: (a) Close-coupled and (b) split system

5. FUNDING AND FINANCING OPTIONS.

One aim of this particular project is to provide affordable and improved standards of living to tenants through provision of services. This may require some level of capital subsidy and joint financing.

Funding for the SWH project could be sought from the following sources:

5.1 Incremental building cost / compensation for omitting SWH from early design.
Where SWH are installed on dwellings where it is practical without any modification, there is not charge.
Where there is a net cost for omitting SWH from design, the cost should be for the project account (ie, use full pressure system, or for building modifications).

5.2 Incremental capital cost on SWH over EWH.
Tenants will be achieving some savings as a result of the SWH programme, and may be able to contribute some of the savings to capital cost repayment. Tenant to repay portion of capital cost at an affordable and non-contentious level, say R10 per month, reducing electricity savings to from R 66-R 100 down to R 56-R 90 pm. R 10 per month will cover approx 25% of capital cost. Substantial savings still passed on.

5.3 The tenant contribution could be reduced through low-interest loan finance.

5.4 Grant funders may find aspects of the project attractive:

- visible, high profile demonstration project in line with current projects (Danced)
- excellent collaboration and learning opportunity with scope for ongoing monitoring within existing structures
- replicable pilot project
- addresses some of the SWH market barriers at pilot scale level
- actual and viable GHG abatement project (GEF) R 259/ton of CO_2 avoided providing services.

5.5 Government or local government may be able to co-fund the project in terms of net economic benefits and provide a level of cross subsidization.

5.6 Operation & Maintenance of SWH
Maintenance and up-keep will be funded entirely by the tenants, and the SHA will co-ordinate and administer the maintenance of the bulk systems installed. Tenants pay an annual maintenance levy of R 159 - R 189 towards a maintenance fund. Management structures already exist for this administration.

6. CONCLUSIONS

6.1 Inclusion of a SWH project at Shayamoya High Density Rental Housing Development provides several opportunities

- **profile:** it is a development project of significant scale in an area where many large housing projects are occurring.
- **replicable pilot project**: offers a partnership in innovative project which aims to set the standards for high density residential rental housing.

- **intervention and integration**: offers a large scale opportunity for integration of many new design ideas, including semi-pressure water system with SWH in a high density development.
- **sustainable**: established framework exists for ongoing input, training and knowledge transfer, and management, reduced ongoing service to user.
- **demonstration**: a viable demonstration project for SWH in an accessible area and of significant scale,
- **economies of scale**: provide services and cost reduction for SWH through the potential scale of the project, including production and installation and maintenance skills
- **controlled feedback** situation for monitoring,
- **learning**: provides estimates of costs of not including SWH in conceptual design from start of design, and will inform architects aware of these costs.
- **economic compatibility**: high capital cost/ low running cost project is designed as grant-funded high capital cost with aim of reducing running costs to user significantly. Design is compatible with SWH economics.
- **SWH barrier removal**: can address some of the SWH barriers to market penetration
- **GHG abatement**: provides a viable GHG abatement project of significant scale.

6.2 It has been shown that SWH is financially viable, and that significant financial benefits can be passed to the tenants. However, the tenants have limited cash-flow resources to cover capital repayment, even though it is viable financially. Capital costs may require additional funding, or low interest loan finance in order to maximise savings to the tenants.

6.3 A SWH project is technically viable, but presents technical challenges in delivering water to SWH in the preferred locations as a result of the current interpretation and application of the semi-pressure water system. Technical options have been explored and incremental building and services costs developed for SWH inclusion.

6.4 Although not all additional building and services costs have been gathered, it has been shown that SWH project at Shayamoya is economically viable provided the extra costs remain within certain limits. These will require additional funding.

6.5 The economic viability translates into an equation suggesting that greater savings and cash-flow benefits can be passed to the tenants through a level of capital subsidy or grant funding toward SWH installation. Those securing or owning the national economic benefits (particularly the intangibles such as GHG abatement credits) could transfer resources to this project.

6.6 Collaborators in any of the above highlighted areas could also partner the project in SWH implementation, and gain valuable insights.

6.7 The project presents an opportunity for funders to spend their money in a controlled and very targeted manner, and pass benefits and savings on the tenants in a controlled and regular manner over a period of time.

Abbreviations

Organizations

BESG	Built Environment support Group
CMDA	Cato Manor Development Association
DBSA	Development Bank of South Africa
GEF	Global Environment Fund of United Nations
SHA	Shayamoya Housing Association
UNDP	United Nations Development Programme

Technical terms

CO_2	Carbon Dioxide, a GHG
CWS	cold water storage tank, a feature of the semi-pressure system developed by Durban Metro Water, and used at Shayamoya
EE	energy efficiency
EIRR	economic internal rate of return
EWH	electric water heater or geyser
GHG	green house gas
IRR	financial internal rate of return
LRMC	long run marginal cost (of elecricity)
RE	renewable energy
SWH	solar water heater
SHS	solar home system

Units

kWh	kilowatt-hour, unit of electrical energy
GWh	Gigawatt-hours = 10^6 kilowatt-hours
MWh	Megawatt-hours = 10^3 kilowatt-hours
kPA	kilo-Pascals , unit of pressure
kL	kilo-litres = 10^3 litres
kWh//m²/day	solar insolation

1. INTRODUCTION

South Africa is endowed with very favourable sunshine conditions in most of the country, throughout the year. This could be used to provide energy and power for services such as space heating and water heating, as well as for electricity generation in some instance. However, very little use is made of renewable energy (RE) technologies in urban developments, and the bulk of the focus in South Africa is on the rural market remote from the electrical grid, where renewable energy is seen as an 'alternative fuel'.

Solar water heating (SWH) is a mature technology that is economically viable in the urban environment, provides substantial long terms energy savings to the end user over electric water heating, offers the same level of service as electrical water heating, and yet does not suffer the inconvenience and environmental hazards of the other cheaper and traditional fuels commonly used.

SWH offers great potential amongst renewable energy technologies for substitution of CO_2 producing coal generated electricity with renewable energy, and so ranks high in terms avoided CO_2 generation for UNDP Global Environment Fund (GEF) project incremental funding.

Further, the potential users of SWH are relatively well-off urban market. However, despite the obvious niche for SWH, the market remains largely untapped, for some of the following reasons:

- like many RE technologies, SWH has high initial costs but low running costs, so presents a financial barrier to those who cannot finance the system over a number of years.
- lack of awareness of potential benefits to all role players, from tenant, developers, technical designers such as architects and engineers, and at municipal and macro-economic level.
- SWH often considered as retro-fit by designers, or add-on, rather than integrated into design from early stage, hence costs are driven up.
- benefits of economies of scale at project level have not been achieved, as could be done in a large development project.
- lack of high profile demonstration projects with well designed feedback systems.
- current low price of electricity makes SWH less obviously financially attractive than it should be.
- ESKOM does not support SWH market development and substitution of electricity, due to overcapacity in thermal power stations.
- no funding mechanism exists for passing some of the potential macro-economic gains to the developer or tenant for overcoming the initial costs.

SWH is a mature technology, a long term investment, which yields real financial returns to the end-user, and yields greater economic returns to the economy as a whole.

2. OBJECTIVES

This pre-feasibility study aims to assess the viability of SWH within a large project, where substantial economies of scale can be achieved, and where the project approach is compatible with the longer term SWH economics.

Primary outputs are to:

- assess the affordability, technical, financial and economic viability of inclusion of SWH in the Shayamoya High Density housing development project, and to formulate preferred technical options,
- determine the incremental costs incurred due to SWH not being included from the start of the design,

- explore financial options for covering capital costs and for ongoing running costs within the project structure,
- determine further inputs required.

3. PROJECT SITE

Hilltop High Density is a Cato Manor Development association (CMDA) Pilot project which aims to provide secure, good quality affordable rental accommodation to low-income groups in the Durban periphery

It is part of a massive development drive to provide housing in the Cato Manor area, and is an area where precedents are being set for future developments.

The project has received Provincial Housing Development Board institutional subsidies, and top-up funding from the Malaysian government.

Approach
The pilot project aims to demonstrate that social housing is a viable delivery mechanism, and while using the existing grant funding optimally, lobby national and local governments for increased subsidies for further development of high density rental housing targeting low income groups.

The approach aims to find the optimal deployment of capital expenditure that will result in reduced recurrent costs to the tenants, making the project more affordable.

Management
The Built Environment Support Group (BESG) is designing and implementing the project on behalf of CMDA. BESG will provide management support to the Shayamoya Housing Association (SHA), who will run the rental project.

SHA approach is to address the needs and achieve long term social benefit by providing good housing for low income groups. SHA will operate on a not-for profit basis and allows the resident community to control policy making and take part in implementation.

Institutional management structure has been developed, and will undertake responsibility for financial and maintenance task, although this will in initially be undertaken by specialised agencies with a capacity building component in the contracts, managed by BESG initially.

Design
A total of 320 high density units are being constructed on a greenfields site. Town planning, urban planning and architectural design criteria have been explicitly stated, though not listed here.

The site design is well developed and construction using local builders has begun.

SWH was not considered as a possibility in the design. Electric geysers (EWH) of 75 litre have been included.

The engineering and architectural design of water supply currently precludes the use of SWH without some modification. The innovative and cost-saving semi-pressure system configuration used is not in itself a limitation. The integration of the system into the building design does not allow feedwater to reach SWH collectors in the most logical and exposed position.. on the roof.

4. PROJECT AND MARKET AREA.

The market area demographics, energy use patterns, expenditure on energy and potential for energy savings, will indicate whether the area is an appropriate area for SWH implementation.

4.1. Tenants

Tenants are drawn from a range of :

- existing Cato Manor residents from over-crowded formal houses
- people occupying shacks in existing Cato Manor informal settlements
- people required by CMDA de-densifying informal settlements
- valid land claimants
- people suggested by Durban Metro for emergency accommodation
- people from the broader Durban Metro area

The intention is for 45% of tenants to be women-based households.

4.2. Income levels per household

The income mix will be as follows:

- 65% between R600 and R1500 per month
- 35% between R1500 and R2500 per month

Monthly rentals are according to capital costs of units and their locations, and geared to the household incomes as follows:

Household Income (R) per month	R 1000-R1200	R1200-R1500	R1500-R2000	R1500-R2000	R2000-R2500
Percentage	5	35	get split	20	15
No.units	16	112	get split	63	50
Unit size (rooms)	$27m^2$ (1 bed)	$34\ m^2$ (2 beds)	$34m^2$ gf (2 beds)	$43\ m^2$ (3 beds)	$43\ m^2$ gf (3 beds)
Rentals	R 270	R 390 - R 405	R475	R550	R 750

A minimum population of 2 persons per room (including lounge) will be expected. The total minimum population is expected to be 1664 persons.

In general, only one income earner will dwell in each flat. It is anticipated that the balance of the population and extended family will be present at the site during the daytime.

4.3 Current expenditure patterns on energy

No primary research or survey work has been undertaken on current energy use patterns or expenditure. However, certain issues bear consideration:

- **Access to electricity does not imply that it will be used for all tasks.**
  Occupants in the low income bracket use a mix of fuels for heating, cooking and lighting, in order to be able to manage energy costs and cash-flow. Uptake of and transition to a 100% usage of electricity is not instantaneous.
- **Electricity is not the cheapest fuel for all energy uses in the house**
  Less convenient or more hazardous fuels are used because they are cheaper, or can be purchased in smaller quantities sizes which match the incoming cash-flows. Access to finance for electrical appliances is a barrier, with the result that the familiar paraffin stove or gas refrigerator are retained instead of a transition to more convenient electrical appliances. Particularly for cooking and water heating, tenants tend to use cheaper fuels, in the Durban area this tends to be paraffin.
- **A 100% energy transition will increase energy expenditure**
  Tenants will be drawn from areas that have not had access to electricity. Further, the lowest income tenants will have been using paraffin for the main energy consuming tasks. A transition to electricity will almost certainly drive the monthly expenditure on energy upwards.
  Some of the tenants will already be electricity users, have electrical appliances and be familiar with electricity and its relative costs.
- **Access to water on tap increases water consumption, and water heating requirements.**
  Tenants who have not had access to piped water within the house, heat water by electric kettle or by paraffin stove (7-11 litres/person/day of hot water). The consumption of water is certain to increase and it expected that hot water consumption will increase to between 25-50 litres per person per day. These tenants will experience higher fuel bills. If electricity is used for water heating, the increase will be substantial. Electrical water heating typically accounts for 40-60% of the electricity bill!

  For illustration, the calculated cost of water heating for a six person household, is as follows:

	Paraffin Primus (monthly energy cost)	**Electric geyser (monthly energy cost)**
6 persons x 10l/capita/day	R30.00	R45.00
6 persons x 36l/capita/day	not practical	R120.00
Assumptions: Water heated from 20 to 60 deg C.	40% stove efficiency, Paraffin cost of R2.00/litre Calorific value of 38MJ/l	68 % geyser efficiency, electricity cost of R0.29/kWh

- Electricity is the best option for lighting, TV, and hi-fi's, refrigeration and even ironing. However, for cooking and water heating it is likely to be more expensive than other fuels, and tenants making the fuel transition or increasing household hot water consumption will be experiencing and needing to manage significantly higher energy bills. This is a significant consideration for sustainable and affordable energy services. However, burning of fossil fuels indoors should be discouraged for health and safety reasons, and an affordable transition to electricity encouraged.

5. ESTIMATE OF ELECTRICAL ENERGY NEEDS AND COSTS, AND HOT WATER DRAW-OFF

For illustration and a context, the energy needs and expenditure on energy are calculated as a portion of disposable income after rentals.

5.1 Energy needs

The following major uses are anticipated and sued as assumptions in further costing:

- Cooking: estimates based on cooking requirements 5 x 1kW hotplate hours/day per 4 person household, and three kettle boils per day, increasing for larger households.
- Ironing: 0.5hour/day per 4 person household, or 3 hour/week, increasing to 6hours/week for an 8 person household.
- Lighting: 5 hours per light per room are assumed. Standard incandescent bulbs of 100W are assumed to be used.
- TV, hi-fi and small appliances: are small energy users, but 5 hours per day can be anticipated, especially during the daytime.
- Dish-washing: energy implication is only for hot-water demand, say 15l of hot water per basin, three times per day.
- Laundry: most houses will probably not have washing machines initially, and clothes will be washed by hand. The energy implication for hot-water demand, say 20l per household, once a day on average (Cold water may be used in some instances).

  Water heating:

  Water will be used in the kitchen, for washing clothes, and for showering, and for flushing toilets. A typical average water use figure for reticulated houses is 100 litres/capita/day, with approximately 36litres of hot water per capita per day.

5.2 Estimated electricity bills

Based on the number of rooms and occupancies etc, estimates of metered electrical energy bills for the range of households using 100% electrical energy, are as follows:

Household Income (R) per month	**R 1000 - R 1200**	**R1200 - R1500**	**R1500 - R2000**	**R1500 - R2000**	**R2000 - R2500**
Unit size (rooms)	$27m^2$ (4 persons)	34 m^2 (6 persons)	$34m^2$ gf (6 persons)	43 m^2 (8 persons)	43 m^2 gf (8 persons)
Daily household hot water requirement @ 36l/capita/day	144 l/day	216 l/day	216 l/day	288 /day	288 l/day
Estimated Expenditure on Electricity					
Cooking	R 45		R 65		R 90
TV & radio	R3		R3		R 3
Refrigeration	R 18		R 18		R 18
Iron	R 9		R 13		R 18
Lighting (incandescent)	R13		R18		R 22
Electrical water heating	R 78		R 107		R 136
Monthly electricity bill	**R 166**	**R224**	**R224**	**R287**	**R287**
Disposable income remaining after Rentals and Electricity	R 564 - 764	R 576 - 876	R800-1300	R663-1163	R 963-1463

Notes:
- The cost of owning and operating individual appliances, which are individuals' choices and responsibilities, are specifically excluded.
- Geyser maintenance costs, which could be either building services or alternatively individual responsibility, are estimated to be R 109-112/annum, and are excluded, but could be part of a maintenance tariff to the SHA.

Clearly, under the assumptions listed, water heating is likely to form the bulk of the electricity budget. Any energy savings that can be passed on to the consumer will have an important on disposable income, and provided the same level of service if supplied.

5.3 Opportunities for saving energy

Tenant managed interventions:
- Remain with cheaper fuels (ie paraffin primus)
- Manage electricity usage (turn off lights etc)
- Manage hot water usage, ie less electricity

Project designer interventions in energy efficiency:
- Energy efficient building design (appropriate building materials, insulting ceilings installed, optimal summer shading, winter sun etc). (already explored in building design)
- CFL's in place of standard incandescent will save energy. Capital cost must be covered (already being explored).
- Electricity pre-payment meter to prevent monthly over-expenditure (rejected)
- SWH for water heating to reduce energy consumption, and ideally use grant funding if capital cost can be covered (subject of this report).

A survey and market verification of the potential occupants needs to be undertaken, to determine their views on, understandings of, and willingness to pay some portion of the upfront and or maintenance costs required to incur the savings should this be necessary.

5.4 Demand profile for hot water

In order to assess the feasibility of SWH, it is necessary to develop a hot-water demand profile. Based on the household structure of one or two income-earners and extended family remaining at home during the day, the hot-water usage patterns are expected to be spread throughout the day.

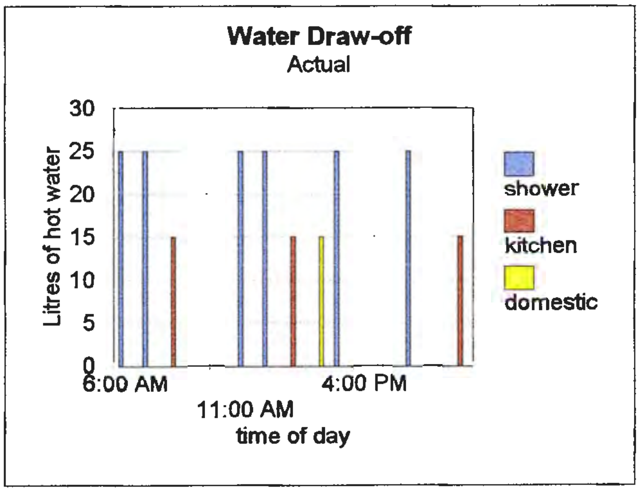


Figure 1 Estimated daily hot water demand profile for a 6 person household.

The existing geyser specification 75litre EWH can supply the average daily hot water demand provided that the average hourly demand is less than 60 l, to enable the EWH to re-heat.

These demand profiles are entirely suitable, if not optimal for SWH application and operation, and it is probable that use patterns would be modified through experience to optimise hot water supply.

The balance of this report reviews the viability of SWH implementation into this exiting project.

6. SWH DESIGN, COSTING AND VIABILITY

6.1 SWH design and costing

The following major underlying assumptions form the basis for the sizing and costing for SWH:

- Cold feed water is delivered to the SWH at suitable pressure and flow.
- System sizes are calculated for North-facing roofs at optimal tilt angle of 30degrees, average annual insolation on tilted surface of 5.0kWh/m²/day assumed for Durban,
- SWH and EWH provide the same level of service in quantity and quality of hot water, so electrical backup is provided to SWH for days when insolation is below the design demand.
- Backup demand is analysed on a monthly basis, but only annual averages presented.
- Economically optimal sizes presented for each case, standardising on sizes where practical.

Unit size (rooms)	**27m² (4 persons)**	**34m² (6 persons)**	**43 m² (8 persons)**
Daily household hot water requirement 36l/capita/day	144 l/day	216 l/day	288 l/day
SWH sizing	**200 l geyser 2.9 m² collector**	**300 l geyser 4.6 m² collector**	**300 l geyser 4.6 m² collector**
Energy 1. Average energy saved over EWH (kWh/annum) 2. Average energy required as back-up (kWh/annum)	2 993 kWh/annum 326 kWh/annum	4 486 kWh/annum 54 kWh/annum	4 486 kWh/annum 1 275 kWh/annum
Costs 1. Capital cost of SWH including installation 2. Electricity bill for water heating (annual) 3. Maintenance levy (annual)	R 5 865 R 93 R 159	R 8 273 R 15 R 183	R 8 273 R 363 R 183
Monthly saving to Tenant 1. If full cost is recovered: 2. If capital cost portion is not recovered:	**R 16** **R 66**	**R 26** **R 100**	**R 26** **R 100**

Notes:

- Local SWH equipment is used, in the direct close-coupled configuration. Substantial economies of scale of at minimum a 15% price reduction on one-off system costs.
- Project life of 15 years is assumed. This is reasonable and in line with local experience.
- Maintenance requirements are minimal, although an annual allowance of R100 has been included, the same as for EWH.

- Repair requirements should be minimal, but an allowance of 15% of the system value has been allowed over 15 year life. As an aggregate value is generous, although some individual systems may spend none of this, and some may spend a substantial sum more than this in reaching 15 year life.
- The total repair and maintenance allowance is approximately R 159-180 per annum . The corresponding allowance for EWH would be R108-112 per annum. Allowances collected and not required to be saved and amortised in a maintenance fund.

6.2 Project viability

The project viability is analysed from both financial and economic perspectives.

As the EWH and SWH systems are designed to provide the same levels of service in terms of quantities of hot water supplied, it is not necessary to capture the benefits for the options, as the benefits are the the same. It is necessary only to capture the financial and economic costs. (The savings passed on to the tenant are reflected as reduced costs.)

The base case is the current EWH installation and associated costs for each flat. The SWH option costs are subtracted from the respective base case costs, and net savings over the project life reflected from both financial and economic perspectives. There is either a net cost or a net saving, with a net saving means project is viable.

Unit size (rooms)	**27m²** **(4 persons)**	**34m²** **(6 persons)**	**43 m²** **(8 persons)**
Daily hot water requirement 36l/capita/day	144 l/day	216 l/day	288 l/day
SWH sizing	200 l geyser 2.9 m² collector	300 l geyser 4.6 m² collector	300 l geyser 4.6 m² collector
NPV of Financial savings (The end-user perspective) <u>including</u> all costs. (Monthly saving =)	**R 1 710** **IRR =13%** R 16	**R 2 928** **IRR = 14%** R 26	**R 2 928** **IRR = 14%** R 26
NPV of Financial savings (The end-user perspective) <u>excluding capital component.</u> (Monthly saving =)	**R 7 301** R 66	**R 10 943** R 100	**R 10 943** R 100
NPV of Economic savings and Economic IRR	**R 3 531** **EIRR = 25%**	**R 4 927** **EIRR = 24%**	**R 4 927** **EIRR = 24%**

Notes:

- A financial and economic discount rate of 8 % is used for the base case.
- Project life of 15 years is assumed.
- LRMC economic cost of electricity is assumed to be 25c/kWh from Durban Metro. (Excludes VAT component and any transfers from the electricity account to other services depts).
- Environmental benefits included in macro-economic study, by means of a net benefit of 5c/kWh of coal-generated electricity avoided.

The full data sheets for financial and economic viability are in Appendix A.

6.2.1 Economic analysis.
The SWH options are viable for each case analysed, always yielding a substantial net economic saving. Proceeding with the project will yield net economic benefits to the country. Further, the excellent economic IRR of 25% is sufficient to justify proceeding with a detailed investigation.

Sensitivity analysis
The viability of SWH over EWH is stable under most conditions explored, and remains economically viable. (Refer to Appendix A..) However, there is some sensitivity to:

- Project life: the NPV of savings are below zero only is project life is reduced from 15 years to 6 years. The 15 year project cycle is considered realistic, and only under bad conditions would a project life be reduced to 10 years.
- Hot water consumption, in that the system must be sized to match the needs, and not over-designed. Over-specification of the system will result in unutilised capacity which will result in wasted capital resources. However, the SWH specified are viable in a wide range from 10l/capita/day to 65l/capita/day, but below 20l/capita are less efficient. Base case hot water needs are estimated at 36 l/capita/day.

This project is economically viable, and options should be explored to make it financially viable from an tenant, SHA, and project developer perspective.

6.2.2 Financial analysis: Tenant perspective
The financial analysis presents the tenant perspective with full cost recovery, the most difficult perspective with most constraints. The project is financially viable even when under these conditions, yielding an effective financial IRR of 13%, compared with a 6% yield typically offered at the bank. However, most tenants are not able to finance the capital requirements.

If the capital portion of the project is provided at no charge to the tenant, then the project is always viable. There are motivations for doing this.

Sensitivity analysis
(Refer to Appendix A..) When there is full cost recovery from the tenant, the project is most sensitive to:

- Discount rate: considered that appropriate DR for tenant is 8%.
- Electricity costs: are currently 25.2c plus VAT, or 29c, but are likely to increase rather than decrease as the real costs of distribution are brought to bear on Durban Metro, who are struggling with cost recovery of low-income households at present.
- System life is a key variable, and when the user must pay for capital, it is critical that the project life of at least 10 years is achieved.

Within the assumptions noted, SWH can meet technically, financially and economically meet the demand, for standard north facing buildings with suitable locations for SWH mounting. However, there is a capital cost barrier to overcome.

6.2.3 Cash flow analysis
It has been determined that the project is economically viable, and financially viable from an tenant perspective. However, due to unfamiliarity with SWH, and lack of access to loan finance, users are not likely to invest in SWH themselves without some form of sweetener. Three options are illustrated:

Option 1
User installs SWH at own cost, with or without finance.

- User is charged for electricity, via individual meter to Durban electricity.
- Capital costs paid by user up-front, or raised via a loan.
- Maintenance and repair are user responsibility.

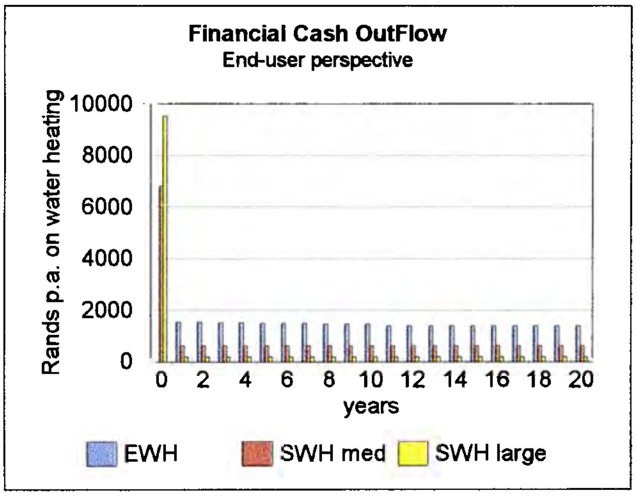


Figure 2. Cash flow

Option 2
The project installs the SWH, and undertakes a situation of full cost recovery. The tenant must repay the capital cost, maintenance cost and electrical back-up cost of the SWH.

- User is charged for electricity, via individual meter to Durban electricity.
- Capital costs recovered in rental and levy, to the project over a 10 year period
- Maintenance and repair costs in form of a monthly levy, payed towards a centralised fund for administration, to SHA.

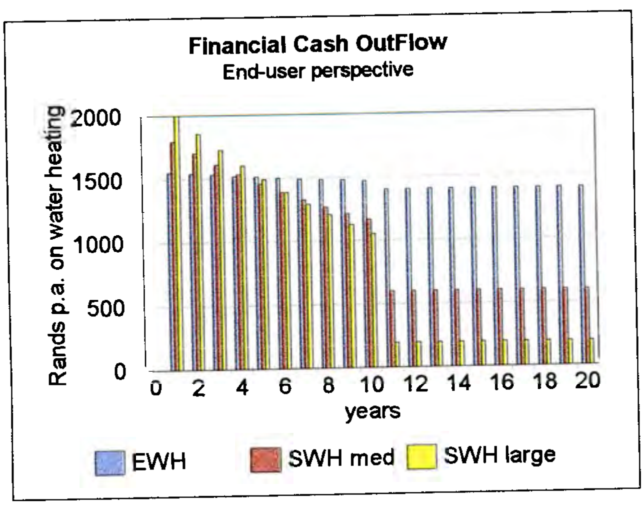


Figure 3. Cash flow

Option 3

The project installs the SWH. Capital cost covered by project, only partially passed on to user, motivated by economic benefits, and reflecting the objectives of the SHA pilot project. Tenant benefits by immediate savings in energy.

- User is charged for electricity, via individual meter to Durban electricity
- Project costs and resources are used to harness resources to recover costs... via grant funding, and possibility access to green funding.. Demonstration project
- Maintenance and repair costs in form of a monthly levy, payed towards a centralised fund for administration, or established as part of maintenance fund.

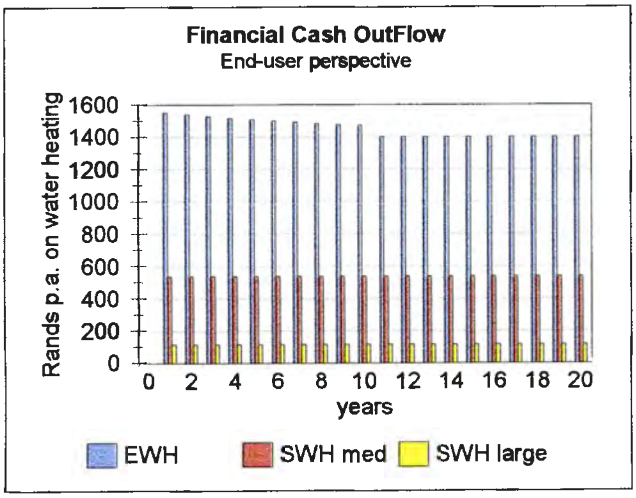


Figure 4. Cash flow

Cash flow conclusions

To make the SWH project attractive from an tenant perspective:

- Electrical energy, required for back-up, is paid for directly by the tenant.
- Maintenance is paid for by the tenant via an annual maintenance levy to SHA, who provide bulk maintenance services to the tenants.

- A portion of the capital cost should be subsidised:
- under motivation of SWH demonstration project (external funders)
- Green finance and GHG abatement (GEF)
- balance recouped from tenant, with low-interest loan (DBSA)

7. TECHNICAL REQUIREMENTS AND CONSTRAINTS / INCREMENTAL COSTS

The costs presented till now are for SWH's fitted to building designs appropriate for SWH. These cost and calculations are applicable for only a few of the units at Shayamoya, namely, the top floor units such as in Drawing Block.... (refer to Appendix D)

In the case of this specific project, several constraints exist, which require building alterations or redesign prior to fitting SWH of the appropriate configuration if SWH is to be made available to all units.

7.1 Solar water heating requirements (SWH)

- SWH requires north facing roofs (plus-minus 15 degrees), ideally unshaded throughout the day, a roof tilt angle of 30 degrees which is optimal for year-round heating in Durban. All of these can be compensated for to a degree.
- The preferred Natural Circulation SWH systems requires SWH geyser outlet to be located at least 600mm above the solar collector. Close-Coupled systems are preferred, with the geyser and collector closely interconnected and both outdoors, as they are cheaper and easier to troubleshoot (no air locks). Split system SWH's with geyser and collector separate from each other require more careful inspection on installation, however the geyser thermostat may be more accessible for adjusting by the user.
- Forced Circulation split systems require variable speed low power pumps to circulate water from the geyser to the collector. The collector may be located above geyser, but entire hot-water system must be pressurized and remain pressurised to water ensure circulation rather than pumping occur, and prevent air-locks. The pump can be operated by solar power, and is not necessarily dependent on mains electricity supply.
- The SWH collector must be certain to remain full of water to prevent damage due to overheating, so sufficient water head pressure must be ensured at all times.
- Solar water heater collectors are best located on roofs, where they are most exposed to sunlight, least shaded least vulnerable and contribute to the most modular approach. They may also be located on building gables or walls on brackets, or ground mounted.

7.2 Shayamoya site constraints

- Site design is well and far developed, construction has begun on site, although currently delayed.
- The housing module design provides a 'service duct' for logical location of most plumbing, sewerage pipes, water reticulation pipework and cables.
- Cold water supply is via the semi-pressure system, likely to be used in future low-cost housing developments, which does not provide the conventional water pressure. At this site, houses can expect 20kPa gravity pressure in their systems. The cold water storage tanks (CWS) are located in the 'service duct' at the ceiling level of each flat.
- Orientation and location of buildings has been designed around the greenfields site. Some buildings are not orientated towards true north, so the exposed roof area for SWH is not optimal. Roof tilt is, however, close to optimal for SWH.
- Trees provide significant relief and shade for many of the buildings. The roofs of many housing modules on site are partly shaded by large trees, or completely shaded. Trees will grow further.

7.3 Suggestions for this site:

The ideal SWH option, as costed in previous sections, is available for only a very limited on small top floor flats with larger flats beneath. Even in these flats, exposure and efficiency of SWH collectors will be reduced due to some shading from top floor flat, but the total effect of this is not quantifiable as detailed plans are not immediately available.

The SWH options available for the balance of the flat units on this site are constrained by the current use of semi-pressure water reticulation at each flat ceiling level, and the current modular design. Options are considered in priority which first minimise structural modification.

7.3.1 Direct main supply to SWH

- Split cold water supply at CWS directly from mains to close-coupled SWH on roof? The main supply flow is limited to 6.5l/minute supply restriction. Is this not sufficient protection?

  Not allowed in terms of semi-pressure water system design. Also complex water flows will result as hot water pressure will drop as soon as CWS draws water.

Or

- Connection to conventional pressurised water main system.

Connection costs for a semi-pressure system are:	Connection fee	R 350.00
	Deposit	R 55.00
	Total	R 405.00
Costs for a full pressure domestic system are:	Connection fee	R 1 094.40
	Deposit:	R 120.00
	Total connection:	R 1 214.40
with 100 kPa pressure reducing valve		R 280.00
	Total	R 1484.40
Difference cost:		R 1089.40

Any alterations which require additional costs of greater than R 1 079.40 to achieve suitable operating water pressure at the SWH are a result of a knowledge gap in planning the design.

If it is at all possible to reconfigure the site on a full pressure water main, then this is the only sensible economic decision. It is a simple solution with no running costs and no moving parts. If it is not possible, then extra costs may be incurred.

If it is a project requirement that the semi-pressure is used, then other options need to be explored.

7.3.2 Electrical pressurizing booster pump on cold water feed to close-coupled roof-mount SWH.

Current CWS location can accommodate SWH system collector on roof only with permanent electrical booster pressuring pump, as module cold water pressure provided is insufficient to supply water to roof.

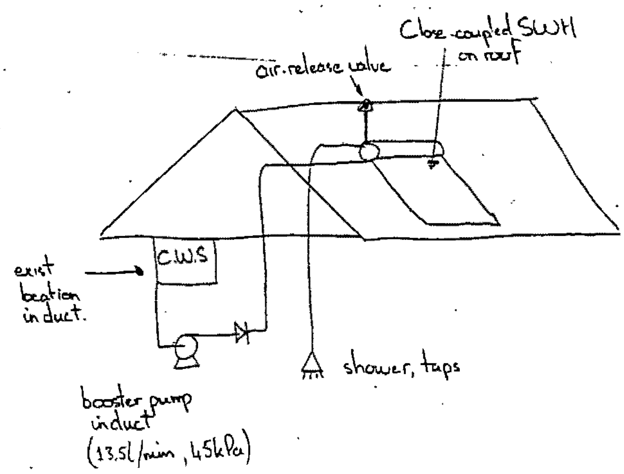


Figure: CWS, pipework, SWH location and auxiliary equipment for SWH option 7.3.2.

Incremental building costs:

•	Cost of 10l/minute booster pump, plus energy supply implication.	R 800
•	Cost of cost of insulated pipework to rooftop SWH, and return to flat.	R 200
•	Cost of power cable from flat DB to rooftop geyser	R 100

Incremental SWH costs

- None

Disadvantages

- No hot water supply when electricity supply interrupted.
- Running cost implication of electrical pump; electricity minimal, service costs a liability.
- Hot water supplied at higher pressure than cold water.
- Geyser on roof not accessible to tenant

Advantages

- No major to building concept design, except for geyser location.
- No aesthetic problems

7.3.3 Split SWH system, with geyser in exist location, and natural convection

Collector mounted on bracket on building North face wall below window, or possible ground mount structure.

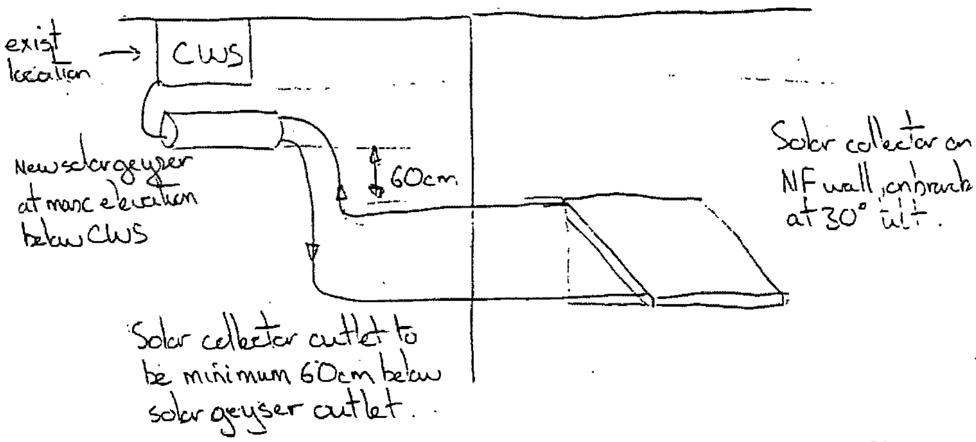


Figure: CWS, pipework, SWH location and auxiliary equipment for SWH option 7.3.3.

Incremental building costs:

- Complex pipework through house on internal dividing wall to prevent air-lock (see drawing) + R 300
- Structural requirements of NF wall (or lower roof for some top story flats) to hold bracket with 70kg filled collector. + R 300

Incremental SWH costs

- Split SWH system and collector
- frame for wall-mounted collector plus installation costs
- extra-lagging 30 m
- Increased installation costs

  total incremental costs =

  [new SWH config cost - close-coupled SWH cost)] *0 .85

  = [(1821*2+2364+400 +210+1400) - (7276+1000)]*0.85
  = -R 221

Disadvantages

- Piping through building to prevent air lock.... may not be practical depending on specific building orientation.
- Possible shading of SWH collector in some instances
- Custom design in case of each module means non-modular approach
- Aesthetic considerations!!
- Worry of danger of SWH collapse or glass breakage
- Structural risk unless significant additional engineering inspection for bracket mounted systems.

Advantages

- Hot and cold supply to user on equal pressure and on LP system.
- Hot water supply on natural gravity feed, heating and supply totally independent of electricity supply.

7.3.4 Close-coupled SWH with geyser and collector on building NF wall or possible GM.

Complete SWH mounted in North-facing wall.

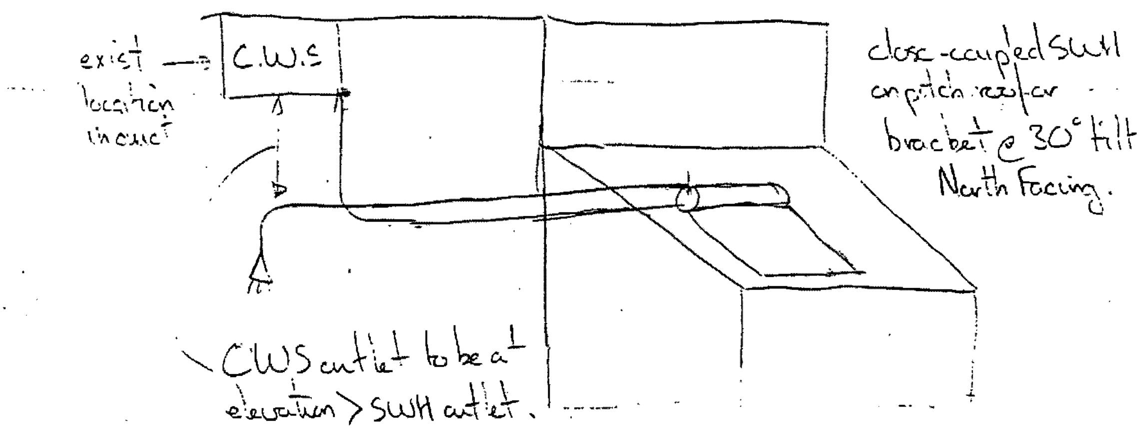


Figure: CWS, pipework, SWH location and auxiliary equipment for SWH option 7.3.4.

Incremental building costs:

- Insulated pipework through house on internal dividing wall. R 100
- Structural requirements of NF wall to hold bracket with 200kg filled SWH R 300

Incremental SWH costs

- frame for wall-mounted collector
- increased installation costs

total incremental costs = [new SWH config cost - close-coupled SWH cost)] *0 .85
= [400+200)]*0.85
= +R 510

Disadvantages

- Possible shading of SWH collector in some instances
- Custom design in case of each module means non-modular approach
- Aesthetic considerations !!
- Worry of danger of SWH collapse or glass breakage
- Structural risk unless significant additional engineering inspection for bracket mounted systems (but not for lower roof mounted).

Advantages

- Hot and cold supply to user on equal pressure and on LP system.
- Hot water supply on natural gravity feed, heating and supply totally independent of electricity supply.

7.3.5 Relocating CWS to provide pressure for roof mount Close-Coupled SWH:

Relocated CWS tank must be in apex of roof to provide sufficient pressure to top of geyser and collector.

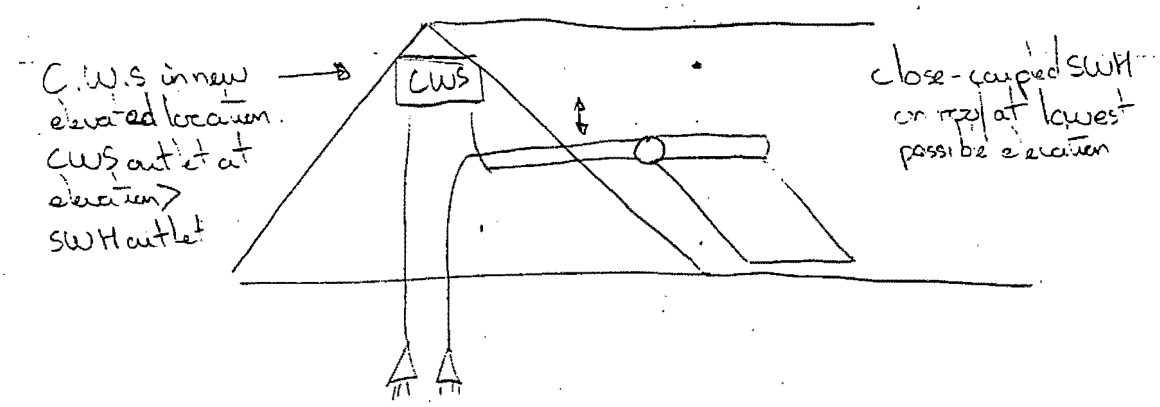


Figure: CWS, pipework, SWH location and auxiliary equipment for SWH option 7.3.5.

Incremental building costs:

- Costs of structural changes to support CWS tank
- May not have sufficient space in roof apex to house 8x CWS tanks.
- Ceilings required in top floor flat to hide CWS
- Considerable redesign, may require to increase roof pitch to accommodate and obtain pressure head (see drawing)
- Roof loading to accommodate several SWH of filled mass 200kg each
- Power cable to roof top geyser from customer DB.
- insulated HW pipe from SWH outlet to customer reticulation via duct
- Small additional length pipe from CWS to Geyser
- Additional length CW feed pipe from CWS to customer via duct

Incremental SWH costs

- None

Disadvantages

- Requires relook at design concept.... upgrading it for greater flexibility.
- Extra structural requirements and redesign
- Access limitation to CWS tanks for maintenance
- User cannot easily adjust geyser thermostat setting
- No easy access to roof for servicing

Advantages

- SWH exposed to maximum sunlight
- Natural water feed, no extra running costs or parts
- System design consistent with semi-pressure system design.
- pressure is higher than with current design (and is higher for lower level flats than upper level)
- Hot and cold water on same pressure

7.3.6 Relocating CWS to provide pressure for roof mount collector for split system with forced circulation.

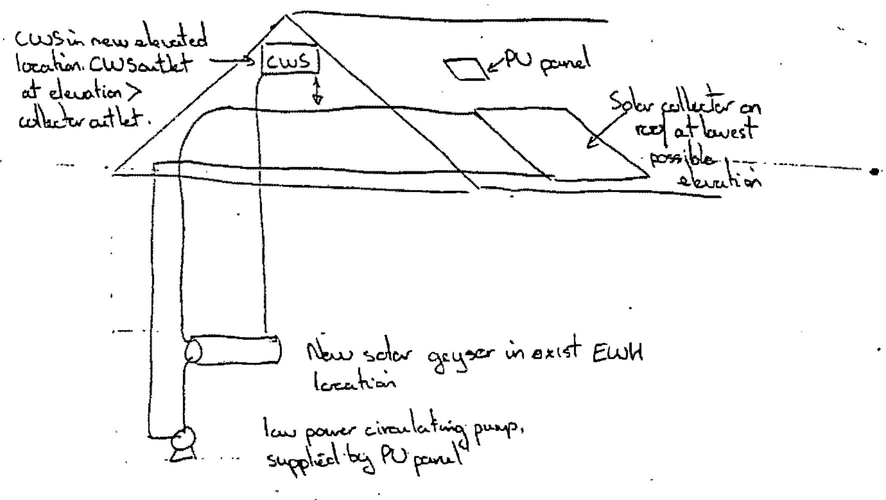


Figure: CWS, pipework, SWH location and auxiliary equipment for SWH option 7.3.6.

Requirements and benefits:

- Specialised geyser to be installed in exist geyser location, customer can easily adjust geyser thermostat setting.
- CWS tank may not be required to be in apex of roof, to ensure pressure head to top of collector (same problems as for Close-coupled, but less extreme. May not need to increase roof pitch.

Incremental building costs

- Costs of structural changes to support CWS tank
- May not have sufficient space in roof apex to house 8x CWS tanks.
- Ceilings required in top floor flat to hide CWS
- Considerable redesign, may be required to increase roof pitch to accommodate and obtain pressure head (see drawing)
- Roof loading to accommodate several SWH of filled mass 70kg each
- Power cable from roof top PV panel to circulating pump in roof in duct.
- insulated HW pipe from geyser outlet, via duct to SWH collector and return to customer reticulation via duct

Incremental SWH costs

- Split SWH system,
- forced circulation with DC pump and solar panel.
- increased installation costs

  total incremental costs = [new SWH config cost - close-coupled SWH cost)] *0 .85
  = [(1821*2+2364+780+210+1400) - (7276+1000)]*0.85
  = +R 102

Disadvantages

- Requires relook at design concept.... upgrading it for greater flexibility.
- Extra structural requirements and redesign
- Access limitation to CWS tanks for maintenance
- No easy access to roof for servicing of collector
- Forced circulation for SWH means SWH operation dependant on external power. Will

power pump by solar PV, so independent of grid electricity.

Advantages:

- SWH exposed to maximum sunlight
- Natural water feed, no extra running costs or parts
- System design consistent with semi-pressure system design.
- pressure is higher than with current design (and is higher for lower level flats than upper level).
- Hot and cold water on same pressure
- User can easily adjust geyser thermostat setting

7.4 Overall assessment of technical options

The preferred technical options are, in order of preference:

- 7.3.1 If a full-pressure water main could be installed, then this is the best and least cost option. It is probably too late!!
- 7.3.4 close-coupled SWH on roof mount for those limited number of dwellings that can accommodate the option.
- 7.3.5 Close coupled SWH on roof, with CWS tank elevated to roof pitch to provide sufficient.
- 7.3.6. Split SWH with collector on roof, CWS tank elevated to roof pitch to provide sufficient head, geyser in exist serviceable location.

Incremental costs are shown:

Option	building and services costs (average per system)	incremental SWH cost (per system)	Total incremental cost to project (per system)	Technical viability
7.3.1	R 1 080	none	R1 080	FULL-PRESSURE Water main
7.3.2	R 1 100	None	R 1 100	not preferred
7.3.3	R 600	-R 221	R 380	possible shading
7.3.4	R 400	R 510	R 910	possible shading
7.3.4 (roof mount)	0	R 100	R 100	for limited dwellings only
7.3.5	Not forthcoming	None	??	significant redesign
7.3.6	Not forthcoming	R 102	??	significant redesign, plus forced circulation

If building redesign could be achieved to generate water head at a cost of less than R 1 080 per flat, then that is the preferred option, as per options 7.3.5, 7.3.5 and 7.3.6.

It is unlikely that water pressure could be supplied at lower cost than the bulk water services could supply water.

8. EFFECT OF INCREMENTAL COSTS ON PROJECT VIABILITY

8.1 Effect on economic analysis (per system)

The SWH under yield a net economic of R 4 000 per small system and R 5 000 per large systems .. They will therefore still be economically viable, although only marginally so, when additional economic costs are imposed up to that value. (The financial costs above must be multiplied by a factor or about 0.75 to translate to marginal economic costs.)

SWH Option 7.3.4 is already viable, for a limited number of dwellings only.

SWH Option 7.3.1, conversion to full pressure system, is economically viable. Note, however, that the long term economic benefits of the semi-pressure system have not been valued in this calculation. Long term benefits over the full pressure system would be reduced water usage and reduced wastage. At a marginal economic cost of R 1.77 / kL, the contribution is not likely to be significant.

For the preferred SWH options 7.3.5 and 7.3.6 to be better than marginally viable, the total additional financial cost of building modifications per system must be less than R 4 000.

The actual amount of building that can be achieved depends on the Block Type, as it is principally roof changes that are required. It is clearly more cost effective to make identical top structure (roof and trusses) building changes to multistory blocks than smaller blocks.

Block type	No. Storeys	No. Units per block	No. blocks in project	Max. incremental expenditure per block for SWH to remain economically viable
Type A	3	6	12	R 24 000
Type B	4	8	6	R 32 000
Type C	2	4	13	R 16 000
Type D	2	4	8	R 16 000
Type E	3	6	7	R 24 000
Type F	2	4	18	R 16 000

It is estimated that if building changes can be done for within these ranges then SWH will be still be economically viable for these technical options 7.3.5 & 7.3.6.

Therefore, even if the marginal costs of not including SWH in the design are costed to the SWH cost centre, the project is viable and should proceed, from an economic basis.

8.2 Effect on financial analysis (per system)

The financial analysis from the tenant perspective is marginally viable for full cost recovery even with incremental costs of R 1 500 for small systems and R 2 500 for large systems. However, the systems are not likely to be attractive as the savings to the end-use will not be visible, and tenants will be unlikely to be prepared to pay these costs.

If the capital costs and/or incremental costs are not passed on to the tenant, then the full benefits will be felt, and the project will always be financially viable from an tenant perspective.

A small and non-contentious contribution of R10/month towards capital contribution would be reasonable, and will generate visible savings.

However, the costs must then be covered from other sources. This will be the constraint on project viability.

8.3 Costs summary

Costs are summarised for two scenarios of implementation:

8.3.1 SWH only in limited dwellings.

where it can be installed without any building modification, (option 7.3.4 roof mount, total 120 units where practical)

	Costs
Total capital cost on 120 SWH systems	120 * R 5 773 = **R 692 760**
Incremental building costs less geyser costs	R 0 **- R 228 956**
Net cost	**R 463 804**
Maintenance fund income	R 18 000 per annum
Saved electricity	120 * 2993kWh = 0.36 GWh/annum = 5.4 GWh over 15 years
CO_2 avoided	170 tons/annum = 2 560 tons over 15 years

8.3.2 SWH installed on all dwellings

	Full-pressure system (SWH option 7.3.1)	Cheapest option (SWH option 7.3.2)	Highest cost allowed (SWH options 7.3.5 or 7.3.6)
Total capital cost on 320 SWH systems	200 * R8 098 + 120 * R 5 773 = **R 2 312 360**		
Incremental building costs less geyser costs	R348 480 - R 228 956 **R 119 524**	R 320 000 - R 228 956 **R 91 044**	R 1 280 000 - R 228 956 **R 1 051 044**
Net cost	**R 2 431 884**	**R 2 403 404**	**R 3 363 404**
Maintenance fund income	R 50 880 per annum for 320 systems		
Saved electricity	120 * 2993kWh + 200 * 4480kWh = 1.25 GWh/annum = 19.5 GWh over 15 years		
CO_2 avoided	597 tons/annum = 8 900 tons over 15 years		

9. FUNDING AND FINANCING OPPORTUNITIES

One aim of this particular project is to provide affordable and improved standard of living to tenants through provision of services. This may require some level of capital subsidy and joint financing.

Funding for the SWH project could be sought from the following sources:

9.1 Incremental building cost / compensation for omitting SWH from early design

- Where SWH are installed on dwellings where it is practical without any modification, there is no charge.
- Where there is a net cost for omitting SWH from design, the cost should be for the project account (ie, use full pressure system, or for building modifications).

9.2 Incremental capital cost on SWH over EWH

- Tenants will be achieving some savings as a result of the SWH programme, and may be able to contribute some of the savings to capital cost repayment. Tenant to repay portion of capital cost at an affordable and non-contentious level, say R10 per month, reducing electricity savings to from R 66-R 100 down to R 56-R 90 pm. R 10 per month will cover approx 25% of capital cost. Substantial savings still passed on.

- The tenant contribution could be reduced through low-interest loan finance.

- Grant funders may find the project attractive:
  - visible, high profile demonstration project in line with current projects (Danced)
  - excellent collaboration and learning opportunity with scope for ongoing monitoring within existing structures
  - addresses some of the SWH market barriers at pilot scale level
  - actual and viable GHG abatement project (GEF) R 259/ton of CO_2 avoided, providing bulk services.

- Government or local government may be able to co-fund the project in terms of net economic benefits, and provide a level of cross subsidization.

9.3 Operation & Maintenance of SWH

Maintenance and up-keep will be funded entirely by the tenants, and the SHA will co-ordinate and administer the maintenance of the bulk systems installed. Tenants pay an annual maintenance levy of R 159 - R 189 towards a maintenance fund. Management structures already exist for this administration.

10. CONCLUSIONS

Inclusion of a SWH project at Shayamoya High Density Rental Housing Development provides several opportunities

- **profile:** it is a development project of significant scale in an area where many large housing projects are occurring.
- **replicable pilot project**: offers a partnership in innovative project which aims to set the standards for high density residential rental accommodation.
- **intervention and integration**: offers a large scale opportunity for integration of many new design ideas, including semi-pressure water system with SWH in a high density development.
- **sustainable**: established framework exists for ongoing input, training and knowledge transfer, and management, reduced ongoing service cost to the user
- **demonstration**: a viable demonstration project for SWH in an accessible area and of significant scale,
- **economies of scale**: provide services and cost reduction for SWH through the potential scale of the project, including production and installation and maintenance skills
- **controlled feedback** situation for monitoring,
- **learning**: provides estimates of costs of not including SWH in conceptual design from start of design, and will inform architects aware of these costs.
- **economic compatibility**: high capital cost/ low running cost project is designed as grant-funded high capital cost with aim of reducing running costs to user significantly. Design is compatible with SWH economics.
- **SWH barrier removal**: can address some of the SWH barriers to market penetration
- **GHG abatement**: provides a viable GHG abatement project of significant scale.

It has been shown that SWH is financially viable, and that significant financial benefits can be passed to the tenants. However, the tenants have limited cash-flow resources to cover capital repayment, even though it is viable financially. Capital costs may require additional funding, or low interest loan finance in order to maximise savings to the tenants.

A SWH project is technically viable, but presents technical challenges in delivering water to SWH in the preferred locations as a result of the current interpretation and application of the semi-pressure water system. Technical options have been explored, and incremental building and services costs developed for SWH inclusion.

Although not all additional building and services costs have been gathered, it has been shown that SWH project at Shayamoya is economically viable provided the extra costs remain within certain limits. These will require additional funding.

The economic viability translates into an equation suggesting that greater savings and cash-flow benefits can be passed to the tenants through a level of capital subsidy or grant funding toward SWH installation. Those securing or owning the national economic benefits (particularly the intangibles such as GHG abatement credits) could transfer resources to this project.

Collaborators in any of the above highlighted areas could also partner the project in SWH implementation, and gain valuable insights.

The project presents an opportunity for funders to spend their money in a targeted manner, and pass benefits and savings on the tenants in a controlled and regular manner over a period of time.

Appendix A

Financial and economic costs of SWH

Solar Water Heater Analysis for Bulk Housing Project in Durban

Financial Analysis

* for 6 persons using 36l/capita/day
* 15 year project life
* 8% DR

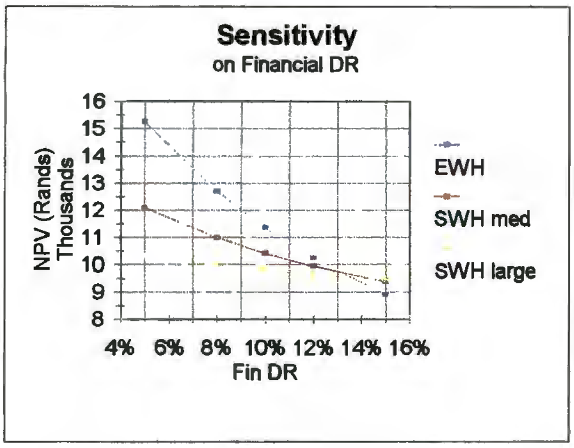
	NPV	delta	IRR
EWH	12707		
SWH med	10896	1811	13%
SWH large	9779	2928	14%

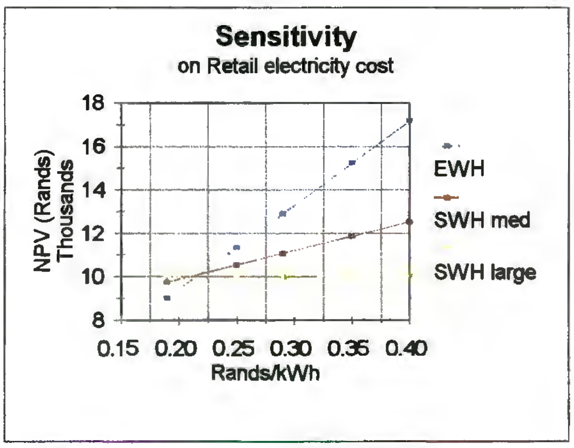
Economic analysis

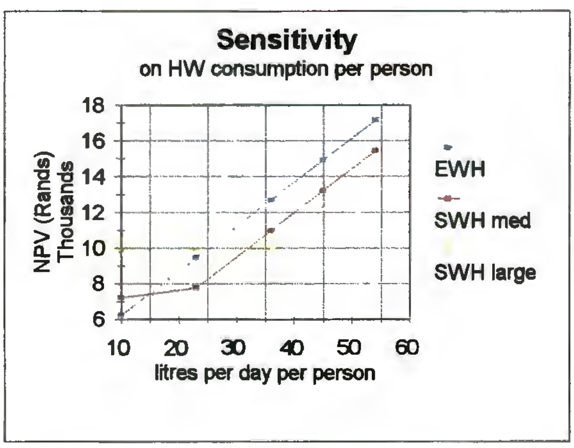
* for 6 persons using 36l/capita/day
* including GHG credits at R100/ton CO2 avoided
* 15 year project life
* 8% DR

	NPV	delta	IRR
EWH	10882		
SWH med	7322	3560	21%
SWH large	5935	4947	22%

Sensitivity analysis







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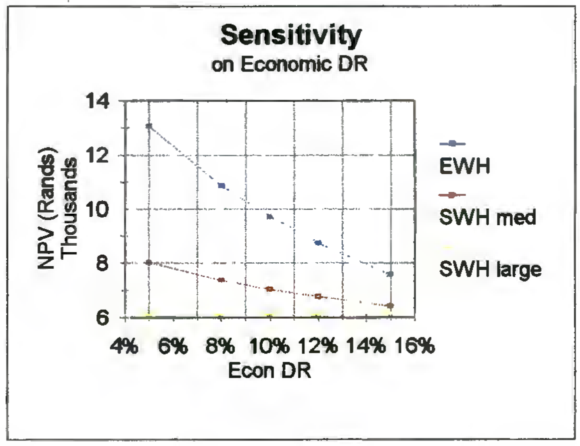
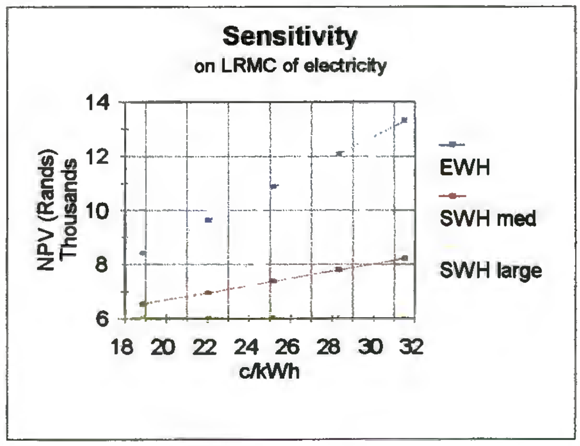
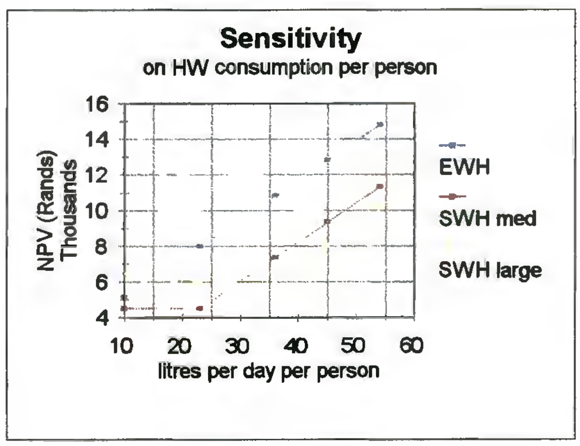
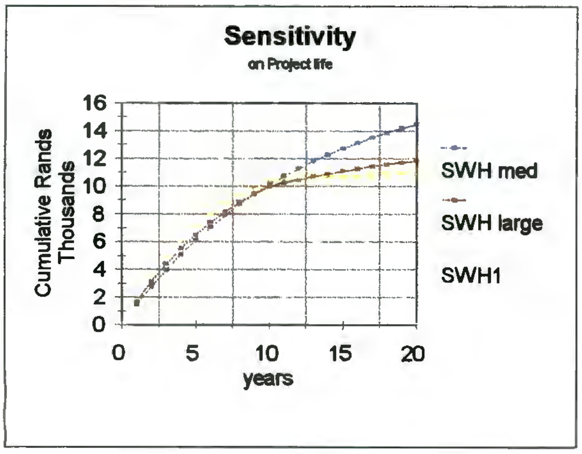


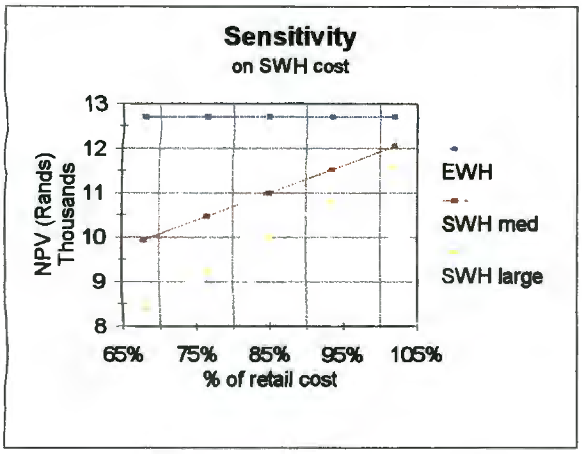


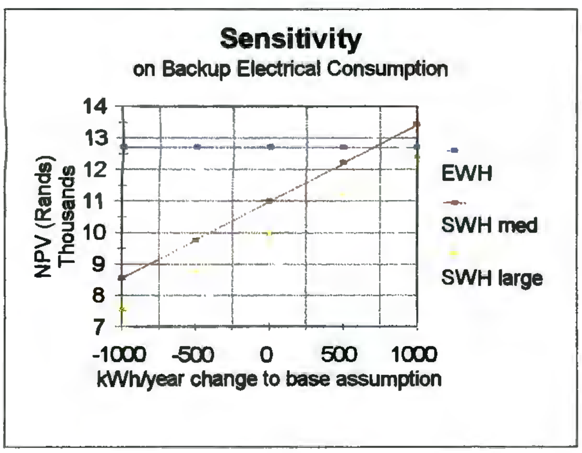


Solar Water Heater Analysis for Bulk Housing Project in Durban

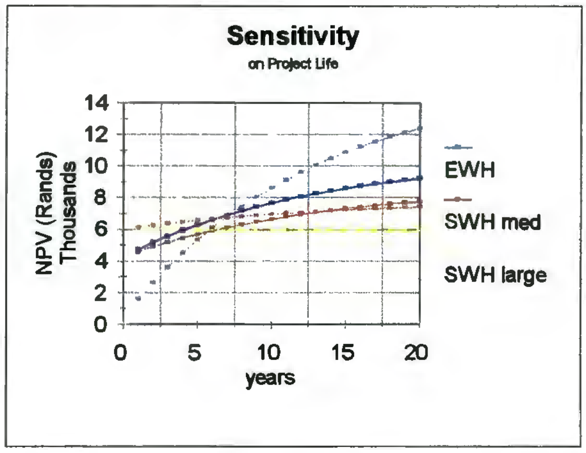
Financial Analysis Sensitivity analysis (contd)

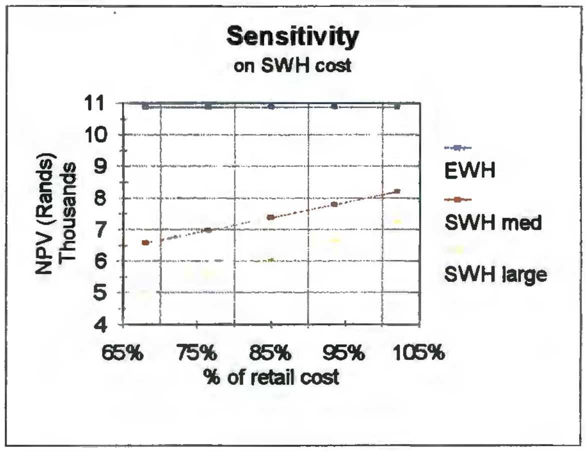


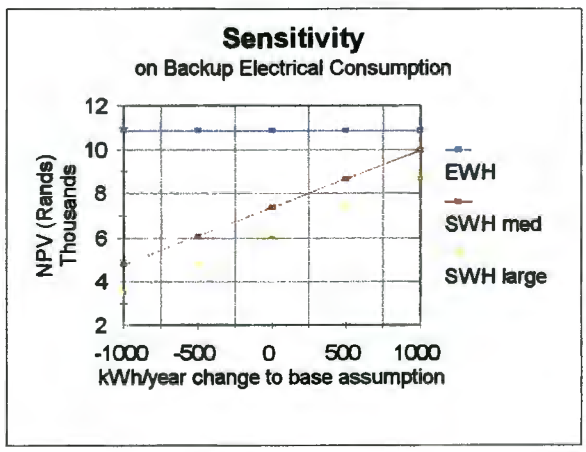


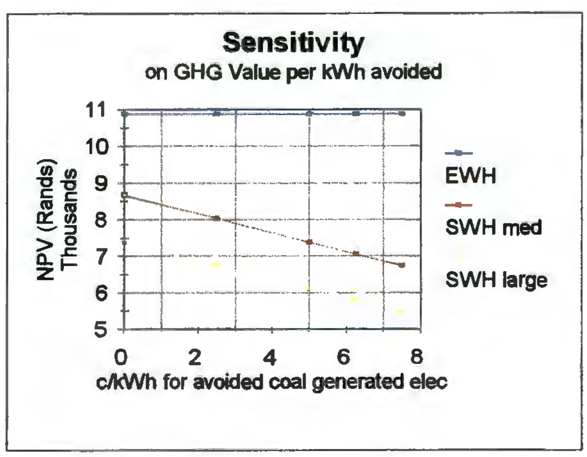


Economic analysis Sensitivity analysis (contd)









Appendix B Retail Costs of SWH

All costs exclude VAT
15% rebate for offered for bulk purchases

Transport to Durban from Cape Town	R 200 per unit for bulk purchases
Close coupled units	
150 litre 2.3m² collector	R 4 199
200	R 4 318
250	R 5 860
300	R 7 276
Valves and pipes etc	
vacuum breaker	R 45
air release valve	R 55
non-return valve	R 22
gate valve	R 26

Installation of close-coupled unit , excluding any specialised mountings, including installation kit
R 700 +R 300 = R 1 000

Split systems
Collectors only

2.3 m²	vertical	R 1 821
	horizontal	R 2 007
2.9 m²	vertical	R 2 355
	horizontal	R 2 355
3.3 m²	vertical	R 2 687
	horizontal	R 2 780

Cylinders / Geysers copper adjustable 200kPa

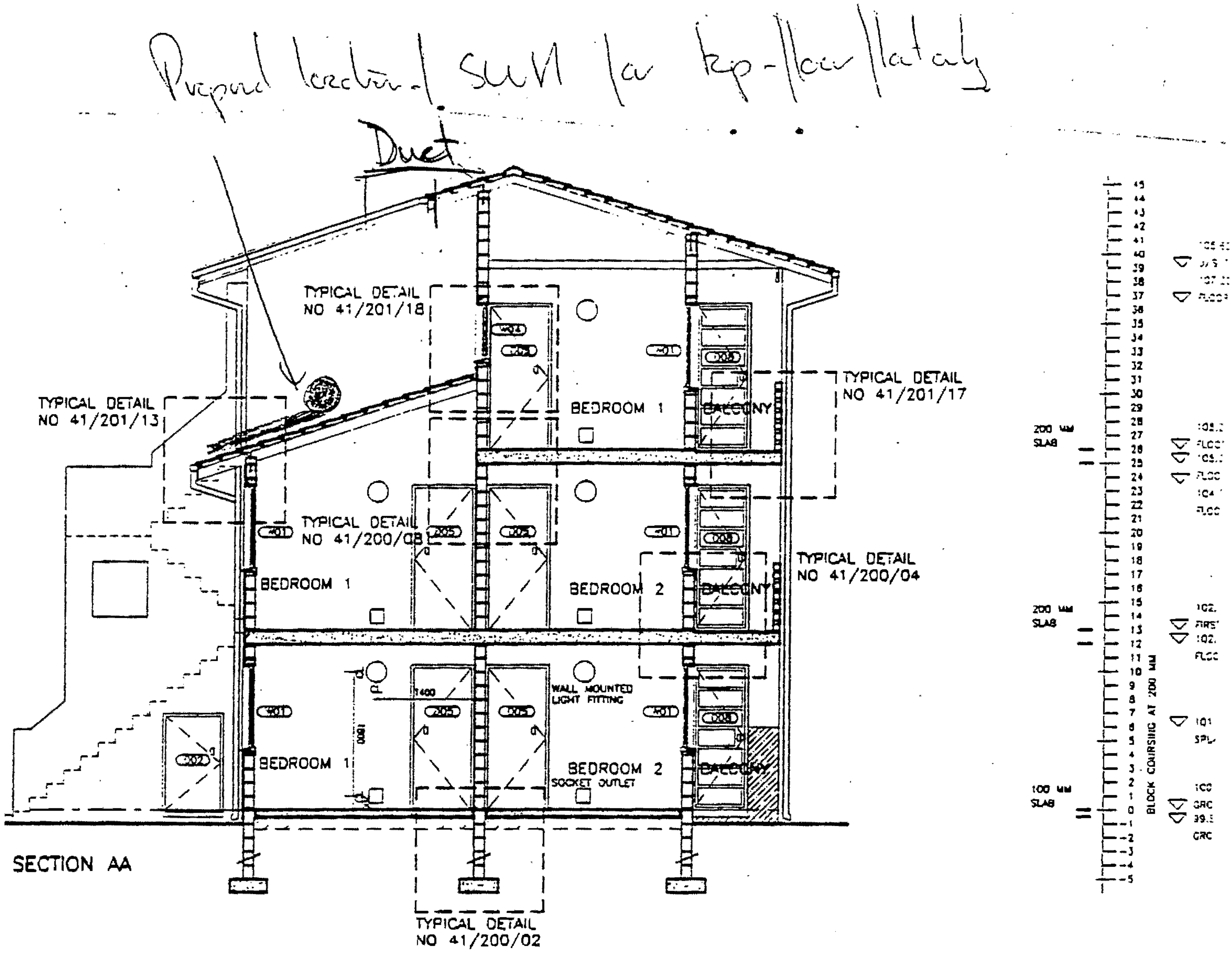
150 litre	R 1 784
200 litre	R 1 859
250 litre	R 2 177
300 litre	R 2 364

Circulation pump with solar panel
R 780

Installation for split system, collector and geyser within 5m of each other;
R 1300 + R 300 + R100 = R1400

Appendix C

Site plans and model photo's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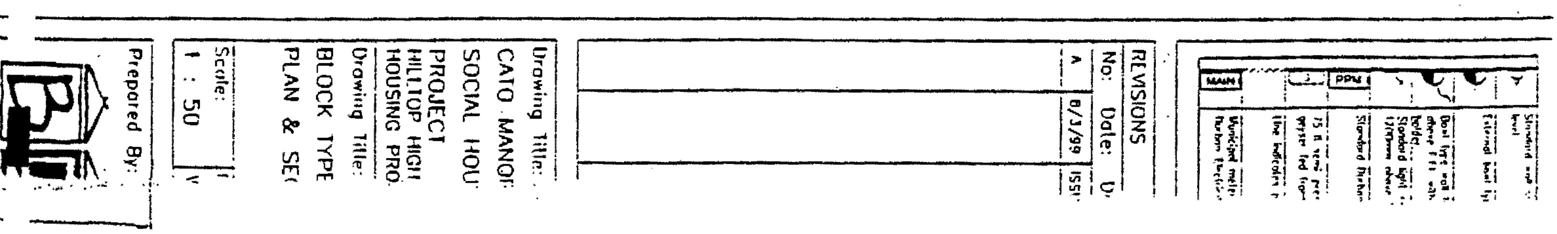
TYPICAL DETAIL NO 41/201/13
TYPICAL DETAIL NO 41/201/17
TYPICAL DETAIL NO 41/200/08
TYPICAL DETAIL NO 41/200/04
TYPICAL DETAIL NO 41/200/02
BEDROOM 1
BEDROOM 2
BALCONY
WALL MOUNTED LIGHT FITTING
SOCKET OUTLET
200 MM SLAB
100 MM SLAB
BLOCK COURSING AT 200 MM
SECTION AA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SOCIAL HOU
PROJECT
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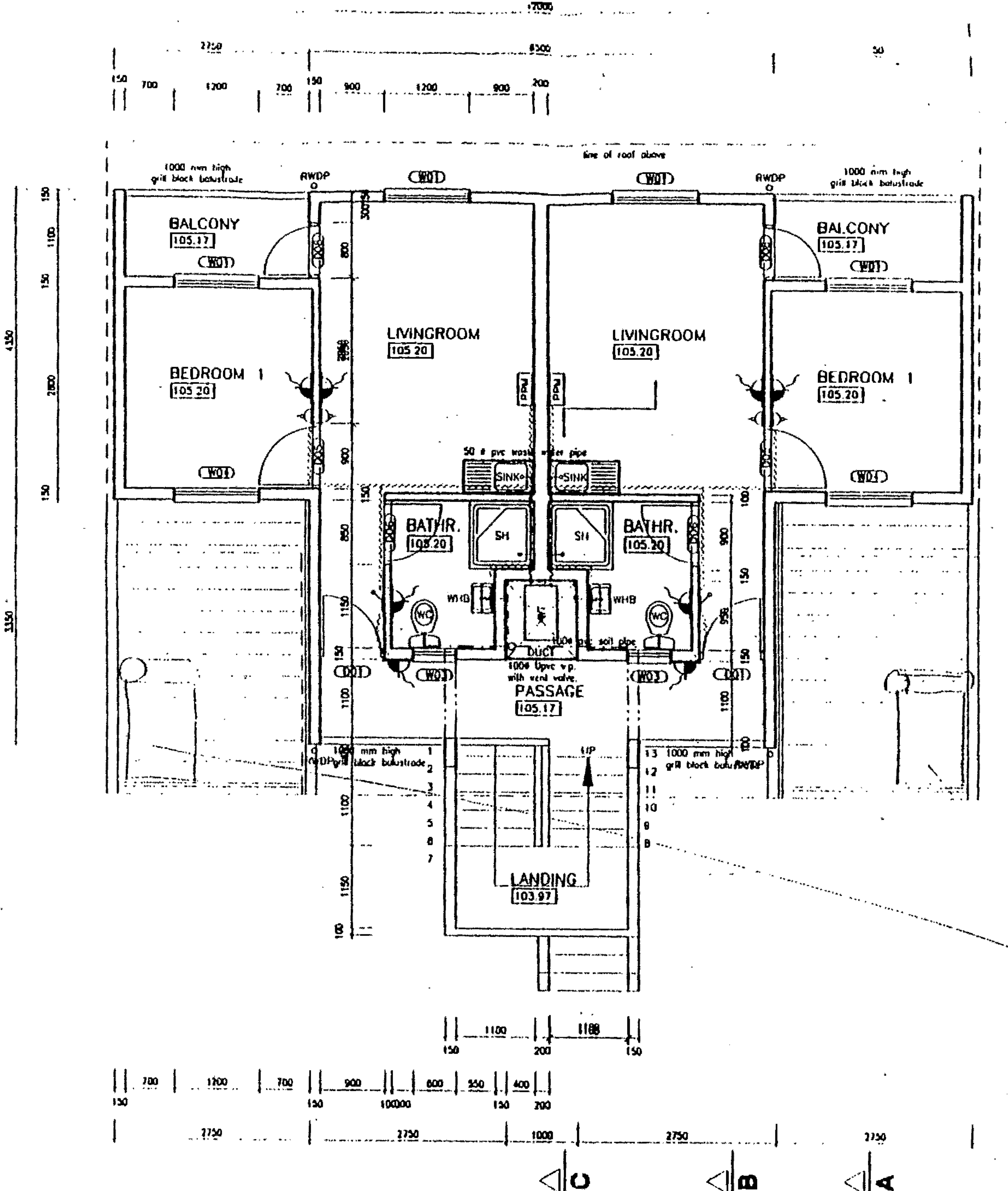
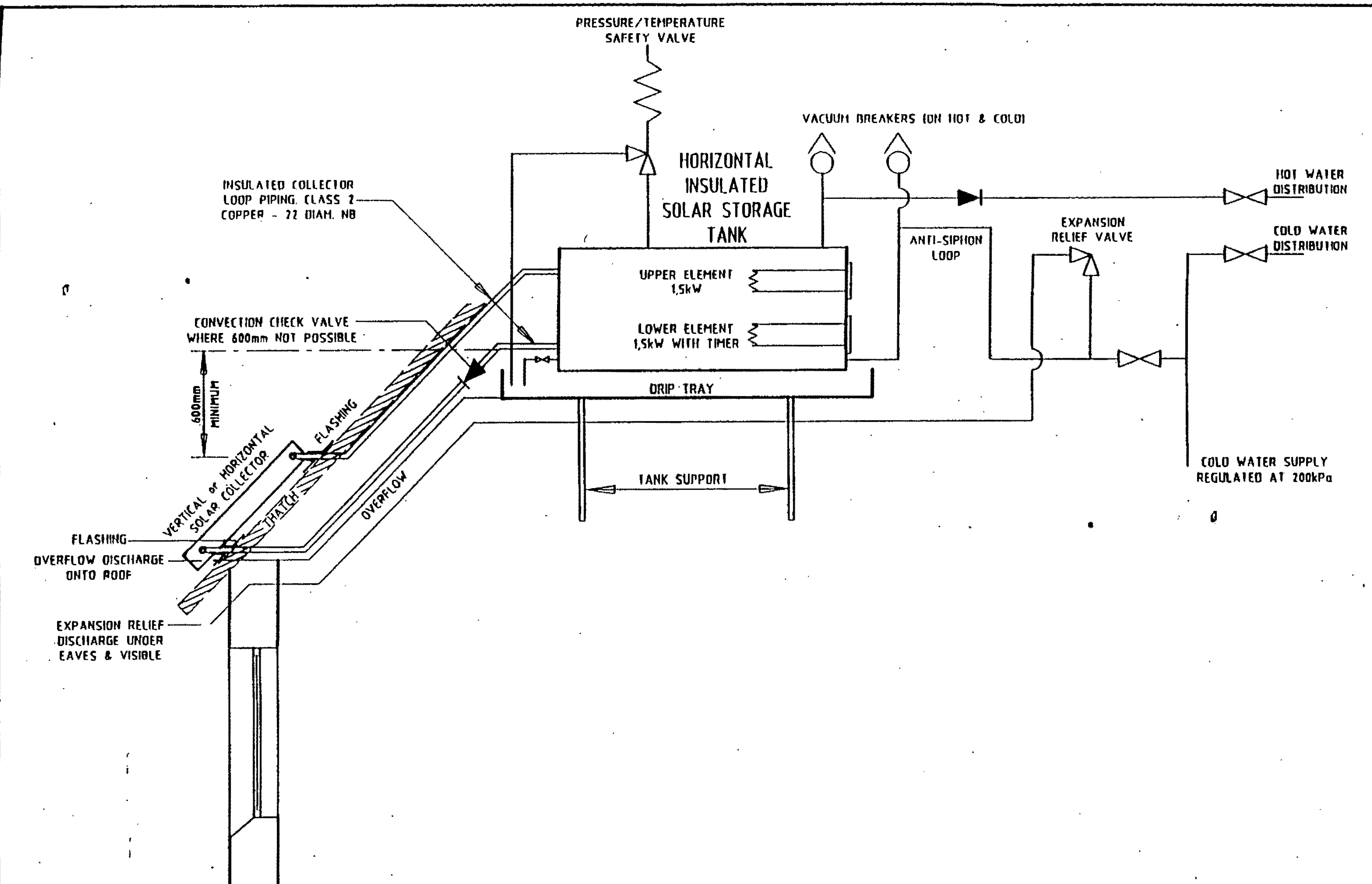
REVISIONS
No: Date:
A 8/3/99



SECOND FLOOR

Appendix D

SWH requirements



SPLIT DOMESTIC SOLAR WATER HEATING SYSTEM
100 - 300 LITRES AT 200kPa / 1,6 - 4,2m²

ENERGY & DEVELOPMENT GROUP
P O Box 281, Noordhoek, 7985, SOUTH AFRICA

SOUTHERN AFRICAN WILDLIFE COLLEGE

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