ANNEX A

Technology Factual Information & Application Case Studies

1. Technology Name*

New Generation of Air Conditioning and Mechanical Ventilation (ACMV) System

2. Technology Category*

(what categories does the technology belong to? Please select at most related sub-categories, where applicable)

☑ ACMV

☐ Envelop and façade system

☐ Lighting

☑ Controls and Operations

☐ Loads

☑ Indoor Environmental Quality

☐ Energy Generation and Storage

☐ Others

3. Suitability in Existing building or New Development*

(The technology is for existing building or new development?)

☑ New development

☑ Exiting building

4. Suitable Building Types*

(What type of buildings does the technology suit?)

☑ Office

☑ Hotel

☑ Retail Mall

☑ Mixed Development

☑ Residential

☑ Institutional

☑ Restaurant

☑ Laboratory

☑ Industry

☑ Healthcare

☑ Datacentre

☐ Other _______________

5. Suitable Building Height*

(What building height does the technology suit?)

☑ Low rise

☑ Mid-rise

☑ High rise

6. Technology Supplier's Address & Contact Information*

Company Name*: Air T&D Pte Ltd

Address*: 86, Phoenix Garden, Singapore-668336

GST registration number (if applicable): 2015xxxxxxx

Website (if applicable): www.airtd.com.sg

Contact email*: sales@airtd.com.sg

Contact tel no. *: 0065-67906538

Contact person name*: Wang Yuqi

7. Originated from

Singapore

8. Local Distributor

Air T&D Pte Ltd

9. Keywords*

(the keywords about the technology)

ACMV, Thermosiphon Beams, Intelligent Air Distribution System, Control & Optimization System, Energy Efficiency, Indoor Environment Quality

10. Technology Description*

(A brief summary or description of the technology - What is the problem solved by this technology? How it works?)

This type of ACMV system consists of air treatment unit, air distribution system, air terminal unit and control system. Differentiate from existing ones are that it can achieve truly independent control of indoor temperature, humidity and ventilation (varying one parameter will not affecting others), so that both lowest energy cost and good indoor environment quality can be guaranteed.

Air treatment unit: three kinds of air treatment units are developed to satisfy different air treatment requirements. Liquid Desiccant Air Conditioning System (LDACS) **(patented**) which can energy efficiently dry the air to very low humidity ratio; Dual-Cycle Air Dehumidification System (DCACS) which is energy efficient, easy to use and can suit most building applications; and Energy Recovery Ventilator (ERV) which recover waste energy from exhaust air with efficiency of over 70%. These systems can be used to treat the ventilation air for dedicated outdoor air systems and can achieve 20% to 40% energy savings when applied to residential and commercial building ACMV systems.

Intelligent air distribution system: a low cost and easy-to-implement Intelligent Air Distribution System (IADS) for dynamic control of building ventilation was developed. The system consists of Indoor Air Quality Sensors, Indoor Controller, Smart Damper and Direct Digital Control System. The Direct Digital Control System receives data from the indoor controllers, Smart Dampers, and fan to build and update the mathematical model for the air duct network. The intelligent adaptive optimization algorithm then computes the required damper positions and fan speed to achieve optimum working conditions in terms of the good IEQ and minimum energy consumption.

Air terminal units: the quiet and energy efficient terminal units are designed based on four major air physical phenomenon: entrainment, thermosiphon, displacement and coanda effects. Our products include Passive Chilled Beams (PCB), Active Chilled Beams (PCB), Dual-Mode Passive Thermosiphon Beams (DMTB) and Tri-Mode Thermosiphon Beams (TMTB). Depending on the application, the combination use of these terminal units provide the best solution in terms of energy, cost and comfort.

Control system: an intelligent building management system (Building STAR) that offers functions of Energy Analytic, Modelling, Control Loop Auto-tuning, System Optimization and Fault Detection and Diagnostics. In BSTAR, disparate building sub-systems can be integrated using a shared network such that they can all be controlled by a centralized common user interface. All information resources of each sub-system can be shared in the platform to optimize building management functions and maximize building performance and efficiency. Reliable and efficient application system with comprehensive management functions can be flexible designed for different scale of buildings, nature of businesses and style of facility management.

The operating principle of the system is as follows:

- Chiller plant generate 10^0C -12^0C chilled water and supplied to both terminal units and air treatment units
- The air treatment units used as Dedicated Outdoor Air system (DOAS) handle all the space latent loads and part of sensible loads
- The treated ventilation air is supplied to different zone through Intelligent Air Distribution System (IADS) according to the space need
- The Thermosiphon Beam (TB) terminal units provide the required sensible cooling with best Indoor Environment Quality (IEQ).
- The Intelligent Energy Management System (BSTAR) coordinate the performance of each element so that the system performance can be optimized at part load conditions

11. Image uploads

Please attach at maximum 5 pictures

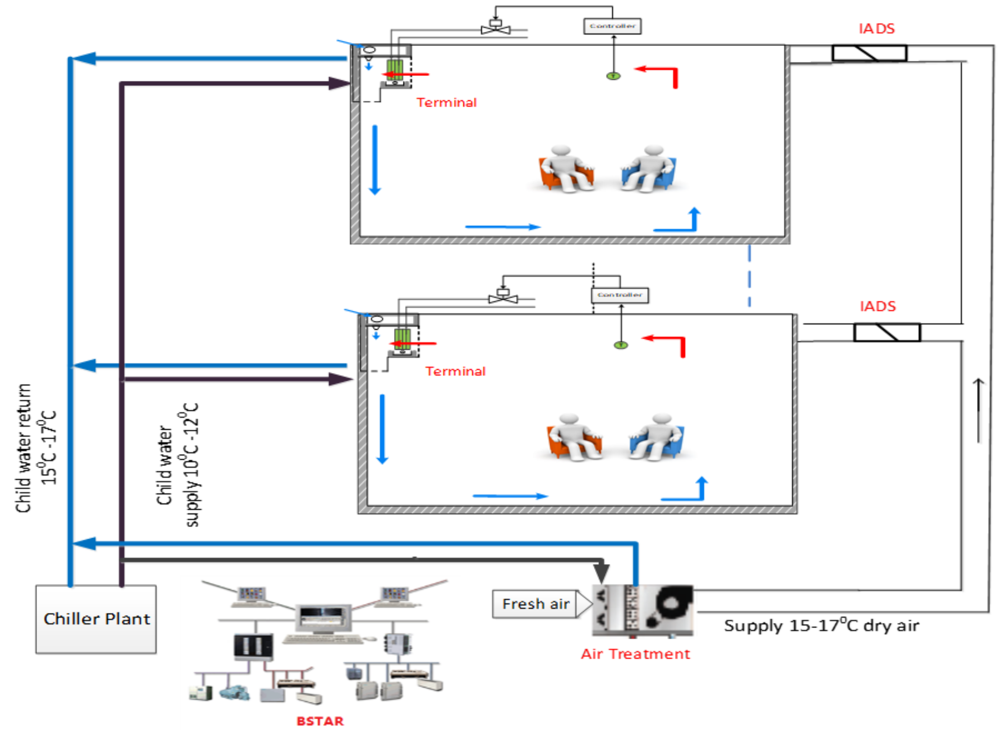


Fig.1 Structure of New Generation of ACMV systems

LDACS DCADS ERV

Fig.2 Air Treatment Units

System Structure Indoor Controller Smart Damper

Fig.3 Intelligent Air Distribution System

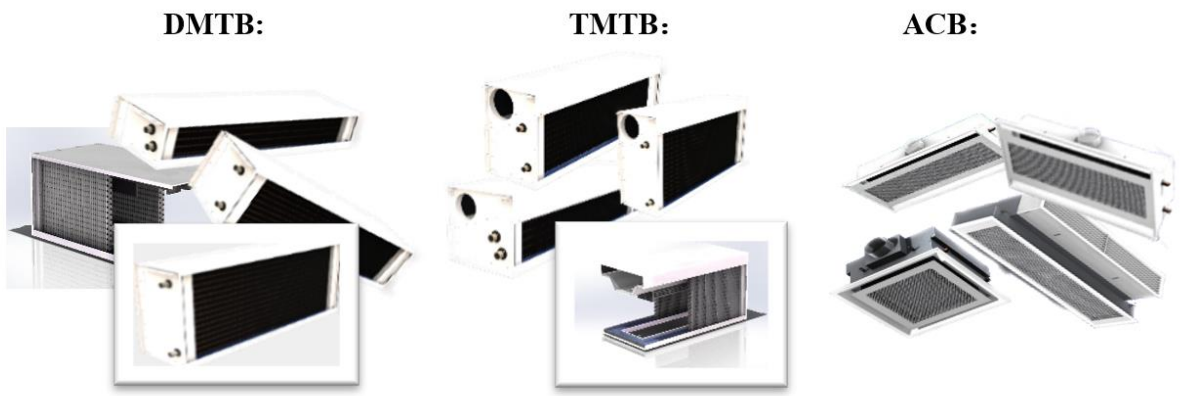


Fig.4 Air Terminal Units

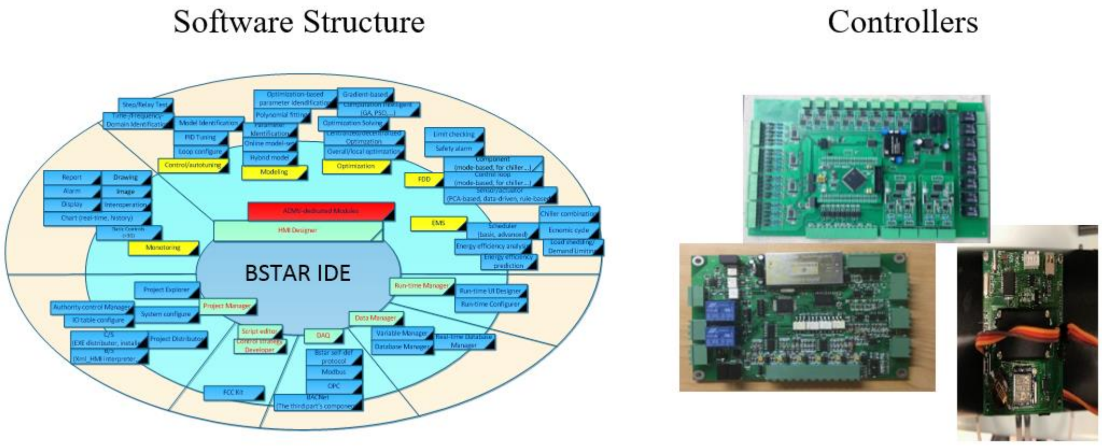


Fig.5 Control Systems

12. Estimated First Cost*

(the range of estimated first cost, in the unit of $/unit, $/m², $/RT)

The cost on the air side for the ACMV system is around 400SGD/ sqm

13. Estimated Maintenance & Operation Cost*

(the range of estimated M&O cost, in the unit of $/unit/year, $/m²/year, man-hours/year)

The operation cost is between 10-15 SGD/sqm/year
The maintenance cost is around 3-5% of the whole project per year

14. Estimated Lifetime*

(the range of estimated lifetime)

20 years (lab tested) for the air treatment units, air distribution system and air terminal units.

15. Estimated Lead Time

1 months

16. Technology Advantages*

(description of technology advantages)

Energy Efficient

- 10^0C -12^0C chilled water supply is 3^0C -5^0C higher compared with the current practice (7^0C). Since every degree increase of chilled water supply temperature resulting 5% of COP improvement, this will increase chiller COP by 15% - 25%;
- Combined Dedicated Outdoor Air System (DOAS) for air treatment and Intelligent Air Distribution System (IADS) reduce ventilation air reduced by 20-70%, resulting 10-40% energy saving in treating and distributing the air;
- Delivering chilled water direct to the air water terminals inside the space instead of centralized air treatment in AHUs reduces both fan power and energy losses through the duct works. This will resulting 5-10% higher efficiency;
- Through modelling, control and optimization, the intelligent energy management system-BSTAR can coordinate the performance of each function block at part load condition, this will further generate 10-15% energy saving.

Better IEQ

- With air treatment unit to handle all the space latent load, duct work and terminal units are working under dry operation that eliminate bacteria growth and remove airborne microorganisms;
- The displacement ventilation offers better air diffusion performance, which leads to lower airflow velocities, reduced drafts and more effective in remove airborne microorganisms etc.;
- The IADS control the ventilation rate according to the indoor air quality requirement, there is no over/under ventilation;
- There is no centralized recirculation air for different zones, so there should be no cross-contamination between spaces served by the system;
- The system typically operates with sound levels below 30 NC.

Other benefits

- For new buildings, one floor area can be created for every five floor of construction. This means the cost reduction, or 25% floor space increment;
- Reduction in sizes and capacities of the air treatment, and air distribution and chiller, results big savings in equipment, operation and maintenance costs.

17. Technology Limitations*

(description of technology limitations, if any)

The proposed ACMV system operates in cooling mode. In areas that need heating, the system design and control strategy need to be adjusted.

18. Cost and Benefit Analysis

(description of how the technology works to save/generate more energy compared to the baseline, the condition of comparison shall be provided, as well as an estimated value of overall improvement in terms of kWh/m2/year, kWh/year, %, together with a simple pay back year calculation)

Assume an office building in Singapore with the areas of conditioned space of 2400m2 which is divided into 5 zones, the temperature and humidity set-points are 25°C and 60% RH, respectively, and operate from 8am to 10pm every day. Each zone is designed for occupants, computers and other electrical appliances.

Internal load: The summary of design information for the space is listed in Table 1.

Table 1 Summary of design information

Total Latent Load	39kW
Total Sensible Load	154.2kW
Total Load	193.2kW

Ventilation: The ventilation requirement for each zone is calculated to meet ventilation codes. For example, using ASHRAE Standard 62-2010 to determine the minimum fresh air flow rate for a typical office space:

$$Q_{oz} = R_p(2.5L/s/person) \times P_z(\text{number of occupants}) + R_a(0.3L/s/m^2) \times A_z(\text{zone area})$$

Let the occupancy rate of 5m^2/person, the ventilation loads for the Zones are

Total: 1920*L/s.*

For the conventional VAV system:

The energy consumptions for the VAV system with cooling based DOAS are:

DOAS Chillers: 65.24kW

Fans: 9.19kW

Pumps: 2.04kW

Total: 76.47kW

For the proposed ACMV system:

The energy consumptions for the proposed ACMV system are:

Chiller: 35.93kW

Fans: 2.933kW

Pumps: 1.26kW

Total: 40.12kW

Compare the two systems, the system bases IERV and hybrid air terminals is much more energy efficient. The saving is

(76.47-40.12)/76.47≈47.5%

19. Reference Documents

(attachments of white paper, Product spec, case studies, etc)

Specification of air treatment unit

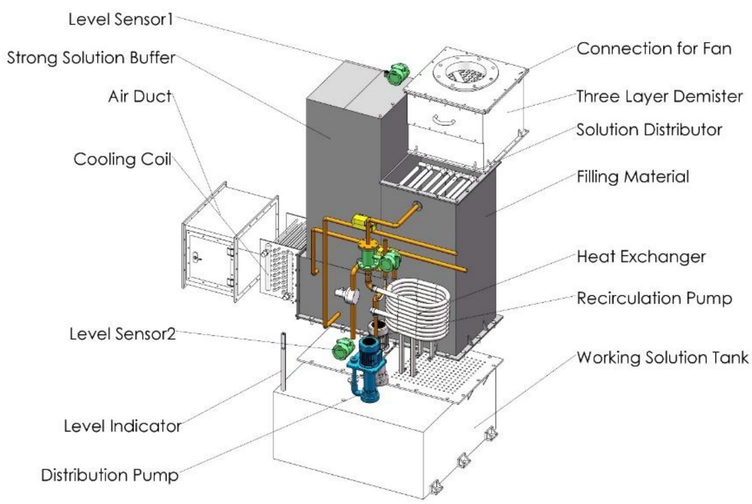


Figure 12 mechanical diagram of LDACS air-conditioner

Table 1 LDACS air-conditioner nominal dimensions

Model	Length L (mm)	Width W (mm)	Height H (mm)	Packing (mm)	Air flow (m^3/h)
AD500	1300	900	2100	380*380*600	250~600
AD1000	1500	1000	2100	450*450*600	500~1200
AD2000	1800	1200	2100	650*650*600	1000~2400
AD4000	2000	1400	2100	850*850*600	2000~4800

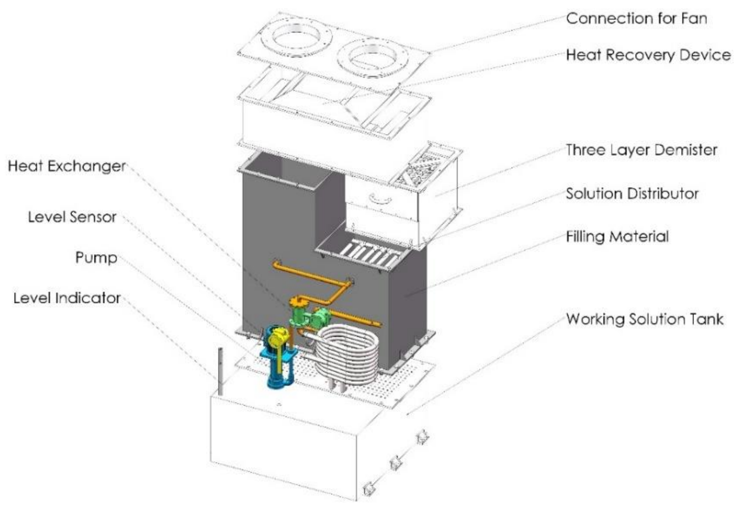
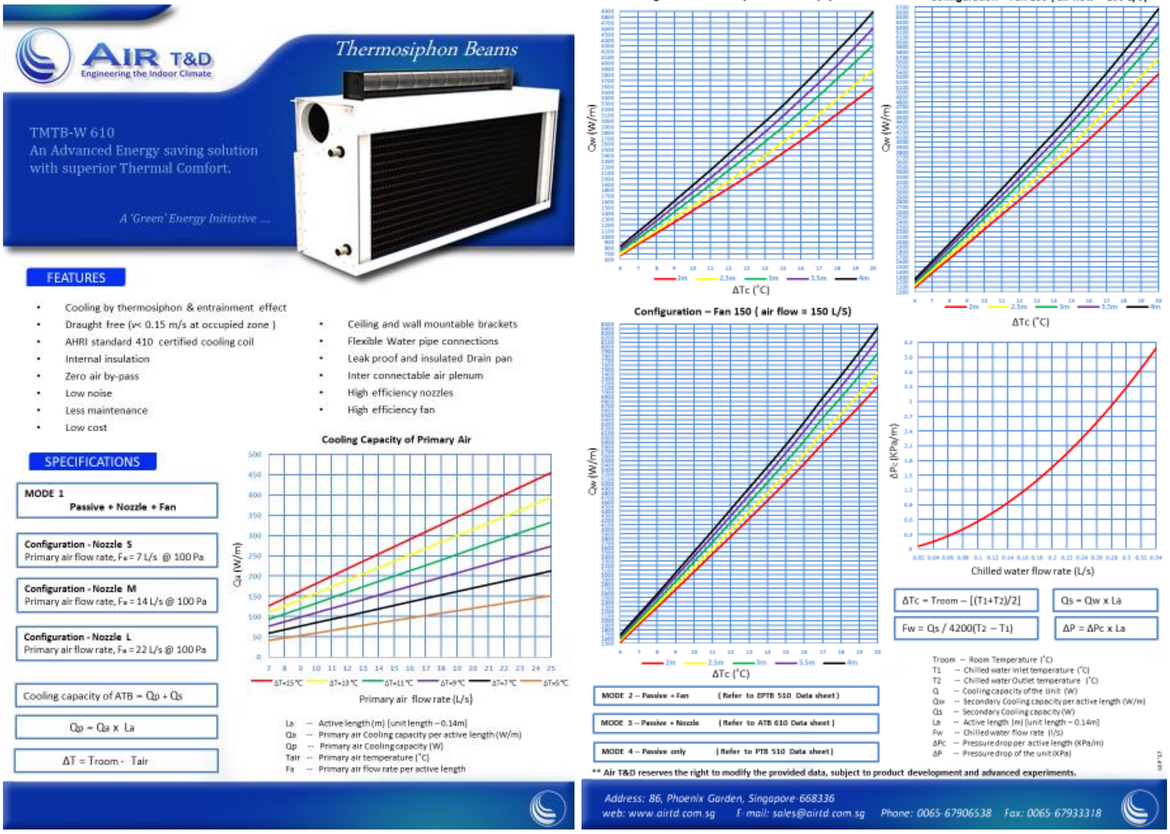


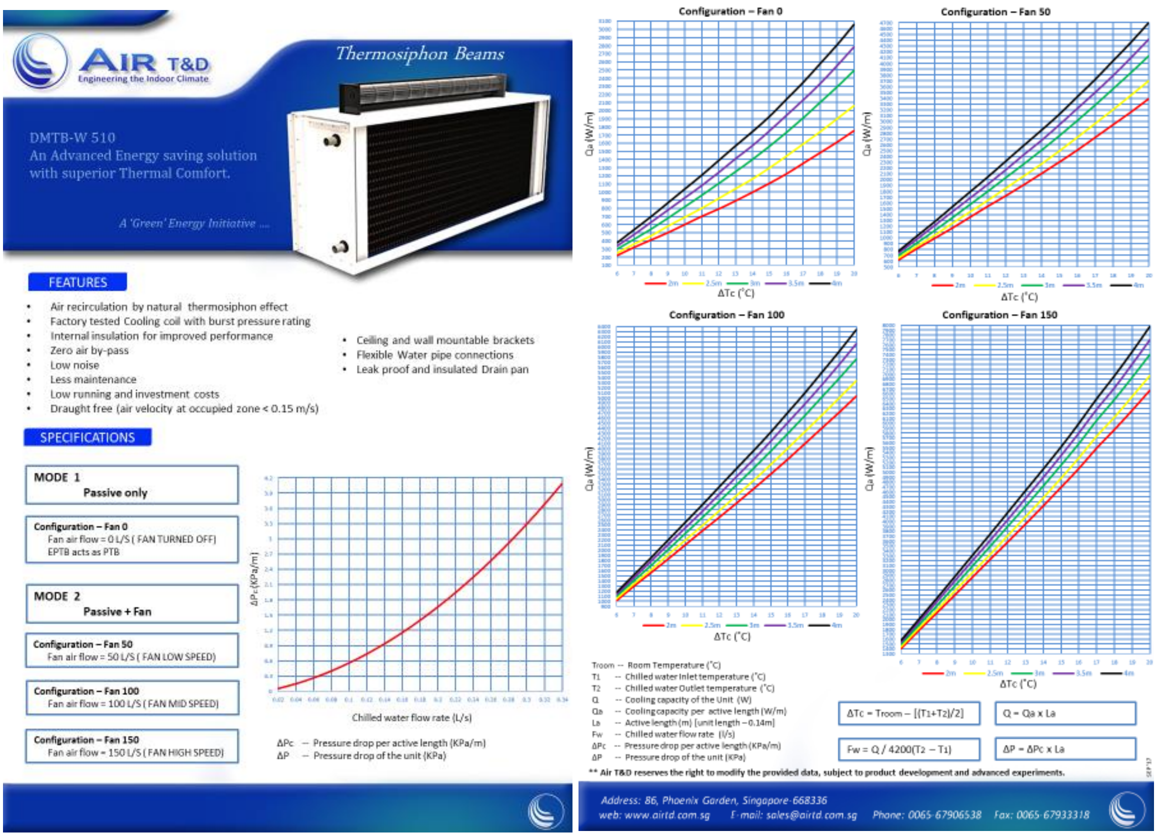
Figure 13 the mechanical diagram of LDACS regenerators

Table 4 LDACS regenerator nominal dimensions

Model	Length L (mm)	Height H (mm)	Width W (mm)	Packing (mm)	Capacity (kg/h)
SR25	930	2100	900	380*380*600	25
SR50	1130	2100	1000	450*450*600	50
SR100	1430	2100	1150	650*650*600	100
SR200	1830	2100	1350	850*850*600	200

Specification of air terminal unit





20. Certification and Awards

(description of certification and awards received for this technology)