Energy Efficiency and Sustainability of Abu Dhabi Neighborhoods: Lessons from the Past

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Abstract:

In Abu Dhabi city, the residential sector consumes 30% of the total electricity and it is projected to grow by 70% during 2020 comparing to 2013. In addition, car dependency and low use of outdoors is a common characteristic of residential real estate areas. This paper compares the energy performance and outdoor comfort of contemporary and traditional Emirati neighborhoods. A common newly built and planned neighborhood in Abu Dhabi is compared to a field-studied traditional neighborhood. In regards to energy consumption, the analysis considers parameters such as glazing, construction materials, design, and for the outdoor comfort, the walking distance, temperature, and predicted mean value (PMV). The results of the contemporary neighborhood model are compared to statistical data from Abu Dhabi government dependences as well as from external consultants for its validation. Preliminary results show that traditional designs outperform contemporary designs in terms of energy efficiency and livable outdoors. Lessons from the past are drawn and recommendations to include elements therefrom in new developments are made without compromising the high-life standards of the Emirati citizens nowadays.

1. Introduction

Ever since the Arabic man inhibited the Arabian Peninsula, climate played a major role in dictating his life style. Beduins based their whole life on chasing better climate conditions for themselves and their cattle. When permanent settlements were built around fresh water sources, climate conditions continued to play a major role and was reflected in the architecture of those settlements. Maximizing the amount of shades, placing windows via north and south directions, and using natural porous building materials are few measures taken to ameliorate the effects of the harsh climate.

Architecture based on locally available materials was replaced with modern architecture when materials such as steel and concrete were produced industrially and became available globally. The global spread and adoption of these materials meant that they are “one size fits all" materials which are not tailored for specific environment or application. This also translates to the architecture used alongside those materials which usually replicates designs used in other countries with different climates and contexts (social, environmental, economic, etc…). The neglect of environmental considerations in the design of modern buildings and type of materials used, manifest itself in the staggering amount of energy required to provide comfortable living standards.

The objective of this report is to compare traditional design of residential homes and neighborhoods to modern design in Abu Dhabi. The comparison is based on three main criteria: (i) energy consumption (ii) outdoor comfort (iii) walkability. Based on the results, conclusions are drawn and suggestions are provided for consideration in future home designs. It begins by conducting a field study of the design of permanent traditional homes reporting the construction materials characteristics, cooling techniques, and design of neighborhood as a whole to evaluate outdoor comfort and walkability. The reporting continues for a modern home to give the reader an idea of the true differences between traditional and modern home architectures.

The outdoor comfort in a neighborhood is connected to the way the residential cells are spread. Each home contributes in reducing the internal and external temperatures. A micro-climate inside a compound interacts with the one of the district. As it will be seen in the two different scenarios were some of these characteristics are simulated.

The walkability on the other hand is another point to be considered in a district. Recently, compounds designed and built do not allow the inhabitants to walk in the area close to the living place. Reaching necessary facilities within a standard time adapted to this type of climate is almost impossible. Thus, requiring residents to use their cars for short trips which could have been made obsolete by a better design of the neighborhood. Urban planners and architects must consider such important variables as it is directly connected to the inhabitants' health and to the air pollution.

The goal of this paper is to address these three pillars of having a more sustainable lifestyle. Most importantly, energy savings, renewable energy use, reducing air pollution, indoor and outdoor comfort, and walkability. All the above points are mentioned in the vision of Abu Dhabi Development Plan 2030 presented by the Urban Planning Council (UPC). The policies are the main constrains that will influence the decision makers according to different demands.

2. Abu Dhabi and energy consumption

Buildings account for 40% of worldwide energy use — which is much more than transportation. In the United Arab Emirates, the historic low production costs and domestic pricing of oil and gas has led to a very high per capita energy consumption, reaching to 9855 kWh in 2012. Also, the population in the UAE is three times higher than 15 years ago, increasing the demand of fossil fuel not only for exportation purposes, but also for local consumption. [2]

In Abu Dhabi, almost 15 GWh were used for the residential areas during 2013, this is around 30% of the total energy consumption of the city. This is the sector that consumes the most energy, and it is projected to grow by 70% in 2020 [3].

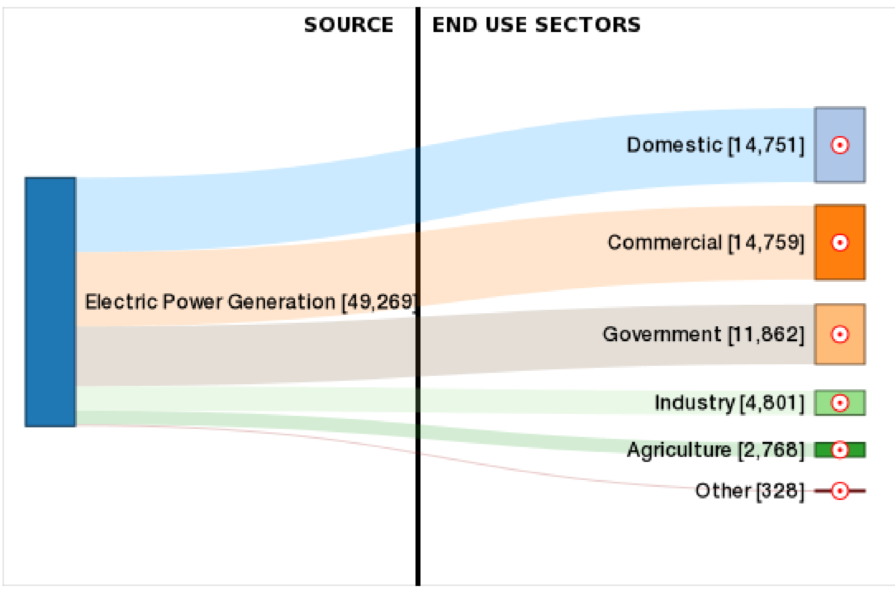

Figure 1 : The energy consumption distribution.

The energy used for the domestic sector, is broken down in figure 1, showing that cooling accounts for almost 55% of the total energy used [4]. This is followed by an unidentified sector that could be related to inefficiency of the systems, lack of maintenance and equipment in general.

With the current weather conditions and the climate change ongoing, the air conditioning systems become a necessity. In the summer days, the temperatures reach over 50 degrees Celsius.

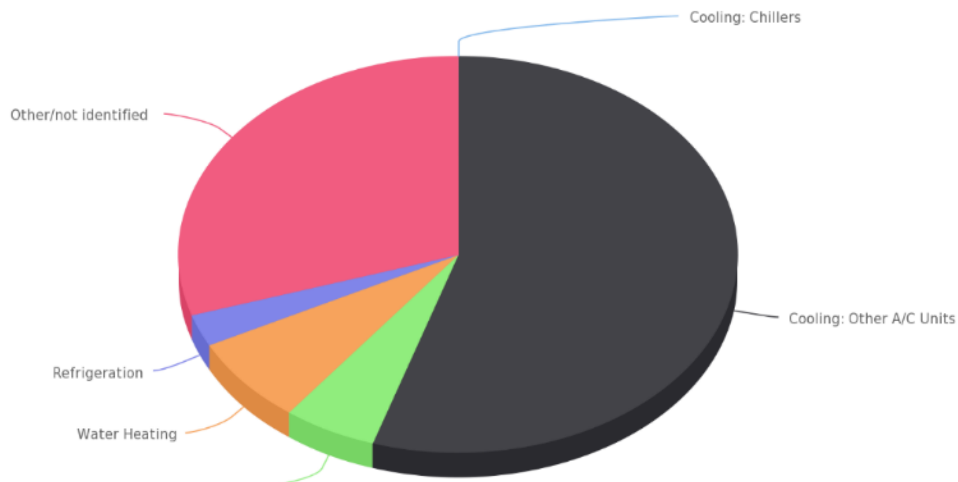

Figure 2: Energy consumption distribution in buildings.

3. Contemporary design

Construction material

The modern contemporary house is based on western architecture, especially after the oil boom in the UAE the adapted these designs in order to create city hubs. The need for modernization also led to the use of several new materials that were available from several places around the world. This meant local sourced materials were not the only ones available at little cost. The result of western architecture in the UAE lead to houses being built in the following design:

Figure 3: Typical contemporary design.

As seen directly, the house itself is very large. This is to accommodate to the large sizes of families in the region. The main thing to notice though is that the materials used now were mainly cement and steel. The steel would create the support and outline the main design of the house, and then the concrete would be used to create further detail inside the house.

Another noticeable feature which is distinct in contemporary houses are large windows all over the house. This is seen also in western areas of the world since the weather is not as harsh as in the Middle East's environment and specifically the Gulf region. This does not work in the favor of the UAE.

Figure 4: Doors in contemporary houses.

As seen in Figure 4, the doors are quite large but are not a strong insulator since the doors are not thick. Contemporary houses also usually include backdoors as well with an average of two doors in a single house that do not act as strong insulators.

Cooling techniques

In regards to cooling techniques, the modern contemporary house has one source: HVAC Systems. On average in the UAE, a house has five to six HVAC system units placed on the roof as seen in the figure 5, also, the neighborhood patterns eliminates the possibility of using efficient large-scale cooling systems such as Central District Cooling.

Figure 5: Air-conditioning units on a villa.

Neighborhood design considerations

When building neighborhoods, the UAE has used the technique of sectors and neighborhood blocks. What is not considered in the designs though are passive shading techniques and accessibility to amenities. To elaborate further, an image from a contemporary house roof will be shown in order to display how far houses are built from each other. The gap between each house is very large and does not consider any shading techniques. This also includes methods of shading built onto the house directly. The neighborhoods also do not consider greenery within a sector or a residential neighborhood. On the contrary, contemporary houses only consider greenery in personal houses and backyards as seen in the figures.

Figure 6: Greenery in a house, greenery in a neighborhood.

4. Traditional design

Traditional home designs took many forms depending on the environment, location, and social status. As mentioned previously, our main goal is to compare modern home designs to traditional ones. Since modern homes are permanent in their nature, it makes sense to compare them to traditional homes that were meant to be inhibited permanently as appose to tents used by Bedouins.

Al Bastakiyyah neighborhood in Dubai is a prime location for conducting field study of permanent traditional homes due to its easy accessibility and well preserved buildings. In the following subsections we report some of the most important highlights distinguishing traditional designs from modern ones.

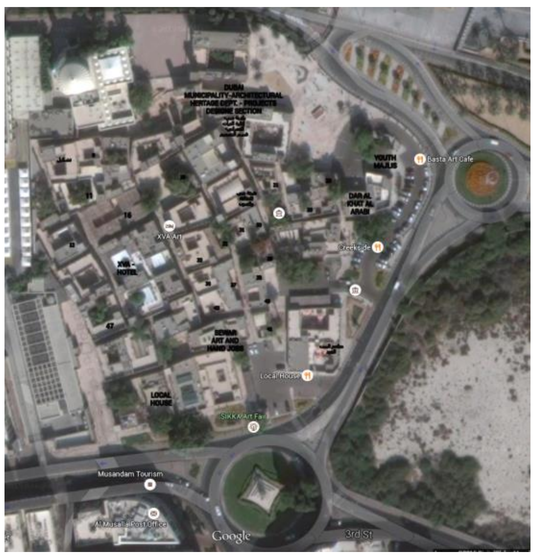

Figure 7: Satelite image from Al Bastakiyyah.

Al Bastakiyyah went through different phases over the previous sixty years. During the renovation period some of the new materials such as concrete was used as seen in Fig. 8 However, most of the old buildings were built using coral and see stones.

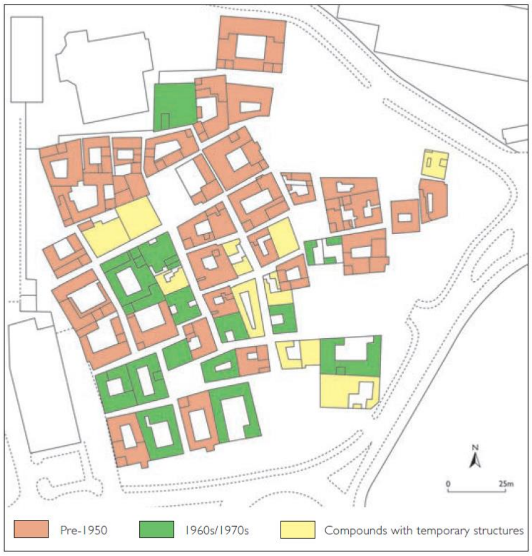

Figure 8: Age of buildings.

Using corals and see stones was attractive to people at that period for three main reasons:

- Economics: Due to the proximity of Al Bastakiyyah to the Arabian Gulf, it was relatively cheap and easy to bring building materials from the gulf. Coral was so abundant to the extent that long walls were built in Dubai using coral as their main material. This can be illustrated in the following figures:

Figure 9: Remaining of a wall using local construction materials.

- Lightweight: Due to its lightweight coral was the main material used to construct long structures such as wind towers [7].
- Cooling purpose: Due to the air pockets in the coral and its thickness, it acted as an
- Excellent insulator cooling during the summer and retaining heat during the winter. The fine structure of the coral stone used to build wind tower is shown in the following figure:

Figure 10: Close up picture of coral stone.

Cooling techniques

In this section some the cooling techniques are provided

- Wind towers (Barjeel) wind towers are square buildings built on top of main rooms in a house for ventilation purposes. The space in the wind tower is divided into four triangles capturing cold breeze at higher altitude and allows hot air in rooms to raise to the top. The symmetric nature of the wind tower allows it to capture cold breeze regardless of the wind direction. The following figure presents a wind tower in Al Bastakiyyah and an illustration of wind tower.

Figure 11: Wind tower (Barjeel) in Al Bastakiyyah

Due to their effectiveness, wind towers were used extensively in Al Bastakiyyah as shown in the following figure.

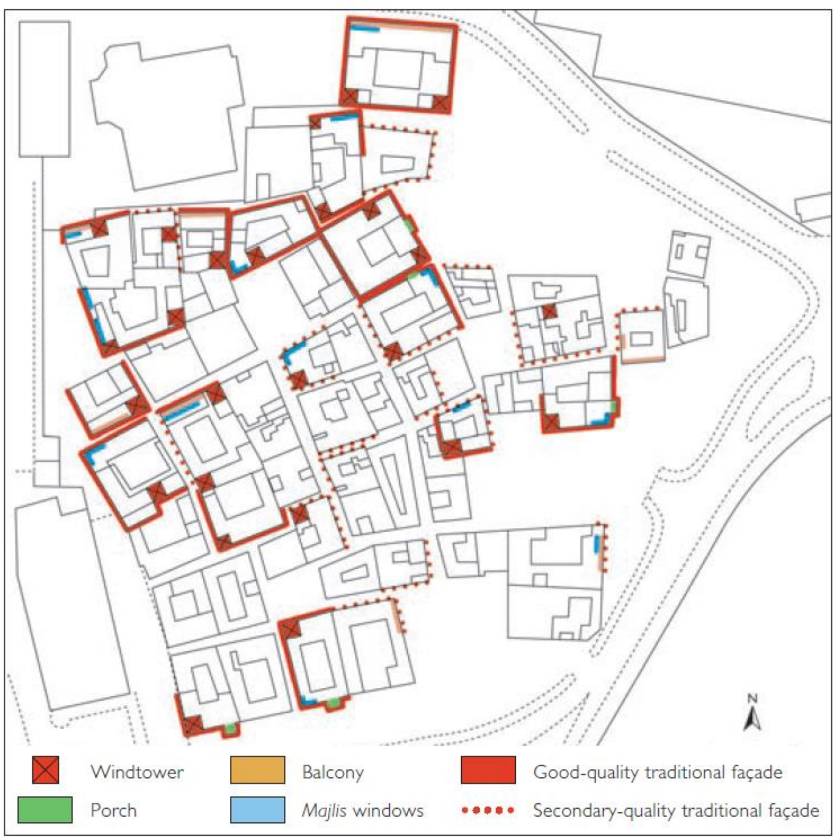

Figure 12: Wind tower distribution. [7]

- Liwan design: This is a type of interior design of homes were rooms are placed alongside the outer wall leaving an empty courtyard in the middle of the house. Using this design methods, allows the doors and interior windows of all the rooms in the house to be in the shaded, in addition to the path connecting all the house rooms. As seen in the Fig. 13 , all the doors and windows of the house are in the shade. In addition, some houses place plants at the center of the courtyard for aesthetics and to provide extra shade. Similar to the wind tower, the Liwan design was used extensively due to its effectiveness.

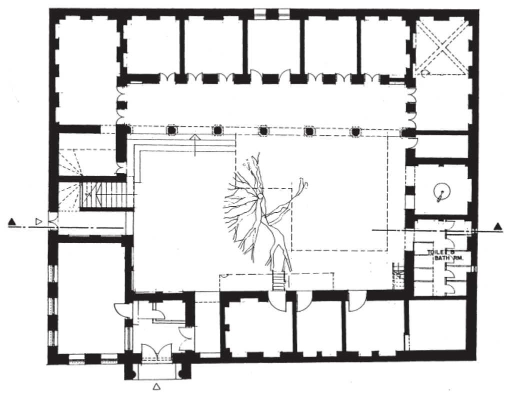

Figure 13: Plan view of a typical house in Al Bastakiyyah with Liwan design. [7]

- Neighborhood design considerations: a final note must be made on the cooling techniques on the neighborhood scale. The proximity of houses which provides shades for all the important passages throughout the neighborhoods. The following figure best illustrates the effectiveness of this approach to neighborhood cooling.

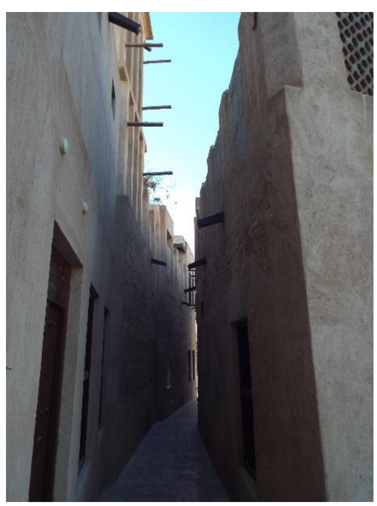

Figure 14: Shading in passages due to proximity of buildings.

5. Assessing Current configuration on Contemporary Design Model

5.1.1 Energy consumption: Model, Assumptions, ***Results, and Validation.***

Figure 15: The energy model, district, defined in Rhinoceros.

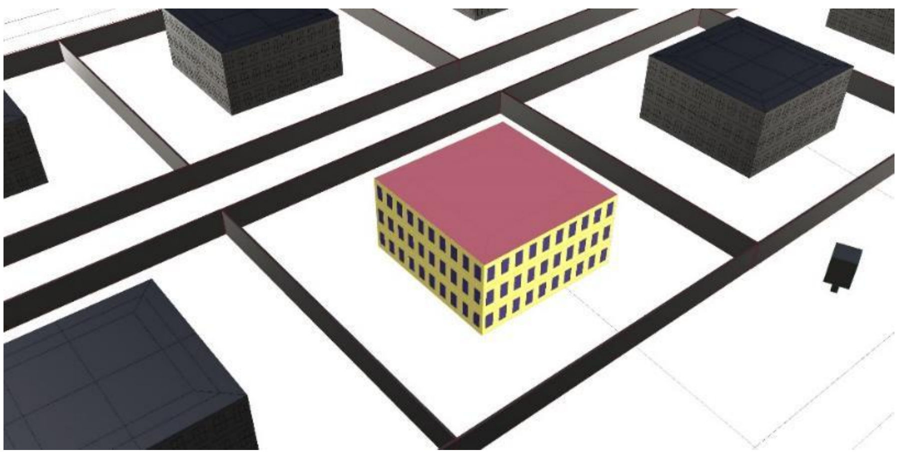

Figure 16: The energy model, unit, defined in Rhinoceros.

For this part of the research there were several steps that were followed in order to reach to the desired results. First of all, a newly built neighborhood was designed in detail using CAD. The areas of the villas were taken based on the design standards.

Sector Three from Al Shawamekh district which has 2 internal streets and a surrounding one on the edges of the plot was used.

The file was exported to Rhinoceros where the 3D model was developed. The floor height taken in this case is a standard of 3.5 meters. Also, in order to proceed with the energy simulation we used a tool called Urban Modelling Interface (UMI). This program was developed at MIT in order to calculate the energy consumption in different district typologies. In our case, we created one building template for the modern design and another for the traditional design. In the template there were several specifications such as the window typology, wall specifications, occupancy schedule, etc... The weather data used in this case is the one measured near the Abu Dhabi Airport. By defining these parameters the tool makes calculations from an energy point of view. Orientation is crucial in order to understand which side of the house will be most exposed to the sun.

The input parameters used to simulate contemporary houses are shown in the table below:

Table 1 Input Values for Contemporary House Typology

Contemporary	Residential
Orientation from North	50
Length x Width	20x20
Total GFA	1200
Number of Floors	3
Floor Height	3.5
WWR	35%
Roof u-value	1.29
Wall u-value	2.25
Window u-value	3.88
SHGC	0.63
Roof albedo	0.2
Wall albedo	0.35
Roof thermal mass (J/K.m2)	1.00E+06
Wall thermal mass (J/K.m2)	5.00E+05
Indoor CHTC (W/K.m2)	2
Roof-air CHTC (W/K.m2)	20
Wall-air CHTC (W/K.m2)	25
Infiltration	0.5
COP	2.2
People Density	6
Fresh air intake & vent. l/s per person	7.5
Thermostat set point (C)	24

The results from the simulation of a single house are shown in the table below. The result we are trying to compare is the annual energy intensity in kW/h/m^2 which can be seen in the bottom of the table:

Table 2: Energy Values

Total energy consumption for contemporary house				
Thermal Zone	Thermal energy (kWh)	Lighting Energy (kWh)	Electric Equip (kWh)	Total per zone (kWh)
1	75183.51731	970.59	12027.0545	**88181.1618**
2	37837.4769	970.59	4109.836321	**42917.90322**
3	38043.35775	970.59	4109.836205	**43123.78395**
4	33990.71667	970.59	4109.836416	**39071.14309**
5	33137.76862	970.59	4109.836836	**38218.19546**
6	83234.75884	970.59	12027.0545	**96232.40334**
7	42058.99509	970.59	4109.836321	**47139.42141**
8	42065.88276	970.59	4109.836205	**47146.30896**
9	37832.31734	970.59	4109.836416	**42912.74376**
10	37030.36124	970.59	4109.836836	**42110.78807**
11	98357.45903	970.59	12027.0545	**111355.1035**
12	47093.75335	970.59	4109.836321	**52174.17967**
13	47154.41527	970.59	4109.836205	**52234.84147**
14	43056.229	970.59	4109.836416	**48136.65542**
15	42258.42338	970.59	4109.836836	**47338.85021**
Total				**838,293.48**

COP	2.2
Total (kWh)	435565.0656
Area (m^2)	1200
Energy Intensity (kWh/m^2)	**363.0**

5.1.2 Energy consumption: Validation.

According to a survey carried out by the A Dhabi Executive Affairs Authority during September 2013, the average villa consumption is 369 kWh per m2. This survey was conducted using a sample of 17 villas within the city of Abu Dhabi. [5] Base on these results, there is an error of 1.6% which is acceptable for the scope of this paper.

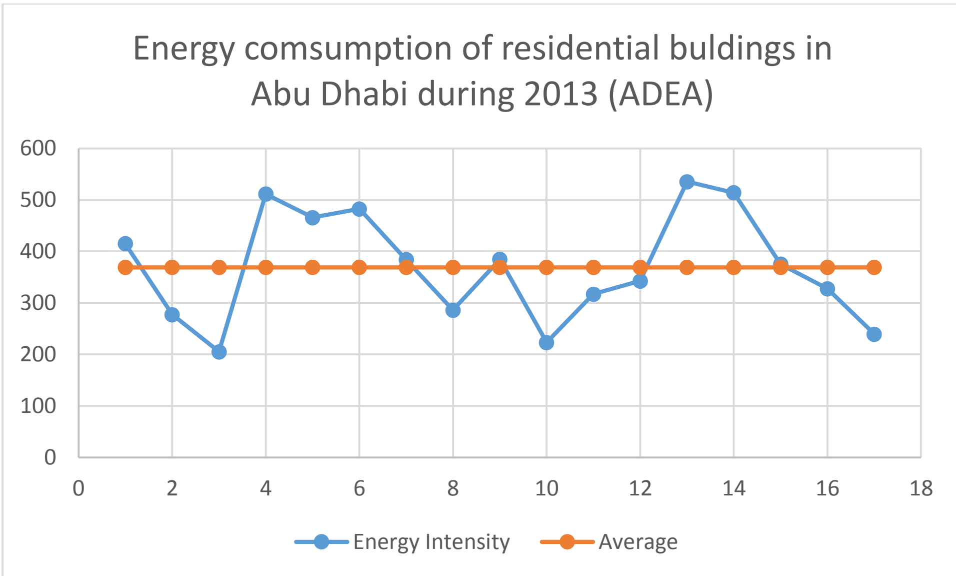

Figure 17: Energy consumption of residential buildings in Abu Dhabi [5]

5.2 Outdoor comfort: Model, Assumptions, *Results, and Validation.*

5.2.1 Outdoor comfort: Model, Assumptions, ***Results.***

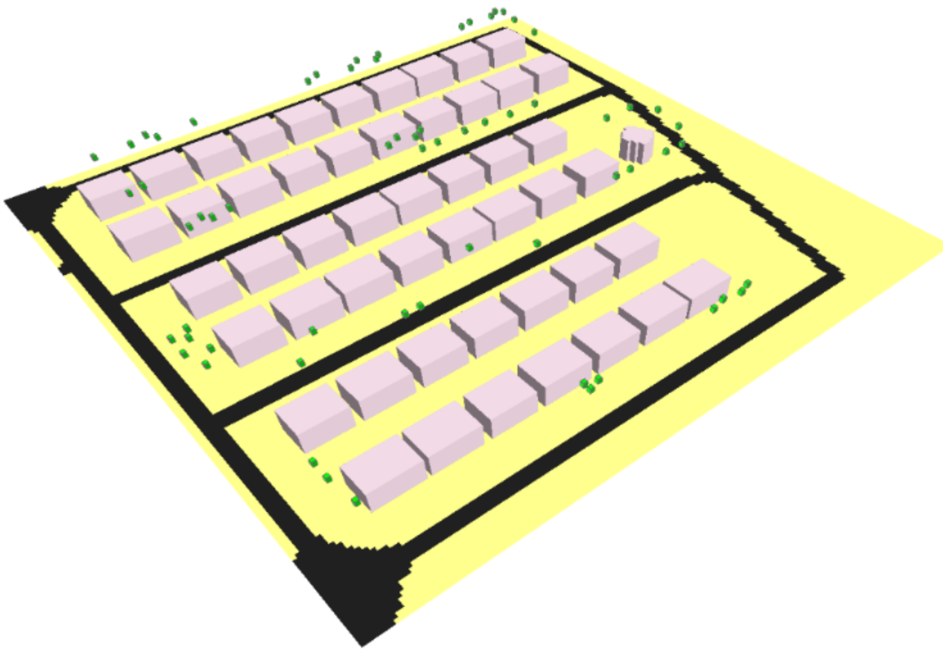

Figure 18: Contemporary design model in ENVI met.

The outdoor comfort has two main components. The first one is related to the temperature and the second to the humidity. These two components play an important role when rating comfort of the residents. This applies for both indoor and outdoor environments.

The PMV index assess the mean response of a large group of people according to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) thermal sensation scale where:

Scale	+3	+2	+1	0	-1	-2	-3
Interpretation	Hot	Warm	Slightly Warm	Neutral	Slightly cool	Cool	Cold

The software ENVI-MET that is used has a wide range of tools. Based on computer fluid dynamics (CFD) analysis the program can show the evaluations of temperatures, relative humidity, and the wind speed of a given urban environment. These variations depend on the size of the buildings, the type of soil, the presence of greenery, and thermal properties of most materials.

These results are put together and converted into a PMV along the neighborhood to show which areas are the least or most comfortable. In this simulation, a typical summer day was reproduced in order to assess the most critical conditions of the year.

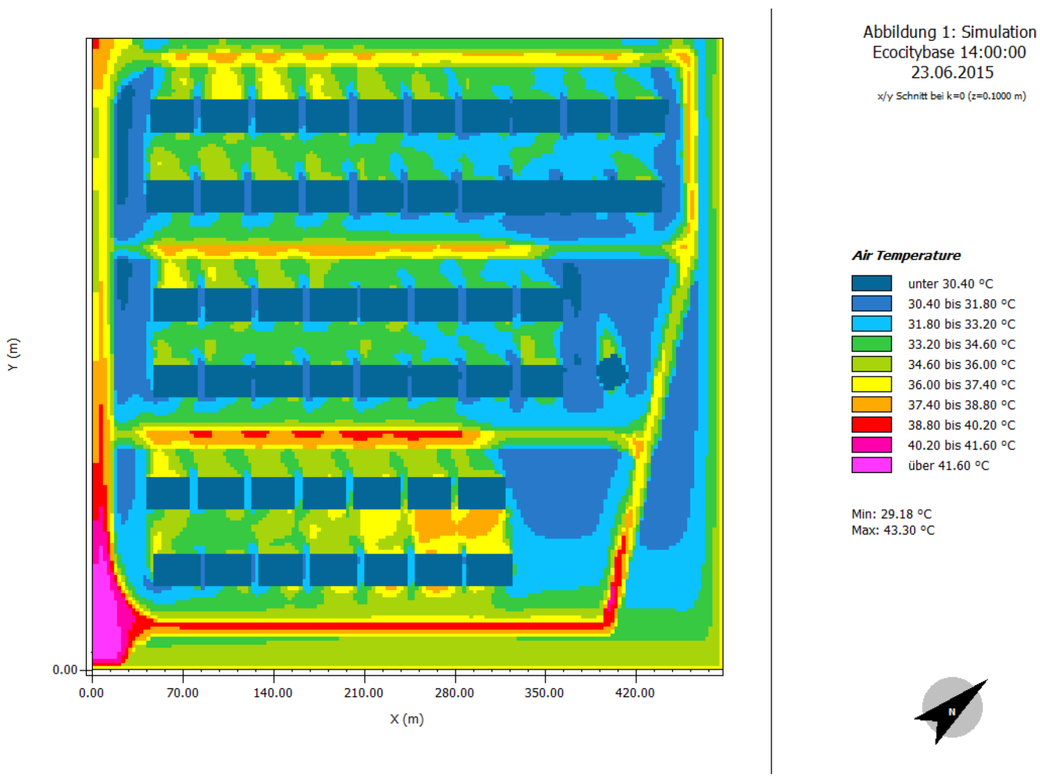

Figure 19: Result 1, temperature values in ENVI met.

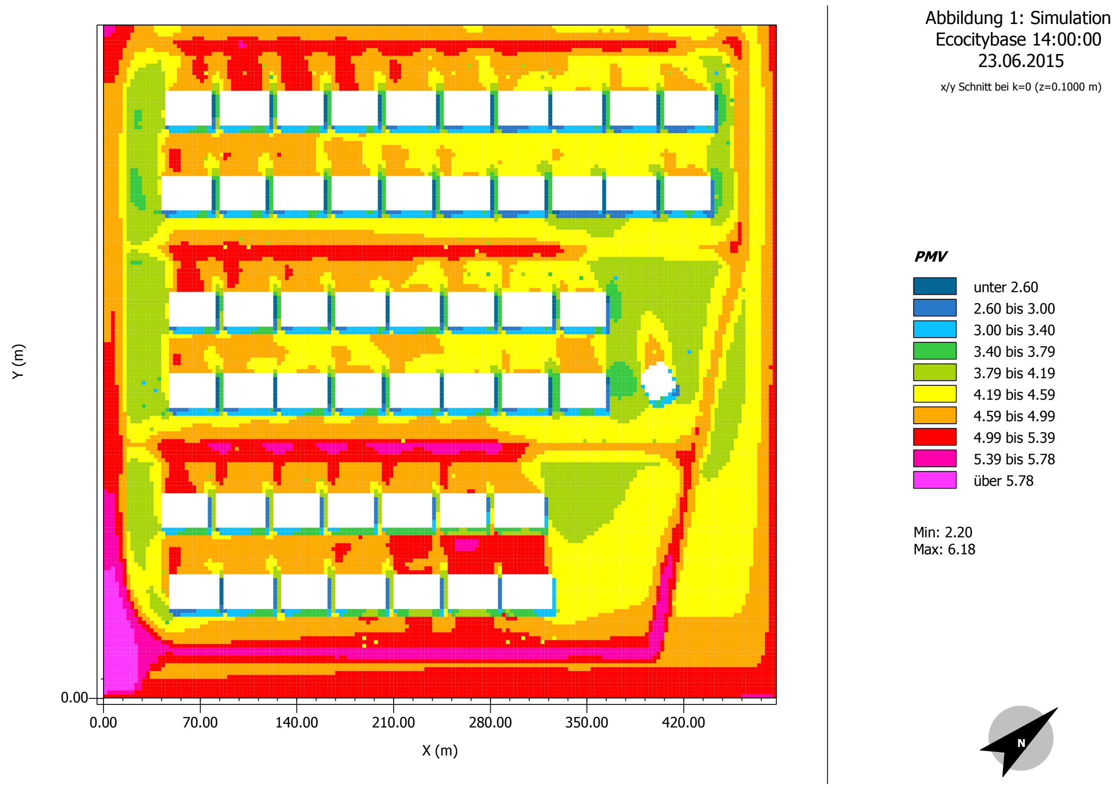

Figure 20: Result 2, relative humidity values in ENVI met.

5.2.1 Outdoor comfort: *Validation.*

Following the same PMV criteria, the below figure depicts the weather patterns from the Abu Dhabi Airport area. It is clear that the highest temperatures that lead to high PMV's are seen in the summer between May and October. It is worth mentioning the ideal condition is '0' as seen on the scale to the right of the figure.

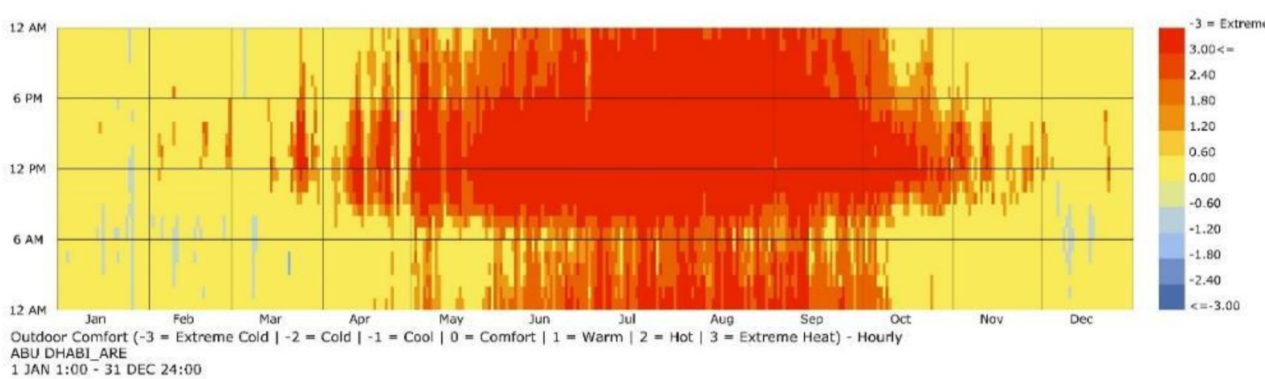

Figure 21: Outdoor comfort base parameters (Abu Dhabi Meteorology station).

In order to validate human comfort, the external consultant RWDI generated an extensive survey in 2009 collecting more than 1,074 responses from online as well as from field surveys. [6]

Table 3: Survey type and responses collected.

Survey Type	Dates Collected	Responses Collected	Dry Bulb Temp
Online Survey 9/3/09 –	9/3/09 – 11/30/09	473	20 - 50
Field Survey – Session 1	9/14/09 – 9/29/09	301	32 - 39
Field Survey – Session 2	2/8/10 – 2/16/10	300	20 - 24

As seen below, when the temperature is 36 degrees Celsius or above people did not feel comfortable in the outdoor areas. In regards to working outdoors, most people reported that they are more sensitive to high temperatures versus people who are preforming leisure outdoor activities. When addressing the general population (working and non-working), 61% reported that they felt uncomfortable walking outdoors during the summer. [6]

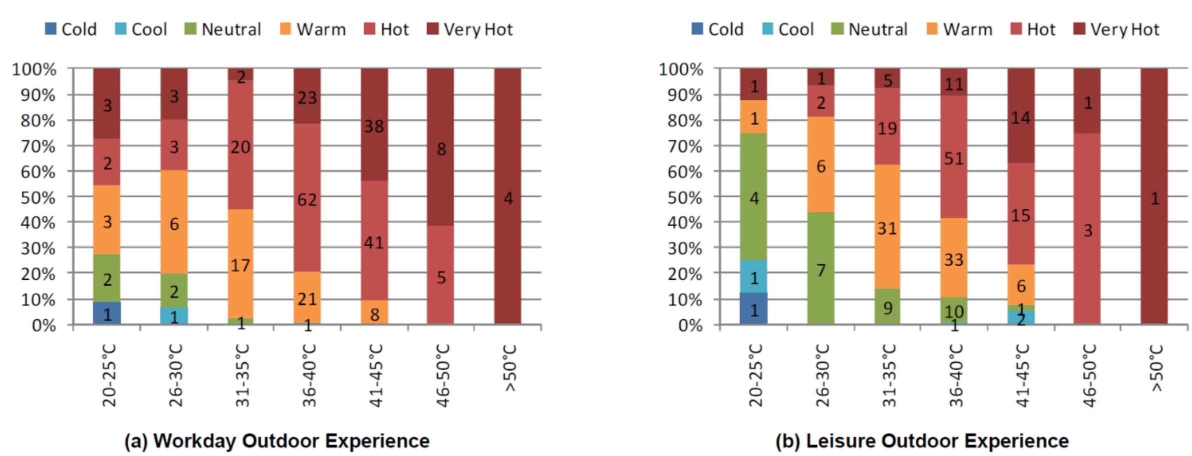

Figure 22: Participant's report comfort levels in recent outdoor experience at various temperatures (September 2009) [6]

5.3 Walkability, Results and Validation.

5.3.1 Walkability, Results.

In order to avoid using a car, a recommend duration of a walk is five minutes or a quarter mile in distance. However, this time may vary depending on weather conditions. In the chart below we see varying colors for the different houses. This represents the likelihood of a person to walk to the mosque rather than drive.

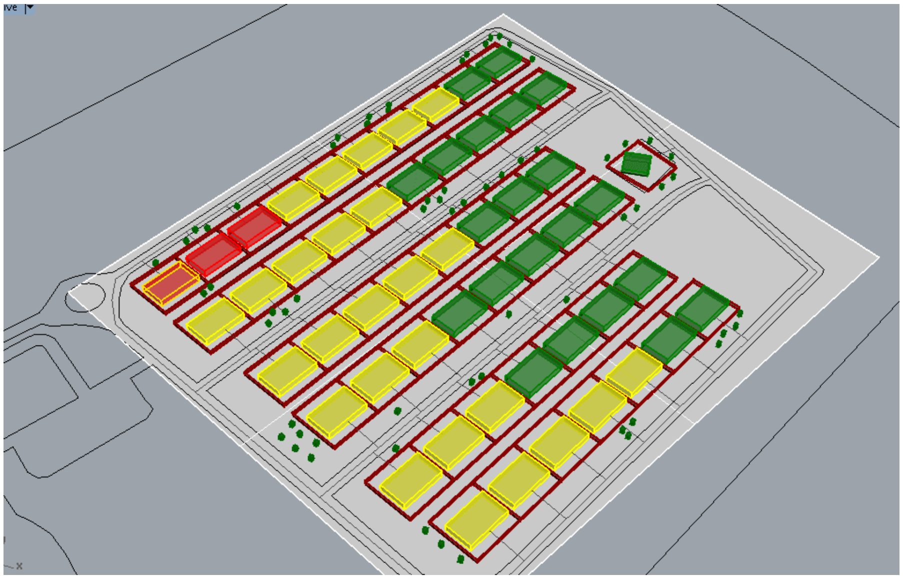

Figure 23: Contemporary design Model, walkability results.

5.3.2 Walkability: Validation.

Finding out how long people are comfortable in the outdoors during summer in Abu Dhabi is important in order to plan activities as well as manage pedestrian walkways. The survey mentioned before also inquired about how much time in the outdoor made the participants uncomfortable during summer under different circumstances. It was reported that 70% of the sample population was uncomfortable for more than 5 minutes in direct sunlight in midday. On another note almost 30% of the population was uncomfortable for more than 5 minutes under a shaded pathway. This information is crucial when designing a neighborhood.

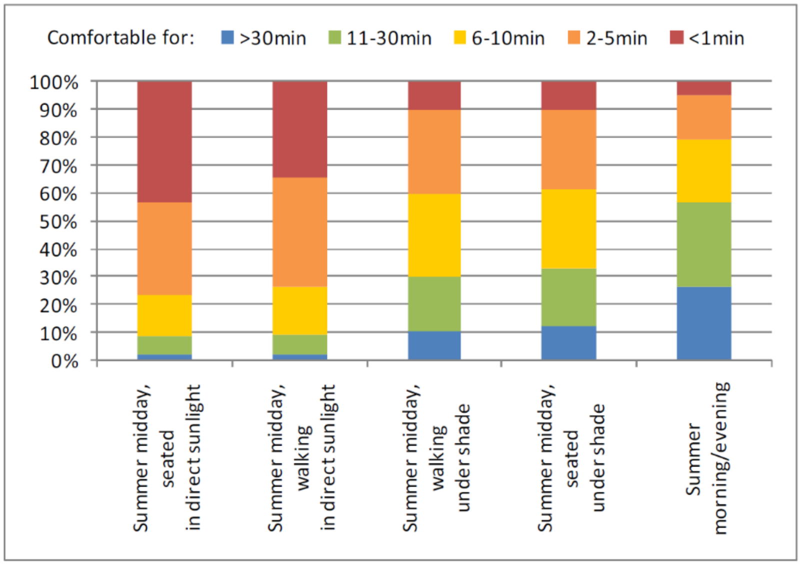

Figure 24: Impact of various conditions on perceived comfortable outdoor duration.

6. Assessing traditional design

6.1 Energy consumption: Model, Assumptions and *Results.*

In order to keep a limited number of variables, the same street pattern as well as the same number of houses were used as the area studied. The changes made in the sector were the location of the mosque, and the greenery. In regards to the houses, they have a courtyard based design, cob walls, and reducing glazed percentage. The figures below refer to the proposed design of the neighborhood.

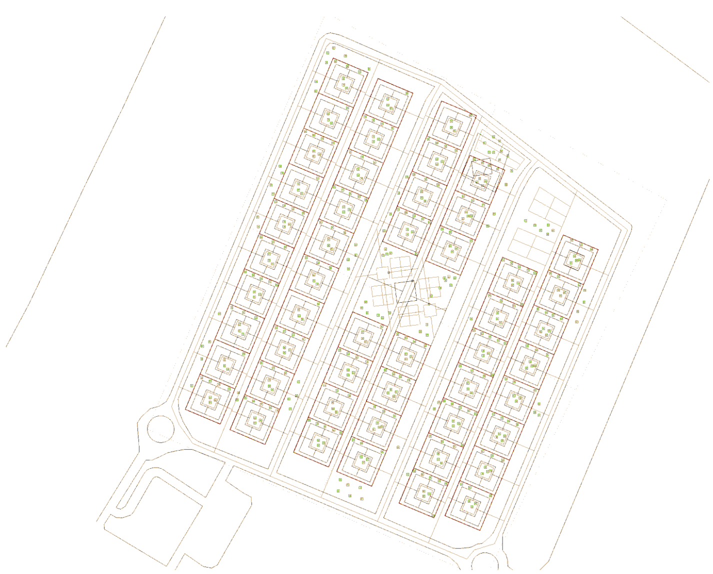

Figure 25: Auto Cad Traditional design model file.

Figure 26: Traditional design Model in Rhinoceros.

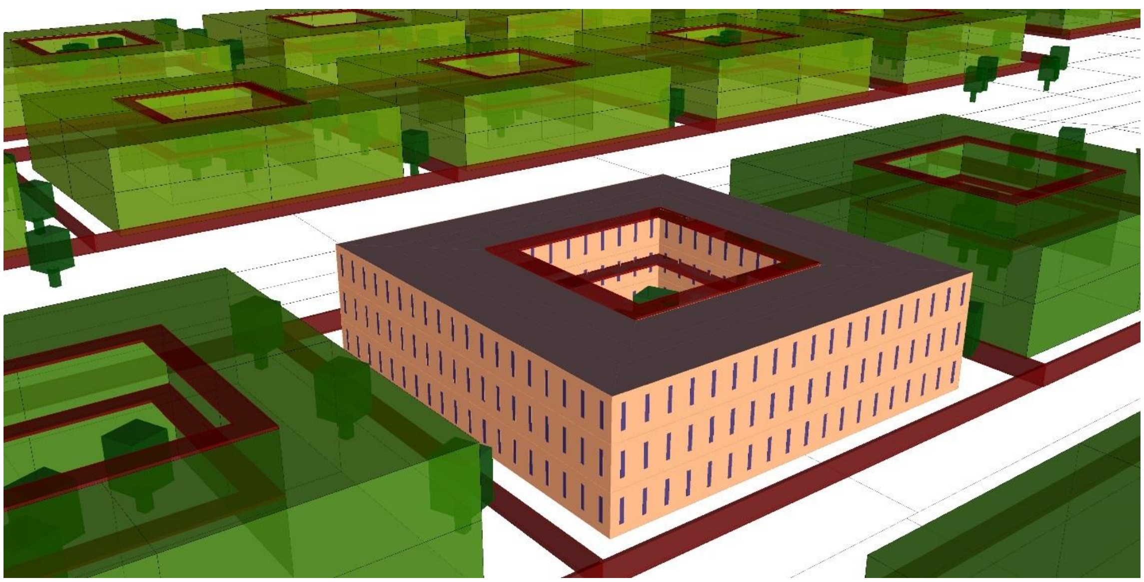

Figure 27: Detailed View of Proposed House Typology

The table below shows the inputs for the simulation of the proposed model. The highlighted inputs were changed to address the new design and its effects on the energy consumption.

Table 4 Input Values for Traditional House Typology

Traditional	
Orientation from North	50
Length x Width	38x38
Total GFA (m^2)	3132
Number of Floors	3
Floor Height (m)	3.5
WWR	10%
Roof u-value	1.29
Wall u-value*	0.51
Window u-value (W/K.m2)	3.88
SHGC	0.63
Roof albedo	0.2
Wall albedo	0.35
Roof thermal mass (J/K.m2)	1.00E+06
Wall thermal mass (J/K.m2)*	9.00E+05
Indoor CHTC (W/K.m2)	2
Roof-air CHTC (W/K.m2)	20
Wall-air CHTC (W/K.m2)	25
Infiltration	0.5
COP	2.2
People Density	6
Fresh air intake & vent. l/s per person	7.5
Thermostat set point (C)	24

**The assumed u-value and wall thermal mass were taken from the simulation from Goodhew & Griffiths, 2004 [8]*

When considering the traditional design simulation, we have more thermal zones due to more complex building layouts. Advanced energy simulation software (Energy Plus for this study) splits the building mass into several pieces to have more accurate results. Another thing to mention is the coefficient of performance (COP) which shows the efficiency of the HVAC system is in a building.

Total energy consumption for contemporary house				
Thermal Zone	Thermal energy (kWh)	Lighting Energy (kWh)	Electric Equip (kWh)	Total per zone (kWh)
1	58126.90288	970.59	8593.338639	**67690.83152**
2	57093.24951	970.59	8593.279547	**66657.11906**
3	57540.46496	970.59	8593.272542	**67104.3275**
4	55260.10404	970.59	8593.301635	**64823.99568**
5	37302.68224	970.59	5853.411844	**44126.68409**
6	37561.89778	970.59	5853.392026	**44385.87981**
7	36693.99785	970.59	5853.433885	**43518.02174**
8	37169.22592	970.59	5853.398433	**43993.21435**
9	98270.78946	970.59	16512.02595	**115753.4054**
10	65116.85282	970.59	8593.338639	**74680.78146**
11	63968.25723	970.59	8593.279547	**73532.12677**
12	64264.8758	970.59	8593.272542	**73828.73834**
13	61545.3472	970.59	8593.301635	**71109.23884**
14	41044.6544	970.59	5853.411844	**47868.65624**
15	41330.75112	970.59	5853.392026	**48154.73315**
16	40,854.67	970.59	5853.433885	**47678.69722**
17	41126.5395	970.59	5853.398433	**47950.52793**
18	111314.8335	970.59	16512.02595	**128797.4495**
19	76833.50511	970.59	8593.338639	**86397.43375**
20	75647.27991	970.59	8593.279547	**85211.14946**
21	75842.19777	970.59	8593.272542	**85406.06031**
22	72988.64993	970.59	8593.301635	**82552.54157**
23	49080.93217	970.59	5853.411844	**55904.93402**
24	49435.37523	970.59	5853.392026	**56259.35726**
25	48865.8968	970.59	5853.433885	**55689.92068**
26	49240.55134	970.59	5853.398433	**56064.53977**
27	137202.5289	970.59	16512.02595	**154685.1448**
Total				**1,889,825.51**
			COP	2.2
			Total (kWh)	994885.6829
			Area (m^2)	3132
			Energy Intensity (kWh/m^2)	**317.7**

6.2 Outdoor comfort: Model, Assumptions and *Results.*

In this case the model of the traditional design has a more complex urban texture as well as more greenery. The same characteristics of the contemporary model are considered for the traditional model. It is noticed that temperatures due to this type of design are reduced and bring a direct impact to the outdoor comfort. A value of one degree is considerable for the human body to notice the difference. As a rule of thumb it is known that every degree can reduce the cooling loads of a building by roughly 10%.

On the other end, the wind speed is improves evapotranspiration effects on the courtyards contributing to the internal ventilation inside each unit. Also, the microclimate created inside the courtyard of each villa interacts with the microclimate of the district. As a side effect greenery in courtyards can lead to a faster release of the heat coming out from the cooling systems making them more efficient. However, these effects are not considered in this study but are noteworthy.

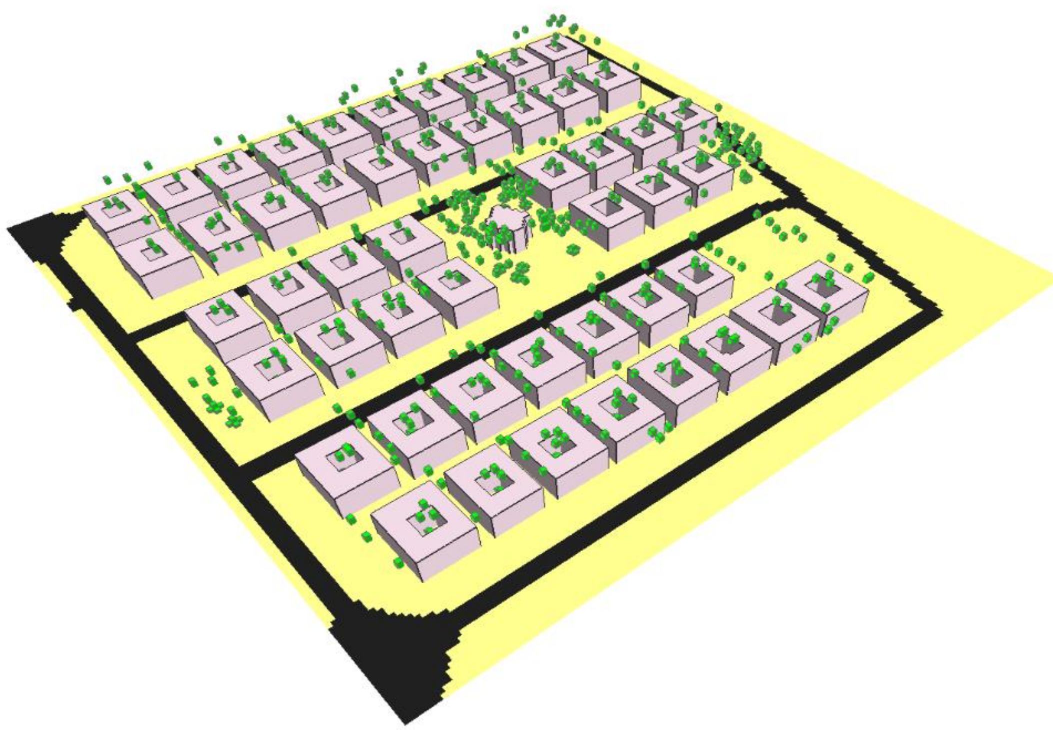

Figure 28: Traditional design Model in ENVI met.

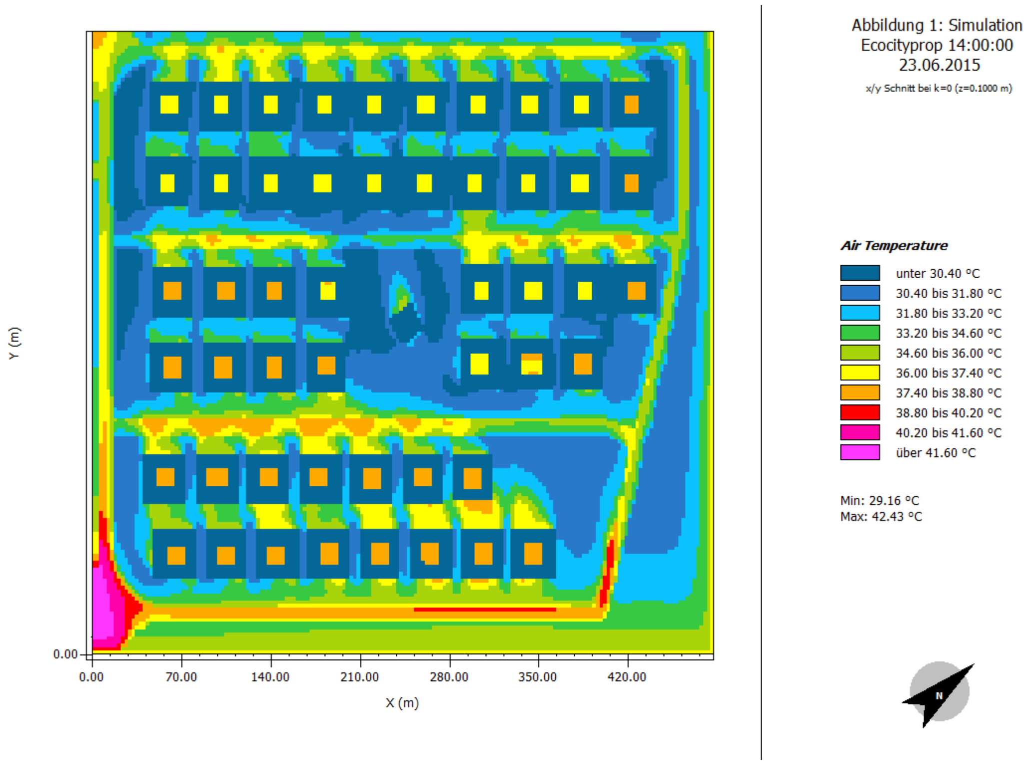

Figure 29: Result 1, temperature values in ENVI met.

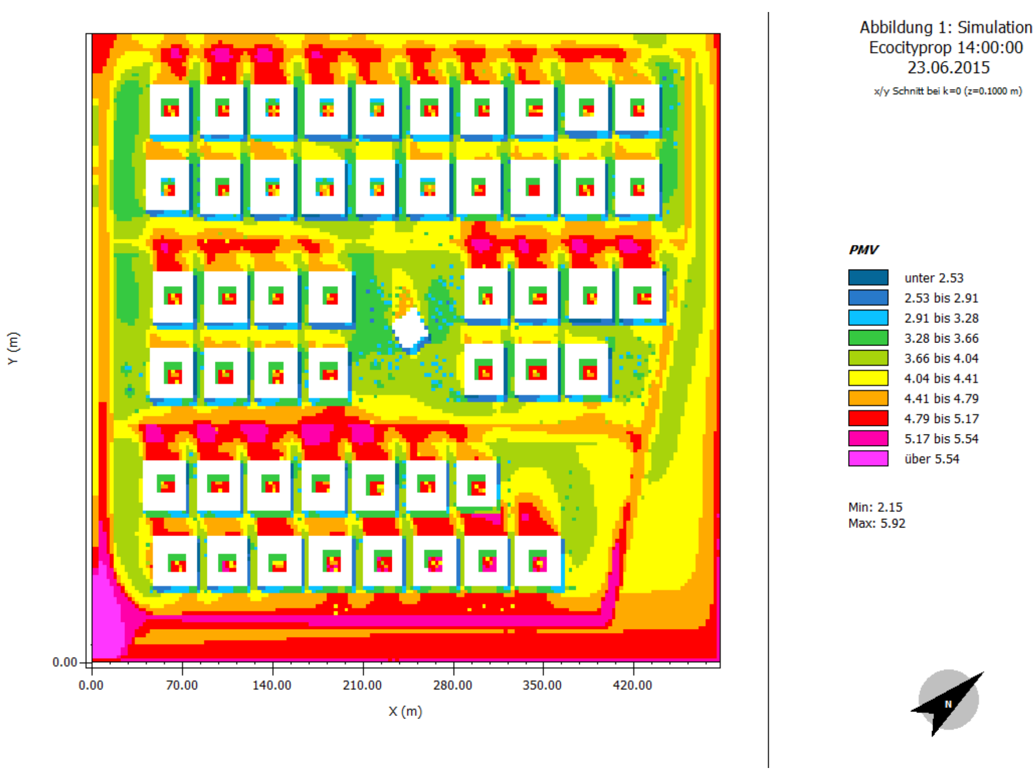

Figure 30: Result 2, relative humidity values in ENVI met.

6.3 Walkability: Model, Assumptions and *Results.*

Figure 31: Traditional design Model, walkability results..

The walkability in this case is improved by rearranging locations of the community facilities within the walkable distance.

This improvement brings encourages pedestrians to walk rather than using other means of transport. This in turn tranlates to healthier citizens, a clean environment and energy savings. Also the district becomes more atractive for various stakeholders that are in an urban planning community.

As it can be seen from the plan, in this new proposal the facilities are centered in the district making them an accessable site for all the residents. A convenient walkable distance to the main facilities is needed.

7. Comparing results

This section is for comparison purpose only, in the conclusions section there are mentioned further definitions on the scope of the whole research. As it can be seen from the simulations the energy results for the traditional designs have considerable savings mainly due to the cooling load. These results in particular are important since today urban planning decision making doesn't refer to such simulations.

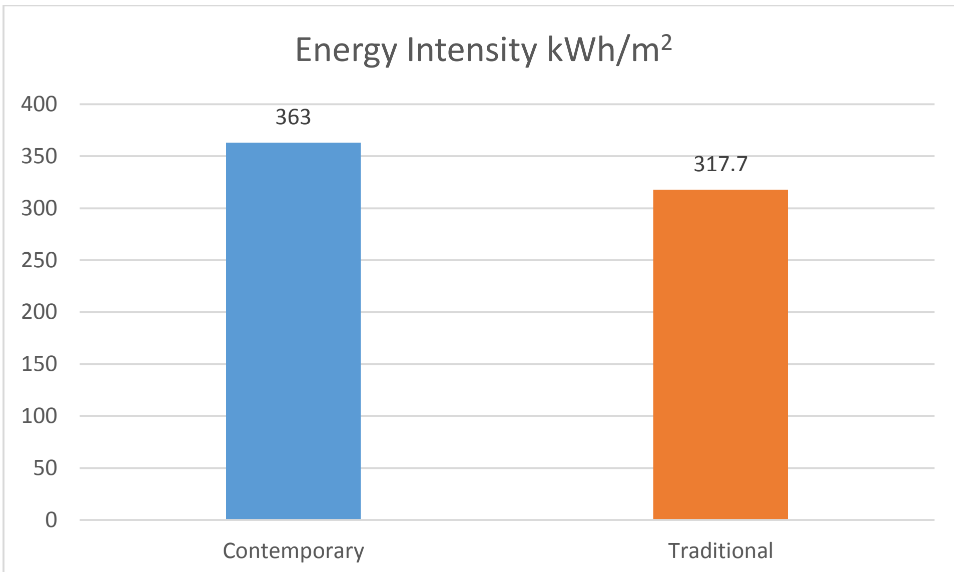

Figure 32 Energy Intensity of Contemporary & Traditional Designs

As it can be seen from the results, the traditional design consumes less energy by 12% when comparing to the current average energy consumption. This may not be a large amount of energy, but if we account for the total energy of the city and Emirate of Abu Dhabi, the result leads to 1770 GWh of energy savings only in terms of electricity. This is 3.5% of the energy consumption of the city itself. It is worth noting that the goal of installed capacity of renewables for Abu Dhabi by 2020 is 7%. [8] Also, the side effects of energy savings is seen terms of transportation due to the reduction of automobile usage.

The average temperature at 2 PM on June 21st for the contemporary neighborhood is 34.11 C, whereas the traditional design shows an average of 33.55 C. This shows a reduction in temperatures of 0.56 C. When looking at the PMV, we see a similar result when comparing the two neighborhoods. For the contemporary design it is at 4.55, while for the traditional design we attain a value of 4.23. These results encourage residents to engage in outdoor activities.

The new setup of the mosque shows how walkability can be improved when applying the traditional design towards the neighborhood. This also depicts the fact that walking time is reduced to a maximum of five minutes. When comparing this to the survey results, people stating five minute walks are acceptable, we can conclude that this is a significant result. This was done by using simple improvements which also helped generate simple results. These results show that the traditional neighborhood encourages walking as a method of transportation.

8. Conclusions

The aim of this paper is to show some hidden advantages in traditional designs when comparing it to contemporary designs in terms of quantitative performance indicators.

Our results are concentrated in three main areas:

- Energy efficiency,
- Outdoor comfort,
- Walkability.

In this research two models were considered: contemporary design and the traditional design. For the analysis the following tools were used: ENVI-met, UMI, Grasshopper, Autocad, Rhinoceros, and Energy Plus (EP).

The simulation results of the contemporary designs were calibrated based on the real measurements done in the along Abu Dhabi city which was provided from the municipality.

Based on the above analysis and results we can see that the energy saving in the Traditional way of design is 12% comparing to contemporary designs. This consumption decrease is mostly due to cooling loads. Current technology has the proper tools to simulate past and current environments. This enabled us to make a direct comparison between the two.

Architects and urban planners have to make consider the fact that these results do not apply to all contexts but are focused in a specific location. This helps simulate a base case for the Middle Eastern climate conditions. Further modifications can be tested such as roofs, the microclimate effects, colors, and passive cooling methods.

In terms of cooling loads, again the traditional design has advantages since the internal courtyard is influences the drop in temperatures by releasing heat in a faster manner. As mentioned earlier, even a change of 1 degree is very important in regards to cooling loads (every 1 degree decreases cooling loads by 10%).

In terms of the walkability, the traditional model has improved facilities placed in the center of the district with the same concept as it used to be designed in old neighborhoods. By having walkable distance facilities this districts gets a higher score in the walkability range. One thing worth mentioning is that walkability and outdoor comfort are related. In other words, the improvement of walkability is partially due to outdoor comfort.

We are able to conclude that this type of analysis will help urban planners, architects, and authorities to have a specific set of criteria when it comes to designing and building a new residential area. Also the deployment of traditional strategies may lead to accomplishing requirements of Estidama, this is mandatory for new developments. Design and proper selection of materials can be an influence to energy savings. If the design is based on sustainable principles as well, benefits can go beyond environmental and include social and economic. The new districts that will expand and be developed in the suburbs of Abu Dhabi, theoretically follow these principles. By combining different design approaches and reviewing lessons from the past traditional sustainability could be achieved without compromising the cultural heritage.

10. References

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