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Appendix 1

1.1 Data from prototype CMTRWHS (Yield and Rainfall)
1.2 Calculation of WSE values from prototype
1.3 Calculation of $Q/Q_0$ for CMTRWH systems
**Appendix 1.1:**

Appendix 1.1 shows the recording of daily rainfall (R) in mm and the corresponding yields $Y_1$ and $Y_2$ from the prototype CMTRWH system (3 Tank model) in m$^3$ from 1st March to 30th April 2010 in Colombo.

**Appendix 1.2:**

Appendix 1.2 shows the water saving efficiency (WSE) values from 1st March to 30th April 2010. It should be noted that a special technique of moving average method is used in calculating the annual rainfall and yield, extrapolated from 15 consecutive days. For parent tank capacity ($S_p$) of 12.5 m$^3$ and upper tank capacities of 1 m$^3$ each with a roof collection area ($A$) of 50 m$^2$, demand fraction $D/AR$, storage fraction $S/AR$ and the corresponding WSE values are found and recorded from the charts to be compared with the calculated values.

**Appendix 1.3:**

Appendix 1.3 shows the calculation of rainwater quantities that can be pumped up from the parent tank of a three tank CMTRWH system for a daily household demand of 300 L, roof collection area $A$ of 50 m$^2$ and with the system located in Colombo where the annual average rainfall is 2500 mm. The parent tank capacity is of 12.5 m$^3$ while the two upper tanks are of 1 m$^3$ each. Also shown is the quantity of make-up water required and the total pumping energy required as a percentage ($E\%$).
Appendix 2

Data on overflow quantities from prototype RWHS
Appendix 2:

Appendix 2 shows the recording of annual volumes of overflows for storage capacities of 1, 1.5, 2 and 2.5 m$^3$ at daily demands of 100 L and 200 L for a roof collection area (A) of 25 m$^2$ and average annual rainfall of 2500 mm from 1st January 2009 to 31st December 2009 in Colombo. Notation [Y,D200,S1] indicates the daily yield from a CTTRWH system of 1 m$^3$ total storage capacity under the daily demand of 200 L. OF 1/200 denotes daily overflow quantities from a 1 m$^3$ storage capacity. For brevity calculations for the period from 31st January to 15th March 2009 are shown in the Appendix. The rest of the calculations are presented in an Annexure to the Thesis.
Appendix 3

3.1 Data from prototype battery assisted SAPV system (OCV values)

3.2 Calculation of $C_S$ and $C_A$ values from prototype.
Appendix 3.1:

Appendix 3.1 shows the recording of daily open circuit voltage (OCV) values in Volts across the storage batteries of SAPV modules with exposure areas of 0.25 m² along with daily global solar radiation values for a constant daily load of 120 Wh and 130 Wh in Colombo (Wet region) and Anuradhapura (Dry region) respectively for the period from 1st January to 15th February 2008.

Appendix 3.2:

Appendix 3.2 shows the calculation of State of Charge (SOC%) values for deep cycle lead acid batteries of 100 Ah capacities using VDC vs. SOC% Charts. Daily available energy balance is calculated from the corresponding OCV values and SOC% values for 100Ah batteries and Cₛ values are calculated by subtracting the value of Energy Balance (EB) divided by the daily load by the corresponding figure when the batteries are at full capacities. In the Table Ca*1.25, Ca*1.5 and Ca*2 denotes the area of exposure of PV array compared to the area of exposure of Ca which is of 0.25 m². ‘Ebal’ denotes energy balance in the battery in Wh, EB/L gives Energy Balance divided by the average daily load L in days and OCV denotes open circuit voltage across battery terminals. For brevity only the calculations for the period from 1st January to 15th February is shown in the Appendix. The rest of the calculations are presented in an Annexure to the thesis.
Appendix 4

4.1 Solar radiation data measured in Colombo, 2009 (National Meteorology Dept. of Sri Lanka)

4.2 Solar radiation data measured at site – Colombo and Anuradhapura

4.2 Calculation of monthly average daily solar radiation in Colombo,

4.3 Calculation of regression coefficients for $K_{T(Clear)}$ and $K_{T(Overcast)}$

4.4 Calculation of incident solar radiation on a tilted surface.
Appendix 4.1:

Appendix 4.1 shows the measured daily global solar radiation data on a horizontal surface for Colombo in 2009. Data obtained from the Meteorological Department of Sri Lanka.

Appendix 4.2:

Appendix 4.2 shows the site measured daily global solar radiation data on a horizontal surface for Colombo and Anuradhapura in 2009.

Appendix 4.3:

Appendix 4.3 shows the calculation of daily extra-terrestrial solar radiation for Colombo. It also shows the recordings of weather data obtained from the Meteorological Department of Sri Lanka to calculate clearness indexes for the selected locations.

The symbols in the Appendix denote the following:

- **S** - Daily sunshine duration in hrs
- **ET** - Extra Terrestrial
- **H** - Global radiation in MJ/m²
- **T** - Temperature in °C
- **TD** - Temperature Difference (T_{max} – T_{min})
- **KT’** - Provisional Clearness Index
- **KT TD** - Clearness Index (Hargreaves-Samani Correlation)
- **KT angr** - Clearness Index (Angstrom Correlation)
- **KT mod** - Clearness Index (Modified Angstrom Correlation)
- **Sat avg** - Monthly average daily solar radiation from Satellite data
- **KT rain** - Clearness Index (rainfall model Correlation)
Appendix 4.4:

Appendix 4.4 shows the calculation of turbidity factor and regression coefficients to determine $K_{T(Clear)}$ and $K_{T(Overcast)}$.

Appendix 4.5:

Appendix 4.5 shows the calculation of tilt factor $R_m$ to determine the incident solar radiation at a given location in Sri Lanka for tilt angles $0^0 – 90^0$ in $15^0$ intervals for the 12 calendar months using data from SWERA and NREL.
Clearness index in clear sky conditions

\[ (K_T)_{Ch} = 0.83e^{-0.026TI/Sin h} \]

\[ TI = \{(h+85)/(39.5e^w + 47.4) + 0.1\} + (16 + 0.22w) \beta \]

Regressions for different solar heights

<table>
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<th>H (rad)</th>
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<th>Sin h</th>
<th>K T clear</th>
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<td>1.0.14252</td>
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</table>

Clearness index in overcast sky conditions

\[ (K_T)_{Oh} = a + b(cc)^2 \text{Sinh} + c (cc)^2 + d \text{Sinh} \]

<table>
<thead>
<tr>
<th>Range of h</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
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<tbody>
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<td>40^0 ≤ h ≤ 60^0</td>
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<td>-0.0467</td>
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<td>0.6423</td>
<td>0.9109</td>
<td>-1.2873</td>
<td>0.1222</td>
</tr>
</tbody>
</table>

Appendix 4.3