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WEB SYSTEM FOR WEATHER DATA PROCESSING TO HVAC DESIGN

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Abstract. *The usage of most accurate weather data enables to reduce safety factors in heating, ventilating and air conditioning (HVAC) designs, resulting in better HVAC dimensioning and consequently reducing operational costs and saving energy. The last is one of the main priorities in the building sector. This manuscript aims at presenting a web system named DwpGen for weather data processing to HVAC design, following the criteria established by American Society of Heating, Ventilating, Refrigerating and Air Conditioning Engineers. Design data for cooling and dehumidification for 3 Brazilian cities were calculated and compared with those recommended by the Brazilian air conditioning standard, as one functionality of this software.*

Keywords: *data processing, climate data, Air conditioning, weather data, software*

1. INTRODUCTION

The usage of most accurate weather data enables to reduce safety factors in heating, ventilating and air conditioning (HVAC) designs, resulting in better HVAC dimensioning and consequently reducing operational costs and saving energy. The last is one of the main priorities in the building sector.

The Brazilian air conditioning design standard NBR-16401 (ABNT, 2008) follows the meteorological data processing method from ASHRAE (2013) and provides climatic data for only 34 Brazilian cities. For other cities, it defines criteria to find among the cities listed, that whose climatic parameters are the closest to the project city, known as the corresponding city. However, the extent of Brazilian territory and the vast climatic diversity suggest the need to obtain specific weather data for each location.

Bulut, *et al.*, 2002 determined new outdoor design conditions for cooling using the ASHRAE method for 78 locations within Turkey. Dry-bulb temperature corresponding to 0.4, 1 and 2% annual cumulative frequencies of occurrence and the mean coincident wet-bulb temperatures were obtained using the hourly data measured at least 13 years. The study's results revealed that cooling design temperatures are generally stringent.

Verbai, *et al.*, 2015 determined new design values only for heating, using outdoor dry bulb temperature data from the last 50 years in Hungary. Those new values reduced the investment costs by approximately 10% for large buildings and the energy savings from intermittent operation decreased by 2-6%.

Bernardes, *et al.*, 2016 compared the impact on thermal load calculation by utilizing weather data from the Typical Meteorological Year (TMY) for cities not listed and from the corresponding city listed in the Brazilian standard. They concluded that, in most of the 5 cases evaluated, using weather data from the Brazilian standard is a good approximation for calculating the thermal load of buildings.

Monteiro, 2017 investigated the influence of urban microclimate on air conditioning design data using values from the closest meteorological station in the municipality of Rio de Janeiro, for where the Brazilian standard presents only two data set from meteorological stations located at airports. He concluded that data from the Brazilian standard are conservative, since the higher relative humidity at the airports located close to the sea.

This manuscript aims at presenting a web system named DwpGen for weather data processing to HVAC design, following the criteria established by ASHRAE (2013). Design data for cooling and dehumidification for 3 Brazilian cities were calculated and compared with those from the corresponding city, as one functionality of this software.

For two American cities design data for cooling and dehumidification were calculated and compared with design data supplied by ASHRAE (2013).

2. MATERIALS AND METHODS

2.1 System Modelling

An application development involves many steps and plays an essential role to determine the database schema requirements.

An important phase is planning application database and, in this work, a traditional approach to data modelling known as entity–relationship model (ER model) was used. This model represents some of the important semantic information about the real world. The main aim is built a diagram that provides requirements in terms of tables, indexes and normalization to storage data and, consequently, to ensure data integrity, information retrieval, and data manipulation (Chen, 1976).

Another important step is to define the database management system (DBMS), which must meet the application's demands efficiently and safely. Furthermore, this case needs a DBMS that encompasses a set of features and functionalities on the use of Online Transaction Processing (OLTP) (Embrapa, 2016).

For each city non listed in Brazilian Standard the procedures described in section 2.2 has been followed and design data for cooling and dehumidification were obtained. For this reason, a relational database system that have integrated JSON was adopted, partly according to the specification given in the ANSI SQL standard (Dusan, 2017).

Other criteria related to scalability, availability and price of hosting platforms were also taken into account to choose PostgreSQL as DBMS. (Embrapa, 2016).

PHP programming language was selected for the web system development because it is multiplatform, robust, rapid, free and easy-learning (Dall'Oglio, P., 2015).

2.2 Study cases

The selected cities come from different Brazilian bioclimatic zones according to the Brazilian standard NBR 15220-3 (ABNT, 2005). Their weather data were supplied by the Instituto Nacional de Meteorologia (INMET). Table 1 shows their latitude, longitude, bioclimatic zone, yearly data available and the corresponding city in the Brazilian standard.

Two American cities presented in ASHRAE (2013) were chosen to validate this Web System. Their weather data were supplied by the National Centers for Environmental Information (NCEI). Table 2 shows the following information about the cities: latitude, longitude, elevation and yearly data available.

Table 1. Chosen Brazilian Cities

City	Latitude	Longitude	Data Available	Bioclimatic Zone	Corresponding City
Itiruçú/BA	-13.31	-40.07	2003-2016	5	Goiânia/GO
Montes Claros/MG	-16.43	-43.52	2002-2016	6	Campo Grande/MS
Resende/RJ	-22.27	-44.27	2006-2016	3	Londrina/PR

Table 2. Chosen American Cities

City	Latitude	Longitude	Elevation	Data Available
Albuquerque/New Mexico/NM	35.04	-106.62	1620	1986-2010
Tampa/Florida/FL	27.96	-82.54	3	1986-2010

2.3 Data processing

The temperature frequency distributions were built as described below:

Step 1. Import the weather data to the DwpGen database;

Step 2. Any month will be discarded if the sum of the dry bulb temperature (DBT) empty intervals greater than 6 hours overcome 15% of the total month hours;

Step 3. Fill DBT and dew point temperature (DPT) gaps by linear interpolation for intervals less or equals to 6 hours.

Step 4. Any month will be discarded if the difference between total diurnal and nocturnal hours is greater than 60.

Step 5. Any month will be discarded if the sum of empty DPT values overcomes 15% of the total DBT available, except when relative humidity (RH) hourly data are supplied.

Step 6. Fill DPT gaps using simultaneous DBT and RH values through psychometrics equations and repeat the step 5.

Step 7. Create a database with the same number of repetitions for all months eliminating the exceeding oldest ones for a minimum of eight years, otherwise the database available is not complete enough for continuing.

Step 8. Compute the design DBT and DPT for the desired frequency levels;

Step 9. Compute the average daily temperature range only for the hottest month.

Step 10. Re-organize the database in decreasing order of DBT and find the points corresponding to the desired frequency levels;

Step 11. Find the coincident wet bulb temperature (cWBT) by averaging the simultaneous WBT values with the corresponding design DBT determined in the step 10.

Daily temperature profiles for the design day were calculated as described in ABNT (2008).

3. RESULTS

Tables 3, 5 and 7 show, respectively, the cooling and dehumidification design data for Itiruçú, Montes Claros and Resende while tables 4, 6 and 8 show design data reproduced from ABNT (2008), for their respectively corresponding cities, Goiânia, Campo Grande and Londrina.

Table 3. Design Data for Itiruçu

BA	Itiruçu	Latitude	Longitude	Elevation(m)	Data available
		-13.31	-40.07	755.61	03-16
Month>Qt	Annual Freq.	Cooling and Dehumidification			
Mar		DBT		WBTc	
	0.4%	31.3		19.8	
	1%	30.3		19.9	
ΔTmd	2%	29.4		19.7	
	99.0%	14.3		-	
11.19	99.6%	13.7		-	

Table 4. Design data for Goiânia from ABNT (2008)

GO	Goiânia	Latitude	Longitude	Elevation(m)	Data available
		-16.63	-49.22	747	82-01
Month>Qt	Annual Freq.	Cooling and Dehumidification			
Out		DBT		WBTc	
ΔTmd	0.4%	35		20.3	
11.7	1%	34		20.7	
	2%	33.1		20.8	

Table 5. Design Data for Montes Claros

MG	Montes Claros	Latitude	Longitude	Elevation(m)	Data available
		-16.43	-43.52	646.29	02-16
Month>Qt	Annual Freq.	Cooling and Dehumidification			
Out		DBT		WBTc	
	0.4%	34.4		18.3	
	1%	34.2		19	
ΔTmd	2%	32.2		18.8	
	99.0%	13.5		-	
12.37	99.6%	12.6		-	

Table 6. Design data for Campo Grande from ABNT (2008)

MS	Campo Grande	Latitude	Longitude	Elevation(m)	Data available
		-20.47	-54.67	556	82-01
Month>Qt	Annual Freq.	Cooling and Dehumidification			
Nov		DBT		WBTc	
ΔTmd	0.4%	35,8		22.6	
10.4	1%	34,8		22.8	
	2%	33,9		23	

Table 7. Design Data for Resende

RJ	Resende	Latitude	Longitude	Elevation(m)	Data available
		-22.57	-44.27	439.89	06-16
Month>Qt	Annual Freq.	Cooling and Dehumidification			
Out		DBT		WBTc	
	0.4%	34.3		20.9	
	1%	33.2		20.7	
ΔTmd	2%	32.2		21	
	99.0%	11.2		-	
13.48	99.6%	10		-	

Table 8. Design data for Londrina from ABNT (2008)

PR	Londrina	Latitude	Longitude	Elevation(m)	Data available
		-23.33	-51.13	570	84-01
Month>Qt	Annual Freq.	Cooling and Dehumidification			
Dez		DBT		WBTc	
ΔTmd	0.4%	33.9		21.7	
10	1%	32.8		21.8	
	2%	31.9		21.9	

Figures 1, 2 and 3 shows, respectively for Itiruçú and Goiânia, Montes Claros and Campo Grande, and Resende and Londrina, at 1% frequency level, the hourly dry bulb temperature profiles for the design day.

Figure 1 shows that the hourly DBT profile from Itiruçu is always below that from Goiânia. Therefore, it is important to evaluate the behavior of the thermal load for the design at Itiriçu to avoid oversizing of the air conditioning system.

Although Monte Claros and Campo Grande have almost the same DBT at the 1% frequency level, the difference in approximately 2°C in their average daily temperature ranges depart their DBT profiles at night and early morning. However, during the peak hours, their temperatures are closer, but Campo Grande keeps presenting higher values.

Figure 3 shows that the DBT profiles for Resende and Londrina are close.

Tables 9 and 10 shows, respectively, the cooling and dehumidification design data for Albuquerque and Tampa while tables 11 and 12 shows design data from Albuquerque and Tampa reproduced from ASHRAE (2013).

Figure 1. Hourly dry-bulb temperature profile at 1% frequency level - Itiruçu and Goiânia

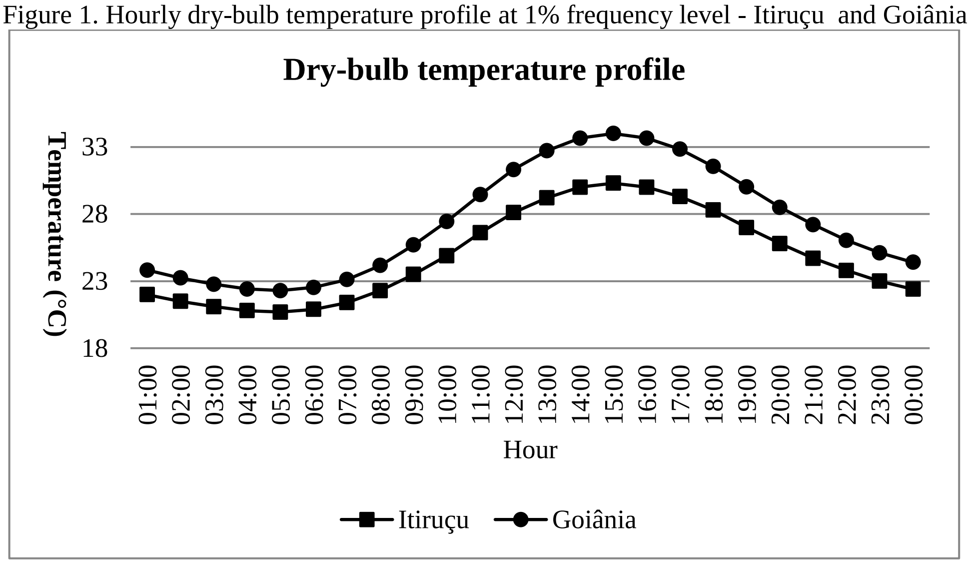


Figure 2. Hourly dry-bulb temperature profile at 1% frequency level - Montes Claros and Campo Grande

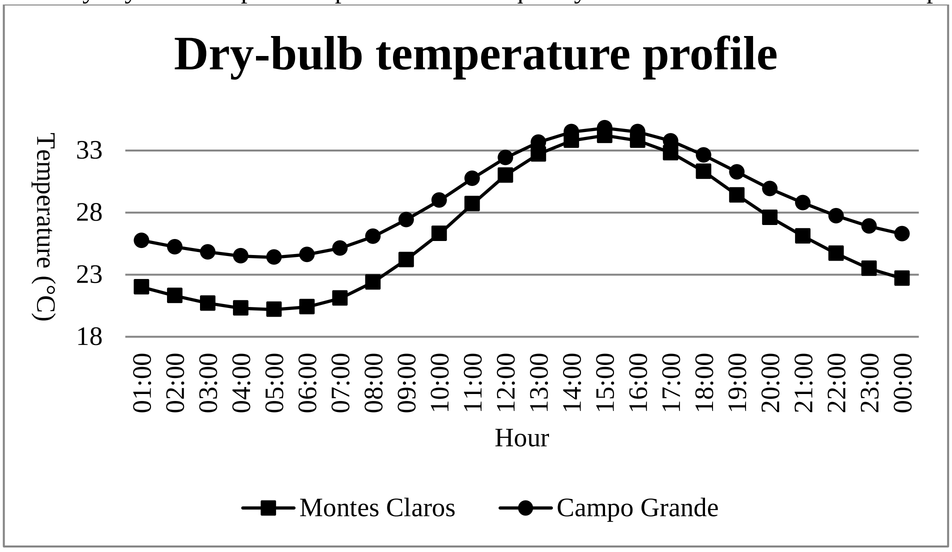


Figure 3. Hourly dry-bulb temperature profile at 1% frequency level - Resende and Londrina

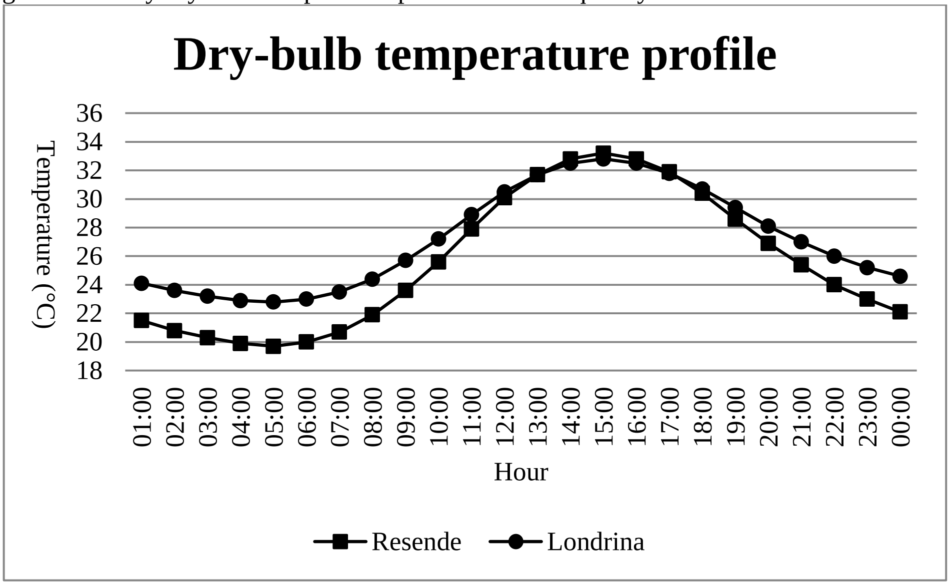


Table 9. Design data for Albuquerque calculated by DwpGen

NM	Albuquerque	Latitude	Longitude	Elevation(m)	Data available
		35.04	-106.62	1618.5	86-10
Month>hot	Annual Freq.	Cooling and Dehumidification			
July		DBT		WBTc	
ΔTmd	0.4%	35		16.5	
13.39	1%	33.9		16.3	
	2%	32.8		16.3	

Table 10. Design data for Tampa from calculated by DwpGen

FL	Tampa	Latitude	Longitude	Elevation(m)	Data available
		27.96	-82.54	5.8	86-10
Month>hot	Annual Freq.	Cooling and Dehumidification			
June		DBT		WBTc	
ΔTmd	0.4%	33.9		25	
8.51	1%	32.8		25.1	
	2%	32.2		25	

Table 11. Design data for Albuquerque from ASHRAE (2013)

NM	Albuquerque	Latitude	Longitude	Elevation(m)	Data available
		35.04	-106.62	1620	-
Month>hot	Annual Freq.	Cooling and Dehumidification			
July		DBT		WBTc	
ΔTmd	0.4%	35.1		15.6	
14.1	1%	33.9		15.4	
	2%	32.6		15.4	

Table 12. Design data for Tampa from ASHRAE (2013)

FL	Tampa	Latitude	Longitude	Elevation(m)	Data available
		27.96	-82.54	3	-
Month>hot	Annual Freq.	Cooling and Dehumidification			
July		DBT		WBTc	
ΔTmd	0.4%	33.6		25.1	
8.1	1%	33		25.1	
	2%	32.4		25.1	

Figures 4 and 5 shows, respectively for Albuquerque and Tampa, at 1% frequency level, the hourly dry bulb temperature profiles for the design day supplied by ASHRAE and calculated by DwpGen.

Figure 4. Hourly dry-bulb temperature profile at 1% frequency level – Albuquerque

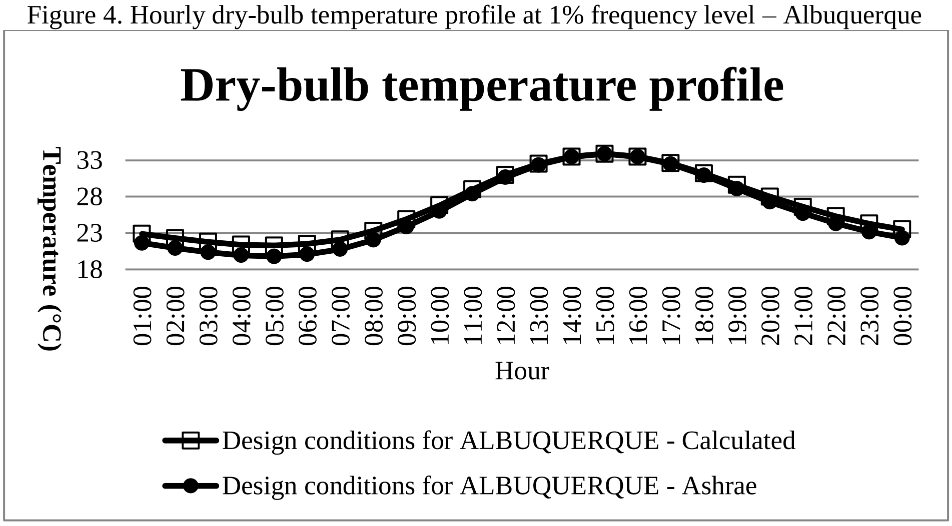
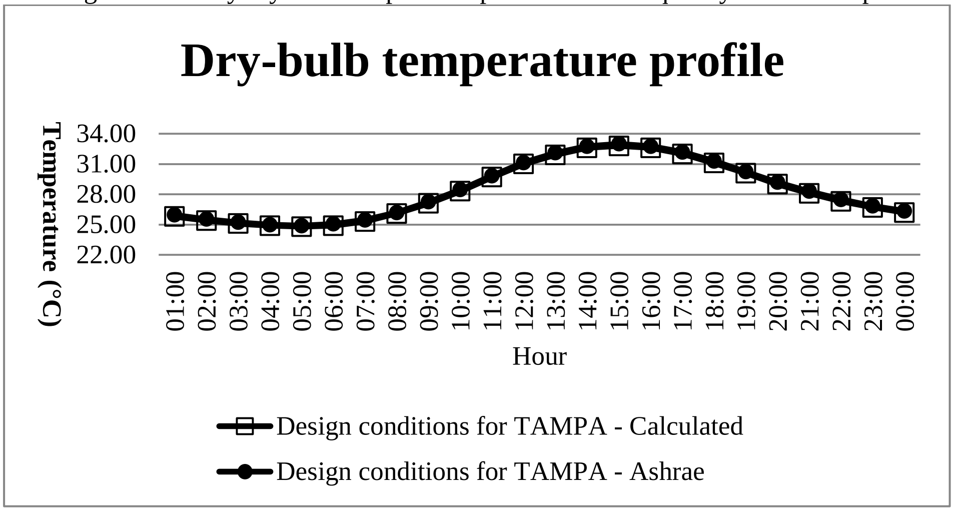


Figure 5. Hourly dry-bulb temperature profile at 1% frequency level - Tampa



Figures 4 and 5 show that DwpGen obtained consistent results when compared with design data supplied by ASHRAE.

4. CONCLUSIONS

The use of DwpGen allows to determine the design parameters for cooling and dehumidification systems for any Brazilian locality based on hourly weather data organized as those provided by the INMET. This tool will enable the designer to perform an accurate analysis of the climatic conditions of the locality where the system will be installed.

The DwpGen was validated through comparison with data presented in ASHRAE (2013) and the results were satisfactory. Better agreement could be achieved if the meteorological data periods for processing were the same.

It should be noted that there are ongoing studies to validate the DwpGen through comparison with data presented in ABNT (2008).

Import tools for weather data types other than those from INMET are under development. The program is growing in functionalities and soon will be able to generate Typical Meteorological Year files as requested for simulation performance of the HVAC systems.

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7. RESPONSIBILITY NOTICE

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