Feasibility of Condensate Recovery in Humid Climates

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Abstract: This study investigates the practicality of using the air-conditioning condensate as an additional source of water. The scarcities of natural water resources, especially in arid regions, represent a major obstacle restraining sustainable development. Exploring new sources of water supplies, like condensate recovery, address this issue. A model is developed to predict the condensate production for any location using hourly weather data and detailed psychrometric analysis. It is further used to investigate influence of climate condition and space occupancy on the amount of condensate generated. Results reveal that the large cost of implementing a recovery system is still justifiable for buildings with high fresh air percentage and in countries with a hot, humid and arid climate. The feasibility of using the collected condensate as cooling tower make-up water is examined. Abu-Dhabi, a city with dry climate, is selected for further study to find the cost of an economically justifiable recovery system.

Keywords: Water resource management, condensate recovery, feasibility study, psychrometric analysis

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1 INTRODUCTION

The availability of conventional water resources is mainly affected by the geographic location and climate conditions. The scarcity of rainfall in arid and semi-arid regions in addition to the high evaporation rate reduces the amount of surface water. This accompanied by the increasing population and heavy pumping of groundwater lead to its depletion. Non-conventional water resources, like desalination plants, have been launched extensively to meet the increasing water demand (Murad et al. 2007). These resources are not only energy consuming but cause several negative environmental impacts on the marine habitats and contribute to global warming (Tourenq 2009). These disadvantages to the society are not usually considered when evaluating the cost of water. There is a difference between the cost of water to the average consumer and the actual value of that water to the society and the environment (Lawrence et al. 2010a).

Exploring new sources of high-quality water supplies instead of relying on non-conventional water resources is essential. There are number of opportunities from which alternative sources of water can be produced including rainwater harvesting, grey/waste water reuse, condensate recovery and others. Due to the weather condition in hot humid regions, condensate recovery is a good potential opportunity that needs to be further investigated. Air-conditioning condensate is produced as a natural by-product during the hot humid days (Guz 2005). Collecting and using the condensate water represents a sustainable solution converting abundant resources into more desirable ones. Two ASHRAE standards, 189.1-2010 (Standard for the Design of High Performance Green Buildings except Low-Rise Residential Buildings) and 191P (Standard for the Efficient Use of Water in Building, Site and Mechanical Systems) address requirements for water use and condensate collection within buildings (Lawrence et al. 2010b).

This research examines the feasibility of using condensate as a potential alternate water source. A generic algorithm is modeled, coded in Microsoft Visual Basic and embedded in a macro-enabled Excel worksheet for ease of use. The worksheet is used to quantify the amount of condensate collected based on hourly
weather data for any location. The model is used to examine various factors that influence the amount of condensate collected. These factors include the location (climate), the building type (mainly the amount of outdoor air required) and the load sensible heat ratio (SHR). A case study is considered for a particular location (Abu Dhabi city, capital of United Arab Emirates) with humid and arid climate conditions to evaluate the feasibility of condensate recovery. The developed model is a potential evaluation tool that could be utilized during water resource planning and management.

2 BACKGROUND

In any climate, depending on the outdoor air temperature, air-conditioning may or may not be needed. Air-conditioning is required to change the indoor air temperature and humidity to an acceptable range for the comfort of the human occupant. The space occupancy (number of persons and their activity) determines the amount of outdoor air (fresh air) required and the amount of moisture in it. All conventional air-conditioning processes utilize the same refrigeration cycle components (compressor, condenser, evaporator and expansion device). They get classified in accordance to the cooling media of its condenser, whether air-cooled or water-cooled. As the air passes across the cold cooling coils, if the coil surface temperature is less than the dew point of the air stream passing by, then water condensation on the coils may occur.

A potential application of the recovered condensate is to use it as make-up water replacing the evaporated one in the cooling tower. Water-cooled air-conditioning system uses cooling tower that consumes a considerable amount of water due to evaporation. Condensate water by itself is distilled pure water, but it may require further treatment as it might get contaminated on the way (Guz 2005). This treatment is necessary if the condensate water is used as potable water for fountains or in the irrigation system, but not if it goes directly into the cooling towers (Guz 2005). For that reason, any building that has a cooling tower located on site is a good candidate for reuse of the collected water (Lawrence et al. 2010a). Collected condensate can also be integrated into rainwater collection system, which may be more expensive than the previous alternative, and would usually involve a storage tank (Lawrence et al. 2010a). The costs of retrofits to add condensate recovery to existing buildings are somewhat high, but still economically justifiable. Costs are higher if the condensate recovery is used for landscape irrigation because storage costs are involved, in addition to the cost of water treatment and pumping (Guz 2005).

Guz (2005) estimated that a typical rate of condensate production for large buildings during summer vary between 0.1 to 0.3 L/kW for every hour the cooling system is operated. This range was based on average production rates measured at a number of large facilities in St. Antonio. Guz (2005) also suggested that for those planning buildings in hot and humid climates, peak condensate production during summer months can be approximated to be between 6 to 7 mL/s/1000 m² of cooled area. Painter (2009) developed a prediction model for a dedicated outdoor air handling units with enthalpy wheel energy recovery, in which he used the expected difference in humidity ratio on the entering and leaving sides of a cooling coil. He developed the model to predict condensate production in three locations in Texas using annual daily average temperature and humidity data (Lawrence et al. 2010b). Lawrence et al. (2010b) presented a methodology for predicting the amount of water collected from an air handling unit. The prediction model could be used to estimate the water collected for either a retrofit or new construction scenario. Data taken in Athens, GA during the 2009 cooling season on 100% outdoor air unit, were used to validate the model developed for the amount of condensate collected (Lawrence et al. 2010b).

3 METHODOLOGY

3.1 Factors Affecting Condensate Production

There are several factors that influence the amount of condensate collected, from those factors the following three are considered: location (climate), building type (mainly the amount of outdoor air required) and SHR.

1. For a specific location, the outside air condition is defined from the hourly weather data of that location. The hourly weather data for different locations was downloaded from the U.S. Department of Energy website (EnergyPlus Energy Simulation Software 2011). This data does not represent a single year or a Test Reference Year-type (TRY) rather a synthetic year. Variables within this synthetic period of record are more appropriate and results in predictions that are closer to the long term average (EnergyPlus Energy Simulation Software 2011).

2. The building type mainly determines the amount of outdoor air required. According to Geshwiler (2005), the occupancy activity influences the fresh air ratio. This ratio may vary from 100% fresh air in applications like kitchen, laundry room, to almost nil in UPS room, electrical room (where there is a pure sensible load).

3. SHR is another variable that reflects the space load behavior (sensible load/ total load). It also corresponds to a standard process cooling coil of the same ratio. The process SHR varies between 0.55-0.85.
3.2 Psychrometric Chart and the Air-conditioning Process

In order to have an accurate prediction of the condensate production, detailed psychrometric analysis is required to determine the moisture content in the air under various conditions. In a typical air conditioning process, it is desired to condition a space to acceptable set values for temperature and humidity, referred to as the indoor design condition. In order to maintain this comfort condition, air is supplied to the space at a certain condition (SA). On the other hand, return air is extracted from the conditioned space (RA) and mixed with fresh air (FA) from the outside in a mixing chamber. This mixed air (MA) is then cooled by passing it over a cooling coil to achieve the required supply air condition. The amount of FA required depends on the space occupancy and application. Psychrometric chart depicted in Figure 1 clearly shows the changes in moisture content for different air conditions. Two different condensations are possible as shown in the chart. The first occurs when the hot humid FA meets the cooler RA at the mixing chamber. The second occurs when the mixed air passes across the cold cooling coil. Figure 1 also illustrates how the psychrometric chart can be used to determine the amount of condensate given a particular ambient FA condition, a specific SHR and FA percentage. Detailed analysis that will be used to develop the model will be discussed in the next section.

3.3 Predicting Condensate Yearly Production Rate

The following is a step by step procedure illustrating how to calculate the condensate amount in case the air-conditioning system was switched on. It is used to predict the amount of condensate that can be recovered in one year period from 1 ton of refrigeration (3.514 kW). The indoor design condition is assumed to be 24°C and 50% relative humidity, which fall within the comfort zone air condition. The off coil dry bulb temperature is assumed to be 10°C less than the design temperature (∆T = 10°C). The potential amount of condensate will be calculated in cubic meters per second (m³/s) then multiplied by 3,600 to determine the condensate recovery during this hour in cubic-meters. This is performed for every hour if the outside air dry bulb temperature is greater than the design dry bulb temperature (24°C), assuming that the air-conditioner will be switched on only under this condition. This assumption represents the worst case scenario since the air-conditioning system may be turned on in cold weather conditions to handle the internal load but this case is not considered in the analysis. The procedure is as follows:

1. Determine the total air flow rate for 1 ton of refrigeration from Eq. (4)

\[ TH = 1.2 \times Q \times \Delta H \]  

\( (1) \)
\[ SH = 1.2 \times Q \times \Delta T \] (2)

\[ LH = 3.0 \times Q \times \Delta W \] (3)

where \( TH \), \( SH \), and \( LH \) are the total, sensible and latent heat in watt, \( Q \) is the total air flow rate in \( L/s \), \( \Delta T \) is the difference between entering (supply air) and leaving (designed) dry bulb temperature, \( \Delta W \) is moisture concentration difference in \( g/kg \) dry air and \( \Delta H \) is the enthalpy difference in \( kJ/kg \) of dry air (Geshwiler 2005). Given the SHR and the total load, the total air flow rate can be determined from Eq. (2) as

\[ Q = \frac{SHR \times TH}{1.2 \times \Delta T} \] (4)

where FA flow rate is assumed to be 30% of total air flow rate.

2. Use the dry bulb and wet bulb temperature of the FA (from the hourly weather data) to determine its humidity ratio (\( kg \) moisture/\( kg \) dry air).

3. Use the dry bulb and wet bulb temperatures of the RA to determine its humidity ratio (\( kg \) moisture/\( kg \) dry air).

4. Define the MA (on coil) condition using flow of FA and flow of RA. Dry bulb temperature of the mixture is simply given by weighted average based on the air flow rate as illustrated in Eq. (5)

\[ T_{MA} = \varphi_{FA} \times T_{FA} + (1 - \varphi_{FA}) \times T_{RA} \] (5)

where \( \varphi_{FA} \) is the volume fraction of fresh air defined to be 30%, \( (1 - \varphi_{FA}) \) is the volume fraction of the return air and \( T_{MA}, T_{FA}, T_{RA} \) are the dry bulb temperature of the air mixture, fresh air and return air respectively.

5. The humidity ratio \( (W_{MA}) \) at the mixing conditions is obtained by the weighted average based on the air flow rate as illustrated in Eq. (6). The mixing point was defined by the two state conditions \( T_{MA} \) and \( W_{MA} \).

\[ W_{MA} = \varphi_{FA} \times W_{FA} + (1 - \varphi_{FA}) \times W_{RA} \] (6)

Dividing Eq. (2) by (1) to derive the SHR that becomes

\[ SHR = \Delta T / \Delta H \] (7)

Using Eq. (7) to define the supply air enthalpy as

\[ H_{SA} = H_{MA} - \frac{T_{MA} - T_{SA}}{SHR} \] (8)

where \( H_{SA}, H_{MA} \) are the supply air and mixed air enthalpy respectively.

6. The supply point conditions is defined by the two state conditions dry bulb temperature equal to 14\( ^o \)C and enthalpy given by Eq. (8).

7. Assuming that the air conditioning system will be only switched on if the outside air temperature is greater than the design temperature (i.e. \( T_{FA} > 24^o \)C), in this case, there are two locations where the condensate can be collected. The first condensate occurs in the mixing chamber when the hot FA comes in contact with the cooler RA flow.

\[ C^1 = FF \times (W_{FA} - W_{MA}) \times \frac{\rho_{air}}{\rho_{water}} \times 3.6. \] (9)

where \( C^1 \) is the condensate happening in the mixing box in \( m^3/h \) and \( FF \) is fresh air flow rate in \( L/s \).

The second condensate occurs when the mixed air meets the cold cooling coil surface.

\[ C^2 = TF \times (W_{MA} - W_{SA}) \times \frac{\rho_{air}}{\rho_{water}} \times 3.6. \] (10)

where \( C^2 \) is the condensate happening on the cooling coil in \( m^3/h \) and \( TF \) is total air flow rate in \( L/s \).

The potential amount of condensate that can be collected is given by

\[ C = C^1 + C^2 \] (11)

where \( C \) is the total condensate in \( m^3/h \).

Steps 1 to 7 are repeated for every hour in the year. The potential amount of condensate per year or per month can be later calculated by summing the condensate per hour for each hour during that period.

### 3.4 Developed Model

The procedure described in the previous section is modeled in Excel to calculate the condensate yearly production rate given hourly weather conditions at any location. The psychrometric analysis is performed using Microsoft Visual Basic macro for use in Excel (Kavanagh et al. 2005). This excel worksheet is designed to be user-friendly. The only requirement from the user is to embed the hourly data for the outside air condition, the load in tons of refrigeration and the SHR. The worksheet automatically calculates the condensate amount per hour, then converts it to cubic meters per month, plots the monthly potential amount of condensate (cubic meters per month) that can be recovered, and conclusively lists the total cubic meters per year.

Using the above developed excel model the predicted amount of condensate for different humid climates is calculated and compared. Sensitivity analysis was performed using the model developed to examine the SHR and \( \varphi_{FA} \) on the amount of condensate recovered per year. To evaluate the feasibility of collecting air conditioning condensate water in a hot humid climate, a case study for the city of Abu Dhabi (capital of the United Arab Emirates) is examined in more details in the following section.

### 4 RESULTS AND DISCUSSION

#### 4.1 Verification of Model

In order to validate the condensate recovery model before using it further, calculations were performed graphically using psychrometric chart, as shown in Figure 1, for a randomly selected point in time during the year. Results were then compared to the excel model
for validation. The point randomly selected for validation is the 31st of July at 9:00 a.m. for Abu Dhabi city, in the United Arab Emirates.

1. Using Eq. (4), a SHR of 0.7, and $\Delta T = 10^\circ{C}$, $Q = 205\, L/s$ for 1 ton of refrigeration. The FA is assumed to be 30% of $Q = 61.5\, L/s$.

2. The outside air condition (from the hourly weather data) at this specific point in time is $36^\circ{C}$ dry bulb temperature and $24^\circ{C}$ wet bulb temperature. The point is located on the psychrometric chart and used to determine its humidity ratio. $W_{FA}$ is equal to 0.0138 kg moisture/kg dry-air. The value of the humidity ratio calculated by the excel worksheet module is 0.0139 kg moisture/kg dry-air.

3. The return air flow rate is $143.5/\, s$, with a Dry Bulb temperature of $24^\circ{C}$ and 50% relative humidity. The point is located on the psychrometric chart and used to determine the humidity ratio. $W_{RA}$ is equal to 0.0093 (kg moisture/kg dry air).

4. The mixture air condition is located on the psychrometric chart and its dry bulb mixture air temperature is approximately $27.8^\circ{C}$.

5. The humidity ratio at the mixing conditions is calculated from Eq. (6) using $T_{MA}$ and $W_{MA}$ to be 0.01065 kg moisture/kg dry air. By locating the point on the psychrometric chart, the mixture air humidity ratio is approximately 0.0107 kg moisture/kg dry air, the enthalpy is $54\, kJ/kg$ dry air, and the wet bulb temperature is $19^\circ{C}$. The value of the mixture air humidity ratio calculated by the excel worksheet module is 0.01059 kg moisture/kg dry air.

6. Using SHR, the supply air point was located on the psychrometric; the humidity ratio at that point is approximately 0.0078 kg moisture/kg dry air using the psychrometric chart. The value of the supply air humidity ratio calculated by the excel worksheet module is 0.008353 kg moisture/kg dry air.

7. Since the outside air temperature is greater than the design temperature, the first type of condensate occurs in the mixing chamber when the hot fresh air comes in contact with the cooler return air flow and amounts to $8.1 \times 10^{-4}\, m^3/h$. The second type of condensate occurs when the mixed air meets the cold cooling coil surface and amounts to $2.53 \times 10^{-3}\, m^3/h$. The potential amount of condensate that can be collected is $3.34 \times 10^{-3}\, m^3/h$. A better estimate for the potential condensate amount is calculated through the excel worksheet module to be $3.1 \times 10^{-3}\, m^3/h$, since it is more precise than the graphical method. Both values lie within 8% difference from each other.

4.2 Effect of Climate Change on Condensate Recovery

Figure 2 illustrates the potential condensate recovery in cubic meters per year for 1 ton of refrigeration. Results reveal that the climate condition has a very high impact on the amount of condensate to be collected. Countries from southwest pacific like Singapore and Malaysia have a tropical climate that is hot, and humid throughout the year. The daytime temperatures rise above $30^\circ{C}$ year-round and night-time temperatures rarely drop below $20^\circ{C}$. Even though the poten-
The potential for condensate collection is high, it may not be economically justifiable to collect it in such a tropical climate with extended periods of rainfall throughout the year. The second category on the list with a high potential for condensate recovery is Abu Dhabi city in the United Arab Emirates which has a hot, humid and arid climate. The arid climate and scarcity of water resources in this city highlights it as potential candidate for condensate recovery. For that reason, the economic feasibility of collecting condensate in this dry climate will be evaluated later and potential uses will be discussed in more details. Riyadh in KSA and Luxor in Egypt are examples of cities where the summer temperature can get very hot, but since it is located away from the sea the humidity is low that is why the potential for condensate water recovery is lower than in the previous climate conditions, even though the climate is dry with rare rainfall. Cairo city in Egypt is an example for a climate with high humidity, due to the river valley’s effects. Temperatures in the summer may reach 40°C, making condensate recovery in it a possible potential.

Figure 3. Potential condensate recovery in different locations

Casablanca in Morocco and Istanbul in Turkey have a Mediterranean climate which lacks extreme heat (i.e. temperature rising above 23°C). Even though Istanbul has high humidity, the lack of extreme heat results does not make it a possible candidate for condensate recovery as the operation of the air conditioning units will not be continuous.

To have a better understanding of how condensate production varies throughout the year, a monthly variation is plotted as illustrated in Figure 3. It can be seen that countries like Malaysia and Singapore have the highest potential for condensate recovery, mainly because the hot humid weather is continuous throughout the year. Other countries exhibit a seasonal climate; the amount of condensate to be collected will be much higher during the summer season.

4.3 Effect of SHR and Fresh Air Percentage on Condensate Recovery

A sensitivity analysis was performed to examine the effects of the SHR and the FA mixture percentage on the predicted condensate amount. Figure 4 illustrates a spider plot revealing the variables significance. As seen from the spider plot in Figure 4, as the fresh air percentage increases, the amount of condensate that could be recovered in one year gets higher. As for the SHR, as it decreases (i.e. the percentage of latent heat out of the total heat increases), the amount of condensate also increases. It can also be seen that the trend is nonlinear, and its significance almost diminishes as the SHR increases by 20 to 30%.

4.4 Potential Uses for Recovered Water

As mentioned earlier there are several usages for the recovered condensate water. Depending on the application, necessary additional treatments for the condensate water may differ; the cost of the piping and pumping network may also differ. One potential low cost application would be adding retrofits to existing buildings to collect the condensate water and recycle it back to the cooling towers to compensate for part of the make-up water. Assuming the make-up water for the cooling tower system is 0.004 L/s/TR (i.e. around 2% of the nominal tower flow rate of 0.2 L/s (3 gallons per minute) for 1 ton of refrigeration). The percentage of make-up water saved is calculated as the...
4.5 Feasibility of Condensate Recovery in Abu Dhabi City, United Arab Emirates

The city of Abu Dhabi, in the United Arab Emirates was selected for further study not just because of its hot and humid weather but rather its dry climate condition. The United Arab emirates exhibits an average rainfall of less than 100 mm/year, accompanied by high evaporation rate (2-3 m/year), low groundwater recharge rate (less than 4% of total annual water used) (Tourenq 2009). According to Kisner (2009), the UAE is the highest per capita energy consumer

Figure 4. Spider plot reflecting the effect of varying the SHR and FA percentage (zero percentage for Abu Dhabi city, 30% FA and 0.7 SHR)

Figure 5. Percentage of make-up water saved in cooling tower through condensate recovery

ratio of the condensate collected to the make-up water consumption during operational hours and illustrated in Figure 5. The trend is not the same as that examined earlier in Figure 2. The seasonal hot, humid weather in certain cities like Istanbul, Casablanca and Cairo show a higher water saving percentage compared to the amount of condensate collected. Even though the amount of condensate water collected is small, the higher percentage of water saved could be attributed to air conditioning system being nonoperational for many months during the year.
and the third highest per capita water consumer in the world. Due to its limited conventional water resources, the UAE has supported the development of non-conventional water resources, which include desalination of seawater or brackish groundwater and treated waste water (Murad et al. 2007). The annual water consumption in the Abu Dhabi Emirate is estimated at 2,486 million m$^3$. Of this 1,692 million m$^3$ (69%) is used for agriculture demands, about 124 million m$^3$ (5%) is used for forestry purposes, 219 million m$^3$ (8%) is used for planting in gardens, parks and roadsides, and about 451 million m$^3$ (18%) is used for domestic purposes (Murad et al. 2007).

As illustrated earlier there is a potential for saving around 20 m$^3$ of condensate water per ton of refrigeration per year depending on the SHR and fresh air requirement of the building for each ton of refrigeration. Due to the hot humid weather of the city of Abu Dhabi, air conditioning is a must. Tabreed, a leading district cooling service provider in Abu Dhabi has a total connected cooling capacity of 555,181 tons of refrigeration by year 2011 (Tabreed 2012). In addition to district cooling, many buildings in city of Abu Dhabi are air cooled. By assuming that cooling capacity of city of Abu Dhabi is 500,000 TR per year (which is an underestimation for the actual exact figure); the potential saving is approximately calculated by 10 millions m$^3$/year (20×500,000). This represents a noticeable percentage of some of the operating desalination plants in Abu Dhabi. It amounts to almost 50% of AlainOUNAH Power Company desalination plant capacity whose production is 18.66 million m$^3$/year (Brook and Dawoud 2005) or 35% of the of Al Mirfa Power Company desalination plant capacity whose production is 27.15 million m$^3$/year (Brook and Dawoud 2005).

By utilizing the condensate water, we are not only saving on the economic cost of desalinating the water but also on the environmental impact of such technology. In order to justify the cost of integrating the retrofits into the existing system or planning a new condensate recovery system, the following present worth (PW) analysis is performed. Assuming the cost of installing the network is ($P$), the price of industrial water is United Arab Emirates Dirham (AED) 11 per cubic meter, an average interest rate ($i$) of 3.11% per year (Trading Economics 2013) and the life time ($n$) for the network to be 25 years. A saving of 20 m$^3$/year per ton of refrigeration could be achieved through condensate recovery. If $L$ denotes the cooling capacity in tons of refrigeration, an annual saving ($A$) of 220 $L$ AED is achieved. Using PW analysis to calculate the maximum budget to be spend in installing the condensate recovery system.

$$ PW = -P + A(P/A, i\%, n) $$

(12)

Setting PW = 0, the value for the $P/A$ factor is obtained from compound interest factor tables ($P/A$, 3%, 25) = 17.57, and solving for $P$

$$ P = 3865L $$

(13)

In order to justify the cost of installing the system, it should be less than AED 3,865/TR as illustrated by Eq. (12). For example, the cost of installing the system should not exceed AED 193, 250 for a 50 ton of refrigeration system. This estimate is an underestimation as it does not include the savings from reducing the dependency on desalination in terms of economic and environmental cost.

5 CONCLUSIONS

This paper presented an in-depth study analyzing the feasibility of condensate recovery. A detailed approach was developed to calculate the amount of condensate generated from weather data using psychrometric analysis and programmed in Excel. Location weather data, information about the building type, and SHR are the required input parameters to run the analysis. The effect of varying these parameters on the amount of condensate was examined. Results revealed that climate conditions have a major influence on the amount of condensate collected. The potential for condensate collection is higher in countries with a hot humid weather throughout the year and justifiable in arid climates with humidity levels. A sensitivity analysis was performed to examine the effect of the other parameters. Results showed that space occupancies with high fresh air percentage yields high condensate while decreasing the SHR increases the amount of condensate generated in a non-linearly proportional manner.

In addition, the study investigated the potential application of the collected condensate and the economical and practical feasibility of implementing a condensate recovery system. One potential low cost application for the recovered condensate water that was examined is through retrofitting existing buildings to collect condensate and reuse it as make-up water for cooling towers. The percentage of make-up water saved was calculated for various locations and compared. Results showed that since condensate recovery is only needed when the air conditioner is turned on, applying the system in regions of high heat throughout the year is not necessary. Lack of excessive heat all year may not be critical for this application as condensate will only be collected when it is needed.

To evaluate the feasibility of collecting the air conditioning condensate water in a hot humid climate and reusing it as cooling tower make-up water, a case study for the city of Abu Dhabi was examined. A more detailed analysis was performed by examining the environmental and economical consequences of implementing such as system. Present Worth analysis was then performed to justify the cost of retrofitting a condensate collection system. Results illustrated that it is possible to determine the economic feasibility of a con-
densate recovery system in terms of the initial cost invested and capacity of the air conditioning unit.

REFERENCES


