Chapter 6

Conclusions and Recommendations

6.1 Conclusions

(a) A simple built-in-storage (BIS) solar water heater has been designed. The system has adopted a check-valve in the flow passage to act as a thermal diode in order to prevent reverse thermosyphon flow of hot water out from the storage during the night. An insulated partition is installed between the collector and storage in order to prevent the heat losses from the system through the front transparent cover. The structure of the system is rather simple hence it is not difficult for local technicians in rural area to construct and maintain. The total cost for construction of the system is about 32,000 Bath (see cost breakdown in Appendix D). It is cheaper than the locally-made conventional solar water heater used for simultaneous tests in this study which costs about 36,000 Bath.

(b) Several experimental tests conducted on the constructed BIS solar water heater under various climate conditions reveals that the check-valve in the system can reduce the reverse circulation of hot water at night and an increase of about 5 % in the average storage efficiency has been found. Comparisons with a locally-made conventional solar water heater which were tested simultaneously under the same varied meteorological conditions have shown that the developed BIS system can produce a comparable amount of energy contained in the hot water stored in the tank for uses in early morning to that produced by the conventional system. Hence the simple design and construction of the developed BIS solar water heater which requires low initial cost would be beneficial to users in rural or remote areas.

(c) A mathematical model has been formulated for simulating the transient thermal performance of the developed BIS solar water heater operated under varying weather conditions of solar irradiance, ambient temperature and wind speed. The model consists of the submodel for three components of the system, i.e. absorber plate collector channel and storage tank. Almost all performance characteristics for components in each submodel can be obtained from either manufacturers' specifications or direct measurements except the very slow thermosyphon flow, which is very difficult to measure accurately. Hence, a submodel for estimating the thermosyphon flow rate along the flow circuit between the collector channel and storage tank has also been proposed. An overall flow coefficient K_f has been introduced in the submodel to reflect the overall effects of various frictions occurring along the water flow passage. Procedure for determining the value of K_f from the experimental test conducted on the BIS system has been described. Finally a computer simulation package is written based on the developed model.

(d) Using experimental data obtained from various test runs on the BIS system under different operations of check-valve, the values of K_f determined according to the above-mentioned procedure have been successfully found to be consistent, that is higher K_f which results in higher flow rate is obtained when the check-valve is forced fully open. Hence the overall flow coefficient K_f can be used as a performance parameter for the BIS system.

(e) The developed simulation model has been used to simulate the thermal performance of the constructed BIS system using the meteorological data obtained from the experimental tests as inputs to the computer program. It has been found from the comparisons that most system performance results predicted by the simulation model satisfactorily agree with these corresponding values observed from the experimental tests. The deviations found are within ± 12 %. Therefore it can be concluded that the developed simulation model can be used for analyzing the thermal performance of BIS solar water heating system and for further development in sizing the system to meet the load requirements under the meteorological conditions at the site location.

6.2 Recommendations for Further Investigations

Several further investigations should be carried out in order to fully utilize the developed simulation model in analyses to improve the BIS system performance as well as to improve the model prediction accuracy. The following suggestions are therefore recommended:

(a) Investigation on the effect of the size of water flow passage in the collector channel as well as the size of the check-valve on the thermosyphon flow rate of water which may consequently affect the system thermal efficiencies.

(b) Investigation on the effects of thickness of the insulated partition between the collector channel and storage tank as well as the type of insulated materials and their conductivities.

(c) Adoptation of a well-recognized minimization method for uses in determining the best value of the overall flow coefficient K_f from the experimental data.

(d) Investigation on the causes of the discrepancies in predicting the water temperatures in the collector channel (T_{fm}).

Once all the above mentioned investigations have been done, an optimization should be carried out to determine the optimal size of the BIS system which meets the requirements of load under any specific location in which its local meteorological data are available.