

RESEARCH COLLABORATION OPPORTUNITY

Research Collaboration Opportunity Ref No.: RCO-CUGE-2020-01

Project Title: Air Conditioning Blowdown Water Recovery System to Irrigate Retrofitted Building Greenery for Thermal Gain Mitigation

1. Key Challenges and Objectives

1.1 In hot and humid Singapore, water-cooled chillers are one of the ways to keep buildings cool for its occupants. The air-conditioning systems rely mostly on wet / evaporative cooling towers that eject heat from the building by evaporating water. Large volumes of cooling tower blowdown waters are discharged into the sewers. The objective is to recover this water resource (treat them to suitable qualities in compliance with PUB & NEA) for irrigating landscapes (both on buildings and on grounds) to cool the city. Current major challenges are as follow:

- Large volumes of cooling tower blowdown waters are discharged as grey water into the sewerage system directly without consideration for reuse (i.e. as alternative water source for irrigation, etc.);
- Landscape and skyrise greenery plants face irrigation challenges during dry months;
- Dry weather conditions are becoming more frequent and prolonged;
- Rainwater harvesting is insufficient during dry months;

1.2 We seek proposals to develop and deliver the following:

- **A Modular Treatment System** - To design & engineer a strategy/system that takes into account the cooling tower blowdown water (from existing cooling tower system) for irrigation purpose while keeping the remaining discharged, in compliance to PUB's controlled watercourse discharge requirements (and all relevant NEA & PUB requirements). This project is to achieve post-treatment water-quality that meet PUB's standards for discharge into open drains.
- The modular system must be:
 - Not affecting the existing on-site cooling tower water treatment system;
 - Installed with control and monitoring system to calibrate/ensuring water qualities according to both irrigation and compliance requirements (all relevant NEA & PUB requirements);
 - Third party accredited laboratory shall be engaged to conduct water quality test to ensure both irrigation and compliance requirements (all relevant NEA & PUB requirements) are met;
 - Desired outcome will be a compact (and scalable), maintainable, operational Water-Treatment-System; with comprehensive operation & maintenance manual; with associated system design and selection guidelines for actual site application.

- Life cycle cost for the modular treatment system shall be provided.
- **Greenery Systems** - Install and maintain the designated green wall and green roofs to be irrigated by the repurposed/treated water:
 - Greenery systems must be designed and retrofitted onto the selected building (JTC LaunchPad Blk79) taking the following into consideration;
 - Accessibility – To look into ways of accessing the plants during maintenance. Usage of boom lift shall be avoided which will be a costly option
 - Plant species – Detail pruning frequency and the types of plant form and species shall be provided as part of the proposal. Certain plants attract pests and hence proper pest control shall be proposed (if applicable).
 - Green mark / sustainability – To include detail for the type of fertilizer to be use (if any)
 - Monitoring – Monthly monitoring (e.g. report) on the general vegetation performances
 - The proposed greenery system & design must have ease of maintenance.
 - Life cycle cost for the greenery system shall be provided.
- **Performance-Monitoring (on thermal benefits)** - One-year monitoring via installed thermal sensors/data-logger to monitor (via wireless transmission) thermal benefits (surface & ambient temperature; against control-surface-measurements) by the green wall and green roof comparatively;
- **Performance-Monitoring (on ACMV waters)** – One-year monitoring via water tests (by accredited water testing laboratories) and data collection of the following parameters:
 - Chiller power consumption;
 - Blowdown water (Volume; the Original water qualities before treatment; the Treated water qualities after treatment);
 - Condensate water (Volume, qualities);
 - Makeup water (Volume, qualities)
 - Indoor room temperature variation from set temperature
- **Performance-Analysis** - A comprehensive collective performance analysis based on the above collected data to develop professional recommendations on water-resourcing & cooling strategies.
- **Comprehensive Maintenance** - For all the above items over a minimum of two years (from the start of the monitoring phase).

1.3 The proposed project should include (but not be limited to):

- (i) Develop the cooling tower blowdown water recovery strategies and build the relevant system;
- (ii) Install all items (including the greenery systems, etc.) successfully on site (with compliance to and clearance by all relevant authorities having jurisdictions);

- (iii) Demonstrate and Monitor the total-set-up's real-world performances (with comprehensive analysis and recommendations on water-resourcing and cooling)
- (iv) Comprehensively maintain (periodically as scheduled to building owner's requirements) all the installed items/systems for a minimum of two years from the start of monitoring phase.

2. **Minimum Project Deliverables**

The deliverables described here represent the minimum outcomes arising from the proposed project. Additional relevant deliverables that are proposed will be favourably considered during project evaluation.

- (i) **Design, Engineer & Build** the cooling tower blow down water recovery system:
 - To achieve post-treatment water-quality that meet PUB's standards for discharge into open drains.
 - With comparison of the water-quality test-results (by third party accredited laboratory) before and after treatment;
 - With comprehensive operation & maintenance documentation;
 - With compliance to (and clearance by) all relevant requirements by authorities;
 - With compliance to building owner's requirements;
 - Any attachment of the water conditioning and recovery system onto the existing building structure shall not affect the structural integrity and/or cause any damage to the waterproofing system of the building

- (ii) **Install** the greenery systems (1 green wall and 3 green roofs; Please refer to Annex) at Blk 79 Ayer Rajah Crescent:
 - With clear method-statements (to ensure orderly construction and safety during installation);
 - Within the loading capacities of the building structural components where the system is attached on (i.e. roof, wall, & column);
 - Any attachment of the greenery systems onto the existing building structure shall not affect the structural integrity and/or cause any damage to the waterproofing system of the building
 - With compliance to (and clearance by) all relevant authorities having jurisdictions;
 - Green wall must not be climber-type;
 - Cost-effective & Safe-Maintainability (for long-term sustenance) are key;
 - Non-soil system with liquid fertiliser (for better pest control);
 - Dense foliage plant species (with infrequent pruning needs);
 - With minimal runoff;
 - Discharge from the irrigation system shall be connected to the nearest sanitary discharge, with compliance to (and clearance by) relevant authorities

- (iii) **Install** suitable thermal sensors/data-logger to safely-monitor (via wireless transmission; minimum one year monitoring) thermal benefits (surface & ambient temperature) by the green wall and green roof comparatively;

- (iv) **Install** suitable sensors/data-logger to monitor (via wireless transmission; minimum one year monitoring) the volumes (and possibly the water qualities where appropriate/feasible) of the blowdown water, condensate and makeup water;
- (v) **Monitor and Document** with comprehensive analysis based upon the above collected data to make recommendations on cooling strategies.
- (vi) **Periodic maintenance** for all these items for a minimum of two years (from the start of the monitoring).
- (vii) Project to be delivered under the following conditions:
 - All works must not impede the day-to-day building's operation. (Reduce disturbance to tenant to the lowest possible.)
 - Conduct risk assessments with risk management in place; with compliance to WSHC's requirements during installation, operation and maintenance.

3. Budget Limits

- 3.1 The proposed budget cannot exceed \$250,000. Proposals that exceed this limit will not be considered. Please note that this amount is simply an indication of budget availability, not an estimate of expected project cost.
- 3.2 The project duration should also not exceed 2 years. Proposals requiring more than 2 years can be considered, but with strong justification.
- 3.3 Please note that NParks' decision on the funding support to be awarded for the project is final.

4. Submission Instructions

- 4.1 For proposal made by an IHL (Institutes of Higher Learning), the relevant institutional clearance/signature is prerequisite to any final decision by NParks. Should an IHL be awarded, the funds will be disbursed to the submitter's institution.
- 4.2 Proposals for the Research Collaboration Opportunity as stated above must be submitted to Poh Choon Hock at poh_choon_hock@nparks.gov.sg by 29th June 2020, 1200 hrs.

5. Enquiries

For transparency, all enquiries and associated clarifications will be published (without details on the identity of the person making the enquiry) on the Research Collaboration

Opportunity page on the CUGE website. We regret that phone enquiries will not be entertained.

For enquiries, please contact Poh Choon Hock at poh_choon_hock@nparks.gov.sg for enquiries.

References:

- The following are some relevant NEA & PUB requirements that may be of implications on the project and its proposals:
 - NEA - *Allowable Limits For Trade Effluent Discharge To Watercourse/Controlled Watercourse*
 - PUB - *Technical Reference for Water Conservation in Cooling Towers*
 - PUB - *Technical Guide for Greywater Recycling System*

ANNEX

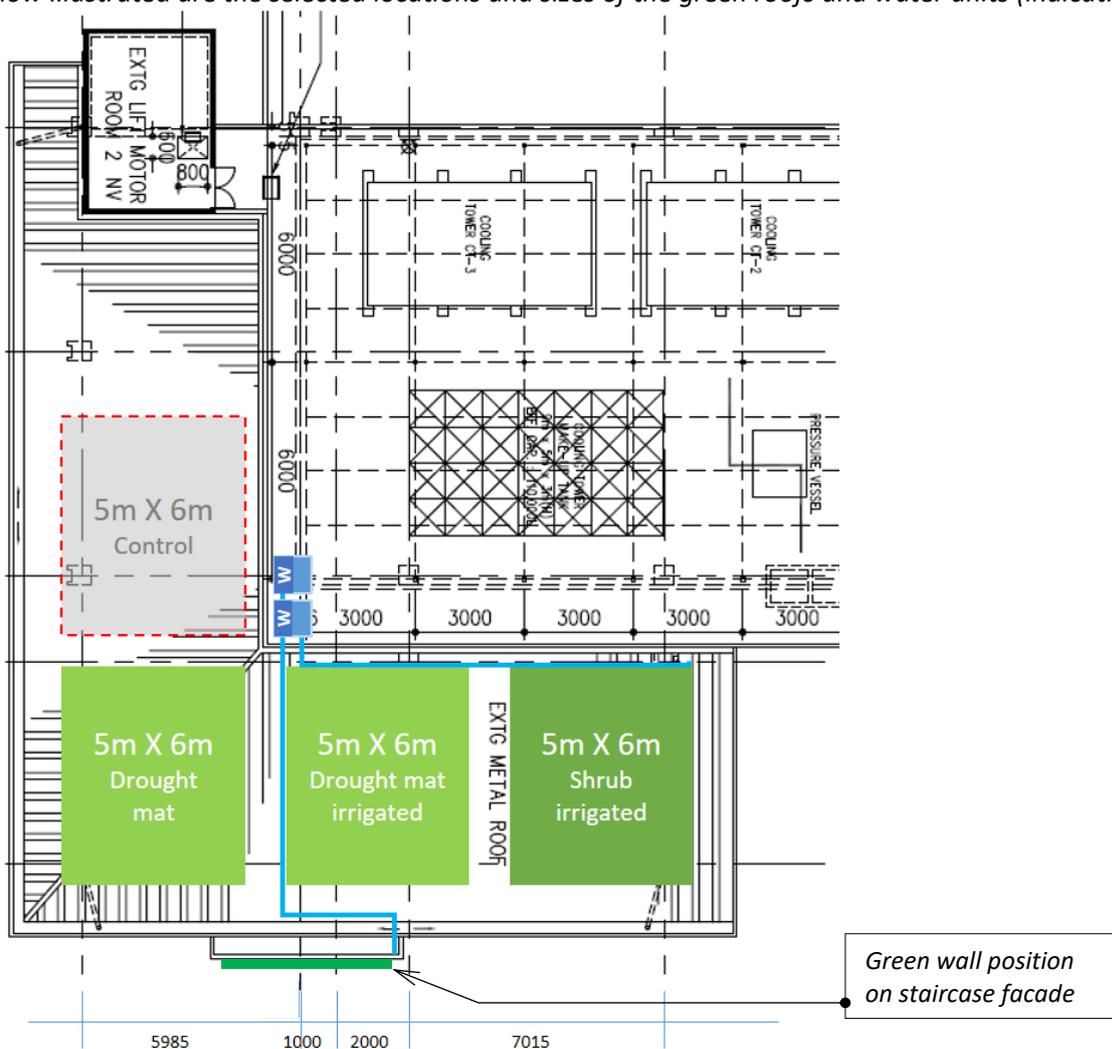
WATER (TREATMENT) UNIT REQUIREMENTS

- Insect-proof (avoidance of stagnant water becoming breeding ground for mosquitos)
- Space efficient and safely maintainable (ex: raised for piping below; avoid water ponding; etc.)
- Weather resistant (against direct sunlight, UV, heat, wet-weather, etc.)
- Within roof site's loading capacity and conditions (actual location to be determine upon award of project)
- Efficient monitoring of performance (i.e. power consumption; water qualities; etc.)
- Efficient conditioning of water qualities to requirement(s).

GREENERY SYSTEM – GREEN ROOFS

- Green roof plots: 3 no. (each 5m X 6m = 30m²)
- Green roof area: 30m² X 3 = 90m²
- Automatic irrigation system inclusive
- Green roof type: lightweight extensive blanket (to meet roof site's loading capacity)
- Drought tolerant species

Below illustrated are the selected locations and sizes of the green roofs and water units (indicative)



GREENERY SYSTEM – GREEN WALL

- Green wall height: 3.75m floor-to-floor X 4 storeys = 15m tall (To verify on site)
- Green wall width: 5m wide (To verify on site)
- Green wall area: estimated to be 15m X 5m = 75m²
- Green wall type: Suitable system such as Pot system, Panel system, etc. (to meet façade's loading capacity)
- Drought tolerant species

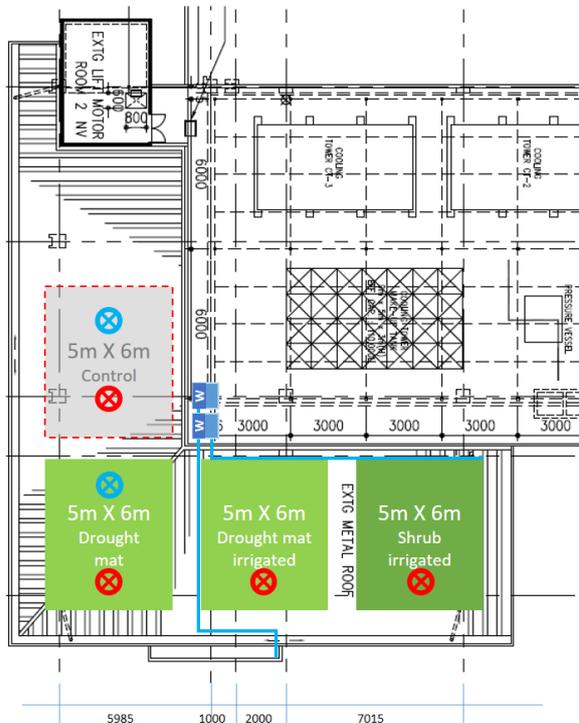
Below illustrated is the selected location and possible size of the green wall



DATA MONITORING SYSTEM

Thermal-Parameters

- Suggested thermal sensor locations on the green roofs and green wall.
- Suggested weather station locations on the green roofs.
- Data logger situated near to Water-Units for easy and safe inspection and maintenance.
- Wireless Sensor Data Transmission system to allow off-site monitoring of data collection.



Proposed **thermal sensor** locations on the green roofs (left image), and green wall (right image) .



Proposed **weather station** locations on the green roofs (left image). Weather stations may be periodically relocated for comparative data collection.

Data logger to be situated near to Water Units for ease of inspection.

Wireless Sensor Data Transmission system to allow off-site monitoring of data collection.

ACMV-Parameters

ACMV-parameters are to be monitored and documented:

- Building's AHU condensate volume per floor
- Cooling tower's makeup water volume
- Cooling tower's blowdown water volume
- Etc.

