# ENVIROMENTAL FRIENDLY TRANSTHERMAL DDC HEAT PUMP ENERGY TECHNOLOGY

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**Abstract**
The advanced 'Transthermal SYM' heat pump for aquatic indoor swimming centres utilises a multiple number & a variety of heat exchangers. That have the capability of transferring energy directly, alternatively and indirectly. Smart heat pump energy transfer systems that reduce $CO_2$ and energy consumption, for a number of single or multiple simultaneous demand energies, that maybe required from heat pump processes, including use of natural ambient energy and waste energy. The paper discuses the design, implementation and integration of component heat transfer assemblies with fans, compressor, pumps, mechanical services, inverters other equipment employed. The engineered applications for heat pump multiple functions that include an evolving family of applications for heating, ventilation air conditioning and reduction of associated energy systems that service the buildings energy requirements. The direct digital micro computer control system provides the optimum operational control, utilising the designed network of COP management functions to provide dehumidification (De-hum.), ventilation, space cooling, heating, pool heating, and water filtration with water and energy recovery. This is essential for minimising energy use and achieving the optimum functional COP outputs, for all year round energy demands.

**Key Words:** Transthermal, Heat Pump, Heat Exchangers, Heat Transfer Assemblies, Increasing COP Operational Efficiencies.

## 1 INTRODUCTION

### Heat Pump Energy Transfer Technology for Aquatic Indoor Pools Facilities & Alternate Energy Demand Management

The Transthermal SYM heat pump system has incorporated refrigerant control heat transfer assemblies that connect with heat transfer equipment and other components for simple control with efficient, effective deviational control of refrigerant flow for multiple heat exchangers incorporating Bi-flow (reverse cycle) heating and or cooling capability for each individual heat exchanger and or Tri - flow configurations using three heat exchangers e.g. combination of one evaporator and two condensers to minimise use of separate individual prioritised conventional heat pump systems that would contain a greater number mechanical, electro mechanical, components, heat exchangers, compressors and refrigerant required to provide heating and cooling functions for more than one purpose.

The heat pump refrigerant control heat transfer assembly, utilising a compressor, delivering compressed refrigerant to selected exchangers via, a number of four way valves (reversing valves) to deliver refrigerant to a first, second, third or fourth condenser heat exchangers (reverse cycle condenser / evaporator), connected together with the first, second, third, fourth thermostatic expansion valves, which selectively delivers expanding refrigerant to the evaporator heat exchanger (dual function evaporator /condenser). A multiple number of assorted exchangers discharges, suctions and liquid pipe connections for refrigerant flows to each is needed to complete the system, so that each of heat exchange are able to invert their function of cooling (Evap.) and heating (Cond.) with one control signal for each.
We have assigned a entity named for the heat exchanger connected with a four way valve and call this a 'component heat transfer assembly' (CHTA). With number of these interconnected together as a 'network of assemblies' (NWA).
The component heat transfer assembly (CHTA) has working default functions which are:

**Default No.1** Exchanger pumped down / ready for evaporating cooling or condensing gas heat, to be applied too.

**Default No.2** Compressor discharge gas is diverting to another or more component heat transfer assemblies of the same.

**Default No.3** The active energised on control function selection engages discharge gas for heating the exchanger or by passing gas.

Because the four way valve has fully open port valve design there is very little inherent pressure drop losses for reversible discharge or suction gas transfer, compared to conventional single direction orifice ported suction or discharge gas solenoid valve hardware or other control valves such as hot gas by pass valves that do not allow bi directional or reversible flow, this in itself creates great disadvantages, when a greater number control valves and inputs are required to provide the equivalent function, this inherently has a greater number of pressure drop losses decreasing efficiency associated with this prior art of refrigerant system control design.

The network assemblies have Bi-directional, Tri-directional & Mono-directional capabilities with efficient low loss four way control valves that only need one control signal for each of component heat transfer assembly's that are contained within the network of assemblies.

These heat pump transfer systems provide simple way of networking the transferring of energy or waste energy for multi purposes and is the key factor in obtaining and delivering high coefficient of performances (COP'S) with the (DDC) microprocessor selecting functions of one, two or more alternate energy needs that can be satisfied simultaneously and have only one primary energy input kW. The microprocessor controls system monitors the 24hour load requirements and determines within the best 24 hour operating time period for simultaneous operation to occur to achieve the best (COP) macros functions for all the selected energy loads. This provides selectable COP envelopes for high energy efficiency ratios (EER's) with "sweet spot" operating conditions in respect to compressor and component needs. That achieves the maximum return for each kW spent for the assembled energy loads.

The DDC microprocessor control centre receives data from the sensors and transducers which flows back to the direct digital control. It is then filtered through proportional bands with the introduction of integral and derivative constants to enable it to apply the processing of all data and control for all the four stages of heat pumps equipment components in the network functions and the configurations for management of multiple COP macros operational programs. The processing incorporates the interfaced of variable speed drives (VSD"s) with direct and reverse acting proportional bands, integral and derivative constants, and dead bands. The global points include time based sequencing for low tariff control, and inrush current limiting, for streamlining the operation process, The COP management objective is focused on use of power, reusing and transferring energy for space comfort utilising the best advantage of natural energy resources to maintain the conditions in the pool and indoor facilities. The sourcing of any of the networks modular four stages of capacity control work in a unison function, or providing four mixed functions from the unloaded stages for energy recovery. The heat pump transfer system provides a simple way of transferring energy or waste energy for other purposes and is the key factor in obtaining and delivering high coefficient of performances. With the ability to selects two or more alternate energy loads that can be satisfied at the same time with one primary input of kW (kilowatts). The DDC control continually monitors the load requirements across all of the load centres and determines the best operating function or time period for simultaneous operation to occur. By the use of all the data flow and the many preloaded macros the controller can achieve the best (COP) for all the energy loads presented at any time. The envelopes for high energy efficiency are controlled using all the refrigeration components, fans and water pumps held in the efficient operating envelopes ("sweet spot") required to achieve and maintain the maximum efficiency for each mode and kW's of input expended.

## 2 AQUATIC INDOOR POOL FACILITIES HEAT PUMP ENERGY MANAGEMENT

### Clem Jones Aquatic Indoor Swimming Pool Centre

The board of directors of the centre were looking for solutions for the indoor pool facility as conventional combination of equipment that has been used in the project for ventilation, dehumidification, air conditioning systems & pool heating heat pump has contributed to high equipment capitol, operational and maintenance costs with low performance.

### Design Considerations for Indoor Pools

The Science of Indoor Heated Swimming Pools with High Operation Costs:

1. Comfort Levels of space temperature, humidity and pool temperature.
2. Guests patrons and the levels of activity (bathers and spectators).
3. Moisture evaporating from the water and spill surfaces.
4. Fresh air unconditioned outdoor air being introduced.
5. Exhaust air ventilation humidity ingress & egress.
6. Building thermal dynamics design.
7. Air Conditioning space cooling & heating.
8. Dehumidification.
9. Pool thermal storage mass design, filtration, hydraulics and sanitation.
10. Water make up, back wash, water & energy retention.
11. Primary resources of energy and energy recovery.

Due to the application of conventional number of equipment apparatus that where designed to specific prioritised demands such ventilation, de-humidification cooling system, air handling & air reheat using heat pump heater, pool heat pumps a number of four or more individual energy consuming tasks that have high capital equipment cost for replacement, associated with a very high running cost to comfort ratio.

Objectives of overcoming the disadvantages of multiple conventional systems with engineered advantages of multi-function heat pumps, to satisfy the objectives. The design solution to combined all apparatus for a holistic heat pump fusion of refrigeration, air conditioning, air handling, air replenishment, heating & mechanical services components into a multi function heat pump system, that is able to manage the change of seasonal heat load conditions, to combined control & integrate all the required equipment components to process the energy loads that can maximise cooling and heating and recovery from the multi heat exchanger assemblies, with programmable heat pump COP function cycles, that include the use of outside ambient air conditions as resources with filtration, pool water circulation & pool thermal storage mass for the indoor conditions of comfort, psychometrics and pool heating, eliminating the use of multiple conventional demand systems hard ware.

### Clem Jones Aquatic Centre Technical Design Criteria for Indoor Pool,

Technical design criteria assessment with thermal heat load modelling software evaluations identifying the following design conditions:

Pool Design: Pool surface area = 550m$^2$, Pool Volume = 700m$^3$, Build Volume = 1260m$^3$,
Area of roof and walls = 1260m$^2$, Thermal resistance of roof and walls (m$^2$/K/w) = 0.5
Buildings thermal design characteristics: Space heat and cooling load kW @ 27$^0$C,
Fresh inlet replenishment air changes/hr. and exhaust outlet air changes/hr. @ 12$^0$C to 35$^0$C
Outside ambient fresh air ventilation air conditioning @ 10$^0$C to 35$^0$C.
Indoor energy loads requirements: Dehumidification kW @ 65 to75% RH, Internal ventilation & sensible losses and gains load kW's, Pool Heating = 200kW, Number of swimmers /day, Pool water heating and filtration pump and back wash make up load.
Pool Hall Operational Times: Heat retention blanket use, off @ 6am and on @ 6pm times.

## Multi-Function Heat Pump Plant Operation for the Network of Design Functions

The number of functions required to manage thermal, psychometric and ventilation requirements using the ‘component heat transfer assembly’ of four way valves with water, air heat exchanges, fans, compressors, and pumps etc. The network operating functions for refrigerant transfer are classified and named as a Basic heat pump energy function (BF), Dual heat pump energy function (DF) and Triple heat pump energy functions (TF) of operable component configurations and these are as follows:

No.1 Pool heating (BF), No.2 Dehumidification (DF), No.3 Space Cooling (BF), No.4 Space Heating (BF), No.5 Dehumidification & Pool Heating (TF), No.6 Pool Heating & Space Cooling (DF), No.7 Space heating & Pool Heating (DF), No.8 Outside air, Exhaust air, Return air volume control used with (BF,DF,TF), No.9 Water circulation for heating & filtration used with either (BF,DF,TF), No.10 Ambient outside air fan coil evaporator / condenser volume control used with either (BF,DF,TF). The Transthermal SYM5000 DHA/CPH Multi-function heat pump dehumidifier and pool heater energy system, with Heating capacity 250kW, Cooling capacity 150kW, Input kW of 45kW has the selected ‘component heat transfer assemblies’ for the COP energy management that will satisfy the objectives.

## The Selectable Multi Functions for COP Management

The network for the individual functions is listed No.1 to 7 as follows:

No.1 Pool Heat utilising ambient air resources basic function (BF).

No.2 Dehumidification, cooling with sensible air heating for space air re-heat (DF).

No.3 Space Cooling with sensible and latent heat removal rejected to ambient air (BF).

No.4 Space Heating, (sensible heating) using ambient air recovery resources (BF).

No.5 Dehumidification Cooling with Pool heating, sensible heat recovery proportionally distributed to space air re-heat and pool water re-heat recovery (TF).

No.6 Pool Heating and Space Cooling, sensible and latent heat recovery to pool water thermal storage mass (DF). Indoor condition

No.7 Space Heating and Pool heating using ambient air resources (DF)

No.8 Outside air volume control load for fresh replenishment and space conditioning economy with outside air volume control dampers; equipment required for mandatory functions.

No.9 Pool water circulation for heating, filtration and sanitation; (VSD) driven equipment required for mandatory functions.

No.10 Ambient & Indoor Air Volume Control for Indoor fan coil and remote fan coil Evap. /Cond. (VSD) driven equipment required for mandatory functions.

This is the network of (DDC) logic macros functions that are selected to control each mode of operation required to provide system operation management.

Table 1 Logic Table for DDC Control System for Figure 1 Refrigerant control

| DDC Logic Function Description | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Controlled Components** | **HWP** | **PWH** | **CWP** | **AERE** | **RV1** | **RV2** | **RV3** | **BI-FV1** | **BI-FV2** | **TX1** | **TX2** | **C1** | **PP1** |
| No.1 Pool Heating | | X | | X | | | | | X | | X | X | X |
| No.2 Space Dehumidification | X | | X | X | X | | X | X | | X | | X | |
| No.3 Space Cooling | | | X | X | | X | X | X | X | X | X | X | |
| No.4 Space Heating | X | | | X | X | | | | X | | X | X | |
| No.5 Dehumidification + Pool Heating | X | X | X | | X | | X | X | | X | | X | X |
| No.6 Pool Heating + Space Cooling | | X | X | | | | X | X | | X | | X | X |
| No.7 Space Heating Pool Heating | X | X | | X | X | | | | X | | X | X | X |

**Nomenclature**

Hot water Plate Hex1 = HWP, Pool water Hex = PWH, Chilled water HEX = CWP, Remote air fin Coil = AERE, Reversing Valves 1 = RV1, 2 = RV2 and 3 = RV3, TX Valve 1= TX1, TX Valve 2= TX2, Compressor = C1, Pool Water Pump = PP1.

The conventional equipment was replaced, retro-fitted with a multi function heat pump for the Clem Jones Aquatic Centre. The comparison of old school engineering and new heat pumping technology will now be a studied assessment. The energy used in the comparison to the conventional heat pumps will undoubtedly be supported by the performance test carried out by the University of Sydney Mech Lab Australia.

**Multi-Function Heat Pump COP Comparison to Conventional Heat Pump COP**

The conventional heat pump systems were replaced and the corresponding COP's. Relative to their catalogue performance data at rated design conditions, numbered No's.1a to 3a and No.4a multi function heat pump with multiple COP's at rated design conditions listed in selectable multi function COP management list from No's.1 to 7 in a previous paragraph.

Referencing the summary performance data Table 2 and comparison in Table 3

No.1a Accent HWP80-3 80kW air to water pool heat pump input 19kW

No.1b Alto Pacific Model BS 230 64.8kW air to water pool heat pump input 12.80kW

No.2a One Air well Aqu@Logic AQL 130 water chiller for dehumidification and Space cooling. Extrapolated from catalogue performance data 131kW of cooling and input 47kW

No.3a One Air well Aqu@Logic AQL 130 water heater for dehumidification air re-heat. Extrapolated from catalogue performance data 170kW input 45kW

No.4a Multi Function Transthermal SYM5000 Dehumidifier pool heater energy system Heating capacity 250kW, Cooling capacity 150kW, input 40kW

**Full Load Capacities for Conventional and Multi Function Heat Pump Systems**

Full load energy consumption for No.1a, 1b, 2a, 3a all heat pump units totalling = 124.5kW

Mean tangible amount of energy displacement heating + cooling = 445.8kW / 123.8kW

Totalling over all net COP = 3.60

**Multi-Function Heat Pump Comparison No.4a**

Multi Function heat pump Transthermal SYM5000 DHA/CPH dehumidifier, pool heater with four stages. Heating capacity 250kW, Cooling capacity 150kW, Input kW of 40kW. Mean tangible amount of energy displacement heating + cooling = 400kW / 40kW = COP 10.0 when compared to conventional individual systems COP of 3.60 / COP of 10.0 = the total difference in systems performance doing 2.77 times more useable energy displaced than conventional individual equipment systems.

The advantage of using the DDC microprocessor is the flexible control of the system and the net work of functions, to process the best COP functions of Table 2 No's.1, 2, 3, 4, 6, 7 for maintaining conditions at any time, using unloaded stages according, to provide alternative heating, cooling or recovery that are required. The constant dehumidification load is the primary Function No.5 De-hum. Cooling and proportional space reheat + sensible pool heating is achieved simultaneously (TF) controlling the RH% constant, the alternate functions maintaining the highest COP's for pool heating and the changing buildings sensible heat load gains or losses from Summer to Winter with exhaust air, and proportional outside air supply from 0 to 100% for economy when outdoor ambient temperature & RH% conditions are favourable.

Compared to the conventional systems that have basic program logic controller with simple thermostats and RH controls for controlling the heat pumps in Table 3, which have a basic function, chiller or heater Heat pumps No. 2a Chiller and 3a Heater cannot provide energy recovery from waste heating or cooling from their operation for dehumidification waste excessive quantities of cooling and heating energy to the ambient so heat pumps No.1a, 1b are required to make up for any other losses in energy for pool heat or space conditioning therefore the input energy to run all the separate heat pumps increases dramatically in comparison to multifunction Transthermal SYM heat pump systems energy use.

**Table 2** Comparison Summary of Transthermal SYM5000 DHA/CPH Multiple Function Heat Pump Unit of four Stage COP Functions Results

| Results COP's No.1 to 7 | | Heating & or Cooling Technology Description | Indoor AC | Outdoor AC | Outdoor WC | Outdoor DS | Indoor DB / WB | Outdoor DB / WB | EWT / LWT WC | EWT / LWT DS | Input Power | Cooling Capacity | Heating Capacity | Desuper Capacity | Total COP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.12 | Pool Heating – Medium temp. | - | X | X | - | - | 27 / 21.7 | 26.7 / MS | - | 32.892 | - | 250 | - | 7.60 |
| | 6.11 | Pool Heating - Low Temp | - | X | X | - | - | 10 / 6.9 | 26.7 / MS | - | 35.200 | - | 164.4 | - | 4.68 |
| 2 | 6.5 | Space Dehumidification | X | - | | X | 27 / 19 | - | 12 / 7 | 30 / 35 | 34.568 | 150 | 199.56 | - | 10.11 |
| 3 | 6.2 | Space Cooling Medium Temp. | X | X | - | - | 27 / 19 | 35 / 24 | - | - | 46.4 | 129.212 | - | - | 2.79 |
| 4 | Expt. | Space Heating Medium Temp. | X | X | - | - | 27 / 19 | 27 / 21.7 | 30 / 35 | | 32.892 | - | 250 | - | 7.60 |
| | Expt. | Space Heating Low Temp | X | X | - | - | 27 / 19 | 10 / 6.9 | - | - | 35.2 | - | 164.4 | - | 4.68 |
| 5 | 6.9 | Dehumidification Pool heat | X | - | X | X | 27 / 19 | - | 26.7 / MS | 30 / 35 | 35.368 | 134.6 | 149.2 | 41.44 | 9.19 |
| 6 | 6.8 | Pool heat Space Cooling | X | - | X | - | 27 / 19 | - | 26.7 / MS | - | 39.908 | 150 | 230.232 | - | 9.53 |
| 7 | Expt. | Space Heating Pool Heat Med. | X | X | X | X | 27/ 19 | 27 / 21.7 | 27.0 | 30 / 35 | 32.89 | - | 208.56 | 41.44 | 7.60 |
| | Expt. | Space Heating Pool Heat Low. | X | X | X | X | 27 / 19 | 10 / 6.9 | 27.0 | 30 / 35 | 35.04 | - | 122.56 | 41.44 | 4.68 |
| Mediu. | Temp | Average Mean COP | | | | | | | | | 40.00kw | 140 | 228.4kw | | 9.21 |
| Low | Temp | Average Mean COP | | | | | | | | | 35.88kw | | 185.52kw | | 5.17 |

**Table 3** Comparison Summary of Conventional Heat Pump System to Multiple Function Heat Pump COP Functions Results

| Heat Pump Equipment No.1a to 4a | | Heating & or Cooling Technology Description | Indoor AC | Outdoor AC | Outdoor WC | Outdoor DS | Indoor DB / WB | Outdoor DB / WB | EWT / LWT WC | EWT / LWT DS | Input Power | Cooling Capacity | Heating Capacity | Desuper Capacity | Total COP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1a | Accent Reheem | HWP80-3 80kw pool heat pump | | X | X Heat | | | 25 / 18<br>15 / 12 | 27<br>27 | -<br>- | 19<br>17.5 | -<br>- | 95<br>80 | -<br>- | 5.0<br>4.6 |
| 1b | Alto Pacific | Model BS230 64.8kw Pool heat pump | | X | X Heat | | | 20 / 15<br>Not Given | 27<br>- | -<br>- | 12.8<br>- | -<br>- | 64.8<br>- | -<br>- | 4.8 |
| 2a | Air Well Email Air | AQL130 water chiller Dehum. | X | | X chill | | 27 / 19<br>- | 35<br>25 | 12 /7<br>12 /7 | -<br>- | 47.0<br>41.3 | 131.0<br>139.3 | -<br>- | -<br>- | 2.78<br>3.37 |
| 3a | Air Well Email Air | AQL130 water heater Dehum.<br>Interpolation | | | X Heat | | 27 / 19 | 15<br>25 | 40 / 45<br>40 / 45 | -<br>- | 45 | -<br>- | 170<br>185 | -<br>- | 3.77<br>4.11 |
| 4a | TET SYM 5000 | Multi Function heat pump<br>A/C Pool Heat hot water | X | X | X | X | 27 / 19<br>27 / 19 | 27 / 19<br>15 | 30 / 35<br>30 / 35 | 40 /45<br>40 /45 | 40<br>42 | 150<br>129 | 250<br>185 | -<br>- | 10.00<br>7.47 |

***Nomenclature for COP Results from Table 2 & Table 3***

AC = Air Cooled (Finned Tube Coil) condenser / evaporator for air conditioning & pool heat

WC = Water Cooled (Refrigerant-Water Heat Exchanger) for water heating or cooling

DS = De-super heater (Refrigerant-Water Heat Exchanger) for potable hot water heating

DB = Dry Bulb Temperature ( $^{o}$ C) under nominated test conditions

WB = Wet Bulb Temperature ($^{o}$ C) under nominated test conditions

MS = Manufacturer Specified, nominated test conditions

Additional input kilowatts for fan coil air handling equipment pumps etc not included for reasons of heat pumps to heat pump comparison of equipment COP’s energy only.

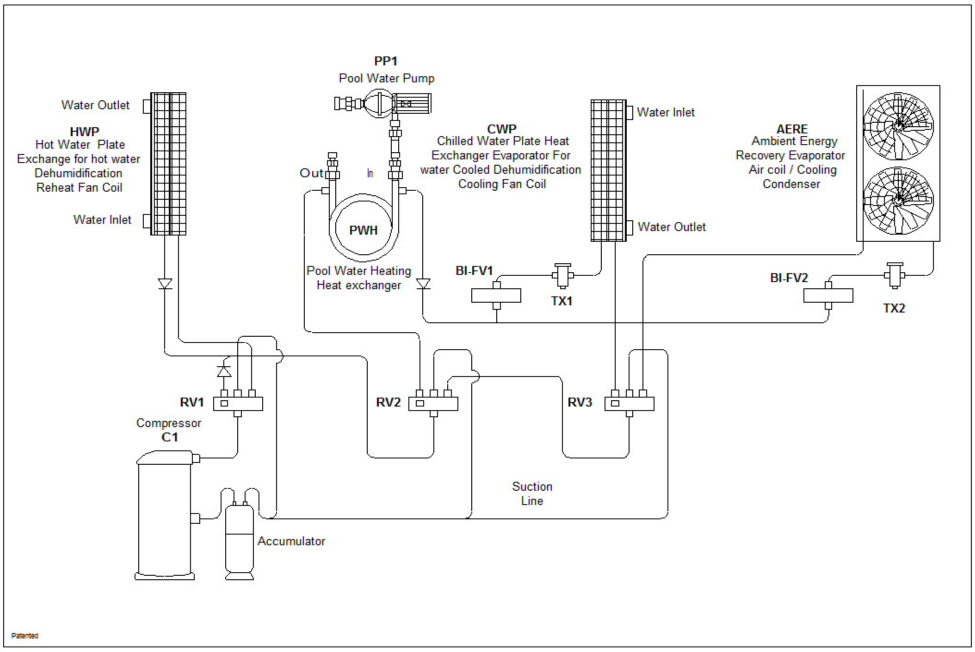


**Figure 1** Transthermal SYM DHA/CPH indoor pool multi function dehumidification heat pump system

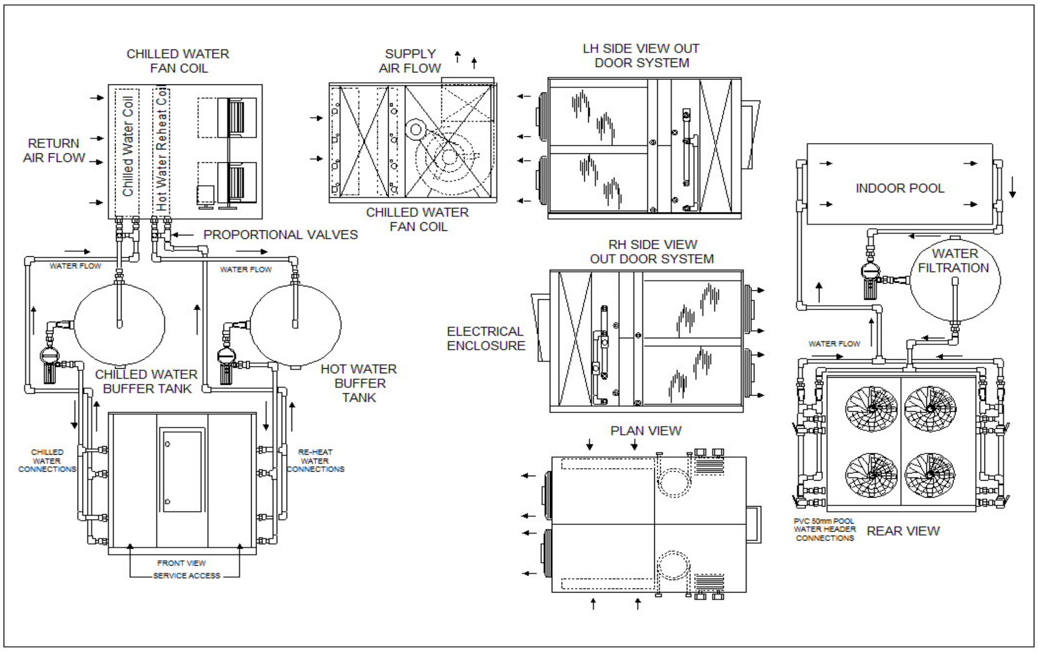


**Figure 1.1**, Aquatic indoor heat pump energy system

**MULTI -FUNCTIONAL HEAT PUMP THERMAL TRANSFER ASSEMBLY – SPACE AIR CONDITIONING, POOL HEATING AND HOT WATER HEATING**

Figure 2 is the first inception of a number of prototypes designed, built and installed into the residential homes. The system operates similarly to a conventional heat pump systems, although programmed functions minimise equipment components and the on and off operation cycles of the compressors, fans, pumps etc, that are required to provide all the seasonal functional demands for air conditioning, swimming pool heating & rapid recovery potable hot water with high temperature de-super heating. There was an immense wealth of operational knowledge & understanding gained from our heat pumping technology research, development and implementation experiences developing the multiple COP network functions for the Transthermal SYM1000 A/CPH pool heating and hot water heat pump.

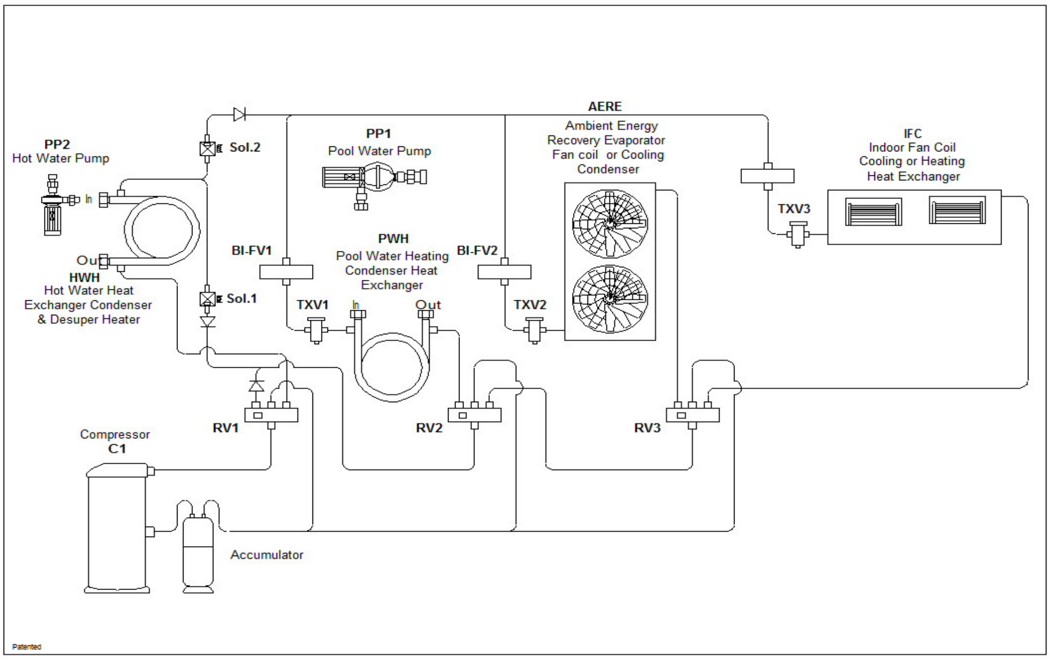


**Figure 2** Transthermal SYM A/CPH Air conditioning, pool heating and hot water heat pump system

**The Selectable Network Multi COP Functions**

Individual functions listed from No.1 to 8 as follows:

Refer to summary of Mech Lab performance test No.'s data in Table 4

No.1 Space cooling using ambient air (BF) Test No.1a 6.2

No.2 Space cooling rejecting waste heat energy into pool water (DF) Test No.3 (i) 6.8

No.3 Space cooling rejecting heat energy via de-superheater, for high temperature hot water maintenance with the pool heating and/or air conditioning or both. (DF, TF) Test No.4a (i) 6.9

No.4 Space heating using ambient air (BF) No. 7a (i) Expt.

No.5 Space heating via de-superheater using heat energy from the ambient air, for high temperature hot water maintenance; (DF) new function test data not available

No.6 Pool heating utilising ambient air; (BF) Test No.5a (i) 6.12

No.7 Pool heating utilising ambient air, rejecting heat energy via the de-superheater, during pool water heating for high temperature of hot water maintenance; (DF) new function, test data not available.

No.8 Hot water rapid ramp utilising ambient air (BF) new function, test data not available.

No.9 Pool and hot water circulation pumps for heating filtration and sanitation.

**Rapid Ramp Hot Water Heating, Condensing & De-superheating**

The rapid ramp condenser hot water heating function No.8 enables the volume of the tank to be ramped up quickly using the total heat rejected from the cooling cycle, or directly from ambient air, to be transferred directly to the storage tank to the safety limit of mechanical and refrigerant envelopes. Additional higher temperature de-superheating engaged during any additional running hours to achieve required temperature sanitation levels. This is preferable to operating separate systems solely dedicated to providing the energy required. This function creates an advanced approach for hot water heating de-superheating and condensing with minimal hot water reheating time.

De-superheat recovery has been used for many years as a method of energy recovery when installing air conditioning systems with quantifiable capacity. This has disadvantages due to limited periods of operational hours and the volume of potable hot water to be heated. This is always dictated by the unpredictability of use due to the random demands of domestic use of air conditioning systems which have a large enough capacity for tangible kW's of recovery in a short acceptable period of time.

**Performance Testing of Multi-Function Thermal Heat Pump Transfer Assembly & Test Conditions for Rated COP's**

The testing of the system to numerous local and international standards to quantify the performance characteristics under various rated conditions was very complex, as set out in the report summary test data Table 4. The performance testing of the proto type at the University of Sydney Thermal Research Laboratory MECH LAB AUSTRALIA Report Number: 700146b, to quantify the performance of the developed heat pump multiple functional heat transfer capabilities, we have been awarded the test results by MECH LAB AUSTRALIA. With testing completed the results directly prove the difference between conventional heat pump systems and the multi function systems. Moreover other different multi-function systems would emulate very similar performance characteristics to this.

**Heat Pump Equipment for Comparison of COP's**

Refer to summary performance test data Table No.4 and comparison Table No.5

No.1 One Accent Standard 38kW air to water pool heat pump, technical catalogue brochure rated performance, Accent HWP38kW input = 8.35kW

No.2 One Air well MFL100-3R410f reverse cycle A/C system Space cooling. Obtained from catalogue performance data 28.0kW of cooling and input 8.9kW

No.3 One Rehem HW20 -3 Hot Water heat pump water heater 400 litre, obtained from brochure catalogue performance data 20.49kW input 5kW

No.4 One Transthermal SYM1000A/CPH A/C heat pump pool & hot water heater energy system. Heating capacity 35.32kW, De-superheater capacity 4.537kW and cooling capacity of 27.055kW input kW of 7.301kw Mech Lab test data at rated design conditions.

**Full Load Capacities Comparison of Heat Pumps COP's**

**Conventional Individual Heat Pump Systems**

Full load input energy consumption for all heat pump units totalling = 22.25kW
Mean tangible amount of energy displacement heating + cooling = 86.49kW / 22.25kW
Totalling over all net COP = 3.88

**Multi Function Heat Pump Comparison Medium Temp**

Refer to summary performance test data Table 4 and comparison Table 5
Transthermal SYM1000 A/CPH A/C heat pump, pool heating and hot water system, Heating capacity, 35.32kW, De-super heater capacity 4.537kW and cooling capacity 27.055kW, Input kW of 7.301kw.
Mean tangible amount of energy heating + cooling done = 66.91kw's / 7.301kw = COP 9.16

And in comparison to conventional individual systems COP of 3.88 / COP of 9.61 = the total difference in systems performance showing 2.47 times more useable energy displaced than conventional standard equipment systems.

The advantage of DDC microprocessor controller that it monitors time & the temperature of the house, pool and hot water while the many preloaded macros software provides strategic energy programs that determine the best COP function in the selectable network function list the from No. 1 to 9 / Table 4 (Mech Lab test report) and time period for simultaneous operation to occur to meet many different needs such as pre-air conditioning of home, rapid ramping hot water with high temperature de-superheating during pool heating or air conditioning prior to residents returning home after the day's events or selectable modes for seasonal economy pool heating cycle or all year use, with off peak low tariff time based control sourcing for any additional energy required from the ambient.

Comparing to conventional single systems in Table 5 No.1, 2, 3 which are unable provide simultaneous heat transfer capabilities that recycle waste heating and cooling from their operation causing excessive amounts of cooling and heating energy to be wasted to the ambient moreover relying on the individual heat pumps for air conditioning needs, maintaining pool temperature and hot water heating, therefore the input energy to run all the separate heat pumps increases dramatically in comparison to multifunction Transthermal SYM heat pump systems energy use.

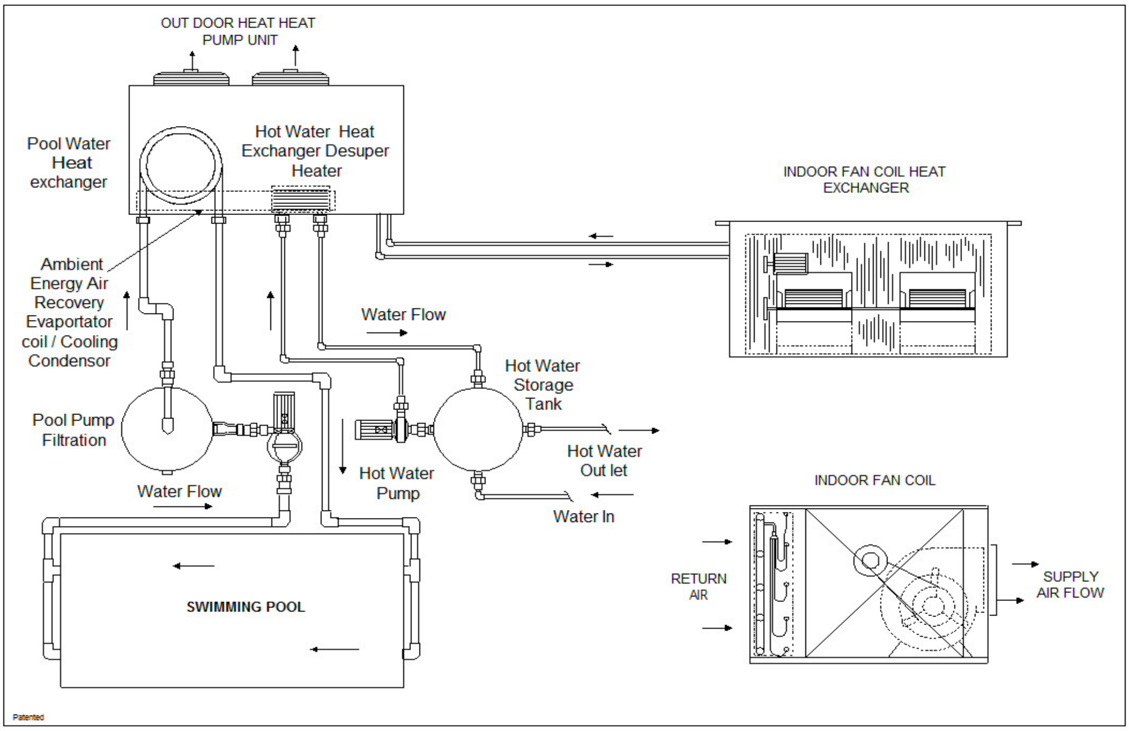


**Figure 2.1** Transthermal SYM A/CPH Air conditioning, pool heating & hot water heat pump energy system

## ***Nomenclature for Test Results from Table 4 & Table 5***

AC = Air Cooled (Finned Tube Coil) condenser / evaporator for air conditioning & pool heat

WC = Water Cooled (Refrigerant-Water Heat Exchanger) for water heating or cooling

DS = De-super heater (Refrigerant-Water Heat Exchanger) for potable hot water heating

DB = Dry Bulb Temperature ( $^{o}$C) under nominated test conditions

WB = Wet Bulb Temperature ($^{o}$C) under nominated test conditions

MS = Manufacturer Specified, nominated test conditions

**Table 4** Summary of Mech Lab Australia 700146bTest Results for Multi Function Heat Pump Thermal Heat Transfer Assembly

| Test | | Heating & or Cooling Technology | Indoor | Outdoor | | | Indoor | Outdoor | EWT / LWT | | Input | Cooling | Heating | Desuper | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | | Description | AC | AC | WC | DS | DB / WB | DB / WB | WC | DS | Power | Capacity | Capacity | Capacity | COP |
| 1a | 6.2 | Space Cooling (T1) | X | X | - | - | 27 / 19 | 35 / 24 | - | - | 8.517 | 23.803 | - | - | 2.79 |
| 2 (i) | 6.3 | Space Cooling (T1) + Hot Water | X | X | - | X | 27 / 19 | 35 / 24 | - | 35 | 9.012 | 25.217 | - | 6.883 | 3.56 |
| 2 (ii) | 6.4 | Space Cooling (T1) + Hot Water | X | X | - | X | 27 / 19 | 35 / 24 | - | 52 | 9.163 | 25.743 | - | 5.872 | 3.45 |
| 3 (i) | 6.8 | Space Cooling (T1) | X | - | X | - | 27 / 19 | 35 / 24 | 26.7 / MS | - | 6.553 | 27.383 | 35.058 | - | 9.53 |
| 3 (ii) | 6.5 | Space Cooling (T1) | X | - | X | - | 27 / 19 | 35 / 24 | 30 / 35 | - | 6.536 | 28.045 | 38.049 | - | 10.11 |
| 4a (i) | 6.9 | Space Cooling (T1) + Hot Water | X | - | X | X | 27 / 19 | 35 / 24 | 26.7 / MS | 35 | 7.251 | 27.413 | 33.650 | 5.526 | 9.18 |
| 4a (ii) | 6.10 | Space Cooling (T1) + Hot Water | X | - | X | X | 27 / 19 | 35 / 24 | 26.7 / MS | 52 | 7.301 | 27.055 | 35.321 | 4.537 | 9.16 |
| 4b (i) | 6.6 | Space Cooling (T1) + Hot Water | X | - | X | X | 27 / 19 | 35 / 24 | 30 / 35 | 35 | 7.287 | 27.485 | 33.383 | 5.360 | 9.09 |
| 4b (ii) | 6.7 | Space Cooling (T1) + Hot Water | X | - | X | X | 27 / 19 | 35 / 24 | 30 / 35 | 52 | 7.340 | 27.433 | 35.146 | 4.525 | 9.14 |
| 5a (i) | 6.12 | Pool Heating - Standard | - | X | X | - | - | 27 / 21.7 | 26.7 / MS | - | 5.380 | - | 40.892 | - | 7.60 |
| 5b (i) | 6.11 | Pool Heating - Low Temp | - | X | X | - | - | 10 / 6.9 | 26.7 / MS | - | 5.851 | - | 27.362 | - | 4.68 |
| 6 | Expt. | Pool Chilling | - | X | X | - | - | 35 / 24 | 26.7 / MS | - | 8.517 | 23.803 | - | - | 2.79 |
| 7a (i) | Expt. | Space Heating (H1) | X | X | - | - | 25 / 19 | 10 / 6.9 | - | - | 5.851 | - | 27.362 | - | 4.68 |
| 7b | Expt. | Space Heating (H1) | X | X | - | - | 25 / 19 | 27 / 21.7 | | | 5.340 | | 40.892 | | 7.60 |

**Table 5** Summary of Conventional Heat Pump Systems to Multiple Function Heat Pump COP Functions Results

| Heat Pump Equipment | | Heating & or Cooling Technology | Indoor | Outdoor | | | Indoor | Outdoor | EWT / LWT | | Input | Cooling | Heating | Desuper | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | | Description | AC | AC | WC | DS | DB / WB | DB / WB | WC | DS | Power | Capacity | Capacity | Capacity | COP |
| 1 | Accent Reheem | HWP38-3 38kw Pool heat pump | | | Heat<br>Heat | | 25 / 18<br>15 / 12 | 25 / 18<br>15 / 12 | 27<br>27 | -<br>- | 8.35<br>8.74 | -<br>- | 43.70<br>38.00 | -<br>- | 5.0<br>4.58 |
| 2 | Air Well A/C | MFL100 3R410f VRF heat pump Reverse Cycle | Cooling<br>Heating | | | | 27 / 19<br>20 | 35<br>7/6 | -<br>- | -<br>- | 8.9<br>8.9 | 28.00<br>- | -<br>31.50 | -<br>- | 3.21<br>3.53 |
| 3 | Accent Reheem | HW20-3 20kw Hot water heat pump | | | Heat | | | 20 / 16<br>Not Given | 61<br>- | -<br>- | 5.0<br>- | -<br>- | 20.49<br>- | -<br>- | 4.1<br>- |
| 4 | Trans SYM 1000A/CP | Multi Function heat pump<br>A/C Pool Heat hot water | X<br>X | X<br>X | X | X | 27 / 19<br>25 / 19 | 35 / 24<br>10 /6.9 | 26.7<br>26.7 | 52 | 7.301<br>5.851 | 27.05<br>- | 35.32<br>27.36 | 4.537<br>- | 9.16<br>4.67 |

## 4 CONCLUSION

The priority of objectives are focused on the points listed below, more over the designing of advanced high technology heat pump energy management systems for high efficiency products for the heat pump industry & the advantages compared to conventional prior art of separate individual equipment performance operations, therefore creating solutions for the heat pumping industries. Decreasing environmental impact and demand on society's infrastructure. Creating a new advanced way of achieving the optimum COP output for energy transmission from other resources, and I think one of the best heat pump ways to achieve this for an unlimited scope of industries sustainability & unlimited growth, for implementation into many areas like Building services, Aquaculture farms, Horticultural grower's enclosures, Food processor manufactures, Hotel Resort industries, Suburban heating & cooling loops for commercial, industrial and domestic applications. The call for action to focus on end use energy technologies, that will enhance the reduction in use of primary energy sources we use every day, this in turn will provide the next level of highly energy efficient, sustainable and economical ways to achieve the our ultimate goal of maximising return for each kilowatt spent with the most environmentally friendlier manner in mind. I'm sure there are many of us who share my passion and vision to contribute to securing our heat pumping and energy future in our world.

- Maximising simultaneous energy transfer efficiencies.
- Maximising directing energy, recycling and recovering energy.
- Environment impact reduction.
- Conservation of fossil fuels and other energy sources.
- Reduction in $CO_2$ emissions and other waste emissions.
- Reduction in Ozone depleting substances.
- Recovery of un-tapped, unharnessed totally discarded waste energies.
- Reduction of energy use of operating multiple conventional heat pumps.
- Minimising capitol equipment cost and maintenance costs.
- Utilising the abundance of alternate energy resources to reduce consumption.

## 5 REFERENCES

MECHLAB @ UNSW September 2004 Report Number: 700146b Testing of a Multi- Function Thermal Transfer Assembly – Space Conditioning, Pool Water Conditioning and Water Heating. AS3823. 1.2: 2001
Prof. E. Leonardi and A. Tayler, Refrigeration and Air-conditioning School of Mechanical and Manufacturing Engineering the University of New South Wales Australia
NATA Accredited Laboratory No.11449

(1) Airwell from Email Air- VRF Variable Refrigerant Flow Logic 2006 Brochure Catalogue Data
(2) Airwell from Email Air- Aqu@logic Water Chillers Technical Brochure Catalogue Data TMAQL-A.2GB March 2006
(3) Accent - Air – Commercial - Technical Brochure – BFD4160-05/10 – A4.PDF
(4) Alto Pacific Internet Brochure alto.en.alibaba.com/product 1635429490-213048210/3-phase-380 to 220v-for-indoor-pool-heat-pump.html