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Thème

Contribution au développement d'une conception énergétique de bâtiment à basse consommation d'énergie.Application aux régions du sudAlgérien

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Theme

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Application to the southern regions of Algeria

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1.1 Introduction :

The adequacy of human shelters to local climatic conditions and particularly the seek for thermal comfort (cooling and heating) inside buildings have been a constant struggle during the history of human settlements[1]. Nowadays, Building is one of the biggest energy consumers in the world, accounting for one-quarter to one-third of all energy use and a similar amount of greenhouse gas emissions[2].

Low energy consumption building design and technology have been developed to reduce the environmental footprint of humans on the planet. Low energy consumption building technology can range from simple technologies such as insulation and double glazing, to more sophisticated technologies such as solar power and green roofing. The arguments for Low energy consumption buildings are strong. If utilized right, solar energy can provide renewable electricity which will reduce demands on the grid, it is also very important to note the differences between the two terms "Low energy consumption building" and "sustainable building" as they are often discussed interchangeably, sustainable buildings tend to be more of a holistic term, while it has a strong focus on environmental sustainability, it and embodies aspects of social and economic sustainability. However, Low energy consumption building buildings tend to be a subset of sustainable buildings and just focus on environmental issues[3].

On the hand, the phenomena of heat and mass transfers and their interactions in the case of buildings and commonplace actions that the opening of a window or the starting up of air conditioning equipment sets the phenomenon extremely complex. On other hand the realization of prototypes for thermal experimentation of buildings on a real scale is often impossible and very expensive. This latter is related to several families of factors, factor responds of the building itself (the size, the geometry, materials of constrictions ... etc), Climatic conditions, the degree of comfort, the behavior of the occupants and the energy systems installed. The minimization of energy consumption and the comfort of users - requires an in-depth analysis of the various phenomena. These two aspects which are can

[1] *(Abel, E. 2006. Shape of new residential buildings in the historical centre of old Havana to favour natural ventilation and thermal comfort (Doctoral dissertation, KATHOLIEKE UNIVERSITEIT LEUVEN).)*

[2] *(Hong, W., Chiang, M. S., Shapiro, R. A., & Clifford, M. L. 2007. Why green buildings are key to Asia's future. Asia Business Council Book, Hong Kong Google Scholar.)*

[3] *(Pan, W., & Ning, Y. 2015. The dialectics of sustainable building. Habitat International, 48,2015, 55-64. doi:10.1016/j.habitatint.2015.03.004.)*

lead to often contradictory recommendations, and only a complete case-by-case analysis can help to define the optimal solution.

1.1 Problem Statements:

Nowadays, the Algerian energy consumption among the residential sector ranks first, it is 42%. The national energetic consumption is growing in an inordinate way, particularly during the last decade because the Algerian state has launched a massive plan of housing construction (urgent solutions for social housing about 2 million units) without taking in consideration the legislation of energy performance. In the absence of a well-founded policy that can respond to the growing need for citizens' demand. In addition, the simultaneous change of users requirements to maintain their comfort, especially in summer, which leads to a large amount of electricity consumption through using air conditioning. This situation has directly affected the quality of the building energy consumption, also the generalization of these so-called good-market models throughout the Algerian territory, without taking in consideration the influence of climate, has created a major energy problem in the recent years (network overload and repeated electrical cuts). The problem is that these models do not take into account the energy side and often neglect aspects of comfort. This, in turn, leads to an increase in loads, which is manifested in high seasonal consumption.

This research will focus on buildings and dwellings in Algeria. There are several reasons for this. First of all, air conditioning represents up to 67% of the total energy consumed in office buildings and dwellings in the arid climate (arid climate represent more than 80% of total surface Algerian)[4].

Today Algeria is facing the challenge of high peak electricity demand due to a large residential and commercial air conditioning penetration in summer. Developing innovative HVAC (Heating, ventilation, and air conditioning) technology towards sustainability is vitally important for Algeria to decrease the national electricity energy consumption and GHG (Green House Gas) emission.

[4]*(Belahya, H., Boubekri, A., & Kriker, 2016. A comparative study about the energetic impact of dry land residential buildings with the integration of photovoltaic system, Environment and Sustainability, TMREES16.)*

1.3 Objectives

The objective of this study is to define, analyze and attempt to optimize the influence parameters, from the energy point of view, on current buildings using the main technologies used in buildings with low energy consumption. These techniques concern particularly the geometric and thermal property of building as envelope (opaque walls, airtightness, sun protection, etc.), the shape (the building shape, the surface, ceiling height, orientation ...etc.) and, the interaction between geometric and thermal parameters as ration wall windows, ventilation, and the integration renewable energy sources (photovoltaic, solar panel, etc.).All these technique make it possible to optimize the energy and possibly to come out of proposals in relation with the expected standardization in this area.

The aim of this research is to develop a method for assessing the design low energy building, develop an analytical model and integrate it into an easy-to-use computer tool.

1.4 Research significance

This research novelty resides in the fact that it is the first study that investigates the energy consumption in buildings sector in Algeria and combines the impact of thermal and geometric parameters in energy consumption. Moreover, new zoning has been developed for the first time based in discomfort degree days.

Those simple Polynomials could be used by any engineer and makers decision to optimize energy consumption in building sector in the Algerian various climats.

This research is examining the relationship between the climate and thermo geometric design for average energy consumption. This research methodology is to assess energy consumption in the built especially for cooling and heating system which could be replicated in many other huge surface country as Algerian (many different climate).

Moreover this research contributes to the wider significance of multi-disciplinary science for several reasons. First, this research combines engineering and socio-economics to assess the behavior of human being and the energy consumption.

Moreover, the results obtained from the Algeria case study can provide a framework of recommendations for each country located in the south of Mediterranean and other countries which have similar climate and socio economic conditions. This research serves the agenda of cooling and heating system and thermo geometric design for optimizing energy consummation.

This research will significantly contribute to find solutions, by which so Algeria can combat high peak electricity demand and Greenhouse effect emissions from the residential building sector.

1.5 Research scope

The scope of this research can be summarized as to better understand the influence and the interaction of some thermo-geometric parameters in residential buildings in diverse climates (Algeria case). More specifically this thesis has three particular research aims and contributions which are:

- Develop new zoning based in DCDHH (DisComfort Degree Hours Heating) and DCDHC(DisComfort Degree Hours Cooling) assisted for design to reduce energy consumption and high peak electricity demand due cooling system for Algerian buildings sector.

- Develop new Co-simulation code which combine and make the optimization between soft wares for reduce the time of simulation and the cost.

- Economic assessment, the proposed method its essay for used by anyone to find the optimum solution or the rehabilitation of insulation.

1.6 Thesis Outline

This research is structured in three parts. It firstly provides a general overview on energy consumption focused on building sector. Algerian has huge surface and different climate, to study their influence in building energy consumption we used discomfort degree days to get zoning suitable in huge surface country as Algeria.

The second part, focused on multiobjective optimization which is the case of building design. Design of experiments was chosen to determine the most influence parameters. Finally, this research develops some possible solutions that can help engineers and maker-decision built low building energy consumption.

In order to achieve the overall aim, this thesis is divided into seven chapters.

Chapter 1 is general introduction in outlines, the research scope and problematic. It also provides an overview of the objectives and significance of the research.
Chapter 2 is presented in covering the topics of energy and an overview of energy consumption around the world, and background of energy in Algeria, mainly in the buildings sector and the impact of air condition in electrical energy consumption.

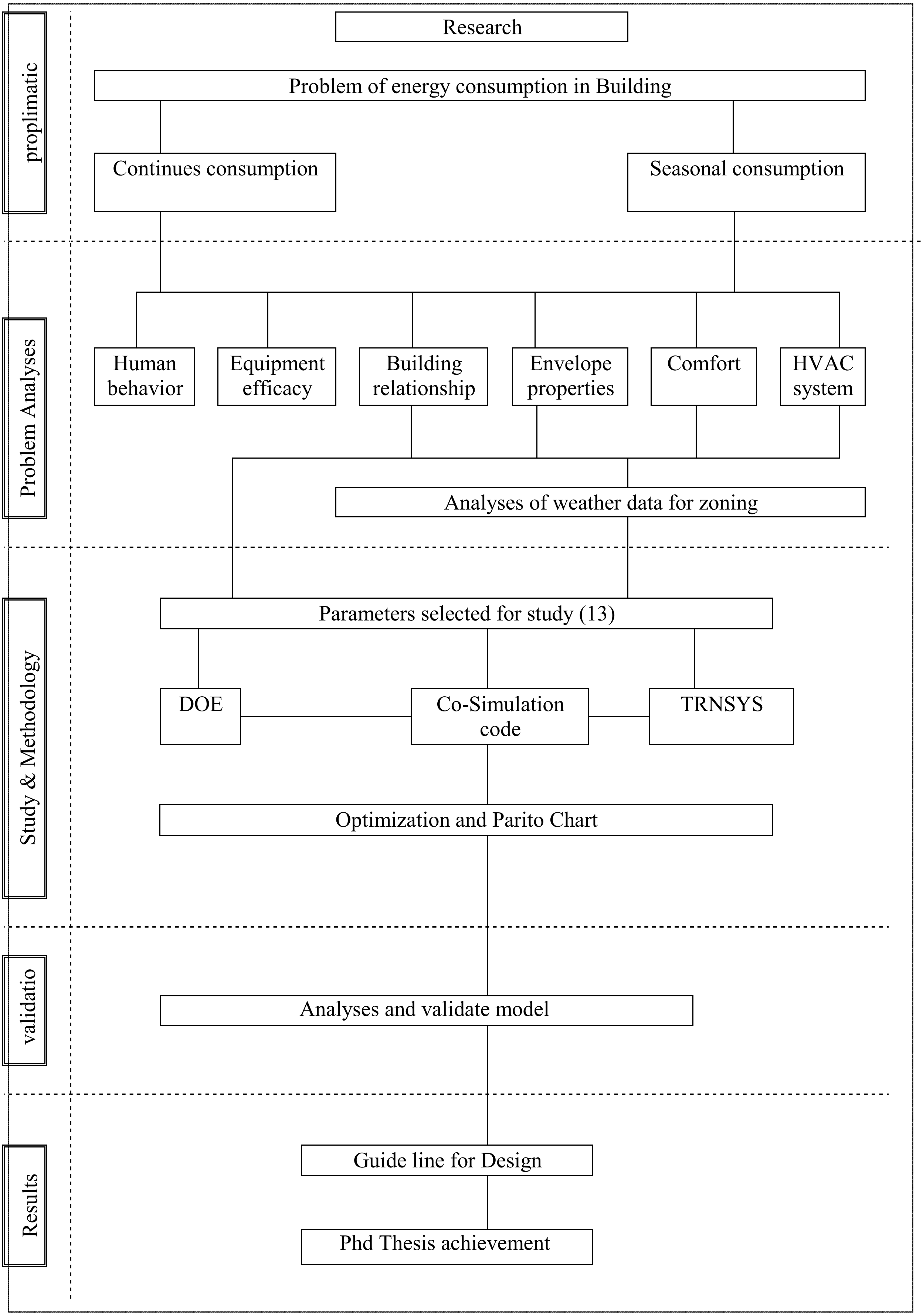
Chapter 3 thermal comfort and climate zoning, building sector and its energy consumption. Thermal comfort and climates zoning. Provides the overall methodology that was used in this research to put new zoning based in DCDHC and DCDHH.

Chapter 4 multiobjective optimization for building energy consumption. In order to provide a clear understanding of the different methods of optimization. Furthermore, multiobjective methodology are discussed with co-simulation as solution for parametric study to solve probabilistic design.

Chapter 5 applications on a case study explains the fundamentals of the proposed design and methodology, of which a brief overview is given at the start of the chapter. Sensitivity analysis moreover identifies those input parameters that are most dominant in this average consumption. These results will be compared with the results of two additional dwellings with a different geometry in order to generalize the conclusions.

Chapter 6 conclusions and future work gives a brief conclusion of this research study as well as recommendations for future work. In order to improve the future energy consumption simulation in the built environment and describes proposes some recommendations for future buildings regulations.

Table 1.1 Schema of the dissertation



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Belahya, H., Boubekri, A., & Kriker, 2016. A comparative study about the energetic impact of dry land residential buildings with the integration of photovoltaic system, Environment and Sustainability, TMREES16.

Hong, W., Chiang, M. S., Shapiro, R. A., & Clifford, M. L. 2007. Why green buildings are key to Asia's future. Asia Business Council Book, Hong Kong Google Scholar.

MODELISATION HYGRO-THERMO-AERAULIQUE DES BATIMENTS MULTIZONES PROPOSITION D'UNE STRATEGIE DE RESOLUTION DU SYSTEME COUPLE.(Monika WOLOSZYN épouse VALLON 1999).

Pan, W., & Ning, Y. 2015. The dialectics of sustainable building. Habitat International, 48,2015, 55-64. doi:10.1016/j.habitatint.2015.03.004.

2.1 Introduction

This chapter presents the energy consumption of the building sector in the world and in Algeria. Building performance became more prominent in the 70's due to the 'oil shock', which forced governments and the academic community to examine ways to reduce the energy consumption of buildings[5].The theme of energy also plays an important role in economic and political debates, the world of energy has to face considerable challenges, notably the fight against climate change and the scarcity of conventional energy reserves in the face of continuing global demand. The intensive consumption of energy into fossil fuels poses various problems, especially the increased concentration of carbon dioxide in the atmosphere, and consequently the greenhouse effect. A considerable part of this damage to the environment is related to buildings and their construction.

Thus, we recall the energy context of the building sector in Algeria and the thermal regulations in order to situate the stakes. The thermal regulation is the set of laws, decrees and by-laws relating to the thermal characteristics and the energy performance of buildings. It defines the precise energy performance to which the new building must respond, for heating and cooling, lighting and ventilation.

2.2. Energy consumption around the world

Energy consumption has increased dramatically in the early 20th century due to the industrial revolution. Industry, transportation and buildings are the main energy consuming sectors worldwide. Buildings account for nearly 50% of the energy consumed in developed countries[6].

In the developing countries, energy is one of the determining factors for the survival of the populations: it is necessary for all human activity and essential for the satisfaction of the daily needs (water, food, health, …etc.) but also to ensure a minimum economic and social development.

[5](Prazeres, L. M. R. (2006). *An exploratory study about the benefits of targeted data perceptualisation techniques and rules in building simulation* (Doctoral dissertation, University of Strathclyde).)

[6] (Harris, D.J. & Elliot, C.J. (1997) '*Energy Accounting for Recycled Building Components*, Proc. 2nd Int. Conf. on Buildings and the Environment: CIB TG8 (Paris), France.)

World energy consumption in 2014 is about 12,274 billion tons of oil equivalent with annual growth of consumption of around 2.5%[7]. With this growth, the world will certainly have reached the limit of proven reserves (800 Gtep) by 2050. In terms of market share, oil is the most common source of energy with nearly 37%. It is followed by coal with 27% and natural gas with 23%. Nuclear represents just under 6% of the world market, hydropower and other renewables about 8%.

Although China, the world's largest energy consumer since 2009, recorded a rebound in growth in 2016, its energy consumption development has seriously slowed over the past three years in comparison to the trend observed over the 2000-2013 period.

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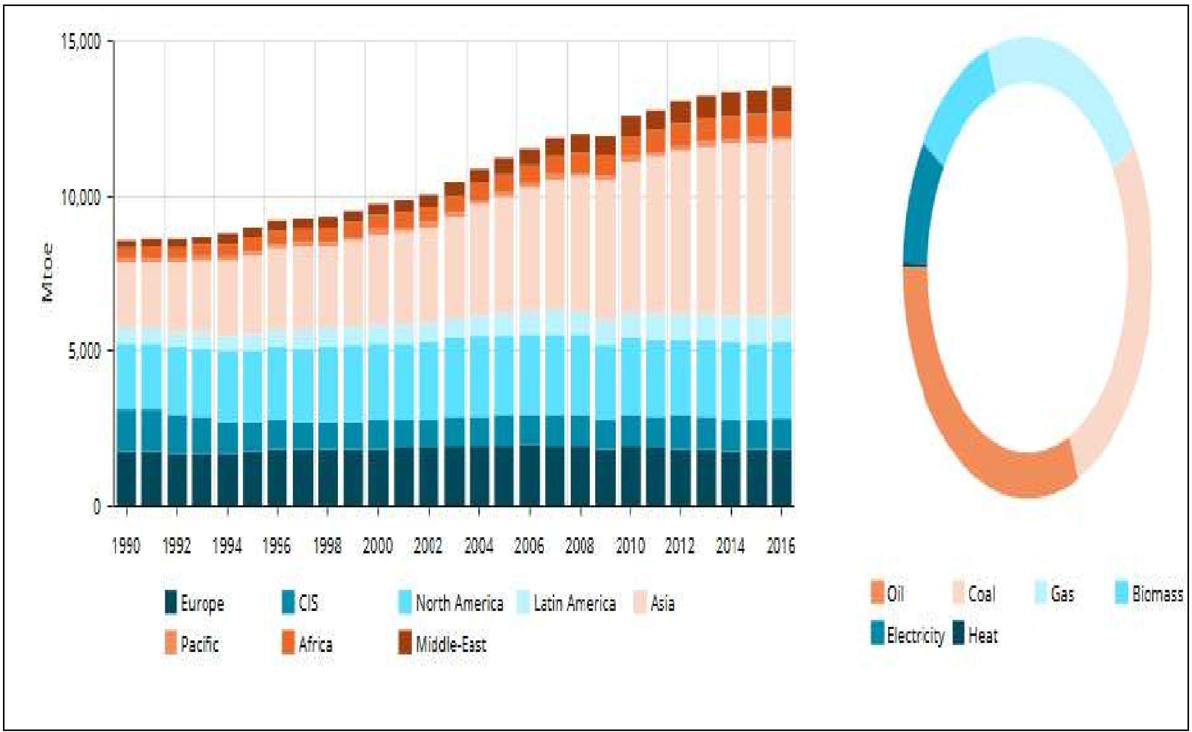

Figure 2-1:Trend over energy consumption 1990 – 2016[8]

Weak economic growth and a move to a less industrial-based economy combined with strong energy efficiency gains and the government's willingness to decarbonize the economy, has reduced coal consumption, and explains recent developments. Energy consumption was flat in the USA in 2016 because of the deep fall in coal use, offset by

[7]*(International Energy Agency (2014) IEA)*

slight increase in oil and gas consumption. India continued to support world energy consumption representing a quarter of the global rise in 2016[8].

Strong rising trends have been recorded in Turkey and in Asian countries such as Indonesia, Malaysia and South Korea. Conversely, energy consumption has declined in Latin America, driven by Brazil, Colombia, Mexico, while that of the European Union remained steady Figure 2-2

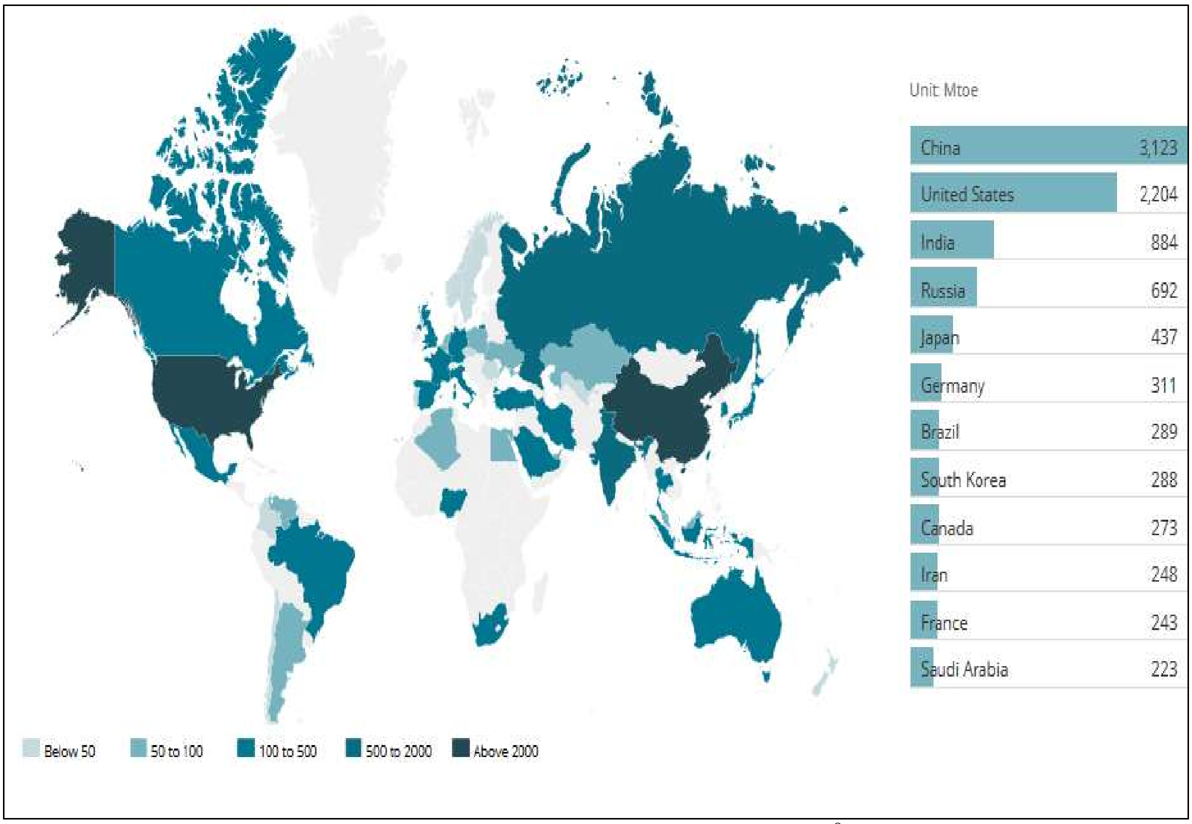

Figure 2-2 :Breakdown by energy (2016)[8]

- **USA Energy consumption**

The buildings sector accounts for about 76% of electricity use and 40% of all U. S. primary energy use, to reduce costs to building owners and tenants. Opportunities for improved efficiency are enormous. By 2030, building energy use could be cut more than 20% using technologies known to be cost effective today and by more than 35% if research goals are met. Much higher savings are technically possible[9].

[8]*(Global Energy Statistical Yearbook 2017)*
[9]*(AN ASSESSMENT OF ENERGY TECHNOLOGIES AND RESEARCH OPPORTUNITIES U.S. Department of Energy, 2015)*

The major areas of energy consumption in buildings are heating, ventilation, and air conditioning 35% of total building energy; lighting 11%; major appliances (water heating, refrigerators and freezers, dryers) 18% with the remaining 36% in miscellaneous areas including electronics. In each case there are opportunities both for improving the performance of system components (e.g., improving the efficiency of lighting devices) and improving the way they are controlled as a part of integrated building systems (e.g., sensors that adjust light levels to occupancy and daylight). Figure 2-3 shows U.S. building energy use in 2014[10] Space conditioning, water heating, and lighting represent well over half of the total, including energy used in outdoor lighting and cooling most data centers. Total primary energy use in buildings is 38.5 Quads (quadrillion Btu; Btu: British thermal unit)

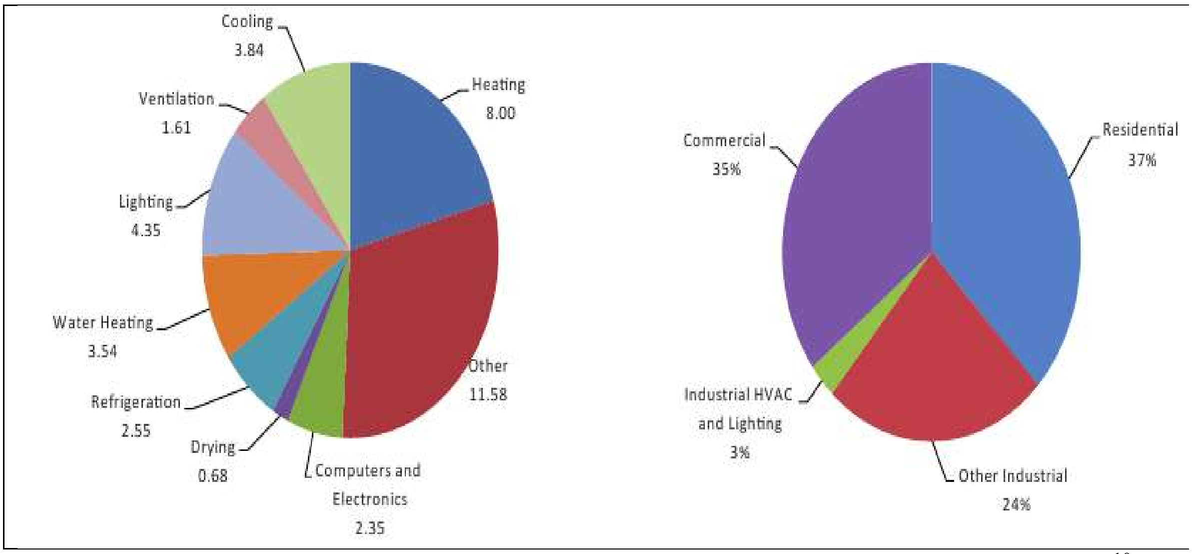

Figure 2.3 Buildings Use More Than 38% of all U.S. Energy and 76% of U.S. Electricity[10]

The building sector's share of electricity use has grown dramatically in the past five decades from 25% of U.S. annual electricity consumption in the 1950s to 40% in the early 1970s to more than 76% by 2012[11].Absent significant increases in building efficiency, total U.S. electricity demand would have grown much more rapidly than it did during this period.

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[10]*("Energy Information Administration (EIA). ," Annual Energy Review 2014. Washington, DC: U.S. Department of Energy, 2014). Available at: http:// www.eia.gov/forecasts/archive/aeo14/*

[11]*(Energy Information Administration (EIA). Manufacturing Energy Consumption Survey 2010., Washington DC: EIA, 2013)*

In the Unites States, greenhouse gas (GHG) emissions from the building sector have been increasing to almost 2 % per year since 1990. CO_2 emissions from residential and commercial buildings are expected to increase continuously at a rate of 1.4 % annually until the year 2025[12]. Given that buildings are responsible for approximately 20 % of the greenhouse gas emissions, there is growing awareness of the important role that buildings play in reducing the environmental effects[13]. On the one hand, emissions associated with buildings and appliances are expected to grow faster than those from any other sector do. On the other hand, reducing the consumption of energy in buildings is estimated to be the least costly way to achieve large reductions in carbon emissions[14].

- **European Energy consumption**

In Europe, buildings account for 40 to 45 % of the total energy consumption[15], according to approximately 25% is used in dwellings[16]. A precise breakdown of how this energy is consumed on a country by country basis is difficult to ascertain, especially considering that such a breakdown is highly dependent on factors such as climate, technology used and other conditions which are variable from country to country[17]. However, an approximate breakdown is given by the European Environmental Agency (EEA)[18], in which indicates that a substantial amount of this energy, about 69%, goes into space heating with the remaining balance accounted for by water heating (15%), providing electricity for appliances and lighting equipment (11%) and cooking activities (5%). In warm climates such as that present in southern European countries, space cooling is the

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[12] *(Brown, M. A., Southworth, F. and Stovall, T. K. Towards a climate-friendly built environment. Prepared for the Pew Center on Global Climate Change. 2005, Oak Ridge National Laboratory. http://www.pewclimate.org/technology-solutions/pubs,)*
[13] *(Stern, N., et al : The Economics of Climate Change. 2006, HM Treasury London.)*
[14] *(McKinsey & Company, 2007, Reducing U.S. greenhouse gas emissions: How much at what cost. http://www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf, [Accessed 13/01/2018)*
[15] *(European Environmental Agency, [EEA 2006])*
[16] *(DG for Energy and Transport (2009). "EU energy and transport in figures" - Luxembourg: Office for the Official Publications of the European communities. European Commission. Luxembourg.)*
[17] *(REMODECE Project Members (2008). "Report with the results of the surveys based on questionnaires for all countries in REMODECE - Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe (IEEA Program Funded Project)".)*
[18] *(European Environmental Agency (2001). Chapter "Households" in "Indicator Fact Sheet Signals 2001" - European Environmental Agency. Available from: http://www.eea.europa.eu/data-and-maps/indicators/household-energy- consumption [Accessed 10/01/2017])*

predominant load[19] Ensuring the efficient provision and use of energy in dwellings is therefore an essential aspect in attaining the overall 20% improvement in energy-efficiency target set out by the Presidency Conclusions of the European Council for 2020.

The existing building stock in European countries accounts for over 40% of final energy consumption in the European Union (EU) member states, of which residential use represents 63% of total energy consumption in the buildings sector. Consequently, an increase of building energy performance can constitute an important instrument in the efforts to alleviate the EU energy import dependency (currently at about 48%) and comply with the Kyoto Protocol to reduce carbon dioxide emissions. This is also in accordance to the European Directive[20] on the energy performance of buildings, which is currently under consideration in all EU member states. This paper presents an overview of the EU residential building stock and focuses on the Hellenic buildings. It elaborates the methodology used to determine the priorities for energy conservation measures (ECMs) in Hellenic residential buildings to reduce the environmental impact from CO_2 emissions, through the implementation of a realistic and effective national action plan. A major obstacle that had to overcome was the need to make suitable assumptions for missing detailed primary data. Accordingly, a qualitative and quantitative assessment of scattered national data resulted to a realistic assessment of the existing residential building stock and energy consumption. This is the first time that this kind of aggregate data is presented on a national level. Different energy conservation scenarios and their impact on the reduction of CO_2 emissions were evaluated. Accordingly, the most effective ECMs are the insulation of external walls (33–60% energy savings), weather proofing of openings (16–21%), the installation of double-glazed windows (14–20%), the regular maintenance of central heating boilers (10–12%), and the installation of solar collectors for sanitary hot water production (50–80%)[21].

2.3. Building energy and performance review in worldwide

[19] *(de Almeida, A. and Fonseca, P. "Residential monitoring to Decrease Energy use and Carbon Emissions in Europe" in European Council for an Energy Efficient Economy, ECEEE Conference 2007 Summer Study. 2007. Côte d´Azur, France, s.d.)*
[20] *(Energy Performance of Buildings Directive, EPBD 2002/91/EC)*
[21] *(A. Balaras et al, European residential buildings and empirical assessment of the Hellenic building stock, energy consumption, emissions and potential energy savings, Building and Environment, Volume 42, Issue 3, March 2007, Pages 1298-1314)*

Buildings, as the largest users of energy, are also our greatest opportunity for energy conservation and protection of the environment. The rapidly growing energy needs have raised global concerns over continued depletion of energy resources and their negative impact on the environment. During the oil crisis in the early 1970 s, issues such as energy demand and efficiency were of enormous political, economic and technical concern worldwide. Consequently, several governments introduced certain measures in an effort to improve energy efficiency and reduce energy consumption. There has been a growing movement towards sustainable construction since the second half of the 1980s, leading to the development of various methods for evaluating the environmental performance of buildings.

The energy required to cool and heat buildings is approximately 7% of the total world energy consumption and this can be reduced by around 2.5% if buildings are efficiently designed. Due to an increase in the standard of living, reduction in the cost of air-conditioning, and urban heat island effects, there is a growth in building cooling even in temperate and cool regions[22].

A building is a complex system for both design and operation. All elements including environment, envelope, technical facilities and occupant activities interact.

The topic of environmental performance and sustainability buildings should be recognized and measured in the building sector is extensively considered. Moreover, sustainability assessments of building are described, as they have demonstrated necessary to incentivize the diffusion of sustainable building. Many sustainability assessment systems for buildings have been proposed in the last 20 years worldwide Figure 2-4. In America, Europe and Asia, sustainability systems have already diffused, and at the present time, only in African countries has the sustainability assessment of building scarcely diffused. Moreover, it should be considered that in Africa, the sustainability of buildings is often intrinsic with building processes, although there is an absence of sustainability assessment systems[23].

[22]*(Agrawal, P.C. (1988) 'A review of passive systems for natural heating and cooling of buildings', Healthy Buildings 88 Conference Proceedings: Stokholm, Sweden, pp585-602.)*

[23]*(Moving to Sustainable Buildings. Paths to Adopt Green Innovations in Developed Countries, Umberto Berardi, Published by Versita 2013)*

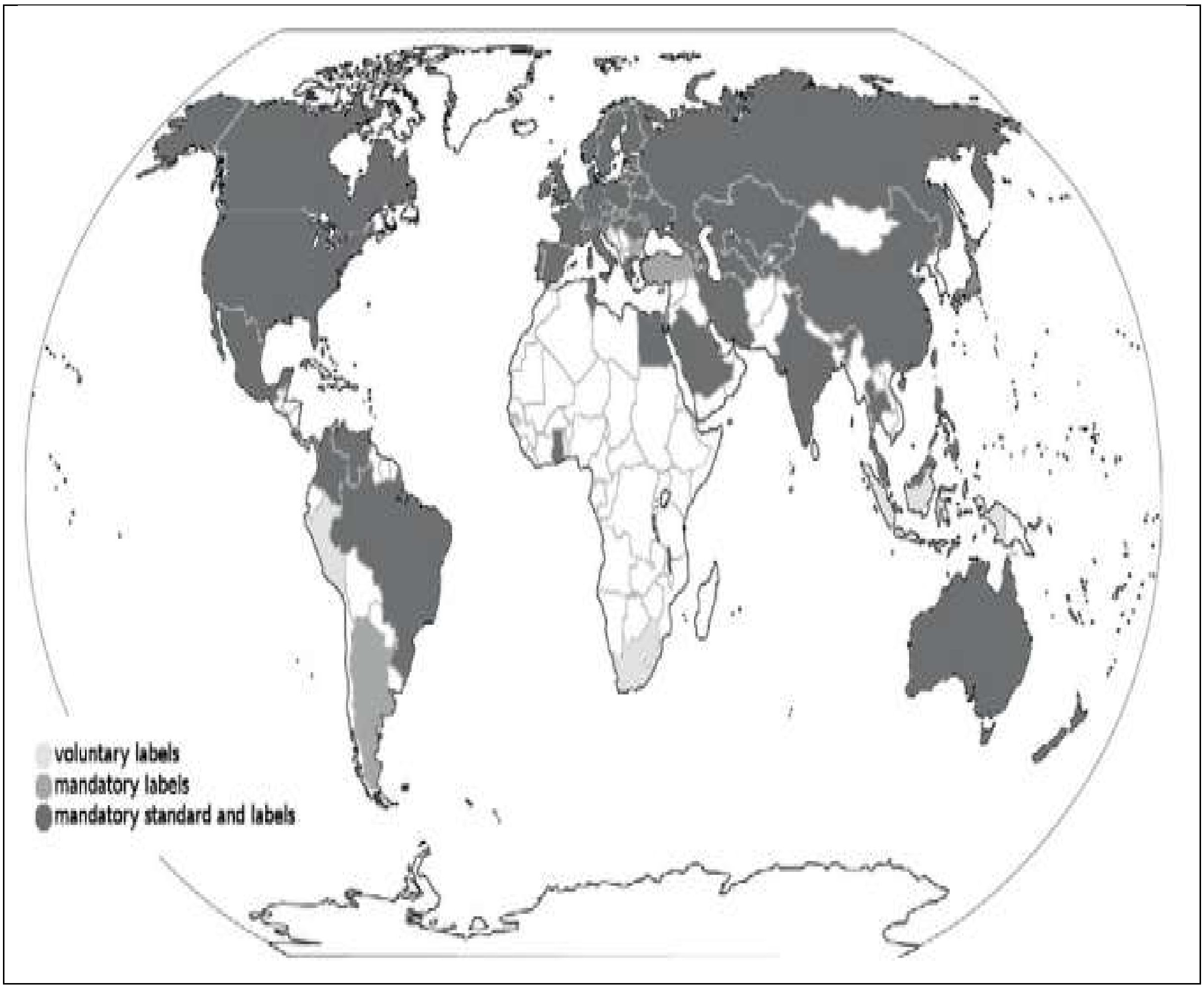

Figure 2-4: Countries with sustainability assessment codes around the world[3].

A label is a voluntary initiative that allows you to go further than the current standard.

The diffusion of the sustainability assessment of buildings is largely increasing. Figure 2-2 reports the number of building surfaces that have obtained a sustainability certification in 2010, together with the expected trends until 2020. Obviously, the number of assessed and certified buildings underestimates the number of buildings that have effectively been constructed in a sustainable way. However, the graph helps to measure the diffusion of sustainable buildings. Figure 2-2 also gives important information about the ratio between residential and commercial sustainable buildings.

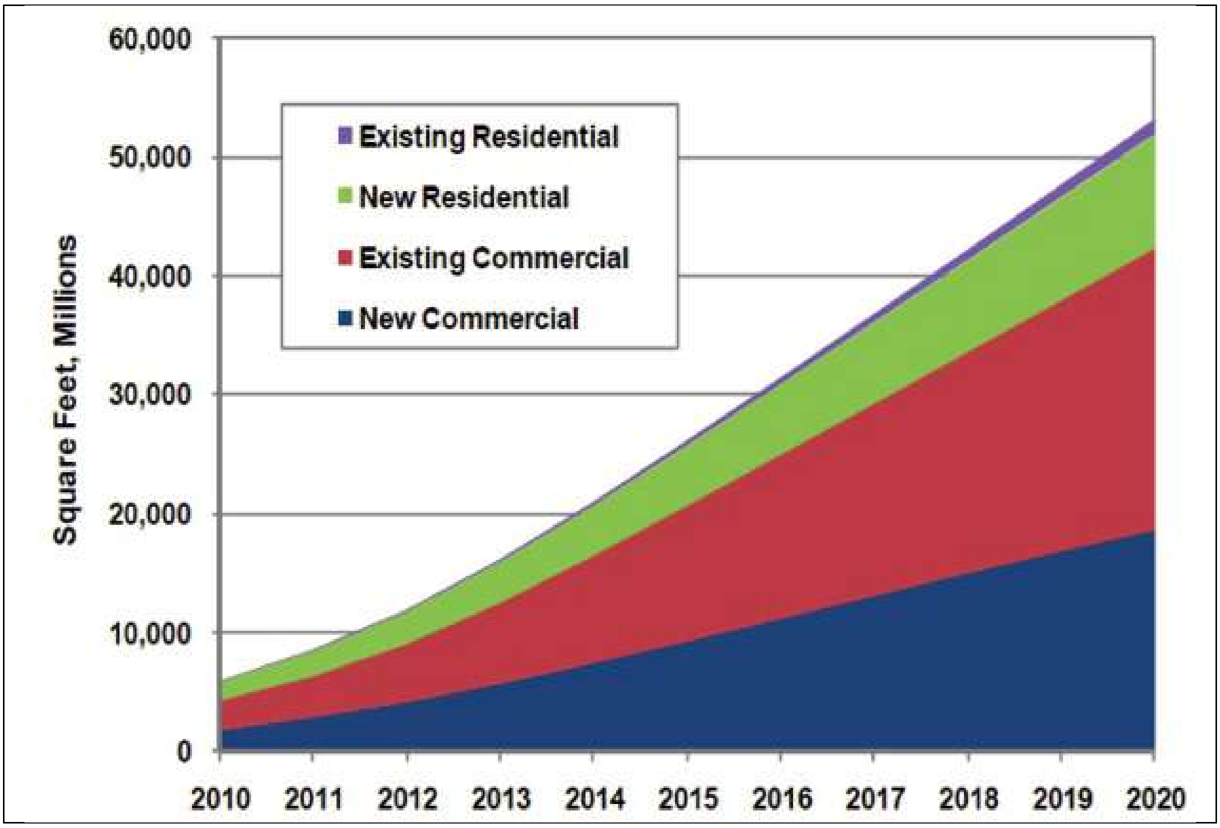

Figure 2-5 : Building surface with sustainability certification and trends until 2020[24]

In commercial buildings, the sustainability transition seems easier than in the residential sector. Moreover, Figure 2-5 shows that in commercial building.

Many sustainability assessment systems for buildings have been proposed in the last 20 years worldwide Figure 2-6. In America, Europe and Asia, sustainability systems have already diffused, and at the present time, only in African countries has the sustainability assessment of building scarcely diffused. Moreover, it should be considered that in Africa, the sustainability of buildings is often intrinsic with building processes, although there is an absence of sustainability assessment systems Figure 2-6. Shows the most well-known systems worldwide, which have diffused in developed countries: BREEAM, CASBEE, LEED and Green Globes[25].

[24]*(Bloom, E., Wheelock, C. 2010. Green Building Certification Programs, Pike Re- search Report 2Q.)*

[25]*(Moving to Sustainable Buildings. Paths to Adopt Green Innovations in Developed Countries, Umberto Berardi, Published by Versita 2013)*

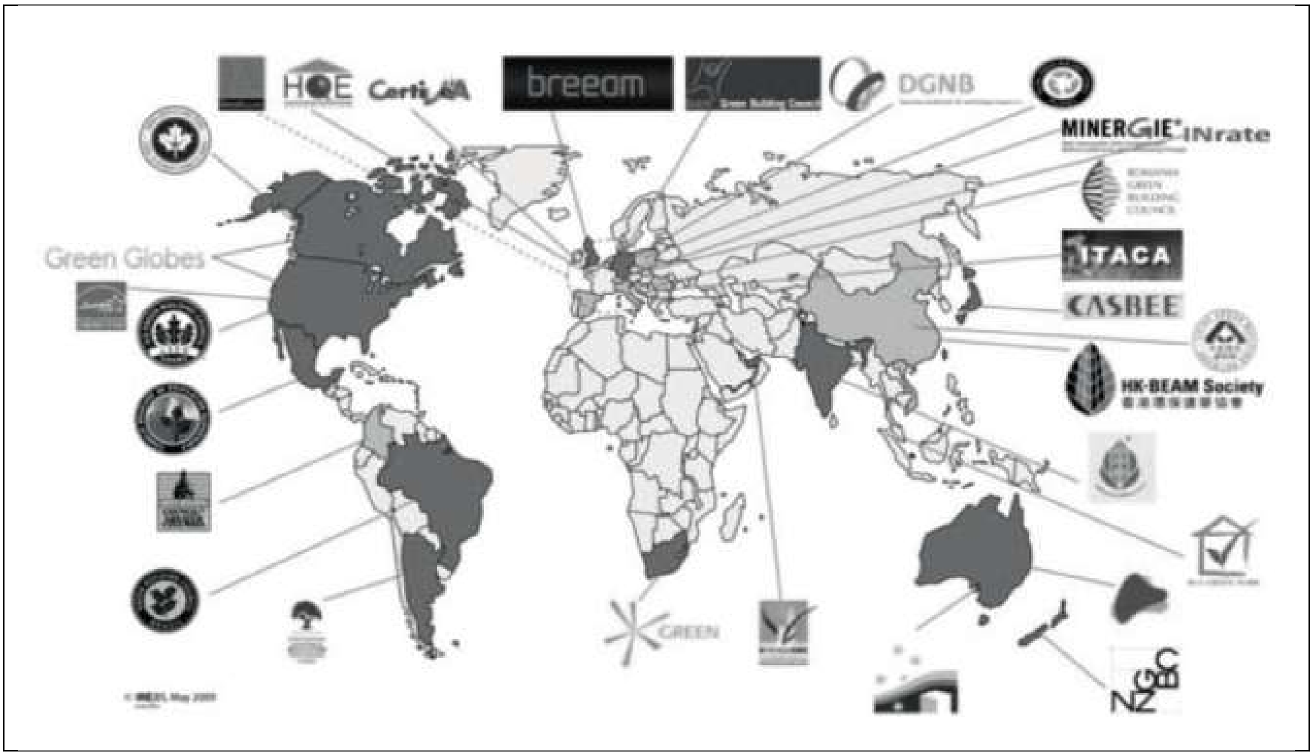

Figure 2-6: Sustainability assessment systems around the world[3].

Next section shows review of current overseas building assessment schemes:

- Leadership in Energy and Environmental Design (LEED) In the United States of America, the Green Building program and the LEED standard were launched to develop green buildings. The LEED tool for residential buildings is not yet fully mature. A pilot version is still being validated. From assessment method and scores awarded for a number of criteria, this method aims to assign an overall score to the building. The criteria considered are site, water, energy and ventilation, materials and resources, indoor air quality, design and innovation. According to this overall score, the building will be awarded a certain level of certification (simple certification, silver, and gold, platinum)[26].

- National Evaluation Standard for Green Building (ESGB), in 2006, China published the first standard which soon became the most widely spread evaluation system in the country. With the fast growth of urbanization, ESGB 2006 version no longer meets the current needs and requires an update. Based on the implementation outcomes of ESGB2006 and expert opinions, the Ministry of Housing and Urban-rural Development published a new version of ESGB in

[26]*(https://new.usgbc.org/leed , 2017)*

2014. With rapid urbanization and industrialization, China is now facing a great challenge in meeting the soaring demand for new buildings and the corresponding energy consumption. Under such circumstances, the setting of a national standard on green buildings would be an effective way to respond. In fact, China has made significant progress in developing national green building standards[27].

Chinese buildings on average consume much less energy than those in the U.S. and Europe; however, this is due to differences in operation practices and not necessarily because the building codes and standards in China are more stringent. Code-compliant Chinese commercial buildings use more energy than the U.S. and could use up to 80% more, if all operated in U.S. conditions. Commercial buildings operated under the Chinese code will have higher site energy use intensity (120 kWh/m^2 in 2015) compared to that of the current version of the U.S. standard ASHRAE 90.1-2013 (100 kWh/m^2) when differences in operating practices are taken into account. If the Chinese buildings defined by the code are operated in the same way as U.S. buildings, they will have even higher energy use intensity values (180 kWh/m^2 in 2015). Similarly, if U.S. buildings operated using Chinese settings, then an additional 10% energy would be saved[28].

- Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)[29], Security of supply has always been at the center of Japan's energy policy, obsessed with its own vulnerability in this area. this is a method of evaluating the environmental quality of buildings, CASBEE was developed according to the following policies:

  1) The system should be structured to award high assessments to superior buildings, thereby enhancing incentives to designers and others.

  2) The assessment system should be as simple as possible.

  3) The system should be applicable to buildings in a wide range of building types.

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[27] *(New Development of China's National Evaluation Standard for Green Building (ESGB 2014): A Comparison of ESGB 2014 to ESGB 2006 ,Conference: 39th IAEE (International Association for Energy Economics) conference: Energy Expectations and Uncertainty, 19-22)*

[28] *(Building Energy Codes in China: Recommendations for Development and Enforcement)*

[29] *(http://www.ibec.or.jp/CASBEE/english/ , 2017)*

4) The system should take into consideration issues and problems peculiar to Japan and Asia.

Four tools have been developed in its framework, a tool for each of the four phases of the life of a building: pre-study, construction, life, renovation. The CASBEE method incorporates the concept of eco-performance (environmental performance) in the form of a factor called BEE (Building Environmental Efficiency, or Performance building environment). BEE represents the quotient of the two diagnostic factors inside and outside the building. Inside, this is the quality factor Q, which represents the performance and environmental quality inside the building (we could speak of service provided by the building). Outside, it is the environmental load factor L, which represents both the consumption of resources and the various discharges. In 2008 CASBEE has become an industry-standard in Japan with societal meaning since a decade after its official publication. In between, it has garnered considerable global interest and been overseas. However, the corresponding growth in its user base has resulted in some first-time users finding the CASBEE system complex and difficult to understand. To addresses such issues, and also for benefit of global users, this book, all written in English, is intended to offer an easy-to-understand comprehensive introduction to the CASBEE system structure, scope and emphasis. Environmental assessment as tool for promoting sustainable buildings has become an important social movement. Amidst such a global trend, we hope CASBEE will make a meaningful contribution to solving global environmental issues. As the movement for the advancement of sustainable buildings continues to evolve, we will strive to further improve the contributions and offerings of CASBEE in this effort.

Japan now considers that the photovoltaic industry is mature enough to stop subsidies. The effect this will have on the market will be analyzed in the years to come. The solar home offer is diversified and is carried by many actors. Installed powers vary greatly from 12 kWc with full solar roof, to 3 kWc with some solar tiles. In some manufacturers, photovoltaic is offered as standard and is no longer an option.

- BREEAM: in United Kingdom BRE's Environmental Assessment Method is the environmental assessment method developed and applied by BRE (Building Research Establishment) in the United Kingdom. This method is available in different versions depending on whether the building to be evaluated is new, in renovation or in operation. This is the "EcoHomes" method that applies to residential buildings. In a similar way to the LEED method, an evaluation grid makes it possible to note various criteria such as management, health and well-being, energy, transport, water, materials and waste, use soil and pollution. The total sum of the scores allows to attribute or not a certification to the building[30].

- EnEV : in Germany, Several initiatives have led to the realization of low energy building. Since 2002, the "Energieeinsparverordnung" (energy saving decree, abbreviated to EnEV) has been applied, setting the "Niedrigenergiehaus" standard. ("Low energy house") as a construction standard for new buildings. Among the criteria to be respected is the primary energy consumption of the building per unit area, the average thermal diffusion coefficient of the walls, the water tightness of the envelope, the thermal bridges, the efficiency of the heating system, etc. The energy requirements of the building must not exceed 75 kWh./m².year, sets maximum values for annual primary energy requirements per unit of heated area and per unit of heated volume, and for the amount of heat lost per unit of building envelope area. All these threshold values depend on the compactness of the building[31].

  Passivhaus (Allemagne): The Passivhaus standard, developed by the Passivhaus Institute and associated with a certification, goes much further than the EnEV regulation but is not imposed by any regulation It is today the most demanding standard in the world, considering that it saves 80% of energy compared to current conventional standards. The standard is defined by its designers as follows: "A passive house is a building in which it is possible to maintain a comfortable indoor climate without an active heating or cooling system. The house warms up and refreshes itself, so in a "passive way". These buildings are characterized by:

[30] *(http://www.breeam.org/, 2017)*
[31] *(http://www.enev-online.com/, 2017)*

1) the need for heating at 15 kWh / m².year (which allows to use air as a heating medium and to save a network of radiators)

2) A very low permeability to air

3) all-purpose consumption of primary energy less than 120kWh / m²/year.

From a technical point of view, these houses generally combine insulation thicknesses of 30 to 40 cm, triple glazing, double-flow ventilation with recovery. The heating is very often provided by a heat input on the ventilation system, the use of a specific distribution network is no longer justified.

- High environmental quality: in France (Haute Qualité Environnementale HQE)This is a voluntary approach and is essentially a method of project management. It aims to respond a growing aspiration of everyone to more comfort and security on the one hand, and to control our extraction of natural resources and energy on the other hand. This approach associated with a brand is managed by the HQE association, which brings together players from the building sector (building owners, project managers, industrialists, experts, associations, etc.). The HQE approach is "a structured approach aimed at coordinating the action of all stakeholders" through a management system of the operation "to achieve the environmental quality objectives set by the client". These environmental quality objectives are divided into 14 targets related to eco-construction, eco-management, comfort and health.

  In France, since 1974, several thermal regulations have been applied to building. Thermal Regulation 2005 (RT2005) sets threshold values for various composite criteria, such as heating requirements and heat losses. It applies to new residential and tertiary buildings and is based on three conditions:

  - the theoretical energy consumption of the building (called "conventional") must be less than the conventional consumption of a building with reference thermal characteristics

  - in summer, the indoor temperature (called "conventional") must be lower than that of a building with reference thermal characteristics

  - Minimum performance is required for certain equipment (insulation, ventilation, heating, domestic hot water, solar protection, etc.) Regulatory compliance can be done in two distinct ways:

- By calculations of energy consumption and conventional indoor temperature, made from physical data using software Chartered

- Through the application of integrated technical solutions, proposed by the Ministry of Housing, that will meet the regulatory requirements, without having to perform calculation.

The RT2012 sets rigorous performance expectations, requiring that residential and non-residential buildings use a maximum of 40-65kWh/m².y depending on locality and altitude of the building. The code is a performance-based code that requires projects to show compliance with the maximum primary energy consumption. It is the maximum conventional consumption of primary energy that considers thermal envelope components and most energy consuming systems including, HVAC, hot water, lighting, heat recovery and auxiliary systems.

- Minergie : in Switzerland is a quality label that was developed in Switzerland in the 1990s . It is managed by the Minergie association. This label is awarded to any building respecting the criteria of the corresponding standard. The criteria of the Minergie standards affect four essential points. Their level of requirement may vary according to the type of building, depending on is a new construction or renovation, and depending on the level of the label.

  Minergie is a voluntary energy-efficient construction standard for both new and renovated buildings; those which meet the Minergie standards can then display the Minergie label. The standard sets an overall limit on energy use for heating, hot water, ventilation and air-conditioning. The maximum energy consumption for new residential buildings is 38kWh/m².y since and for renovated residential buildings 60kWh / m².y since 1 January 2008 (previously the limits were 42kWh/m² and 80kWh/m² respectively). Minergie also has standards for non-residential buildings (commercial, industrial, hospitals, sporting facilities etc.). In 2003, the Minergie-P standard and label was launched, corresponding to passive house standards; the typical Minergie-P residential building consumes 10% of the energy as compared to a regular house meeting current building requirements. Maximum energy consumption of a Minergie-P residential building is 30kWh / m² y; Minergie-P standards also apply to non-residential buildings. While based on the same Minergie standard, it takes fuller advantage of passive heating and cooling, has more stringent requirements on thermal efficiency, windows and appliances, and uses renewable energy sources. Minergie Modules are building components that meet Minergie efficiency standards; using these components in construction would meet Minergie standards for the building envelope. Minergie Modules include walls and roofs, windows, doors and luminaries. Since 1 January 2009, U-values for wall and roof modules were tightened to 0.15 $W/m^2.y$ from 0.2 $W/m^2.y$. Most cantons offer financial incentives for new and/or renovated, Minergie and/or Minergie-P buildings[32].

- National Australian Building Environmental Rating Scheme (NABERS in Australia) is a national rating system that measures the environmental performance of Australian buildings, tenancies and homes[33]. NABERS measures the energy efficiency, water usage, waste management and indoor environment quality of a building or tenancy and its impact on the environment.

Barriers to scaling-up energy efficiency in the Arabic region, Scaling up energy efficiency requires energy consumers and business managers to modify their consumption and investment behavior. Consumer and investor behavior is governed by complex interactions of relative prices of competing goods and services, consumer habits and preferences, rules and regulations, decision making practices, and cultural considerations. Only by influencing consumer and investor behavior will energy efficiency improvements take place. However, changing behavior is often hampered by market, financial, information, institutional, and technical barriers. For example, investment decisions by households and businesses are often made based on the purchase price of an appliance, rather than the sum of the purchase and operating costs over the lifetime of the device. Subsidized energy prices cause extensive market distortions that prevent consumers and businesses from investing in energy efficiency[34]. Arab countries face additional barriers that are regionally specific. These include:

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[32] *(https://www.minergie.ch/fr/publications, 2017)*
[33] *(https://www.nabers.gov.au, 2017)*
[34] *(Energy Efficiency Policies for the SEMED-Arab Region An Energy Efficiency Experts' Roundtable Report)*

-Low capacity for manufacturing or servicing energy efficient products, including appliances, efficient lighting, and equipment

-Highly subsidized energy prices in most countries, approaching 90% in some countries Algeria for example Figure 2-7

-Very rapid energy demand growth, well over 5% in some countries

-Lack of accredited equipment testing laboratories

-Low capacity for enforcing regulatory policies, such as building energy codes

-Low private sector capacity for identifying, developing and implementing energy efficiency projects

-Institutional coordination across sectoral ministries (e.g., energy, construction, industry)

-Providing a stable stream of funding for energy efficiency policies.

-Demanding climactic conditions, with extremely hot conditions during summer months

-Lack of capital for infrastructure projects such as street lighting and public buildings.

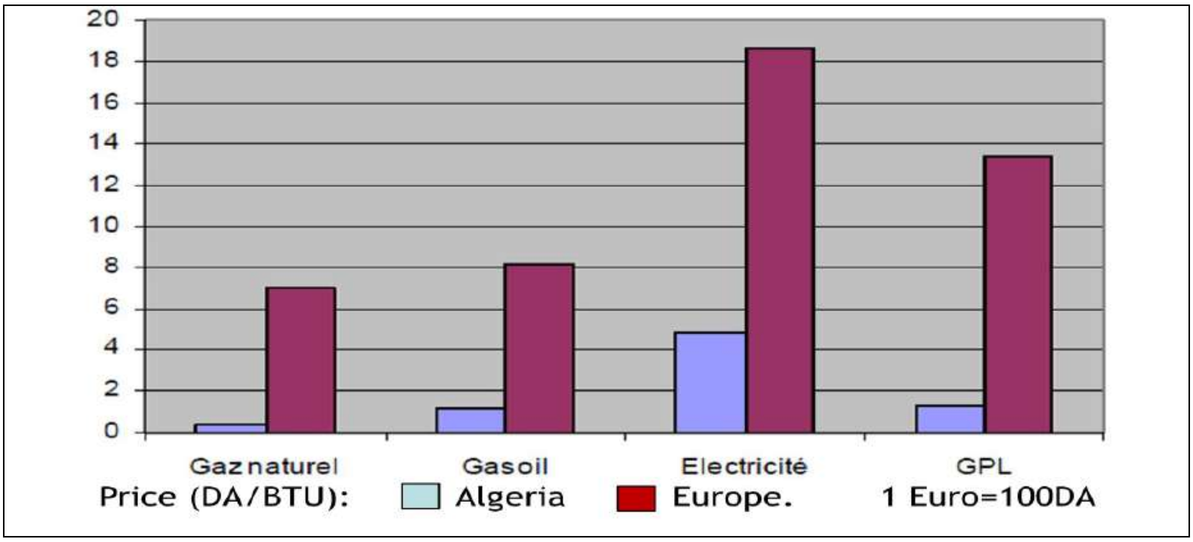

Figure 2-7 : Price of Energy in Algeria ,2015

2.4. Algeria energy consumption

Algeria is located in North Africa, Algeria is by far the largest North African country. and borders Tunisia and Libya in the east, Niger and Mali in the south, and Mauritania, Western Sahara, and Morocco in the west. In the north, Algeria's vast coast of over 1,500 km extends to the Mediterranean Sea. With its more than two million km² of national territory 2,381,740 However, most of its national territory is occupied by the Sahara.

Algeria, a producer and exporter of oil and gas, has experienced a new national oil policy. The state has enabled the financing of a vast industrial, social and economic program. The current high demand for energy consumption in Algeria is mainly due to the increase in the standard of living of the population and the resulting comfort, as well as to the growth of industrial activities. It challenges us about the need for a new energy policy as well as new user behaviors[35].

Algeria, with its large deposits of oil and gas, decided to nationalize its oil sector as well as the control and control of oil and gas resources in February 1971. Natural gas, which constitutes 60% of its fossil fuel reserves, supplies up to 30% of its foreign exchange earnings, hence the need for energy control regulation is needed by making the following arguments:

- The preservation of conventional energy resources;
- Reducing the costs of energy investments, especially in heating and air conditioning;
- Reducing the impact of fossil fuels on the environment.

The Algerian Council of Ministers has just adopted a new national energy efficiency program. By 2030, this program should save Algeria 63 million tons of oil equivalent (TOE), representing a financial gain of 42 billion dollars.

Algerian policy in terms of energy efficiency, mainly in the energy sector is reflected in the actions of some entities:

- The National Agency for the Promotion and Rationalization of the Use of Energy(**APRUE**)[32] the agency has for missions:

-Coordination and animation of the national energy management policy.

- The implementation and monitoring of the National Program of Energy Management (PNME).

-Awareness-raising and dissemination of information on energy management towards the various targets (general public, professionals, school environment ...).

[35]*(www.aprue.org.dz/, 2017)*

-Setting up sectoral programs and projects in partnership with the sectors concerned (Industry, Building, Transport, ...)

- National Fund for the Control of Energy (**FNME**)is responsible for:

-development and application of specific regulations relating to the management of energy consumption in the various sectors of activity;
-introduction of energy efficiency requirements and standards, particularly in the building and equipment fields;
-development of tariff structures for energy products that encourage better use of energy;
-energy efficiency control organization for buildings and equipment;
-thermal insulation in new buildings;

- National Program for the Control of Energy (**PNME**)is responsible for

- the evaluation of potentials and the definition of the objectives of the control of energy;
- the existing means of action and to be implemented to achieve the long-term objectives;
- a five-year action program.

- National Center for Integrated Building Research & Studies (**CNERIB**)is responsible for[36]:

- Gather the necessary elements for the identification of the research projects to be undertaken as well as the data allowing their programming, execution and evaluation
-To stimulate and favor the assimilation, the control, the progress of sciences and techniques as well as the technological innovation in its field of activity;
-Ensure a scientific and technological watch in relation to its object.
-Gather and process scientific and technical information and ensure its preservation and dissemination.
-Contribute to the valorization of the results of research by ensuring in particular their diffusion, their exploitation and their use;
-Provide continuing education, retraining and development of research personnel.
-Contribute to training by and for research.
-Coordinate, monitor and evaluate units, laboratories and research teams.

[36]*(http://www.cnerib.edu.dz, 2017)*

In addition, the center is responsible for developing and implementing national scientific research and technology development programs within its area of expertise, including the development and development of materials, products, materials and processes in the field of research and development. Housing and urban planning.

- Renewable Energy Development Center (**CDER**)[37] its Missions:

-Gather necessary information for the identification of research projects to be undertaken and data allowing their programming, implementation and evaluation;
-Stimulate and foster assimilation, mastery and the progress of science and engineering and technological innovation in renewable energies;
-Provide scientific and technological intelligence in dealing with renewable energies;
-Collect and process scientific and technical information and ensure the preservation and dissemination;
-Contribute to the development of research results including ensuring their dissemination, exploitation and use;
-Ongoing training, retraining and development research teams;
-Contribute in the training by and for research;
-Ensure the coordination, monitoring and evaluation of units, laboratories and research teams;

The aim of the Energy Efficiency program **EEP** is to reduce energy consumption related to home heating and cooling by about 40%.Algeria has created a green momentum by launching an ambitious program to develop renewable energies (REn) and promote energy efficiency. This program[38] leans on a strategy focused on developing and expanding the use of inexhaustible resources, such as solar energy in order to diversify energy sources and prepares Algeria of tomorrow. Through combining initiatives and the acquisition of knowledge, Algeria is engaged in a new age of sustainable energy use.
The program consists of installing up to 22,000 MW of power generating capacity from renewable sources between 2011 and 2030 Figure 2-8, of which 12,000 MW will be intended to meet the domestic electricity demand and 10,000 MW destined for export. This last option depends on the availability of a demand that is ensured on the long term by reliable partners as well as on attractive external funding.

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[37] *(https://www.cder.dz, 2017)*
[38] *(Renewable Energy and Energy Efficiency Program in Algeria. March 2011)*

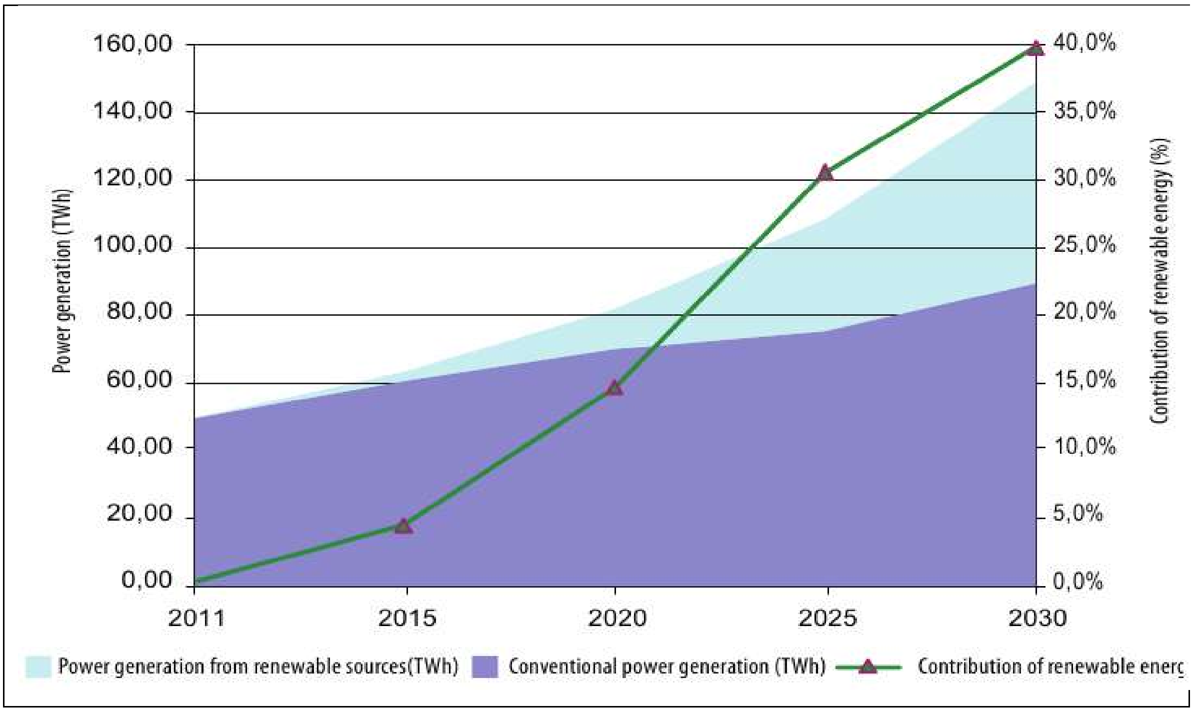

Figure 2-8:Contribution of renewable energies for power generation in TWh

In this program, renewable energies are at the heart of Algeria's energy and economic policies: It is expected that about 40% of electricity produced for domestic consumption will be from renewable energy sources by 2030. Algeria is indeed aiming to be a major actor in the production of electricity from solar photovoltaic and solar power, which will be drivers of sustainable economic development to promote a new model of growth.

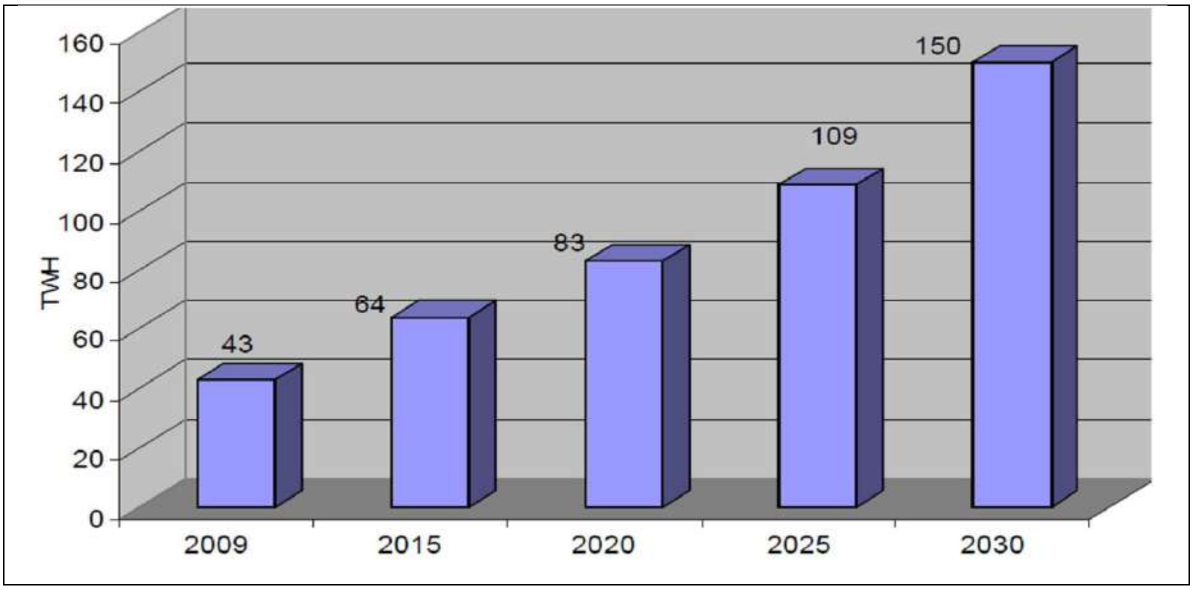

Figure 2-9: Electric Consumption in Algeria 2009-2030 (TWh)

The national potential for renewable energy is strongly dominated by solar energy. Algeria considers this source of energy as an opportunity and a lever for economic and social development, particularly through the establishment of wealth and job-creating industries.

The potential for wind, biomass, geothermal and hydropower energies is comparatively very small. This does not, however, preclude the launch of several wind farm development projects and the implementation of experimental projects in biomass and geothermal energy. The renewable energy and energy efficiency program is organized in five chapters:

- Capacities to install by field of energy activity,
- Energy efficiency program,
- Industrial capacities to build in order to back up the program,
- Research and development,
- Incentives and regulatory measures.

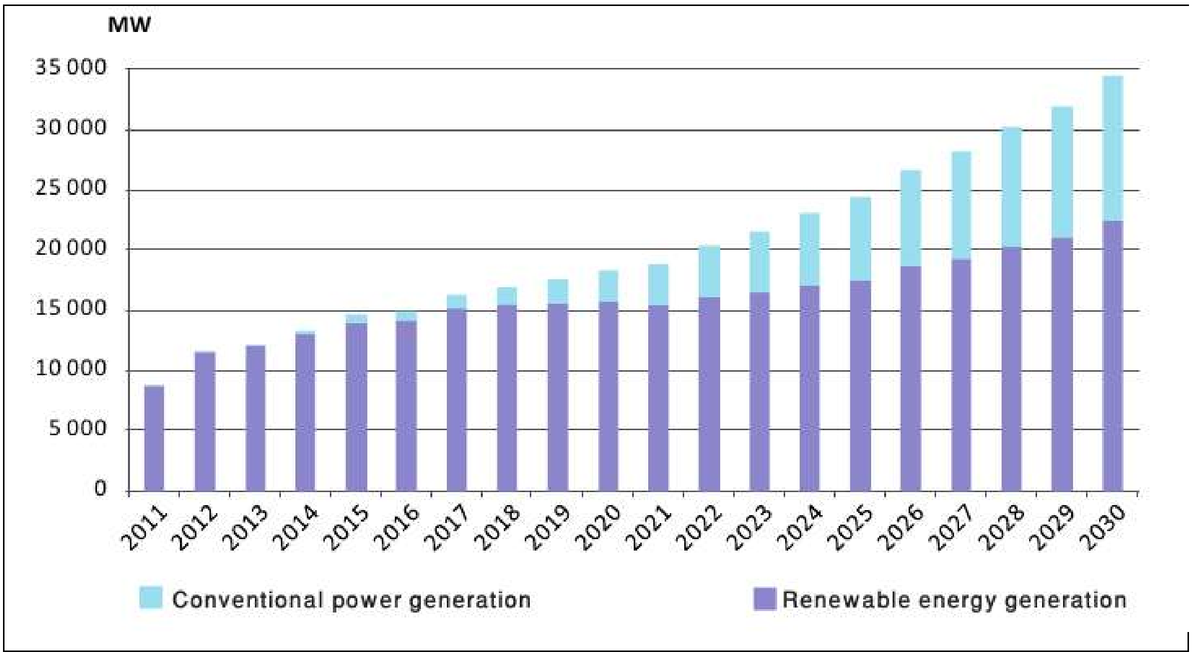

Figure 2-10:Structure of the national power generation in MW

2.5. Building sector in Algeria

Today, buildings in Algeria play an important role in proposed measures to achieve energy efficiency in this sector include the introduction of thermal insulation of buildings.This program, which launched in 2016, focuses on the sectors of industry, transport and housing. In the building sector, the program provides for the thermal insulation of 100,000 housing units annually, with a financial commitment from the state that will cover 80% of the additional costs associated with this operation. The application of this thermal regulation was bound to lead to the thermal insulation of new buildings, with the aim of achieving a reduction in energy consumption related to heating and air conditioning of around 30%. Unfortunately, to date, this regulation has not yet come into force (DTR C3-2 relates to the winter period & DTR C3-4 is reserved for the summer period), due in part to the lack of a body to verify its application but also to the lack of operational tools allowing the offices to studies to incorporate the requirements of this regulation into the design of buildings[39].

Housing construction has become a priority axis of the country's development policy. The energy demand sector as they account for more than 42% of total electric energy consumption. The building sector is booming as a result of decades of accumulated backlogs of housing shortages. In Algeria, the housing deficit is assessed at more 1.5 million units and with the high rate of growth of the population needs only increase, not to mention the effect of rural desertification leaving their traditional homes that often benefited without their knowledge, a very high energy efficiency thanks to bioclimatic methods that have proved their worth, in favor of new homes most often built without any energy consideration. It is therefore very likely that this upward trend in energy consumption of housing is accentuated because of a fortuitous housing policy, coupled with an uncontrolled demand for energy in a context of widespread access. Electricity and demand for comfort more and more high.

The introduction of energy standards in the building code seems to have no perceptible effect, APRUE has a number of programs and initiatives aimed at controlling energy in the building sector.

ECO-BAT program :(ECO-BAT to provide financial and technical support to energy-saving for heating and cooling of households)aimed at the housing sector with the objectives[40]:

- Improve thermal comfort in homes and reduce energy consumption for heating and cooling;

[39] *(https://portail.cder.dz/spip.php?article4969, 2017)*
[40] *(APRUE, 2007)*

- Mobilization of building stakeholders around the issue of energy efficiency;
- Demonstrate the feasibility of high energy performance projects in Algeria;

Strengthen training practices to consider aspects of energy efficiency in building design. The program will focus on the construction of 600 high-energy housing units. These dwellings will integrate the principles of thermal comfort and energy saving in the architectural design, the choice of building materials as well as in the details of implementation. The implementation of the ECO-BAT program will be supported by incentives in the form of expertise and a financial contribution from the National Fund for Energy Efficiency (FNME). It will also be accompanied by good mediation and the launch of training courses for design offices and building owners. Lastly, technical days bringing together all the players in the building sector will also be organized. As part of the implementation of this project, a partnership agreement was signed between APRUE and eleven Real Estate Promotion and Management Offices (OPGI) in May 2009 at the Ministry of Housing and Urban Development. This agreement sets the conditions for the integration of efficiency measures in 600 pilot homes in different climatic zones of the country; the financing of additional costs is ensured through the National Energy Control Fund. Climatic conditions of the country. Among the technical solutions to be put into practice in the realization of the project, we site in winter we seek to limit heat losses (Insulation) and in summer it is the sun protection and natural ventilation. To clarify more, we can say that we build in general with:

- Polystyrene in the air space;
- Stabilized concrete wall;
- The double glazed joinery.

Five-year program PNME 2010-2014: As part of the 2010-2014 NMEP, a program to build 3,000 new, energy-efficient homes and 4,000 existing homes to be thermally rehabilitated is proposed and is currently being validated.

Thermal insulation project of 1500 dwellings: Total or partial thermal insulation of 1,500 homes, an average of 500 renovated dwellings per year through:

- Replacement of existing joinery with watertight ones with double glazing;

- Establishment of a thermal insulation.

Generalization of the use of low-energy lamps: The objective assigned to the action strategy is to ban the marketing of incandescent lamps (conventional lamps commonly used by households) on the national market by 2020.

Introduction of the main techniques of solar air conditioning: The use of solar energy for air conditioning is an application to be promoted especially in the South of the country, especially as cold needs coincide most of the time with the availability of solar radiation (running over the sun). In addition, the solar collector field could also be used for domestic hot water production and space heating during the cold season. The overall efficiency of the installation is therefore very interesting.

Thermal insulation of buildings in Algeria, the building sector is the most energy-intensive sector. Its consumption represents more than 42% of the final consumption. The energy control measures proposed for this sector include the introduction of thermal insulation of buildings that will reduce the energy consumption of heating and cooling of a dwelling of about 40%.

2.6. Integration and additional solution in Building

The annual energy consumption worldwide is equivalent to the radiation emitted by the sun in the space of forty-five minutes. The exploitation of this energy is possible by directly converting solar radiation into heat or electricity, or by using wind, thermo-oceanic, hydraulic or biomass energy, including biotechnology. It should be noted that renewable energies have less impact on the environment and human health. They do not cause waste problems or reactor accidents and do not produce gases harmful to the atmosphere.

Today buildings combine the latest technology, and have the ability to actively adapt to the environmental conditions in order to obtain the optimum solution. They can change their properties, their parameters, based on external conditions to best provide acceptable thermal comfort levels[41]. In the industry, computer programs for building design and simulation have developed to become very sophisticated and precise, but in the process

[41](*Wigginton, M., & Harris, J. Intelligent Skins. Oxford: Architectural Press 2002.)*

the user of the tools have a very steep learning curve and require large amounts of data and time to produce useful results[42].

More specifically, to the conditions of interior comfort of the building (air conditioning heating and air conditioning). Especially since the architecture of the 20th century has tended to give up all its values to the detriment of high technology, neglecting the function of naturally offering a more pleasant and comfortable indoor microclimate (Crawley, D. et al. 2008)[43].

The modern technologies in designing and building has a variety of definitions and interpretations. Indeed, engineers contend that such uses of technology depend on conditions, background and the presumptions of the design and the location. The use of technology to design and build constructions with respect to their conditions and situations is considered to be a novel and particular concept in modern architecture. The accurate and appropriate use of technology can result in the creation of perfect and flawless buildings.
the solutions and techniques implemented so far, these solutions can be divided into three entities:

-Passive solutions that include: building envelope and orientation, passive solar, natural ventilation ... etc.
-Active solutions such as: HAVEC system, home automation, renewable energies ... etc.
-User behavior and equipment's.

- **FAÇADE TECHNOLOGIES**

The building façade in general can be understood as a skin, similar to the skin of the human body, it is the interface between the external and internal environments of a building.

[42]*(Crawley, D. B., Hand, J. W., Kummert, M., & Griffith, B. T. (2008). Contrasting the capabilities of building energy performance simulation programs. Building and Environment, 43(4), 661-673. doi:10.1016/j.buildenv.2006.10.027)*

The building façade is one of the most significant contributors to the energy conservation and comfort parameters of any building. Therefore, it has a large impact on occupants' interface with the surrounding environment; energy efficiency and the indoor environmental quality performance of a building, such as lighting and electricity loads; and peak load to maintain good lighting level and thermal comfort for the occupants.

Strategies and technologies that allow us to maintain our satisfaction with the interior environment while consuming fewer of the resources have always been the major objectives for contemporary façade design. A well designed façade can effectively control the physical environmental factors such as heat, light and sound, thus improve the occupant comfort within a building Figure 2-10. The location and climate are crucial factors in selecting appropriate façade materials and deciding on the design strategies for sustainable facades. Due to the multiple important roles – i.e., aesthetics, thermal comfort, day lighting quality, visual connection to the outdoor environment, acoustic performance, and energy-related performances – building façades, especially glazing systems, have received much attention in research and development. High performance building façade systems involve selecting and deploying the right materials, advanced technologies, good detailing and installation, all of which must be contextually and functionally appropriate. This results in a wide range of products and technologies available to achieve high

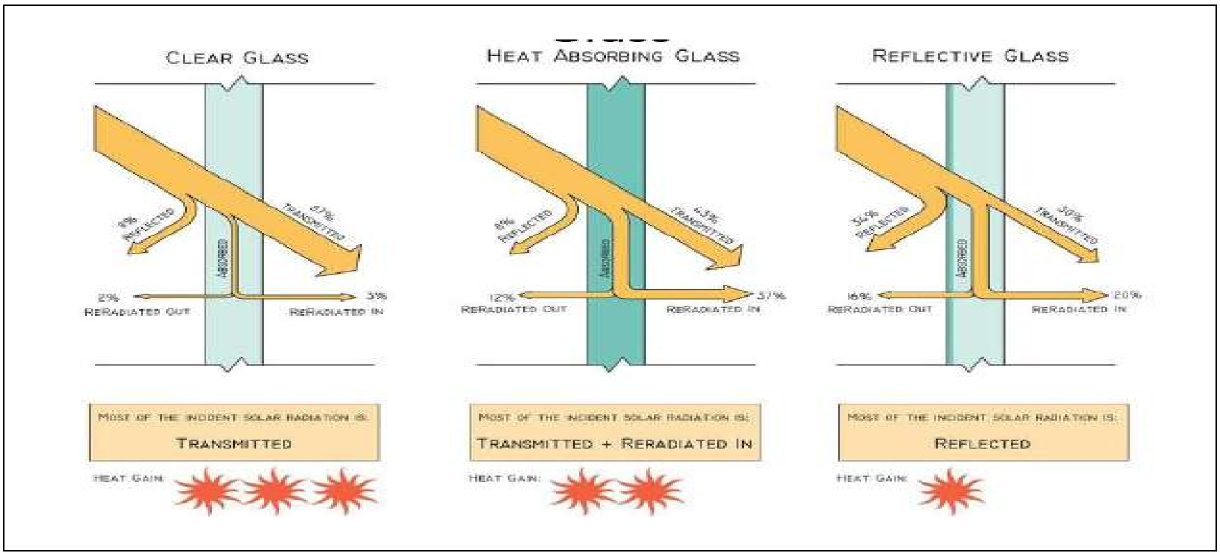

Figure 2-11 :Light Solar Transmission through Varying Types of Glass[44]

performance systems.

[44](*What is Sustainable Design? Part Three: The Basic Principles of Passive Design. 2011. T. Boake, Professor School of Architecture University of Waterloo)*

➢ Phase Change Energy Storage Materials

Unlike sensible energy storage materials, PCM absorbs and releases heat at a constant temperature, a process that is completely reversible. Such materials store 5–14 times more heat per unit volume than sensible storage materials[45]. Once the melting or solidification process is complete, any further heat stored will manifest as a temperature rise. The latent heat stored during the phase change is equal to the enthalpy differences between the solid and liquid phases, and is termed the solid-liquid phase enthalpy change, melting enthalpy or heat of fusion

The thermal energy storage of walls and ceilings can be improved by incorporating PCM: the latent heat capacity of wallboard with 30% PCM by weight is about five times greater than the heat uptake of conventional wallboard for a 5.5°C rise in temperature. The PCM effectively increases the thermal mass of the building material during the transition temperature process of the PCM.

➢ PVT Panels

Photovoltaic Thermal (PVT) combine the solar thermal and photovoltaic systems. This technique benefits from both light and heat of the solar radiation to produce electricity and hot fluids. Research in PVT systems is rapidly growing with more methods and techniques to increase the overall efficiency, reduce the cost, improve the modeling, and maintain the system for long periods of time and employing them for suitable application[46].

More emphasis on increasing electrical efficiency for photovoltaic and thermal efficiency for solar thermal systems. Photovoltaic thermal (PVT) systems offer the opportunity to utilize more of the solar spectrum where both heat and light are being harvested. On the other hand, it also saves space by combining the two structure to cover lesser area than two systems separately. The base fluid used in the thermal system is very important to ensure better cooling for the PV panel as well as heat gain for the thermal system's output.

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[45] *(Alaa Liaq Hashem Al-Mosawi, Phd Thesis: Thermal Energy Storage for Building- Integrated Photovoltaic Components, 2011, Energy Systems Research Unit Department of Mechanical Engineering University of Strathclyde Glasgow, Scotland)*

[46] *(Photovoltaic Thermal PVT systems: A review. Ali H. A. International Journal of Computation and Applied Sciences IJOCAAS, Volume2, Issue 2, April 2017, ISSN: 2399-4509)*

Many fluids have been used in this type of solar technologies such as water, air, water and air, phase change material.
The installation of PV systems in buildings has important benefits. For example, no additional areas are necessary because the solar generator can be mounted on existing parts of a building, such as the roof or facade; flat roofs are especially suitable because the PV components can be mounted in optimal orientation and inclination. By installing components on sloped roofs or on facades, it is possible to use only the south-oriented areas of the buildings.
The main disadvantage of placing panels on facades is that they are oriented in a non-optimal direction. In this case, the solar radiation incidence angle will be large during summer months (usually above 65˚C), decreasing the amount of solar energy that can be absorbed. More than 80% of the solar radiation falling on PV cells is not converted to electricity, but is either reflected or converted to thermal energy. This leads to an increase in the PV cell's working temperature and, consequently, a drop in electricity conversion efficiency. In the summer, with high ambient temperatures, the PV temperature can reach about 70˚C. If the PV is insulated at the rear side, it can only lose heat from the front side, which reduces its heat loss capability. If possible, an air gap should then be introduced between the PV and the building structure behind it to allow cooling of the PV laminate by natural convection.

Khelifa et al[47]. Presented a modeling method for PVT collector using both experimental and theoretical steps. As for the theoretical part authors performed energy balance equations. Heat balance equations were performed for each element in the system such as the glass cover, absorber place and PV panel. Authors claimed to find a 69% efficiency for PVT with 14.8% of it coming from PV and 55% from ST. The efficiency is higher due to careful planning and detailed study of the heat. This is an important point to be raise which is understanding the heat flow within the system and detecting the losses. The study recommends utilizing advantage material to lower the costs. Here again, the compromise between efficiency and cost is present but it is less because the design of the system is much more suitable to avoiding losses.

[47]*(Khelifa A., Touafek K., & Ben Moussa H., 2015, "Approach for the modelling of hybrid photovoltaic–thermal solar collector", IET Renewable Power Generation, Vol. 9, Issue 3, pp. 207 – 217.)*

➢ **Mechanical ventilation**

Ventilation is the process of supplying fresh air to an indoor space or removing stale air from a room or building, in order to mitigate or eliminate air contaminants and control humidity and temperature. Purpose-provided ventilation is distinguished from unintentional flow of air, such as infiltration and duct leakage, which often act counter-actively to ventilation and degrade its performance.

Outdoor air flowing into a space by ventilation could be either mixed with or dis-place indoor air. In the first case, ventilation is characterized as "mixing" and is enhanced by the natural forces of wind or by the proper design of air suppliers. In "dis- placement" ventilation, outdoor air is introduced through suppliers located at the lower levels of the ventilated space and gradually displaces indoor air. The latter is exhausted through outlets placed at the higher levels of the space. Ventilation is classified into the following categories:

• Natural ventilation is generated from the effects of wind and temperature through intentionally provided or other existing openings of the building, such as windows and doors.

• Mechanical ventilation is provided from the operation of mechanical equipment, such as fans or HVAC systems. Operable windows or wind-driven turbine ventilators do not fall into the category of mechanical ventilation.

• Hybrid or mixed mode ventilation, in which the complementary or concurrent operation of naturally-driven ventilation and mechanical systems is implemented. The primary tasks of ventilation systems - either mechanical or natural- are as follows:

• Control and improvement of indoor air quality, with the displacement or dilution of indoor air pollutants by the provision of clean outdoor air.

• Direct advective cooling, where the warm indoor air is displaced or diluted by the flow of outdoor, cooler air.

Direct personal cooling, where outdoor air at lower temperatures than the indoor is directed at an adequate rate to the building occupants and allows the transfer of heat and moisture from them.

• Indirect night cooling, where the building fabric is pre-cooled by outdoor air during night resulting in the indirect cooling of indoor spaces.

- **COOLING**

Air conditioning (AC) is the process of removing heat from the interior of an occupied space, to improve the comfort of occupants. Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment, typically for humans or animals; however, air conditioning is also used to cool/dehumidify rooms filled with heat-producing electronic devices, such as computer servers, power amplifiers, and even to display and store artwork[48].

Air conditioners often use a fan to distribute the conditioned air to an occupied space such as a building or a car to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small bedroom, which can be carried by a single adult, to massive units installed on the roof of office towers that can cool an entire building. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used. Air conditioning systems can also be made based on desiccants (chemicals which remove moisture from the air) and subterraneous pipes that can distribute the heated refrigerant to the ground for cooling[49].

In the most general sense, air conditioning can refer to any form of technology that modifies the condition of air (heating, cooling, de-humidification, cleaning, ventilation, or air movement). In common usage, though, "air conditioning" refers to systems which cool air. In construction, a complete system of heating, ventilation, and air conditioning is referred to as heating, ventilation, and air conditioning.

2.7. Continue and Seasonal consumption approach

Energy consumption in the building sector has increased significantly in recent decades and continues to grow fairly steadily. The sustained economic development of Algeria in recent years, which has led to a considerable improvement in the standard of living of

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[48] *(Nagengast, Bernard (February 1999). "A History of Comfort Cooling Using Ice" (PDF). ASHRAE Journal: 49. Retrieved 22 July 2013.)*

[49] *(McDowall, Robert (2006). Fundamentals of HVAC Systems. Elsevier. p. 3.)*

households. This has led to a noticeable increase in comfort needs, which is reflected in particular in the increasing use of heating and air conditioning equipment.

The exceptional heat in summer leads to an increase in electricity consumption, the high temperatures forcing "to make more cold": refrigerators, freezers, air conditioners, fans and industrial cooling instruments have indeed been fully solicited. According to several studies carried out by the Algerian Electricity and Gas Company (SONALGAZ) on the evolution of electricity consumption at the national level, it turns out that the electric load curve is characterized by peak periods during which demand for electricity peaks. In fact, the peak annual peak load is often recorded in the morning more precisely around noon, in summer (Figure 2-12. This is particularly due to the increased use of air conditioning.

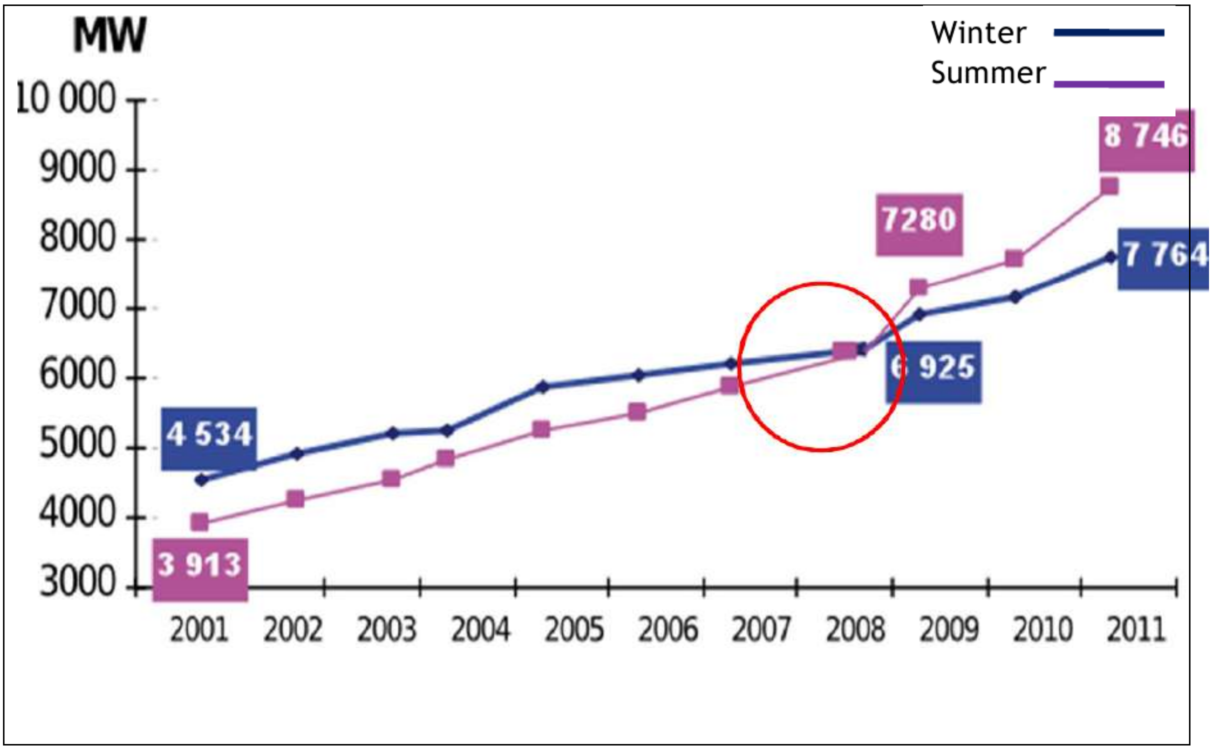

Figure 2-12: Electricity Peak Load Demand 2001 to 2011

A continuing upward trend in domestic electricity consumption is an obvious and deeply worrying sign. In fact, the electricity consumed by household domestic appliances doubled between 2010 and 2015 it was 263.16 GWh and reached 450.46 GWh (+70%), is anticipated to rise by a further 140% by 2020. This rise is not solely associated with the increasing number of devices within houses, but also with human behavior resulting in wasted energy that would have otherwise been saved. Reducing this wastage is a challenge that can be addressed either by increasing public energy efficiency awareness or through the implementation of systems to help people manage energy use effectively without compromising their comfort levels or environmental expectations.

Analyze energy consumption in Ouargla agglomeration

A significant proportion of energy utilization in any nation is used to meet the energy demands of buildings, especially those associated with the residential sector. Domestic energy consumption has also increased since 2005to 2015 by huge way. This is due to several factors, including the increase in the number of households, population growth, increased usage of appliances, increasing household disposable income, etc. The energy demand within the residential sector can be specifically classified into air condition space, hot water, lighting and household appliances …etc.

Analysis of the annual of consumption it is interesting to study the distribution of consumption according to the different seasons we can distinguish two periods:

• Low consumption: period when the building dos not need any air-condition, this fixed portion of around 220 kWh / month, for electrical energy minimum tools, lighting ...etc. to 492 kWh / month, for gas energy minimum used by cooking and hot water.

• High consumption: this is the period of use of the building air-condition with a non-linear curve   that "follows" the summer for cooling and the winter for heating which breaks down into: High consumption - Low consumption = Seasonal consumption

Seasonal consumption (variable portion) for electricity it’s from 492kWh to 1027kWh it is about523 kWh / month, which corresponds to the summer's consumption of cooling Figure 2-13. It is represent heating consumption in winter.

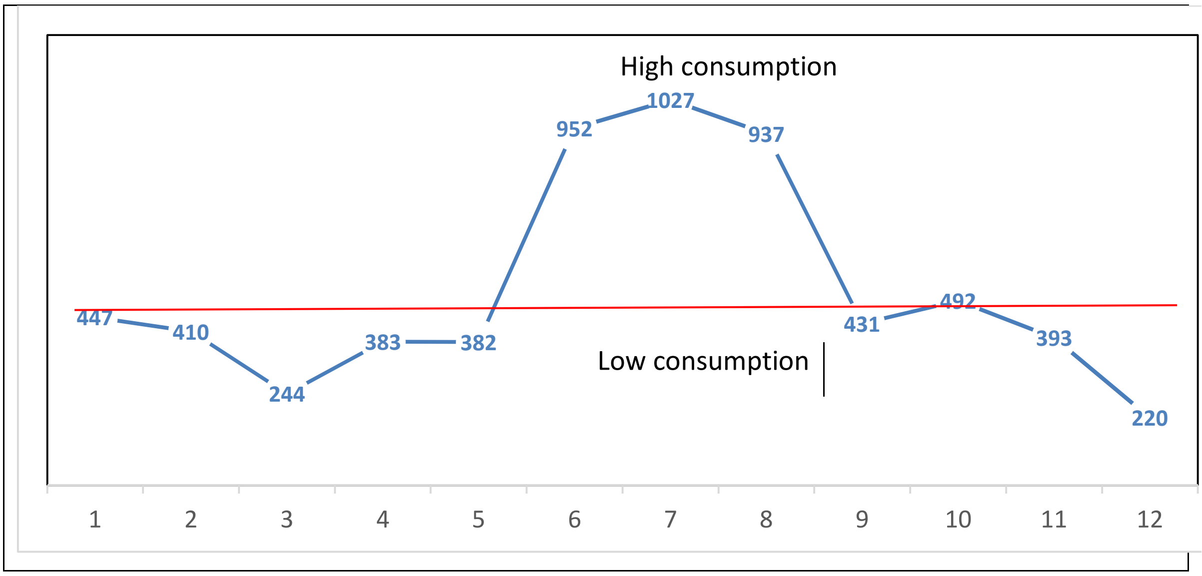

Figure 2-13: Annual electricity energy consumption for one typical customer (kWh)

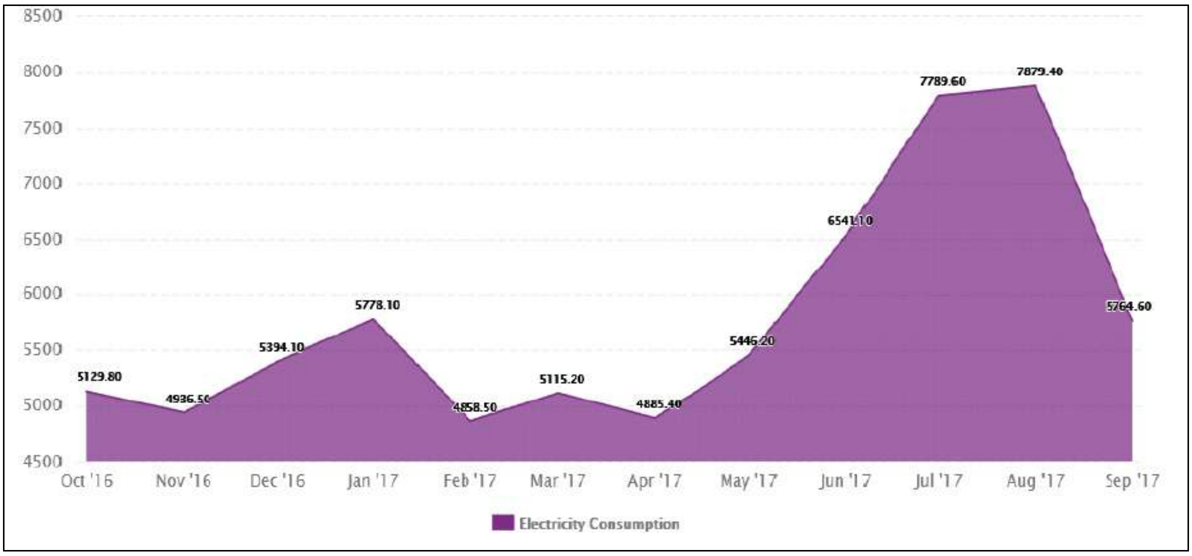

Figure 2-14: Annual electricity energy consumption in Algeria 2017 (Gwh)

In order to improve the yearly average energy consumption. We depend in our study on two types of electrical energy consumption; the first is seasonal consumption which is the value of the seasonal consumed energy (air conditioning in summer and heating in winter), while the continuous consumption is the value of the yearly consumed energy. The historical energetic data analysis of one year shows that the cooling system of the building counts more than an average of 63% of the total energy consumption Figure 2-14. The following figure shows the continuous and seasonal consumption of electric energy in the 5 zones of Ouargla (agglomeration).

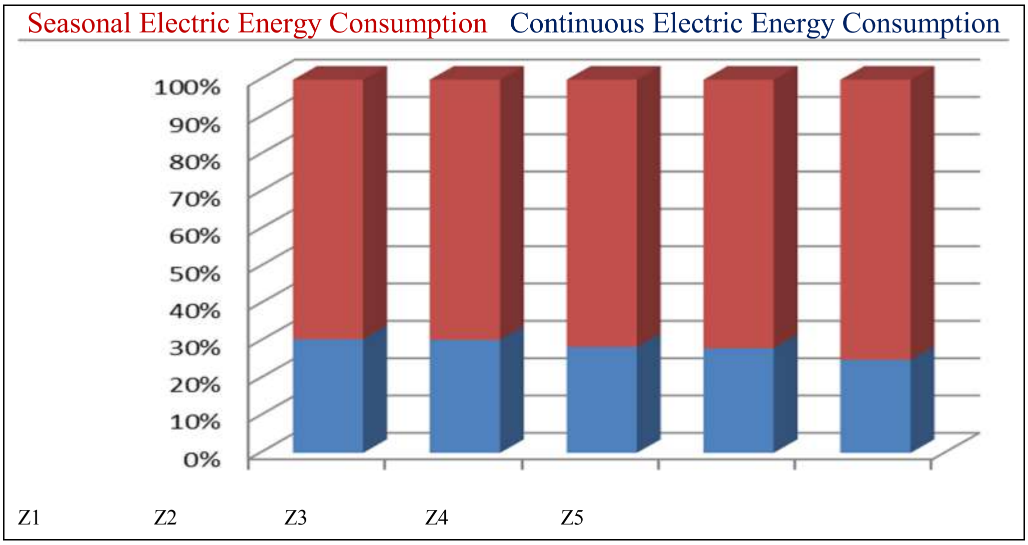

Figure2-15: Continuous and seasonal electric energy consumption

The massive use of air conditioning equipment in the hottest hours causes peak electrical power demands that can lead to problems in the generation, transmission and distribution of electricity at times when grids are particularly vulnerable and fragile, annual reported (2015) that a portion of Ouargla agglomeration consumers had been without electricity during some noon's of summer 2015. This cut was caused by an extremely rapid growth in demand for air conditioning[50].

If individual air conditioning remains marginal, the consumption could eventually significantly increase electricity consumption and weaken electricity grids. Solutions exist to reconcile the need for summer comfort and the necessary reduction of the impacts of air conditioning: improvement of equipment, better building design, use of the building ... The implementation of these solutions of efficiency and sobriety energy efficiency would avoid a significant generalization of inefficient air conditioning systems.

2.8. Conclusion

More energy efficiency measures and innovative technologies are needed in order to eliminate or at least reduce buildings' ever increasing energy demands. Moreover, energy efficiency measures should be applied on both new and existing buildings. Over the last few years governments worldwide have been increasing efforts to improve energy saving and energy efficiency of the building sector; a major step in Europe, USA and other countries aiming to reduce energy demand of the building sector and promote energy efficiency. These countries may have either fully regulated, voluntary adoption of guidelines and standards or a mix of both for the green building sector.

Energy efficiency policies in the Arab region have not been adopted as widely as in other regions of the world. Although some Arab region countries have some form of an energy efficiency lead institution, fewer those countries in this region have appliance labelling programs.

The direct translation of models and regulatory framework designs could compromise the potential success in Algeria if there is policies; up to now, there have been no comprehensive studies on the implementation of energy efficiency policies in the building sector (also known as public buildings sector), and there is very little information

[50] *(SONALGAZ annual report 2015)*

on the overview of the existing projects and actions in this field. Building sector consuming nearly 42% of energy in 2015, if nothing is done to optimize energy utilization, the sector will continue to contribute significantly towards the greenhouse gas emissions (GHG).

There are barriers towards the wide spread implementation of energy efficiency for buildings: Institutional barriers; Policy and regulatory barriers; Financial barriers; Information and awareness barriers; Technical barriers. However, the green initiative requires strong support from all the stakeholders. The awareness campaigns need to be intensified. Interestingly, the green building campaign tends to focus on top and middle management but little is conducted on the site workers that execute the project. Hence the site workers have no affinity with the green initiative and provide a lackluster respond. It should be introduced across various level of community that involve in building industries. A cohesive approach will provide better implementation. Sustainable development in building industries requires cooperation from all the stakeholders. Research has been mainly focused on residential housing buildings energy efficiency or on tools for energy efficiency policy implementation.

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3.1. Introduction

First, the present chapter trends in the field of thermal comfort and some definitions are discussed. Thermal comfort is probably one of the quickest things to think about when it comes to comfort in a building. Provide a feeling of warmth in winter and maintain overheating in summer. Thermal comfort is expressed through the adaptation of the thermal environment of a building to its occupants. If it is essentially of the order of feeling and therefore not always measurable, a certain number of criteria make it possible to appreciate it. Too often, the architectural models produced during the last decades, do not take into consideration the climatic and cultural specificities of the regions. In this chapter, we will present the concept of comfort in the building, we treat different types of comfort in the hydrothermal, visual and thermal building and we define the various factors that contribute to comfort.

The second section deals with the several climatic contexts which are also considered. Finally, a climate zoning are presented focusing on Algeria is zoning

3.2. Comfort indoor building:

Personal comfort is affected by climate factors that influence the interior living space and by others that directly influence the occupants. The first, concern temperature, humidity and air flowing, noise, lighting, smells, etc. Relatively to the building users, their physical and psychological well-being are influenced by their activity and clothing, their metabolism, age and sex.

The concept of comfort remains wider and cannot be limited to the only physical conditions that determine the comfort of hydrothermal type (temperature, humidity etc.), sound or olfactory. This notion also includes aesthetic and psychological parameters (quality of light, green spaces, landscape, security, prestige ... etc.). Also the conditions of comfort are not frozen in time and space. On the contrary, they vary socially (by standard of living and class), geographically (by region) and historically (by period). So, far from being an immanent value, comfort is a cultural construct that is elaborated and transformed according to the dominant myths and values of the culture in which it unfolds.

Occupants 'quality of living in building is mainly determined by main factors as: thermal comfort, visual comfort, acoustic comfort, indoor air quality comfort etc...

3.2.1. Visual comfort:

Visual comfort has a strong influence on the individual physiologically and psychologically. Visual comfort has several definitions: it is a satisfactory visual relation with the outside or an optimal natural lighting in terms of comfort and energy expenditure; it can also be a satisfactory artificial lighting and a supplement to the natural lighting. Overall, visual comfort is a subjective impression of the quantity, quality and distribution of light and represents its satisfaction with the visual environment that gives us a feeling of comfort when we can see the objects clearly without fatigue, in a pleasant colorful atmosphere. Obtaining a comfortable visual environment in a room promotes the well-being of its occupants. On the other hand, lighting that is too weak or too strong, poorly distributed in space or whose light spectrum is poorly adapted to the sensitivity of the eye or to the vision of the colors, causes more or less fatigue, or even visual disturbances, along with a feeling of discomfort and reduced visual performance. Good visibility is not a sufficient condition to ensure visual comfort, understood as the subjective appreciation of a pleasant light environment.

The type of glazing is an important parameter in the quality of lighting since it is a major intermediate between the outside and the inside. The windows become the only contact with the outside. The quality of the light transmitted by a glazing becomes an important parameter in the satisfaction of a space.

The visual comfort concerns windows and artificial lighting. The windows size and parameters influence the solar gains and modify the envelope thermal performance. During the occupancy period, the room illumination must be satisfied by the natural light, the artificial light or by the two combined of both. The artificial lighting, when switched on, produces heat which also modifies the heat balance.

The illumination unit is the LUX. The standard EN12464 recommends 500 LUX for offices, 100 LUX for corridors and toilets, 150 LUX for stairs. For the residential building, the recommended illumination is: 300 LUX for kitchen, 150 LUX for bathrooms and living room, 100 LUX for the rest of the house. Depending on the lamp efficiency, a lighting power is set. It varies from 1.58 to 3.6 W/ (m2for 100 LUX) for the studied buildings[51].

Visual comfort is related with the availability of a sufficient level of luminance while, in parallel with the decrease, the greatest possible number of other stimuli coming from the environment. In a non-comfortable environment, from a visual point of view, the phenomenon of glare is introduced. There are two kinds of glare: a dazzle of discomfort and a glare of incapacity. The first is due to the existence of extremely bright objects in the visual field

In order to achieve visual comfort conditions in the indoor environment of buildings, it is necessary to ensure:

- Optimal natural lighting in terms of comfort in order to make the most of natural light; the client must ensure a sufficient level of illumination for the visual tasks to be performed and limit the risk of glare produced by the sun (direct or indirect);
- Artificial lighting satisfactory in the absence or in addition to natural light. The client generally seeks to obtain a sufficient level of artificial lighting and distributed uniformly for the visual task to be performed. He also seeks to limit the risks of glare by the luminaires and to have a quality of the light emitted satisfactory in terms of rendering of colors and apparent color.
- In order to avoid the compensation effect of calculating an arithmetic mean between premises, it is preferable, when reasoning is done at the building scale, to enter the percentage of premises that respond to the concern. This percentage depends on the use of the building.

3.2.2. Acoustic comfort

According to ASHARE, the average hearing threshold is 0 dB and the discomfort threshold is 110 dB. The average noise level in a quiet residential area is 40 dB and the minimum threshold of discomfort is 110 dB. Beyond these limits, there is severe sleep disruption. It should be noted that exposure to noise leads to a decrease in perception. The acoustic comfort associated with the main characteristics of a room therefore depends on: the typology use of the room, its volume, wall materials etc. In terms of acoustic comfort, minimum performance is required by the regulations, depending on the types of buildings

[51] *(Sebastien THOMAS Analysis of solar air-conditioning systems and their integration in buildings, (Ph.D.) in Sciences 2013, University Liege)*

and uses. However, the specificities of a project in connection with the site, the activity hosted, etc. can justify a design beyond the levels regulatory.

The acoustic treatment target in particular the insulation compared toexternal noise, airborne noise from adjacent premises, noise from shocks (no ormovement of objects on the upper floors) and noises generated by equipment heating,ventilation …etc.

3.2.3. Air quality

Ventilation is required to evacuate the pollutants created by the occupants and other materials from the buildings. Moreover, some activities necessitate extra ventilation such as cooking. Each person in a building category II needs at least 25 m^3/h fresh air (EN15251, 2007). This accounts for occupancy period. One hour before occupancy, a volume flow equal to two times the volume flow required for occupancy must be blown. Two kind of flows have to be distinguished: the fresh air flow and the extracted air flow. For dry rooms, the “fresh air” comes from outside while for humid rooms (bathrooms, toilets, kitchen) the air is extracted. It means the air can move from dry to humid rooms in a building. For residential buildings, the table 3.1 specifies the required volume flows based on the standard EN15251 (2007). This is consistent for permanent ventilation during occupancy. There are no specifications about a higher ventilation flow during cooking. During absence, a minimal ventilation flow, 0.18 to 0.32 $m^3/(h\ m^2)$ corresponding to an air change rate of 0.075 to 0.15 vol/h (for a room height of 2.5 m) is required. Here as well, the infiltration could be included in this flow.

Dry rooms	Fresh air flow	Unit
Bedroom, living, dining rooms	25	[m3/h]
Wet rooms	Extracted air flow	
Toilets	36	[m3/h]
Bathroom	48	[m3/h]
Kitchen	72	[m3/h]

Table 3-1: Recommended permanent ventilation during occupancy in residential buildings (EN15251, 2007)

3.2.4. Thermal Comfort:

Since comfort is assessed by subjective evaluation, this gives rise to discrepancies between studies. Investigations have also found that different cultures express thermal sensation with more acute language than others. Several definitions of 'Thermal Comfort' have been formulated. This obviously makes it difficult to apply a thermal comfort model globally, and so although many countries have adopted the definition above and its associated comfort criteria, most have also created their own comfort standards[52].

The simplest way to apprehend summer comfort is to consider only the effect of the ambient temperature and to evaluate the number of hours during which this temperature exceeds a given value (often 26° C). To take into account the radiation in comfort, we can introduce the notion of operating temperature which is a weighted average of the air temperature and that of the walls.

Macpheson[53] in 1962 took seven parameters described 'Thermal Comfort' by part: ambient or air Temperature (Ta), Mean Radiant Temperature (MRT), water VapourPressure (Pv) or Relative Humidity (RH), relative air Velocity (V), and personal parameters: clothing or thermal resistance (Icl) and activity or Metabolic rate (M).

Fanger[54] in 1967 investigated the human body's physiological processes, when it is close to neutral to define the actual comfort equation. He had defined 'thermal neutrality' for a person "as the condition in which the subject would prefer neither warmer nor cooler surroundings." The Predicted Mean Vote (PMV) refers to a thermal scale that runs from Cold (-3) to Hot (+3), originally developed by Fanger and later adopted as an ISO standard. The original data was collected by subjecting a large number of people to different conditions within a climate chamber and having them select a position on the scale the best described their comfort sensation. A mathematical model of the relationship between all the environmental and physiological factors considered was then derived from the data. The result relates the size thermal comfort factors to each other through heat balance principles and produces the following sensation scale is as follows:

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[52]*(Abel E. TABLADA DE LA TORRE, Phd: SHAPE OF NEW RESIDENTIAL BUILDINGS IN THE HISTORICAL CENTRE OF OLD HAVANA TO FAVOUR NATURAL VENTILATION AND THERMAL COMFORT, 2006, KATHOLIEKE UNIVERSITEIT LEUVEN)*
[53]*(Macpheson RK. "The Assessment of the Thermal Environment, a review", 1962; pp.19. in: Sayigh, A., Marafia, A., "Thermal Comfort and the development of bioclimatic concept in building design", 1998. pp. 4.)*
[54]*(Fanger, P.O., "Thermal Comfort", 1972)*

-3: cold, -2: cool, -1: slightly cool, 0: neutral, 1: slightly warm, 2: warm, 3: hot.

According to Fanger, what is required in practice is that thecomfort conditions are expressed in controllable factors, which Fanger has given interms of six fundamental parameters:

air temperature,
radiant temperature,
relative
humidity,
air velocity,
activity and clothing

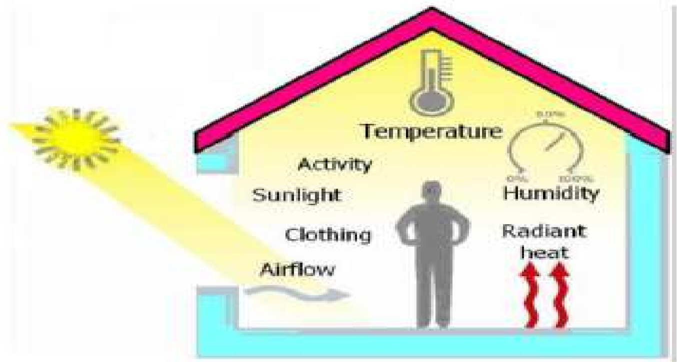

Figure 3-1: Schematic of the Fanger's comfort criteria [55]

Thermal Comfort = function {air temperature, radiant temperature, relative humidity,air velocity, activity and clothing} Eq.3.1

The American Society for Heating, Refrigeration and Air-conditioning (ASHRAE) expresses comfort as "that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation"[56], According to ASHRAE one simple way of predicting thermal comfort is using figures and tables from manuals and the other is using numerical and more rigorous predictions by applying the PMV/PPD This index accounts for the persons voting as thermally dissatisfied. It considers the votes that are not in between -1 and +1 of the thermal and comfort scales and two-node models[57].

Fanger's comfort model is now widely used, including in Europe, USA and China, and the PMV index is as close as it comes to a set of global thermal standards. The point at which a building fails to provide thermal comfort though, will naturally differ across the globe, as that will depend on the perception of occupants who have adapted to different climates.

[55] *(Yousaf Ali Khalid, Phd: Controllability of Building Systems, 2011, University of Strathclyde)*
[56] *(ASHRAE 55-74 Standards. "Thermal Environmental Conditions for Human Occupancy". 1974)*
[57] *(ASHRAE Fundamentals Handbook (SI), pp. 8.16 , 2001.)*

Bioclimatic diagram:these diagrams are based on experiments. They present a succession of different adjacent zones and which give information on the thermal environment and propose "bioclimatic" recommendations, by using passive or mechanical systems of climate control, of a given agglomeration, with the aim of arriving at optimum comfort. In addition to thermic indices, there have been attempts to combine environmental factors in the form of graphical tools that allow indoor conditions in or near the comfort zone to be reduced. VOLGYAY was the first to develop a procedure that is based on a bioclimatic diagram where he determined a confine zone with summer and winter beaches and measures of corrections in the case where the combination of moisture and the temperature is outside the confession zone, also the tables of MAHONEY which have lost some of their usefulness because of the new developments and still they remain table, Then the bioclimatic diagram of B. GIVONI which establishes a more performing method as V. OLGYAY, evaluate the physiological exigencies of comfort. For it recommends two approaches of passive cooling (either by ventilation, or by reduction of internal temperatures compared to outside). S. V. SZOCOLAY has set up a new bioclimatic method which resembles GIVONI, where the development of the neutral zone is more accurately determined and the zones specific to each region, according to meteorological data.

3.2.4.1. The Apparent Temperature (TAPP)

One attempt to define exposure to heat waves considers both extreme daytime and high nighttime temperatures. The apparent temperature (TAPP) scale is a discomfort index based on air temperature and dew point temperature[58], as shown in Equation 3.1

$$Tapp = -2.653 + 0.994(Tair) + 0.0153(Tdewpt)^2 \qquad \text{Eq. 3-2}$$

Where

Tapp: is the apparent temperature (or the sensation temperature),

Tair : is air temperature

Tdewpt : is the dew point temperature (to introduce a humidity factor).

[58] *(D. D'Ippoliti, P. Michelozzi, and C. Marino, "The impact of heat waves on mortality in 9 European cities: results from the EuroHEAT project," Environ. Heal. Glob. Access Sci. Source, vol. 9, no. 1, p. 37, 2010.)*

3.2.4.2. The Universal Thermal Climate Index (UTCI)

The *UTCI*[59]is defined as the air temperature (*Ta*) of the reference condition causing the same model response as actual conditions. The offset, i.e. the deviation of *UTCI* from air temperature, depends on the actual values of air and mean radiant temperature (*Tmrt*), wind speed (*va*) and humidity, expressed as water vapor pressure (*vp*) or relative humidity (*RH*) (Fig. 1). This may be written in mathematical terms as

$$UTCI = f(Ta; Tmrt; va; vp) = Ta + \text{Offset}(Ta; Tmrt; va; vp) \qquad \text{Eq. 3.3}$$

Whilst the TAPP index incorporates air temperature and humidity, the Universal Thermal Climate Index (UTCI) is an index which lumps together all meteorological variables that affect the human heat balance equation[60],

In theory TAPP and UTCI could better identify health risks in hot weather, since they account for a multitude of variables that affect human heat stress. In the case of UTCI, an equivalent temperature is calculated with associated health risks

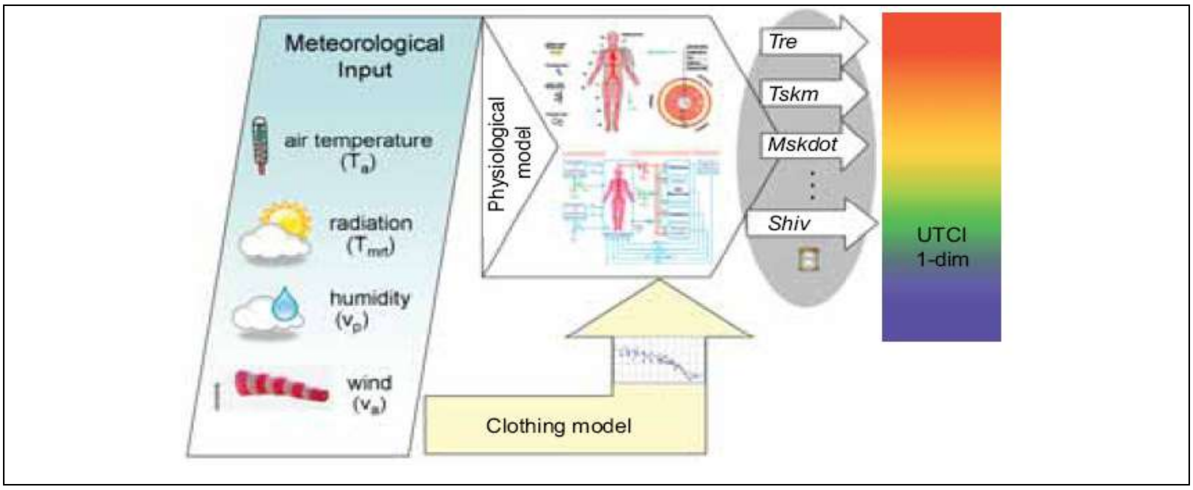

Figure 3-2: Concept of the *UTCI* derived as equivalent temperature from the dynamic multivariate response of the thermophysiological *UTCI*-Fiala model[10]

The different values of the *UTCI* are categorized in terms of thermal stress. The present approach looks at responses to reference conditions and deducts the load (i.e. the heat or

[59] *(BLAZEJCZYK, K. et al, 2013. An introduction to the Universal Thermal Climate Index (UTCI). Geographia Polonica, 86 (1), pp.5-10.)*

[60] *(P. Bröde, K. Błazejczyk, and D. Fiala, "The Universal Thermal Climate Index UTCI compared to ergonomics standards for assessing the thermal environment.," Ind. Health, vol. 51, no. 1, pp. 16–24, Jan. 2013.)*

cold stress) caused by the organism's physiological response to actual environmental conditions. Table 3-2 presents the labelled stress categories and a list of physiological criteria.

Table 3-2: *UTCI* equivalent temperature categorized in terms of thermal stress.		
UTCI (°C)	range Stress	Category Physiological responses
above +46	extreme heat stress	– increase in *Tre* time gradient – steep decrease in total net heat loss – averaged sweat rate >650 g/h, steep increase
+38 to +46	very strong heat stress	– core to skin temperature gradient < 1K (at 30 min) – increase in *Tre* at 30 min
+32 to +38	strong heat stress	– dynamic Thermal Sensation (DTS) at 120 min >+2 – averaged sweat rate > 200 g/h – increase in *Tre* at 120 min – latent heat loss >40 W at 30 min – instantaneous change in skin temperature > 0 K/min
+26 to +32	Moderate heat stress	– change of slopes in sweat rate, *Tre* and skin temperature: mean (*Tskm*), face (*Tskfc*), hand (*Tskhn*) – occurrence of sweating at 30 min – steep increase in skin wittedness
+9 to +26	no thermal stress	– averaged sweat rate > 100 g/h – DTS at 120 min < 1 – DTS between
-0.5 and +0.5	(averaged value)	– latent heat loss >40 W, averaged over time – plateau in *Tre* time gradient
+9 to 0	slight cold stress	– DTS at 120 min < -1 – local minimum of *Tskhn*(use gloves)
0 to -13	moderate cold stress	– DTS at 120 min < -2 – skin blood flow at 120 min lower than at 30 min (vasoconstriction) – averaged *Tskfc*< 15°C (pain) – decrease in *Tskhn* – *Tre* time gradient < 0 K/h – 30 min face skin temperature < 15°C (pain) – *Tmsk* time gradient < -1 K/h (for reference)
-13 to -27	strong cold stress	– averaged *Tskfc*< 7°C (numbness) – *Tre* time gradient < -0.1 K/h – *Tre* decreases from 30 to 120 min – increase in core to skin temperature gradient
-27 to -40	very strong cold stress	– 120 min *Tskfc*< 0°C (frostbite) – steeper decrease in *Tre* – 30 min *Tskfc*< 7°C (numbness) – occurrence of shivering

		– *Tre* time gradient < -0.2 K/h – averaged *Tskfc*< 0°C (frostbite). – 120 min *Tskfc*< -5°C (high risk of frostbite) below -40 extreme cold stress – *Tre* time gradient < -0.3 K/h – 30 min *Tskfc*< 0°C (frostbite)

3.2. Climate analysis:

Some definitions of climate enunciated by eminent climatologists are givenbelow:

Koeppe and De Long define "Climate as a summary, a composite of weather conditions over a long period of time, truly portrayed: it includes details of variations- extremes frequencies, sequences of the weather elements which occur from year to year. Particularly, in temperature and precipitation, climate is the aggregate of the weather".

Kendrew opines that "'Climate is a composite idea, a generalization of the manifold weather conditions from day to day throughout the year - certainly no picture of it is at all real unless it is painted of the seasons which are the really prominent features. It is inadequate to give merely the mean state of any element".

The word climate finds two different notions: that of average climate and that of climatic variability. The average climate corresponds to all the conditions that characterize the average state of the atmosphere in a given place or region. The variability of the climate corresponds to the static dispersion of its characteristic elements around their average value.

It may therefore be held that the climate is the usual succession of atmospheric circumstances over a place and through a given time. The knowledge of its variables and their different combinations represents an essential principle in the design and comfort in the habitat.

Climate is the summary on the resultant of all the manifold weather influences. The air temperature, pressure, direction and velocity of wind, humidity, the amount of cloudiness and precipitation are some of the most important weather elements. Each of these elements affects human activities in its own way. It would be worthwhile to focus attention on some of these elements which are directly related to our physical and mental energy, and which largely

3.2.1 Climate scales: The climate depends on cosmic, geographical and local factors. For the understanding of the climate concept, the notion of scale of climate has been introduced with a fraction of the space under a varied order of magnitude. So there is a global climate, some zonal climates, a great number of regional climates and a multitude of microclimates. Figure 3-3below shows the characteristics of each of them:

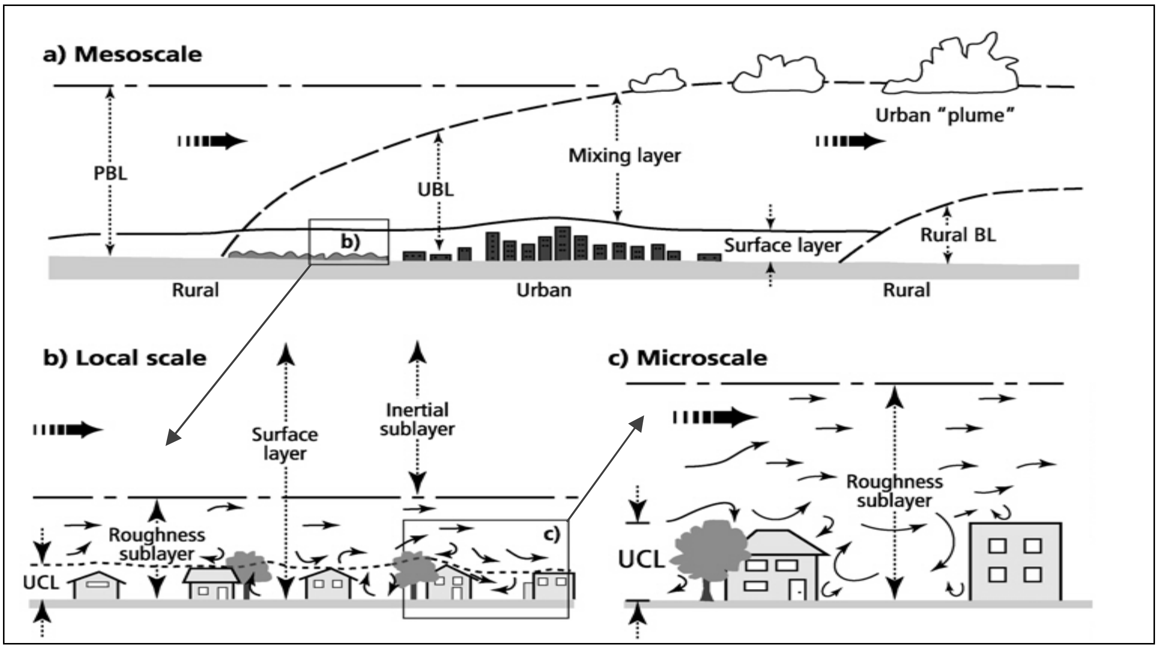

Figure 3-3: Climatescales, A) Mesoscale, B) Localscale, C) Microscale

The notion of a climate scale has led to the appearance of two large sets of climate groupings. On the one hand those that are based on genetic classification. On the other hand, those based on a combination of climatic parameters grouped or not in indices.

3.2.2. Approaches to climatic classification the notion of a climate scale has led to the appearance of two large sets of climate groupings. On the one hand those that are based on genetic classification. On the other hand, those based on a combination of climatic parameters grouped or not in indices called empirical classification[61]

3.2.2.1. Genetic classifications

Genetic classifications group climates by their causes. Among such methods, three types may be distinguished:

[61] (World Map of the Köppen-Geiger climate classification updated. Kottek, Markus, et al. Meteorologische Zeitschrift 15.3 (2006): 259-263.)

(1) Those based on the geographic determinants of climate

(2) Those based on the surface energy budget

(3) Those derived from air mass analysis

In the first class are a number of schemes (largely the work of German climatologists) that categorize climates according to such factors as latitudinal control of temperature, continentally versus ocean-influenced factors, location with respect to pressure and wind belts, and effects of mountains. These classifications all share a common shortcoming: they are qualitative, so that climatic regions are designated in a subjective manner rather than as a result of the application of some rigorous differentiating formula.

An interesting example of a method based on the energy balance of Earth's surface is the 1976 classification of Werner H. Terjung[62], an American geographer. His method utilizes data for more than 1,000 locations worldwide on the net solar radiation received at the surface, the available energy for evaporating water, and the available energy for heating the air and subsurface. The annual patterns are classified according to the maximum energy input, the annual range in input, the shape of the annual curve, and the number of months with negative magnitudes (energy deficits). The combination of characteristics for a location is represented by a label consisting of several letters with defined meanings, and regions having similar net radiation climates are mapped.

Probably the most extensively used genetic systems, however, are those that employ air mass concepts. Air masses are large bodies of air that, in principle, possess relatively homogeneous properties of temperature, humidity, etc., in the horizontal. Weather on individual days may be interpreted in terms of these features and their contrasts at fronts.

Location with respect to pressure and wind belts, and effects of mountains. These classifications all share a common shortcoming: they are qualitative, so that climatic regions are designated in a subjective manner rather than as a result of the application of some rigorous differentiating formula.

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[62]*(Werner H. Terjung, Climatology for geographers, 1976 Annals of the Association of American Geographers)*

3.2.2.2. Empirical classifications

Most empirical classifications are those that seek to group climates based on one or more aspects of the climate system. While many such phenomena have been used in this way, natural vegetation stands out as one of prime importance. The view held by many climatologists is that natural vegetation functions as a long-term integrator of the climate in a region; the vegetation, in effect, is an instrument for measuring climate in the same way that a thermometer measures temperature. Its preeminence is apparent in the fact that many textbooks and other sources refer to climates using the names of vegetation (for example, rainforest, taiga, and tundra).

Wladimir Köppen, a German botanist-climatologist, developed the most popular (but not the first) of these vegetation-based classifications. His aim was to devise formulas that would define climatic boundaries in such a way as to correspond to those of the vegetation zones that were being mapped for the first time during his lifetime. Köppen published his first scheme in 1900 and a revised version in 1918. He continued to revise his system of classification until his death in 1940. Other climatologists modified portions of Köppen's procedure on the basis of their experience in various parts of the world.

Köppen's classification is based on a subdivision of terrestrial climates into five major types, which are represented by the capital letters A, B, C, D, and E. Each of these climate types except for B is defined by temperature criteria. Type B designates climates in which the controlling factor on vegetation is dryness (rather than coldness). Aridity is not a matter of precipitation alone but is defined by the relationship between the precipitation input to the soil in which the plants grow and the evaporative losses. Since evaporation is difficult to evaluate and is not a conventional measurement at meteorological stations, Köppen was forced to substitute a formula that identifies aridity in terms of a temperature-precipitation index (that is, evaporation is assumed to be controlled by temperature) Figure 3-4. Dry climates are divided into arid (BW) and semiarid (BS) subtypes, and each may be differentiated further by adding a third code, for warm (h) or cold (k).

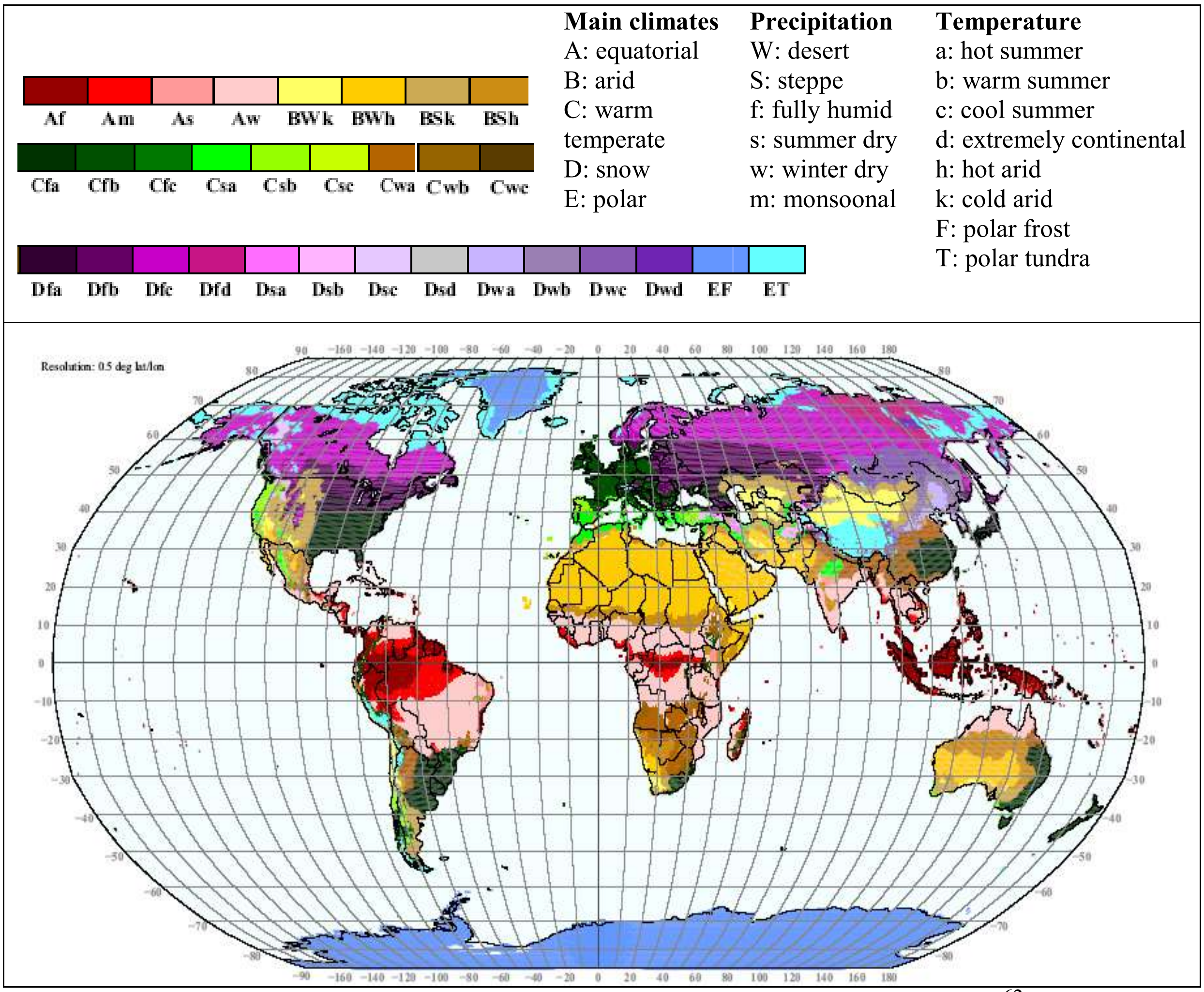

Figure 3-4: World Map of Köppen−Geiger Climate Classification [62]
updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000

Numerous cliatic indices have been empirically defined to allow the most aridity of a climate. De Martonne in 1923 calculated an aridity index to characterize the evaporative power of air from the temperature.

$$IDM = P / T+10 \qquad \text{Eq 3.3}$$

P: annual precipitation &T: annual average temperature.

Table 3.3 : Aridity index based on De Martonne

Classification	Aridity Index
Hyperarid	$0 < IDM < 5$
Arid	$5 < IDM < 10$
Semi-arid	$10 < IDM < 20$
Semi humide	$20 < IDM < 30$

Humide	30 < IDM < 55

3.3. Degreehours method:

Degree-hours method has its origins in agricultural research where knowledge of the cumulative variation in outdoor air temperature is important. This concept is readily transferable to buildings and can be used in the analysis and assessment of weather related energy consumption in buildings. Degree-Hours are essentially a summation of the differences between the outdoor temperature and a base temperature over a specified time period. A key issue in the application of degree-Hours is the definition of this base temperature, which, in buildings, relates to the energy balance of the building and systems. This applies to both heating and cooling systems, which leads to the dual concepts of Cooling Degree Hours (CDH) and Heating Degree Hours (HDH)

Heating and cooling degree-hours are defined as the sumof the differences between hourly average temperatures and the base temperature. The number of cooling degree-hours (CDH) in a day is defined as

$$CDH_b = \sum_{i=1}^{N} (T_i - T_b)^+ \qquad \text{Eq 3.4}$$

Where *N* is the number of hours in the day, *Tb* is the base temperature to which the degree-hours are calculated Figure 3.4, and *Ti is* the average hourly temperature. The "+" superscript indicates that only positive values of the bracketed quantity are taken into account in the sum. Similarly, daily heating degree-hours (HDH) are defined as

$$HDH_b = \sum_{i=1}^{N} (T_b - T_i)^+ . \qquad \text{Eq 3.5}$$

Monthly degree-hours are simply the sum of daily degree-hours over the number of days in the month. Likewise, yearly degree-hours are the sum of monthly degree-hours over the 12 months of the year. Degree hours are not just useful to estimate heating and cooling needs; they also help make comparisons between buildings more fair. A building in a mild climate like will need less heating and cooling energy than a building in a cold climate, even if this building is much better built. Comparing the energy intensities of different buildings with the heating and cooling degree days at each site helps make these comparisons more accurate representations of how efficiently the buildings are designed.

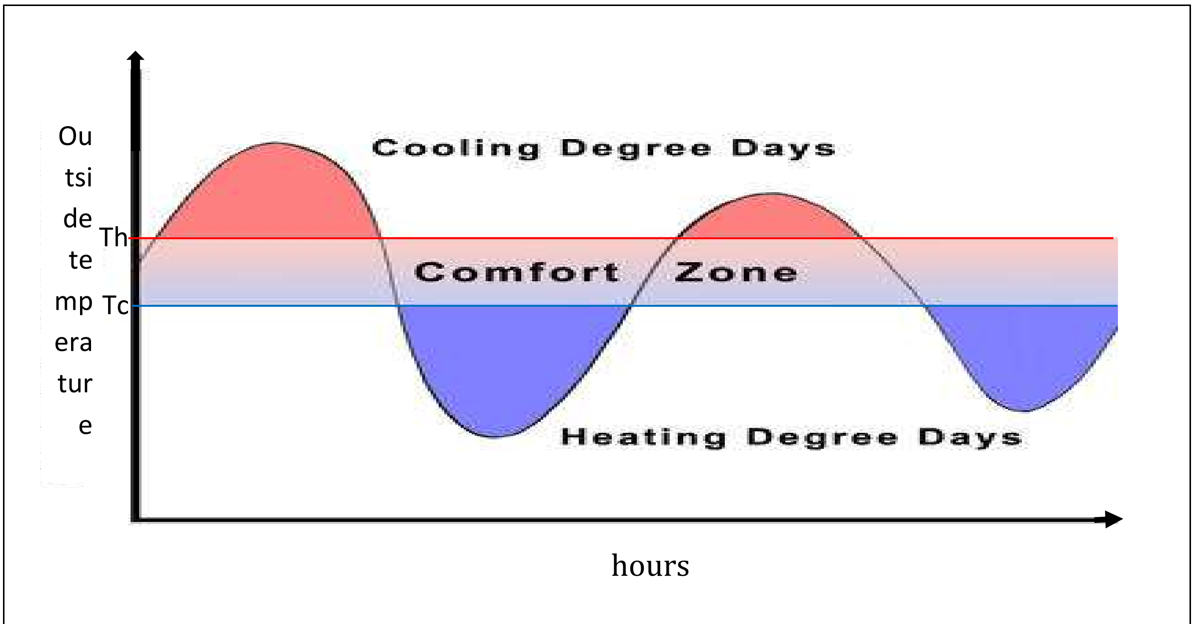

Figure 3-5: degree-hours for *Tb* is the base temperature to which the degree-hours are calculated

3.4. GIS system

A Geographic Information System (GIS) allows the user to collect and analyze spatial data and interpret reports. Computerized GIS systems have been in use since the 1960s and their use has evolved in three different types of applications. First, the system has been used for collection, coordination and access of geographic data. Gradually, GIS has been used more often as an analytical tool, representing mathematical relationships between spatial data, such as map layers, and various information. The newest use was the application of GIS as a decision support system in Multi-Criteria Decision Analysis (ADMC) methods, GIS software coupling and ADMC optimization methods[63].

A geographic information system is a powerful tool used for digital mapping and spatial analysis. GIS provides functionality for capturing, analyzing, displaying and producing geographic information. Geographic information systems are information systems that will enable us to acquire, process, organize and present geo-referenced data. Although it is customary to hear that a GIS is mainly used to produce maps and paper plans, this could be somewhat reductive because a GIS can also be used to manage its heritage of spatial data, the GIS being thus a tool data management system and a system that encompasses both:

-the software that can be used (ArcGIS, QGis, MapInfo, Gvsig, etc.),

-the data that will be used by the same software (urban data, network data, road data, etc.),

-the computer equipment (capacity, operating system etc.)

-Thematic skills (it is the user and his thematic "baggage" which determines how to use the software).

A GIS project is considered as a set of activities triggered to make a decision related to a problem. This set of activities takes place in different phases:

-Identification of objectives in relation to a problem,

-Evaluation of needs in thematic layers, Design of the database,

-Collection and acquisition of data,

-Integration and structuring of data in the database,

-Data processing (management, attribute or spatial queries),

-Restitution of results (Maps, queries, tables, diagrams),

-Interpretation and decision.

[63]*(GOUAREH A. these : Maîtrise et optimisation de la gestion énergétique, Université Djillali Liabès de Sidi Bel Abbès, 2017)*

3.5. Climate zones and classification in Algeria

In Algeria hot/dry are regions represent approximately 80%, buildings in this such climates in the Northern hemisphere require the use of mechanical cooling continuously from April to November in order for occupants to be thermally comfortable. Cooling degree days is more than 3,000 hours/year for a base temperature of 26C°, the average cooling energy consumption in Saharan climate is very high for example in domestic UAE buildings is 213kWh/m².y whereas the existing residential building cooling energy consumption profile in the GCC region (Gulf Cooperation Council region) stretches to 250kWh/m².y.

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6.1. Introduction

This final chapter concludes this research by giving an overview of the thesis, highlighting the main outcomes and making recommendations on possible future work which may be developed as a continuation to this thesis.

6.2. Overview of the thesis

Thermal comfort is currently a major issue in the building sector for both the quality of indoor environments and for the energy and environmental impacts for which it is responsible. The main objective of this work was the development of a methodology to carry out design studies of low-energy buildings. The principle of the methodology was to develop using numerical simulation tools and based on the designs of experimental method, models for the evaluation of energy performance and thermal comfort of buildings. In our work, we studied 13 parameters related to the geometric and thermal properties of the envelope for typical house.

The work carried out in this thesis is part of a modeling process based on parametric study towards simple and accessible polynomials which could be used by any engineer and makers decision makes to optimize energy consumption in building sector in south Algerian climate. The choices made seek to find a relevant compromise between the level of finesse of modeling and usability of use, making the models adapted to a large number of players in the building design.

6.3. Outcomes of the thesis

The outcomes of this thesis can be grouped in two categories. The first category describes outcomes obtained as a direct result. These primarily include three folds:

-Extend previous work done on energy consumption in residential buildings to include rational approach which can regroup the most influential thermal and geometric parameters related to envelop design aspect to optimize the seasonal energy consumption.

- Developing a detailed polynomials model capable to calculate building energy consumption. The models developed in this research relies on a novel approach whereby, it can be easily used by any user, also those models reduce drastically the resource and the time of simulation, contrast the energy consumption software those polynomials can help to study the interactions between the parameters and get the multiobjective optimization including the economic and environmental assessment.

-Developed new Code based on the design of experiment and TRNBuild, using the co-simulation to investigate how a residential energy consumption would perform under realistic levels for each parameters.

The second outcome category relates to the indirect results:

-Developed new zoning based in DCDHH and DCDHC by Arc-Gis software, this zoning help for chose specified solution related to the meteorological data.

-Developed Code based on the design of experiment can related with other TRNSYS Type to do parametric study. Which save drastically time and avoid any errors made by user when he introduce the data from software to another by hand.

6.4. Concluding remarks

This thesis has presented the main findings with regards to optimize the energy consumption in building sector in current energy buildings. It has also explored how different factors especially thermal and geometric will affect in seasonal energy consumption. In doing so the research has managed not only to produce results in relation to the main research task but also to develop tools which can be used in residential building to optimize seasonal energy consumption. These co-simulation tools useful in further improving and developing the current knowledge on energy performance in buildings.

The following list therefore describes only the main key findings:

-If WWR less than 15%, Orientation effect varies between zone to other, this parameters doesn't have very important influence in the case for cooling exception the south face for zone 5,6 and 7 the glazed surface need protection in summer. In heating case the orientation has significant influence which can reduce heating needs and used as passive solution especially in the zone 6 and 7, this parameters has less influence in the zone 4 and medium influence in zone 5. We can conclude that the choice of an adequate orientation of the building, can reduces heating energy requirements from 50% to 20 % (average 65 kWh / m².year).

- In the fact the linear polynomials double interactions are more precise than the polynomial of the first interactions, a priori means that there are veritable interaction between parameters each than other, with nonlinear variation in the levels of study. In Indeed, the terms of the second degree make it possible to take into account linear variations of some parameters. The absence of these terms in the first degree polynomials degrades the accuracy In this case of cooling the maximum mistake of relative error does not exceed 1% with the exception case of zone 7, the maximum mistake of relative error reached 15% Even if the accuracy is not very satisfactory, it remains acceptable to predict at least the trend of reducing summer thermal discomfort. The maximum mistake of coefficient of regression R^2 does not exceed 0.02% with the exception of Zone 5. The maximum mistake of coefficient of regression R^2 reached 3.64%. In this case of heating needs, the average error of coefficient of regression R^2 is a little higher than the cooling prediction models. The maximum mistake does not exceed 0.02% with the exception of zone 5. The maximum mistake reached 3.74%.

- The analyses of results shows there is strong interactions in the first and the second order between parameters that's explain why simple linear model without interactions doesn't give accurate results, The largest effect is the area parameters in the case of cooling needs for all climatic zones. In contrast to trends in the need for cooling, the area doesn't have strong influence in the case of heating. Also the first parameters in near than the second for all climatic zones. In zone 4 the first significant value is the interception between coefficient transmissions of window and ceiling high, the second parameter is the area, the next values are near each than other which explain strong interaction in the first and the second order.

We can conclude from this results shows high sensibility of the envelop design with different zones, the seam envelope design gives significant difference in seasonal energy consumption.

Apart from the main findings in this thesis related in energy consumption, new zoning on Arc-Gis developed based in DCDHH and DCDHC for assisted building envelope designer. Also the study developed economic assessment model essay for used by anyone to find the optimum solution for new design or for rehabilitation existing individual house.

6.5. Future work

This study has resulted in the contribution of design low building energy consumption and a demonstration of the savings that could be made by parametric optimization. Further development is highly recommended to continue this work, in particular to test and evaluate a more parameters have high influence in the design of envelop.

Evaluation and simulation assisted in this study was evaluated orientation as independent factor. In a future study, if there is enough resource in the power station could be used to attempt interaction with other geometric and thermal parameters. Time step of simulation used in this study was one hours, for more accuracy results and depend of the capacity of power station can chose short than this time step...etc.

Currently in the energy context, there are some integration solution in the envelop of building, as solar systems, those system are strongly developed in the building sector. Among these systems there is solar chimney, air-ground heat exchanger, phase change material…etc. Also greene solution related to the envelop design as greene roof, green wall …etc. Those solution can added as parameters in seam problem, which make the study more complex and need smart resolution, the co-simulation can resolve this problem.

Annex 1: Frequency Temperatuer

Temperatuer	Frequency			
	Zone Bayadah	Zone Tamanrasset	Zone Ouargla	Zone Adrar
-5	1	0	0	0
-4	6	0	0	0
-3	24	0	0	0
-2	34	0	0	0
-1	56	0	0	0
0	74	2	5	0
1	113	10	10	1
2	165	16	26	3
3	234	28	39	5
4	281	53	63	10
5	308	95	72	19
6	319	139	123	36
7	340	170	153	55
8	383	234	176	84
9	366	277	226	105
10	356	307	230	137
11	371	319	249	155
12	340	335	257	192
13	321	332	285	196
14	317	352	320	222
15	301	317	311	240
16	295	330	286	233
17	291	323	293	265
18	291	302	305	253
19	272	305	280	269
20	277	288	276	278
21	263	289	275	294
22	260	290	292	284
23	244	282	295	264
24	229	305	288	293
25	233	249	278	290
26	235	273	272	284
27	187	257	289	289
28	171	262	273	305
29	136	258	267	312
30	129	243	243	308
31	135	244	253	336
32	109	200	245	293
33	100	190	233	281
34	83	167	202	265

Temperatuer	Frequency			
	Zone Bayadah	Zone Tamanrasset	Zone Ouargla	Zone Adrar
36	36	149	178	233
37	9	126	146	197
38	4	91	128	193
39	0	63	110	202
40	0	54	92	180
41	0	41	64	164
42	0	8	58	155
43	0	5	44	138
44	0	3	35	83
45	0	0	15	81
46	0	0	4	37
47	0	0	0	9

Annex 2 : HDD & CDD

Wilya Code	WILAYA	Geo. Coor		HDD			CDD		
		Lati.	Long.	18	19	20	24	25	26
1	ADRAR	27.82	-0.18	10109	12331	14829	45079	40230	35671
2	CHLEF	36.22	1.33	25075	29498	34256	13997	11655	9596
3	LAGOUAT	33.75	2.93	23127	27085	31341	21329	18280	15489
4	OUM EL BOUA	35.87	7.12	68354	75078	82040	3979	3126	2413
5	BATNA	35.72	6.35	68367	75093	82056	3987	3132	2418
6	BEJAIA	36.72	5.07	50036	56020	62316	5929	4684	3625
7	BISKRA	34.80	5.73	17757	21359	25285	23910	20552	17518
8	BECHAR	31.63	-2.25	22739	26539	30640	22805	19589	16658
9	Blida	36.46	2.82	37364	42837	48625	7006	5507	4256
10	Bouira	36.37	3.89	35589	41120	47080	3831	2707	1833
11	TAMENRASSET	22.82	5.45	12805	15474	18493	20673	16964	13665
12	TEBESSA	35.42	8.12	61891	68622	75612	2743	2035	1464
13	TLEMCEN	35.02	-1.45	27139	32030	37354	6328	4787	3534
14	TIARET	35.35	1.47	40633	46354	52391	6072	4693	3566
15	TIZI OUZOU	36.70	4.05	42495	48078	53973	7835	6286	4961
16	DAR EL BEIDA	36.68	3.22	35589	41120	47080	3831	2707	1833
17	DJELFA	34.33	3.38	65631	72134	78871	4509	3530	2701
18	JIJEL	36.81	5.77	37945	43403	49167	8657	7033	5635
19	SETIF	36.18	5.25	68354	75078	82040	3979	3126	2413
20	SAIDA	34.87	0.15	38583	43767	49245	11276	9313	7583
21	SKIKDA	36.88	6.90	37945	43403	49167	8657	7033	5635
22	SIDI BEL ABBES	35.20	-0.62	42468	47834	53473	9616	7863	6347
23	ANNABA	36.83	7.82	32578	37964	43771	4064	2880	1992
24	GUELMA	36.47	7.47	48918	54875	61129	6137	4905	3849
25	CONSTANTINE	36.28	6.62	50194	56147	62387	5609	4381	3360
26	MEDEA	36.28	2.73	37318	42835	48668	6973	5451	4183
27	MOSTAGANEM	35.88	0.12	26388	31190	36419	5705	4200	3001
28	M'SILA	35.67	4.50	42517	48102	54000	7824	6277	4954
29	MASCARA	35.60	0.30	26388	31190	36419	5705	4200	3001
30	OUARGLA	31.93	5.40	19839	23276	26999	28414	24804	21474
31	ORAN SENIA	35.63	-0.60	24425	29205	34458	5361	3882	2694
32	EL BAYADH	33.67	1.00	46843	52442	58312	8142	6530	5147
33	ILLIZI	26.50	8.43	15764	18559	21630	30981	26847	23057
34	BORDJ BOU	36.07	4.77	42501	48083	53979	7832	6284	4960
35	TENES	36.50	1.33	33268	38739	44646	4036	2882	1985
36	EL KALA	36.90	8.45	34484	39822	45508	8591	6958	5550
37	TINDOUF	27.70	-8.17	14371	18520	23402	2245	1345	795
38	TISMSILTE	35.6	1.81	36174	41301	46716	13089	11037	9214
39	EL OUED	33.50	6.78	20026	23693	27664	23811	20465	17416
40	KHENCHELA	35.47	7.08	49330	55261	61490	6412	5112	3999
41	SOUK AHRAS	36.28	7.97	49851	55917	62272	5671	4492	3503
42	TIPAZA	36.59	2.44	37824	43330	49149	6906	5399	4153

43	AIN MELILA	36.45	6.26	50343	56285	62489	6098	4824	3746
44	AIN DEFLA	36.26	1.97	25090	29509	34267	13997	11656	9598
45	NAAMA	33.27	-0.30	42903	48283	53926	10043	8183	6566
46	AIN TIMOUCI	35.3	-1.14	26844	31844	37313	4817	3460	2391
47	GHARDAIA	32.40	3.80	23130	27089	31345	21335	18288	15496
48	RALIZANE	35.73	0.55	26408	31251	36531	5641	4135	2924

Annex 3 : DOE polynomial models

3 Factors and 2 levels (full runs)

Full Linear model

```
COOL = 83.1 + 23.1 WALL_-1 - 23.1 WALL_1 + 15.6 ROOF_-1 - 15.6 ROOF_1 -
 33.8 FLOOR_-1 + 33.8 FLOOR_1

HEATA = 46.43 + 20.06 WALL_-1 - 20.06 WALL_1 + 6.91 ROOF_-1 - 6.91 ROOF_1
+ 13.93 FLOOR_-1- 13.93 FLOOR_1
```

Full Linear model with simple interactions

```
COOL = 83.1 + 23.1 WALL_-1 - 23.1 WALL_1 + 15.6 ROOF_-1 - 15.6 ROOF_1 -
 33.8 FLOOR_-1
       + 33.8 FLOOR_1 - 8.0 WALL*ROOF_-1 -1 + 8.0 WALL*ROOF_-1 1
+ 8.0 WALL*ROOF_1 -1    - 8.0 WALL*ROOF_1 1 + 5.0 WALL*FLOOR_-1 -1 -
 5.0 WALL*FLOOR_-1 1 - 5.0 WALL*FLOOR_1 -1 + 5.0 WALL*FLOOR_1 1 -
 15.6 ROOF*FLOOR_-1 -1 + 15.6 ROOF*FLOOR_-1 1 + 15.6 ROOF*FLOOR_1 -1 -
 15.6 ROOF*FLOOR_1 1

HEATA = 46.43 + 20.06 WALL_-1 - 20.06 WALL_1 + 6.91 ROOF_-1 - 6.91 ROOF_1
+ 13.93 FLOOR_-1   - 13.93 FLOOR_1 + 10.82 WALL*ROOF_-1 -1 - 10.82 WALL*ROOF_-1
1 - 10.82 WALL*ROOF_1 -1  + 10.82 WALL*ROOF_1 1 - 5.83 WALL*FLOOR_-1 -1
+ 5.83 WALL*FLOOR_-1 1 + 5.83 WALL*FLOOR_1 -1 - 5.83 WALL*FLOOR_1 1 -
 1.00 ROOF*FLOOR_-1 -1   + 1.00 ROOF*FLOOR_-1 1 + 1.00 ROOF*FLOOR_1 -1 -
 1.00 ROOF*FLOOR_1 1
```

Full Linear model with double interactions

```
COOL = 83.11 + 23.07 WALL_-1 - 23.07 WALL_1 + 15.62 ROOF_-1 - 15.62 ROOF_1 -
 33.82 FLOOR_-1  + 33.82 FLOOR_1 - 8.042 WALL*ROOF_-1 -1 + 8.042 WALL*ROOF_-1 1
+ 8.042 WALL*ROOF_1 -1   - 8.042 WALL*ROOF_1 1 + 4.969 WALL*FLOOR_-1 -1 -
 4.969 WALL*FLOOR_-1 1- 4.969 WALL*FLOOR_1 -1 + 4.969 WALL*FLOOR_1 1 -
 15.63 ROOF*FLOOR_-1 -1  + 15.63 ROOF*FLOOR_-1 1 + 15.63 ROOF*FLOOR_1 -1 -
 15.63 ROOF*FLOOR_1 1   - 13.22 WALL*ROOF*FLOOR_-1 -1 -1
+ 13.22 WALL*ROOF*FLOOR_-1 -1 1     + 13.22 WALL*ROOF*FLOOR_-1 1 -1 -
 13.22 WALL*ROOF*FLOOR_-1 1 1
       + 13.22 WALL*ROOF*FLOOR_1 -1 -1 - 13.22 WALL*ROOF*FLOOR_1 -1 1
       - 13.22 WALL*ROOF*FLOOR_1 1 -1 + 13.22 WALL*ROOF*FLOOR_1 1 1

HEATA = 46.43 + 20.06 WALL_-1 - 20.06 WALL_1 + 6.913 ROOF_-1 - 6.913 ROOF_1
+ 13.93 FLOOR_-1 - 13.93 FLOOR_1 + 10.82 WALL*ROOF_-1 -1 - 10.82 WALL*ROOF_-1 1
- 10.82 WALL*ROOF_1 -1 + 10.82 WALL*ROOF_1 1 - 5.832 WALL*FLOOR_-1 -1
+ 5.832 WALL*FLOOR_-1 1  + 5.832 WALL*FLOOR_1 -1 - 5.832 WALL*FLOOR_1 1 -
 0.9988 ROOF*FLOOR_-1 -1+ 0.9988 ROOF*FLOOR_-1 1 + 0.9988 ROOF*FLOOR_1 -1 -
 0.9988 ROOF*FLOOR_1 1+ 9.093 WALL*ROOF*FLOOR_-1 -1 -1 - 9.093 WALL*ROOF*FLOOR_-
1 -1 1    - 9.093 WALL*ROOF*FLOOR_-1 1 -1 + 9.093 WALL*ROOF*FLOOR_-1 1 1 -
 9.093 WALL*ROOF*FLOOR_1 -1 -1 + 9.093 WALL*ROOF*FLOOR_1 -1 1
        + 9.093 WALL*ROOF*FLOOR_1 1 -1 - 9.093 WALL*ROOF*FLOOR_1 1 1
```

Full Linear model with simple interactions for Ouargla 128 runs

```
cool OGX = 50.7299 + 0.196947 Uwall_-1 - 0.196947 Uwall_1 - 0.205042 Uroof_-1
           + 0.205042 Uroof_1 - 0.246938 Uground_-1 + 0.246938 Uground_1
           + 0.000062 ColorWall_-1 - 0.000062 ColorWall_1 - 0.644062 ColorRoof_-
1
           + 0.644062 ColorRoof_1 - 0.000033 Uwind_-1 + 0.000033 Uwind_1
+ 0.389053 WWR_N_-1- 0.389053 WWR_N_1 + 0.207947 WWR_S_-1 - 0.207947 WWR_S_1 -
 0.380062 WWR_E_-1  + 0.380062 WWR_E_1 - 0.244958 WWR_W_-1 + 0.244958 WWR_W_1
           + 0.406042 CeilingHeight_-1 - 0.406042 CeilingHeight_1
+ 9.98204 Area_-1
           - 9.98204 Area_1 - 0.073062 FormSheap_-1 + 0.073062 FormSheap_1
           - 0.000033 Uwall*Uroof_-1 -1 + 0.000033 Uwall*Uroof_-1 1
+ 0.000033 Uwall*Uroof_1
           -1 - 0.000033 Uwall*Uroof_1 1 + 0.000053 Uwall*Uground_-1 -1
           - 0.000053 Uwall*Uground_-1 1 - 0.000053 Uwall*Uground_1 -1
           + 0.000053 Uwall*Uground_1 1 + 0.000053 Uwall*ColorWall_-1 -1
           - 0.000053 Uwall*ColorWall_-1 1 - 0.000053 Uwall*ColorWall_1 -1
           + 0.000053 Uwall*ColorWall_1 1 - 0.000053 Uwall*ColorRoof_-1 -1
           + 0.000053 Uwall*ColorRoof_-1 1 + 0.000053 Uwall*ColorRoof_1 -1
           - 0.000053 Uwall*ColorRoof_1 1 - 0.000042 Uwall*Uwind_-1 -1
           + 0.000042 Uwall*Uwind_-1 1 + 0.000042 Uwall*Uwind_1 -1 -
 0.000042 Uwall*Uwind_1 1
           + 0.000062 Uwall*WWR_N_-1 -1 - 0.000062 Uwall*WWR_N_-1 1 -
 0.000062 Uwall*WWR_N_1
           -1 + 0.000062 Uwall*WWR_N_1 1 - 0.000062 Uwall*WWR_S_-1 -1
           + 0.000062 Uwall*WWR_S_-1 1 + 0.000062 Uwall*WWR_S_1 -1 -
 0.000062 Uwall*WWR_S_1 1
           - 0.000053 Uwall*WWR_E_-1 -1 + 0.000053 Uwall*WWR_E_-1 1
+ 0.000053 Uwall*WWR_E_1
           -1 - 0.000053 Uwall*WWR_E_1 1 + 0.000033 Uwall*WWR_W_-1 -1
           - 0.000033 Uwall*WWR_W_-1 1 - 0.000033 Uwall*WWR_W_1 -1
+ 0.000033 Uwall*WWR_W_1 1
           + 0.000033 Uwall*CeilingHeight_-1 -1 - 0.000033 Uwall*CeilingHeight_-
1 1
           - 0.000033 Uwall*CeilingHeight_1 -1 + 0.000033 Uwall*CeilingHeight_1
1
           + 0.000033 Uwall*Area_-1 -1 - 0.000033 Uwall*Area_-1 1 -
 0.000033 Uwall*Area_1 -1
           + 0.000033 Uwall*Area_1 1 - 0.000053 Uwall*FormSheap_-1 -1
           + 0.000053 Uwall*FormSheap_-1 1 + 0.000053 Uwall*FormSheap_1 -1
           - 0.000053 Uwall*FormSheap_1 1 + 0.000042 Uroof*Uground_-1 -1
           - 0.000042 Uroof*Uground_-1 1 - 0.000042 Uroof*Uground_1 -1
           + 0.000042 Uroof*Uground_1 1 + 0.000042 Uroof*ColorWall_-1 -1
           - 0.000042 Uroof*ColorWall_-1 1 - 0.000042 Uroof*ColorWall_1 -1
           + 0.000042 Uroof*ColorWall_1 1 - 0.000042 Uroof*ColorRoof_-1 -1
           + 0.000042 Uroof*ColorRoof_-1 1 + 0.000042 Uroof*ColorRoof_1 -1
           - 0.000042 Uroof*ColorRoof_1 1 - 0.000053 Uroof*Uwind_-1 -1
           + 0.000053 Uroof*Uwind_-1 1 + 0.000053 Uroof*Uwind_1 -1 -
 0.000053 Uroof*Uwind_1 1
           + 0.000033 Uroof*WWR_N_-1 -1 - 0.000033 Uroof*WWR_N_-1 1 -
 0.000033 Uroof*WWR_N_1
           -1 + 0.000033 Uroof*WWR_N_1 1 - 0.000033 Uroof*WWR_S_-1 -1
           + 0.000033 Uroof*WWR_S_-1 1 + 0.000033 Uroof*WWR_S_1 -1 -
 0.000033 Uroof*WWR_S_1 1
           - 0.000042 Uroof*WWR_E_-1 -1 + 0.000042 Uroof*WWR_E_-1 1
+ 0.000042 Uroof*WWR_E_1
           -1 - 0.000042 Uroof*WWR_E_1 1 + 0.000062 Uroof*WWR_W_-1 -1
           - 0.000062 Uroof*WWR_W_-1 1 - 0.000062 Uroof*WWR_W_1 -1
+ 0.000062 Uroof*WWR_W_1 1
           + 0.000062 Uroof*CeilingHeight_-1 -1 - 0.000062 Uroof*CeilingHeight_-
1 1
           - 0.000062 Uroof*CeilingHeight_1 -1 + 0.000062 Uroof*CeilingHeight_1
1
           + 0.000062 Uroof*Area_-1 -1 - 0.000062 Uroof*Area_-1 1 -
 0.000062 Uroof*Area_1 -1
           + 0.000062 Uroof*Area_1 1 - 0.000042 Uroof*FormSheap_-1 -1
           + 0.000042 Uroof*FormSheap_-1 1 + 0.000042 Uroof*FormSheap_1 -1
```

- 0.000042 Uroof*FormSheap_1 1 - 0.000062 Uground*ColorWall_-1 -1
+ 0.000062 Uground*ColorWall_-1 1 + 0.000062 Uground*ColorWall_1 -1
- 0.000062 Uground*ColorWall_1 1 + 0.000062 Uground*ColorRoof_-1 -1
- 0.000062 Uground*ColorRoof_-1 1 - 0.000062 Uground*ColorRoof_1 -1
+ 0.000062 Uground*ColorRoof_1 1 + 0.000033 Uground*Uwind_-1 -1
- 0.000033 Uground*Uwind_-1 1 - 0.000033 Uground*Uwind_1 -1
+ 0.000033 Uground*Uwind_1 1 - 0.000053 Uground*WWR_N_-1 -1
+ 0.000053 Uground*WWR_N_-1 1 + 0.000053 Uground*WWR_N_1 -1
- 0.000053 Uground*WWR_N_1 1 + 0.000053 Uground*WWR_S_-1 -1
- 0.000053 Uground*WWR_S_-1 1 - 0.000053 Uground*WWR_S_1 -1
+ 0.000053 Uground*WWR_S_1 1 + 0.000062 Uground*WWR_E_-1 -1
- 0.000062 Uground*WWR_E_-1 1 - 0.000062 Uground*WWR_E_1 -1
+ 0.000062 Uground*WWR_E_1 1 - 0.000042 Uground*WWR_W_-1 -1
+ 0.000042 Uground*WWR_W_-1 1 + 0.000042 Uground*WWR_W_1 -1
- 0.000042 Uground*WWR_W_1 1 - 0.000042 Uground*CeilingHeight_-1 -1
+ 0.000042 Uground*CeilingHeight_-1 1
+ 0.000042 Uground*CeilingHeight_1 -1 - 0.000042 Uground*CeilingHeight_1
1 - 0.000042 Uground*Area_-1 -1
+ 0.000042 Uground*Area_-1 1 + 0.000042 Uground*Area_1 -1
- 0.000042 Uground*Area_1 1 + 0.000062 Uground*FormSheap_-1 -1
- 0.000062 Uground*FormSheap_-1 1 - 0.000062 Uground*FormSheap_1 -1
+ 0.000062 Uground*FormSheap_1 1 + 0.000062 ColorWall*ColorRoof_-1 -1
- 0.000062 ColorWall*ColorRoof_-1 1 - 0.000062 ColorWall*ColorRoof_1
-1
+ 0.000062 ColorWall*ColorRoof_1 1 + 0.146913 ColorWall*Uwind_-1 -1
- 0.146913 ColorWall*Uwind_-1 1 - 0.146913 ColorWall*Uwind_1 -1
+ 0.146913 ColorWall*Uwind_1 1 - 0.000053 ColorWall*WWR_N_-1 -1
+ 0.000053 ColorWall*WWR_N_-1 1 + 0.000053 ColorWall*WWR_N_1 -1
- 0.000053 ColorWall*WWR_N_1 1 + 0.000053 ColorWall*WWR_S_-1 -1
- 0.000053 ColorWall*WWR_S_-1 1 - 0.000053 ColorWall*WWR_S_1 -1
+ 0.000053 ColorWall*WWR_S_1 1 + 0.000062 ColorWall*WWR_E_-1 -1
- 0.000062 ColorWall*WWR_E_-1 1 - 0.000062 ColorWall*WWR_E_1 -1
+ 0.000062 ColorWall*WWR_E_1 1 - 0.000042 ColorWall*WWR_W_-1 -1
+ 0.000042 ColorWall*WWR_W_-1 1 + 0.000042 ColorWall*WWR_W_1 -1
- 0.000042 ColorWall*WWR_W_1 1 - 0.000042 ColorWall*CeilingHeight_-1
-1
+ 0.000042 ColorWall*CeilingHeight_-1 1
+ 0.000042 ColorWall*CeilingHeight_1 -1
- 0.000042 ColorWall*CeilingHeight_1 1 - 0.000042 ColorWall*Area_-1 -
1
+ 0.000042 ColorWall*Area_-1 1 + 0.000042 ColorWall*Area_1 -1
- 0.000042 ColorWall*Area_1 1 + 0.000062 ColorWall*FormSheap_-1 -1
- 0.000062 ColorWall*FormSheap_-1 1 - 0.000062 ColorWall*FormSheap_1
-1
+ 0.000062 ColorWall*FormSheap_1 1 - 0.000033 ColorRoof*Uwind_-1 -1
+ 0.000033 ColorRoof*Uwind_-1 1 + 0.000033 ColorRoof*Uwind_1 -1
- 0.000033 ColorRoof*Uwind_1 1 + 0.000053 ColorRoof*WWR_N_-1 -1
- 0.000053 ColorRoof*WWR_N_-1 1 - 0.000053 ColorRoof*WWR_N_1 -1
+ 0.000053 ColorRoof*WWR_N_1 1 - 0.000053 ColorRoof*WWR_S_-1 -1
+ 0.000053 ColorRoof*WWR_S_-1 1 + 0.000053 ColorRoof*WWR_S_1 -1
- 0.000053 ColorRoof*WWR_S_1 1 - 0.000062 ColorRoof*WWR_E_-1 -1
+ 0.000062 ColorRoof*WWR_E_-1 1 + 0.000062 ColorRoof*WWR_E_1 -1
- 0.000062 ColorRoof*WWR_E_1 1 + 0.000042 ColorRoof*WWR_W_-1 -1
- 0.000042 ColorRoof*WWR_W_-1 1 - 0.000042 ColorRoof*WWR_W_1 -1
+ 0.000042 ColorRoof*WWR_W_1 1 + 0.000042 ColorRoof*CeilingHeight_-1
-1
- 0.000042 ColorRoof*CeilingHeight_-1 1 -
0.000042 ColorRoof*CeilingHeight_1 -1
+ 0.000042 ColorRoof*CeilingHeight_1 1 + 0.000042 ColorRoof*Area_-1 -
1
- 0.000042 ColorRoof*Area_-1 1 - 0.000042 ColorRoof*Area_1 -1
+ 0.000042 ColorRoof*Area_1 1 - 0.000062 ColorRoof*FormSheap_-1 -1
+ 0.000062 ColorRoof*FormSheap_-1 1 + 0.000062 ColorRoof*FormSheap_1
-1
- 0.000062 ColorRoof*FormSheap_1 1 + 0.000042 Uwind*WWR_N_-1 -1
- 0.000042 Uwind*WWR_N_-1 1 - 0.000042 Uwind*WWR_N_1 -1
+ 0.000042 Uwind*WWR_N_1 1

```
          - 0.000042 Uwind*WWR_S_-1 -1 + 0.000042 Uwind*WWR_S_-1 1
+ 0.000042 Uwind*WWR_S_1
          -1 - 0.000042 Uwind*WWR_S_1 1 - 0.000033 Uwind*WWR_E_-1 -1
          + 0.000033 Uwind*WWR_E_-1 1 + 0.000033 Uwind*WWR_E_1 -1 -
 0.000033 Uwind*WWR_E_1 1
          + 0.000053 Uwind*WWR_W_-1 -1 - 0.000053 Uwind*WWR_W_-1 1 -
 0.000053 Uwind*WWR_W_1
          -1 + 0.000053 Uwind*WWR_W_1 1 + 0.000053 Uwind*CeilingHeight_-1 -1
          - 0.000053 Uwind*CeilingHeight_-1 1 - 0.000053 Uwind*CeilingHeight_1
-1
          + 0.000053 Uwind*CeilingHeight_1 1 + 0.000053 Uwind*Area_-1 -1
          - 0.000053 Uwind*Area_-1 1 - 0.000053 Uwind*Area_1 -1
+ 0.000053 Uwind*Area_1 1
          - 0.000033 Uwind*FormSheap_-1 -1 + 0.000033 Uwind*FormSheap_-1 1
          + 0.000033 Uwind*FormSheap_1 -1 - 0.000033 Uwind*FormSheap_1 1
          + 0.000062 WWR_N*WWR_S_-1 -1 - 0.000062 WWR_N*WWR_S_-1 1 -
 0.000062 WWR_N*WWR_S_1
          -1 + 0.000062 WWR_N*WWR_S_1 1 + 0.000053 WWR_N*WWR_E_-1 -1
          - 0.000053 WWR_N*WWR_E_-1 1 - 0.000053 WWR_N*WWR_E_1 -1
+ 0.000053 WWR_N*WWR_E_1 1
          - 0.000033 WWR_N*WWR_W_-1 -1 + 0.000033 WWR_N*WWR_W_-1 1
+ 0.000033 WWR_N*WWR_W_1
          -1 - 0.000033 WWR_N*WWR_W_1 1 - 0.000033 WWR_N*CeilingHeight_-1 -1
          + 0.000033 WWR_N*CeilingHeight_-1 1 + 0.000033 WWR_N*CeilingHeight_1
-1
          - 0.000033 WWR_N*CeilingHeight_1 1 - 0.000033 WWR_N*Area_-1 -1
          + 0.000033 WWR_N*Area_-1 1 + 0.000033 WWR_N*Area_1 -1 -
 0.000033 WWR_N*Area_1 1
          + 0.000053 WWR_N*FormSheap_-1 -1 - 0.000053 WWR_N*FormSheap_-1 1
          - 0.000053 WWR_N*FormSheap_1 -1 + 0.000053 WWR_N*FormSheap_1 1
          - 0.000053 WWR_S*WWR_E_-1 -1 + 0.000053 WWR_S*WWR_E_-1 1
+ 0.000053 WWR_S*WWR_E_1
          -1 - 0.000053 WWR_S*WWR_E_1 1 + 0.000033 WWR_S*WWR_W_-1 -1
          - 0.000033 WWR_S*WWR_W_-1 1 - 0.000033 WWR_S*WWR_W_1 -1
+ 0.000033 WWR_S*WWR_W_1 1
          + 0.000033 WWR_S*CeilingHeight_-1 -1 - 0.000033 WWR_S*CeilingHeight_-
1 1
          - 0.000033 WWR_S*CeilingHeight_1 -1 + 0.000033 WWR_S*CeilingHeight_1
1
          + 0.000033 WWR_S*Area_-1 -1 - 0.000033 WWR_S*Area_-1 1 -
 0.000033 WWR_S*Area_1 -1
          + 0.000033 WWR_S*Area_1 1 - 0.000053 WWR_S*FormSheap_-1 -1
          + 0.000053 WWR_S*FormSheap_-1 1 + 0.000053 WWR_S*FormSheap_1 -1
          - 0.000053 WWR_S*FormSheap_1 1 + 0.000042 WWR_E*WWR_W_-1 -1
          - 0.000042 WWR_E*WWR_W_-1 1 - 0.000042 WWR_E*WWR_W_1 -1
+ 0.000042 WWR_E*WWR_W_1 1
          + 0.000042 WWR_E*CeilingHeight_-1 -1 - 0.000042 WWR_E*CeilingHeight_-
1 1
          - 0.000042 WWR_E*CeilingHeight_1 -1 + 0.000042 WWR_E*CeilingHeight_1
1
          + 0.000042 WWR_E*Area_-1 -1 - 0.000042 WWR_E*Area_-1 1 -
 0.000042 WWR_E*Area_1 -1
          + 0.000042 WWR_E*Area_1 1 - 0.000062 WWR_E*FormSheap_-1 -1
          + 0.000062 WWR_E*FormSheap_-1 1 + 0.000062 WWR_E*FormSheap_1 -1
          - 0.000062 WWR_E*FormSheap_1 1 - 0.000062 WWR_W*CeilingHeight_-1 -1
          + 0.000062 WWR_W*CeilingHeight_-1 1 + 0.000062 WWR_W*CeilingHeight_1
-1
          - 0.000062 WWR_W*CeilingHeight_1 1 - 0.000062 WWR_W*Area_-1 -1
          + 0.000062 WWR_W*Area_-1 1 + 0.000062 WWR_W*Area_1 -1 -
 0.000062 WWR_W*Area_1 1
          + 0.000042 WWR_W*FormSheap_-1 -1 - 0.000042 WWR_W*FormSheap_-1 1
          - 0.000042 WWR_W*FormSheap_1 -1 + 0.000042 WWR_W*FormSheap_1 1
          - 0.000062 CeilingHeight*Area_-1 -1 + 0.000062 CeilingHeight*Area_-1
1
          + 0.000062 CeilingHeight*Area_1 -1 - 0.000062 CeilingHeight*Area_1 1
          + 0.000042 CeilingHeight*FormSheap_-1 -1 -
 0.000042 CeilingHeight*FormSheap_-1 1
```

```
          - 0.000042 CeilingHeight*FormSheap_1 -1
+ 0.000042 CeilingHeight*FormSheap_1 1
          + 0.000042 Area*FormSheap_-1 -1 - 0.000042 Area*FormSheap_-1 1
          - 0.000042 Area*FormSheap_1 -1 + 0.000042 Area*FormSheap_1 1
```

Design Table (128 randomized)

Run	A	B	C	D	E	F	G	H	J	K	L	M	N
1	−	−	−	−	−	−	−	+	+	−	−	+	−
2	+	+	−	−	+	+	−	+	+	−	−	−	−
3	−	+	+	+	−	−	−	−	+	+	−	−	−
4	+	−	−	+	+	−	+	−	+	−	+	+	+
5	+	−	+	+	−	+	+	−	+	−	+	−	−
6	+	+	−	+	+	−	−	+	+	−	−	+	−
7	+	+	+	−	−	−	+	−	−	+	−	+	+
8	+	+	+	+	−	+	−	+	+	−	−	−	+
9	−	−	+	+	+	−	−	+	+	−	−	+	+
10	−	−	+	−	+	−	+	+	−	−	+	+	+
11	+	+	+	−	+	−	−	−	−	−	+	−	+
12	+	+	−	+	+	+	+	+	−	−	+	−	−
13	+	−	−	−	−	−	−	+	+	−	+	−	+
14	+	+	−	−	−	−	+	−	+	−	−	−	−
15	−	−	+	+	+	−	+	−	−	+	−	+	+
16	+	+	−	−	−	−	−	+	−	+	−	−	−
17	−	+	−	+	−	+	+	−	+	−	+	−	+
18	+	+	−	−	−	+	+	+	+	+	+	+	−
19	−	+	−	+	−	+	−	+	−	+	+	−	+
20	+	+	+	−	−	+	−	−	+	+	+	−	+
21	+	−	−	+	−	−	−	−	+	+	−	−	+
22	−	−	+	−	+	+	−	+	+	−	−	−	+
23	+	−	−	+	+	−	−	+	−	+	+	+	+
24	−	−	+	+	+	+	+	+	−	−	+	−	+
25	−	+	+	+	−	+	+	−	−	+	+	+	−
26	−	−	−	+	+	+	+	+	+	+	+	+	−
27	+	−	−	+	+	+	−	−	−	−	−	−	+
28	−	+	+	+	−	+	−	+	+	−	+	+	−
29	−	−	−	+	−	−	+	+	−	−	+	+	−
30	−	+	+	−	−	−	+	−	−	+	+	−	−
31	+	+	−	+	+	+	−	−	+	+	+	−	−
32	+	+	+	+	+	−	−	+	−	+	−	−	+
33	−	+	−	+	+	−	−	+	+	−	+	−	+
34	−	−	−	−	−	+	+	+	−	−	+	−	−
35	+	−	−	−	+	−	−	−	−	−	−	+	+
36	−	−	+	+	−	+	−	+	−	+	−	+	+
37	−	−	−	+	−	−	−	−	+	+	+	+	−
38	+	−	+	−	−	−	−	+	−	+	+	+	−
39	−	+	−	−	−	−	+	−	+	−	+	+	+
40	−	+	+	+	+	+	−	−	−	−	−	−	−
41	−	+	+	+	+	−	+	−	+	−	+	+	−
42	−	+	−	+	+	+	−	−	+	+	−	+	+
43	+	−	−	+	+	+	+	+	+	+	−	−	+
44	−	−	−	−	−	+	−	−	+	+	+	−	−
45	+	−	+	+	−	−	−	−	−	−	−	+	−
46	+	−	−	+	−	+	−	+	+	−	+	+	+
47	−	+	+	−	+	+	+	−	+	−	+	−	−
48	+	−	−	−	−	+	−	−	+	+	−	+	+
49	+	+	−	+	−	+	+	−	+	−	−	+	−
50	−	+	+	−	+	+	−	+	−	+	+	−	−
51	−	+	−	−	+	+	−	+	+	−	+	+	+
52	−	−	−	−	+	−	−	−	−	−	+	−	−
53	−	−	+	−	−	−	+	−	+	−	−	−	+
54	−	+	−	+	+	+	+	+	−	−	−	+	+
55	+	−	+	−	−	−	+	−	+	−	+	+	−
56	−	+	−	−	+	−	+	+	−	−	−	−	+
57	−	+	−	+	+	−	+	−	−	+	+	−	+
58	−	−	−	−	−	−	+	−	−	+	−	+	−
59	+	−	+	+	+	+	+	+	−	−	−	+	−
60	+	+	+	−	+	+	−	+	−	+	−	+	+
61	−	+	−	+	−	−	+	+	+	+	−	+	+
62	+	−	+	−	+	−	+	+	−	−	−	−	−
63	+	−	+	+	−	−	+	+	+	+	−	+	−

64	+	−	+	−	+	−	−	−	+	+	−	−	−
65	+	−	−	+	−	+	+	−	−	+	+	+	+
66	−	+	−	−	−	−	−	+	−	+	+	+	+
67	+	−	−	+	−	−	+	+	−	−	−	−	+
68	−	−	+	−	−	−	−	+	−	+	−	−	+
69	−	−	+	+	−	+	+	−	+	−	−	+	+
70	+	+	+	+	−	−	−	−	+	+	+	+	+
71	+	−	+	−	+	+	−	+	+	−	+	+	−
72	+	+	−	−	−	+	−	−	−	−	+	+	−
73	+	+	−	−	+	−	+	+	−	−	+	+	−
74	−	−	−	+	+	−	−	+	−	+	−	−	−
75	−	−	−	−	+	+	−	+	−	+	−	+	−
76	+	+	+	+	+	+	+	+	+	+	+	+	+
77	−	−	+	−	+	+	+	−	−	+	−	−	+
78	+	−	−	−	+	+	−	+	−	+	+	−	+
79	−	−	−	−	+	−	+	+	+	+	+	−	−
80	−	−	+	+	+	+	−	−	+	+	+	−	+
81	−	+	+	+	+	+	+	+	+	+	−	−	−
82	+	+	−	+	−	−	−	−	−	−	+	−	−
83	−	+	+	+	+	−	−	+	−	+	+	+	−
84	+	−	−	−	−	−	+	−	−	+	+	−	+
85	+	+	+	−	+	−	+	+	+	+	+	−	+
86	+	−	+	−	−	+	−	−	−	−	−	−	−
87	−	+	−	−	+	−	−	−	+	+	−	−	+
88	−	+	−	+	−	−	−	−	−	−	−	+	+
89	−	−	−	+	+	+	−	−	−	−	+	+	−
90	+	+	−	−	+	−	−	−	+	+	+	+	−
91	+	+	−	−	+	+	+	−	−	+	−	−	−
92	−	−	−	+	+	−	+	−	+	−	−	−	−
93	−	+	+	+	−	−	+	+	−	−	−	−	−
94	+	+	+	−	−	−	−	+	+	−	−	+	+
95	−	+	+	−	+	−	−	−	−	−	−	+	−
96	+	+	+	−	−	+	+	+	−	−	+	−	+
97	+	−	+	−	−	+	+	+	+	+	−	−	−
98	+	−	+	+	+	−	+	−	−	+	+	−	−
99	−	−	−	+	−	+	+	−	−	+	−	−	−
100	−	+	+	−	−	−	−	+	+	−	+	−	−
101	+	−	+	+	+	−	−	+	+	−	+	−	−
102	+	+	+	+	−	+	+	−	−	+	−	−	+
103	+	+	+	+	−	−	+	+	−	−	+	+	+
104	+	+	+	+	+	+	−	−	−	−	+	+	+
105	+	+	−	+	+	−	+	−	−	+	−	+	−
106	−	+	+	−	−	+	−	−	+	+	−	+	−
107	−	+	−	−	−	+	+	+	+	+	−	−	+
108	−	+	+	−	−	+	+	+	−	−	−	+	−
109	+	+	+	−	+	+	+	−	+	−	−	+	+
110	−	−	+	+	−	−	+	+	+	+	+	−	+
111	−	−	+	−	−	+	−	−	−	−	+	+	+
112	+	−	+	+	−	+	−	+	−	+	+	−	−
113	−	+	+	−	+	−	+	+	+	+	−	+	−
114	−	+	−	−	+	+	+	−	−	+	+	+	+
115	+	+	−	+	−	−	+	+	+	+	+	−	−
116	−	−	−	+	−	+	−	+	+	−	−	−	−
117	+	−	−	−	+	−	+	+	+	+	−	+	+
118	+	+	−	+	−	+	−	+	−	+	−	+	−
119	−	−	+	−	+	−	−	−	+	+	+	+	+
120	+	−	−	−	+	+	+	−	+	−	+	−	+
121	+	+	+	+	+	−	+	−	+	−	−	−	+
122	−	−	+	+	−	−	−	−	−	−	+	−	+
123	+	−	+	−	+	+	+	−	−	+	+	+	−
124	+	−	−	−	−	+	+	+	−	−	−	+	+
125	+	−	+	+	+	+	−	−	+	+	−	+	−
126	−	−	+	−	−	+	+	+	+	+	+	+	+
127	−	−	−	−	+	+	+	−	+	−	−	+	−
128	−	+	−	−	−	+	−	−	−	−	−	−	+

Analysis of Variance (Bayadh 128 for cooling)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	93	54280.3	583.66	9.40	0.000
Linear	13	10453.3	804.10	12.95	0.000
U wall	1	2118.4	2118.41	34.12	0.000
U roof	1	23.2	23.21	0.37	0.545
U grou	1	12.0	12.03	0.19	0.663
ColorWall	1	273.2	273.19	4.40	0.043
ColorRoof	1	402.9	402.91	6.49	0.016
U wind	1	1039.1	1039.06	16.74	0.000
WWR_N	1	8.0	7.97	0.13	0.722
WWR_S	1	1.4	1.36	0.02	0.883
WWR_E	1	181.5	181.53	2.92	0.096
WWR_W	1	2708.0	2707.95	43.62	0.000
CELING	1	167.9	167.88	2.70	0.109
AREA	1	2703.0	2703.02	43.54	0.000
FORM	1	814.8	814.80	13.13	0.001
2-Way Interactions	56	30631.5	546.99	8.81	0.000
U wall*U roof	1	0.1	0.12	0.00	0.966
U wall*U grou	1	220.4	220.45	3.55	0.068
U wall*ColorWall	1	645.0	644.96	10.39	0.003
U wall*ColorRoof	1	79.2	79.25	1.28	0.266
U wall*U wind	1	607.6	607.63	9.79	0.004
U wall*WWR_N	1	56.9	56.95	0.92	0.345
U wall*WWR_S	1	1.3	1.30	0.02	0.886
U wall*WWR_E	1	148.9	148.89	2.40	0.131
U wall*WWR_W	1	1025.9	1025.85	16.53	0.000
U wall*CELING	1	46.5	46.46	0.75	0.393
U wall*AREA	1	840.9	840.86	13.55	0.001
U wall*FORM	1	198.2	198.16	3.19	0.083
U roof*ColorWall	1	2179.4	2179.36	35.11	0.000
U roof*ColorRoof	1	536.1	536.13	8.64	0.006
U roof*U wind	1	86.8	86.77	1.40	0.245
U roof*WWR_N	1	1.7	1.69	0.03	0.870
U roof*WWR_S	1	692.8	692.78	11.16	0.002
U roof*WWR_E	1	357.7	357.73	5.76	0.022
U roof*WWR_W	1	567.8	567.81	9.15	0.005
U roof*CELING	1	200.2	200.20	3.22	0.081
U roof*AREA	1	13.6	13.56	0.22	0.643
U grou*ColorWall	1	1395.5	1395.50	22.48	0.000
U grou*ColorRoof	1	1099.6	1099.59	17.71	0.000
U grou*WWR_N	1	254.1	254.07	4.09	0.051
U grou*WWR_S	1	2038.4	2038.45	32.84	0.000
U grou*WWR_E	1	610.5	610.51	9.83	0.004
U grou*CELING	1	161.5	161.49	2.60	0.116
ColorWall*ColorRoof	1	587.1	587.09	9.46	0.004
ColorWall*U wind	1	1496.1	1496.06	24.10	0.000
ColorWall*WWR_N	1	480.9	480.94	7.75	0.009
ColorWall*WWR_S	1	8.7	8.67	0.14	0.711
ColorWall*WWR_E	1	477.8	477.84	7.70	0.009
ColorWall*CELING	1	132.0	132.01	2.13	0.154
ColorWall*AREA	1	269.3	269.26	4.34	0.045
ColorRoof*U wind	1	159.9	159.91	2.58	0.118
ColorRoof*WWR_N	1	902.2	902.17	14.53	0.001
ColorRoof*WWR_E	1	642.9	642.86	10.36	0.003
ColorRoof*WWR_W	1	647.5	647.49	10.43	0.003
ColorRoof*CELING	1	30.5	30.51	0.49	0.488
U wind*WWR_S	1	421.1	421.12	6.78	0.014
U wind*WWR_W	1	137.8	137.83	2.22	0.145
U wind*CELING	1	2695.8	2695.85	43.43	0.000
U wind*AREA	1	1251.4	1251.41	20.16	0.000
U wind*FORM	1	262.7	262.74	4.23	0.047
WWR_N*WWR_S	1	666.2	666.20	10.73	0.002
WWR_N*WWR_E	1	1060.1	1060.11	17.08	0.000
WWR_N*WWR_W	1	1088.5	1088.45	17.53	0.000

WWR_N*CELING	1	37.5	37.53	0.60	0.442
WWR_N*AREA	1	93.6	93.62	1.51	0.228
WWR_N*FORM	1	206.2	206.17	3.32	0.077
WWR_S*CELING	1	166.7	166.66	2.68	0.111
WWR_S*FORM	1	298.2	298.16	4.80	0.035
WWR_E*CELING	1	1212.6	1212.61	19.53	0.000
WWR_E*FORM	1	609.9	609.95	9.83	0.004
WWR_W*AREA	1	194.1	194.05	3.13	0.086
CELING*AREA	1	327.7	327.69	5.28	0.028
3-Way Interactions	24	13195.6	549.81	8.86	0.000
U wall*U roof*ColorWall	1	1602.6	1602.58	25.82	0.000
U wall*U roof*ColorRoof	1	428.2	428.20	6.90	0.013
U wall*U roof*U wind	1	756.8	756.75	12.19	0.001
U wall*U roof*AREA	1	152.3	152.35	2.45	0.126
U wall*U grou*ColorWall	1	554.1	554.09	8.93	0.005
U wall*U grou*WWR_N	1	278.7	278.69	4.49	0.041
U wall*U grou*WWR_S	1	350.1	350.14	5.64	0.023
U wall*U grou*WWR_E	1	768.5	768.54	12.38	0.001
U wall*ColorWall*ColorRoof	1	353.9	353.90	5.70	0.023
U wall*ColorWall*U wind	1	705.7	705.66	11.37	0.002
U wall*ColorWall*WWR_N	1	500.1	500.09	8.06	0.008
U wall*ColorWall*WWR_S	1	1077.5	1077.46	17.36	0.000
U wall*ColorRoof*CELING	1	1157.6	1157.64	18.65	0.000
U wall*U wind*WWR_S	1	1141.7	1141.73	18.39	0.000
U wall*U wind*CELING	1	355.3	355.27	5.72	0.022
U wall*U wind*FORM	1	247.0	246.99	3.98	0.054
U wall*WWR_N*WWR_W	1	167.8	167.79	2.70	0.109
U wall*WWR_N*AREA	1	229.1	229.07	3.69	0.063
U wall*WWR_W*AREA	1	553.3	553.35	8.91	0.005
U roof*ColorWall*WWR_N	1	594.2	594.19	9.57	0.004
U roof*ColorWall*WWR_S	1	143.4	143.39	2.31	0.138
U grou*ColorWall*ColorRoof	1	469.4	469.35	7.56	0.009
ColorWall*WWR_N*CELING	1	154.0	153.95	2.48	0.125
ColorWall*WWR_E*CELING	1	454.4	454.38	7.32	0.011
Error	34	2110.7	62.08		
Total	127	56391.0			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
7.87897	96.26%	86.02%	46.95%

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		23.589	0.696	33.87	0.000	
U wall	8.136	4.068	0.696	5.84	0.000	1.00
U roof	0.852	0.426	0.696	0.61	0.545	1.00
U grou	-0.613	-0.307	0.696	-0.44	0.663	1.00
ColorWall	-2.922	-1.461	0.696	-2.10	0.043	1.00
ColorRoof	3.548	1.774	0.696	2.55	0.016	1.00
U wind	5.698	2.849	0.696	4.09	0.000	1.00
WWR_N	-0.499	-0.249	0.696	-0.36	0.722	1.00
WWR_S	0.206	0.103	0.696	0.15	0.883	1.00
WWR_E	-2.382	-1.191	0.696	-1.71	0.096	1.00
WWR_W	-9.199	-4.600	0.696	-6.60	0.000	1.00
CELING	-2.290	-1.145	0.696	-1.64	0.109	1.00
AREA	-9.191	-4.595	0.696	-6.60	0.000	1.00
FORM	5.046	2.523	0.696	3.62	0.001	1.00
U wall*U roof	0.061	0.030	0.696	0.04	0.966	1.00
U wall*U grou	2.625	1.312	0.696	1.88	0.068	1.00
U wall*ColorWall	4.489	2.245	0.696	3.22	0.003	1.00
U wall*ColorRoof	-1.574	-0.787	0.696	-1.13	0.266	1.00
U wall*U wind	-4.358	-2.179	0.696	-3.13	0.004	1.00
U wall*WWR_N	-1.334	-0.667	0.696	-0.96	0.345	1.00
U wall*WWR_S	-0.202	-0.101	0.696	-0.14	0.886	1.00

U wall*WWR_E	-2.157	-1.079	0.696	-1.55	0.131	1.00
U wall*WWR_W	-5.662	-2.831	0.696	-4.07	0.000	1.00
U wall*CELING	-1.205	-0.602	0.696	-0.87	0.393	1.00
U wall*AREA	5.126	2.563	0.696	3.68	0.001	1.00
U wall*FORM	-2.488	-1.244	0.696	-1.79	0.083	1.00
U roof*ColorWall	-8.253	-4.126	0.696	-5.93	0.000	1.00
U roof*ColorRoof	4.093	2.047	0.696	2.94	0.006	1.00
U roof*U wind	-1.647	-0.823	0.696	-1.18	0.245	1.00
U roof*WWR_N	-0.230	-0.115	0.696	-0.17	0.870	1.00
U roof*WWR_S	4.653	2.326	0.696	3.34	0.002	1.00
U roof*WWR_E	-3.343	-1.672	0.696	-2.40	0.022	1.00
U roof*WWR_W	-4.212	-2.106	0.696	-3.02	0.005	1.00
U roof*CELING	-2.501	-1.251	0.696	-1.80	0.081	1.00
U roof*AREA	0.651	0.326	0.696	0.47	0.643	1.00
U grou*ColorWall	6.604	3.302	0.696	4.74	0.000	1.00
U grou*ColorRoof	5.862	2.931	0.696	4.21	0.000	1.00
U grou*WWR_N	2.818	1.409	0.696	2.02	0.051	1.00
U grou*WWR_S	-7.981	-3.991	0.696	-5.73	0.000	1.00
U grou*WWR_E	-4.368	-2.184	0.696	-3.14	0.004	1.00
U grou*CELING	2.246	1.123	0.696	1.61	0.116	1.00
ColorWall*ColorRoof	4.283	2.142	0.696	3.08	0.004	1.00
ColorWall*U wind	-6.838	-3.419	0.696	-4.91	0.000	1.00
ColorWall*WWR_N	3.877	1.938	0.696	2.78	0.009	1.00
ColorWall*WWR_S	-0.520	-0.260	0.696	-0.37	0.711	1.00
ColorWall*WWR_E	3.864	1.932	0.696	2.77	0.009	1.00
ColorWall*CELING	2.031	1.016	0.696	1.46	0.154	1.00
ColorWall*AREA	2.901	1.450	0.696	2.08	0.045	1.00
ColorRoof*U wind	-2.235	-1.118	0.696	-1.60	0.118	1.00
ColorRoof*WWR_N	5.310	2.655	0.696	3.81	0.001	1.00
ColorRoof*WWR_E	-4.482	-2.241	0.696	-3.22	0.003	1.00
ColorRoof*WWR_W	4.498	2.249	0.696	3.23	0.003	1.00
ColorRoof*CELING	-0.976	-0.488	0.696	-0.70	0.488	1.00
U wind*WWR_S	3.628	1.814	0.696	2.60	0.014	1.00
U wind*WWR_W	2.075	1.038	0.696	1.49	0.145	1.00
U wind*CELING	9.179	4.589	0.696	6.59	0.000	1.00
U wind*AREA	-6.254	-3.127	0.696	-4.49	0.000	1.00
U wind*FORM	-2.865	-1.433	0.696	-2.06	0.047	1.00
WWR_N*WWR_S	4.563	2.281	0.696	3.28	0.002	1.00
WWR_N*WWR_E	-5.756	-2.878	0.696	-4.13	0.000	1.00
WWR_N*WWR_W	-5.832	-2.916	0.696	-4.19	0.000	1.00
WWR_N*CELING	1.083	0.541	0.696	0.78	0.442	1.00
WWR_N*AREA	-1.710	-0.855	0.696	-1.23	0.228	1.00
WWR_N*FORM	-2.538	-1.269	0.696	-1.82	0.077	1.00
WWR_S*CELING	-2.282	-1.141	0.696	-1.64	0.111	1.00
WWR_S*FORM	-3.052	-1.526	0.696	-2.19	0.035	1.00
WWR_E*CELING	6.156	3.078	0.696	4.42	0.000	1.00
WWR_E*FORM	4.366	2.183	0.696	3.13	0.004	1.00
WWR_W*AREA	2.463	1.231	0.696	1.77	0.086	1.00
CELING*AREA	-3.200	-1.600	0.696	-2.30	0.028	1.00
U wall*U roof*ColorWall	7.077	3.538	0.696	5.08	0.000	1.00
U wall*U roof*ColorRoof	3.658	1.829	0.696	2.63	0.013	1.00
U wall*U roof*U wind	4.863	2.431	0.696	3.49	0.001	1.00
U wall*U roof*AREA	-2.182	-1.091	0.696	-1.57	0.126	1.00
U wall*U grou*ColorWall	-4.161	-2.081	0.696	-2.99	0.005	1.00
U wall*U grou*WWR_N	-2.951	-1.476	0.696	-2.12	0.041	1.00
U wall*U grou*WWR_S	-3.308	-1.654	0.696	-2.37	0.023	1.00
U wall*U grou*WWR_E	4.901	2.450	0.696	3.52	0.001	1.00
U wall*ColorWall*ColorRoof	3.326	1.663	0.696	2.39	0.023	1.00
U wall*ColorWall*U wind	4.696	2.348	0.696	3.37	0.002	1.00
U wall*ColorWall*WWR_N	3.953	1.977	0.696	2.84	0.008	1.00
U wall*ColorWall*WWR_S	-5.803	-2.901	0.696	-4.17	0.000	1.00
U wall*ColorRoof*CELING	-6.015	-3.007	0.696	-4.32	0.000	1.00
U wall*U wind*WWR_S	5.973	2.987	0.696	4.29	0.000	1.00
U wall*U wind*CELING	-3.332	-1.666	0.696	-2.39	0.022	1.00
U wall*U wind*FORM	-2.778	-1.389	0.696	-1.99	0.054	1.00
U wall*WWR_N*WWR_W	-2.290	-1.145	0.696	-1.64	0.109	1.00
U wall*WWR_N*AREA	-2.676	-1.338	0.696	-1.92	0.063	1.00
U wall*WWR_W*AREA	4.158	2.079	0.696	2.99	0.005	1.00

U roof*ColorWall*WWR_N	4.309	2.155	0.696	3.09	0.004	1.00
U roof*ColorWall*WWR_S	-2.117	-1.058	0.696	-1.52	0.138	1.00
U grou*ColorWall*ColorRoof	-3.830	-1.915	0.696	-2.75	0.009	1.00
ColorWall*WWR_N*CELING	2.193	1.097	0.696	1.57	0.125	1.00
ColorWall*WWR_E*CELING	-3.768	-1.884	0.696	-2.71	0.011	1.00

Regression Equation in Uncoded Units

```
cooling = 77.392 - 6.035 U wall - 0.995 U roof + 1.253 U grou + 0.053 ColorWall
          + 0.928 ColorRoof - 2.815 U wind + 0.339 WWR_N - 6.120 WWR_S -
 2.478 WWR_E   + 1.772 WWR_W + 0.456 CELING - 14.423 AREA - 2.275 FORM -
 0.075 U wall*U roof    + 1.231 U wall*U grou - 1.684 U wall*ColorWall
+ 3.281 U wall*ColorRoof   + 3.556 U wall*U wind + 2.497 U wall*WWR_N -
 1.158 U wall*WWR_S   - 0.698 U wall*WWR_E + 0.650 U wall*WWR_W
+ 3.056 U wall*CELING - 3.812 U wall*AREA      + 3.161 U wall*FORM
+ 8.313 U roof*ColorWall - 1.658 U roof*ColorRoof
          - 3.111 U roof*U wind + 3.116 U roof*WWR_N - 0.006 U roof*WWR_S
          + 0.070 U roof*WWR_E + 1.185 U roof*WWR_W + 0.665 U roof*CELING
+ 0.577 U roof*AREA  - 6.767 U grou*ColorWall - 2.156 U grou*ColorRoof -
 0.913 U grou*U wind    - 1.849 U grou*WWR_N + 3.306 U grou*WWR_S
+ 5.959 U grou*WWR_E + 2.406 U grou*WWR_W
          - 4.641 U grou*CELING + 1.595 U grou*AREA - 3.170 ColorWall*ColorRoof
          + 2.553 ColorWall*U wind - 2.332 ColorWall*WWR_N -
 5.602 ColorWall*WWR_S
          - 2.493 ColorWall*WWR_E - 0.740 ColorWall*WWR_W -
 3.515 ColorWall*CELING
          - 0.735 ColorWall*AREA - 1.233 ColorWall*FORM + 1.510 ColorRoof*U wind
          - 4.072 ColorRoof*WWR_N + 1.562 ColorRoof*WWR_S
+ 1.730 ColorRoof*WWR_E
          - 0.469 ColorRoof*WWR_W + 1.795 ColorRoof*CELING -
 5.065 ColorRoof*AREA
          - 2.597 ColorRoof*FORM + 1.067 U wind*WWR_N - 3.062 U wind*WWR_S
          - 0.560 U wind*WWR_E - 3.861 U wind*WWR_W - 1.291 U wind*CELING
+ 2.826 U wind*AREA   + 5.928 U wind*FORM - 2.650 WWR_N*WWR_S
+ 6.041 WWR_N*WWR_E + 0.075 WWR_N*WWR_W  - 0.718 WWR_N*CELING + 0.432 WWR_N*AREA
+ 2.415 WWR_N*FORM - 0.023 WWR_S*CELING   + 3.514 WWR_S*AREA - 2.127 WWR_S*FORM
- 0.754 WWR_E*CELING + 1.544 WWR_E*AREA  - 6.878 WWR_E*FORM - 0.455 WWR_W*CELING
+ 0.208 WWR_W*AREA - 1.350 WWR_W*FORM   - 2.185 CELING*AREA - 0.359 AREA*FORM -
 2.976 U wall*U roof*ColorWall
          - 0.542 U wall*U roof*ColorRoof - 5.311 U wall*U roof*U wind
          - 1.668 U wall*U roof*AREA + 1.079 U wall*U grou*WWR_N
+ 5.540 U wall*U grou*WWR_S
          - 2.358 U wall*U grou*WWR_E + 3.021 U wall*U grou*WWR_W
          - 4.481 U wall*U grou*CELING + 0.488 U wall*ColorWall*ColorRoof
          - 2.859 U wall*ColorWall*U wind - 2.776 U wall*ColorWall*WWR_N
          + 2.512 U wall*ColorWall*WWR_S - 3.040 U wall*ColorWall*WWR_W
          + 3.059 U wall*ColorRoof*CELING - 0.599 U wall*U wind*WWR_S
          - 0.844 U wall*U wind*WWR_E - 1.296 U wall*U wind*WWR_W
          + 2.014 U wall*U wind*CELING + 0.269 U wall*U wind*FORM
+ 0.976 U wall*WWR_N*WWR_W
          + 0.907 U wall*WWR_N*AREA - 0.704 U wall*WWR_S*AREA -
 0.391 U wall*WWR_E*AREA
          + 0.859 U wall*WWR_W*AREA + 2.102 U roof*ColorWall*WWR_N
          - 0.662 U roof*ColorWall*WWR_S + 0.740 U roof*ColorWall*WWR_E
          + 4.079 U roof*ColorWall*WWR_W - 2.138 U roof*WWR_N*WWR_W
          + 0.397 U grou*ColorWall*ColorRoof - 2.348 U grou*U wind*CELING
          - 4.283 ColorWall*ColorRoof*AREA - 2.050 ColorWall*U wind*AREA
          + 3.723 ColorWall*WWR_N*WWR_E + 2.080 ColorWall*WWR_N*CELING
          - 1.751 ColorWall*WWR_S*CELING + 3.787 ColorWall*WWR_E*CELING
          - 4.336 ColorWall*WWR_W*CELING
```

Analysis of Variance (Bayadh 128 for heating)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	127	194415	1530.8	*	*
Linear	13	26092	2007.1	*	*
Uwall	1	2832	2832.4	*	*
Uroof	1	28	27.5	*	*
Uground	1	2131	2131.4	*	*
ColorWall	1	1165	1164.5	*	*
ColorRoof	1	238	237.5	*	*
Uwind	1	589	588.6	*	*
WWR_N	1	1198	1197.8	*	*
WWR_S	1	1076	1075.7	*	*
WWR_E	1	681	680.7	*	*
WWR_W	1	1269	1268.9	*	*
CeilingHeight	1	2604	2604.5	*	*
Area	1	10801	10801.0	*	*
FormSheap	1	1481	1481.4	*	*
2-Way Interactions	72	101097	1404.1	*	*
Uwall*Uroof	1	488	488.3	*	*
Uwall*Uground	1	767	766.6	*	*
Uwall*ColorWall	1	568	568.2	*	*
Uwall*ColorRoof	1	577	576.7	*	*
Uwall*Uwind	1	60	60.3	*	*
Uwall*WWR_N	1	164	164.3	*	*
Uwall*WWR_S	1	725	724.8	*	*
Uwall*WWR_E	1	65	65.1	*	*
Uwall*WWR_W	1	9	8.7	*	*
Uwall*CeilingHeight	1	1	0.7	*	*
Uwall*Area	1	490	490.0	*	*
Uwall*FormSheap	1	1070	1069.8	*	*
Uroof*ColorWall	1	919	919.2	*	*
Uroof*ColorRoof	1	16	16.1	*	*
Uroof*Uwind	1	206	206.5	*	*
Uroof*WWR_N	1	2404	2404.4	*	*
Uroof*WWR_S	1	26	25.7	*	*
Uroof*WWR_E	1	1528	1528.5	*	*
Uroof*WWR_W	1	3421	3421.1	*	*
Uroof*CeilingHeight	1	3179	3178.6	*	*
Uroof*Area	1	488	487.9	*	*
Uground*ColorWall	1	498	498.0	*	*
Uground*ColorRoof	1	1472	1472.3	*	*
Uground*Uwind	1	1289	1289.2	*	*
Uground*WWR_N	1	97	97.0	*	*
Uground*WWR_S	1	265	265.2	*	*
Uground*WWR_E	1	272	272.4	*	*
Uground*WWR_W	1	3797	3797.0	*	*
Uground*CeilingHeight	1	1920	1920.1	*	*
Uground*Area	1	80	80.4	*	*
ColorWall*ColorRoof	1	126	125.8	*	*
ColorWall*Uwind	1	2039	2039.0	*	*
ColorWall*WWR_N	1	238	237.7	*	*
ColorWall*WWR_S	1	1854	1853.8	*	*
ColorWall*WWR_E	1	407	407.4	*	*
ColorWall*WWR_W	1	11223	11222.8	*	*
ColorWall*CeilingHeight	1	1532	1532.0	*	*
ColorWall*Area	1	2354	2354.0	*	*
ColorWall*FormSheap	1	1026	1026.1	*	*
ColorRoof*Uwind	1	3011	3010.6	*	*
ColorRoof*WWR_N	1	3752	3751.5	*	*
ColorRoof*WWR_S	1	27	27.4	*	*
ColorRoof*WWR_E	1	109	109.2	*	*
ColorRoof*WWR_W	1	157	157.4	*	*

ColorRoof*CeilingHeight	1	682	681.9	*	*
ColorRoof*Area	1	1565	1564.6	*	*
ColorRoof*FormSheap	1	3850	3849.9	*	*
Uwind*WWR_N	1	288	287.6	*	*
Uwind*WWR_S	1	3943	3942.8	*	*
Uwind*WWR_E	1	524	524.3	*	*
Uwind*WWR_W	1	8458	8457.7	*	*
Uwind*CeilingHeight	1	796	796.5	*	*
Uwind*Area	1	12	12.0	*	*
Uwind*FormSheap	1	1255	1254.8	*	*
WWR_N*WWR_S	1	1445	1444.7	*	*
WWR_N*WWR_E	1	1112	1112.4	*	*
WWR_N*WWR_W	1	3424	3423.8	*	*
WWR_N*CeilingHeight	1	1407	1407.1	*	*
WWR_N*Area	1	2599	2599.1	*	*
WWR_N*FormSheap	1	993	992.8	*	*
WWR_S*CeilingHeight	1	1247	1247.5	*	*
WWR_S*Area	1	4159	4159.2	*	*
WWR_S*FormSheap	1	213	212.8	*	*
WWR_E*CeilingHeight	1	19	19.2	*	*
WWR_E*Area	1	414	414.1	*	*
WWR_E*FormSheap	1	336	336.2	*	*
WWR_W*CeilingHeight	1	625	625.4	*	*
WWR_W*Area	1	1955	1955.4	*	*
WWR_W*FormSheap	1	1199	1198.8	*	*
CeilingHeight*Area	1	1931	1931.2	*	*
CeilingHeight*FormSheap	1	1858	1857.6	*	*
Area*FormSheap	1	70	69.8	*	*
3-Way Interactions	42	67226	1600.6	*	*
Uwall*Uroof*ColorWall	1	567	567.2	*	*
Uwall*Uroof*ColorRoof	1	142	142.4	*	*
Uwall*Uroof*Uwind	1	1	0.6	*	*
Uwall*Uroof*Area	1	1928	1928.3	*	*
Uwall*Uground*ColorWall	1	345	344.8	*	*
Uwall*Uground*WWR_N	1	776	775.7	*	*
Uwall*Uground*WWR_S	1	5	4.9	*	*
Uwall*Uground*WWR_E	1	1655	1655.5	*	*
Uwall*Uground*WWR_W	1	1953	1953.3	*	*
Uwall*Uground*CeilingHeight	1	76	75.7	*	*
Uwall*ColorWall*ColorRoof	1	337	336.9	*	*
Uwall*ColorWall*Uwind	1	803	803.2	*	*
Uwall*ColorWall*WWR_N	1	1281	1281.3	*	*
Uwall*ColorWall*WWR_S	1	1729	1729.5	*	*
Uwall*ColorWall*WWR_E	1	11083	11082.7	*	*
Uwall*ColorWall*WWR_W	1	3024	3024.3	*	*
Uwall*ColorRoof*CeilingHeight	1	1012	1012.3	*	*
Uwall*Uwind*WWR_N	1	59	59.0	*	*
Uwall*Uwind*WWR_S	1	928	928.1	*	*
Uwall*Uwind*WWR_E	1	5753	5753.1	*	*
Uwall*Uwind*WWR_W	1	2210	2210.3	*	*
Uwall*Uwind*CeilingHeight	1	2207	2206.7	*	*
Uwall*Uwind*FormSheap	1	2050	2049.9	*	*
Uwall*WWR_N*WWR_W	1	5666	5665.7	*	*
Uwall*WWR_N*Area	1	904	903.6	*	*
Uwall*WWR_S*Area	1	2582	2581.8	*	*
Uwall*WWR_E*Area	1	26	25.9	*	*
Uwall*WWR_W*Area	1	92	92.4	*	*
Uroof*ColorWall*WWR_N	1	416	416.3	*	*
Uroof*ColorWall*WWR_S	1	145	145.4	*	*
Uroof*ColorWall*WWR_E	1	59	58.9	*	*
Uroof*ColorWall*WWR_W	1	18	17.6	*	*
Uroof*WWR_N*WWR_W	1	4609	4609.3	*	*
Uground*ColorWall*ColorRoof	1	4883	4883.3	*	*
Uground*Uwind*CeilingHeight	1	282	282.4	*	*
ColorWall*ColorRoof*Area	1	842	842.4	*	*
ColorWall*Uwind*Area	1	4578	4578.5	*	*
ColorWall*WWR_N*WWR_E	1	219	219.4	*	*
ColorWall*WWR_N*CeilingHeight	1	9	8.6	*	*

ColorWall*WWR_S*CeilingHeight	1	902	902.0	*	*
ColorWall*WWR_E*CeilingHeight	1	1066	1066.2	*	*
ColorWall*WWR_W*CeilingHeight	1	0	0.2	*	*
Error	0	*	*		
Total	127	194415			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		52.64	*	*	*	
Uwall	-9.408	-4.704	*	*	*	1.00
Uroof	-0.9274	-0.4637	*	*	*	1.00
Uground	-8.161	-4.081	*	*	*	1.00
ColorWall	-6.033	-3.016	*	*	*	1.00
ColorRoof	2.724	1.362	*	*	*	1.00
Uwind	4.289	2.144	*	*	*	1.00
WWR_N	6.118	3.059	*	*	*	1.00
WWR_S	-5.798	-2.899	*	*	*	1.00
WWR_E	4.612	2.306	*	*	*	1.00
WWR_W	-6.297	-3.149	*	*	*	1.00
CeilingHeight	9.022	4.511	*	*	*	1.00
Area	18.372	9.186	*	*	*	1.00
FormSheap	6.804	3.402	*	*	*	1.00
Uwall*Uroof	3.906	1.953	*	*	*	1.00
Uwall*Uground	4.895	2.447	*	*	*	1.00
Uwall*ColorWall	4.214	2.107	*	*	*	1.00
Uwall*ColorRoof	4.245	2.123	*	*	*	1.00
Uwall*Uwind	-1.3728	-0.6864	*	*	*	1.00
Uwall*WWR_N	-2.266	-1.133	*	*	*	1.00
Uwall*WWR_S	-4.759	-2.380	*	*	*	1.00
Uwall*WWR_E	-1.4258	-0.7129	*	*	*	1.00
Uwall*WWR_W	0.5218	0.2609	*	*	*	1.00
Uwall*CeilingHeight	0.14696	0.07348	*	*	*	1.00
Uwall*Area	-3.913	-1.957	*	*	*	1.00
Uwall*FormSheap	-5.782	-2.891	*	*	*	1.00
Uroof*ColorWall	5.360	2.680	*	*	*	1.00
Uroof*ColorRoof	-0.7094	-0.3547	*	*	*	1.00
Uroof*Uwind	2.540	1.270	*	*	*	1.00
Uroof*WWR_N	8.668	4.334	*	*	*	1.00
Uroof*WWR_S	0.8970	0.4485	*	*	*	1.00
Uroof*WWR_E	6.911	3.456	*	*	*	1.00
Uroof*WWR_W	10.340	5.170	*	*	*	1.00
Uroof*CeilingHeight	9.967	4.983	*	*	*	1.00
Uroof*Area	-3.905	-1.952	*	*	*	1.00
Uground*ColorWall	3.945	1.972	*	*	*	1.00
Uground*ColorRoof	6.783	3.392	*	*	*	1.00
Uground*Uwind	6.347	3.174	*	*	*	1.00
Uground*WWR_N	-1.7413	-0.8706	*	*	*	1.00
Uground*WWR_S	2.879	1.439	*	*	*	1.00
Uground*WWR_E	-2.918	-1.459	*	*	*	1.00
Uground*WWR_W	-10.893	-5.447	*	*	*	1.00
Uground*CeilingHeight	7.746	3.873	*	*	*	1.00
Uground*Area	1.5851	0.7925	*	*	*	1.00
ColorWall*ColorRoof	-1.9826	-0.9913	*	*	*	1.00
ColorWall*Uwind	-7.982	-3.991	*	*	*	1.00
ColorWall*WWR_N	2.725	1.363	*	*	*	1.00
ColorWall*WWR_S	7.611	3.806	*	*	*	1.00
ColorWall*WWR_E	-3.568	-1.784	*	*	*	1.00
ColorWall*WWR_W	18.727	9.364	*	*	*	1.00
ColorWall*CeilingHeight	-6.919	-3.460	*	*	*	1.00

ColorWall*Area	-8.577	-4.288	*	*	*	1.00
ColorWall*FormSheap	5.663	2.831	*	*	*	1.00
ColorRoof*Uwind	9.699	4.850	*	*	*	1.00
ColorRoof*WWR_N	10.828	5.414	*	*	*	1.00
ColorRoof*WWR_S	-0.9256	-0.4628	*	*	*	1.00
ColorRoof*WWR_E	-1.8477	-0.9238	*	*	*	1.00
ColorRoof*WWR_W	2.218	1.109	*	*	*	1.00
ColorRoof*CeilingHeight	-4.616	-2.308	*	*	*	1.00
ColorRoof*Area	-6.992	-3.496	*	*	*	1.00
ColorRoof*FormSheap	10.969	5.484	*	*	*	1.00
Uwind*WWR_N	-2.998	-1.499	*	*	*	1.00
Uwind*WWR_S	-11.100	-5.550	*	*	*	1.00
Uwind*WWR_E	-4.048	-2.024	*	*	*	1.00
Uwind*WWR_W	16.257	8.129	*	*	*	1.00
Uwind*CeilingHeight	-4.989	-2.495	*	*	*	1.00
Uwind*Area	0.6122	0.3061	*	*	*	1.00
Uwind*FormSheap	6.262	3.131	*	*	*	1.00
WWR_N*WWR_S	-6.719	-3.360	*	*	*	1.00
WWR_N*WWR_E	-5.896	-2.948	*	*	*	1.00
WWR_N*WWR_W	-10.344	-5.172	*	*	*	1.00
WWR_N*CeilingHeight	-6.631	-3.316	*	*	*	1.00
WWR_N*Area	9.012	4.506	*	*	*	1.00
WWR_N*FormSheap	-5.570	-2.785	*	*	*	1.00
WWR_S*CeilingHeight	-6.244	-3.122	*	*	*	1.00
WWR_S*Area	-11.401	-5.700	*	*	*	1.00
WWR_S*FormSheap	2.579	1.289	*	*	*	1.00
WWR_E*CeilingHeight	-0.7745	-0.3873	*	*	*	1.00
WWR_E*Area	-3.597	-1.799	*	*	*	1.00
WWR_E*FormSheap	3.241	1.621	*	*	*	1.00
WWR_W*CeilingHeight	4.421	2.210	*	*	*	1.00
WWR_W*Area	7.817	3.909	*	*	*	1.00
WWR_W*FormSheap	6.121	3.060	*	*	*	1.00
CeilingHeight*Area	7.769	3.884	*	*	*	1.00
CeilingHeight*FormSheap	7.619	3.809	*	*	*	1.00
Area*FormSheap	1.4772	0.7386	*	*	*	1.00
Uwall*Uroof*ColorWall	4.210	2.105	*	*	*	1.00
Uwall*Uroof*ColorRoof	2.110	1.055	*	*	*	1.00
Uwall*Uroof*Uwind	-0.13460	-0.06730	*	*	*	1.00
Uwall*Uroof*Area	7.763	3.881	*	*	*	1.00
Uwall*Uground*ColorWall	-3.282	-1.641	*	*	*	1.00
Uwall*Uground*WWR_N	-4.923	-2.462	*	*	*	1.00
Uwall*Uground*WWR_S	-0.3911	-0.1955	*	*	*	1.00
Uwall*Uground*WWR_E	7.193	3.596	*	*	*	1.00
Uwall*Uground*WWR_W	-7.813	-3.906	*	*	*	1.00
Uwall*Uground*CeilingHeight	1.5381	0.7690	*	*	*	1.00
Uwall*ColorWall*ColorRoof	3.245	1.622	*	*	*	1.00
Uwall*ColorWall*Uwind	-5.010	-2.505	*	*	*	1.00
Uwall*ColorWall*WWR_N	6.328	3.164	*	*	*	1.00
Uwall*ColorWall*WWR_S	7.352	3.676	*	*	*	1.00
Uwall*ColorWall*WWR_E	-18.610	-9.305	*	*	*	1.00
Uwall*ColorWall*WWR_W	-9.722	-4.861	*	*	*	1.00
Uwall*ColorRoof*CeilingHeight	-5.624	-2.812	*	*	*	1.00
Uwall*Uwind*WWR_N	1.3576	0.6788	*	*	*	1.00
Uwall*Uwind*WWR_S	5.386	2.693	*	*	*	1.00
Uwall*Uwind*WWR_E	13.408	6.704	*	*	*	1.00
Uwall*Uwind*WWR_W	-8.311	-4.156	*	*	*	1.00
Uwall*Uwind*CeilingHeight	8.304	4.152	*	*	*	1.00
Uwall*Uwind*FormSheap	8.004	4.002	*	*	*	1.00
Uwall*WWR_N*WWR_W	13.306	6.653	*	*	*	1.00
Uwall*WWR_N*Area	5.314	2.657	*	*	*	1.00
Uwall*WWR_S*Area	8.982	4.491	*	*	*	1.00
Uwall*WWR_E*Area	-0.8989	-0.4494	*	*	*	1.00
Uwall*WWR_W*Area	-1.6990	-0.8495	*	*	*	1.00
Uroof*ColorWall*WWR_N	3.607	1.803	*	*	*	1.00
Uroof*ColorWall*WWR_S	-2.131	-1.066	*	*	*	1.00
Uroof*ColorWall*WWR_E	1.3565	0.6783	*	*	*	1.00
Uroof*ColorWall*WWR_W	0.7419	0.3709	*	*	*	1.00
Uroof*WWR_N*WWR_W	12.002	6.001	*	*	*	1.00

Uground*ColorWall*ColorRoof	12.353	6.177	*	*	*	1.00
Uground*Uwind*CeilingHeight	-2.971	-1.485	*	*	*	1.00
ColorWall*ColorRoof*Area	-5.131	-2.565	*	*	*	1.00
ColorWall*Uwind*Area	11.961	5.981	*	*	*	1.00
ColorWall*WWR_N*WWR_E	-2.619	-1.309	*	*	*	1.00
ColorWall*WWR_N*CeilingHeight	-0.5179	-0.2590	*	*	*	1.00
ColorWall*WWR_S*CeilingHeight	-5.309	-2.655	*	*	*	1.00
ColorWall*WWR_E*CeilingHeight	5.772	2.886	*	*	*	1.00
ColorWall*WWR_W*CeilingHeight	-0.07277	-0.03638	*	*	*	1.00

Regression Equation in Uncoded Units

```
HEAT = 52.64 - 4.704 Uwall - 0.4637 Uroof - 4.081 Uground - 3.016 ColorWall
+ 1.362 ColorRoof
       + 2.144 Uwind + 3.059 WWR_N - 2.899 WWR_S + 2.306 WWR_E - 3.149 WWR_W
       + 4.511 CeilingHeight + 9.186 Area + 3.402 FormSheap + 1.953 Uwall*Uroof
       + 2.447 Uwall*Uground + 2.107 Uwall*ColorWall + 2.123 Uwall*ColorRoof
       - 0.6864 Uwall*Uwind - 1.133 Uwall*WWR_N - 2.380 Uwall*WWR_S -
 0.7129 Uwall*WWR_E
       + 0.2609 Uwall*WWR_W + 0.07348 Uwall*CeilingHeight - 1.957 Uwall*Area
       - 2.891 Uwall*FormSheap + 2.680 Uroof*ColorWall - 0.3547 Uroof*ColorRoof
       + 1.270 Uroof*Uwind + 4.334 Uroof*WWR_N + 0.4485 Uroof*WWR_S
+ 3.456 Uroof*WWR_E
       + 5.170 Uroof*WWR_W + 4.983 Uroof*CeilingHeight - 1.952 Uroof*Area
       + 1.972 Uground*ColorWall + 3.392 Uground*ColorRoof + 3.174 Uground*Uwind
       - 0.8706 Uground*WWR_N + 1.439 Uground*WWR_S - 1.459 Uground*WWR_E
       - 5.447 Uground*WWR_W + 3.873 Uground*CeilingHeight + 0.7925 Uground*Area
       - 0.9913 ColorWall*ColorRoof - 3.991 ColorWall*Uwind
+ 1.363 ColorWall*WWR_N
       + 3.806 ColorWall*WWR_S - 1.784 ColorWall*WWR_E + 9.364 ColorWall*WWR_W
       - 3.460 ColorWall*CeilingHeight - 4.288 ColorWall*Area
+ 2.831 ColorWall*FormSheap
       + 4.850 ColorRoof*Uwind + 5.414 ColorRoof*WWR_N - 0.4628 ColorRoof*WWR_S
       - 0.9238 ColorRoof*WWR_E + 1.109 ColorRoof*WWR_W -
 2.308 ColorRoof*CeilingHeight
       - 3.496 ColorRoof*Area + 5.484 ColorRoof*FormSheap - 1.499 Uwind*WWR_N
       - 5.550 Uwind*WWR_S - 2.024 Uwind*WWR_E + 8.129 Uwind*WWR_W
       - 2.495 Uwind*CeilingHeight + 0.3061 Uwind*Area + 3.131 Uwind*FormSheap
       - 3.360 WWR_N*WWR_S - 2.948 WWR_N*WWR_E - 5.172 WWR_N*WWR_W
       - 3.316 WWR_N*CeilingHeight + 4.506 WWR_N*Area - 2.785 WWR_N*FormSheap
       - 3.122 WWR_S*CeilingHeight - 5.700 WWR_S*Area + 1.289 WWR_S*FormSheap
       - 0.3873 WWR_E*CeilingHeight - 1.799 WWR_E*Area + 1.621 WWR_E*FormSheap
       + 2.210 WWR_W*CeilingHeight + 3.909 WWR_W*Area + 3.060 WWR_W*FormSheap
       + 3.884 CeilingHeight*Area + 3.809 CeilingHeight*FormSheap
+ 0.7386 Area*FormSheap
       + 2.105 Uwall*Uroof*ColorWall + 1.055 Uwall*Uroof*ColorRoof
       - 0.06730 Uwall*Uroof*Uwind + 3.881 Uwall*Uroof*Area -
 1.641 Uwall*Uground*ColorWall
       - 2.462 Uwall*Uground*WWR_N - 0.1955 Uwall*Uground*WWR_S
+ 3.596 Uwall*Uground*WWR_E
       - 3.906 Uwall*Uground*WWR_W + 0.7690 Uwall*Uground*CeilingHeight
       + 1.622 Uwall*ColorWall*ColorRoof - 2.505 Uwall*ColorWall*Uwind
       + 3.164 Uwall*ColorWall*WWR_N + 3.676 Uwall*ColorWall*WWR_S
       - 9.305 Uwall*ColorWall*WWR_E - 4.861 Uwall*ColorWall*WWR_W
       - 2.812 Uwall*ColorRoof*CeilingHeight + 0.6788 Uwall*Uwind*WWR_N
       + 2.693 Uwall*Uwind*WWR_S + 6.704 Uwall*Uwind*WWR_E -
 4.156 Uwall*Uwind*WWR_W
       + 4.152 Uwall*Uwind*CeilingHeight + 4.002 Uwall*Uwind*FormSheap
       + 6.653 Uwall*WWR_N*WWR_W + 2.657 Uwall*WWR_N*Area
+ 4.491 Uwall*WWR_S*Area
       - 0.4494 Uwall*WWR_E*Area - 0.8495 Uwall*WWR_W*Area
+ 1.803 Uroof*ColorWall*WWR_N
       - 1.066 Uroof*ColorWall*WWR_S + 0.6783 Uroof*ColorWall*WWR_E
       + 0.3709 Uroof*ColorWall*WWR_W + 6.001 Uroof*WWR_N*WWR_W
       + 6.177 Uground*ColorWall*ColorRoof - 1.485 Uground*Uwind*CeilingHeight
       - 2.565 ColorWall*ColorRoof*Area + 5.981 ColorWall*Uwind*Area
       - 1.309 ColorWall*WWR_N*WWR_E - 0.2590 ColorWall*WWR_N*CeilingHeight
```

- 2.655 ColorWall*WWR_S*CeilingHeight
+ 2.886 ColorWall*WWR_E*CeilingHeight
- 0.03638 ColorWall*WWR_W*CeilingHeight

Analysis of Variance (Ouargla 128 for cooing)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	118	157287	1332.94	27318.42	0.000
Linear	13	23520	1809.26	37080.31	0.000
U wall	1	3206	3206.18	65710.01	0.000
U roof	1	110	110.13	2257.07	0.000
U grou	1	44	44.41	910.10	0.001
ColorWall	1	25	24.68	505.72	0.002
ColorRoof	1	354	353.76	7250.15	0.000
U wind	1	281	281.06	5760.35	0.000
WWR_N	1	18	18.16	372.14	0.003
WWR_S	1	1556	1555.67	31883.24	0.000
WWR_E	1	6	5.86	120.05	0.008
WWR_W	1	134	133.54	2736.82	0.000
CELING	1	26	25.57	523.96	0.002
AREA	1	81	81.23	1664.76	0.001
FORM	1	329	328.66	6735.77	0.000
2-Way Interactions	70	94989	1356.99	27811.13	0.000
U wall*U roof	1	22	22.23	455.52	0.002
U wall*U grou	1	214	214.36	4393.26	0.000
U wall*ColorWall	1	1145	1144.82	23462.81	0.000
U wall*ColorRoof	1	106	106.27	2177.98	0.000
U wall*U wind	1	55	54.75	1122.12	0.001
U wall*WWR_N	1	449	448.78	9197.56	0.000
U wall*WWR_S	1	23	22.63	463.76	0.002
U wall*WWR_E	1	77	77.04	1578.98	0.001
U wall*WWR_W	1	15	15.46	316.93	0.003
U wall*CELING	1	211	211.46	4333.80	0.000
U wall*AREA	1	1612	1612.23	33042.35	0.000
U wall*FORM	1	13	12.61	258.47	0.004
U roof*ColorWall	1	2451	2450.73	50227.13	0.000
U roof*ColorRoof	1	6	5.99	122.75	0.008
U roof*U wind	1	5	5.21	106.77	0.009
U roof*WWR_N	1	82	81.82	1676.84	0.001
U roof*WWR_S	1	44	43.87	899.13	0.001
U roof*WWR_E	1	4	3.74	76.63	0.013
U roof*WWR_W	1	233	233.11	4777.57	0.000
U roof*CELING	1	139	139.07	2850.28	0.000
U roof*AREA	1	171	170.65	3497.44	0.000
U grou*ColorWall	1	4999	4999.27	102459.09	0.000
U grou*ColorRoof	1	0	0.17	3.39	0.207
U grou*U wind	1	1848	1848.21	37878.60	0.000
U grou*WWR_N	1	214	213.58	4377.35	0.000
U grou*WWR_S	1	204	204.01	4181.22	0.000
U grou*WWR_E	1	1338	1337.76	27417.13	0.000
U grou*WWR_W	1	169	168.58	3455.11	0.000
U grou*CELING	1	32	31.70	649.71	0.002
U grou*AREA	1	154	153.92	3154.47	0.000
ColorWall*ColorRoof	1	2799	2799.22	57369.37	0.000
ColorWall*U wind	1	75	74.80	1532.94	0.001
ColorWall*WWR_N	1	75	75.16	1540.39	0.001
ColorWall*WWR_S	1	3499	3499.20	71715.49	0.000
ColorWall*WWR_E	1	309	308.73	6327.39	0.000
ColorWall*WWR_W	1	174	173.78	3561.56	0.000
ColorWall*CELING	1	343	343.43	7038.53	0.000
ColorWall*AREA	1	1112	1111.72	22784.46	0.000
ColorWall*FORM	1	41	40.58	831.68	0.001
ColorRoof*U wind	1	2896	2895.87	59350.16	0.000
ColorRoof*WWR_N	1	123	123.22	2525.28	0.000
ColorRoof*WWR_E	1	21	20.56	421.37	0.002
ColorRoof*WWR_W	1	712	712.00	14592.37	0.000
ColorRoof*CELING	1	2623	2623.27	53763.37	0.000
ColorRoof*AREA	1	129	128.57	2635.12	0.000

ColorRoof*FORM	1	1089	1088.70	22312.63	0.000
U wind*WWR_N	1	16	15.58	319.27	0.003
U wind*WWR_S	1	276	276.17	5660.03	0.000
U wind*WWR_E	1	0	0.01	0.14	0.747
U wind*WWR_W	1	820	819.83	16802.29	0.000
U wind*CELING	1	40	40.11	821.94	0.001
U wind*AREA	1	612	612.04	12543.56	0.000
U wind*FORM	1	1334	1334.49	27350.15	0.000
WWR_N*WWR_S	1	215	214.72	4400.61	0.000
WWR_N*WWR_E	1	225	225.29	4617.31	0.000
WWR_N*WWR_W	1	63	63.10	1293.17	0.001
WWR_N*CELING	1	4	3.58	73.39	0.013
WWR_N*AREA	1	0	0.28	5.66	0.140
WWR_N*FORM	1	650	650.02	13322.06	0.000
WWR_S*CELING	1	0	0.08	1.61	0.333
WWR_S*AREA	1	221	220.77	4524.56	0.000
WWR_S*FORM	1	690	689.65	14134.24	0.000
WWR_E*CELING	1	245	245.00	5021.17	0.000
WWR_E*AREA	1	4	3.75	76.92	0.013
WWR_W*CELING	1	86	85.76	1757.67	0.001
WWR_W*AREA	1	5	4.70	96.28	0.010
WWR_W*FORM	1	1	1.42	29.05	0.033
CELING*AREA	1	246	246.46	5051.21	0.000
CELING*FORM	1	525	525.04	10760.64	0.000
AREA*FORM	1	15	14.84	304.13	0.003
3-Way Interactions	35	32014	914.69	18746.42	0.000
U wall*U roof*ColorWall	1	2442	2441.87	50045.54	0.000
U wall*U roof*ColorRoof	1	44	44.15	904.83	0.001
U wall*U roof*AREA	1	34	33.73	691.21	0.001
U wall*U grou*ColorWall	1	110	109.75	2249.36	0.000
U wall*U grou*WWR_N	1	181	180.81	3705.59	0.000
U wall*U grou*WWR_S	1	2206	2206.05	45212.58	0.000
U wall*U grou*WWR_E	1	1472	1472.21	30172.61	0.000
U wall*U grou*WWR_W	1	6	6.00	122.87	0.008
U wall*U grou*CELING	1	1	0.85	17.48	0.053
U wall*ColorWall*ColorRoof	1	603	603.16	12361.59	0.000
U wall*ColorWall*U wind	1	109	108.93	2232.45	0.000
U wall*ColorWall*WWR_N	1	21	20.85	427.41	0.002
U wall*ColorWall*WWR_S	1	114	113.54	2327.08	0.000
U wall*ColorWall*WWR_E	1	722	722.30	14803.43	0.000
U wall*ColorWall*WWR_W	1	50	50.36	1032.10	0.001
U wall*ColorRoof*CELING	1	1604	1604.39	32881.68	0.000
U wall*U wind*WWR_N	1	122	121.78	2495.76	0.000
U wall*U wind*WWR_S	1	65	65.12	1334.52	0.001
U wall*U wind*WWR_E	1	0	0.09	1.77	0.314
U wall*U wind*WWR_W	1	273	273.12	5597.49	0.000
U wall*U wind*CELING	1	270	270.14	5536.50	0.000
U wall*U wind*FORM	1	124	123.85	2538.30	0.000
U wall*WWR_N*WWR_W	1	104	104.26	2136.82	0.000
U wall*WWR_E*AREA	1	188	187.94	3851.79	0.000
U wall*WWR_W*AREA	1	1	0.79	16.11	0.057
U roof*ColorWall*WWR_N	1	1120	1120.31	22960.52	0.000
U roof*ColorWall*WWR_E	1	6	5.99	122.77	0.008
U grou*ColorWall*ColorRoof	1	0	0.47	9.56	0.091
U grou*U wind*CELING	1	1798	1798.37	36857.33	0.000
ColorWall*ColorRoof*AREA	1	253	253.07	5186.66	0.000
ColorWall*U wind*AREA	1	754	754.25	15458.23	0.000
ColorWall*WWR_N*WWR_E	1	92	92.23	1890.32	0.001
ColorWall*WWR_N*CELING	1	27	27.02	553.72	0.002
ColorWall*WWR_S*CELING	1	6	6.30	129.12	0.008
ColorWall*WWR_W*CELING	1	1090	1089.74	22333.95	0.000
Error	2	0	0.05		
Total	120	157288			

Model Summary

S   R-sq R-sq(adj) R-sq(pred)

0.220891 100.00%   100.00%   *

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		77.2854	0.0382	2025.80	0.000	
U wall	-18.2335	-9.1167	0.0356	-256.34	0.000	3.13
U roof	-6.7121	-3.3561	0.0706	-47.51	0.000	12.37
U grou	-1.8111	-0.9055	0.0300	-30.17	0.001	2.23
ColorWall	-1.8343	-0.9172	0.0408	-22.49	0.002	4.12
ColorRoof	-7.6676	-3.8338	0.0450	-85.15	0.000	5.03
U wind	-8.2867	-4.1433	0.0546	-75.90	0.000	7.39
WWR_N	1.4719	0.7360	0.0382	19.29	0.003	3.60
WWR_S	-16.8837	-8.4419	0.0473	-178.56	0.000	5.54
WWR_E	-0.8508	-0.4254	0.0388	-10.96	0.008	3.74
WWR_W	5.0038	2.5019	0.0478	52.31	0.000	5.67
CELING	-1.2641	-0.6320	0.0276	-22.89	0.002	1.89
AREA	5.1290	2.5645	0.0629	40.80	0.001	9.79
FORM	-5.0672	-2.5336	0.0309	-82.07	0.000	2.36
U wall*U roof	-1.3415	-0.6707	0.0314	-21.34	0.002	2.45
U wall*U grou	-3.9407	-1.9703	0.0297	-66.28	0.000	2.19
U wall*ColorWall	-10.1217	-5.0608	0.0330	-153.18	0.000	2.71
U wall*ColorRoof	2.4572	1.2286	0.0263	46.67	0.000	1.72
U wall*U wind	3.8943	1.9472	0.0581	33.50	0.001	8.38
U wall*WWR_N	6.8217	3.4108	0.0356	95.90	0.000	3.13
U wall*WWR_S	-2.2959	-1.1480	0.0533	-21.54	0.002	7.04
U wall*WWR_E	2.7279	1.3640	0.0343	39.74	0.001	2.92
U wall*WWR_W	1.6702	0.8351	0.0469	17.80	0.003	5.45
U wall*CELING	7.0399	3.5200	0.0535	65.83	0.000	7.08
U wall*AREA	-9.6899	-4.8449	0.0267	-181.78	0.000	1.76
U wall*FORM	1.2556	0.6278	0.0390	16.08	0.004	3.78
U roof*ColorWall	15.8317	7.9158	0.0353	224.11	0.000	3.09
U roof*ColorRoof	-0.8094	-0.4047	0.0365	-11.08	0.008	3.31
U roof*U wind	-0.9265	-0.4632	0.0448	-10.33	0.009	4.98
U roof*WWR_N	5.7854	2.8927	0.0706	40.95	0.001	12.37
U roof*WWR_S	-3.2066	-1.6033	0.0535	-29.99	0.001	7.08
U roof*WWR_E	-0.5204	-0.2602	0.0297	-8.75	0.013	2.19
U roof*WWR_W	-3.2551	-1.6276	0.0235	-69.12	0.000	1.37
U roof*CELING	-5.6919	-2.8460	0.0533	-53.39	0.000	7.04
U roof*AREA	4.6186	2.3093	0.0390	59.14	0.000	3.78
U grou*ColorWall	-16.8538	-8.4269	0.0263	-320.09	0.000	1.72
U grou*ColorRoof	-0.1094	-0.0547	0.0297	-1.84	0.207	2.19
U grou*U wind	10.2475	5.1238	0.0263	194.62	0.000	1.72
U grou*WWR_N	-3.9719	-1.9860	0.0300	-66.16	0.000	2.23
U grou*WWR_S	3.8444	1.9222	0.0297	64.66	0.000	2.19
U grou*WWR_E	12.0962	6.0481	0.0365	165.58	0.000	3.31
U grou*WWR_W	-3.2460	-1.6230	0.0276	-58.78	0.000	1.89
U grou*CELING	-1.8006	-0.9003	0.0353	-25.49	0.002	3.09
U grou*AREA	5.2901	2.6450	0.0471	56.16	0.000	5.50
ColorWall*ColorRoof	-14.2402	-7.1201	0.0297	-239.52	0.000	2.19
ColorWall*U wind	2.0615	1.0308	0.0263	39.15	0.001	1.72
ColorWall*WWR_N	-3.2014	-1.6007	0.0408	-39.25	0.001	4.12
ColorWall*WWR_S	-15.9215	-7.9607	0.0297	-267.80	0.000	2.19
ColorWall*WWR_E	5.1721	2.5861	0.0325	79.54	0.000	2.62
ColorWall*WWR_W	-5.2580	-2.6290	0.0441	-59.68	0.000	4.81
ColorWall*CELING	-5.7595	-2.8798	0.0343	-83.90	0.000	2.92
ColorWall*AREA	7.9477	3.9738	0.0263	150.95	0.000	1.72
ColorWall*FORM	2.4602	1.2301	0.0427	28.84	0.001	4.50
ColorRoof*U wind	14.4840	7.2420	0.0297	243.62	0.000	2.19
ColorRoof*WWR_N	4.5252	2.2626	0.0450	50.25	0.000	5.03
ColorRoof*WWR_E	1.6031	0.8016	0.0390	20.53	0.002	3.78
ColorRoof*WWR_W	-9.1621	-4.5810	0.0379	-120.80	0.000	3.57
ColorRoof*CELING	15.0765	7.5382	0.0325	231.87	0.000	2.62
ColorRoof*AREA	-2.7364	-1.3682	0.0267	-51.33	0.000	1.76
ColorRoof*FORM	-10.2547	-5.1273	0.0343	-149.37	0.000	2.92
U wind*WWR_N	1.9509	0.9755	0.0546	17.87	0.003	7.39
U wind*WWR_S	4.4729	2.2364	0.0297	75.23	0.000	2.19

U wind*WWR_E	-0.0315	-0.0158	0.0427	-0.37	0.747	4.51
U wind*WWR_W	-11.4205	-5.7103	0.0441	-129.62	0.000	4.81
U wind*CELING	-2.0253	-1.0126	0.0353	-28.67	0.001	3.09
U wind*AREA	15.0345	7.5173	0.0671	112.00	0.000	11.17
U wind*FORM	10.3946	5.1973	0.0314	165.38	0.000	2.45
WWR_N*WWR_S	-6.2725	-3.1363	0.0473	-66.34	0.000	5.54
WWR_N*WWR_E	5.2765	2.6382	0.0388	67.95	0.000	3.74
WWR_N*WWR_W	-3.4396	-1.7198	0.0478	-35.96	0.001	5.67
WWR_N*CELING	-0.4731	-0.2365	0.0276	-8.57	0.013	1.89
WWR_N*AREA	0.2991	0.1496	0.0629	2.38	0.140	9.79
WWR_N*FORM	7.1262	3.5631	0.0309	115.42	0.000	2.36
WWR_S*CELING	0.0797	0.0398	0.0314	1.27	0.333	2.45
WWR_S*AREA	8.0178	4.0089	0.0596	67.26	0.000	8.81
WWR_S*FORM	-8.3984	-4.1992	0.0353	-118.89	0.000	3.09
WWR_E*CELING	-7.8039	-3.9020	0.0551	-70.86	0.000	7.52
WWR_E*AREA	-0.4560	-0.2280	0.0260	-8.77	0.013	1.67
WWR_W*CELING	-5.6279	-2.8140	0.0671	-41.92	0.001	11.17
WWR_W*AREA	-0.6932	-0.3466	0.0353	-9.81	0.010	3.09
WWR_W*FORM	-0.5693	-0.2847	0.0528	-5.39	0.033	6.92
CELING*AREA	-6.2618	-3.1309	0.0441	-71.07	0.000	4.81
CELING*FORM	-6.1673	-3.0837	0.0297	-103.73	0.000	2.19
AREA*FORM	-0.9067	-0.4533	0.0260	-17.44	0.003	1.68
U wall*U roof*ColorWall	-13.8120	-6.9060	0.0309	-223.71	0.000	2.36
U wall*U roof*ColorRoof	-2.1249	-1.0625	0.0353	-30.08	0.001	3.09
U wall*U roof*AREA	-2.2428	-1.1214	0.0427	-26.29	0.001	4.51
U wall*U grou*ColorWall	-5.6533	-2.8266	0.0596	-47.43	0.000	8.81
U wall*U grou*WWR_N	3.6191	1.8096	0.0297	60.87	0.000	2.19
U wall*U grou*WWR_S	11.1957	5.5979	0.0263	212.63	0.000	1.72
U wall*U grou*WWR_E	-12.2706	-6.1353	0.0353	-173.70	0.000	3.09
U wall*U grou*WWR_W	0.7207	0.3604	0.0325	11.08	0.008	2.62
U wall*U grou*CELING	-0.3171	-0.1585	0.0379	-4.18	0.053	3.57
U wall*ColorWall*ColorRoof	-6.6747	-3.3373	0.0300	-111.18	0.000	2.23
U wall*ColorWall*U wind	-4.9911	-2.4955	0.0528	-47.25	0.000	6.92
U wall*ColorWall*WWR_N	1.3661	0.6831	0.0330	20.67	0.002	2.71
U wall*ColorWall*WWR_S	4.5436	2.2718	0.0471	48.24	0.000	5.50
U wall*ColorWall*WWR_E	8.5949	4.2974	0.0353	121.67	0.000	3.09
U wall*ColorWall*WWR_W	2.0193	1.0096	0.0314	32.13	0.001	2.45
U wall*ColorRoof*CELING	10.0137	5.0069	0.0276	181.33	0.000	1.89
U wall*U wind*WWR_N	5.8078	2.9039	0.0581	49.96	0.000	8.38
U wall*U wind*WWR_S	2.1931	1.0965	0.0300	36.53	0.001	2.23
U wall*U wind*WWR_E	0.1040	0.0520	0.0390	1.33	0.314	3.78
U wall*U wind*WWR_W	-6.3824	-3.1912	0.0427	-74.82	0.000	4.50
U wall*U wind*CELING	11.5392	5.7696	0.0775	74.41	0.000	14.91
U wall*U wind*FORM	-4.4389	-2.2194	0.0441	-50.38	0.000	4.81
U wall*WWR_N*WWR_W	-4.3369	-2.1684	0.0469	-46.23	0.000	5.45
U wall*WWR_E*AREA	-5.5648	-2.7824	0.0448	-62.06	0.000	4.98
U wall*WWR_W*AREA	-0.6225	-0.3112	0.0775	-4.01	0.057	14.91
U roof*ColorWall*WWR_N	10.7041	5.3520	0.0353	151.53	0.000	3.09
U roof*ColorWall*WWR_E	-0.7437	-0.3718	0.0336	-11.08	0.008	2.79
U grou*ColorWall*ColorRoof	0.2076	0.1038	0.0336	3.09	0.091	2.79
U grou*U wind*CELING	-13.5619	-6.7809	0.0353	-191.98	0.000	3.09
ColorWall*ColorRoof*AREA	-7.9315	-3.9657	0.0551	-72.02	0.000	7.52
ColorWall*U wind*AREA	-7.4640	-3.7320	0.0300	-124.33	0.000	2.23
ColorWall*WWR_N*WWR_E	-2.8270	-1.4135	0.0325	-43.48	0.001	2.62
ColorWall*WWR_N*CELING	1.6154	0.8077	0.0343	23.53	0.002	2.92
ColorWall*WWR_S*CELING	0.7016	0.3508	0.0309	11.36	0.008	2.36
ColorWall*WWR_W*CELING	-8.9717	-4.4859	0.0300	-149.45	0.000	2.23

Regression Equation in Uncoded Units

cooling = 77.2854 - 9.1167 U wall - 3.3561 U roof - 0.9055 U grou -
0.9172 ColorWall
- 3.8338 ColorRoof - 4.1433 U wind + 0.7360 WWR_N - 8.4419 WWR_S -
0.4254 WWR_E
+ 2.5019 WWR_W - 0.6320 CELING + 2.5645 AREA - 2.5336 FORM -
0.6707 U wall*U roof

- 1.9703 U wall*U grou - 5.0608 U wall*ColorWall
+ 1.2286 U wall*ColorRoof
+ 1.9472 U wall*U wind + 3.4108 U wall*WWR_N - 1.1480 U wall*WWR_S
+ 1.3640 U wall*WWR_E + 0.8351 U wall*WWR_W + 3.5200 U wall*CELING
- 4.8449 U wall*AREA + 0.6278 U wall*FORM + 7.9158 U roof*ColorWall
- 0.4047 U roof*ColorRoof - 0.4632 U roof*U wind + 2.8927 U roof*WWR_N
- 1.6033 U roof*WWR_S - 0.2602 U roof*WWR_E - 1.6276 U roof*WWR_W
- 2.8460 U roof*CELING + 2.3093 U roof*AREA - 8.4269 U grou*ColorWall
- 0.0547 U grou*ColorRoof + 5.1238 U grou*U wind - 1.9860 U grou*WWR_N
+ 1.9222 U grou*WWR_S + 6.0481 U grou*WWR_E - 1.6230 U grou*WWR_W
- 0.9003 U grou*CELING + 2.6450 U grou*AREA -
7.1201 ColorWall*ColorRoof
+ 1.0308 ColorWall*U wind - 1.6007 ColorWall*WWR_N -
7.9607 ColorWall*WWR_S
+ 2.5861 ColorWall*WWR_E - 2.6290 ColorWall*WWR_W -
2.8798 ColorWall*CELING
+ 3.9738 ColorWall*AREA + 1.2301 ColorWall*FORM
+ 7.2420 ColorRoof*U wind
+ 2.2626 ColorRoof*WWR_N + 0.8016 ColorRoof*WWR_E -
4.5810 ColorRoof*WWR_W
+ 7.5382 ColorRoof*CELING - 1.3682 ColorRoof*AREA -
5.1273 ColorRoof*FORM
+ 0.9755 U wind*WWR_N + 2.2364 U wind*WWR_S - 0.0158 U wind*WWR_E
- 5.7103 U wind*WWR_W - 1.0126 U wind*CELING + 7.5173 U wind*AREA
+ 5.1973 U wind*FORM - 3.1363 WWR_N*WWR_S + 2.6382 WWR_N*WWR_E -
1.7198 WWR_N*WWR_W
- 0.2365 WWR_N*CELING + 0.1496 WWR_N*AREA + 3.5631 WWR_N*FORM
+ 0.0398 WWR_S*CELING
+ 4.0089 WWR_S*AREA - 4.1992 WWR_S*FORM - 3.9020 WWR_E*CELING -
0.2280 WWR_E*AREA
- 2.8140 WWR_W*CELING - 0.3466 WWR_W*AREA - 0.2847 WWR_W*FORM -
3.1309 CELING*AREA
- 3.0837 CELING*FORM - 0.4533 AREA*FORM -
6.9060 U wall*U roof*ColorWall
- 1.0625 U wall*U roof*ColorRoof - 1.1214 U wall*U roof*AREA
- 2.8266 U wall*U grou*ColorWall + 1.8096 U wall*U grou*WWR_N
+ 5.5979 U wall*U grou*WWR_S - 6.1353 U wall*U grou*WWR_E
+ 0.3604 U wall*U grou*WWR_W - 0.1585 U wall*U grou*CELING
- 3.3373 U wall*ColorWall*ColorRoof - 2.4955 U wall*ColorWall*U wind
+ 0.6831 U wall*ColorWall*WWR_N + 2.2718 U wall*ColorWall*WWR_S
+ 4.2974 U wall*ColorWall*WWR_E + 1.0096 U wall*ColorWall*WWR_W
+ 5.0069 U wall*ColorRoof*CELING + 2.9039 U wall*U wind*WWR_N
+ 1.0965 U wall*U wind*WWR_S + 0.0520 U wall*U wind*WWR_E
- 3.1912 U wall*U wind*WWR_W + 5.7696 U wall*U wind*CELING
- 2.2194 U wall*U wind*FORM - 2.1684 U wall*WWR_N*WWR_W -
2.7824 U wall*WWR_E*AREA
- 0.3112 U wall*WWR_W*AREA + 5.3520 U roof*ColorWall*WWR_N
- 0.3718 U roof*ColorWall*WWR_E + 0.1038 U grou*ColorWall*ColorRoof
- 6.7809 U grou*U wind*CELING - 3.9657 ColorWall*ColorRoof*AREA
- 3.7320 ColorWall*U wind*AREA - 1.4135 ColorWall*WWR_N*WWR_E
+ 0.8077 ColorWall*WWR_N*CELING + 0.3508 ColorWall*WWR_S*CELING
- 4.4859 ColorWall*WWR_W*CELING

Analysis of Variance (Ouargla 128 for heating)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	116	190373	1641.14	19177.99	0.000
Linear	13	21291	1637.81	19138.99	0.000
U wall	1	6672	6672.05	77967.96	0.000
U roof	1	157	156.83	1832.70	0.000
U grou	1	45	45.44	531.05	0.000
ColorWall	1	1	0.91	10.65	0.031
ColorRoof	1	254	253.99	2968.03	0.000
U wind	1	134	134.14	1567.56	0.000
WWR_N	1	431	430.54	5031.23	0.000
WWR_S	1	7	7.32	85.56	0.001
WWR_E	1	837	837.12	9782.32	0.000
WWR_W	1	2391	2390.54	27935.24	0.000
CELING	1	634	634.14	7410.41	0.000
AREA	1	772	771.84	9019.48	0.000
FORM	1	3379	3379.30	39489.64	0.000
2-Way Interactions	67	105786	1578.89	18450.56	0.000
U wall*U roof	1	14	13.75	160.73	0.000
U wall*U grou	1	503	503.20	5880.30	0.000
U wall*ColorWall	1	2495	2494.90	29154.76	0.000
U wall*ColorRoof	1	29	28.93	338.07	0.000
U wall*U wind	1	1138	1137.98	13298.20	0.000
U wall*WWR_N	1	448	447.98	5234.94	0.000
U wall*WWR_S	1	0	0.01	0.14	0.725
U wall*WWR_E	1	2765	2764.96	32310.69	0.000
U wall*WWR_W	1	231	231.29	2702.79	0.000
U wall*CELING	1	921	920.91	10761.55	0.000
U wall*AREA	1	235	235.04	2746.59	0.000
U wall*FORM	1	333	332.60	3886.70	0.000
U roof*ColorWall	1	4335	4334.84	50655.92	0.000
U roof*ColorRoof	1	1109	1109.18	12961.56	0.000
U roof*U wind	1	223	222.63	2601.59	0.000
U roof*WWR_N	1	380	380.38	4444.99	0.000
U roof*WWR_S	1	3305	3304.96	38620.97	0.000
U roof*WWR_E	1	493	493.02	5761.33	0.000
U roof*WWR_W	1	315	315.49	3686.72	0.000
U roof*CELING	1	54	53.60	626.34	0.000
U roof*AREA	1	284	283.87	3317.26	0.000
U grou*ColorWall	1	35	34.70	405.55	0.000
U grou*ColorRoof	1	1718	1718.22	20078.74	0.000
U grou*U wind	1	1122	1122.17	13113.41	0.000
U grou*WWR_S	1	15	14.71	171.89	0.000
U grou*WWR_E	1	2430	2430.09	28397.42	0.000
U grou*WWR_W	1	10	10.21	119.29	0.000
U grou*CELING	1	803	802.85	9381.87	0.000
ColorWall*ColorRoof	1	199	199.36	2329.63	0.000
ColorWall*U wind	1	4149	4148.95	48483.59	0.000
ColorWall*WWR_N	1	77	77.38	904.23	0.000
ColorWall*WWR_S	1	479	478.78	5594.89	0.000
ColorWall*WWR_E	1	305	304.88	3562.77	0.000
ColorWall*WWR_W	1	1311	1311.26	15323.02	0.000
ColorWall*CELING	1	335	334.89	3913.49	0.000
ColorWall*AREA	1	19	19.48	227.62	0.000
ColorWall*FORM	1	702	701.62	8199.02	0.000
ColorRoof*WWR_N	1	5402	5402.09	63127.54	0.000
ColorRoof*WWR_S	1	52	52.42	612.59	0.000
ColorRoof*WWR_E	1	7034	7034.02	82197.88	0.000
ColorRoof*WWR_W	1	1498	1497.98	17505.05	0.000
ColorRoof*CELING	1	6	6.12	71.51	0.001
ColorRoof*AREA	1	33	32.81	383.39	0.000
ColorRoof*FORM	1	461	460.61	5382.58	0.000
U wind*WWR_N	1	631	630.63	7369.35	0.000
U wind*WWR_S	1	2043	2043.04	23874.46	0.000
U wind*WWR_E	1	365	364.69	4261.68	0.000

U wind*WWR_W	1	248	248.17	2900.09	0.000
U wind*CELING	1	3651	3651.08	42665.65	0.000
U wind*AREA	1	137	137.36	1605.18	0.000
U wind*FORM	1	70	69.64	813.76	0.000
WWR_N*WWR_E	1	1021	1021.42	11936.01	0.000
WWR_N*WWR_W	1	821	821.10	9595.12	0.000
WWR_N*CELING	1	25	25.33	295.97	0.000
WWR_N*AREA	1	503	502.92	5877.05	0.000
WWR_N*FORM	1	2026	2026.02	23675.63	0.000
WWR_S*CELING	1	508	507.92	5935.43	0.000
WWR_S*AREA	1	48	48.03	561.25	0.000
WWR_S*FORM	1	3767	3767.20	44022.63	0.000
WWR_E*CELING	1	4718	4718.13	55134.87	0.000
WWR_E*AREA	1	2	2.15	25.17	0.007
WWR_E*FORM	1	1234	1234.07	14421.00	0.000
WWR_W*CELING	1	1241	1240.96	14501.60	0.000
WWR_W*AREA	1	54	54.33	634.91	0.000
WWR_W*FORM	1	2769	2769.12	32359.22	0.000
CELING*AREA	1	185	184.51	2156.13	0.000
CELING*FORM	1	2892	2891.60	33790.54	0.000
3-Way Interactions	36	47530	1320.27	15428.37	0.000
U wall*U roof*ColorWall	1	6579	6578.94	76879.91	0.000
U wall*U roof*ColorRoof	1	3000	2999.75	35054.34	0.000
U wall*U roof*U wind	1	3489	3488.51	40765.88	0.000
U wall*U roof*AREA	1	11	10.57	123.47	0.000
U wall*U grou*ColorWall	1	1752	1751.91	20472.41	0.000
U wall*U grou*WWR_S	1	902	901.63	10536.21	0.000
U wall*U grou*WWR_E	1	84	83.96	981.10	0.000
U wall*U grou*CELING	1	0	0.40	4.69	0.096
U wall*ColorWall*WWR_N	1	16	15.79	184.53	0.000
U wall*ColorWall*WWR_S	1	53	53.31	622.98	0.000
U wall*ColorWall*WWR_E	1	12	11.71	136.87	0.000
U wall*ColorWall*WWR_W	1	1	0.95	11.07	0.029
U wall*ColorRoof*CELING	1	607	607.25	7096.22	0.000
U wall*U wind*WWR_N	1	182	181.78	2124.18	0.000
U wall*U wind*WWR_S	1	6195	6194.95	72392.68	0.000
U wall*U wind*WWR_E	1	7	7.22	84.37	0.001
U wall*U wind*WWR_W	1	2670	2670.44	31206.14	0.000
U wall*U wind*CELING	1	340	340.32	3976.86	0.000
U wall*U wind*FORM	1	2387	2386.52	27888.23	0.000
U wall*WWR_N*WWR_W	1	1865	1864.91	21792.83	0.000
U wall*WWR_N*AREA	1	7	7.10	82.99	0.001
U wall*WWR_S*AREA	1	1586	1586.38	18538.05	0.000
U wall*WWR_E*AREA	1	98	98.22	1147.73	0.000
U wall*WWR_W*AREA	1	106	105.82	1236.54	0.000
U roof*ColorWall*WWR_N	1	2454	2454.44	28682.02	0.000
U roof*ColorWall*WWR_S	1	51	51.31	599.58	0.000
U roof*ColorWall*WWR_E	1	1262	1261.94	14746.76	0.000
U roof*ColorWall*WWR_W	1	142	142.18	1661.45	0.000
U roof*WWR_N*WWR_W	1	67	67.06	783.61	0.000
U grou*ColorWall*ColorRoof	1	49	49.09	573.67	0.000
U grou*U wind*CELING	1	1512	1512.16	17670.75	0.000
ColorWall*ColorRoof*AREA	1	1360	1359.86	15891.01	0.000
ColorWall*U wind*AREA	1	129	128.75	1504.57	0.000
ColorWall*WWR_N*WWR_E	1	700	699.71	8176.62	0.000
ColorWall*WWR_N*CELING	1	1193	1192.86	13939.48	0.000
ColorWall*WWR_W*CELING	1	9	9.24	107.95	0.000
Error	4	0	0.09		
Total	120	190373			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.292531	100.00%	99.99%	*

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		52.5284	0.0438	1198.14	0.000	
U wall	21.8409	10.9205	0.0391	279.23	0.000	2.16
U roof	3.1160	1.5580	0.0364	42.81	0.000	1.87
U grou	-1.4503	-0.7251	0.0315	-23.04	0.000	1.40
ColorWall	0.2706	0.1353	0.0415	3.26	0.031	2.43
ColorRoof	3.6700	1.8350	0.0337	54.48	0.000	1.60
U wind	-3.4186	-1.7093	0.0432	-39.59	0.000	2.63
WWR_N	-6.2195	-3.1097	0.0438	-70.93	0.000	2.71
WWR_S	0.6252	0.3126	0.0338	9.25	0.001	1.61
WWR_E	-7.0949	-3.5475	0.0359	-98.91	0.000	1.82
WWR_W	-14.6262	-7.3131	0.0438	-167.14	0.000	2.71
CELING	-7.9595	-3.9798	0.0462	-86.08	0.000	3.02
AREA	-7.9283	-3.9641	0.0417	-94.97	0.000	2.46
FORM	17.5730	8.7865	0.0442	198.72	0.000	2.76
U wall*U roof	-0.9718	-0.4859	0.0383	-12.68	0.000	2.08
U wall*U grou	-5.1658	-2.5829	0.0337	-76.68	0.000	1.60
U wall*ColorWall	12.2485	6.1242	0.0359	170.75	0.000	1.82
U wall*ColorRoof	1.3383	0.6691	0.0364	18.39	0.000	1.87
U wall*U wind	-9.7865	-4.8932	0.0424	-115.32	0.000	2.55
U wall*WWR_N	-5.6594	-2.8297	0.0391	-72.35	0.000	2.16
U wall*WWR_S	-0.0273	-0.0136	0.0361	-0.38	0.725	1.85
U wall*WWR_E	-13.6226	-6.8113	0.0379	-179.75	0.000	2.03
U wall*WWR_W	-4.6418	-2.3209	0.0446	-51.99	0.000	2.81
U wall*CELING	-8.4499	-4.2250	0.0407	-103.74	0.000	2.34
U wall*AREA	5.0894	2.5447	0.0486	52.41	0.000	3.33
U wall*FORM	4.6406	2.3203	0.0372	62.34	0.000	1.96
U roof*ColorWall	-14.3801	-7.1901	0.0319	-225.07	0.000	1.44
U roof*ColorRoof	8.1669	4.0834	0.0359	113.85	0.000	1.82
U roof*U wind	-3.9096	-1.9548	0.0383	-51.01	0.000	2.08
U roof*WWR_N	-4.8527	-2.4263	0.0364	-66.67	0.000	1.87
U roof*WWR_S	16.0076	8.0038	0.0407	196.52	0.000	2.34
U roof*WWR_E	-7.5006	-3.7503	0.0494	-75.90	0.000	3.45
U roof*WWR_W	-4.7493	-2.3747	0.0391	-60.72	0.000	2.16
U roof*CELING	-1.8094	-0.9047	0.0361	-25.03	0.000	1.85
U roof*AREA	4.1316	2.0658	0.0359	57.60	0.000	1.82
U grou*ColorWall	1.5791	0.7896	0.0392	20.14	0.000	2.17
U grou*ColorRoof	14.0024	7.0012	0.0494	141.70	0.000	3.45
U grou*U wind	-8.2146	-4.1073	0.0359	-114.51	0.000	1.82
U grou*WWR_S	-1.0777	-0.5388	0.0411	-13.11	0.000	2.39
U grou*WWR_E	-12.0883	-6.0442	0.0359	-168.52	0.000	1.82
U grou*WWR_W	0.6812	0.3406	0.0312	10.92	0.000	1.37
U grou*CELING	6.7540	3.3770	0.0349	96.86	0.000	1.72
ColorWall*ColorRoof	3.4895	1.7448	0.0361	48.27	0.000	1.84
ColorWall*U wind	-18.9604	-9.4802	0.0431	-220.19	0.000	2.62
ColorWall*WWR_N	2.4938	1.2469	0.0415	30.07	0.000	2.43
ColorWall*WWR_S	-5.1003	-2.5502	0.0341	-74.80	0.000	1.64
ColorWall*WWR_E	4.4795	2.2397	0.0375	59.69	0.000	1.99
ColorWall*WWR_W	8.9494	4.4747	0.0361	123.79	0.000	1.85
ColorWall*CELING	-4.8932	-2.4466	0.0391	-62.56	0.000	2.16
ColorWall*AREA	1.0908	0.5454	0.0361	15.09	0.000	1.85
ColorWall*FORM	8.2323	4.1161	0.0455	90.55	0.000	2.92
ColorRoof*WWR_N	16.9256	8.4628	0.0337	251.25	0.000	1.60
ColorRoof*WWR_S	-2.1312	-1.0656	0.0431	-24.75	0.000	2.62
ColorRoof*WWR_E	-21.3412	-10.6706	0.0372	-286.70	0.000	1.96
ColorRoof*WWR_W	9.3687	4.6843	0.0354	132.31	0.000	1.77
ColorRoof*CELING	-0.5716	-0.2858	0.0338	-8.46	0.001	1.61
ColorRoof*AREA	-1.3176	-0.6588	0.0336	-19.58	0.000	1.60
ColorRoof*FORM	5.5601	2.7800	0.0379	73.37	0.000	2.03
U wind*WWR_N	7.4122	3.7061	0.0432	85.84	0.000	2.63
U wind*WWR_S	11.1709	5.5854	0.0361	154.51	0.000	1.84
U wind*WWR_E	-4.9474	-2.4737	0.0379	-65.28	0.000	2.03
U wind*WWR_W	-4.4265	-2.2133	0.0411	-53.85	0.000	2.39
U wind*CELING	20.1878	10.0939	0.0489	206.56	0.000	3.38
U wind*AREA	-3.4096	-1.7048	0.0426	-40.06	0.000	2.56
U wind*FORM	-2.4814	-1.2407	0.0435	-28.53	0.000	2.67
WWR_N*WWR_E	-7.8371	-3.9186	0.0359	-109.25	0.000	1.82

WWR_N*WWR_W	-8.5720	-4.2860	0.0438	-97.95	0.000	2.71
WWR_N*CELING	1.5907	0.7954	0.0462	17.20	0.000	3.02
WWR_N*AREA	6.3998	3.1999	0.0417	76.66	0.000	2.46
WWR_N*FORM	-13.6067	-6.8034	0.0442	-153.87	0.000	2.76
WWR_S*CELING	-5.9052	-2.9526	0.0383	-77.04	0.000	2.08
WWR_S*AREA	1.8531	0.9265	0.0391	23.69	0.000	2.16
WWR_S*FORM	-14.6303	-7.3152	0.0349	-209.82	0.000	1.72
WWR_E*CELING	18.4121	9.2060	0.0392	234.81	0.000	2.17
WWR_E*AREA	-0.3651	-0.1826	0.0364	-5.02	0.007	1.87
WWR_E*FORM	8.7406	4.3703	0.0364	120.09	0.000	1.87
WWR_W*CELING	-10.2484	-5.1242	0.0426	-120.42	0.000	2.56
WWR_W*AREA	-2.4627	-1.2313	0.0489	-25.20	0.000	3.38
WWR_W*FORM	12.1045	6.0523	0.0336	179.89	0.000	1.60
CELING*AREA	-3.8168	-1.9084	0.0411	-46.43	0.000	2.39
CELING*FORM	-15.1097	-7.5548	0.0411	-183.82	0.000	2.39
U wall*U roof*ColorWall	16.2720	8.1360	0.0293	277.27	0.000	1.22
U wall*U roof*ColorRoof	13.7830	6.8915	0.0368	187.23	0.000	1.92
U wall*U roof*U wind	14.6958	7.3479	0.0364	201.91	0.000	1.87
U wall*U roof*AREA	0.8421	0.4211	0.0379	11.11	0.000	2.03
U wall*U grou*ColorWall	-11.1917	-5.5959	0.0391	-143.08	0.000	2.16
U wall*U grou*WWR_S	7.4210	3.7105	0.0361	102.65	0.000	1.85
U wall*U grou*WWR_E	-2.3058	-1.1529	0.0368	-31.32	0.000	1.92
U wall*U grou*CELING	-0.1533	-0.0766	0.0354	-2.16	0.096	1.77
U wall*ColorWall*WWR_N	0.9745	0.4872	0.0359	13.58	0.000	1.82
U wall*ColorWall*WWR_S	-1.6280	-0.8140	0.0326	-24.96	0.000	1.50
U wall*ColorWall*WWR_E	-0.8613	-0.4306	0.0368	-11.70	0.000	1.92
U wall*ColorWall*WWR_W	0.2894	0.1447	0.0435	3.33	0.029	2.67
U wall*ColorRoof*CELING	-5.2538	-2.6269	0.0312	-84.24	0.000	1.37
U wall*U wind*WWR_N	-3.9113	-1.9557	0.0424	-46.09	0.000	2.55
U wall*U wind*WWR_S	18.1857	9.0929	0.0338	269.06	0.000	1.61
U wall*U wind*WWR_E	0.6589	0.3295	0.0359	9.19	0.001	1.82
U wall*U wind*WWR_W	-16.0605	-8.0303	0.0455	-176.65	0.000	2.92
U wall*U wind*CELING	5.0776	2.5388	0.0403	63.06	0.000	2.29
U wall*U wind*FORM	-12.0734	-6.0367	0.0361	-167.00	0.000	1.85
U wall*WWR_N*WWR_W	-13.1807	-6.5904	0.0446	-147.62	0.000	2.81
U wall*WWR_N*AREA	-0.8847	-0.4423	0.0486	-9.11	0.001	3.33
U wall*WWR_S*AREA	10.6763	5.3382	0.0392	136.15	0.000	2.17
U wall*WWR_E*AREA	-2.5967	-1.2984	0.0383	-33.88	0.000	2.08
U wall*WWR_W*AREA	-2.8313	-1.4157	0.0403	-35.16	0.000	2.29
U roof*ColorWall*WWR_N	10.8206	5.4103	0.0319	169.36	0.000	1.44
U roof*ColorWall*WWR_S	-1.6477	-0.8238	0.0336	-24.49	0.000	1.60
U roof*ColorWall*WWR_E	-9.3080	-4.6540	0.0383	-121.44	0.000	2.08
U roof*ColorWall*WWR_W	2.9240	1.4620	0.0359	40.76	0.000	1.82
U roof*WWR_N*WWR_W	2.1896	1.0948	0.0391	27.99	0.000	2.16
U grou*ColorWall*ColorRoof	-1.8359	-0.9179	0.0383	-23.95	0.000	2.08
U grou*U wind*CELING	-9.7859	-4.8929	0.0368	-132.93	0.000	1.92
ColorWall*ColorRoof*AREA	-9.8847	-4.9424	0.0392	-126.06	0.000	2.17
ColorWall*U wind*AREA	-2.8873	-1.4437	0.0372	-38.79	0.000	1.96
ColorWall*WWR_N*WWR_E	6.7861	3.3930	0.0375	90.42	0.000	1.99
ColorWall*WWR_N*CELING	9.2350	4.6175	0.0391	118.07	0.000	2.16
ColorWall*WWR_W*CELING	-0.7734	-0.3867	0.0372	-10.39	0.000	1.96

Regression Equation in Uncoded Units

heat = 52.5284 + 10.9205 U wall + 1.5580 U roof - 0.7251 U grou
+ 0.1353 ColorWall
 + 1.8350 ColorRoof - 1.7093 U wind - 3.1097 WWR_N + 0.3126 WWR_S -
 3.5475 WWR_E
 - 7.3131 WWR_W - 3.9798 CELING - 3.9641 AREA + 8.7865 FORM -
 0.4859 U wall*U roof
 - 2.5829 U wall*U grou + 6.1242 U wall*ColorWall
+ 0.6691 U wall*ColorRoof
 - 4.8932 U wall*U wind - 2.8297 U wall*WWR_N - 0.0136 U wall*WWR_S
 - 6.8113 U wall*WWR_E - 2.3209 U wall*WWR_W - 4.2250 U wall*CELING
 + 2.5447 U wall*AREA + 2.3203 U wall*FORM - 7.1901 U roof*ColorWall
 + 4.0834 U roof*ColorRoof - 1.9548 U roof*U wind - 2.4263 U roof*WWR_N
 + 8.0038 U roof*WWR_S - 3.7503 U roof*WWR_E - 2.3747 U roof*WWR_W

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       - 0.9047 U roof*CELING + 2.0658 U roof*AREA + 0.7896 U grou*ColorWall
       + 7.0012 U grou*ColorRoof - 4.1073 U grou*U wind - 0.5388 U grou*WWR_S
       - 6.0442 U grou*WWR_E + 0.3406 U grou*WWR_W + 3.3770 U grou*CELING
       + 1.7448 ColorWall*ColorRoof - 9.4802 ColorWall*U wind
+ 1.2469 ColorWall*WWR_N
       - 2.5502 ColorWall*WWR_S + 2.2397 ColorWall*WWR_E
+ 4.4747 ColorWall*WWR_W
       - 2.4466 ColorWall*CELING + 0.5454 ColorWall*AREA + 4.1161 ColorWall*FORM
       + 8.4628 ColorRoof*WWR_N - 1.0656 ColorRoof*WWR_S -
 10.6706 ColorRoof*WWR_E
       + 4.6843 ColorRoof*WWR_W - 0.2858 ColorRoof*CELING -
 0.6588 ColorRoof*AREA
       + 2.7800 ColorRoof*FORM + 3.7061 U wind*WWR_N + 5.5854 U wind*WWR_S
       - 2.4737 U wind*WWR_E - 2.2133 U wind*WWR_W + 10.0939 U wind*CELING
       - 1.7048 U wind*AREA - 1.2407 U wind*FORM - 3.9186 WWR_N*WWR_E -
 4.2860 WWR_N*WWR_W
       + 0.7954 WWR_N*CELING + 3.1999 WWR_N*AREA - 6.8034 WWR_N*FORM -
 2.9526 WWR_S*CELING
       + 0.9265 WWR_S*AREA - 7.3152 WWR_S*FORM + 9.2060 WWR_E*CELING -
 0.1826 WWR_E*AREA
       + 4.3703 WWR_E*FORM - 5.1242 WWR_W*CELING - 1.2313 WWR_W*AREA
+ 6.0523 WWR_W*FORM
       - 1.9084 CELING*AREA - 7.5548 CELING*FORM
+ 8.1360 U wall*U roof*ColorWall
       + 6.8915 U wall*U roof*ColorRoof + 7.3479 U wall*U roof*U wind
       + 0.4211 U wall*U roof*AREA - 5.5959 U wall*U grou*ColorWall
       + 3.7105 U wall*U grou*WWR_S - 1.1529 U wall*U grou*WWR_E
       - 0.0766 U wall*U grou*CELING + 0.4872 U wall*ColorWall*WWR_N
       - 0.8140 U wall*ColorWall*WWR_S - 0.4306 U wall*ColorWall*WWR_E
       + 0.1447 U wall*ColorWall*WWR_W - 2.6269 U wall*ColorRoof*CELING
       - 1.9557 U wall*U wind*WWR_N + 9.0929 U wall*U wind*WWR_S
+ 0.3295 U wall*U wind*WWR_E
       - 8.0303 U wall*U wind*WWR_W + 2.5388 U wall*U wind*CELING -
 6.0367 U wall*U wind*FORM
       - 6.5904 U wall*WWR_N*WWR_W - 0.4423 U wall*WWR_N*AREA
+ 5.3382 U wall*WWR_S*AREA
       - 1.2984 U wall*WWR_E*AREA - 1.4157 U wall*WWR_W*AREA
+ 5.4103 U roof*ColorWall*WWR_N
       - 0.8238 U roof*ColorWall*WWR_S - 4.6540 U roof*ColorWall*WWR_E
       + 1.4620 U roof*ColorWall*WWR_W + 1.0948 U roof*WWR_N*WWR_W
       - 0.9179 U grou*ColorWall*ColorRoof - 4.8929 U grou*U wind*CELING
       - 4.9424 ColorWall*ColorRoof*AREA - 1.4437 ColorWall*U wind*AREA
       + 3.3930 ColorWall*WWR_N*WWR_E + 4.6175 ColorWall*WWR_N*CELING
       - 0.3867 ColorWall*WWR_W*CELING
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Analysis of Variance (Adrar 128 for cooling)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	123	158913	1292.0	6166.92	0.000
Linear	13	40659	3127.6	14928.88	0.000
U wall	1	5835	5834.9	27851.59	0.000
U roof	1	375	375.4	1791.69	0.000
U grou	1	37	36.7	175.12	0.000
ColorWall	1	76	75.9	362.25	0.000
ColorRoof	1	347	346.6	1654.55	0.000
U wind	1	1597	1597.1	7623.39	0.000
WWR_N	1	18	18.3	87.42	0.001
WWR_S	1	5983	5983.2	28559.31	0.000
WWR_E	1	397	397.0	1894.86	0.000
WWR_W	1	793	793.2	3785.92	0.000
CELING	1	9	8.7	41.53	0.003
AREA	1	24046	24045.8	114776.80	0.000
FORM	1	1146	1146.2	5470.98	0.000
2-Way Interactions	71	83285	1173.0	5599.18	0.000
U wall*U roof	1	80	80.2	383.05	0.000
U wall*U grou	1	34	33.8	161.10	0.000
U wall*ColorWall	1	120	119.6	570.88	0.000
U wall*ColorRoof	1	2046	2045.6	9764.38	0.000
U wall*U wind	1	1032	1031.7	4924.50	0.000
U wall*WWR_N	1	405	405.4	1934.86	0.000
U wall*WWR_S	1	450	450.1	2148.26	0.000
U wall*WWR_E	1	0	0.0	0.22	0.664
U wall*WWR_W	1	239	239.3	1142.40	0.000
U wall*CELING	1	700	700.4	3343.41	0.000
U wall*AREA	1	1226	1225.7	5850.64	0.000
U wall*FORM	1	764	764.4	3648.58	0.000
U roof*ColorWall	1	10437	10437.4	49820.46	0.000
U roof*ColorRoof	1	113	113.4	541.23	0.000
U roof*U wind	1	1876	1875.7	8952.97	0.000
U roof*WWR_N	1	737	736.6	3515.80	0.000
U roof*WWR_S	1	67	66.9	319.11	0.000
U roof*WWR_E	1	79	79.2	378.27	0.000
U roof*WWR_W	1	463	463.1	2210.56	0.000
U roof*AREA	1	214	214.2	1022.57	0.000
U grou*ColorWall	1	4684	4684.4	22359.78	0.000
U grou*ColorRoof	1	265	264.9	1264.59	0.000
U grou*U wind	1	340	340.2	1623.98	0.000
U grou*WWR_N	1	843	842.6	4021.84	0.000
U grou*WWR_S	1	858	857.6	4093.75	0.000
U grou*WWR_E	1	5706	5705.7	27234.84	0.000
U grou*WWR_W	1	1249	1248.7	5960.43	0.000
U grou*CELING	1	3674	3674.4	17539.07	0.000
U grou*AREA	1	684	684.1	3265.45	0.000
ColorWall*ColorRoof	1	1934	1933.6	9229.56	0.000
ColorWall*U wind	1	1369	1369.2	6535.57	0.000
ColorWall*WWR_N	1	334	333.9	1593.69	0.000
ColorWall*WWR_S	1	3054	3054.1	14577.98	0.000
ColorWall*WWR_E	1	1319	1318.7	6294.30	0.000
ColorWall*WWR_W	1	272	271.8	1297.14	0.000
ColorWall*CELING	1	1002	1001.7	4781.61	0.000
ColorWall*AREA	1	270	270.0	1288.65	0.000
ColorWall*FORM	1	34	34.1	162.69	0.000
ColorRoof*U wind	1	635	635.1	3031.44	0.000
ColorRoof*WWR_N	1	1441	1441.0	6878.21	0.000
ColorRoof*WWR_S	1	665	664.9	3173.66	0.000
ColorRoof*WWR_E	1	131	131.3	626.51	0.000
ColorRoof*WWR_W	1	180	180.0	859.37	0.000
ColorRoof*CELING	1	808	808.0	3856.75	0.000
ColorRoof*AREA	1	4280	4279.9	20428.86	0.000
ColorRoof*FORM	1	452	452.2	2158.62	0.000

U wind*WWR_N	1	16	15.7	74.90	0.001
U wind*WWR_S	1	1828	1828.5	8727.83	0.000
U wind*WWR_E	1	3	3.2	15.11	0.018
U wind*WWR_W	1	1265	1264.9	6037.89	0.000
U wind*CELING	1	516	516.1	2463.57	0.000
U wind*AREA	1	1607	1606.9	7669.92	0.000
U wind*FORM	1	3476	3475.8	16590.68	0.000
WWR_N*WWR_S	1	1452	1451.5	6928.47	0.000
WWR_N*WWR_E	1	5846	5846.5	27906.76	0.000
WWR_N*WWR_W	1	80	80.4	383.63	0.000
WWR_N*CELING	1	264	263.7	1258.49	0.000
WWR_N*AREA	1	169	168.9	806.25	0.000
WWR_N*FORM	1	369	368.9	1760.95	0.000
WWR_S*CELING	1	70	70.2	335.10	0.000
WWR_S*AREA	1	2291	2291.0	10935.69	0.000
WWR_S*FORM	1	1036	1035.7	4943.48	0.000
WWR_E*CELING	1	0	0.2	0.81	0.419
WWR_E*AREA	1	88	87.6	417.91	0.000
WWR_E*FORM	1	4859	4858.9	23192.60	0.000
WWR_W*CELING	1	9	8.8	41.95	0.003
WWR_W*AREA	1	33	33.2	158.34	0.000
WWR_W*FORM	1	51	51.3	244.97	0.000
CELING*AREA	1	276	275.9	1316.85	0.000
CELING*FORM	1	100	100.4	479.40	0.000
AREA*FORM	1	16	16.4	78.32	0.001
3-Way Interactions	39	34969	896.6	4279.85	0.000
U wall*U roof*ColorWall	1	653	653.2	3117.83	0.000
U wall*U roof*ColorRoof	1	4	3.9	18.74	0.012
U wall*U roof*U wind	1	4652	4651.9	22204.72	0.000
U wall*U roof*AREA	1	116	115.8	552.87	0.000
U wall*U grou*ColorWall	1	51	51.4	245.17	0.000
U wall*U grou*WWR_N	1	17	16.8	79.96	0.001
U wall*U grou*WWR_S	1	2978	2977.5	14212.43	0.000
U wall*U grou*WWR_E	1	344	344.5	1644.28	0.000
U wall*U grou*WWR_W	1	1789	1788.6	8537.65	0.000
U wall*U grou*CELING	1	3458	3458.4	16507.85	0.000
U wall*ColorWall*ColorRoof	1	7	6.7	32.15	0.005
U wall*ColorWall*U wind	1	587	587.1	2802.51	0.000
U wall*ColorWall*WWR_N	1	543	542.6	2590.19	0.000
U wall*ColorWall*WWR_S	1	1335	1335.0	6372.51	0.000
U wall*ColorWall*WWR_E	1	40	40.3	192.21	0.000
U wall*ColorWall*WWR_W	1	1806	1806.5	8622.71	0.000
U wall*ColorRoof*CELING	1	1825	1824.9	8710.60	0.000
U wall*U wind*WWR_N	1	77	76.7	366.02	0.000
U wall*U wind*WWR_S	1	222	221.7	1058.15	0.000
U wall*U wind*WWR_E	1	2	2.1	9.90	0.035
U wall*U wind*WWR_W	1	43	42.9	204.85	0.000
U wall*U wind*CELING	1	215	215.3	1027.53	0.000
U wall*U wind*FORM	1	26	25.7	122.46	0.000
U wall*WWR_N*WWR_W	1	367	366.9	1751.41	0.000
U wall*WWR_N*AREA	1	338	337.7	1611.89	0.000
U wall*WWR_E*AREA	1	157	157.3	750.82	0.000
U wall*WWR_W*AREA	1	3	2.6	12.31	0.025
U roof*ColorWall*WWR_N	1	1018	1017.5	4856.96	0.000
U roof*ColorWall*WWR_W	1	1447	1446.7	6905.29	0.000
U roof*WWR_N*WWR_W	1	258	258.3	1233.05	0.000
U grou*ColorWall*ColorRoof	1	13	13.1	62.46	0.001
U grou*U wind*CELING	1	1202	1202.2	5738.58	0.000
ColorWall*ColorRoof*AREA	1	1627	1627.2	7766.83	0.000
ColorWall*U wind*AREA	1	980	979.9	4677.12	0.000
ColorWall*WWR_N*WWR_E	1	1157	1156.8	5521.90	0.000
ColorWall*WWR_N*CELING	1	1002	1001.7	4781.30	0.000
ColorWall*WWR_S*CELING	1	137	136.7	652.55	0.000
ColorWall*WWR_E*CELING	1	1206	1206.3	5757.79	0.000
ColorWall*WWR_W*CELING	1	3268	3268.3	15600.45	0.000
Error	4	1	0.2		
Total	127	158913			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.457712	100.00%	99.98%	99.46%

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		76.6752	0.0405	1895.25	0.000	
U wall	-13.5034	-6.7517	0.0405	-166.89	0.000	1.00
U roof	-3.4249	-1.7125	0.0405	-42.33	0.000	1.00
U grou	1.0708	0.5354	0.0405	13.23	0.000	1.00
ColorWall	1.5400	0.7700	0.0405	19.03	0.000	1.00
ColorRoof	3.2912	1.6456	0.0405	40.68	0.000	1.00
U wind	-7.0647	-3.5323	0.0405	-87.31	0.000	1.00
WWR_N	-0.7565	-0.3783	0.0405	-9.35	0.001	1.00
WWR_S	-13.6739	-6.8369	0.0405	-168.99	0.000	1.00
WWR_E	-3.5221	-1.7611	0.0405	-43.53	0.000	1.00
WWR_W	4.9786	2.4893	0.0405	61.53	0.000	1.00
CELING	-0.5214	-0.2607	0.0405	-6.44	0.003	1.00
AREA	-27.4122	-13.7061	0.0405	-338.79	0.000	1.00
FORM	-5.9848	-2.9924	0.0405	-73.97	0.000	1.00
U wall*U roof	-1.5836	-0.7918	0.0405	-19.57	0.000	1.00
U wall*U grou	1.0270	0.5135	0.0405	12.69	0.000	1.00
U wall*ColorWall	-1.9333	-0.9666	0.0405	-23.89	0.000	1.00
U wall*ColorRoof	7.9954	3.9977	0.0405	98.81	0.000	1.00
U wall*U wind	5.6780	2.8390	0.0405	70.17	0.000	1.00
U wall*WWR_N	3.5591	1.7796	0.0405	43.99	0.000	1.00
U wall*WWR_S	-3.7503	-1.8751	0.0405	-46.35	0.000	1.00
U wall*WWR_E	0.0379	0.0190	0.0405	0.47	0.664	1.00
U wall*WWR_W	2.7348	1.3674	0.0405	33.80	0.000	1.00
U wall*CELING	4.6786	2.3393	0.0405	57.82	0.000	1.00
U wall*AREA	-6.1890	-3.0945	0.0405	-76.49	0.000	1.00
U wall*FORM	4.8874	2.4437	0.0405	60.40	0.000	1.00
U roof*ColorWall	18.0602	9.0301	0.0405	223.20	0.000	1.00
U roof*ColorRoof	-1.8824	-0.9412	0.0405	-23.26	0.000	1.00
U roof*U wind	-7.6560	-3.8280	0.0405	-94.62	0.000	1.00
U roof*WWR_N	4.7977	2.3988	0.0405	59.29	0.000	1.00
U roof*WWR_S	-1.4454	-0.7227	0.0405	-17.86	0.000	1.00
U roof*WWR_E	1.5737	0.7868	0.0405	19.45	0.000	1.00
U roof*WWR_W	3.8042	1.9021	0.0405	47.02	0.000	1.00
U roof*AREA	2.5874	1.2937	0.0405	31.98	0.000	1.00
U grou*ColorWall	-12.0990	-6.0495	0.0405	-149.53	0.000	1.00
U grou*ColorRoof	-2.8773	-1.4387	0.0405	-35.56	0.000	1.00
U grou*U wind	-3.2607	-1.6303	0.0405	-40.30	0.000	1.00
U grou*WWR_N	-5.1313	-2.5657	0.0405	-63.42	0.000	1.00
U grou*WWR_S	5.1770	2.5885	0.0405	63.98	0.000	1.00
U grou*WWR_E	13.3530	6.6765	0.0405	165.03	0.000	1.00
U grou*WWR_W	6.2468	3.1234	0.0405	77.20	0.000	1.00
U grou*CELING	-10.7157	-5.3579	0.0405	-132.44	0.000	1.00
U grou*AREA	4.6237	2.3118	0.0405	57.14	0.000	1.00
ColorWall*ColorRoof	-7.7733	-3.8867	0.0405	-96.07	0.000	1.00
ColorWall*U wind	6.5412	3.2706	0.0405	80.84	0.000	1.00
ColorWall*WWR_N	-3.2301	-1.6151	0.0405	-39.92	0.000	1.00
ColorWall*WWR_S	-9.7694	-4.8847	0.0405	-120.74	0.000	1.00
ColorWall*WWR_E	-6.4194	-3.2097	0.0405	-79.34	0.000	1.00
ColorWall*WWR_W	-2.9141	-1.4571	0.0405	-36.02	0.000	1.00
ColorWall*CELING	-5.5951	-2.7975	0.0405	-69.15	0.000	1.00
ColorWall*AREA	-2.9046	-1.4523	0.0405	-35.90	0.000	1.00
ColorWall*FORM	-1.0320	-0.5160	0.0405	-12.75	0.000	1.00
ColorRoof*U wind	4.4549	2.2275	0.0405	55.06	0.000	1.00
ColorRoof*WWR_N	-6.7105	-3.3553	0.0405	-82.93	0.000	1.00
ColorRoof*WWR_S	4.5582	2.2791	0.0405	56.34	0.000	1.00
ColorRoof*WWR_E	2.0253	1.0126	0.0405	25.03	0.000	1.00
ColorRoof*WWR_W	-2.3720	-1.1860	0.0405	-29.31	0.000	1.00
ColorRoof*CELING	5.0249	2.5125	0.0405	62.10	0.000	1.00

ColorRoof*AREA	-11.5648	-5.7824	0.0405	-142.93	0.000	1.00
ColorRoof*FORM	-3.7593	-1.8796	0.0405	-46.46	0.000	1.00
U wind*WWR_N	0.7003	0.3501	0.0405	8.65	0.001	1.00
U wind*WWR_S	-7.5591	-3.7796	0.0405	-93.42	0.000	1.00
U wind*WWR_E	0.3145	0.1572	0.0405	3.89	0.018	1.00
U wind*WWR_W	-6.2872	-3.1436	0.0405	-77.70	0.000	1.00
U wind*CELING	-4.0161	-2.0080	0.0405	-49.63	0.000	1.00
U wind*AREA	7.0862	3.5431	0.0405	87.58	0.000	1.00
U wind*FORM	10.4220	5.2110	0.0405	128.80	0.000	1.00
WWR_N*WWR_S	-6.7350	-3.3675	0.0405	-83.24	0.000	1.00
WWR_N*WWR_E	13.5167	6.7584	0.0405	167.05	0.000	1.00
WWR_N*WWR_W	1.5848	0.7924	0.0405	19.59	0.000	1.00
WWR_N*CELING	-2.8704	-1.4352	0.0405	-35.48	0.000	1.00
WWR_N*AREA	2.2975	1.1487	0.0405	28.39	0.000	1.00
WWR_N*FORM	3.3954	1.6977	0.0405	41.96	0.000	1.00
WWR_S*CELING	-1.4812	-0.7406	0.0405	-18.31	0.000	1.00
WWR_S*AREA	8.4614	4.2307	0.0405	104.57	0.000	1.00
WWR_S*FORM	-5.6890	-2.8445	0.0405	-70.31	0.000	1.00
WWR_E*CELING	-0.0728	-0.0364	0.0405	-0.90	0.419	1.00
WWR_E*AREA	1.6541	0.8270	0.0405	20.44	0.000	1.00
WWR_E*FORM	-12.3223	-6.1612	0.0405	-152.29	0.000	1.00
WWR_W*CELING	0.5240	0.2620	0.0405	6.48	0.003	1.00
WWR_W*AREA	-1.0181	-0.5091	0.0405	-12.58	0.000	1.00
WWR_W*FORM	-1.2664	-0.6332	0.0405	-15.65	0.000	1.00
CELING*AREA	-2.9362	-1.4681	0.0405	-36.29	0.000	1.00
CELING*FORM	-1.7716	-0.8858	0.0405	-21.90	0.000	1.00
AREA*FORM	0.7161	0.3580	0.0405	8.85	0.001	1.00
U wall*U roof*ColorWall	-4.5180	-2.2590	0.0405	-55.84	0.000	1.00
U wall*U roof*ColorRoof	0.3503	0.1751	0.0405	4.33	0.012	1.00
U wall*U roof*U wind	-12.0570	-6.0285	0.0405	-149.01	0.000	1.00
U wall*U roof*AREA	-1.9025	-0.9513	0.0405	-23.51	0.000	1.00
U wall*U grou*ColorWall	1.2669	0.6335	0.0405	15.66	0.000	1.00
U wall*U grou*WWR_N	0.7235	0.3618	0.0405	8.94	0.001	1.00
U wall*U grou*WWR_S	9.6461	4.8230	0.0405	119.22	0.000	1.00
U wall*U grou*WWR_E	-3.2810	-1.6405	0.0405	-40.55	0.000	1.00
U wall*U grou*WWR_W	7.4763	3.7381	0.0405	92.40	0.000	1.00
U wall*U grou*CELING	-10.3959	-5.1980	0.0405	-128.48	0.000	1.00
U wall*ColorWall*ColorRoof	-0.4588	-0.2294	0.0405	-5.67	0.005	1.00
U wall*ColorWall*U wind	-4.2834	-2.1417	0.0405	-52.94	0.000	1.00
U wall*ColorWall*WWR_N	-4.1180	-2.0590	0.0405	-50.89	0.000	1.00
U wall*ColorWall*WWR_S	6.4591	3.2296	0.0405	79.83	0.000	1.00
U wall*ColorWall*WWR_E	-1.1218	-0.5609	0.0405	-13.86	0.000	1.00
U wall*ColorWall*WWR_W	-7.5135	-3.7567	0.0405	-92.86	0.000	1.00
U wall*ColorRoof*CELING	7.5516	3.7758	0.0405	93.33	0.000	1.00
U wall*U wind*WWR_N	-1.5480	-0.7740	0.0405	-19.13	0.000	1.00
U wall*U wind*WWR_S	-2.6320	-1.3160	0.0405	-32.53	0.000	1.00
U wall*U wind*WWR_E	-0.2546	-0.1273	0.0405	-3.15	0.035	1.00
U wall*U wind*WWR_W	-1.1581	-0.5790	0.0405	-14.31	0.000	1.00
U wall*U wind*CELING	2.5937	1.2968	0.0405	32.06	0.000	1.00
U wall*U wind*FORM	-0.8954	-0.4477	0.0405	-11.07	0.000	1.00
U wall*WWR_N*WWR_W	3.3862	1.6931	0.0405	41.85	0.000	1.00
U wall*WWR_N*AREA	3.2485	1.6243	0.0405	40.15	0.000	1.00
U wall*WWR_E*AREA	-2.2171	-1.1085	0.0405	-27.40	0.000	1.00
U wall*WWR_W*AREA	0.2839	0.1420	0.0405	3.51	0.025	1.00
U roof*ColorWall*WWR_N	5.6390	2.8195	0.0405	69.69	0.000	1.00
U roof*ColorWall*WWR_W	6.7237	3.3619	0.0405	83.10	0.000	1.00
U roof*WWR_N*WWR_W	-2.8412	-1.4206	0.0405	-35.11	0.000	1.00
U grou*ColorWall*ColorRoof	-0.6395	-0.3197	0.0405	-7.90	0.001	1.00
U grou*U wind*CELING	-6.1294	-3.0647	0.0405	-75.75	0.000	1.00
ColorWall*ColorRoof*AREA	-7.1308	-3.5654	0.0405	-88.13	0.000	1.00
ColorWall*U wind*AREA	-5.5336	-2.7668	0.0405	-68.39	0.000	1.00
ColorWall*WWR_N*WWR_E	6.0126	3.0063	0.0405	74.31	0.000	1.00
ColorWall*WWR_N*CELING	5.5949	2.7974	0.0405	69.15	0.000	1.00
ColorWall*WWR_S*CELING	-2.0669	-1.0335	0.0405	-25.55	0.000	1.00
ColorWall*WWR_E*CELING	6.1397	3.0698	0.0405	75.88	0.000	1.00
ColorWall*WWR_W*CELING	-10.1062	-5.0531	0.0405	-124.90	0.000	1.00

Regression Equation in Uncoded Units

```
cooling = 76.6752 - 6.7517 U wall - 1.7125 U roof + 0.5354 U grou
+ 0.7700 ColorWall
          + 1.6456 ColorRoof - 3.5323 U wind - 0.3783 WWR_N - 6.8369 WWR_S -
 1.7611 WWR_E
          + 2.4893 WWR_W - 0.2607 CELING - 13.7061 AREA - 2.9924 FORM -
 0.7918 U wall*U roof
          + 0.5135 U wall*U grou - 0.9666 U wall*ColorWall
+ 3.9977 U wall*ColorRoof
          + 2.8390 U wall*U wind + 1.7796 U wall*WWR_N - 1.8751 U wall*WWR_S
          + 0.0190 U wall*WWR_E + 1.3674 U wall*WWR_W + 2.3393 U wall*CELING
          - 3.0945 U wall*AREA + 2.4437 U wall*FORM + 9.0301 U roof*ColorWall
          - 0.9412 U roof*ColorRoof - 3.8280 U roof*U wind + 2.3988 U roof*WWR_N
          - 0.7227 U roof*WWR_S + 0.7868 U roof*WWR_E + 1.9021 U roof*WWR_W
          + 1.2937 U roof*AREA - 6.0495 U grou*ColorWall -
 1.4387 U grou*ColorRoof
          - 1.6303 U grou*U wind - 2.5657 U grou*WWR_N + 2.5885 U grou*WWR_S
          + 6.6765 U grou*WWR_E + 3.1234 U grou*WWR_W - 5.3579 U grou*CELING
          + 2.3118 U grou*AREA - 3.8867 ColorWall*ColorRoof
+ 3.2706 ColorWall*U wind
          - 1.6151 ColorWall*WWR_N - 4.8847 ColorWall*WWR_S -
 3.2097 ColorWall*WWR_E
          - 1.4571 ColorWall*WWR_W - 2.7975 ColorWall*CELING -
 1.4523 ColorWall*AREA
          - 0.5160 ColorWall*FORM + 2.2275 ColorRoof*U wind -
 3.3553 ColorRoof*WWR_N
          + 2.2791 ColorRoof*WWR_S + 1.0126 ColorRoof*WWR_E -
 1.1860 ColorRoof*WWR_W
          + 2.5125 ColorRoof*CELING - 5.7824 ColorRoof*AREA -
 1.8796 ColorRoof*FORM
          + 0.3501 U wind*WWR_N - 3.7796 U wind*WWR_S + 0.1572 U wind*WWR_E
          - 3.1436 U wind*WWR_W - 2.0080 U wind*CELING + 3.5431 U wind*AREA
          + 5.2110 U wind*FORM - 3.3675 WWR_N*WWR_S + 6.7584 WWR_N*WWR_E
+ 0.7924 WWR_N*WWR_W
          - 1.4352 WWR_N*CELING + 1.1487 WWR_N*AREA + 1.6977 WWR_N*FORM -
 0.7406 WWR_S*CELING
          + 4.2307 WWR_S*AREA - 2.8445 WWR_S*FORM - 0.0364 WWR_E*CELING
+ 0.8270 WWR_E*AREA
          - 6.1612 WWR_E*FORM + 0.2620 WWR_W*CELING - 0.5091 WWR_W*AREA -
 0.6332 WWR_W*FORM
          - 1.4681 CELING*AREA - 0.8858 CELING*FORM + 0.3580 AREA*FORM
          - 2.2590 U wall*U roof*ColorWall + 0.1751 U wall*U roof*ColorRoof
          - 6.0285 U wall*U roof*U wind - 0.9513 U wall*U roof*AREA
          + 0.6335 U wall*U grou*ColorWall + 0.3618 U wall*U grou*WWR_N
          + 4.8230 U wall*U grou*WWR_S - 1.6405 U wall*U grou*WWR_E
          + 3.7381 U wall*U grou*WWR_W - 5.1980 U wall*U grou*CELING
          - 0.2294 U wall*ColorWall*ColorRoof - 2.1417 U wall*ColorWall*U wind
          - 2.0590 U wall*ColorWall*WWR_N + 3.2296 U wall*ColorWall*WWR_S
          - 0.5609 U wall*ColorWall*WWR_E - 3.7567 U wall*ColorWall*WWR_W
          + 3.7758 U wall*ColorRoof*CELING - 0.7740 U wall*U wind*WWR_N
          - 1.3160 U wall*U wind*WWR_S - 0.1273 U wall*U wind*WWR_E
          - 0.5790 U wall*U wind*WWR_W + 1.2968 U wall*U wind*CELING
          - 0.4477 U wall*U wind*FORM + 1.6931 U wall*WWR_N*WWR_W
+ 1.6243 U wall*WWR_N*AREA
          - 1.1085 U wall*WWR_E*AREA + 0.1420 U wall*WWR_W*AREA
          + 2.8195 U roof*ColorWall*WWR_N + 3.3619 U roof*ColorWall*WWR_W
          - 1.4206 U roof*WWR_N*WWR_W - 0.3197 U grou*ColorWall*ColorRoof
          - 3.0647 U grou*U wind*CELING - 3.5654 ColorWall*ColorRoof*AREA
          - 2.7668 ColorWall*U wind*AREA + 3.0063 ColorWall*WWR_N*WWR_E
          + 2.7974 ColorWall*WWR_N*CELING - 1.0335 ColorWall*WWR_S*CELING
          + 3.0698 ColorWall*WWR_E*CELING - 5.0531 ColorWall*WWR_W*CELING
```

Analysis of Variance (Adrar 128 for heating)

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	127	194415	1530.8	*	*
Linear	13	26092	2007.1	*	*
Uwall	1	2832	2832.4	*	*
Uroof	1	28	27.5	*	*
Uground	1	2131	2131.4	*	*
ColorWall	1	1165	1164.5	*	*
ColorRoof	1	238	237.5	*	*
Uwind	1	589	588.6	*	*
WWR_N	1	1198	1197.8	*	*
WWR_S	1	1076	1075.7	*	*
WWR_E	1	681	680.7	*	*
WWR_W	1	1269	1268.9	*	*
CeilingHeight	1	2604	2604.5	*	*
Area	1	10801	10801.0	*	*
FormSheap	1	1481	1481.4	*	*
2-Way Interactions	72	101097	1404.1	*	*
Uwall*Uroof	1	488	488.3	*	*
Uwall*Uground	1	767	766.6	*	*
Uwall*ColorWall	1	568	568.2	*	*
Uwall*ColorRoof	1	577	576.7	*	*
Uwall*Uwind	1	60	60.3	*	*
Uwall*WWR_N	1	164	164.3	*	*
Uwall*WWR_S	1	725	724.8	*	*
Uwall*WWR_E	1	65	65.1	*	*
Uwall*WWR_W	1	9	8.7	*	*
Uwall*CeilingHeight	1	1	0.7	*	*
Uwall*Area	1	490	490.0	*	*
Uwall*FormSheap	1	1070	1069.8	*	*
Uroof*ColorWall	1	919	919.2	*	*
Uroof*ColorRoof	1	16	16.1	*	*
Uroof*Uwind	1	206	206.5	*	*
Uroof*WWR_N	1	2404	2404.4	*	*
Uroof*WWR_S	1	26	25.7	*	*
Uroof*WWR_E	1	1528	1528.5	*	*
Uroof*WWR_W	1	3421	3421.1	*	*
Uroof*CeilingHeight	1	3179	3178.6	*	*
Uroof*Area	1	488	487.9	*	*
Uground*ColorWall	1	498	498.0	*	*
Uground*ColorRoof	1	1472	1472.3	*	*
Uground*Uwind	1	1289	1289.2	*	*
Uground*WWR_N	1	97	97.0	*	*
Uground*WWR_S	1	265	265.2	*	*
Uground*WWR_E	1	272	272.4	*	*
Uground*WWR_W	1	3797	3797.0	*	*
Uground*CeilingHeight	1	1920	1920.1	*	*
Uground*Area	1	80	80.4	*	*
ColorWall*ColorRoof	1	126	125.8	*	*
ColorWall*Uwind	1	2039	2039.0	*	*
ColorWall*WWR_N	1	238	237.7	*	*
ColorWall*WWR_S	1	1854	1853.8	*	*
ColorWall*WWR_E	1	407	407.4	*	*
ColorWall*WWR_W	1	11223	11222.8	*	*
ColorWall*CeilingHeight	1	1532	1532.0	*	*
ColorWall*Area	1	2354	2354.0	*	*
ColorWall*FormSheap	1	1026	1026.1	*	*
ColorRoof*Uwind	1	3011	3010.6	*	*
ColorRoof*WWR_N	1	3752	3751.5	*	*
ColorRoof*WWR_S	1	27	27.4	*	*
ColorRoof*WWR_E	1	109	109.2	*	*
ColorRoof*WWR_W	1	157	157.4	*	*
ColorRoof*CeilingHeight	1	682	681.9	*	*
ColorRoof*Area	1	1565	1564.6	*	*

ColorRoof*FormSheap	1	3850	3849.9	*	*
Uwind*WWR_N	1	288	287.6	*	*
Uwind*WWR_S	1	3943	3942.8	*	*
Uwind*WWR_E	1	524	524.3	*	*
Uwind*WWR_W	1	8458	8457.7	*	*
Uwind*CeilingHeight	1	796	796.5	*	*
Uwind*Area	1	12	12.0	*	*
Uwind*FormSheap	1	1255	1254.8	*	*
WWR_N*WWR_S	1	1445	1444.7	*	*
WWR_N*WWR_E	1	1112	1112.4	*	*
WWR_N*WWR_W	1	3424	3423.8	*	*
WWR_N*CeilingHeight	1	1407	1407.1	*	*
WWR_N*Area	1	2599	2599.1	*	*
WWR_N*FormSheap	1	993	992.8	*	*
WWR_S*CeilingHeight	1	1247	1247.5	*	*
WWR_S*Area	1	4159	4159.2	*	*
WWR_S*FormSheap	1	213	212.8	*	*
WWR_E*CeilingHeight	1	19	19.2	*	*
WWR_E*Area	1	414	414.1	*	*
WWR_E*FormSheap	1	336	336.2	*	*
WWR_W*CeilingHeight	1	625	625.4	*	*
WWR_W*Area	1	1955	1955.4	*	*
WWR_W*FormSheap	1	1199	1198.8	*	*
CeilingHeight*Area	1	1931	1931.2	*	*
CeilingHeight*FormSheap	1	1858	1857.6	*	*
Area*FormSheap	1	70	69.8	*	*
3-Way Interactions	42	67226	1600.6	*	*
Uwall*Uroof*ColorWall	1	567	567.2	*	*
Uwall*Uroof*ColorRoof	1	142	142.4	*	*
Uwall*Uroof*Uwind	1	1	0.6	*	*
Uwall*Uroof*Area	1	1928	1928.3	*	*
Uwall*Uground*ColorWall	1	345	344.8	*	*
Uwall*Uground*WWR_N	1	776	775.7	*	*
Uwall*Uground*WWR_S	1	5	4.9	*	*
Uwall*Uground*WWR_E	1	1655	1655.5	*	*
Uwall*Uground*WWR_W	1	1953	1953.3	*	*
Uwall*Uground*CeilingHeight	1	76	75.7	*	*
Uwall*ColorWall*ColorRoof	1	337	336.9	*	*
Uwall*ColorWall*Uwind	1	803	803.2	*	*
Uwall*ColorWall*WWR_N	1	1281	1281.3	*	*
Uwall*ColorWall*WWR_S	1	1729	1729.5	*	*
Uwall*ColorWall*WWR_E	1	11083	11082.7	*	*
Uwall*ColorWall*WWR_W	1	3024	3024.3	*	*
Uwall*ColorRoof*CeilingHeight	1	1012	1012.3	*	*
Uwall*Uwind*WWR_N	1	59	59.0	*	*
Uwall*Uwind*WWR_S	1	928	928.1	*	*
Uwall*Uwind*WWR_E	1	5753	5753.1	*	*
Uwall*Uwind*WWR_W	1	2210	2210.3	*	*
Uwall*Uwind*CeilingHeight	1	2207	2206.7	*	*
Uwall*Uwind*FormSheap	1	2050	2049.9	*	*
Uwall*WWR_N*WWR_W	1	5666	5665.7	*	*
Uwall*WWR_N*Area	1	904	903.6	*	*
Uwall*WWR_S*Area	1	2582	2581.8	*	*
Uwall*WWR_E*Area	1	26	25.9	*	*
Uwall*WWR_W*Area	1	92	92.4	*	*
Uroof*ColorWall*WWR_N	1	416	416.3	*	*
Uroof*ColorWall*WWR_S	1	145	145.4	*	*
Uroof*ColorWall*WWR_E	1	59	58.9	*	*
Uroof*ColorWall*WWR_W	1	18	17.6	*	*
Uroof*WWR_N*WWR_W	1	4609	4609.3	*	*
Uground*ColorWall*ColorRoof	1	4883	4883.3	*	*
Uground*Uwind*CeilingHeight	1	282	282.4	*	*
ColorWall*ColorRoof*Area	1	842	842.4	*	*
ColorWall*Uwind*Area	1	4578	4578.5	*	*
ColorWall*WWR_N*WWR_E	1	219	219.4	*	*
ColorWall*WWR_N*CeilingHeight	1	9	8.6	*	*
ColorWall*WWR_S*CeilingHeight	1	902	902.0	*	*
ColorWall*WWR_E*CeilingHeight	1	1066	1066.2	*	*

ColorWall*WWR_W*CeilingHeight	1	0	0.2	*	*
Error	0	*	*		
Total	127	194415			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100.00%	*	*

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		52.64	*	*	*	
Uwall	-9.408	-4.704	*	*	*	1.00
Uroof	-0.9274	-0.4637	*	*	*	1.00
Uground	-8.161	-4.081	*	*	*	1.00
ColorWall	-6.033	-3.016	*	*	*	1.00
ColorRoof	2.724	1.362	*	*	*	1.00
Uwind	4.289	2.144	*	*	*	1.00
WWR_N	6.118	3.059	*	*	*	1.00
WWR_S	-5.798	-2.899	*	*	*	1.00
WWR_E	4.612	2.306	*	*	*	1.00
WWR_W	-6.297	-3.149	*	*	*	1.00
CeilingHeight	9.022	4.511	*	*	*	1.00
Area	18.372	9.186	*	*	*	1.00
FormSheap	6.804	3.402	*	*	*	1.00
Uwall*Uroof	3.906	1.953	*	*	*	1.00
Uwall*Uground	4.895	2.447	*	*	*	1.00
Uwall*ColorWall	4.214	2.107	*	*	*	1.00
Uwall*ColorRoof	4.245	2.123	*	*	*	1.00
Uwall*Uwind	-1.3728	-0.6864	*	*	*	1.00
Uwall*WWR_N	-2.266	-1.133	*	*	*	1.00
Uwall*WWR_S	-4.759	-2.380	*	*	*	1.00
Uwall*WWR_E	-1.4258	-0.7129	*	*	*	1.00
Uwall*WWR_W	0.5218	0.2609	*	*	*	1.00
Uwall*CeilingHeight	0.14696	0.07348	*	*	*	1.00
Uwall*Area	-3.913	-1.957	*	*	*	1.00
Uwall*FormSheap	-5.782	-2.891	*	*	*	1.00
Uroof*ColorWall	5.360	2.680	*	*	*	1.00
Uroof*ColorRoof	-0.7094	-0.3547	*	*	*	1.00
Uroof*Uwind	2.540	1.270	*	*	*	1.00
Uroof*WWR_N	8.668	4.334	*	*	*	1.00
Uroof*WWR_S	0.8970	0.4485	*	*	*	1.00
Uroof*WWR_E	6.911	3.456	*	*	*	1.00
Uroof*WWR_W	10.340	5.170	*	*	*	1.00
Uroof*CeilingHeight	9.967	4.983	*	*	*	1.00
Uroof*Area	-3.905	-1.952	*	*	*	1.00
Uground*ColorWall	3.945	1.972	*	*	*	1.00
Uground*ColorRoof	6.783	3.392	*	*	*	1.00
Uground*Uwind	6.347	3.174	*	*	*	1.00
Uground*WWR_N	-1.7413	-0.8706	*	*	*	1.00
Uground*WWR_S	2.879	1.439	*	*	*	1.00
Uground*WWR_E	-2.918	-1.459	*	*	*	1.00
Uground*WWR_W	-10.893	-5.447	*	*	*	1.00
Uground*CeilingHeight	7.746	3.873	*	*	*	1.00
Uground*Area	1.5851	0.7925	*	*	*	1.00
ColorWall*ColorRoof	-1.9826	-0.9913	*	*	*	1.00
ColorWall*Uwind	-7.982	-3.991	*	*	*	1.00
ColorWall*WWR_N	2.725	1.363	*	*	*	1.00
ColorWall*WWR_S	7.611	3.806	*	*	*	1.00
ColorWall*WWR_E	-3.568	-1.784	*	*	*	1.00
ColorWall*WWR_W	18.727	9.364	*	*	*	1.00
ColorWall*CeilingHeight	-6.919	-3.460	*	*	*	1.00
ColorWall*Area	-8.577	-4.288	*	*	*	1.00
ColorWall*FormSheap	5.663	2.831	*	*	*	1.00

ColorRoof*Uwind	9.699	4.850	*	*	*	1.00
ColorRoof*WWR_N	10.828	5.414	*	*	*	1.00
ColorRoof*WWR_S	-0.9256	-0.4628	*	*	*	1.00
ColorRoof*WWR_E	-1.8477	-0.9238	*	*	*	1.00
ColorRoof*WWR_W	2.218	1.109	*	*	*	1.00
ColorRoof*CeilingHeight	-4.616	-2.308	*	*	*	1.00
ColorRoof*Area	-6.992	-3.496	*	*	*	1.00
ColorRoof*FormSheap	10.969	5.484	*	*	*	1.00
Uwind*WWR_N	-2.998	-1.499	*	*	*	1.00
Uwind*WWR_S	-11.100	-5.550	*	*	*	1.00
Uwind*WWR_E	-4.048	-2.024	*	*	*	1.00
Uwind*WWR_W	16.257	8.129	*	*	*	1.00
Uwind*CeilingHeight	-4.989	-2.495	*	*	*	1.00
Uwind*Area	0.6122	0.3061	*	*	*	1.00
Uwind*FormSheap	6.262	3.131	*	*	*	1.00
WWR_N*WWR_S	-6.719	-3.360	*	*	*	1.00
WWR_N*WWR_E	-5.896	-2.948	*	*	*	1.00
WWR_N*WWR_W	-10.344	-5.172	*	*	*	1.00
WWR_N*CeilingHeight	-6.631	-3.316	*	*	*	1.00
WWR_N*Area	9.012	4.506	*	*	*	1.00
WWR_N*FormSheap	-5.570	-2.785	*	*	*	1.00
WWR_S*CeilingHeight	-6.244	-3.122	*	*	*	1.00
WWR_S*Area	-11.401	-5.700	*	*	*	1.00
WWR_S*FormSheap	2.579	1.289	*	*	*	1.00
WWR_E*CeilingHeight	-0.7745	-0.3873	*	*	*	1.00
WWR_E*Area	-3.597	-1.799	*	*	*	1.00
WWR_E*FormSheap	3.241	1.621	*	*	*	1.00
WWR_W*CeilingHeight	4.421	2.210	*	*	*	1.00
WWR_W*Area	7.817	3.909	*	*	*	1.00
WWR_W*FormSheap	6.121	3.060	*	*	*	1.00
CeilingHeight*Area	7.769	3.884	*	*	*	1.00
CeilingHeight*FormSheap	7.619	3.809	*	*	*	1.00
Area*FormSheap	1.4772	0.7386	*	*	*	1.00
Uwall*Uroof*ColorWall	4.210	2.105	*	*	*	1.00
Uwall*Uroof*ColorRoof	2.110	1.055	*	*	*	1.00
Uwall*Uroof*Uwind	-0.13460	-0.06730	*	*	*	1.00
Uwall*Uroof*Area	7.763	3.881	*	*	*	1.00
Uwall*Uground*ColorWall	-3.282	-1.641	*	*	*	1.00
Uwall*Uground*WWR_N	-4.923	-2.462	*	*	*	1.00
Uwall*Uground*WWR_S	-0.3911	-0.1955	*	*	*	1.00
Uwall*Uground*WWR_E	7.193	3.596	*	*	*	1.00
Uwall*Uground*WWR_W	-7.813	-3.906	*	*	*	1.00
Uwall*Uground*CeilingHeight	1.5381	0.7690	*	*	*	1.00
Uwall*ColorWall*ColorRoof	3.245	1.622	*	*	*	1.00
Uwall*ColorWall*Uwind	-5.010	-2.505	*	*	*	1.00
Uwall*ColorWall*WWR_N	6.328	3.164	*	*	*	1.00
Uwall*ColorWall*WWR_S	7.352	3.676	*	*	*	1.00
Uwall*ColorWall*WWR_E	-18.610	-9.305	*	*	*	1.00
Uwall*ColorWall*WWR_W	-9.722	-4.861	*	*	*	1.00
Uwall*ColorRoof*CeilingHeight	-5.624	-2.812	*	*	*	1.00
Uwall*Uwind*WWR_N	1.3576	0.6788	*	*	*	1.00
Uwall*Uwind*WWR_S	5.386	2.693	*	*	*	1.00
Uwall*Uwind*WWR_E	13.408	6.704	*	*	*	1.00
Uwall*Uwind*WWR_W	-8.311	-4.156	*	*	*	1.00
Uwall*Uwind*CeilingHeight	8.304	4.152	*	*	*	1.00
Uwall*Uwind*FormSheap	8.004	4.002	*	*	*	1.00
Uwall*WWR_N*WWR_W	13.306	6.653	*	*	*	1.00
Uwall*WWR_N*Area	5.314	2.657	*	*	*	1.00
Uwall*WWR_S*Area	8.982	4.491	*	*	*	1.00
Uwall*WWR_E*Area	-0.8989	-0.4494	*	*	*	1.00
Uwall*WWR_W*Area	-1.6990	-0.8495	*	*	*	1.00
Uroof*ColorWall*WWR_N	3.607	1.803	*	*	*	1.00
Uroof*ColorWall*WWR_S	-2.131	-1.066	*	*	*	1.00
Uroof*ColorWall*WWR_E	1.3565	0.6783	*	*	*	1.00
Uroof*ColorWall*WWR_W	0.7419	0.3709	*	*	*	1.00
Uroof*WWR_N*WWR_W	12.002	6.001	*	*	*	1.00
Uground*ColorWall*ColorRoof	12.353	6.177	*	*	*	1.00
Uground*Uwind*CeilingHeight	-2.971	-1.485	*	*	*	1.00

ColorWall*ColorRoof*Area	-5.131	-2.565	*	*	*	1.00
ColorWall*Uwind*Area	11.961	5.981	*	*	*	1.00
ColorWall*WWR_N*WWR_E	-2.619	-1.309	*	*	*	1.00
ColorWall*WWR_N*CeilingHeight	-0.5179	-0.2590	*	*	*	1.00
ColorWall*WWR_S*CeilingHeight	-5.309	-2.655	*	*	*	1.00
ColorWall*WWR_E*CeilingHeight	5.772	2.886	*	*	*	1.00
ColorWall*WWR_W*CeilingHeight	-0.07277	-0.03638	*	*	*	1.00

Regression Equation in Uncoded Units

```
HEAT = 52.64 - 4.704 Uwall - 0.4637 Uroof - 4.081 Uground - 3.016 ColorWall
+ 1.362 ColorRoof
       + 2.144 Uwind + 3.059 WWR_N - 2.899 WWR_S + 2.306 WWR_E - 3.149 WWR_W
       + 4.511 CeilingHeight + 9.186 Area + 3.402 FormSheap + 1.953 Uwall*Uroof
       + 2.447 Uwall*Uground + 2.107 Uwall*ColorWall + 2.123 Uwall*ColorRoof
       - 0.6864 Uwall*Uwind - 1.133 Uwall*WWR_N - 2.380 Uwall*WWR_S -
 0.7129 Uwall*WWR_E
       + 0.2609 Uwall*WWR_W + 0.07348 Uwall*CeilingHeight - 1.957 Uwall*Area
       - 2.891 Uwall*FormSheap + 2.680 Uroof*ColorWall - 0.3547 Uroof*ColorRoof
       + 1.270 Uroof*Uwind + 4.334 Uroof*WWR_N + 0.4485 Uroof*WWR_S
+ 3.456 Uroof*WWR_E
       + 5.170 Uroof*WWR_W + 4.983 Uroof*CeilingHeight - 1.952 Uroof*Area
       + 1.972 Uground*ColorWall + 3.392 Uground*ColorRoof + 3.174 Uground*Uwind
       - 0.8706 Uground*WWR_N + 1.439 Uground*WWR_S - 1.459 Uground*WWR_E
       - 5.447 Uground*WWR_W + 3.873 Uground*CeilingHeight + 0.7925 Uground*Area
       - 0.9913 ColorWall*ColorRoof - 3.991 ColorWall*Uwind
+ 1.363 ColorWall*WWR_N
       + 3.806 ColorWall*WWR_S - 1.784 ColorWall*WWR_E + 9.364 ColorWall*WWR_W
       - 3.460 ColorWall*CeilingHeight - 4.288 ColorWall*Area
+ 2.831 ColorWall*FormSheap
       + 4.850 ColorRoof*Uwind + 5.414 ColorRoof*WWR_N - 0.4628 ColorRoof*WWR_S
       - 0.9238 ColorRoof*WWR_E + 1.109 ColorRoof*WWR_W -
 2.308 ColorRoof*CeilingHeight
       - 3.496 ColorRoof*Area + 5.484 ColorRoof*FormSheap - 1.499 Uwind*WWR_N
       - 5.550 Uwind*WWR_S - 2.024 Uwind*WWR_E + 8.129 Uwind*WWR_W
       - 2.495 Uwind*CeilingHeight + 0.3061 Uwind*Area + 3.131 Uwind*FormSheap
       - 3.360 WWR_N*WWR_S - 2.948 WWR_N*WWR_E - 5.172 WWR_N*WWR_W
       - 3.316 WWR_N*CeilingHeight + 4.506 WWR_N*Area - 2.785 WWR_N*FormSheap
       - 3.122 WWR_S*CeilingHeight - 5.700 WWR_S*Area + 1.289 WWR_S*FormSheap
       - 0.3873 WWR_E*CeilingHeight - 1.799 WWR_E*Area + 1.621 WWR_E*FormSheap
       + 2.210 WWR_W*CeilingHeight + 3.909 WWR_W*Area + 3.060 WWR_W*FormSheap
       + 3.884 CeilingHeight*Area + 3.809 CeilingHeight*FormSheap
+ 0.7386 Area*FormSheap
       + 2.105 Uwall*Uroof*ColorWall + 1.055 Uwall*Uroof*ColorRoof
       - 0.06730 Uwall*Uroof*Uwind + 3.881 Uwall*Uroof*Area -
 1.641 Uwall*Uground*ColorWall
       - 2.462 Uwall*Uground*WWR_N - 0.1955 Uwall*Uground*WWR_S
+ 3.596 Uwall*Uground*WWR_E
       - 3.906 Uwall*Uground*WWR_W + 0.7690 Uwall*Uground*CeilingHeight
       + 1.622 Uwall*ColorWall*ColorRoof - 2.505 Uwall*ColorWall*Uwind
       + 3.164 Uwall*ColorWall*WWR_N + 3.676 Uwall*ColorWall*WWR_S
       - 9.305 Uwall*ColorWall*WWR_E - 4.861 Uwall*ColorWall*WWR_W
       - 2.812 Uwall*ColorRoof*CeilingHeight + 0.6788 Uwall*Uwind*WWR_N
       + 2.693 Uwall*Uwind*WWR_S + 6.704 Uwall*Uwind*WWR_E -
 4.156 Uwall*Uwind*WWR_W
       + 4.152 Uwall*Uwind*CeilingHeight + 4.002 Uwall*Uwind*FormSheap
       + 6.653 Uwall*WWR_N*WWR_W + 2.657 Uwall*WWR_N*Area
+ 4.491 Uwall*WWR_S*Area
       - 0.4494 Uwall*WWR_E*Area - 0.8495 Uwall*WWR_W*Area
+ 1.803 Uroof*ColorWall*WWR_N
       - 1.066 Uroof*ColorWall*WWR_S + 0.6783 Uroof*ColorWall*WWR_E
       + 0.3709 Uroof*ColorWall*WWR_W + 6.001 Uroof*WWR_N*WWR_W
       + 6.177 Uground*ColorWall*ColorRoof - 1.485 Uground*Uwind*CeilingHeight
       - 2.565 ColorWall*ColorRoof*Area + 5.981 ColorWall*Uwind*Area
       - 1.309 ColorWall*WWR_N*WWR_E - 0.2590 ColorWall*WWR_N*CeilingHeight
       - 2.655 ColorWall*WWR_S*CeilingHeight
+ 2.886 ColorWall*WWR_E*CeilingHeight
```

- 0.03638 ColorWall*WWR_W*CeilingHeight

Analysis of Variance (Tamnrasset 128 for cooling)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	120	113317	944.3	352.84	0.000
Linear	13	29062	2235.6	835.31	0.000
U wall	1	5234	5234.3	1955.77	0.000
U roof	1	52	51.9	19.39	0.003
U grou	1	218	217.8	81.37	0.000
ColorWall	1	2	1.5	0.58	0.473
ColorRoof	1	16	15.9	5.96	0.045
U wind	1	707	707.5	264.35	0.000
WWR_N	1	18	17.6	6.59	0.037
WWR_S	1	2566	2566.4	958.93	0.000
WWR_E	1	390	389.8	145.66	0.000
WWR_W	1	854	854.2	319.17	0.000
CELING	1	38	38.4	14.36	0.007
AREA	1	18197	18196.9	6799.19	0.000
FORM	1	770	770.0	287.70	0.000
2-Way Interactions	69	59123	856.8	320.16	0.000
U wall*U roof	1	2	2.5	0.92	0.369
U wall*U grou	1	92	91.9	34.34	0.001
U wall*ColorWall	1	248	248.5	92.84	0.000
U wall*ColorRoof	1	814	813.8	304.06	0.000
U wall*U wind	1	996	996.0	372.16	0.000
U wall*WWR_N	1	758	757.9	283.18	0.000
U wall*WWR_S	1	45	44.6	16.68	0.005
U wall*WWR_E	1	1	0.8	0.30	0.602
U wall*WWR_W	1	86	85.7	32.02	0.001
U wall*CELING	1	806	805.6	301.03	0.000
U wall*AREA	1	1035	1034.9	386.69	0.000
U wall*FORM	1	1082	1081.5	404.11	0.000
U roof*ColorWall	1	7536	7536.3	2815.89	0.000
U roof*ColorRoof	1	364	363.8	135.95	0.000
U roof*U wind	1	588	588.1	219.75	0.000
U roof*WWR_N	1	593	592.7	221.44	0.000
U roof*WWR_S	1	20	20.0	7.47	0.029
U roof*WWR_E	1	18	17.8	6.64	0.037
U roof*WWR_W	1	449	448.6	167.60	0.000
U roof*CELING	1	65	64.5	24.12	0.002
U roof*AREA	1	7	7.2	2.69	0.145
U grou*ColorWall	1	4377	4377.4	1635.61	0.000
U grou*ColorRoof	1	650	650.0	242.86	0.000
U grou*U wind	1	37	37.3	13.94	0.007
U grou*WWR_N	1	210	210.0	78.48	0.000
U grou*WWR_S	1	1298	1298.1	485.01	0.000
U grou*WWR_E	1	4272	4271.8	1596.13	0.000
U grou*WWR_W	1	349	348.6	130.27	0.000
U grou*CELING	1	2351	2351.3	878.56	0.000
U grou*AREA	1	16	15.6	5.84	0.046
ColorWall*ColorRoof	1	834	833.8	311.53	0.000
ColorWall*U wind	1	1372	1372.3	512.74	0.000
ColorWall*WWR_N	1	430	429.9	160.64	0.000
ColorWall*WWR_S	1	2859	2858.6	1068.09	0.000
ColorWall*WWR_E	1	911	911.0	340.40	0.000
ColorWall*WWR_W	1	27	26.9	10.07	0.016
ColorWall*CELING	1	1155	1155.4	431.70	0.000
ColorWall*AREA	1	62	62.0	23.18	0.002
ColorWall*FORM	1	151	150.7	56.32	0.000
ColorRoof*U wind	1	214	214.0	79.95	0.000
ColorRoof*WWR_N	1	1842	1841.9	688.21	0.000
ColorRoof*WWR_S	1	277	276.5	103.33	0.000
ColorRoof*WWR_E	1	319	318.8	119.13	0.000
ColorRoof*WWR_W	1	284	283.6	105.95	0.000
ColorRoof*CELING	1	281	280.6	104.84	0.000
ColorRoof*AREA	1	1742	1741.9	650.87	0.000
ColorRoof*FORM	1	444	444.3	166.01	0.000
U wind*WWR_N	1	70	70.0	26.16	0.001

U wind*WWR_S	1	851	850.8	317.90	0.000
U wind*WWR_E	1	51	51.3	19.18	0.003
U wind*WWR_W	1	981	980.7	366.44	0.000
U wind*CELING	1	873	872.7	326.09	0.000
U wind*AREA	1	1104	1103.9	412.48	0.000
U wind*FORM	1	2887	2887.0	1078.71	0.000
WWR_N*WWR_S	1	578	578.1	216.01	0.000
WWR_N*WWR_E	1	2942	2941.7	1099.16	0.000
WWR_N*WWR_W	1	187	186.6	69.71	0.000
WWR_N*CELING	1	29	28.8	10.75	0.014
WWR_N*AREA	1	14	14.5	5.40	0.053
WWR_N*FORM	1	566	566.1	211.52	0.000
WWR_S*CELING	1	47	46.6	17.41	0.004
WWR_S*AREA	1	788	788.5	294.60	0.000
WWR_S*FORM	1	132	132.4	49.46	0.000
WWR_E*CELING	1	207	207.5	77.53	0.000
WWR_E*AREA	1	41	40.7	15.21	0.006
WWR_E*FORM	1	4055	4054.6	1514.97	0.000
WWR_W*CELING	1	21	21.2	7.91	0.026
WWR_W*FORM	1	156	156.0	58.30	0.000
CELING*AREA	1	178	177.9	66.47	0.000
3-Way Interactions	38	25132	661.4	247.12	0.000
U wall*U roof*ColorWall	1	1577	1577.1	589.27	0.000
U wall*U roof*U wind	1	2987	2987.1	1116.10	0.000
U wall*U roof*AREA	1	177	177.0	66.13	0.000
U wall*U grou*ColorWall	1	11	10.7	4.00	0.086
U wall*U grou*WWR_N	1	156	156.1	58.31	0.000
U wall*U grou*WWR_S	1	2580	2580.5	964.18	0.000
U wall*U grou*WWR_E	1	946	945.6	353.30	0.000
U wall*U grou*WWR_W	1	1012	1011.8	378.07	0.000
U wall*U grou*CELING	1	1153	1152.8	430.73	0.000
U wall*ColorWall*U wind	1	1393	1393.2	520.54	0.000
U wall*ColorWall*WWR_N	1	772	771.7	288.33	0.000
U wall*ColorWall*WWR_S	1	685	684.5	255.77	0.000
U wall*ColorWall*WWR_W	1	992	991.5	370.48	0.000
U wall*ColorRoof*CELING	1	1125	1124.8	420.28	0.000
U wall*U wind*WWR_N	1	33	33.1	12.38	0.010
U wall*U wind*WWR_S	1	197	196.7	73.50	0.000
U wall*U wind*WWR_E	1	139	139.5	52.11	0.000
U wall*U wind*WWR_W	1	144	143.7	53.70	0.000
U wall*U wind*CELING	1	485	484.6	181.06	0.000
U wall*U wind*FORM	1	13	13.3	4.96	0.061
U wall*WWR_N*WWR_W	1	123	123.3	46.06	0.000
U wall*WWR_N*AREA	1	17	17.1	6.38	0.039
U wall*WWR_S*AREA	1	189	188.9	70.57	0.000
U wall*WWR_E*AREA	1	9	8.5	3.19	0.117
U roof*ColorWall*WWR_N	1	296	296.0	110.61	0.000
U roof*ColorWall*WWR_S	1	10	10.5	3.92	0.088
U roof*ColorWall*WWR_E	1	66	66.1	24.70	0.002
U roof*ColorWall*WWR_W	1	1530	1529.7	571.57	0.000
U roof*WWR_N*WWR_W	1	428	427.8	159.83	0.000
U grou*ColorWall*ColorRoof	1	172	172.1	64.30	0.000
U grou*U wind*CELING	1	394	393.6	147.07	0.000
ColorWall*ColorRoof*AREA	1	1199	1198.8	447.91	0.000
ColorWall*U wind*AREA	1	511	511.4	191.10	0.000
ColorWall*WWR_N*WWR_E	1	524	524.1	195.84	0.000
ColorWall*WWR_N*CELING	1	263	262.9	98.24	0.000
ColorWall*WWR_S*CELING	1	151	150.5	56.25	0.000
ColorWall*WWR_E*CELING	1	1177	1177.4	439.95	0.000
ColorWall*WWR_W*CELING	1	1499	1498.5	559.91	0.000
Error	7	19	2.7		
Total	127	113336			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.63595	99.98%	99.70%	94.47%

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		61.546	0.145	425.63	0.000	
U wall	-12.789	-6.395	0.145	-44.22	0.000	1.00
U roof	-1.273	-0.637	0.145	-4.40	0.003	1.00
U grou	2.609	1.304	0.145	9.02	0.000	1.00
ColorWall	0.220	0.110	0.145	0.76	0.473	1.00
ColorRoof	0.706	0.353	0.145	2.44	0.045	1.00
U wind	-4.702	-2.351	0.145	-16.26	0.000	1.00
WWR_N	0.742	0.371	0.145	2.57	0.037	1.00
WWR_S	-8.955	-4.478	0.145	-30.97	0.000	1.00
WWR_E	-3.490	-1.745	0.145	-12.07	0.000	1.00
WWR_W	5.167	2.583	0.145	17.87	0.000	1.00
CELING	1.096	0.548	0.145	3.79	0.007	1.00
AREA	-23.846	-11.923	0.145	-82.46	0.000	1.00
FORM	-4.905	-2.453	0.145	-16.96	0.000	1.00
U wall*U roof	-0.277	-0.139	0.145	-0.96	0.369	1.00
U wall*U grou	1.695	0.847	0.145	5.86	0.001	1.00
U wall*ColorWall	-2.787	-1.393	0.145	-9.64	0.000	1.00
U wall*ColorRoof	5.043	2.521	0.145	17.44	0.000	1.00
U wall*U wind	5.579	2.790	0.145	19.29	0.000	1.00
U wall*WWR_N	4.867	2.433	0.145	16.83	0.000	1.00
U wall*WWR_S	-1.181	-0.590	0.145	-4.08	0.005	1.00
U wall*WWR_E	0.158	0.079	0.145	0.55	0.602	1.00
U wall*WWR_W	1.637	0.818	0.145	5.66	0.001	1.00
U wall*CELING	5.018	2.509	0.145	17.35	0.000	1.00
U wall*AREA	-5.687	-2.843	0.145	-19.66	0.000	1.00
U wall*FORM	5.814	2.907	0.145	20.10	0.000	1.00
U roof*ColorWall	15.346	7.673	0.145	53.06	0.000	1.00
U roof*ColorRoof	-3.372	-1.686	0.145	-11.66	0.000	1.00
U roof*U wind	-4.287	-2.144	0.145	-14.82	0.000	1.00
U roof*WWR_N	4.304	2.152	0.145	14.88	0.000	1.00
U roof*WWR_S	-0.791	-0.395	0.145	-2.73	0.029	1.00
U roof*WWR_E	0.745	0.373	0.145	2.58	0.037	1.00
U roof*WWR_W	3.744	1.872	0.145	12.95	0.000	1.00
U roof*CELING	1.420	0.710	0.145	4.91	0.002	1.00
U roof*AREA	0.474	0.237	0.145	1.64	0.145	1.00
U grou*ColorWall	-11.696	-5.848	0.145	-40.44	0.000	1.00
U grou*ColorRoof	-4.507	-2.253	0.145	-15.58	0.000	1.00
U grou*U wind	-1.080	-0.540	0.145	-3.73	0.007	1.00
U grou*WWR_N	-2.562	-1.281	0.145	-8.86	0.000	1.00
U grou*WWR_S	6.369	3.185	0.145	22.02	0.000	1.00
U grou*WWR_E	11.554	5.777	0.145	39.95	0.000	1.00
U grou*WWR_W	3.301	1.650	0.145	11.41	0.000	1.00
U grou*CELING	-8.572	-4.286	0.145	-29.64	0.000	1.00
U grou*AREA	0.699	0.349	0.145	2.42	0.046	1.00
ColorWall*ColorRoof	-5.104	-2.552	0.145	-17.65	0.000	1.00
ColorWall*U wind	6.549	3.274	0.145	22.64	0.000	1.00
ColorWall*WWR_N	-3.665	-1.833	0.145	-12.67	0.000	1.00
ColorWall*WWR_S	-9.451	-4.726	0.145	-32.68	0.000	1.00
ColorWall*WWR_E	-5.336	-2.668	0.145	-18.45	0.000	1.00
ColorWall*WWR_W	-0.918	-0.459	0.145	-3.17	0.016	1.00
ColorWall*CELING	-6.009	-3.004	0.145	-20.78	0.000	1.00
ColorWall*AREA	-1.392	-0.696	0.145	-4.81	0.002	1.00
ColorWall*FORM	-2.170	-1.085	0.145	-7.50	0.000	1.00
ColorRoof*U wind	2.586	1.293	0.145	8.94	0.000	1.00
ColorRoof*WWR_N	-7.587	-3.793	0.145	-26.23	0.000	1.00
ColorRoof*WWR_S	2.940	1.470	0.145	10.16	0.000	1.00
ColorRoof*WWR_E	3.157	1.578	0.145	10.91	0.000	1.00
ColorRoof*WWR_W	-2.977	-1.488	0.145	-10.29	0.000	1.00
ColorRoof*CELING	2.961	1.481	0.145	10.24	0.000	1.00
ColorRoof*AREA	-7.378	-3.689	0.145	-25.51	0.000	1.00
ColorRoof*FORM	-3.726	-1.863	0.145	-12.88	0.000	1.00
U wind*WWR_N	1.479	0.740	0.145	5.11	0.001	1.00
U wind*WWR_S	-5.156	-2.578	0.145	-17.83	0.000	1.00

U wind*WWR_E	-1.267	-0.633	0.145	-4.38	0.003	1.00
U wind*WWR_W	-5.536	-2.768	0.145	-19.14	0.000	1.00
U wind*CELING	-5.222	-2.611	0.145	-18.06	0.000	1.00
U wind*AREA	5.874	2.937	0.145	20.31	0.000	1.00
U wind*FORM	9.498	4.749	0.145	32.84	0.000	1.00
WWR_N*WWR_S	-4.250	-2.125	0.145	-14.70	0.000	1.00
WWR_N*WWR_E	9.588	4.794	0.145	33.15	0.000	1.00
WWR_N*WWR_W	2.415	1.207	0.145	8.35	0.000	1.00
WWR_N*CELING	-0.948	-0.474	0.145	-3.28	0.014	1.00
WWR_N*AREA	0.672	0.336	0.145	2.32	0.053	1.00
WWR_N*FORM	4.206	2.103	0.145	14.54	0.000	1.00
WWR_S*CELING	1.207	0.603	0.145	4.17	0.004	1.00
WWR_S*AREA	4.964	2.482	0.145	17.16	0.000	1.00
WWR_S*FORM	-2.034	-1.017	0.145	-7.03	0.000	1.00
WWR_E*CELING	-2.546	-1.273	0.145	-8.81	0.000	1.00
WWR_E*AREA	1.128	0.564	0.145	3.90	0.006	1.00
WWR_E*FORM	-11.256	-5.628	0.145	-38.92	0.000	1.00
WWR_W*CELING	-0.813	-0.407	0.145	-2.81	0.026	1.00
WWR_W*FORM	-2.208	-1.104	0.145	-7.64	0.000	1.00
CELING*AREA	-2.358	-1.179	0.145	-8.15	0.000	1.00
U wall*U roof*ColorWall	-7.020	-3.510	0.145	-24.27	0.000	1.00
U wall*U roof*U wind	-9.662	-4.831	0.145	-33.41	0.000	1.00
U wall*U roof*AREA	-2.352	-1.176	0.145	-8.13	0.000	1.00
U wall*U grou*ColorWall	0.578	0.289	0.145	2.00	0.086	1.00
U wall*U grou*WWR_N	2.208	1.104	0.145	7.64	0.000	1.00
U wall*U grou*WWR_S	8.980	4.490	0.145	31.05	0.000	1.00
U wall*U grou*WWR_E	-5.436	-2.718	0.145	-18.80	0.000	1.00
U wall*U grou*WWR_W	5.623	2.812	0.145	19.44	0.000	1.00
U wall*U grou*CELING	-6.002	-3.001	0.145	-20.75	0.000	1.00
U wall*ColorWall*U wind	-6.598	-3.299	0.145	-22.82	0.000	1.00
U wall*ColorWall*WWR_N	-4.911	-2.455	0.145	-16.98	0.000	1.00
U wall*ColorWall*WWR_S	4.625	2.313	0.145	15.99	0.000	1.00
U wall*ColorWall*WWR_W	-5.566	-2.783	0.145	-19.25	0.000	1.00
U wall*ColorRoof*CELING	5.929	2.964	0.145	20.50	0.000	1.00
U wall*U wind*WWR_N	1.017	0.509	0.145	3.52	0.010	1.00
U wall*U wind*WWR_S	-2.479	-1.240	0.145	-8.57	0.000	1.00
U wall*U wind*WWR_E	-2.088	-1.044	0.145	-7.22	0.000	1.00
U wall*U wind*WWR_W	-2.119	-1.060	0.145	-7.33	0.000	1.00
U wall*U wind*CELING	3.891	1.946	0.145	13.46	0.000	1.00
U wall*U wind*FORM	0.644	0.322	0.145	2.23	0.061	1.00
U wall*WWR_N*WWR_W	1.963	0.981	0.145	6.79	0.000	1.00
U wall*WWR_N*AREA	0.731	0.365	0.145	2.53	0.039	1.00
U wall*WWR_S*AREA	-2.429	-1.215	0.145	-8.40	0.000	1.00
U wall*WWR_E*AREA	-0.517	-0.258	0.145	-1.79	0.117	1.00
U roof*ColorWall*WWR_N	3.042	1.521	0.145	10.52	0.000	1.00
U roof*ColorWall*WWR_S	-0.573	-0.286	0.145	-1.98	0.088	1.00
U roof*ColorWall*WWR_E	1.437	0.719	0.145	4.97	0.002	1.00
U roof*ColorWall*WWR_W	6.914	3.457	0.145	23.91	0.000	1.00
U roof*WWR_N*WWR_W	-3.656	-1.828	0.145	-12.64	0.000	1.00
U grou*ColorWall*ColorRoof	2.319	1.160	0.145	8.02	0.000	1.00
U grou*U wind*CELING	-3.507	-1.754	0.145	-12.13	0.000	1.00
ColorWall*ColorRoof*AREA	-6.121	-3.060	0.145	-21.16	0.000	1.00
ColorWall*U wind*AREA	-3.998	-1.999	0.145	-13.82	0.000	1.00
ColorWall*WWR_N*WWR_E	4.047	2.024	0.145	13.99	0.000	1.00
ColorWall*WWR_N*CELING	2.866	1.433	0.145	9.91	0.000	1.00
ColorWall*WWR_S*CELING	-2.169	-1.085	0.145	-7.50	0.000	1.00
ColorWall*WWR_E*CELING	6.066	3.033	0.145	20.97	0.000	1.00
ColorWall*WWR_W*CELING	-6.843	-3.422	0.145	-23.66	0.000	1.00

Regression Equation in Uncoded Units

```
cooling = 61.546 - 6.395 U wall - 0.637 U roof + 1.304 U grou + 0.110 ColorWall
          + 0.353 ColorRoof - 2.351 U wind + 0.371 WWR_N - 4.478 WWR_S -
 1.745 WWR_E
          + 2.583 WWR_W + 0.548 CELING - 11.923 AREA - 2.453 FORM -
 0.139 U wall*U roof
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          + 0.847 U wall*U grou - 1.393 U wall*ColorWall
+ 2.521 U wall*ColorRoof
          + 2.790 U wall*U wind + 2.433 U wall*WWR_N - 0.590 U wall*WWR_S
          + 0.079 U wall*WWR_E + 0.818 U wall*WWR_W + 2.509 U wall*CELING -
 2.843 U wall*AREA
          + 2.907 U wall*FORM + 7.673 U roof*ColorWall - 1.686 U roof*ColorRoof
          - 2.144 U roof*U wind + 2.152 U roof*WWR_N - 0.395 U roof*WWR_S
          + 0.373 U roof*WWR_E + 1.872 U roof*WWR_W + 0.710 U roof*CELING
+ 0.237 U roof*AREA
          - 5.848 U grou*ColorWall - 2.253 U grou*ColorRoof -
 0.540 U grou*U wind
          - 1.281 U grou*WWR_N + 3.185 U grou*WWR_S + 5.777 U grou*WWR_E
+ 1.650 U grou*WWR_W
          - 4.286 U grou*CELING + 0.349 U grou*AREA - 2.552 ColorWall*ColorRoof
          + 3.274 ColorWall*U wind - 1.833 ColorWall*WWR_N -
 4.726 ColorWall*WWR_S
          - 2.668 ColorWall*WWR_E - 0.459 ColorWall*WWR_W -
 3.004 ColorWall*CELING
          - 0.696 ColorWall*AREA - 1.085 ColorWall*FORM + 1.293 ColorRoof*U wind
          - 3.793 ColorRoof*WWR_N + 1.470 ColorRoof*WWR_S
+ 1.578 ColorRoof*WWR_E
          - 1.488 ColorRoof*WWR_W + 1.481 ColorRoof*CELING -
 3.689 ColorRoof*AREA
          - 1.863 ColorRoof*FORM + 0.740 U wind*WWR_N - 2.578 U wind*WWR_S
          - 0.633 U wind*WWR_E - 2.768 U wind*WWR_W - 2.611 U wind*CELING
+ 2.937 U wind*AREA
          + 4.749 U wind*FORM - 2.125 WWR_N*WWR_S + 4.794 WWR_N*WWR_E
+ 1.207 WWR_N*WWR_W
          - 0.474 WWR_N*CELING + 0.336 WWR_N*AREA + 2.103 WWR_N*FORM
+ 0.603 WWR_S*CELING
          + 2.482 WWR_S*AREA - 1.017 WWR_S*FORM - 1.273 WWR_E*CELING
+ 0.564 WWR_E*AREA
          - 5.628 WWR_E*FORM - 0.407 WWR_W*CELING - 1.104 WWR_W*FORM -
 1.179 CELING*AREA
          - 3.510 U wall*U roof*ColorWall - 4.831 U wall*U roof*U wind
          - 1.176 U wall*U roof*AREA + 0.289 U wall*U grou*ColorWall
          + 1.104 U wall*U grou*WWR_N + 4.490 U wall*U grou*WWR_S -
 2.718 U wall*U grou*WWR_E
          + 2.812 U wall*U grou*WWR_W - 3.001 U wall*U grou*CELING
          - 3.299 U wall*ColorWall*U wind - 2.455 U wall*ColorWall*WWR_N
          + 2.313 U wall*ColorWall*WWR_S - 2.783 U wall*ColorWall*WWR_W
          + 2.964 U wall*ColorRoof*CELING + 0.509 U wall*U wind*WWR_N
          - 1.240 U wall*U wind*WWR_S - 1.044 U wall*U wind*WWR_E -
 1.060 U wall*U wind*WWR_W
          + 1.946 U wall*U wind*CELING + 0.322 U wall*U wind*FORM
+ 0.981 U wall*WWR_N*WWR_W
          + 0.365 U wall*WWR_N*AREA - 1.215 U wall*WWR_S*AREA -
 0.258 U wall*WWR_E*AREA
          + 1.521 U roof*ColorWall*WWR_N - 0.286 U roof*ColorWall*WWR_S
          + 0.719 U roof*ColorWall*WWR_E + 3.457 U roof*ColorWall*WWR_W
          - 1.828 U roof*WWR_N*WWR_W + 1.160 U grou*ColorWall*ColorRoof
          - 1.754 U grou*U wind*CELING - 3.060 ColorWall*ColorRoof*AREA
          - 1.999 ColorWall*U wind*AREA + 2.024 ColorWall*WWR_N*WWR_E
          + 1.433 ColorWall*WWR_N*CELING - 1.085 ColorWall*WWR_S*CELING
          + 3.033 ColorWall*WWR_E*CELING - 3.422 ColorWall*WWR_W*CELING
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Analysis of Variance (Tamnrasset 128 for heating)

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	125	280386	2243.1	2485.83	0.000
Linear	13	56170	4320.7	4788.31	0.000
U wall	1	12082	12082.1	13389.61	0.000
U roof	1	22	21.7	24.00	0.039
U grou	1	68	67.7	75.03	0.013
ColorWall	1	1009	1009.1	1118.32	0.001
ColorRoof	1	2539	2539.0	2813.71	0.000
U wind	1	3777	3777.5	4186.28	0.000
WWR_N	1	44	43.5	48.21	0.020
WWR_S	1	298	297.6	329.78	0.003
WWR_E	1	1347	1346.6	1492.28	0.001
WWR_W	1	14909	14909.3	16522.66	0.000
CELING	1	1072	1072.4	1188.42	0.001
AREA	1	14817	14817.3	16420.72	0.000
FORM	1	4186	4186.0	4639.00	0.000
2-Way Interactions	72	151249	2100.7	2328.01	0.000
U wall*U roof	1	0	0.2	0.27	0.657
U wall*U grou	1	1168	1168.2	1294.60	0.001
U wall*ColorWall	1	2220	2220.4	2460.72	0.000
U wall*ColorRoof	1	112	111.8	123.91	0.008
U wall*U wind	1	1611	1611.4	1785.77	0.001
U wall*WWR_N	1	261	260.8	289.06	0.003
U wall*WWR_S	1	101	101.0	111.94	0.009
U wall*WWR_E	1	1506	1505.7	1668.60	0.001
U wall*WWR_W	1	4372	4372.1	4845.24	0.000
U wall*CELING	1	55	55.3	61.30	0.016
U wall*AREA	1	2097	2097.2	2324.12	0.000
U wall*FORM	1	886	886.3	982.17	0.001
U roof*ColorWall	1	9198	9198.2	10193.57	0.000
U roof*ColorRoof	1	2521	2520.6	2793.37	0.000
U roof*U wind	1	1142	1142.3	1265.86	0.001
U roof*WWR_N	1	95	95.2	105.54	0.009
U roof*WWR_S	1	3663	3663.1	4059.46	0.000
U roof*WWR_E	1	1934	1934.5	2143.82	0.000
U roof*WWR_W	1	3873	3873.3	4292.40	0.000
U roof*CELING	1	913	913.2	1012.03	0.001
U roof*AREA	1	143	142.6	157.98	0.006
U grou*ColorWall	1	4451	4451.5	4933.18	0.000
U grou*ColorRoof	1	4940	4940.0	5474.63	0.000
U grou*U wind	1	753	753.2	834.73	0.001
U grou*WWR_N	1	772	772.0	855.51	0.001
U grou*WWR_S	1	8748	8747.8	9694.46	0.000
U grou*WWR_E	1	3086	3085.9	3419.79	0.000
U grou*WWR_W	1	886	885.9	981.82	0.001
U grou*CELING	1	773	772.8	856.39	0.001
U grou*AREA	1	1436	1436.4	1591.82	0.001
ColorWall*ColorRoof	1	1407	1407.2	1559.47	0.001
ColorWall*U wind	1	9220	9220.2	10217.99	0.000
ColorWall*WWR_N	1	1295	1295.1	1435.21	0.001
ColorWall*WWR_S	1	88	88.4	97.98	0.010
ColorWall*WWR_E	1	2968	2967.6	3288.74	0.000
ColorWall*WWR_W	1	177	177.5	196.68	0.005
ColorWall*CELING	1	360	360.4	399.37	0.002
ColorWall*AREA	1	1092	1092.4	1210.63	0.001
ColorWall*FORM	1	604	603.5	668.83	0.001
ColorRoof*U wind	1	507	507.1	561.94	0.002
ColorRoof*WWR_N	1	3661	3660.9	4057.11	0.000
ColorRoof*WWR_S	1	487	487.2	539.97	0.002
ColorRoof*WWR_E	1	2527	2527.1	2800.59	0.000
ColorRoof*WWR_W	1	5322	5321.5	5897.42	0.000
ColorRoof*CELING	1	142	141.9	157.31	0.006
ColorRoof*AREA	1	935	934.7	1035.83	0.001
ColorRoof*FORM	1	73	73.5	81.42	0.012

U wind*WWR_N	1	352	352.2	390.32	0.003
U wind*WWR_S	1	1437	1437.2	1592.70	0.001
U wind*WWR_E	1	221	221.4	245.32	0.004
U wind*WWR_W	1	144	144.0	159.63	0.006
U wind*CELING	1	16619	16619.3	18417.80	0.000
U wind*AREA	1	6507	6507.4	7211.64	0.000
U wind*FORM	1	514	513.8	569.41	0.002
WWR_N*WWR_S	1	2344	2344.2	2597.87	0.000
WWR_N*WWR_E	1	2481	2481.0	2749.46	0.000
WWR_N*WWR_W	1	7565	7565.4	8384.11	0.000
WWR_N*CELING	1	94	93.9	104.02	0.009
WWR_N*AREA	1	322	322.3	357.13	0.003
WWR_N*FORM	1	862	861.8	955.06	0.001
WWR_S*CELING	1	1507	1507.1	1670.24	0.001
WWR_S*AREA	1	577	576.7	639.12	0.002
WWR_S*FORM	1	2254	2254.4	2498.40	0.000
WWR_E*CELING	1	5650	5650.0	6261.36	0.000
WWR_E*AREA	1	1291	1291.2	1430.93	0.001
WWR_E*FORM	1	1967	1966.7	2179.51	0.000
WWR_W*CELING	1	12	12.0	13.30	0.068
WWR_W*AREA	1	1134	1133.6	1256.33	0.001
WWR_W*FORM	1	17	17.5	19.34	0.048
CELING*AREA	1	2378	2378.4	2635.77	0.000
CELING*FORM	1	301	301.0	333.58	0.003
AREA*FORM	1	112	111.8	123.95	0.008
3-Way Interactions	40	72967	1824.2	2021.58	0.000
U wall*U roof*ColorWall	1	8605	8604.7	9535.90	0.000
U wall*U roof*ColorRoof	1	1056	1055.9	1170.15	0.001
U wall*U roof*U wind	1	2933	2933.1	3250.47	0.000
U wall*U roof*AREA	1	932	932.4	1033.26	0.001
U wall*U grou*ColorWall	1	2759	2759.5	3058.09	0.000
U wall*U grou*WWR_N	1	1624	1624.4	1800.24	0.001
U wall*U grou*WWR_S	1	664	664.4	736.26	0.001
U wall*U grou*WWR_E	1	4346	4345.6	4815.91	0.000
U wall*U grou*WWR_W	1	670	670.4	742.91	0.001
U wall*U grou*CELING	1	972	972.0	1077.16	0.001
U wall*ColorWall*ColorRoof	1	2767	2766.6	3066.01	0.000
U wall*ColorWall*U wind	1	4168	4168.2	4619.21	0.000
U wall*ColorWall*WWR_N	1	1786	1786.0	1979.25	0.001
U wall*ColorWall*WWR_S	1	4620	4620.4	5120.38	0.000
U wall*ColorWall*WWR_E	1	175	175.5	194.44	0.005
U wall*ColorWall*WWR_W	1	26	26.3	29.19	0.033
U wall*ColorRoof*CELING	1	4626	4625.8	5126.39	0.000
U wall*U wind*WWR_N	1	1248	1248.3	1383.40	0.001
U wall*U wind*WWR_S	1	6610	6610.1	7325.39	0.000
U wall*U wind*WWR_W	1	219	219.1	242.85	0.004
U wall*U wind*CELING	1	1421	1421.5	1575.31	0.001
U wall*U wind*FORM	1	1109	1109.0	1229.02	0.001
U wall*WWR_N*WWR_W	1	743	743.3	823.70	0.001
U wall*WWR_N*AREA	1	565	564.9	626.02	0.002
U wall*WWR_S*AREA	1	1179	1179.3	1306.95	0.001
U wall*WWR_E*AREA	1	663	662.5	734.21	0.001
U wall*WWR_W*AREA	1	2999	2998.8	3323.35	0.000
U roof*ColorWall*WWR_N	1	2875	2875.2	3186.34	0.000
U roof*ColorWall*WWR_S	1	828	828.1	917.74	0.001
U roof*ColorWall*WWR_E	1	92	91.9	101.89	0.010
U roof*ColorWall*WWR_W	1	369	369.3	409.25	0.002
U grou*ColorWall*ColorRoof	1	3542	3541.6	3924.84	0.000
U grou*U wind*CELING	1	8	8.1	8.99	0.096
ColorWall*ColorRoof*AREA	1	458	458.4	507.98	0.002
ColorWall*U wind*AREA	1	319	318.7	353.16	0.003
ColorWall*WWR_N*WWR_E	1	2802	2802.2	3105.49	0.000
ColorWall*WWR_N*CELING	1	1054	1054.4	1168.45	0.001
ColorWall*WWR_S*CELING	1	121	120.8	133.83	0.007
ColorWall*WWR_E*CELING	1	933	933.1	1034.10	0.001
ColorWall*WWR_W*CELING	1	77	77.5	85.86	0.011
Error	2	2	0.9		
Total	127	280388			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.949922	100.00%	99.96%	97.36%

Coded Coefficients

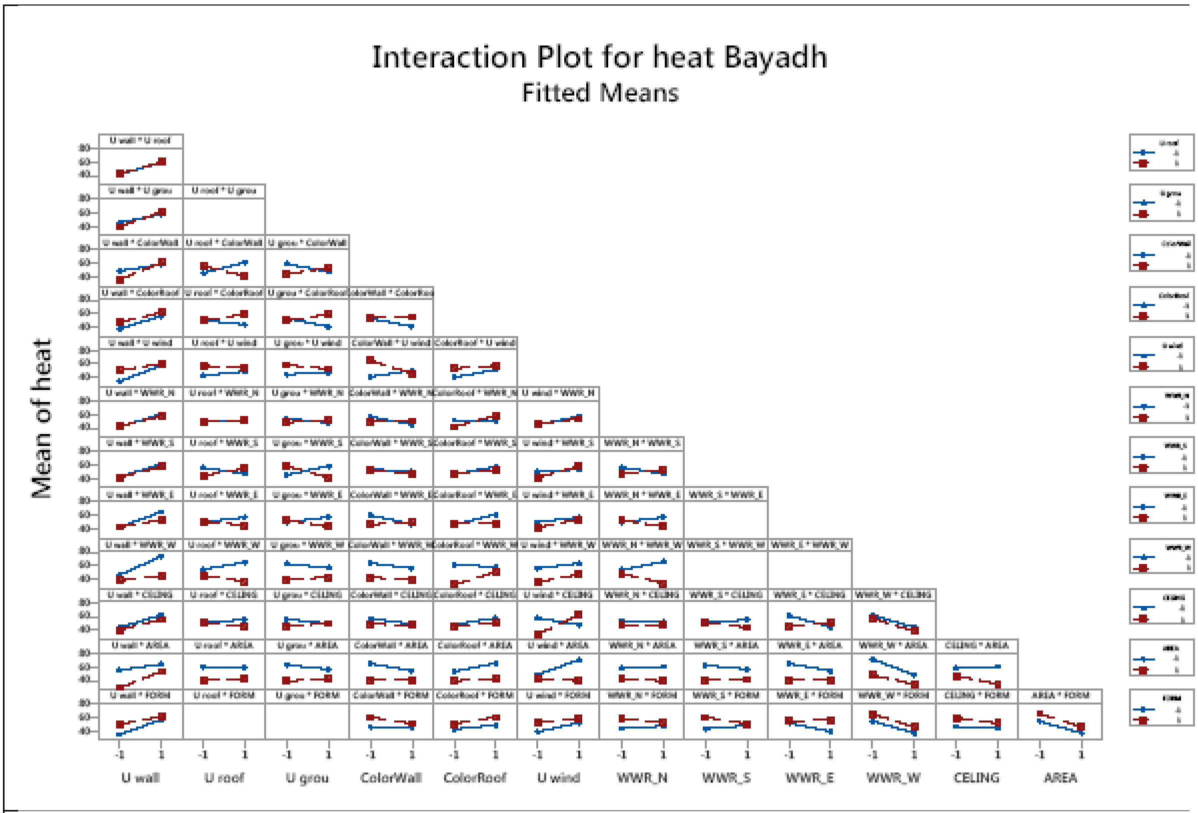
Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		58.7933	0.0840	700.24	0.000	
U wall	19.4311	9.7155	0.0840	115.71	0.000	1.00
U roof	0.8227	0.4113	0.0840	4.90	0.039	1.00
U grou	-1.4545	-0.7273	0.0840	-8.66	0.013	1.00
ColorWall	-5.6156	-2.8078	0.0840	-33.44	0.001	1.00
ColorRoof	8.9074	4.4537	0.0840	53.04	0.000	1.00
U wind	10.8649	5.4325	0.0840	64.70	0.000	1.00
WWR_N	-1.1660	-0.5830	0.0840	-6.94	0.020	1.00
WWR_S	-3.0495	-1.5247	0.0840	-18.16	0.003	1.00
WWR_E	-6.4869	-3.2435	0.0840	-38.63	0.001	1.00
WWR_W	-21.5850	-10.7925	0.0840	-128.54	0.000	1.00
CELING	-5.7889	-2.8945	0.0840	-34.47	0.001	1.00
AREA	-21.5184	-10.7592	0.0840	-128.14	0.000	1.00
FORM	11.4373	5.7187	0.0840	68.11	0.000	1.00
U wall*U roof	-0.0868	-0.0434	0.0840	-0.52	0.657	1.00
U wall*U grou	6.0420	3.0210	0.0840	35.98	0.001	1.00
U wall*ColorWall	8.3300	4.1650	0.0840	49.61	0.000	1.00
U wall*ColorRoof	-1.8692	-0.9346	0.0840	-11.13	0.008	1.00
U wall*U wind	-7.0962	-3.5481	0.0840	-42.26	0.001	1.00
U wall*WWR_N	-2.8550	-1.4275	0.0840	-17.00	0.003	1.00
U wall*WWR_S	-1.7767	-0.8883	0.0840	-10.58	0.009	1.00
U wall*WWR_E	-6.8595	-3.4297	0.0840	-40.85	0.001	1.00
U wall*WWR_W	-11.6888	-5.8444	0.0840	-69.61	0.000	1.00
U wall*CELING	-1.3147	-0.6574	0.0840	-7.83	0.016	1.00
U wall*AREA	8.0955	4.0477	0.0840	48.21	0.000	1.00
U wall*FORM	-5.2627	-2.6313	0.0840	-31.34	0.001	1.00
U roof*ColorWall	-16.9542	-8.4771	0.0840	-100.96	0.000	1.00
U roof*ColorRoof	8.8752	4.4376	0.0840	52.85	0.000	1.00
U roof*U wind	-5.9746	-2.9873	0.0840	-35.58	0.001	1.00
U roof*WWR_N	1.7252	0.8626	0.0840	10.27	0.009	1.00
U roof*WWR_S	10.6991	5.3495	0.0840	63.71	0.000	1.00
U roof*WWR_E	-7.7751	-3.8876	0.0840	-46.30	0.000	1.00
U roof*WWR_W	-11.0018	-5.5009	0.0840	-65.52	0.000	1.00
U roof*CELING	-5.3421	-2.6710	0.0840	-31.81	0.001	1.00
U roof*AREA	2.1106	1.0553	0.0840	12.57	0.006	1.00
U grou*ColorWall	11.7944	5.8972	0.0840	70.24	0.000	1.00
U grou*ColorRoof	12.4248	6.2124	0.0840	73.99	0.000	1.00
U grou*U wind	-4.8516	-2.4258	0.0840	-28.89	0.001	1.00
U grou*WWR_N	4.9116	2.4558	0.0840	29.25	0.001	1.00
U grou*WWR_S	-16.5339	-8.2669	0.0840	-98.46	0.000	1.00
U grou*WWR_E	-9.8200	-4.9100	0.0840	-58.48	0.000	1.00
U grou*WWR_W	5.2617	2.6309	0.0840	31.33	0.001	1.00
U grou*CELING	4.9142	2.4571	0.0840	29.26	0.001	1.00
U grou*AREA	6.6998	3.3499	0.0840	39.90	0.001	1.00
ColorWall*ColorRoof	6.6313	3.3157	0.0840	39.49	0.001	1.00
ColorWall*U wind	-16.9745	-8.4872	0.0840	-101.08	0.000	1.00
ColorWall*WWR_N	6.3617	3.1808	0.0840	37.88	0.001	1.00
ColorWall*WWR_S	-1.6622	-0.8311	0.0840	-9.90	0.010	1.00
ColorWall*WWR_E	9.6300	4.8150	0.0840	57.35	0.000	1.00
ColorWall*WWR_W	2.3550	1.1775	0.0840	14.02	0.005	1.00
ColorWall*CELING	3.3558	1.6779	0.0840	19.98	0.002	1.00
ColorWall*AREA	5.8428	2.9214	0.0840	34.79	0.001	1.00
ColorWall*FORM	-4.3428	-2.1714	0.0840	-25.86	0.001	1.00
ColorRoof*U wind	-3.9807	-1.9903	0.0840	-23.71	0.002	1.00
ColorRoof*WWR_N	10.6960	5.3480	0.0840	63.70	0.000	1.00
ColorRoof*WWR_S	-3.9021	-1.9511	0.0840	-23.24	0.002	1.00
ColorRoof*WWR_E	-8.8867	-4.4433	0.0840	-52.92	0.000	1.00

ColorRoof*WWR_W	12.8957	6.4478	0.0840	76.79	0.000	1.00
ColorRoof*CELING	-2.1061	-1.0531	0.0840	-12.54	0.006	1.00
ColorRoof*AREA	-5.4045	-2.7023	0.0840	-32.18	0.001	1.00
ColorRoof*FORM	1.5152	0.7576	0.0840	9.02	0.012	1.00
U wind*WWR_N	-3.3176	-1.6588	0.0840	-19.76	0.003	1.00
U wind*WWR_S	6.7016	3.3508	0.0840	39.91	0.001	1.00
U wind*WWR_E	2.6302	1.3151	0.0840	15.66	0.004	1.00
U wind*WWR_W	2.1216	1.0608	0.0840	12.63	0.006	1.00
U wind*CELING	22.7894	11.3947	0.0840	135.71	0.000	1.00
U wind*AREA	-14.2603	-7.1302	0.0840	-84.92	0.000	1.00
U wind*FORM	-4.0071	-2.0035	0.0840	-23.86	0.002	1.00
WWR_N*WWR_S	8.5590	4.2795	0.0840	50.97	0.000	1.00
WWR_N*WWR_E	-8.8052	-4.4026	0.0840	-52.44	0.000	1.00
WWR_N*WWR_W	-15.3759	-7.6880	0.0840	-91.56	0.000	1.00
WWR_N*CELING	1.7127	0.8563	0.0840	10.20	0.009	1.00
WWR_N*AREA	-3.1734	-1.5867	0.0840	-18.90	0.003	1.00
WWR_N*FORM	-5.1895	-2.5948	0.0840	-30.90	0.001	1.00
WWR_S*CELING	-6.8628	-3.4314	0.0840	-40.87	0.001	1.00
WWR_S*AREA	4.2453	2.1226	0.0840	25.28	0.002	1.00
WWR_S*FORM	-8.3935	-4.1968	0.0840	-49.98	0.000	1.00
WWR_E*CELING	13.2876	6.6438	0.0840	79.13	0.000	1.00
WWR_E*AREA	6.3522	3.1761	0.0840	37.83	0.001	1.00
WWR_E*FORM	7.8396	3.9198	0.0840	46.69	0.000	1.00
WWR_W*CELING	-0.6125	-0.3063	0.0840	-3.65	0.068	1.00
WWR_W*AREA	5.9520	2.9760	0.0840	35.44	0.001	1.00
WWR_W*FORM	-0.7386	-0.3693	0.0840	-4.40	0.048	1.00
CELING*AREA	-8.6212	-4.3106	0.0840	-51.34	0.000	1.00
CELING*FORM	-3.0670	-1.5335	0.0840	-18.26	0.003	1.00
AREA*FORM	-1.8695	-0.9348	0.0840	-11.13	0.008	1.00
U wall*U roof*ColorWall	16.3981	8.1991	0.0840	97.65	0.000	1.00
U wall*U roof*ColorRoof	5.7443	2.8721	0.0840	34.21	0.001	1.00
U wall*U roof*U wind	9.5738	4.7869	0.0840	57.01	0.000	1.00
U wall*U roof*AREA	-5.3978	-2.6989	0.0840	-32.14	0.001	1.00
U wall*U grou*ColorWall	-9.2862	-4.6431	0.0840	-55.30	0.000	1.00
U wall*U grou*WWR_N	-7.1249	-3.5624	0.0840	-42.43	0.001	1.00
U wall*U grou*WWR_S	-4.5565	-2.2782	0.0840	-27.13	0.001	1.00
U wall*U grou*WWR_E	11.6534	5.8267	0.0840	69.40	0.000	1.00
U wall*U grou*WWR_W	-4.5770	-2.2885	0.0840	-27.26	0.001	1.00
U wall*U grou*CELING	-5.5113	-2.7556	0.0840	-32.82	0.001	1.00
U wall*ColorWall*ColorRoof	9.2982	4.6491	0.0840	55.37	0.000	1.00
U wall*ColorWall*U wind	11.4129	5.7065	0.0840	67.96	0.000	1.00
U wall*ColorWall*WWR_N	7.4707	3.7354	0.0840	44.49	0.001	1.00
U wall*ColorWall*WWR_S	-12.0161	-6.0081	0.0840	-71.56	0.000	1.00
U wall*ColorWall*WWR_E	-2.3416	-1.1708	0.0840	-13.94	0.005	1.00
U wall*ColorWall*WWR_W	0.9073	0.4537	0.0840	5.40	0.033	1.00
U wall*ColorRoof*CELING	-12.0232	-6.0116	0.0840	-71.60	0.000	1.00
U wall*U wind*WWR_N	-6.2458	-3.1229	0.0840	-37.19	0.001	1.00
U wall*U wind*WWR_S	14.3724	7.1862	0.0840	85.59	0.000	1.00
U wall*U wind*WWR_W	-2.6169	-1.3084	0.0840	-15.58	0.004	1.00
U wall*U wind*CELING	-6.6649	-3.3325	0.0840	-39.69	0.001	1.00
U wall*U wind*FORM	-5.8870	-2.9435	0.0840	-35.06	0.001	1.00
U wall*WWR_N*WWR_W	-4.8194	-2.4097	0.0840	-28.70	0.001	1.00
U wall*WWR_N*AREA	-4.2015	-2.1008	0.0840	-25.02	0.002	1.00
U wall*WWR_S*AREA	6.0708	3.0354	0.0840	36.15	0.001	1.00
U wall*WWR_E*AREA	-4.5501	-2.2751	0.0840	-27.10	0.001	1.00
U wall*WWR_W*AREA	9.6806	4.8403	0.0840	57.65	0.000	1.00
U roof*ColorWall*WWR_N	9.4789	4.7395	0.0840	56.45	0.000	1.00
U roof*ColorWall*WWR_S	-5.0871	-2.5436	0.0840	-30.29	0.001	1.00
U roof*ColorWall*WWR_E	-1.6951	-0.8475	0.0840	-10.09	0.010	1.00
U roof*ColorWall*WWR_W	-3.3971	-1.6985	0.0840	-20.23	0.002	1.00
U grou*ColorWall*ColorRoof	-10.5202	-5.2601	0.0840	-62.65	0.000	1.00
U grou*U wind*CELING	-0.5035	-0.2517	0.0840	-3.00	0.096	1.00
ColorWall*ColorRoof*AREA	-3.7848	-1.8924	0.0840	-22.54	0.002	1.00
ColorWall*U wind*AREA	3.1557	1.5779	0.0840	18.79	0.003	1.00
ColorWall*WWR_N*WWR_E	9.3579	4.6789	0.0840	55.73	0.000	1.00
ColorWall*WWR_N*CELING	5.7401	2.8700	0.0840	34.18	0.001	1.00
ColorWall*WWR_S*CELING	1.9427	0.9713	0.0840	11.57	0.007	1.00
ColorWall*WWR_E*CELING	-5.4000	-2.7000	0.0840	-32.16	0.001	1.00

```
ColorWall*WWR_W*CELING       -1.5560   -0.7780   0.0840    -9.27    0.011  1.00


Regression Equation in Uncoded Units

heat = 58.7933 + 9.7155 U wall + 0.4113 U roof - 0.7273 U grou -
 2.8078 ColorWall
       + 4.4537 ColorRoof + 5.4325 U wind - 0.5830 WWR_N - 1.5247 WWR_S -
 3.2435 WWR_E
       - 10.7925 WWR_W - 2.8945 CELING - 10.7592 AREA + 5.7187 FORM -
 0.0434 U wall*U roof
       + 3.0210 U wall*U grou + 4.1650 U wall*ColorWall -
 0.9346 U wall*ColorRoof
       - 3.5481 U wall*U wind - 1.4275 U wall*WWR_N - 0.8883 U wall*WWR_S
       - 3.4297 U wall*WWR_E - 5.8444 U wall*WWR_W - 0.6574 U wall*CELING
       + 4.0477 U wall*AREA - 2.6313 U wall*FORM - 8.4771 U roof*ColorWall
       + 4.4376 U roof*ColorRoof - 2.9873 U roof*U wind + 0.8626 U roof*WWR_N
       + 5.3495 U roof*WWR_S - 3.8876 U roof*WWR_E - 5.5009 U roof*WWR_W
       - 2.6710 U roof*CELING + 1.0553 U roof*AREA + 5.8972 U grou*ColorWall
       + 6.2124 U grou*ColorRoof - 2.4258 U grou*U wind + 2.4558 U grou*WWR_N
       - 8.2669 U grou*WWR_S - 4.9100 U grou*WWR_E + 2.6309 U grou*WWR_W
       + 2.4571 U grou*CELING + 3.3499 U grou*AREA + 3.3157 ColorWall*ColorRoof
       - 8.4872 ColorWall*U wind + 3.1808 ColorWall*WWR_N -
 0.8311 ColorWall*WWR_S
       + 4.8150 ColorWall*WWR_E + 1.1775 ColorWall*WWR_W
+ 1.6779 ColorWall*CELING
       + 2.9214 ColorWall*AREA - 2.1714 ColorWall*FORM - 1.9903 ColorRoof*U wind
       + 5.3480 ColorRoof*WWR_N - 1.9511 ColorRoof*WWR_S -
 4.4433 ColorRoof*WWR_E
       + 6.4478 ColorRoof*WWR_W - 1.0531 ColorRoof*CELING -
 2.7023 ColorRoof*AREA
       + 0.7576 ColorRoof*FORM - 1.6588 U wind*WWR_N + 3.3508 U wind*WWR_S
       + 1.3151 U wind*WWR_E + 1.0608 U wind*WWR_W + 11.3947 U wind*CELING
       - 7.1302 U wind*AREA - 2.0035 U wind*FORM + 4.2795 WWR_N*WWR_S -
 4.4026 WWR_N*WWR_E
       - 7.6880 WWR_N*WWR_W + 0.8563 WWR_N*CELING - 1.5867 WWR_N*AREA -
 2.5948 WWR_N*FORM
       - 3.4314 WWR_S*CELING + 2.1226 WWR_S*AREA - 4.1968 WWR_S*FORM
+ 6.6438 WWR_E*CELING
       + 3.1761 WWR_E*AREA + 3.9198 WWR_E*FORM - 0.3063 WWR_W*CELING
+ 2.9760 WWR_W*AREA
       - 0.3693 WWR_W*FORM - 4.3106 CELING*AREA - 1.5335 CELING*FORM -
 0.9348 AREA*FORM
       + 8.1991 U wall*U roof*ColorWall + 2.8721 U wall*U roof*ColorRoof
       + 4.7869 U wall*U roof*U wind - 2.6989 U wall*U roof*AREA
       - 4.6431 U wall*U grou*ColorWall - 3.5624 U wall*U grou*WWR_N
       - 2.2782 U wall*U grou*WWR_S + 5.8267 U wall*U grou*WWR_E -
 2.2885 U wall*U grou*WWR_W
       - 2.7556 U wall*U grou*CELING + 4.6491 U wall*ColorWall*ColorRoof
       + 5.7065 U wall*ColorWall*U wind + 3.7354 U wall*ColorWall*WWR_N
       - 6.0081 U wall*ColorWall*WWR_S - 1.1708 U wall*ColorWall*WWR_E
       + 0.4537 U wall*ColorWall*WWR_W - 6.0116 U wall*ColorRoof*CELING
       - 3.1229 U wall*U wind*WWR_N + 7.1862 U wall*U wind*WWR_S -
 1.3084 U wall*U wind*WWR_W
       - 3.3325 U wall*U wind*CELING - 2.9435 U wall*U wind*FORM -
 2.4097 U wall*WWR_N*WWR_W
       - 2.1008 U wall*WWR_N*AREA + 3.0354 U wall*WWR_S*AREA -
 2.2751 U wall*WWR_E*AREA
       + 4.8403 U wall*WWR_W*AREA + 4.7395 U roof*ColorWall*WWR_N
       - 2.5436 U roof*ColorWall*WWR_S - 0.8475 U roof*ColorWall*WWR_E
       - 1.6985 U roof*ColorWall*WWR_W - 5.2601 U grou*ColorWall*ColorRoof
       - 0.2517 U grou*U wind*CELING - 1.8924 ColorWall*ColorRoof*AREA
       + 1.5779 ColorWall*U wind*AREA + 4.6789 ColorWall*WWR_N*WWR_E
       + 2.8700 ColorWall*WWR_N*CELING + 0.9713 ColorWall*WWR_S*CELING
       - 2.7000 ColorWall*WWR_E*CELING - 0.7780 ColorWall*WWR_W*CELING
```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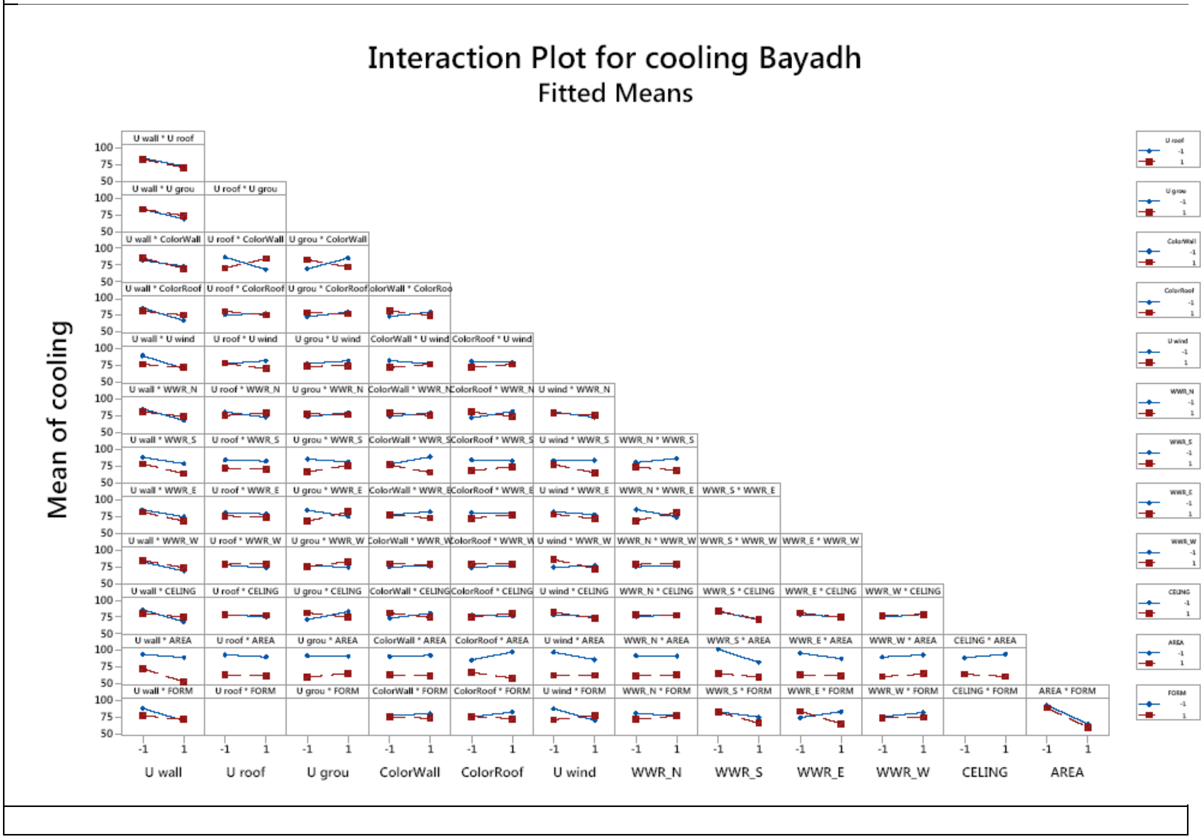
Fitted Means
Mean of heat
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
WWR_N
WWR_S
WWR_E
WWR_W
CELING
AREA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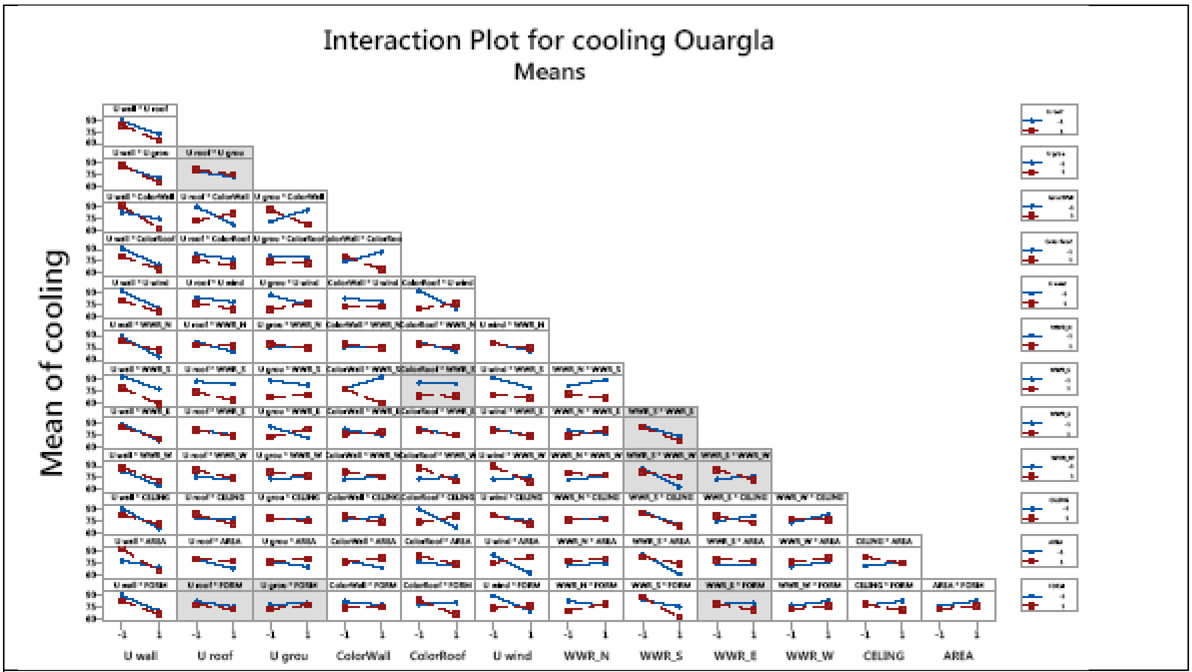
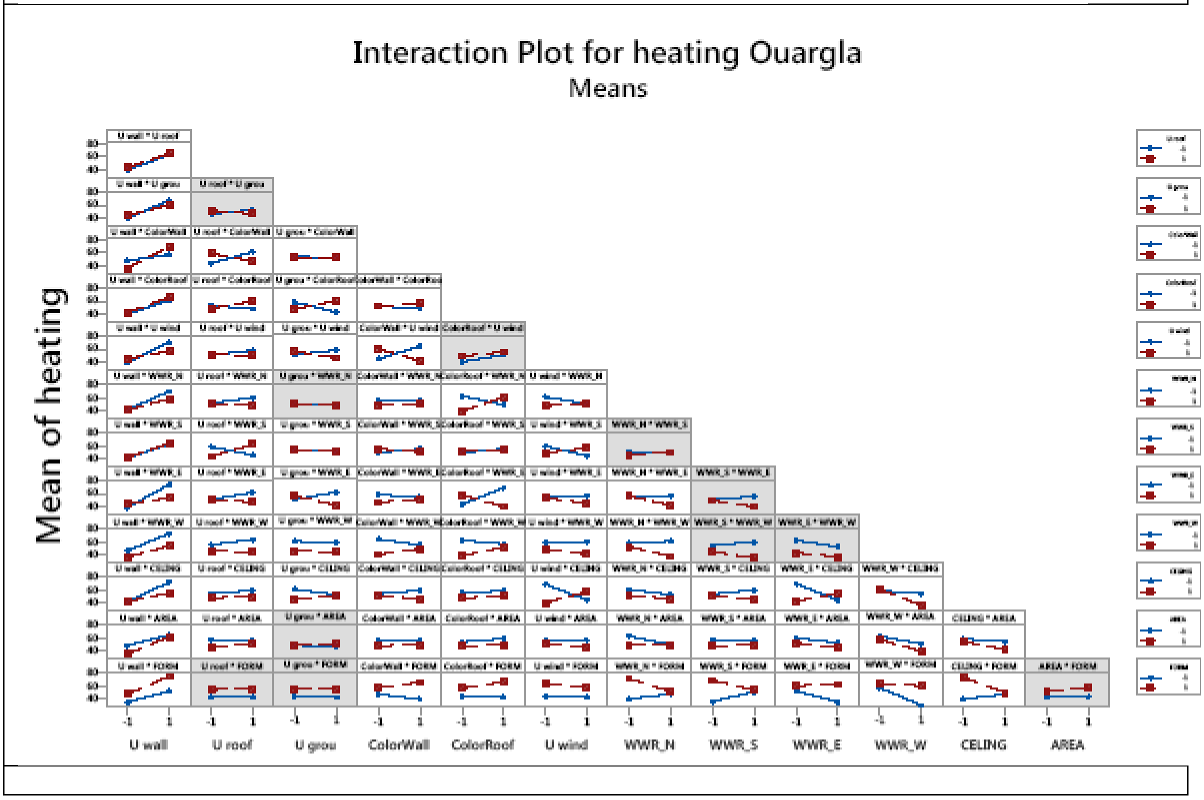
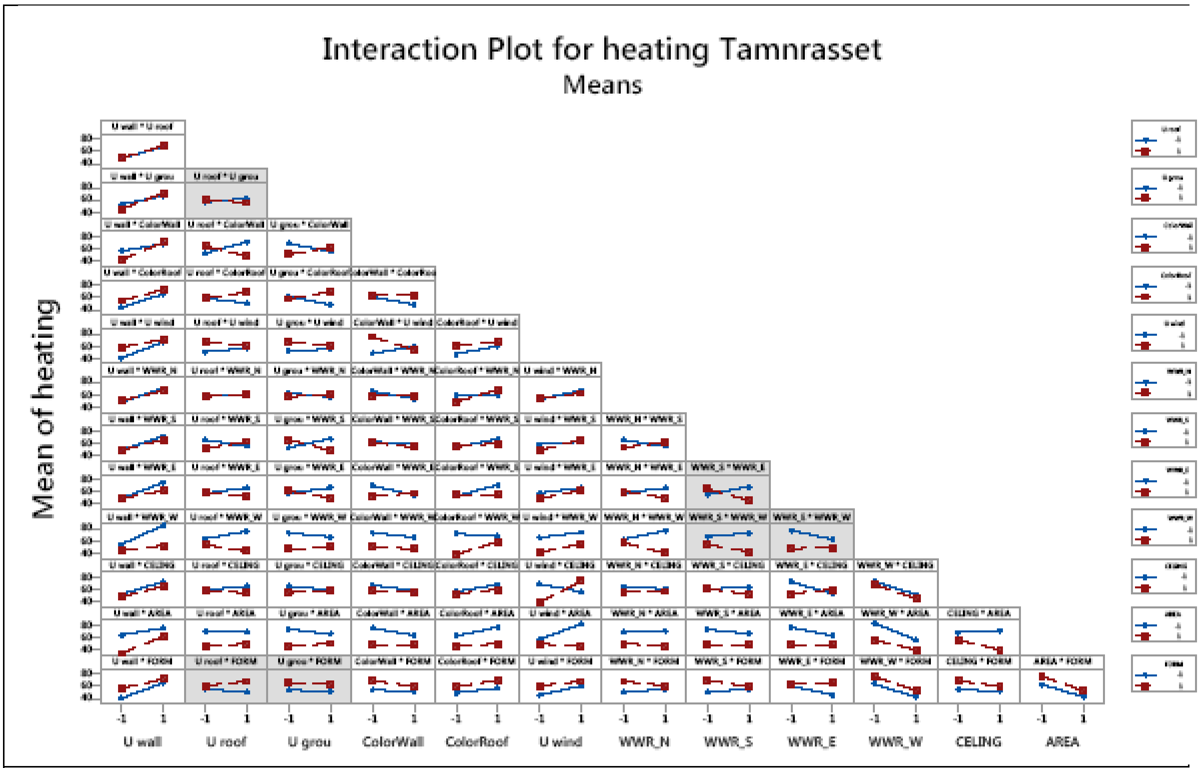
Fitted Means
Mean of cooling
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
WWR_N
WWR_S
WWR_E
WWR_W
CELING
AREA



Interaction Plot for cooling Ouargla
Means
Mean of cooling
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
WWR_N
WWR_S
WWR_E
WWR_W
CELING
AREA



Interaction Plot for heating Ouargla
Means
Mean of heating
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
WWR_N
WWR_S
WWR_E
WWR_W
CELING
AREA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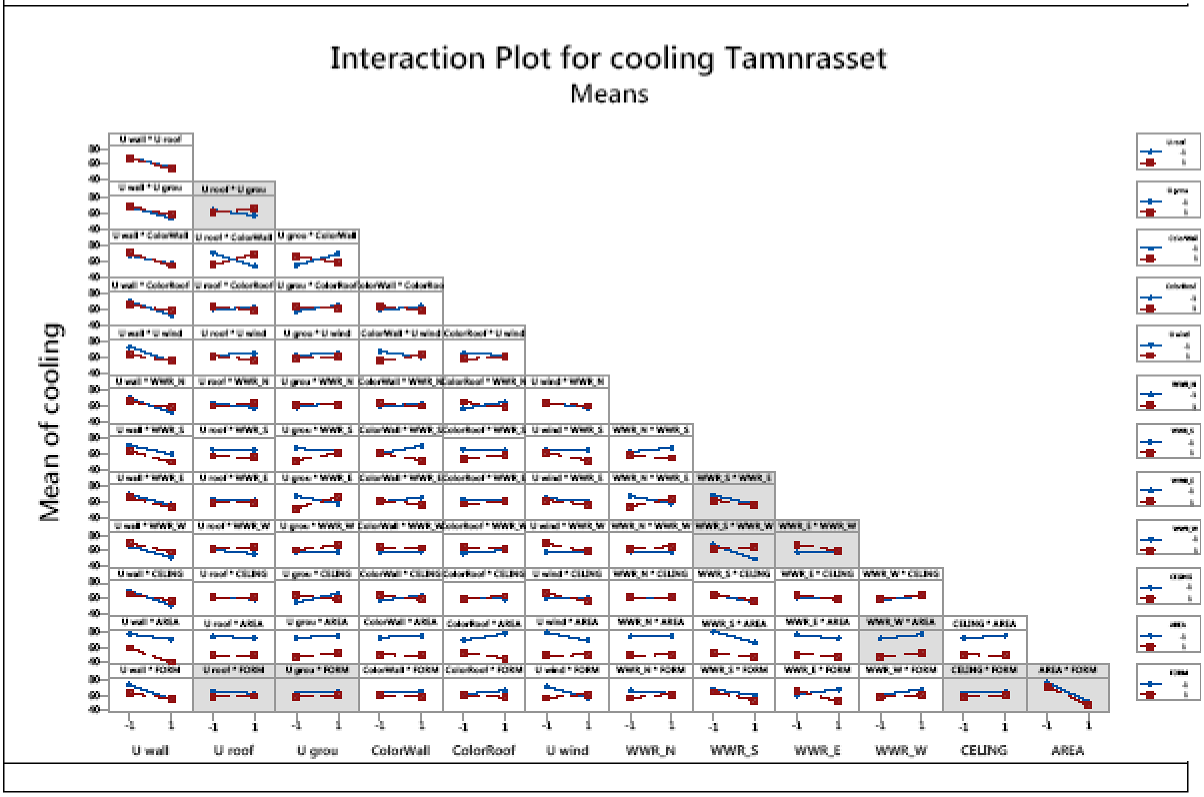
Means
Mean of heating
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
WWR_N
WWR_S
WWR_E
WWR_W
CELING
AREA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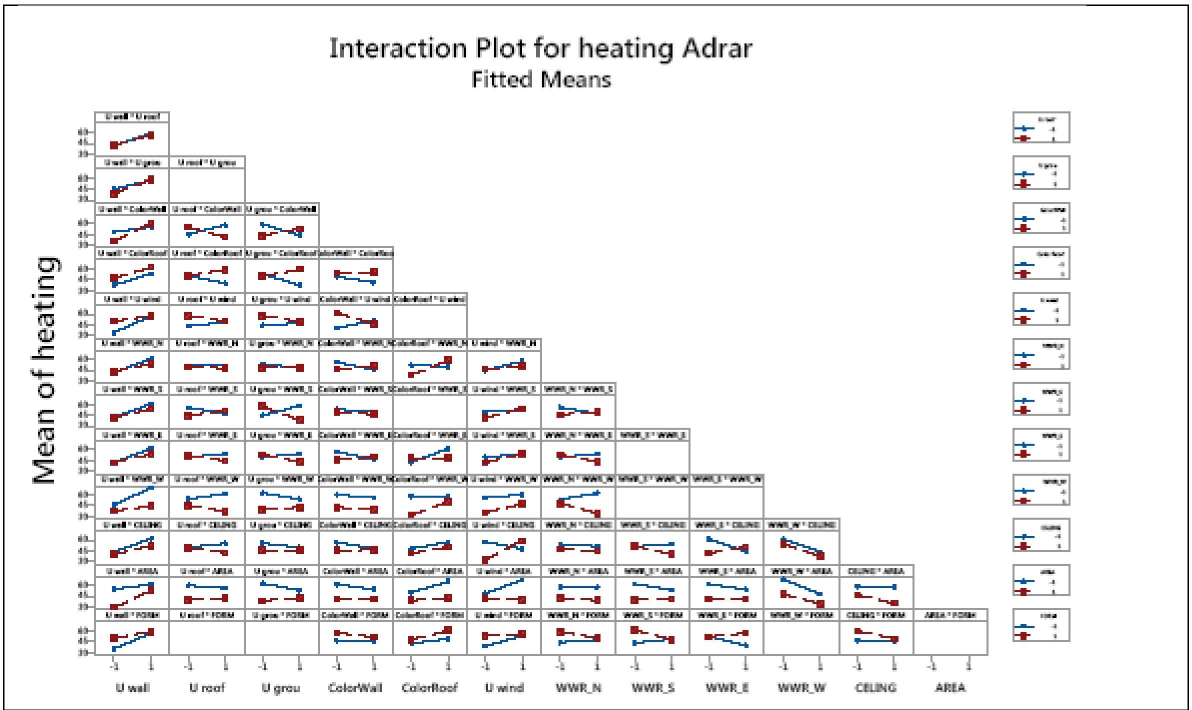
Means
Mean of cooling
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
WWR_N
WWR_S
WWR_E
WWR_W
CELING
AREA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Fitted Means
Mean of heating
U wall
U roof
U grou
ColorWall
ColorRoof
U wind
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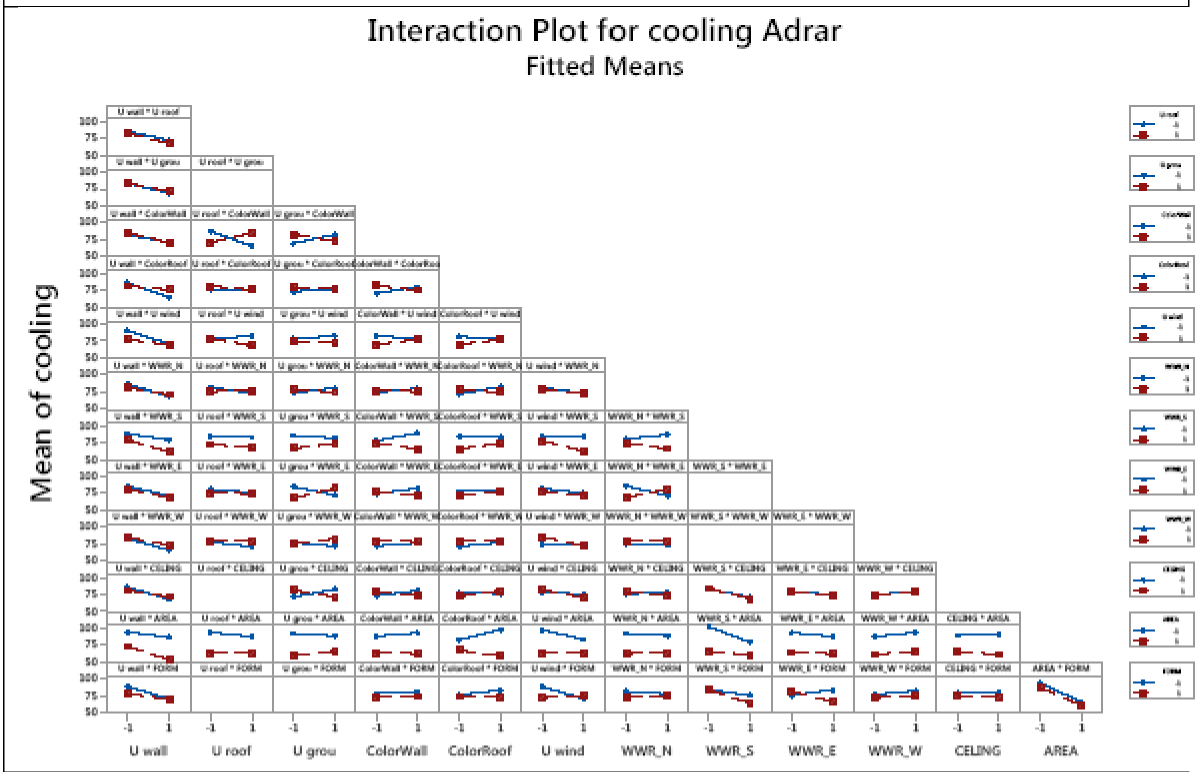
WWR_W
CELING
AREA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Fitted Means
Mean of cooling
U wall
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WWR_N
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WWR_W
CELING
AREA

Abstract

Building sector is one of the effective consumer energy by 42% in Algeria. The need for energy has continued to grow, in inordinate way, due to lack of legislation on energy performance in this large consumer sector. Another reason is the simultaneous change of users' requirements to maintain their comfort, especially summer in dry lands and parts of southern Algeria, where the town of Ouargla presents a typical example which leads to a large amount of electricity consumption through the use of air conditioning. In order to achieve a high performance envelope of the building, an optimization of major parameters building envelope is required, using design of experiments (DOE).

design of The objective of this work is to develop a methodology to carry out studies of buildings with low energy consumption. The methodology consists of to determine polynomial models for the assessment of energy performance and thermal comfort of buildings, using the method of experimental designs and digital simulation tools. These polynomial models make it possible to simplify parametric studies, providing an alternative response to simulation tools digital solutions for finding solutions to design low buildings energy consumption. The methodology is applied to a typical house. can determine the most effective parameters and eliminate the less importance. The study building is often complex and time consuming due to the large number of parameters to consider. This study focuses on reducing the computing time and determines the major parameters of building energy consumption, such as area of building, factor shape, ration walls to windows …etc to make some proposal models in order to minimize the seasonal energy consumption due to air conditioning needs.

Key words: air conditioning, Design Of Experiments (DOE), Building low energy consumption, TRNSYS,

Résumé

Le secteur du bâtiment est l'un d'effectif consommateur d'énergies, il consomme de 42% en Algérie. Le besoin d'énergie a continué croître de manière démesurée, en raison de l'absence de législation sur la performance énergétique dans ce secteur. Une autre raison est le changement simultané des besoins des utilisateurs pour maintenir leur confort, en particulier l'été dans les terres arides et les régions du sud de l'Algérie, où la ville d'Ouargla présente un exemple typique qui conduit à une grande consommation d'électricité. Afin de réaliser un enveloppe de haute performance du bâtiment, une optimisation des principaux paramètres de l'enveloppe du bâtiment est nécessaire, en utilisant la méthode plan d'expériences (DOE).

L'objectif de ce travail est de développer une méthodologie pour réaliser des études de conception de bâtiments à basse consommation d'énergie. La méthodologie consiste à déterminer des modèles polynômiaux pour l'évaluation des performances énergétique et du confort thermique, à l'aide de la méthode des plans d'expériences et des outils de simulation numérique. Ces modèles polynômiaux permettent de simplifier les études paramétriques, en apportant une réponse alternative aux outils de simulations numériques pour la recherche de solutions afin de concevoir des bâtiments à basse consommation d'énergie.

La méthodologie est appliquée sur une maison typique peut déterminer les paramètres les plus efficaces et éliminer le moins d'importance. L'étude de bâtiment est souvent complexe et prend du temps en raison du grand nombre de paramètres à prendre en compte. Cette étude se concentre sur la réduction du temps de calcul et détermine les principaux paramètres de la consommation énergétique du bâtiment, tels que la surface de construction, facteur de forme, l'orientation, ration murs fenêtres, etc. pour optimiser le besoins de conditionnement d'air.

Mots-clés: climatisation, plan des expériences, Bâtiment à faible consommation d'énergie, TRNSYS

مختصر.

قطاع البناء هو أحد انشط القطاعات الفعالة المستهلكية للطاقة بنسبة 42٪ في الجزائر وظلت الحاجة إلى الطاقة تنمو بشكل مفرط، نظرا لعدم وجود تشريع بشأن أداء الطاقة في هذا القطاع . سبب آخر هو التغيير المتزامن لمتطلبات المستخدمين للحفاظ على راحتهم، وخاصة في فصل الصيف في الأراضي الجافة وأجزاء من جنوب الجزائر، حيث تقدم مدينة ورقلة مثالا نموذجيا مما يؤدي إلى كمية كبيرة في استهلاك الكهرباء من خلال استخدام تكييف الهواء .من أجل تحقيق غلاف ذو أداء عالي للمبنى، المطلوب تحديد الاولويات الرئيسية للتصميم الأمثل لغلاف المباني ، وذلك باستخدام طريقة تصميم التجارب (DOE).

الهدف من هذا العمل هو تطوير منهجية لإجراء دراسات تصميم المباني مع انخفاض استهلاك الطاقة .المنهجية تتكون من لتحديد نماذج متعددة الحدود لتقييم أداء الطاقة والراحة الحرارية للمباني ، وذلك باستخدام طريقة التصاميم التجريبية و أدوات المحاكاة الرقمية .هذه النماذج متعددة الحدود تجعل من الممكن تبسيطها لدراسات حدية، وتوفير استجابة بديلة لأدوات المحاكاة الرقمية لإيجاد حلول لتصميم المباني المنخفضة الاستهلاك الطاقي .يتم تطبيق المنهجية على مبنى نموذجي

ويمكن تحديد الموشرات الأكثر فعالية واقصاء الاقل أهمية .دراسة المبانى غالبا ما تكون معقدة وتستغرق وقتا طويلا نظرا للكمية الكبيرة للمعلومات .وتركز هذه الدراسة على تقليل الوقت الحاسوبي وتحدد المؤشرات الرئيسية لاستهلاك الطاقة في المباني، مثل الشكل الهندسي و مساحة البناء، معامل نسبة النوافذ للجدران ، والاتجاه،... الخ لتقديم الاقتراحات و نماذج من أجل تقليل الاحتياجات.لاستهلاك الطاقة الموسمية إلى الحد الأدنى في تكييف الهواء

الكلمات المفتاحية: تكييف الهواء ، تصميم التجارب (DOE) ، البناءات منخفضة استهلاك الطاقة ، TRNSYS