Mitigating Climate Change
Through Improvement of Energy Efficiency
in Building Sector

ASSESSMENT OF METHODOLOGIES FOR THE CALCULATION OF ENERGY PERFORMANCE OF BUILDINGS, CORRESPONDING CLIMATE PARAMETER AND CLIMATE DATA REQUIREMENTS

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Introduction

The Government of the Republic of Macedonia considers energy efficiency to be very important for its economy. Energy Efficiency (EE) has the capacity to generate employment, improve the quality of citizens' lives, decrease energy import, and improve chances of EU accession. Moreover, energy efficiency is environment friendly and economically viable under the current circumstances. EE is one of the most important measures for climate change mitigation, because it can largely contribute to reduction of greenhouse gasses emissions.

The National Development Strategy states that "Energy resources available for use in our country and elsewhere are limited and finite. From this aspect, it is necessary to achieve the economic development of the society with as small a consumption of energy as possible. Reduced energy consumption has an additional, very important effect, which will become even more important in the future, and that is the reduction of pollution of the environment."

The implementing legislation on energy efficiency (rulebooks, regulations, procedures, standards) is in an early stage of development. Considerable efforts for adoption of secondary legislation are yet to be undertaken, including harmonization of the laws and regulations from different sectors (construction/building, transport, environment, etc.) which address sustainable energy issues.

The Rulebook on Building Energy Performances (EPB) (2008) established the first very important step for building energy audit and certification, determining the maximal values for energy transparency of buildings envelopes. It should be noted that they are voluntary, not obligatory, rules.

High priority is given to preparing the legal basis (amending existing Energy Law) to transpose into national bylaws the rest of Directive 2002/91/EC on the Energy Performances of Buildings (EPB EC Directive) – preparation of national methodology for performance computing, authorization of independent energy auditors, regular control of water boilers for central heating and air conditioners with capacity over 12 kW.

It is crucial that the implementation of these measures becomes mandatory.

The Austrian Government financial support to Macedonia, envisaged for energy efficiency sector, was delayed for a whole year. Prepared Rulebook on EPB in 2008 was escorted with explanation for necessity of preparation of additional items, which are taken as SoW for ADA project. Additional Project which is realizing in parallel tracks is dedicated to define Macedonian' climatic conditions and characteristics of the building stock, with intention to determine the benchmarks for Buildings Energy Performance Rating.

The synergy of these projects will result with determination of differences between climatic regions in the State, thermal/energy characteristics of the building stock, prepared national methodology for calculation of EPB , as well as training of the energy auditors.

Background

The Republic of Macedonia is a signatory of the Energy Charter Treaty. This agreement, aims at intensifying energy sector cooperation between Western Europe and the former socialist countries of Eastern Europe. The Republic of Macedonia is also a signatory of the Energy Community Treaty. Both of these Treaties impose an obligation for the country to harmonize its legal framework, especially in the energy sector, with the existing regulation of the European Union (*acqui communautaire*).

The project is one of three components of Energy Efficiency programme, financed by the Austrian Development Cooperation, and aims at enabling the environment for mitigating climate change in the country through improved energy efficiency in the building sector, enhanced awareness and capacities of stakeholders involved in energy efficiency issues.

The programme aims related to this Project are as follows:

- Development of energy efficiency (EE) regulations in the building sector,
- Development of applicable EE tools.

On the long term, the activities will contribute to the reduction of energy consumption in the residential and public buildings, thus decreasing not only the energy demands, energy losses and greenhouse gas emissions, but also increase the energy independence of the country.

The main outputs of the project will be a national **database on climate parameters per region**, a nationwide inventory of public buildings, and most effective investment–oriented energy efficient building programme.

It is in line with Energy Efficiency Strategy, and wider with Sustainable Development Program of the Republic of Macedonia. Macedonia has limited supplies of commercial energy resources and will be increasingly dependent on energy imports. Energy efficiency practices can mitigate that dependence, extend domestic reserves, and postpone the need for investing in new energy infrastructures, all at a lower cost than investing in increased supplies and expanded infrastructure.

Energy efficiency is an important component of any energy policy because it means using less energy to provide the same services or perform the same tasks. Energy efficiency also contributes to reduced emissions of the fossil fuel combustion's by-products; thereby helping the local and global environment.

The residential sector is the second largest energy end-use consumer in Macedonia with 29 percent of the total final energy consumption according to the data from year 2006. Households take the largest electricity consumption stake among the sectors.

The dominant forms of energy in household consumption are electricity (especially for appliances, but with substantive share still used for heating purposes) (52.6 percent) and biomass (firewood) (33.3 percent). Liquid fuels and thermal energy (district heating) are participating with similar percentages (6.7 and 6.9 percent) respectively. There is still no use of natural gas in the residential sector.

Scope of work

The analysis is directed towards assessing, evaluation and determination of the technical aspects regarding the development of a Climate Database (Output 1 of the UNDP Energy Efficiency Project), with special emphasis on the required climate parameters per regions and its compatibility to country specific calculation methodology.

Identification of available foreign methodologies for the calculation of energy performance of buildings and reviewing of national laws is the first phase in the enquiry for the methodology best fitting to Macedonian conditions that should be developed in Republic of Macedonia.

These include necessity of long-term overview, scanning and analysis of the climatic parameters required for estimation of country climate map as well as creation and development of the appropriate methodology, accordingly.

The EU country methodologies for integrated building energy performance calculation use different approaches in calculating their particular Building Energy performances. The comparative analysis of the advantages and disadvantages of these methodologies should result in recommendations to be embedded into the Macedonian methodology.

The analysis of the capacity of the existing meteorological institutions and stations will provide the necessary data to determinate the climate regions specifics. One of the most important queries is whether the collected data is publicly accessible and whether it was prepared in a form and manner to be further electronically processed by other parties.
Moreover, the final recommendations should identify list of missing meteorological collection data to be gathered in the future.

It is necessary to identify dependencies between the obtained results and recommendations by the ADA Project Outputs, as well as to identify and address additional activities in this direction.

Review national laws, strategies and action plans that refer to/influence the development of a methodology for calculating the integrated energy performance of buildings and other important aspects of the assignment

National Legislative Base

The Department of Energy, within the Ministry of Economy, oversees the entire energy sector and is currently in charge of all energy efficiency-related issues, especially from a policy perspective, including the Energy Efficiency Strategy. Within the energy efficiency field, the Ministry of Economy cooperates with the Ministry of Environment and Physical Planning, Ministry of Finance, Ministry of Transport and Communications, and Energy Agency.

The implementation of the national EE Policy in parts referring to the public and residential buildings will have to be coordinated with the Ministries of Environment and Physical Planning (regulation of construction norms in new buildings), Ministry of Transport and Communications (work with existing housing and home-owners, energy efficiency in social housing, optimization of transport network and bus fleet, etc.), Ministry of Local Government for municipal energy planning. All aspects of the EE Policy requiring public finance, including incentives, establishment of new entities, investments in public buildings, etc. will need coordination and cooperation with the Ministry of Finance. The local government will play a cross-cutting role in all buildings and transport sector initiatives.

Main documents influencing the particular methodology for integrated energy performance of buildings calculation are: the Energy Law, the Building Law, the Rulebook for Energy Efficiency of Buildings and the Rulebook for Building Essential Requirements.

Energy Law

This law and its amendment represent the main legislation for the sector. Providing a legal framework for promotion of increased use of Renewable Energy Sources (RES) and EE, the Energy Law is the most important achievement along this line. This law governs the objectives of the energy policy and the manner of its realization, energy activities and the manner of regulating the energy activities, construction of energy facilities and etc.

Special emphasis is put on the building sector pursued in Article 130 in relation to the new and reconstructed old buildings and respective requirements that need to be fulfilled. This article states that new and reconstructed buildings shall meet the requirements for the manner of construction in regard to energy efficiency.

Another requirement is the marking of the building structures in regard of their energy-related characteristics, as well as the way of control of approximation of the facilities with the provisions of the rule.

The entities certified to provide energy efficiency evaluations and energy efficiency services shall be responsible for the surveillance over the fulfillment of the referred requirements upon prior consent by the Minister of Economy.

One paragraph in the Article 132 addresses characteristics of appliances, volume, and energy efficiency of appliance construction and other relevant factors, as relevant elements for setting the maximum level of permitted electricity consumption.

Amendments to the existing Energy Law

The Energy Law is in procedure of refreshing, and new articles and amendments to the existing will be introduced.
The overlook to the existing not official draft proposals (non-paper document) shows that most of the items required for implementation of the EPB EC DIRECTIVE are introduced. However, there are few missing elements to fully transpose the legislative basis of the Directive.

The Article 158 outlines one of the most important points i.e. it provisions that the Minister responsible for the energy sector activities imposes the Methodology for calculation of building energy performances including the technical regulations (standards) and the sequence of computation.

The mentioned Article prescribes the requirements and preconditions for the manner of new buildings construction and reconstruction of existing ones, building energy performance mark up, maximum allowed energy requirements and method for controlling the EPB Rulebook requirements fulfilment in order to achieve EE of the new buildings and the reconstructed ones..

The new entry in the Article 152 is the introduction of the legal provision that the Energy Auditors are physical persons (in accordance with the Directive) not legal entities as prescribed in the old legal provision thus being the case in the Rulebook as well. The Article identifies the conditions an Energy Auditor has to fulfill in order to become accredited by the Minister.

The Article 159 prescribes the electrical appliances to be energy efficiency labeled as well as the requirements for maximum level of energy consumption.

The reviewed document does not include the legal provisions for Inspection of boilers fired by non-renewable liquid or solid fuel of an effective rated output of 20 kW to 100 kW and Inspection of air-conditioning systems of an effective rated output of more than 12 kW (Articles 8 and 9 from EPB EC DIRECTIVE).

The Rulebook for Building Energy Performances

The Rulebook for Energy Performance of Buildings (EPB) has been published in the Official Gazette Nº 143/08, governing the standards related to heating techniques and thermal insulation issues. The existing regulations were embedded provisions that slowly change the attitude of these sectors stakeholders towards the energy saving in buildings.

This was done mainly thru defining of the maximum values for heat transmittance - U values that reduce the energy consumption up to 40% in comparison to the JUS standards that were used beforehand.

The energy performance label, to be issued upon the Energy Audit, anticipates some elements that are not obligatory by the Directive but soon to become obligatory following the expected EPB EC DIRECTIVE Recast. The Certificate deals with comparison of the energy performance as well as comparison in terms of CO2 emission that will become obligation after the Directive Recast.

The Certificate also identify the potential opportunities for energy performance improvements related to the total primary energy, CO_2 emissions as well as separately the heating, cooling, ventilation and sanitary hot water preparation.

However, an important feature about this Rulebook is that it has to be amended in the following manner:

The current regulatory framework does not envision:

- Development of national methodology for calculating the integrated energy performance of buildings;
- Accreditation of Energy Auditors – physical persons;
- Conditions for accreditation of physical persons as Energy Auditors, training and registry keeping;
- Obligation for control of water heating boilers with low capacity;
- Obligation for control of air-conditioning units with capacity over 12 kW;
- Manner and conditions for accreditation of institutions for Energy Auditors’ education and training;
- Lack of climatic characteristics for Macedonia;
- Lack of buildings stock’ data on the basic energy characteristics and typical groups in line with the Directive.

The Rulebook enforcement was postponed to the end of 2010, in need to establish legal basis for full implementation of the Directive 2002/91/EC on the Energy Performances of Buildings. This vacuum period will be used to develop national methodology for EPB calculation, rules for energy auditors’ authorization and their training, pilot project realization and preparation of Macedonian Climatic Atlas as an important part of the Methodology. In the meanwhile, future auditors,[1] designers and academic institutions will be trained to implement prescribed rules into their daily routine.

The preparation of the climatic data as well as the determination of the basic characteristics of the building sector in respect to their energy performance will enable development of methodology for building energy performance calculation, furthermore implementation of the recommendations anticipated in the EPB Rulebook and by all means realization of the projected savings of the National Energy Efficiency Action Plan (NEEAP) and the building sector of the Energy Efficiency Strategy.

Rulebook for basic requirements in buildings that needs to be fulfilled in the process of determination of the construction products characteristics

The Article 8 of this rulebook defines that the buildings’ designing shall be based on energy saving for heating, cooling and ventilation in line with the local climatic conditions and the number of people to dwell in the building.

[1] Donation of Austrian Government to the Government of the Republic of Macedonia. Realization in 2010/11, Project leaded by Austrian Energy Agency, already started with such program

Strategic documents

Energy Efficiency Strategy of the Republic of Macedonia

In the EE Strategy up till 2020 (2004) and the updated version (recently done) important role has been appointed to the EPB, the energy auditing and the building certification.

The chapter on Strategy Elements assumes the following:

" 1. Preparation and enforcement of primary and secondary legislation and regulatory framework harmonized with EU acqui communautaire."

The specific initiatives in this sphere shall include a set of reform actions, including development of new legal-regulatory documents, as well as amendments of the existing ones. More specifically, initiatives covered will include the following:

- Updating of the Energy Law
    - Energy audit of technological processes – energy part, is a method to aware energy managers on necessity of application of high efficient technologies, to collect data on energy consumption, to evaluate realization of EE measures and to protect environment.
- Amendments to the Building Law
    - Mandatory preparation of an Energy Efficiency study during the building design phase, as a prerequisite for obtaining a construction permit will ensure implementation of measures determined in the Energy Law and Rule book on Building Energy Performances.
- Rulebook on EPB
    - In order to start the process of buildings certification, hot water boilers and air condition systems control, the Rule book on Building Energy Performances has to be completed.
- Energy Auditors
    - Building Energy Code development: Using a Building Energy Code for New Construction will ensure that all new buildings are built as energy efficiently as possible, within a reason range of cost-effectiveness.
    - Energy audit procedures and certification of energy auditors: Respective secondary legislation will provide minimal requirements and instructions for conduct of energy audits, as well as define the professional certification procedures for energy auditors, thus regulating the quality for future energy audits and laying out the rules and conditions for the energy audit market development."

International Legislative Base

Directive 2002/91/EC on the Energy Performances of Buildings (EPB EC DIRECTIVE)

Objective

The European Parliament and the Council of the European Union, having regard to the Treaty establishing the European Community, have adopted Directive 2002/91/EC on the Energy Performances of Buildings (EPB EC DIRECTIVE)

The goal of this Directive is to promote the building energy performance improvements taking into account the outdoor climatic factors and the local conditions as well as the indoor climatic requirements and efficiency.

This EPB EC DIRECTIVE outlines several requirements:

(a) the general framework for a methodology of calculation of the integrated energy performance of buildings;
(b) the application of minimum requirements on the energy performance of new buildings;
(c) the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
(d) energy certification of buildings; and
(e) regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

Adoption of a methodology

Methodology of calculation of the energy performance of buildings shell be determined at national or regional level. It shell be applied on the basis of the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use of the building, which may include, heating, hot water heating, cooling, ventilation and lighting. This amount shall be reflected in one or more numeric indicators which have been calculated, taking into account insulation, technical and installation characteristics, design and positioning in relation to climatic aspects, solar exposure and influence of neighbouring structures, own-energy generation and other factors, including indoor climate, that influence the energy demand.

Before construction starts it is necessary to be taken into account the positive influence of the active solar systems and other heating and electricity systems based on renewable energy sources, electricity produced by Combined Heat and Power (CHP), natural lighting etc.

For the purpose of this calculation buildings should be adequately classified into categories such as: single-family houses, apartment blocks, offices, education buildings, hospitals, hotels and restaurants, sports facilities, wholesale and retail trade services buildings and other types of energy-consuming buildings..

Based on the adopted methodology minimum energy performance requirements for buildings are set, making differences between new and existing buildings and different categories of buildings.

The general indoor climate conditions requirements shall considered, in order avoiding possible negative effects of inadequate ventilation, local conditions and the designated function and the age of the building. These requirements shall be reviewed at regular intervals.

Minimum energy performance requirements

For **new buildings** with a total useful floor area over 1 000 m^2, shall ensure that the technical, environmental and economic feasibility of alternative systems such as: decentralised energy supply systems based on renewable energy, CHP, district or block heating or cooling, if available, heat pumps (under certain conditions), is considered and is taken into account before construction starts.

For **existing buildings** with a total useful floor area over 1 000 m when undergo major renovation, it shall take the necessary measures to ensure that their energy performance is upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible.

Energy performance certificate

Energy performance certificate of a building is a document recognised by the Government or a legal person designated by it, which includes the energy performance of a building calculated according to the adopted methodology. The certificate should describe the actual energy-performance situation of the building and may be revised accordingly. It includes reference values such as current legal standards and benchmarks in order to make it possible for consumers to compare and assess the energy performance of the building. The certificate shall be accompanied by recommendations for the cost-effective improvement of the energy performance.

The objective of the certificates shall be limited to the provision of information.

When buildings are constructed, sold or rented out, an energy performance certificate should be made available to the owner or by the owner to the prospective buyer or tenant, as the case might be. Certification for apartments or units designed for separate use in blocks may be based on a common certification of the whole building for blocks with a common heating system, or on the assessment of another representative apartment in the same block.

Public buildings with a total useful floor area over 1000 m^2 frequently visited by persons an energy certificate, not older than 10 years, have to be placed in a prominent place clearly visible to the public.

Independent experts

The certification of buildings, the drafting of the accompanying recommendations and the inspection of boilers and air-conditioning systems have to be carried out in an independent manner by qualified trained and well educated personnel and/or accredited experts, whether operating as sole traders or employed by public or private enterprise bodies.

General framework for calculations and additional positive influence of different alternative energy sources is defined in the ANNEX of the EPB EC DIRECTIVE and give a deeper understanding of the importance of this document.

Recast of the EPB EC DIRECTIVE: the proposed changes in relation to energy performances calculation procedures

On the 13th of November 2008 the European Commission presented a proposal for the recast of the EPB EC DIRECTIVE. The recast intends to strengthen the effectiveness and impact of the EPB EC DIRECTIVE.

Energy use in residential and commercial buildings is responsible for about 40% of the EU's total final energy consumption and CO2 emissions. The cost-effective energy saving potential by 2020 is significant: 30% less energy use within the sector is feasible. This equals to a reduction of 11% of the EU's final energy use.
The Commission proposes a revision of the Directive on the energy performance of buildings (2002/91/EC). While Member States are responsible for establishing the concrete requirements, the directive gives a framework for the application of minimum requirements to the energy performance of buildings, for the issuing of energy certificates and for regular inspections of boilers and airconditioning systems.
The Commission proposes that the 1000 m2 threshold for existing buildings when they undergo major renovation is eliminated: energy performance requirements will apply to more houses. The latter alone leads to € 8 billion additional capital investments a year but triggers € 25 billion annual energy cost savings by 2020. Energy performance certificates should become more reliable and widely known by

the public. The proposed modifications give Member States the opportunity to reap more than half of the remaining cost-effective potential in the sector. This equals 5–6% per year of the EU's total primary energy demand in 2020.

Institutional setup for collection, processing, management and dissemination of climatological data

Designated Institution in the Republic of Macedonia

The Directorate for Hydro-Meteorology (DHM) Affairs is the designate institution for climatic data collection in the Republic of Macedonia.

Department for climatology consists of:

- Sector for meteorological observations and measurements,
- Sector for climatology,
- Sector for agro-meteorology.

Under mutual agreement, DHM is submitting climatic data to the Statistical Office of the Republic of Macedonia

Sector for meteorological observations and measurements is responsible *inter alia* for:

- Organization and preparation of the development, technically operational programs and programs for organization of the meteorological data collection and monitoring as well as meteorological data collection and monitoring of the aerological station;
- Development of Guidelines and methods for data collection and monitoring in accordance with the resolution documents and WMO recommendations;
- Research of methods for rationalizations and optimization of the meteorological monitoring system and its findings implementation in various scientific and economic disciplines;
- Meteorological station organization and management in the course of their comprehensive synoptical - meteorological, climatological, agrometeorological, fenological, mesometeorological data collection as well as monitoring of the air radiation, precipitation and other specialized data collection;
- Meteorological data collection and monitoring realization, data processing, coding of present meteorological data and submit of the full documentations for further processing;
- Work Plan Development and realization of the WMO Plans related to the meteorological stations network
- Realization of the operational-technical works at the meteorological stations network;
- Realization of the laboratory controls, calibrations and observation of the meteorological instruments and equipment;

Sector for climatology realizes following activities:

- Establishments of methods for basic and in-debt data processing and critical control of the data collection results and monitoring of the meteorological monitoring system of the Republic of Macedonia;
- Data collection results analysis, monitoring as well as weather and climatic data issue;
- Critical analysis and processing of the specialized data collection and monitoring data and setting regularities in relation to the other weather and climate parameters;
- Establishment and maintenance of meteorological documentation archive of the original meteorological data and results processing gathered by the meteorological data collection system of the Republic of Macedonia;

- Gathering materials for the purposes of publishing meteorological – climatological monthly and annual reports;
- Development of climatic maps of the Republic of Macedonia using the GIS technology

The Ministry for Environment and Physical Planning (MEPP), DHM, the Institute for Health Protection in Skopje and the Institute for Health Protection in Veles are automatically collecting data on the air quality at 43 station located in the cities over Macedonia. The measuring stations of the MEPP are equipped *inter alia* with instruments for measuring climatic data (air temperature and humidity, pressure, wind direction and intensity and solar global radiation).

The data gathered by the stations located in the cities or near cross-roads is mainly data on air quality. The climatic data is of secondary importance.

The data is publicly accessible on the website of the MEPP. The data can be found in the following format (example from one station):

Lisice, January 2010, average daily data						
	Temperature [°C]	**Humidity [%]**	**Wind direction [deg]**	**Wind velocity [m/s]**	**Pressure [hPa]**	**Global radiation [W/m2]**
01.01.2010	9,2	71	261	0,1		30,8
02.01.2010	9,4	68	261	0,1		22,4
03.01.2010	3,9	66	261	0,1		14,3
•••	•••	•••	•••	•••		•••
••••	••••	••••	••••	••••		••••
•••••	•••••	•••••	•••••	•••••		•••••
29.01.2010	0,0	77	261	0,1		27,2
30.01.2010	1,2	76	261	0,1		31,3
31.01.2010	5,9	68	261	0,1		26,9

These stations are located in the following cities: Skopje, Bitola, Veles, Kicevo, Kumanovo, Kocani, Tetovo, Kavadarci, municipality Ilinden and Lazaropole. Results from monitoring stations are collected on the hourly basis into Central Station in Skopje, at Macedonian Environmental Informative Center.

Identify available methodologies for the calculation of energy performance of buildings, and the climatological parameters required for each of them

Overview of National Methodologies and their reference to the Climatic Parameters

The calculation methodology, as part of the three main components needed for implementation of the EPB EC DIRECTIVE is used to determine the data for the energy certificate, as stated in the **CEN/BT WG 173 EPBD N 15 rev**, or also called "Umbrella document". The calculation methodology (WI 14) emphasizes the three types of complexity: simplified hourly calculation, simplified monthly calculation and detailed calculations.

Hereby, the document includes, explanations about calculation of the building's net energy according to the EN ISO 13790 requiring punctual data about the indoor climate requirements, internal gains, building properties and outdoor climatic conditions are also present in this document.

It should be noted that the Section 4D[2] contains the standards related to the indoor conditions and specifications for the calculation and presentation of climatic data (not climatic data itself, but its specifications).
To find the best fitting tool for Macedonia to be used in the process of assuring energy efficiency of the buildings, short information concerning the available methodologies on disposal used in few EU member countries and from the Balkan region is introduced as well.

IRELAND - DEAP, the Ireland's methodology says that the mean internal temperature is calculated by month, taking account the external temperatures monthly mean.

NORTHERN IRELAND (UNITED KINGDOM) - In the "A Consultation Document" dating November 2004, Northern Ireland is defining the methodology for calculating energy performance of buildings taking into account the local climatic conditions and also points out the SAP as national calculation methodology.

BULGARIA- The document" НАРЕДБА № 7 от 15 декември 2004 г. за топлосъхранение и икономия на енергия в сгради (ДВ, бр. 5 от 2005 г.)", features the temperature of outside air and the external humidity as most important climatic factors. The external air temperature t_e of Article 21, Article 22, represents a binding factor for the time period of diffuse humidification for buildings without any kind of central installations for cooling.
This document explains the specification and procedure for collecting the external climatic parameters indicated through the monthly temperature mean of the external air, hourly intensity mean of the solar radiation calculated on 24 hour basis.
As another climate parameter, this document includes calculation of heat losses through the amplitude of the monthly temperature mean (as shown in Figure 3.26, page 38). As usual, the temperature of the outside air is used as a key parameter for the starting or extension of the heating period.
The "ORDINANCE № 18 of November 12, 2004, Bulgaria for energy characteristics of sites (promulgated in State Gazette, issue 108/10.12.2004, into force since January 1, 2005)" in Art.6 constitutes the external computed temperature, average monthly external air temperature, average hourly intensity of full sunlight warming and duration of heating season as basic values for the climatic factors determining the energy consumption indicators and energy characteristics of sites. The document also defines the interrelation between the DD and average monthly external air temperature.
The importance of the external climate conditions for the energy characteristics of sites are stated in Art.8, and Art.9. The Art.13 shows the correlation between the external computed temperature and projected temperature for heating.
Heating Day-Degrees (DD) for calculation of the energy consumption indicators and energy characteristics are calculated on the monthly level, as a product of the number of days in the month and the difference between the average temperature of the building and the average monthly external air temperature.
In case the altitude of a settlement is higher than 500 m above sea level, the annual energy consumption shall be calculated according to the data for the relevant climatic zone where the settlement belongs. These shall be multiplied by the quotient of the Day-Degrees of the settlement and the Day-Degrees of the zone.

SLOVENIA- The Slovenian "PRAVILNIK o učinkoviti rabi energije v stavbah" (in force from 15.11.2008 till now) defines the design external temperature, solar gains, temperature deficit and average daily air temperature as important climatic parameters for calculation of the energy performances of buildings. It also defines the possibilities for the use of solar thermal and PV panels.

SPAIN- The Spain's methodology (associated with EPB EC DIRECTIVE) includes the law abiding directions for calculating the buildings energy performance.

CHECH REPUBLIC- "Energetická náročnost budov, Podrobnosti výpočtové metody, METODICKÁ PŘÍRUČKA" document shows the calculation of the energy need for heating and renewable energy sources use which includes the outside air temperature, humidity of the outside air, total solar radiation during the calculated period.

UNITED KINGDOM- UK methodology for calculation of EPB shows obviosly the same parameters as used in other countries of the EU. It also includes the external air temperature and humidity, including parameters that shows the amount and presence of solar radiation.

[2] CEN/BT WG 173 N 68: "Umbrella Document V7 (prCEN/TR 15615). Energy Performance of Buildings Project Group, August 2006

HUNGARY- The Hungarian “7 / 2006. (V 24th) TNM Regulation the energy performance of buildings”, among other things, shows the calculation of the several climatic factors needed for calculation of EPB. The average daily temperature difference between the internal and external temperature is shown in part IV.4. There are tables that show the location of the outside air temperatures throughout the day during the whole year, which can be used to calculate the right amount of energy needed to cover the most of the buildings needs.
Finally, the method for calculating the heat gains from solar radiation is shown on page 13.

CROATIA- The document “TEHNIČKI PROPIS O UŠTEDI TOPLINSKE ENERGIJE I TOPLINSKOJ ZAŠTITI U ZGRADAMA” defines the outside air temperature and also the mean monthly outside temperature for calculating the energy needs of the building (, point 17 and, point 8).
This document also brings up the importance of emphasizing the climate data into the project’s technical documents in the process of designing of buildings.

GERMANY-In the DIN V 18599 the information on the climate data includes radiation intensities and temperatures for the referent climate specifics of Germany. These average monthly radiation intensities for different orientations and inclinations components are indicated as well. Furthermore, the design values for heating and cooling are summarized in a table.

Methodologies for calculation (softwares)

PASSPORT. The method is based on a steady-state energy balance for the building zone, with an allowance for external temperature variations and an utilisation factor taking account of the dynamic effect of internal and solar gains. The gain utilisation factor is given as a function of the gain to load ratio (GLR) and an inertia parameter t (time constant of the building or of the zone). The method treats separately two phenomena associated with intermittent heating: decreased losses due to lower inside temperatures and reduction in of the utilised gains to take account of periods when the building is not heated. Two intermittency factors are obtained from formulae taking account of the heating pattern and the time constant of the building. To deal with multi-zone passive solar buildings, uniform temperature zones are defined; then the calculation method is applied to each zone. To take account of the interaction between the zones, an interactive procedure is used to solve the heat balance for all zones.

SBEM. Simplified tool which provides an analysis of a building's energy consumption primarily for the purposes of assessing compliance with Part L (England & Wales), Section 6 (Scotland) and Part F (Northern Ireland) of Building Regulations and eventually for building performance certification EPB EC DIRECTIVE in UK. SBEM (Simplified Building Energy Model) calculates monthly energy use and carbon dioxide emissions of a building given a description of the building’s geometry, construction, use, and HVAC and lighting equipment. It was originally based on the Dutch methodology NEN 2916:1998 (Energy Performance of Non-Residential Buildings) and has since been modified to comply with the emerging CEN Standards. SBEM makes use of standard sets of data for different activity areas and calls on databases of construction and building service elements. It is accompanied by a basic user interface - iSBEM.
The purpose of this simplified tool, SBEM and its interface, is to produce consistent and reliable evaluations of energy use in non-domestic buildings primarily for the purposes of assessing compliance with UK Building Regulations 2006 and eventually for building performance certification.

BSim. Package of easy-to-use and flexible programs for evaluating the indoor climate and energy conditions as well as the designing of the heating, cooling and ventilation plants. The BSim package comprise the programs: SimView (user interface and graphic model editor), tsbi5 (simultaneous thermal and moisture building simulation tool), XSun (dynamic solar and shadow simulation and visualisation), SimLight (daylight calculation tool), SimDXF (CAD import facility) and SimPV (building integrated PV-system calculation).
The thermal simulation core has been validated in the IEA (International Energy Agency) Task 12 / Annex 21 "Empirical validation of thermal building simulation programs using test room data" activity. Any additions to the program since then have been validated individually by external experts.
Analysis of the indoor thermal and moisture climate in complex buildings or buildings with special requirements for the indoor climate. Simultaneous simulation of energy and moisture transfer in building constructions. Multi zone natural air flow simulations. Intuitive graphic user interface.

The Danish Building Research Institute is continuously updating BSim to accommodate changes and developments in the building industry.

COMcheck. Designed to streamline the energy code compliance and approval process and is focused on the needs of those who design, build, and enforce building codes for commercial and high-rise residential building projects. The software addresses the enforceable provisions in commercial building energy codes based on ASHRAE/IESNA Standard 90.1-1989/1999 and IECC 1998, 2000 and 2001 that are applicable to commercial and high-rise residential projects, including building envelope, lighting, HVAC, and service water heating requirements.
Output : Preformatted compliance report, which can be sent to a printer or written to a file.

Czech National Calculation Tool. Published since October 2007 for use in the Czech Republic. The calculation method is based on the delivered energy needed under standard indoor and outdoor conditions. The basic process of the calculation is divided into two stages:
Calculation of energy demand (calculated on the standard use) of the building, or its zones; the calculation of heat losses, and heat gains, required in each space in order to maintain specified internal conditions;
Calculation of energy consumption (building, zones, according to the energy demands); the calculation of the energy required by the energy systems (boilers, AHU units, DHW systems, lighting, etc.) needed to provide the necessary heating or cooling, or humidity control, etc.
The calculation method is based on the simplified dynamic calculation. The energy demand can be calculated from monthly, daily, and hourly simplified values. Hourly calculations better represent the complexities of HVAC systems (mainly because of cooling) performance.
Czech national and CEN standards were used for developing the Tool.

DesignBuilder. User-friendly modelling environment where you can work (and play) with building models. It provides a range of environmental performance data such as: energy consumption, internal comfort data and HVAC component sizes. Output is based on detailed sub-hourly simulation time steps using the EnergyPlus simulation engine. DesignBuilder can be used for simulations of many common HVAC types, naturally ventilated buildings, buildings with delighting control, double facades, advanced solar shading strategies etc.
Output: A comprehensive range of simulation data can be shown in annual, monthly, daily, hourly or sub-hourly intervals:
Energy consumption broken down by fuel and end-use.
Site weather data:

- Heat transmission through building fabric including walls, roofs, infiltration, ventilation etc.
- Heating and cooling loads.
- CO2 generation.
- Heating and cooling plant sizes can be calculated using design weather data.

Data can be displayed graphically or in tabular form and can be exported in a range of formats to spreadsheet and custom reports.

Diag DPE. Simple, easy way to obtain a calculation for the European Energy Performance Directive. Diag DPE also immediately shows the potential improvements recommended for that building.

DIN V 18599. Excel-based calculation tool for the German DIN V 18599. DIN V 18599 is a holistic performance assessment tool for all energy types required by the EPB EC DIRECTIVE (heating, ventilation, cooling, lighting, DHW). Developed for the German field test study for non-residential buildings of the Federal Ministry for Buildings. (German language)

DOE-2. Hourly, whole-building energy analysis program calculating energy performance and life-cycle cost of operation. Can be used to analyze energy efficiency of given designs or efficiency of new technologies. Other uses include utility demand-side management and rebate programs, development and implementation of energy efficiency standards and compliance certification, and training new corps of energy-efficiency conscious building professionals in architecture and engineering schools.

EE4 CBIP. Designed to demonstrate a building's compliance to the requirements of the Commercial Building Incentive Program (CBIP) performance path approach. EE4 CBIP is offered by Natural Resources Canada's Office of Energy Efficiency to building owners and developers for the design and construction of new commercial and institutional buildings that the Model National Energy Code for Buildings (MNECB). EE4 CBIP use 25% less energy than similar buildings built to the requirements of may also be used to perform non-compliance energy analyses and thus to predict a building's annual energy consumption, and to assess the impact of design changes to the building. Alternatively, EE4 CBIP can be used to determine a building's heating and cooling loads for equipment sizing. EE4 CBIP calculations are based on an approved version of DOE-2.1E

ENSI – Energy Auditing of Buildings Software. User-friendly tool for calculating the energy performance of buildings. The software is suitable for energy auditing of new and existing buildings and for building certification. Main features:

- Designed according to the EU norms and standards - Directive 2002/91/EC, ISO 13790:2008 and references
- Monthly calculations, reflecting the influence between parameters
- All basic parameters for energy calculations included: geometry, U-values, infiltration, indoor temperatures, occupancy schedules, heating schedules, ventilation rates, operation periods, lighting, various equipment, system efficiencies
- Calculations for "Actual", "Baseline" and "After measures"
- Results presented as energy need, energy use and heat loss coefficients
- Savings presented for each measure
- E-t curve

Energy performance calculation. The EAB Software is calculating the total, annual energy use of the building, divided into seven budget items: Heating, Ventilation (heating), Domestic hot water, Cooling, Fans & pumps, Lighting and Various equipment.

Country specific Software.To prepares a tailored version of the ENSI Software for a new country, it is necessary to define and include:

- Climatic data for selected places, and
- Reference values (including national Building Codes).

The Software is prepared for easy translation into new languages. 11 people were trained as energy auditor trainers. Additionally 15 people were trained to use it. Energy performances of over than 50 buildings were estimated using this software in the Republic of Macedonia.

Dependence of Energy Consumption Indicators to Climatic Factors

Determination of energy consumption indicators and energy characteristics of buildings shall be done with the basic values of the following climatic factors :

- Design external air temperature for selected towns of the climatic zones, is the external temperature laid down as the design basis for the sizing of the heating system;
- External air design temperature for cooling for selected towns of the climatic zones, is the external temperature laid down as the design basis for the sizing of the cooling system;
- Design external air moisture for heating season for determined climatic zones;
- Design external air moisture for cooling season for determined climatic zones;
- Average monthly external air temperature ;
- Average daily air temperature - is defined according to MEN ISO 15927-1;
- Beginning of the heating season (for DHCs in the Republic of Macedonia it is defined as the next day following a contiguous period of three days with external air temperatures lower than 12^{o}C at 9 p.m);
- End of heating season (for DHCs in the Republic of Macedonia it is defined by means of the time period when, on three contiguous days, the external air temperature at 9 p.m. exceeds 12^{o}C, and following which, in the particular year, there is no period of three contiguous days with temperatures of 12^{o}C or lower);
- Duration of heating season;
- Duration of cooling season;
- Global solar irradiation, (kWh/m^2) heat energy means solar radiation on unit area during a specified period;

- Heating Day-Degrees (DD) for calculation of the energy consumption indicators and energy characteristics shall be calculated every month, as a product of the number of days in the month and the difference between the average/base temperature of the building and the average monthly external air temperature.
- Cooling Day-Degrees (DD) for calculation of the energy consumption indicators and energy characteristics shall be calculated every month, as a product of the number of days in the month and the difference between the average/base temperature of the building and the average monthly external air temperature.
- Wind direction and speed summaries.
- For the purpose of the “Design external air temperature” Macedonia uses the values determined 50 years ago, in accordance with the former JUS/DIN standards. Compared to the existing methods for design temperatures determination, there are significant differences if one uses the probability method. For example in case of City of Skopje, the designers use -14°C as winter design temperature, instead of - 9,7°C determined by means of probability method.

Statement: It is necessary to determine winter and summer design external air temperatures for different climatic zones in the State!

Assess the comparative advantages and disadvantages of these methodologies under special consideration of the country context and recommend the methodology that is considered as the best in the given context

There are two approaches during the phase of preparation and application of the methodologies for EPB calculation. Both are based on the approach using climatic characteristics for determination of the required energy capacity for heating, cooling and ventilation but moreover the energy needed for hot water preparation and electricity (solar energy as a source) are taken into account as well.

There are two basic types of method:

- dynamic methods, calculating the heat balance with one hour times steps taking into account the heat stored in, and released from the building,

- quasi-steady-state methods, calculating the heat balance over a sufficiently (one month or a whole season) long time, which enables to take dynamic effects into account by an empirically determined gain and loss utilization factor.

In the **dynamic methods**, an instantaneous surplus of heat during the heating period has the effect that the internal temperature rises above the set-point, thus removing the surplus heat by extra transmission, ventilation and accumulation. A thermostat set-back or switch-off might not lead directly to a drop in the internal temperature, due to the inertia of the building. A similar situation applies to cooling

In the **quasi-steady-state methods (**monthly and seasonal), the dynamic effects are taken into account by introducing correlation factors. For heating, a utilization factor for the internal and solar heat gains takes account of the fact that only part of the internal and solar heat gains is utilized to decrease the energy need for heating. The rest of the heat gains leading to an undesired increase of the internal temperature above the set-point.

In case when detailed climatic data is available or in a form allowing its easily numeric processing (electronic processing), the more sophisticated holistic dynamic method for energy consumption determination (calculation procedures for detailed (e.g. hourly) dynamic simulation methods) may be applied i.e. EPB of the building being analyzed. This methodology enables acquiring of more precise data. The method applies specially for the heat gains calculation because of the solar radiation which significantly varies during the day and throughout the season, influencing the required cooling energy calculation for a particular building. Procedures using more detailed simulation methods ensure compatibility and consistency among the application of different method types.

There is another group of countries that applies the simplified “monthly” method (quasi-steady-state method) for determination of the building energy needs, also the EPB, using the average monthly values of the outdoor air in winter and summer time as well as the duration of the heating/cooling season and the average monthly values of the solar radiation/intensity. The monthly calculation gives precise results on annual basis, but the results for individual months closer to the beginning and the end of the heating and cooling season can be biased and lead to larger relative errors.

On the basis of these starting values, the first alternative is to approach towards calculation of the total annual energy needs of the subject building, while the second calculation alternative for the energy needs focuses on the individual energy needs calculation such as heating, ventilation, cooling and hot water preparation and lighting.

The alternative **simple method for hourly calculations** has been added to facilitate the calculation using hourly user schedules (such as temperature set-points, ventilation modes, operation schedule of movable solarshading and/or hourly control options based on outdoor or indoor climatic conditions). This method produces hourly results, but the results for individual hours are not validated and individual hourly values can have large relative errors.

At national level, it may be decided which of these three types of method will be allowed to be used, depending on the application (purpose of the calculation) and building type.
The choice typically depends on the use of the building (residential, office, etc.), the complexity of the building and/or system, the application (energy performance requirement, energy performance certificate or recommended energy performance measures, other). There is a need to maintain balance between accuracy, transparency, robustness and reproducibility

National Methodology for Calculation of Energy Performance of Buildings

One of the first steps is to set the minimum energy performance requirements for buildings.
The minimum requirements consist of: heating, cooling, ventilation, domestic hot water preparation, and lighting.

As for the process start, the first task is to determine the average value of energy requirements for the building stock in the State **(R_s).**
The ages of building residential stock in Macedonia is as follows:

before 1919	1,11 %
1919 – 1945	3,95 %
1946 – 1970	30,12 %
1971 – 1989	47,80 %
after 1991	17,02 %.

The same has to be determined for different building categories (see EPB EC DIRECTIVE, Annex).

The national maximum allowed annual energy requirements **(R_r)** should be determined e.g. as 50% of energy requirements of the average value determined for the existing building stock.

EPB EC DIRECTIVE stipulates that the EU-members and applicants shall apply the methodology for EPB according to the standards and norms that are accepted by their governments or are in the process of acceptance (Art.3). Macedonia has adopted as national standard MKS EN ISO 13790:2009 addressing EPB, and methodology has to be prepared in accordance with it.

MKS EN ISO 13790:2009 (*Energy performance of buildings -- Calculation of energy use for space heating and cooling)* consisting:

- monthly method for annual energy use for heating,
- similar monthly method for annual energy use for cooling,
- simple hourly method providing both heating and cooling energy use,
- detailed calculations;

Outputs:

- heat transfer by transmission and ventilation of the building,
- contribution of internal and solar heat gains,
- annual heat flow for heating and cooling,
- annual energy required by the heating and cooling systems,
- additional annual energy required by the ventilation system;

and MKS EN 15603:2009 (*Energy performance of buildings - Overall energy use and definition of energy ratings*) provides methods for:

- computing energy ratings
- assessing a measured energy rating
- improving confidence in the building calculation model by comparison with actual energy use
- assessing the energy effectiveness of possible improvements.

The 2 upper mentioned standards offer different ways of dealing with interrelation between a building and its systems. There are two methods, both taking the recoverable thermal losses of the building systems into account.

Which approach (holistic or simplified) should be used, and when?

The national documents define the conditions when either of the two methods shall be applied. There are several aspects determining the method choice. At first the purpose of the assessment should be considered as it influences the level of details required. The type and complexity of the building and its technical system are also relevant parameters. In general, the holistic approach is applied for complex systems and when a high level of details is required.

Detailed method will be used for the purpose of design and construction of buildings, when estimating the conformity of the investment projects with the energy efficiency regulations according to the Macedonian standards. The detailed calculation method is not, but any implementation must be validated according to the criteria in MKS EN 15265:2009 (Energy performance of buildings - Calculation of energy needs for space heating and cooling using dynamic methods - General criteria and validation procedures).

The national calculation methodology for energy performance of buildings shall provide a tool, to determine in simplified manner, whether the audited buildings meet the criteria for minimum energy efficiency requirements i.e." the maximum allowed annual/monthly energy needs depending on the building utilization purpose, location, geometry and construction materials' characteristics".

"...Marking of the building structures in regard of their energy-related characteristics" (Energy Law, Article 130, Article 158 into new refreshed Energy Law). This methodology enables comparison between the buildings' energy performances and previously defined values for the maximum allowed annual/monthly energy needs and shall be harmonized with the national standards for energy needs calculation.

Quasi-steady-state method, calculating the heat balance over one month long time, (simplified "monthly" method) which enables to take dynamic effects into account by an empirically determined gain and loss utilization factor ***can be recommended, as optimal solution for Macedonia****.* The energy needs will be determined against its individual needs i.e. individual energy needs for heating, cooling, ventilation, hot water preparation and lighting.
The choice depends on the purpose of application- simplified tool which provides an analysis of a building's energy consumption primarily for the purposes of assessing compliance with EPB EC DIRECTIVE, as well as for building performance certification.
The Method should be prepared on the basis of Macedonian standards, especially addressing MKC EH 13790; MKS EN 15316; MKS EN 15243:2009; MKS EN 15241 2009; MKS EN 15193; MKS EN 15232: 2009.
The method should be prepared balancing some controversial preconditions. In particular, when the calculation procedures are used to judge compliance with minimum energy performance requirements, or to assess the energy performance rating and classification on an official energy performance certificate, it is important to find the right balance between the accuracy of the method, the quality of the input data and the reproducibility of the results. Some of the quality aspects as "unambiguous", "transparent" and "robust" may be more or less contradictory to "flexible", "accurate" and "distinctive".
Discussing the quality aspects, the tendency is to focus on simple input rather than simple methods. These two issues should, however, be clearly distinguished:

- *simplified input should be unambiguous, measurable, verifiable and maintainable;*
- *simplified method should combine transparency, reproducibility and robustness with balanced accuracy.*

Energy Performance Rating

The Energy Performance Rating (EPR) is a calculated standard rating or a measured rating, expressed as:

- Primary energy used by the building;
- CO_2 emitted by the building, based on primary energy;
- Weighted sum of energy carriers delivered to the building with weights based on national energy policy .

Calculated energy rating means energy rating based on calculations of the net delivered energy used by a building for heating, cooling, ventilation, domestic hot water and lighting

NOTE: National bodies decide whether other energy uses resulting from occupants' activities such as cooking, production, laundering, etc. are included or not. If included, standard input data shall be provided for the various types of building and uses. Lighting is always included except (by decision of national bodies) for residential buildings.

Standard energy rating means calculated energy rating using actual data for the building and standard use data set
NOTE 1: It represents the intrinsic annual energy use of a building under standardised conditions. This is particularly relevant to certification of standard energy performance.
NOTE 2: It can also be termed "asset energy rating".

Measured energy rating means energy rating based on measured amounts of delivered and exported energy.
NOTE 1 The measured rating is the weighted sum of all energywares used by the building, as measured by meters or other means. It is a measure of the in-use performance of the building. This is particularly relevant to certification of actual energy performance.
NOTE 2 Also known as "operational rating".

Presentation of possible manner how to determine different categories of buildings depending to their energy requirements is shown on the following graph (Figure 1), based on EPR limit R_r and building stock median R_s for the considered building type:

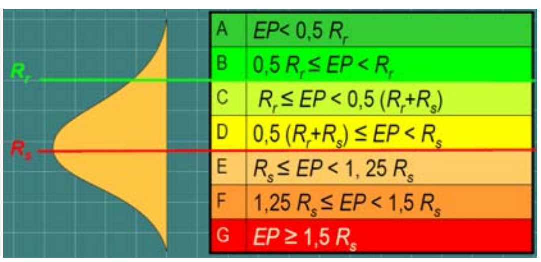


Figure 1 Energy performance Rating - example

In line with the EPB it is important to determine:

- The proper minimum required values depending on the adequate building categories,
- Aged analysis of the national building stock and correlation with specific annual energy demand (kWh/m^2 year).

National methodology for determination/calculation of the EPB should include at itemized lists in EPB EC DIRECTIVE Annex.

- The calculations have to be based on the characteristics of a building and its installed equipment, as listed in the Annex of the EPB EC DIRECTIVE. They may be structured in three levels:
- calculation of the building net energy (energy needs for heating and cooling), together with that for ventilation, hot water and lighting;
- calculation of the building' delivered energy;
- calculation of the overall energy performance indicators (primary energy, CO_2 emissions, etc.).

The calculation sequence is as follows:

a) Calculate the building net energy, using applicable standards of Section 3, Appendix 1[3].This part of the calculation considers only the building properties and not those of the heating/cooling system and results in the net energy use (energy to be given out by heat emitters, or to be extracted from the conditioned space, in order to maintain the specified internal temperature). MKS EN ISO 13790:2009 covers both heating and cooling. To perform this calculation, data for indoor climate requirements, internal heat gains, building properties and outdoor climatic conditions are needed, and these are obtained using the standards of Section 4, Appendix 1[4]. MKS EN ISO 13790:2009 includes guidance for partitioning a complex building into separate zones for the purposes of the calculation.

[3] CEN/BT WG 173 N 68: "Umbrella Document V7 (prCEN/TR 15615). Energy Performance of Buildings Project Group, August 2006
[4] IBID

b) Take into account the characteristics of heating, cooling, domestic hot water and lighting systems, inclusive of controls and building automation, to calculate the delivered energy, by using the standards in Section 2. Energy used for different purposes and by different fuels is separately recorded. The calculations include the following:

- o heat emission,
- o distribution,
- o storage and generation, and
- o include the auxiliary energy needed for fans, pumps etc.

c) Combine the results got under step b) for different purposes and from different fuels to obtain the overall energy use and associated performance indicators, using the standards of Section 1[5].

There is an interlinkage between steps a) and b) because some of the system losses count as gains for the building part of the calculation. In case these cannot be predicted without having information about the heating and cooling needs, steps a) and b) should be repeated or performed twice. In the first calculation, the system gains shall be omitted from the calculation of the net energy, while the second is inclusive of them.
The following Figure 2 illustrates the overall scheme. The overall calculation process involves the following energy flows from the left to the right of Figure.

The characteristics of the technical building systems are included via:

- Heating systems, MKC EH 13790 ; MKS EN 15316-1:2009 and MKS EN 15316-4 (various parts);
- Domestic hot water,MKS EN 15316-3 (various parts);
- Cooling systems, MKS EN 15243:2009
- Ventilation,MKS EN 15241 2009;
- Lighting, MKS EN 15193; and
- Integrated building automation and controls, MKS EN 15232: 2009.

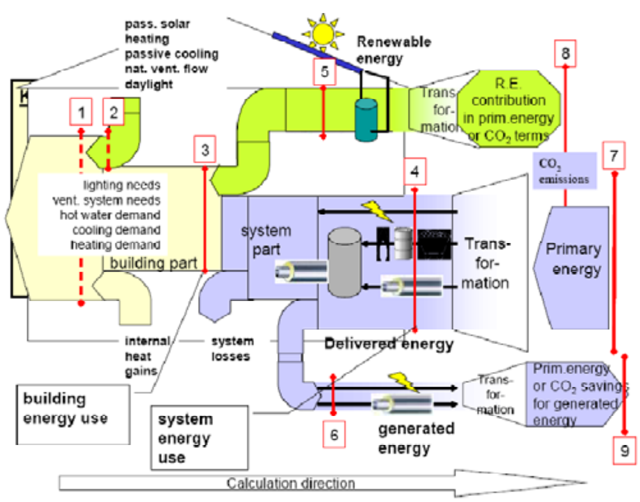


Figure 2 – Flow chart for calculation process[6]

[5] IBID
[6] IBID

“[1] is the gross energy needs – user's requirements for heating, lighting, cooling etc, which are specified for the purposes of the calculation.
[2] is the "natural" energy gains – passive solar, ventilation cooling, daylighting, etc
[3] the building's net energy use is obtained from [1] and [2] along with the characteristics of the building itself.
[4] is the delivered energy, represented separately for each energy carrier, inclusive of auxiliary energy, used by heating, cooling, ventilation, hot water and lighting systems, taking into account renewable energy sources and co-generation. This may be expressed in energy units or in units of the energyware (kg, m³, kWh, etc).
[5] is renewable energy produces on the building premises.
[6] is generated energy – produced on the premises and exported to the market; this can include part of [5].
[7] represents the primary energy usage or the CO_2 emissions associated with the building.
[8] represents the primary energy or emissions associated with on-site generation that is used on-site and so is not subtracted from [7].
[9] represents the primary energy or CO_2 saving associated with exported energy, which is subtracted from [7].”[7]

Determine required climate parameters that should be incorporated in the climate database

The determination of the climatic parameters, in accordance with which one climatic region is being defined, have to be input in the climatic database and are generally unified worldwide however there are significant variations between the micro regions they refer to. The main differences apply to the geographical position or the latitude, altitude, closeness to large water expanses humidity wise (seas and oceans), relief related to wind influences.
At regional level all of these parameters show as: temperature and outdoor air humidity, solar radiation values and its duration, wind (relief, vegetation, direction and intensity), rainfalls – quantity, intensity and type.
On the basis of these general assumptions, the following data shall be entered the main database:

- External air temperature
- External air humidity
- Global solar irradiation
- Design external air temperature
- Design external air moisture
- Duration of the heating/cooling season
- Heating/cooling Day-Degrees (DD)
- Wind direction and speed summaries

In order to prepare the climatic basis, the database shall encompass data analysis of 30 years period of time, taking in account the present availability of data.
The data on the outdoor air temperatures, humidity, solar radiation and wind intensity and direction shall be collected and registered every hour (hourly values). The designed external air temperature, designed external air moisture, duration of the heating/cooling season and heating/cooling Day-Degrees or Hour-Degrees (DD/HD) may be determined on such a basis.
To obtain easier and faster data processing automatic data acquisition is required.

[7] IBID

In accordance with the data for average monthly temperatures during heating period, it was prepared a list of cities with calculated DD (as basis taken 19°C inside temperature), which can be used as an example of that how to start preparing of climatic map for the Republic of Macedonia.
The available data indicates that it is possible to present the Macedonian territory in 3 or 4 different climatic areas, depending to DD or external design air temperature (demonstration only for the winter period):

Table 1 Example of possible determination of climatic regions depending to methodology for EPB determination[8]

City	Heating DD	Average air temperature during heating season	DD Range	Difference in DD
Lazaropole* □	3245	1,1		
Berovo*	2932	2,8		
Kriva Palanka*	2757	3,8	**2900-2700**	**203**
Gostivar	2728	3,9		
Tetovo □	2662	4,3		
Bitola* □	2635	4,5	**2700 – 2500**	**33**
Kicevo □	2632	4,5		
Prilep*	2629	4,5		
Skopje* □❶	2536	5,0		
Ohrid*	2501	5,2	**2500-2300**	
Stip*	2388	5,8		**173**
Strumica*	2364	6,0		
Veles □	2303	6,3		
Kavadarci □ (Demir Kapija)	2241	6,6	**2300-2100**	**223**
Gevgelija*	2080	7,5		
Period: 1960-1990	**2528**			

* Meteorological station in vicinity
□ Air quality monitoring stations
❶Skopje and Ohrid are with quite similar DD and are forming a group which belongs to the worm region

Blue- cold regions, yellow – moderate regions, pink –worm regions, red - hot regions
The difference between the climatic regions is in the frame of cca. 200 DD.

Compared to the world map of Koppen – Geiger Climate Classification, it can be concluded that Macedonian classification presented as example in Table 1 is in line with this classification!

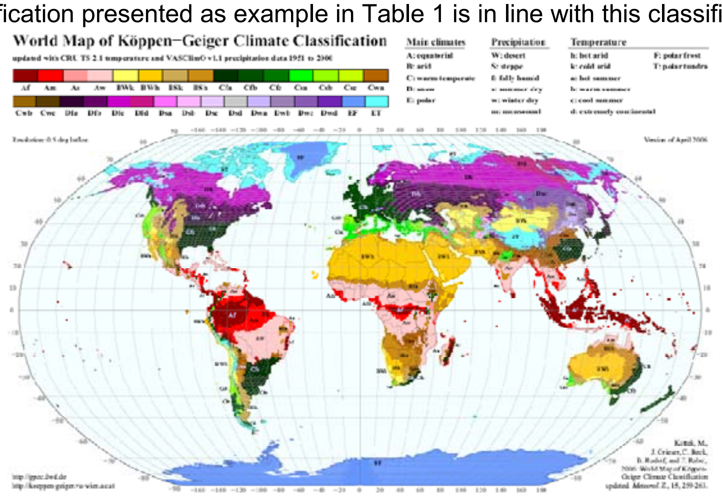


Figure 3 – World map of Koppen-Geiger Climate Classification

Macedonian territory belongs to 3 climatic zones Cfa, Cfb and Csb, with main characteristics as shown below:

[8] Results are determined in accordance with 5 years period of observation

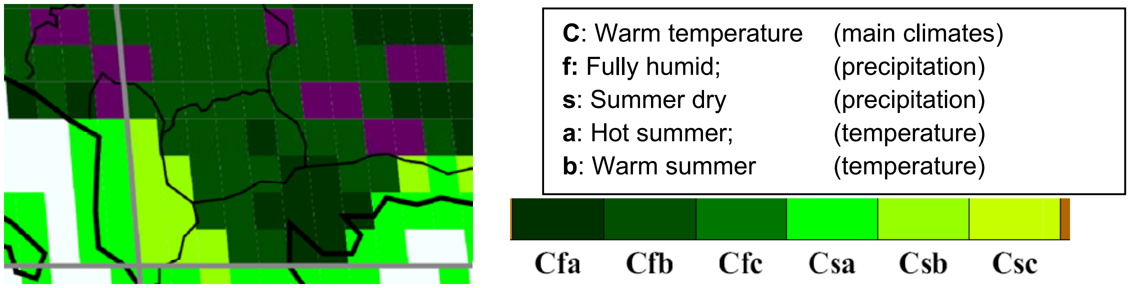


Figure 4 Climatic regions of the Republic of Macedonia in accordance to World map of Koppen-Geiger Climate Classification

Meteorological stations identification within the specified climate regions in the country

The scope of DHM organizational structure consists of Meteorological and Climatological departments. They perform their work using 14 meteorological stations and 18 climatological stations, shown in the picture below:

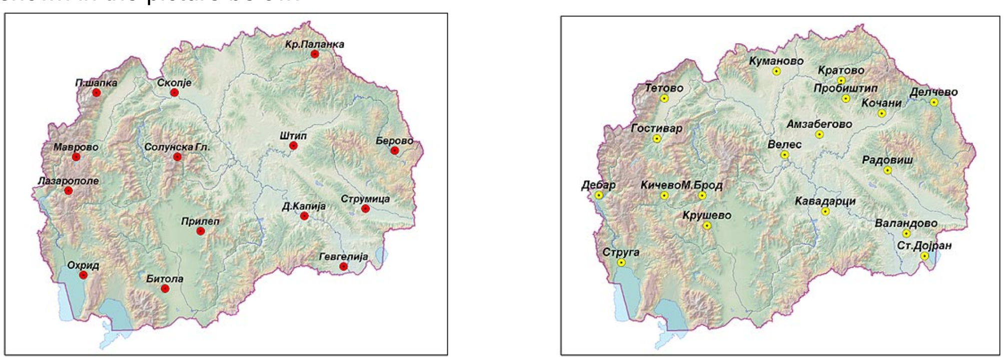


Figure 5 Meteorological and Climatological stations

The data are collected during the working period of the stations, where part of them are noted with analog type drawing instruments, part by manually recording of the measured data.
Only 3 times/day data are reported electronically to the central unit.

The working regime of the meteorological stations is as follows:

	Meteorological station	working period
1	Skopje	00-24,00
2	Bitola	00-24,00
3	Stip	00-24,00
4	Kriva Palanka	3,30-22,30
5	Berovo	3,30-22,30
6	Prilep	3,30-22,30
7	Lazaropole	3,30-21,00
8	Gevgelija	6,00-21,00
9	Strumica	6,00-21,00
10	Demir Kapija	6,00-21,00
11	Ohrid	6,00-21,00
12	Mavrovo	6,00-21,00
13	Popova Sapka	6,00-21,00
14	Solunska Glava	6,00-21,00

The manually collected data is performed three times daily i.e. 07:00, 14:00 and 21:00.

Climatological data which is collected at the meteorological stations include the following:

- Air temperature (wet and dry bulb temperature),
- Extreme air temperatures (minimal and maximal, during the day and night),
- Air humidity,
- Pressure,
- Wind direction and intensity,
- Cloudiness,
- Precipitation (volume, type and intensity), and
- Insolation (due to heliograph) (not intensity)

Directorate for Hydro-Meteorology collects these data on daily, monthly and multiyear level, in accordance with previous mentioned characteristics.
A portion of the data is presented (Figure 6) on the web site of the State Statistical Office climatic data such as:

- Average monthly air temperatures for 11 sites (see below as example from http://www.meteo.gov.mk/MeterolKlimaMesecno.asp?Par=MMPTmax&God=2009),
- Average monthly maximal air temperatures,
- Average monthly minimal air temperatures, and
- Monthly sum (in mm) of precipitations.

МЕСЕЧНИ ПОДАТОЦИ

Средномесечни температури на воздухот во °C

Средни Т | 2009 | Потврди

Изберете Параметар за приказ на Податоци.

Податоци на располагање има за 11 главни станици.

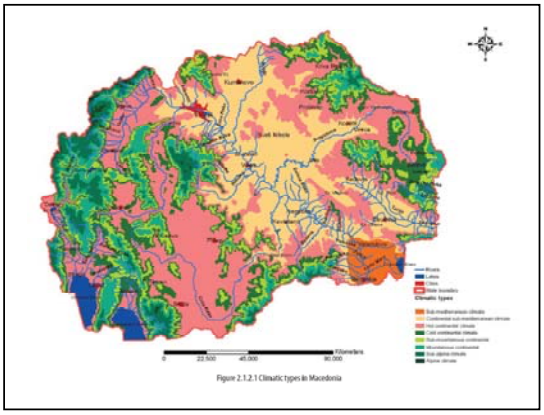
СТАНИЦА	2009	1	2	3	4	5	6	7	8	9	10	11	12	Прос
Берово	2009	0,1	0	3,1	8,8	13,7	17,2	19,1	18,4	14,4	9,7	5,7		10
Битола	2009	1,4	2,4	5,8	11,8	16,8	19,7	23,3	22,1	17,9	10,8	7,6	7,6	12,3
Гевгелија	2009	4,4	5,8	9	14	20,4	23,8	26,9	25,4	21	15	10,8		16
Демир Капија	2009	2,5	4,6	8	14,4	19,7	23,4	26	24,9	20,6	14,2	9,1		15,2
Крива Паланка	2009	0,4	1,2	4,3	10,7	15,5	18,2	20,1	19,9	16,1	0,7			10,7
Лазарополе	2009	-0,2	-2,5	1	7,3	12,4	14,3	17,3	16,6	12,7	7,6	5,9		8,4
Охрид	2009	3	2,5	5,3	11,5	16	18,4	22,1	21,6	17,6	11,6			13
Прилеп	2009	1,4	2	5,5	11,8	17,2	19,6	22,9	22	17,7	11,8	8,1	8,1	12,3
Скопје-3 Рид	2009	1	3,3	7,1	13,4	18	21	24,1	23,8	19,3	12,7	8,3		13,8
Струмица	2009	2	4	7,6	13,2	18,9	22,4	24,9	23,7	19,3	13,4	8,5		14,4
Штип	2009	1,7	3,7	7,3	13,7	18,4	22,2	24,7	23,7	19,8	13,3	9,2		14,3

Figure 6 Standardized climatic data presentations

Review of existing climate information

The First National Communication on Climate Change identifies seven climate regions in the country (Figure 7). Although the country is small, the heterogeneity of climate conditions on this area is very high. This is also evident from the observations of air temperature and precipitation on selected fifteen meteorological stations analyzed within the First National Communication on Climate Change (2003) and the Second National Communication. The locations represent different climatic types and subtypes in the regions of the country, which are a combination of three major climate drivers: Mediterranean, Continental and Alpine climate impacts.

In spite of the relatively small area of Macedonia, the climate is diverse. The following, more homogeneous climate regions and sub-regions are differentiated:
Region with a sub-Mediterranean climate − (50 - 500 m);
− Region with a moderate-continental-sub-Mediterranean climate (to 600 m);



− Region with a hot continental climate (600 - 900 m);
− Region with a cold continental climate (900 – 1,100 m);
− Region with a sub-forest-continental-mountainous climate (1,100 -1,300 m);
− Region with a forest-continental mountainous climate (1,300 – 1,650 m);
− Region with a sub-alpine mountainous climate (1,650 – 2,250 m);
− Region with an alpine mountainous climate (hs >2,250 m).

Figure 7 Seven climate regions in the Republic of Macedonia

This classification cannot satisfy necessities for determination of climatic influences to EPB. The most important parameters are the duration of external air temperatures (expressed through design temperature and moisture, followed by Day-Degree), duration, direction and wind velocity, as well as solar intensity.

An objective for any effective climatic classification is to maximize between-group variation over the parameters of interest, while minimizing within-group variation. A large between-group variation will enable generalizations embedded in the code requirements to be better tailored to each climate zone. A small within-group variation will ensure that the generalizations will fit each zone.

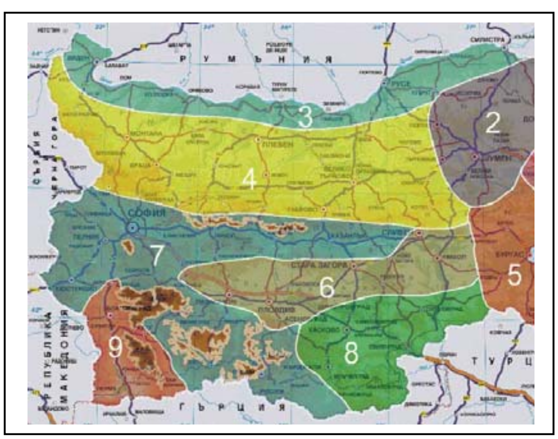
In the USA there are two chief differences between the classifications:

" 1) most dividing lines are based on 1000 degree-days Celsius (1800 degree-days Fahrenheit) divisions rather than

2) 278 degree-day Celsius (500 degree-day Fahrenheit) increments.

The increase in the size of degree-day bands has reduced the number of climate zones but also the coherence of the resulting zones, at least with respect to the degree-day parameters. Most interested parties seem willing to accept the reduced coherence in exchange for the significant (roughly 50%) reduction in the number of zones. However, offsetting the reduction in coherence due to larger degree-day bands is the fact that many of the new divisions simply make more sense climatically than those they are designed to replace. "

In the event of reviewing presentation the presentations of neighbouring countries' climatic data (maps or tables) it can be concluded that there are significant differences.



In **Bulgaria** there are 9 different climatic areas (Figure 8) depending on the DD (100 or 200 DD difference) and design air temperature as follows (DD determined with inside temperature =19^{o}C, there is another table where DD is estimated with inside temperature of 17 ^{o}C):

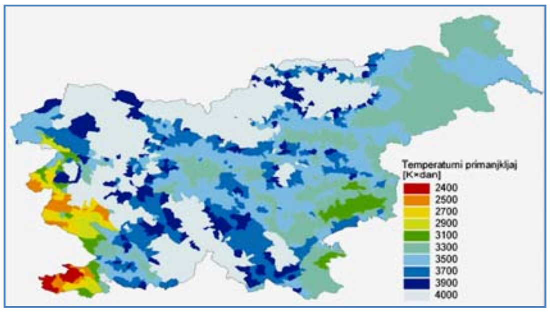
Figure 8 Climatic areas in the Republic of Bulgaria

Table 2 Characteristics of Bulgarian climatic regions

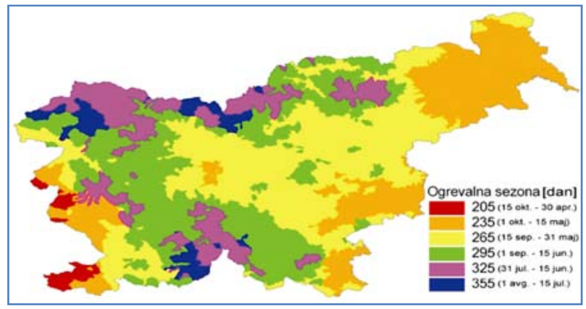
Climatic zone	K1	K2	K3	K4	K5	K6	K7	K8	K9
DD	2400	2800	2600	2700	2300	2400	2900	2300	2100
$t_{out\ d}$	-11	-15	-17	-17	-10	-15	-16	-14	-10

The climatic specifics in the **Republic of Slovenia** (Figure 9) are prepared and shown as follows:

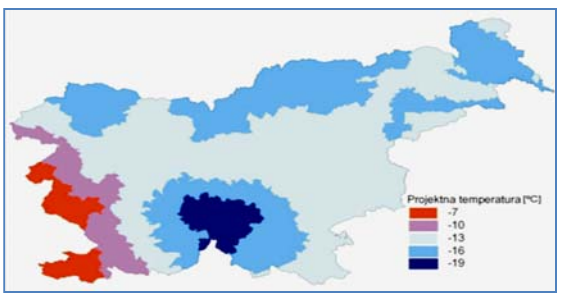
1. Show differences in DD (200 DD);
2. Duration of heating season (in number of days);
3. Design air temperature for heating season;
4. Solar intensity (Wh/m^2).



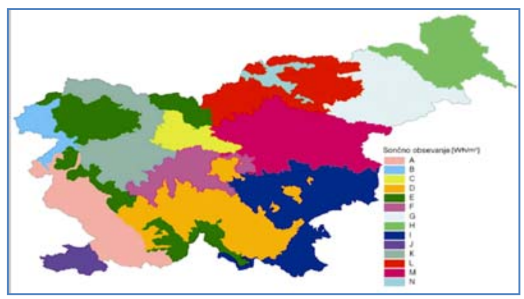
Degree Days



Heating season duration



Design air temperature



Solar intensity

Figure 9 Presentation of climatic characteristic in Slovenia

In Slovenian regulation the definition “Temperature deficit” or Day-Degrees, *DD (K*day)* is the difference of the internal temperature (20^{o}C) of heated space and the average daily external air temperature. In calculating the temperature deficit, only those days with the average external air temperature lower than 12^{o}C are taken into account;

The Croatian legislation on climatic conditions is presented in the form of tables, for the main settlements, where following data is indicated:

- Altitude,
- Geographical coordinates,
- Outer air temperatures for each month,
  - average
  - minimal
  - maximal
  - period of measurement (7:00, 14:00)
- Solar irradiation(for each month, declination and main azimuths),

- Relative air moisture,
- Wind velocity,
- Number of days in the heating season, and
- DD.

Climate Data Gap-Analysis and Recommendations for Acquisition of Missing Data

The territory of the Republic of Macedonia is covered with meteorological data collection stations enabling the development of climatic maps. The main weakness is that there are no quality data available on the solar radiation.

The available values refer to average daily values (Ministry for Environment and Physical Planning) while DHM has no valid data on disposal.

The climatic data collected at the automatic measuring stations of the MEPP may be used as indicative data because of its location (the primary task is monitoring of the air pollution).

A mayor weakness is also the manner of acquisition of the meteorological data. The main stations, encompass data analogue recording (most frequently in form of graphs), or data reading and its manual recording during working hours. The way they function usually gives opportunity for questioning the accuracy of the recorded data.

That manner of data collection gives no possibility for immediate access (on line) and their automatic processing, but it requires additional computer data entry.

The State and the DHM should provide financial means for purchasing contemporary stations for automatic measuring of the identified parameters. Especially for equipping them with instruments for solar activity monitoring including their direct data connection and transfer to the central station for their further processing. The DHM shall immediately approach to the manually/ graphically gathered meteorological data processing so as to enable their effective processing and further utilisation across sectors in the society.

Specific recommendations on further climate data requirements and public availability

As stated above, to ensure appropriate conditions for methodology preparation, it is necessary to have on disposal main meteorological data, not only required by EPB EC DIRECTIVE, but also for designing process in the building sector, influencing later building energy performances control.

Table 3 Requered main climate data:

Climate prameter	Simbol	Dimension	Interval	Availability
The dry-bulb outdoor temperature	θ	°C	1 hour	Should be prepared by DHM. The data are not available for electronic processing.
The relative humidity	φ	%	1 hour	
Wind by speed and direction	v	m/sec	1 hour	
Solar irradiance (global, diffuse, direct radiation)	G_s	W/m^2	1 hour	The data are collected by MEPP. Preparation of data for analyse should be realized by DHM' experts with eventual

				outsourcing.
Design Air Temperature for heating*	θ_{DH}	^oC		Calculation in correlation with previous climate parameters
Design Air Temperature for cooling*	θ_{DC}	^oC		
Degree-day heating	DD_H			
Degree-day cooling	DD_C			

* DATs are not prerequisites in EPB EC DIRECTIVE. They are quite necessary during the designing process. If there is mandatory requirement to prepare EE elaborate to obtain building permission, without proper determination of DAT it will be impossible.

The period over which parameters are calculated should not be shorter than 20 years, optimal is 30 year data set.
These parameters shall be presented in tabular form similar to the example shown in the Annex I. Berovo, Bitola, Skopje, Stip and Gevgelija' climatology stations parameters will be used and prepared as referent climatology points for different regions.

Parameters DD, DAT or both will be used as references to design climatic map for EPB purpose of the Republic of Macedonia.

Dependencies to relevant ADA Project Outputs and identify additional activities to address these dependencies

There is strong correlation with the ADA Project "Enabling the Environment for Introducing Energy Efficiency in Buildings in the Republic of Macedonia".

The results will be used into Chapter 6, Component 2 (Legislation and Enabling environment) Task 1 consisting of:
Task 1 of component 2 is setting the basis for implementation of the Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings (EPB EC DIRECTIVE). This Directive is set to promote the improvement of energy performance of buildings with the following requirements to be implemented:

- Revise the existing framework, Book of Rules (Activity C2T1.1) and define its update accordingly during Project's inception period (first 3 months).
- The general framework for a methodology of calculation (Activity C2T1.2) of the integrated energy performance of buildings.
- The application of minimum requirements (Activity C2T1.4) on the energy performance of new buildings.
- The application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation.
- Energy performance certification (Activity C2T1.5) including the energy efficiency label for buildings.

Assumed activities are dependent on the data concerning climatic issues. The preparatory process of reviewing the existing EPB Rulebook, starting with the preparation of national methodology of calculation can be realized simultaneously with the development of the climatic classification for the Republic of Macedonia.
The next phase may introduce the climatic characteristics as climatic coefficients. It represents an acceptable methodology ensuring clear comparison of buildings EPR. The mentioned method, for example, is used in the Directive on CHP promotion (Directive 2004/8/EC) where calculation of PES (Primary Energy Savings) are performed depending to the standard ISO environmental status

(temperature 15°C, pressure 1,013 bars, relative humidity 60 %), and using correction factors for each 1°C temperature difference. The correction is 0,1%- point efficiency loss for every degree above 15 °C, and 0,1%- point efficiency gain for every degree under 15 °C.

The application of minimum requirements for the new buildings' energy performance into EPB Rulebook will depend on the finalization timing of data collection for the existing Macedonian building stock and its thermal specifications, accompanied with determination of the energy requirements.
The realization of these items is a prerequisite for finalization of the EPB Rulebook and rules for EP certification.

Conclusions

To enable fast realization of EPB control and certificate issuance, it is necessary to prepare calculation software by using national methodology as its basis. This methodology and software have to be prepared under the main preconditions such as:

- To ensure comparison between buildings.
- To ensure assessing compliance with EPB.
- To investigate opportunity to prepare unified methodology for the whole territory of the State, rendered as one climatic region. Climatic factors to be considered as influencing coefficients
- To introduce elements which are suggested in the Recast of the EPB EC DIRECTIVE.
- To prepare National Climatic Classification in strong correlation with design air temperatures and humidity, wind influence, duration of heating/cooling period and solar irradiation. Existing classification is not appropriate.
- It is necessary to prepare hourly duration of air temperatures for period of 30 years.
- It is necessary to determine design (winter/summer) air temperature and relative air humidity.
- It is necessary to start measuring and data collecting for solar irradiance in all of determined climatic zones.
- It is necessary to start collection and preparation of all climatic data in digital form.
- Determination of DD or DH (Degree-Hours) should be realized with special care.* (Annex II)

Recommendation

Depending to climatic data on disposal, time frame and financial capabilties it can be recommended to start with preparation of the folowing parameters:

***Table 1 Annex 1- Monthly and annual mean temperatures**:* Having in mind time frame for finalization of the project database (September 2010), representatives from HMI to provide mean daily values for the temperature based on 3 daily reference values for 15-year interval (1994-2009) for 4 referent stations. Values of hourly dry-bulb outdoor temperature in percentage have to be additionally calculated.

Table 2 Annex 1– Dry-bulb outdoor temperature duration: Hourly data from HMI will be used to fill this table for the last 10 year period.

Table 3 Annex 1– Monthly and annual mean humidity: Mean daily values for the humidity based on 3 daily reference values for 15-year interval (1994-2009) to be provided from HMI for 4 referent stations. Values of relative humidity in percentage and monthly means of water vapor pressure have to be additionally calculated.

***Table 4 Annex 1– wind speed and direction**:* Necessary data needed for the wind parameter are direction, intensity, speed and duration. This table should be redesigned to include duration parameter and to simplify speed just for 2 values (less that 4m/s and more than 4m/s).

Table 5 Annex 1– solar radiation: HMI has no record of data for solar radiation. Data from MOEPP have to be used to fill this table for the last 7 year period. Thus, it is important to select meteorological station from both institutions that will cover same climate regions.

***Climate regions and referent meteorological stations**:* It is feasible to divide the country in 4 climate regions on basis of diference of 200 Degree Days. Suggested referent stations (one for each climate region) from HMI are: Skopje, Bitola, Berovo and Demir Kapija. Selected referent stations (one for each climate region) from Ministry of Environment and Physical Planing have to be: Skopje – Gazi baba, Bitola, Kavadarci and Kocani.

Annex I

1. *Sample table of monthly and annual mean temperatures*

MKC EN ISO15927-2		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
The monthly means of the dry-bulb outdoor temperature	$\theta_m m$													
Air temperature mean standard deviation over a month	$\theta_{Sd} m$													
The minimum value of the hourly dry bulb outdoor temperatures	θ_{min}													
The values of the hourly dry-bulb outdoor temperature at the 1 %, 5 %, 10%, 90 %, 95 % and 99 % percentiles.	θ_{p1}													
	θ_{p5}													
	θ_{p10}													
	θ_{p90}													
	θ_{p95}													
	θ_{p99}													
The maximum value of the hourly dry-bulb outdoor temperatures	θ_{max}													

2. *Dry-bulb outdoor temperature duration*

Heating season-January			
θ	**h**	**θ**	**h**
°C	**-**	**°C**	**-**
-18<		1	
-17		2	
-16		3	
-15		4	
-14		5	
-13		6	
-12		7	
-11		8	
-10		9	
-9		10	
-8		11	
-7		12	
-6		13	
-5		14	
-4		15	
-3		16	
-2		17	
-1		18	
0		19	
		20	

Cooling season - June	
θ	**h**
°C	**-**
25<	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
>40	
∑	720

>20	
∑	744

The same tables for heating season: January, February, March, April, October, November, December.
The similar tables for cooling season: May, June, July, August, September

3. *Sample table of monthly and annual means (with distribution of relative humidity)*

MKC EN ISO15927-2		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
The monthly means of the dry-bulb outdoor temperature (°C)	θ_mm													
The monthly means of water vapor pressure (hPa)	P_mm													
The monthly means of the relative humidity (%)	φ_mm													
The minimum value of the hourly relative humidity (%)	φ_{min}													
The values of the relative humidity at the 1 %, 5 %, 10%, 90 %, 95 % and 99 % percentiles.	φ_{p1}													
	φ_{p5}													
	φ_{p10}													
	φ_{p90}													
	φ_{p95}													
	φ_{p99}													
The maximum value of the hourly relative humidity (%)	φ_{max}													

4. *Sample table of monthly or annual frequency of wind by speed and direction*

Speed m/s	Direction												All directions
	345 to 15	15 to 45	45 to 75	75 to 105	105 to 135	135 to 165	165 to 195	195 to 225	225 to 255	255 to 285	285 to 315	315 to 345	
>14													
12 to 14													
10 to 12													
8 to 10													
6 to 8													
4 to 6													
2 to 4													
0 to 2													
All speeds													**100**
	N			**E**			**S**			**W**			

5. *Sample table of monthly means of solar radiation horizontal and vertical surfaces*

Station:												
Heat. season	Start:			Stop:			Design outdoor temperatures			ºC		
Cooling season	Start:			Stop:			Design outdoor temperatures			ºC		
Month	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average temperatures [ºC]												
Solar radiation including average clouding, vertical surfaces [W/m²]												
North												

East/West												
South												
Horizontal												

Annex II

* Degree days are a simplified form of historical weather data. They are commonly used in monitoring and targeting to model the relationship between energy consumption and outside air temperature. **Weather normalization of energy consumption** is one of the most common such uses of degree days. In theory, weather normalization (or "*weather correction*") enables a like-for-like comparison of energy consumption from different periods or places with different weather conditions.

Weather normalization techniques are often based around *regression analysis of past energy consumption data*, a method that is frequently used with degree days to:

- **Identify signs of waste** from past energy-consumption data.
- **Assess recent energy performance** by comparing recent consumption with a past-performance-based estimate of *expected* consumption. In particular, this process is often used to identify *excess* consumption (or *overspend*), and to quantify the savings from improvements in energy efficiency.

Although much of the theory behind these methods is sound, the results are usually a lot less accurate than many people realize. Such degree-day-based methods are central to many energy management programmes, and, as a result, important decisions are frequently based on figures that can be **dangerously misleading** to those that put too much faith in them.

Heating degree days (HDD) are used for calculations that relate to the heating of buildings. For example, HDD can be used to normalize the energy consumption of buildings with central heating. Heating degree-day figures come with a "*base temperature*", and provide a measure of how much (in degrees), and for how long (in days), the outside temperature was below that base temperature.

Cooling degree days (CDD) are used for calculations relating to the cooling of buildings. For example, CDD can be used to normalize the energy consumption of buildings with air conditioning. Cooling degree-day figures also come with a base temperature, and provide a measure of how much, and for how long, the outside temperature was *above* that base temperature.

The base temperature problem

In degree-day theory, the *base temperature*, or "*balance point*" of a building is the outside temperature above which the building does not require heating. Different buildings have different base temperatures.

In the UK, for example, the majority of energy professionals primarily use degree days with a base temperature of 15.5°C.

Use of a 15.5°C base temperature is often justified with arguments along the lines of:

Buildings are typically heated to a temperature of around 19°C.

The heating system does not need to supply *all* the heat necessary to ensure that the building is heated to 19°C: some heat comes from other sources such as the people and equipment in the building. These sources contribute to an "average internal heat gain" that is typically worth around 3.5°C.

If you subtract the typical average internal heat gain from the typical building temperature (19°C - 3.5°C) you get a base temperature of 15.5°C. This is effectively the temperature that the heating system needs to heat the building to, as the average internal heat gain supplies the difference. 15.5°C is therefore an appropriate base temperature for degree-day-based calculations relating to the energy consumption of the heating system.

The method of calculating an appropriate base temperature by subtracting the average internal heat gain from the building temperature is a sensible approximation. However, the figures used in the above arguments are where the problems lie:

- **Different buildings are heated to different temperatures**. Although it's *often recommended* that office buildings are heated to 19°C, in reality they are often several degrees warmer. Industrial buildings are often several degrees cooler.
- **Average internal heat gain varies greatly from building to building**. Clearly a crowded office packed with people and equipment will have a much higher average internal heat gain than a sparsely-filled office with a high ceiling. Clearly the internal heat gain from industrial processes depends greatly on the processes in question.

In reality, 15.5°C is rarely the most appropriate base temperature to use for degree-day-based calculations. This is important, as degree-day-based calculations can be greatly affected by the base temperature of the degree days used.

The base temperature with which degree days are most readily available actually varies from country to country. For example, the "default" base temperature in the **UK is 15.5°C**, whilst, **in the US, it's 18°C** (65°F). This alone is a pretty strong indication that the one-base-temperature-fits-all approach to degree-day-based calculations is inappropriate!

Annex III Minutes of the Working Group Meeting

For finalization of the report for the assessment of methodologies for the calculation of energy performance of buildings, corresponding climate parameters and climate data requirements

Project Mitigating climate change through improving energy efficiency in building sector
Project No 00059896
Time/Date: 12:00-14:30, 7 May 2010

PARTICIPANTS:

Name	Institution
Mr. Konstantin Dimitrov	MACEF
Ms. Natasa Markovska	Macedonian Academy of Sciences and Arts (MANU)
Mr. Tamara Teofilova Bojadzi	Faculty of architecture
Ms. Todorka Samardzioska	Faculty for civil engineering
Mr. Jordan Angelovski	Energy Agency of the Republic of Macedonia
Mr. Nina Aleksovska	Hydro-meteorological Institute (HMI)
Mr. Pece Ristevski	Hydro-meteorological Institute
Mr. Zdravko Stefanovski	Toplifikacija inzenering
Mr. Marko Serafimov	Faculty for mechanical engineering
Mr. Igor Atanasov	Ministry of Environment and Physical Planning (MOEPP)
Mr. Ilija Sazdovski	Project Manager /UNDP
Ms. Pavlina Zdraveva	Project Assistant/UNDP

Objective:

- Comments from participants of the consultative workshop
- Determine climate zones
- Climate parameters values
- Referent climatological stations

BACKGROUND

Mr. Konstantin Dimitrov, was hired in 2009 as consultant to perform an assessment, evaluation and determination of the specialized technical aspects regarding the development of a Climate Database (Output 1 of the project), with special emphasis on the required climate parameters per regions and its compatibility to country specific calculation methodology. During the fulfillment of the assignment, there was regular communication and exchange of findings with the project manager. Draft report, reflecting tasks as outlined in the TOR was prepared on time.

On a consultative meeting with representatives from UNDP, MOEPP and technical consultant engaged for the project, it was decided to ask for additional peer review of the document the insure that the international best practices are incorporated in the report. The report, with incorporated comments from the project stakeholders (as specified above) was sent for peer review to selected international consultant, Mr. Klemen Bergant, Director of Meteorological Office within the Environmental Agency of the Republic of Slovenia.

Presentation of the findings of the final report was done on a consultation workshop that was held on 22 April in ERA CITY, Skopje, with an audience of app. 40 relevant stakeholders. Conclusions from the workshop were:

- Work group of representatives from following institutions was identified: HMI, Energy Agency, Faculties of architecture, civil engineering, mechanical engineering and private sector, to further discuss on the open issues regarding meteorological data needed for the project output;
- All participants should submit comments (if any) by mail to project manager/assistant latest by May 6, 2010
- Written proposal for creation of legal background to ensure future update and sustainability of the project databases should be prepared and sent to designated authorities (MOEPP and Ministry of Economy). They should initiate further steps to implement recommendations from the proposal.

Regarding the comments from participants on the workshop, not one comment was received within the given two week period.

A consultative meeting was scheduled on 7 May with a small group of relevant stakeholders (as specified in the list of participants and agreed on the workshop) to finalize the open issues of the report, i.e. required climate parameters (hourly or mean daily values for the temperature, humidity, solar radiation and wind – speed and direction), as well as to agree on number on climate regions and referent stations.

The final report will be submitted by Mr. Dimitrov after the consultative meeting, incorporating suggestions/comments/conclusions from Mr. Bergant and from the meeting.

CLIMATOLOGICAL DATA

The following climatologically data were identified by the consultant as input for the climatological database developed as one of the project activities:

- **External air temperature**
- **External air humidity**
- **Global solar radiation**
- **Wind direction and speed summaries**
- Design external air temperature
- Design external air moisture
- Duration of the heating/cooling season
- Heating/cooling Day-Degrees (DD)

The consultant recommended the database should encompass data analysis of **30 years period** of time. The data on the outdoor temperatures, humidity, solar radiation and wind intensity and direction are recommended to be **hourly values**. The designed external air temperature, designed external air moisture, duration of the heating/cooling season and heating/cooling Day- Degrees or Hour-Degrees (DD/HD) may be determined on such a basis.

The final report will be submitted by Mr. Dimitrov after the consultative meeting, incorporating suggestions/comments/conclusions from Mr. Bergant and from the meeting.

DISCUSSION AND CONCLUSIONS FROM THE MEETING:

Project manager, Mr. Sazdovski, welcomed the participants on the meeting and shortly presented the background and the purpose of the meeting. He pointed out that the climate parameters defined in the project document “Mitigating climate change through improving energy efficiency in building sector” are rather general, and one of the assignments of the engaged consultant i.e. Mr. Konstantin Dimitrov, was to actually make prioritisation of the needed climatological data. As such, the period (10/20/30 years) and time interval (hourly or three daily values) of the needed data are very important in terms of providing data for the climatological database needed for the project.

Mr. Sazdovski also briefly presented the situation regarding availability of climatological data in the country: 14 meteorological stations within the State Hydro-meteorological Institute (HMI) and 15 stations within the Ministry of Environment and Physical Planning (MOEPP). The meteorological stations from both institutions are not positioned on same places, but both have positive and negative sides:

- HMI is an official institution for collecting and validating climatological data from their meteorological stations. They can provide data for longer period. However, they are not obliged to insert hourly data for temperature and humidity into their database (they have them only in written form, and it would take too long to digitalise the data. HMI also doesn't have data on solar radiation.
- MOEPP has hourly data for their meteorological stations on all needed parameters: temperature, humidity, wind and solar radiation for the last 7 years. They are willing to share these data free of charge. However, their data are not validated.

Mr. Dimitrov pointed that on todays meeting conclusions should be adopted reflecting both state and project developers interests.Thus, certain level of qualitative data will be provided, which will be further updated and eventually extended. Climatological data specified in the report in five tables are in accordance with Macedonian standards.

The following issues were highlighted and discussed:

- ***Table 1 - Monthly and annual mean temperatures****:* Having in mind time frame for finalization of the project database (September 2010), representatives from HMI suggested to provide mean daily values for the temperature based on 3 daily reference values for 15-year interval (1994-2009) for 4 referent stations. Values of hourly dry-bulb outdoor temperature in percentage will be additionally calculated, and HMI takes no responsibility to make these calculations.
- ***Table 2 – Dry-bulb outdoor temperature duration:*** Hourly data from HMI will be used to fill this table for the last 10 year period.
- ***Table 3 – Monthly and annual mean humidity:*** Mean daily values for the humidity based on 3 daily reference values for 15-year interval (1994-2009) will be provided from HMI for 4 referent stations. Values of relative humidity in percentage and monthly means of water vapor pressure will be additionally calculated, and HMI has no responsibility to make these calculations.
- ***Table 4 – wind speed and direction****:* Necessary data needed for the wind parameter are direction, intensity, speed and duration. This table should be redesigned to include duration parameter and to simplify speed just for 2 values (less that 4m/s and more than 4m/s).
- ***Table 5 – solar radiation:*** HMI has no record of data for solar radiation. Participants concluded that data from MOEPP will be used to fill this table for the last 7 year period. Thus, it is important to select meteorological station from both institutions that will cover same climate regions.
- ***Climate regions and referent meteorological stations****:* After in-depth discussion, participants agreed that it is feasible to divide the country in 4 climate regions on basis of diference of 200 Degree Days. Selected referent stations (one for each climate region) from HMI are: Skopje, Bitola, Berovo and Demir Kapija. Selected referent stations (one for each climate region) from MOEPP are: Skopje – Gazi baba, Bitola, Kavadarci and Kocani.

Any Other Business (AOB):

- *METEONORM* – Ms. Markovska pointed software METEONORM as possibility to validate climatological data from MOEPP f.e. data from MOEPP for can be entered in the software for one year, and based on this prediction for other year can be compared with data from HMI. MANU has used this software and tested it for period of 3 years to calculate the uncertainty of data predicted from METOENORM and actual data from HMI. The determined confidence range was within ±2%, which is an acceptable range. Participants agreed that data from METEONORM are not option for providing meteorological data for the whole state, but it would be really usefull to validate data from MOEPP wich will be used to cover gaps. Representatives from HMI refused to validate data from MOEPP, so participants on this meeting concluded that is would be extremly usefull for MOEPP to purchas METEONORM and to train several employees to use this software for validatuion of data from their automatic meteorological stations.
- *Hourly climatological data* – Mr. Sazdovski pointed that even though hourly data cannot be provided at the moment due to many technical details, the software that will be developed by the project will include possibility to import hourly data for the temperature and humidity.

Conclusions of the meeting:

1) HMI will provide mean daily data (based on 3 daily reference values) for temperature, humidity and wind (direction, speed, duration) for 15 year period (1994-2009) for 4 meteorological stations.
2) HMI will provide hourly data for dry bulb temperature duration for 10 year period for 4 meteorological stations
3) MOEPP will provide hourly data for solar radiation, humidity and temperature for up the longest period of measurement for 4 meteorological stations.
4) 4 climate regions were defined and responding meteorological station from both MOEPP and HMI.

Prepared by the Project team

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