Co-funded by the Intelligent Energy Europe Programme of the European Union

IEE PassREg

PASSIVE HOUSE REGIONS WITH RENEWABLE ENERGY

Identifying characteristic climate data for energy balance calculations

Climate data as a baseline boundary condition (D 5.3.2) & climatic datasets for PassREg beacons (D 5.3.1)

Developed by the Passive House Institute (PHI)

in collaboration with the PassREg consortium

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INTRODUCTION

In order to achieve high energy efficiency a building must be optimised for the local climate conditions – both in terms of the envelope and the building services. The basis of any energy calculation is therefore the climatic data, which represents the fundamental boundary condition of the optimisation process. Not only the outside temperature, also the amount of solar radiation and the humidity level are deciding factors.

Within PassREg the Passive House Institute (PHI) conducted research on local boundary conditions to be used in the different regions for the energy calculations (task 5.3.2) – one important aspect being the climatic data. This report summarises the findings for the different countries/regions of PassREg in terms of climate data availability and suitability for energy calculations. Based on the findings, specific climate datasets were then generated for each beacon location (task 5.3.1).

2

CLIMATE DATA FOR ENERGY CALCULATIONS

The weather changes from year to year, which inevitably causes varying energy consumption of any building. With the aim of predicting an average performance, climate data used for energy calculations should represent typical average conditions at the construction site. Such typical conditions can best be obtained from long-term measured data. The World Meteorological Organization (WMO) uses a period length of *at least* 10 years to determine average conditions. 30 years are used for so-called climate "normals", which are reliably representative for the local conditions and used for the analysis of climatic trends. The current standard reference period is 1961-1990, which will be succeeded by the following 30-year period 1991-2020. As the climate does not only vary on an annual basis but is also subject to a more gradual change, it is advisable to use the most recent reference period available.

Climate data is available from various sources (see section 3) and in different formats. The required format for energy calculations depends on the tools used and the value to be determined. Averaged monthly values of the selected reference period are sufficient for calculating the energy demand of a building with a stationary energy balance, e.g. with the Passive House Planning Package (PHPP).

More detailed hourly values are needed for dynamic building simulations. So-called "Test Reference Year" (TRY) or "Typical Meteorological Year" (TMY) data is often used. To obtain such a representative data set with information for each hour of the year, statistical methods are applied for each month of the year to select the most representative out of the measured data period. These individual representative

months are then combined into an artificial one-year data set. Guidelines on the methodology to generate a TRY set from measured climate data is described e.g. in the regulation EN ISO 15927-4.

In addition to calculation the energy demand for heating and cooling of a building, climate data is needed for appropriate sizing of the building services. In this case, the climate data must represent suitable boundary conditions from which a building's maximum load for heating and cooling can be determined. The thermal dynamics of a building change with its efficiency level, as it usually features much higher inertia. Applying conventional procedures therefore often leads to oversized heating and cooling systems in highly energy efficient buildings. This can cause unnecessarily high investment costs and suboptimal system efficiency. The Passive House Planning Package (PHPP) includes an alternative heating and cooling load calculation procedure suitable for energy efficient buildings. The required climate data is an integral part of the PHPP climate data files.

Questions are often raised concerning climate data to be used for energy calculations. There are, for example, uncertainties regarding the required and achievable accuracy of a dataset, its range of applicability for a surrounding area, the assessment of microclimatic effects etc. It is important to assess the suitability of any climate dataset on an individual basis for the purpose of the calculation tool at hand. The quality of the original data source is very important, as is the way the data has been processed. Averaging long-term values is a recommended approach for energy demand calculations. The same data, however, is not at all suitable for deriving heating or cooling load design data, because the correlation between temperature and radiation gets lost. Comparing data from different sources is generally recommended. This approach ensures that systematic errors can be ruled out which might otherwise go unnoticed; it also helps to get a feeling for project relevant climatic differences in location and time.

It is worth noting that the user influence once a building is in use, is often larger than local micro-climatic effects or yearly weather variations. The difference in user behaviour can cause the consumption to triple or more (see Figure 1), whilst yearly weather variations cause differences around 5 kWh/(m²a) in the heating demand of a Passive House (Figure 2 and Figure 3). The required and achievable level of accuracy for climate data as a boundary for energy calculation is at least within this range of 5 kWh/(m²a), depending on data availability. The purpose of the climate data is not to predict the energy consumption of a specific building to the precise kWh but rather to ensure that the planned design is suitable for the location and that, once completed, it will operate well with a high level of energy efficiency.

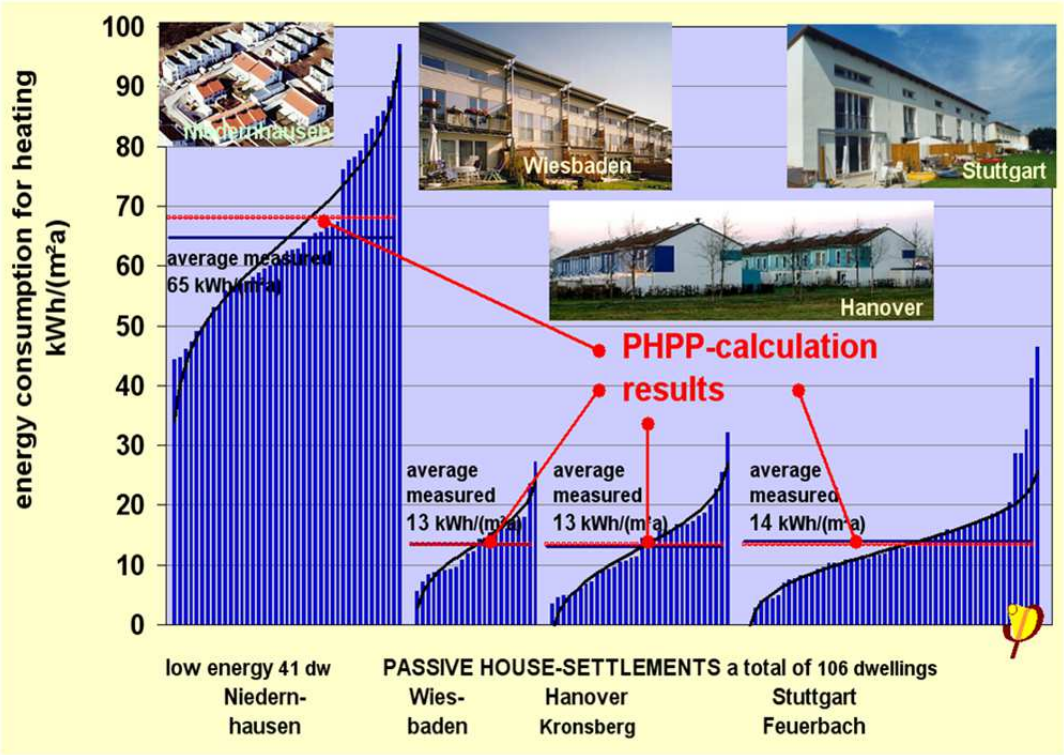

Figure 1: The energy consumption of low energy building complex and three sets of terraced Passive Houses. For each set of building with very similar specifications a large variation in consumption around approximately +/- 50% of the average value was observed (15 kWh/(m²a) consumption variation for the Passive Houses). This is caused mainly by different user behaviour (e.g. higher or lower individual temperature settings). Source: Passive House Institute.

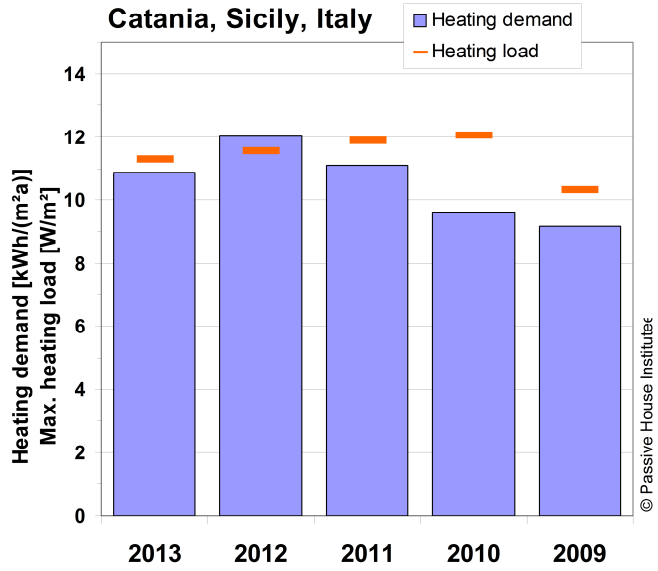

Figure 2:

The variations in the energy demand calculated with the PHPP for an exemplary Passive House based on ground-measured climate data in Catania (Italy) from five consecutive years are less than 5 kWh/(m²a).

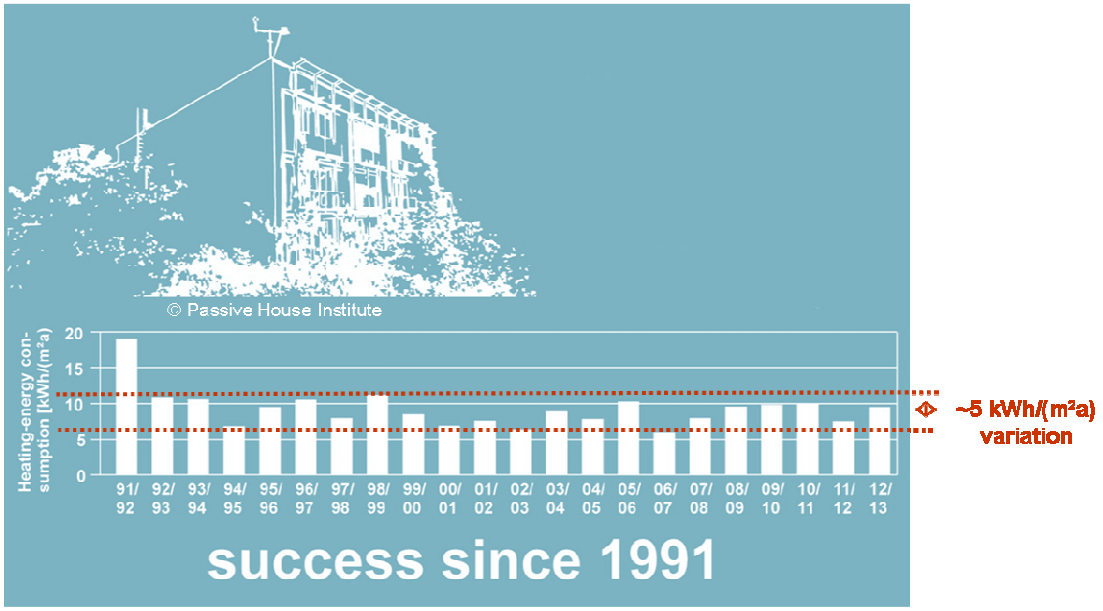

Figure 3: The measured annual energy consumption of the fist Passive House in Darmstadt (Germany) since 1991 with the same occupants has not varied by more than around 5 kWh/(m²a). The first year is excluded from the analysis.

3

CLIMATE DATA SOURCES

Climate data is based either on ground-based measurements or satellite data. Data from different stations/sources is often interpolated if climate data is required for a specific location where no local measurements exist. Alternatively, climate data from specific locations is often used as representative data for a surrounding zone with similar climatic conditions.

The following is a list of *examples* of worldwide climate data sources:

- Many weather stations are listed with individual station IDs at the World Meteorological Organization (WMO). Data from these stations is used to determine official climate normals and is often readily available. One example of accessing this data is through the World Data Center for Meteorology and their publication of World Weather Records (WWR).
- The software Meteonorm (www.meteonorm.com) is a worldwide meteorological database. Climate data can be extracted in a variety of formats (including PHPP) for any location on the globe and different reference periods.

- Climatic conditions are continuously recorded by satellites orbiting the earth. Worldwide data from the NASA Langley Research Center Atmospheric Sciences Data Center POWER Project has been converted by the PHI into the format required for the PHPP and is available for download from the climate data tool integrated into Passipedia (www.passipedia.com).
- Weather stations are usually maintained by the national meteorological organisations. These organisations therefore are a first point of contact when searching for climate data.
- The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has published a selection of hourly climatic datasets named International Weather for Energy Calculations (IWEC). This data is derived from a period of up to 18 years (1982-1999, depending on availability) and categorised into three different groups (I = can be used confidently , II = use with caution, III = use at own risk).
- A number of climate data sets from a variety of different sources (including some of the above) have been converted into the data format required for the simulations software Energy Plus. The weather data is available online on the website of the U.S. Department of Energy, Department of Energy Efficiency and Renewable Energy.
- Average climatic conditions are often documented in national regulations.
- The PHPP contains monthly data in the required format for a large number of international locations from various original data sources.

4

CLIMATE DATA FOR PASSREG

Within PassREg each country/region with beacon projects was analysed carefully in terms of climate data availability. Climate data from national regulations was compared with available data from local weather stations and the data sources listed in section 3. The assembled information – making no claim to be exhaustive - is to be used as a guideline for people wishing to carry our energy calculations for buildings in the respective regions.

Furthermore, specific climate datasets were generated for all locations of the beacon projects listed on the PassREg website (see Figure 4) as proposition for energy calculations with the PHPP. The data is documented in an Excel spreadsheet submitted separately to this document and will be integrated into future versions of the PHPP.

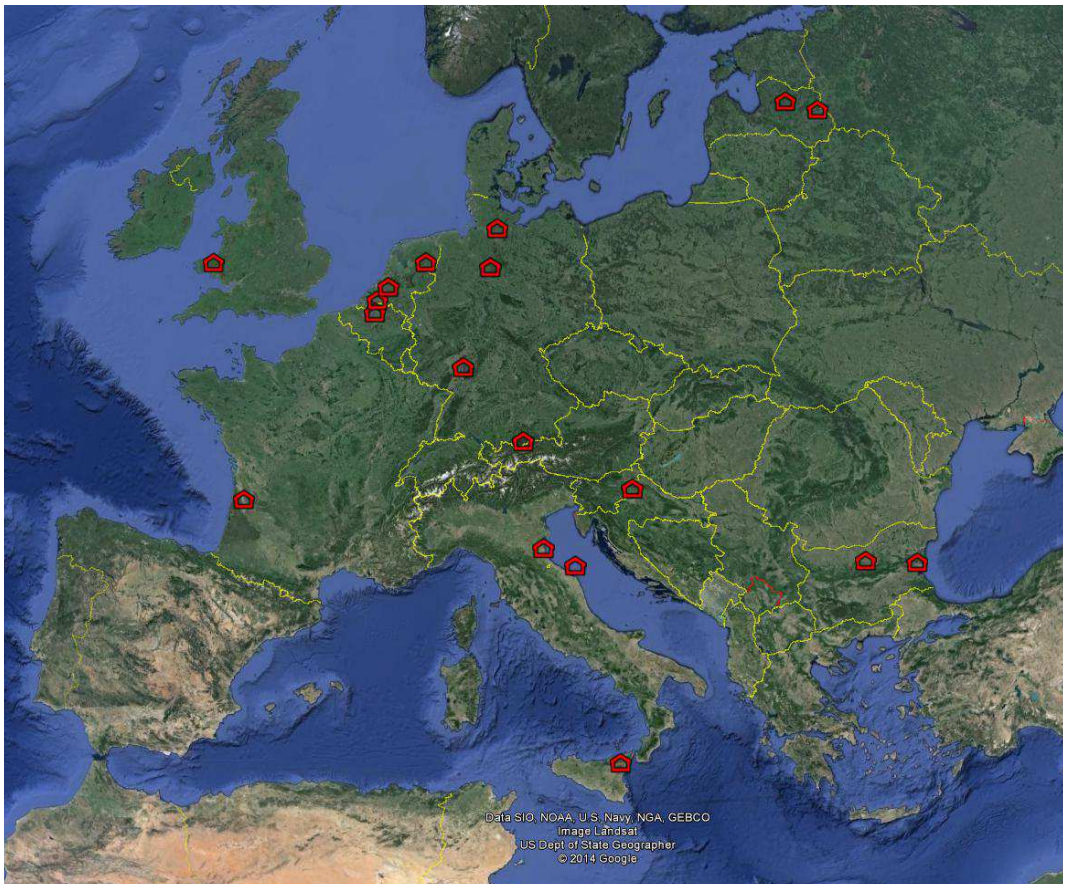

Figure 4: Google Earth Screenshot with all PassREg beacon locations for which the climatic boundary conditions were carefully reviewed.
(Data: SIO, NOAA, U.S.Navy, NGA, GEBCO; Image: Landsat; US Dept of State Geographer © 2014 Google)

4.1 AUSTRIA

National Meteorological Organisation:

Central Institute for Meteorology and Geodynamics (www.zamg.ac.at)

In Austrian: Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

Data availability for energy calculations:

- Climate data is available in different formats through the national meteorological organisation ZAMG. Climate *normals* (average monthly data) from the reference periods 1961-1990 and 1971-2000 are accessible online for a number of weather stations. Test Reference Year data is not available free of charge but can be ordered from the ZAMG for any required location.
- An online tool exists on the website of the Federal Ministry of Science, Research and Economy, which can be used to generate monthly temperature and radiation data any location with Austria. The tool is based on original data from the ZAMG with interpolations for location in between.
- IWEC:
  5 stations (Graz, Innsbruck, Linz, Salzburg, Vienna), all category I

PHPP climate data:

The current version of the PHPP V.8 contains a total of 47 climatic datasets for Austria. Almost all of these datasets were calculated in 2007 based on original daily data from the ZAMG. New climate data sets in Austria are being generated for Passive House projects on a demand basis. Generating reliable climate data for energy calculations in Austria is very difficult due to the mountainous geography and significant microclimatic effects.

PassREg beacons:

A new dataset for **Innsbruck** was derived in 2013 for the PHPP based on an hourly Test Reference Year dataset from the ZAMG. The same data was newly converted with the improved conversion tools developed by the PHI partly within PassREg.

PHI is now in contact with the ZAMG, working towards establishing general recommendation for the use of climate data as basis for energy calculations with the PHPP throughout Austria.

4.2 BELGIUM

National Meteorological Organisation:

Royal Meteorological Institute (www.meteo.be)

In Flemish: Koninklijk Meteorologisch Instituut van België (KMI)

Data availability for energy calculations:

- Climate data in various formats in available through the national meteorological organisation KMI. The reference whether station for the country is Uccle (near Brussels), which is also used for the EPBD calculations.
- TRY data is only available based on a fairly old reference period (1958-1975) from the Commission of the European Communities. Three climate regions are covered: Coast (Oostende), Central (Uccle, Brussels) and Ardennes (Saint-Hubert).
- IWEC:
  3 stations (Brussels, Oostende, Saint Hubert), all category I

PHPP climate data:

The current version of the PHPP V.8 contains 7 climate data sets for Belgium, two of which are representative for Brussels based on different original data sources. These datasets are currently used representatively for the climate regions shown in the image below (provided by PHI' partner organisations PMP (Platforme Maison Passive) and PHP (Passiefhuis-Platform).

PassREg beacons:

Within PassREg the existing PHPP climate datasets were reviewed in the light of additional and more recent climate data sources. Both beacon locations, **Antwerp** and **Brussels** are within the same climatic region of Central Belgium and can be represented with the same climate data. A new dataset was generated for Uccle, based on climate normals from the reference period 1981-2010 from the KMI, supplemented with radiation data from Meteonorm.

The remaining climate data for Belgium are also to be reviewed and updated for a future version of the PHPP. It is under discussion whether all 6 representative locations are required or whether a climate zone division into three zones (Coast, Central & Ardennes) is sufficiently accurate.

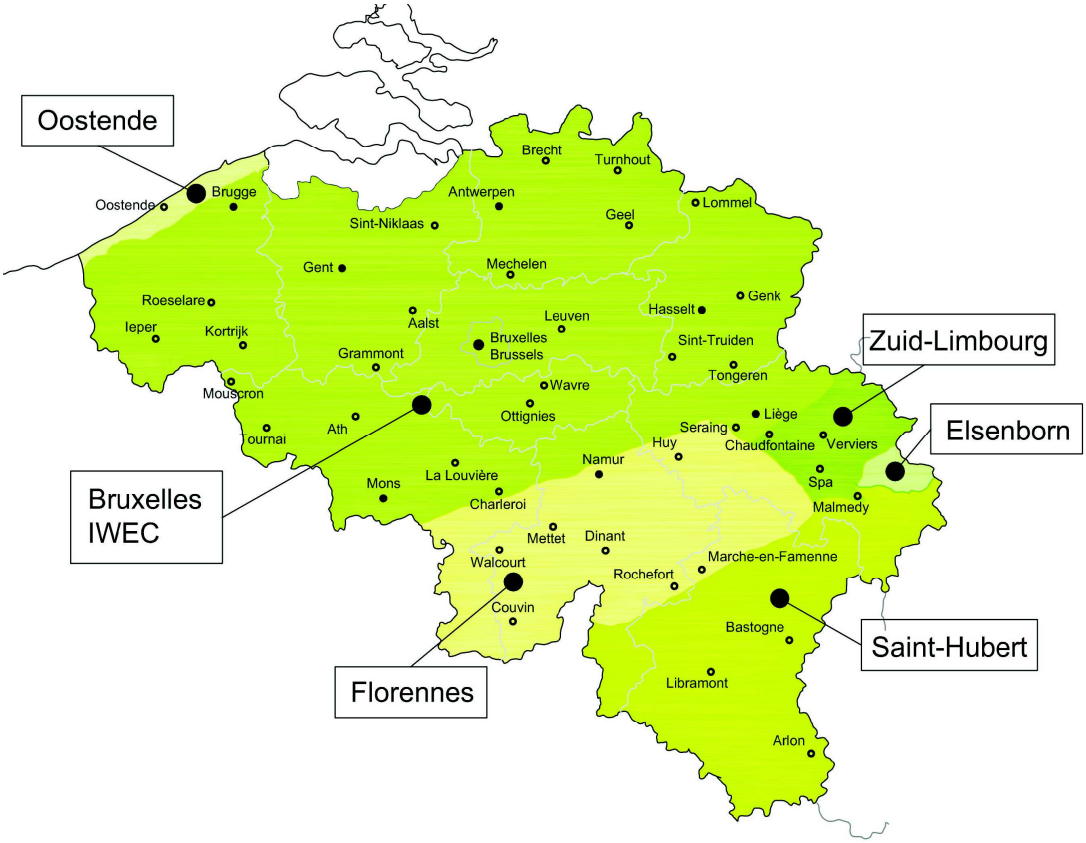

Figure 5: Climate zones and the corresponding PHPP climate datasets used up-to-date (map provided by PHP / PMP).

4.3 BULGARIA

National Meteorological Organisation:

National Institute of Meteorology and Hydrology (www.meteo.bg)

In Bulgarian: Национален институт по метеорология и хидрология

Data availability for energy calculations:

- Nine climate zones are defined in the local building regulations. Each zone is represented by one climate data set of a selected location with monthly values of temperature and solar radiation.
- IWEC:
  3 stations (Plovdiv, Sofia, Varna), all category II

PHPP climate data:

In 2011 climate data sets were developed in the PHPP format by PHI together with the Information Group Passive House Bulgaria (IGPHB). One dataset was generated for each representative location of the nine official climate zones according to the national building regulations. The climate data can be obtained with the Bulgarian translation of the PHPP. The international (English) version of the PHPP includes only the dataset for the capital city Sofia.

PassREg beacons:

Within PassREg the PHPP climate data from 2011 was reviewed in the light of additional and more recent climate data sources. The PHPP data from 2011 was approved as appropriate and should continue to be used as a basis for PH planning and certification in Bulgaria.

Burgas is the representative location for climate zone 5. A PHPP climate dataset exists for this location and its suitability was confirmed.

Gabrowo lies within climate zone 4 where the reference location is Veliko Tarnovo. It could be verified that the same climate data set can also be used for Gabrowo if an altitude correction is applied in the PHPP.

4.4 CROATIA

National Meteorological Organisation:

Meterological and Hydrological Service (www.meteo.hr)

In Croatian: Državni hidrometeorološki zavod (DHMZ)

Data for energy calculations:

- Climate data is available through the national meteorological organisation DHMZ. Amongst other data, the published Climate Atlas of Croatia contains monthly data for 20 locations from the WMO reference period 1691-1990 and the more recent 30 year period 1971-2000. With direct relevance for the PHPP, these datasets contain values for the average temperature, humidity and global horizontal radiation.
- There are three climate zones according to the official bulletin SFRJ 35/70
- IWEC: 0 stations

PHPP climate data:

Up to date climate data for Passive House projects in Croatia is being generated on a demand basis for the respective site location. The current version of the PHPP V.8 contains two datasets for Croatia: Zagreb and Buzet.

PassREg beacons:

The PHPP already contained a climate dataset for **Zagreb**. However, this dataset was not complete (no information on humidity, no load data). In the context of PassREg the dataset was updated with the data from DHMZ's climate atlas and completed with humidity and load data.

4.5 FRANCE

National Meteorological Organisation:

Météo-France (www.meteofrance.com)

Data availability for energy calculations:

- Climate normals from the period 1961-1990 and 1971-2000 can be purchased from Météo France.
- IWEC: 12 stations, all category I

PHPP climate data:

The current version of the PHPP V.8 contains 17 climate data sets for France.

PassREg beacons:

The existing climate data set for **Bordeaux** was reviewed in the context of PassREg by comparison with various other sources. The existing data represents the period from 1961-1990 very well. As in many other locations, the data sources suggest a tendency towards warmer temperatures throughout the year in more recent times. However, the data availability was not sufficient to generate an updated data set. Since Bordeaux is a heating dominated climate, as opposed to cooling, the existing climate data set is somewhat on the safe side and will be kept for the time being. The sky temperature was slightly corrected and two cooling load data sets added as an update from PHPP version 7 to version 8.

4.6 GERMANY

National Meteorological Organisation:

Germany's National Meteorological Service (www.dwd.de)

In German: Deutscher Wetterdienst (DWD)

Data availability for energy calculations:

- Climate data is available in different formats from the national meteorological organisation DWD. Test Reference Year (TRY) data for 15 climate zones are publicly available. These datasets were first released in 2004 and updated in 2011 based on a more recent time period. This new data is summarised as monthly values in the regulation 18599, which has replaced the monthly data listed in the regulation DIN 4108-6 previously to be used for energy calculations.
- IWEC:
  9 stations, all category I

PHPP climate data:

The PHPP up-to-date included the monthly climate data from the regulation DIN 4108-6 with load data calculated from TRY data from 2004. The climate data in the regulations were updated in 2014 according to the new TRY data; the corresponding new climate data will be incorporated also into the next version of the PHPP.

PassREg beacons:

In the context of PassREg the new PHPP climate data set with monthly data, heating and cooling load data was derived for the beacon cities **Heidelberg** (TRY region No. 12, reference location Mannheim), **Hannover** and **Hamburg** (both TRY region No. 3, reference location Hamburg).

Comparison with the old data set from the same climate region shows that the calculated heating demand for the PHPP V8.5 example building decreases by 1-2 kWh/(m²a) and the overheating frequency increases by approx 4 %.

4.7 ITALY

National Meteorological Organisation:

National Centre of Meteorology and Climatology (www.meteoam.it)

In Italian: Servizio Meteorologico dell'Aeronautica Militare

Data availability for energy calculations:

- Climate data to be used according to the national standard: UNI 10349 Monthly values of the Italian provinces (relevant for PHPP: temperature and radiation for the different orientations, temperature swing). For localised data the data from the surrounding provinces are combined (regionally varying altitude correction & interpolation of the radiation data).
- Test Reference Years data is available from the CTI (Comitato Termotecnico Italiano – Italian Thermotechnical Committee) for each province, calculated according to the norm UNI EN ISO 15927-4. The reference period is 2002-2009. For localised data the data from the surrounding provinces are interpolated.
- Data normals for 1961-1990 and 1971-2000 are available free of charge from the Climatology Department of the National Centre of Meteorology and Climatology. As PHPP relevant data this source only contains average monthly temperatures.
- IGDG climate data is a climatic data collection „Gianni De Giorgio" created by Professor Livio Mazzarella, Politecnico di Milano. It was originally intended for simulation for renewable energy systems. 66 weather files are provided, each based on a reference period 1951-1970. The reference period is fairly old to be used as boundary condition for energy calculations; comparison with other sources further indicates that the radiation data is generally too low.
- IWEC: 10 stations
  Category I: 8
  Category II: 2

PHPP climate data:

The current version of the PHPP V.8 contains 24 climate data sets for Italy based on the old reference period in Meteonorm and the IGDG data.

PassREg beacons:

The PHPP 8 already contains a climate dataset for **Ancona**, which was reviewed under the newly available data. The existing dataset was only slightly modified regarding the temperatures. Cooling load data was added according to the new conventions of the PHPP 8.

A new dataset was generated for **Cesena** based on the nearest weather station at Cervia airport.

Determining suitable and reliable climate data for **Mascalucia** in Sicily was not an easy task. The closest reference weather stations are in Catania, which is only about 10 km away (as the crow flies). However, Catania is at the coast with an elevation about 20 m above sea level, whilst Mascalucia is at approximately 400 m. Both locations lie at the foot of Mount Etna, the peak of which has an elevation of 3 350 m. A PHPP climate dataset for Mascalucia would ideally be determined based on long-term measurements from a nearby weather station at a similar altitude. The closest weather station than could be identified is Pedara, which - at approx. 600 m - is higher than Mascalucia. Data from this station is only available since mid-2009 with significant gaps in the data recordings; its usefulness is therefore restricted. Based on the limited data availability, Catania is being submitted as a proposal for a PHPP climate data to be used for Passive House planning in Mascalucia. It is very important that an altitude correction is applied in the PHPP, which leads to lower temperatures at the higher altitude of Mascalucia.

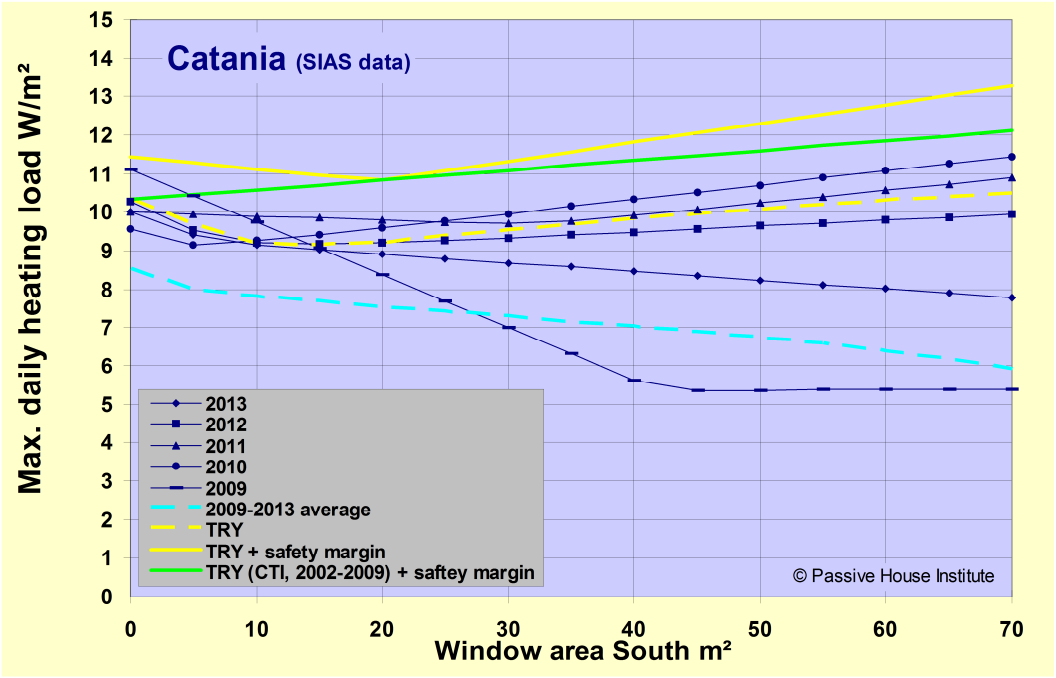

Figure 6: A detailed analysis was carried out on the heat load data for a PH under the climate conditions of Catania based on hourly measured data from 2009-2013. The results shown in this graph clearly show that the maximum heat load will vary from year to year. As expected, averaging the hourly data from the measurements is **not** suitable for deriving a heat load data set (light blue dashed line), as this does not accurately depict the correlation between temperature and radiation. When using a Test Reference Year dataset, it is recommended to apply a safety margin, such that the heat load calculations remain valid also for colder years.

4.8 LATVIA

National Meteorological Organisation:

Latvian Environment, Geology and Meteorology Agency (www.meteo.lv)

In Latvian: Latvijas Vides, ģeoloģijas un meteoroloģijas centrs (LVGMC)

Climate data:

- Climate data to be used according to the national standard: LBN 003-01
  Monthly values for ten stations. Average (1961-1990), minimum and maximum temperature, as well as temperature amplitudes, partial water vapor pressure, relative humidity, precipitation, wind data, snow and frost related information, solar radiation from different orientations on a cloudless day in July.
- Additional climate data can be obtained in various formats from the national meteorological organisation LVGMC.
- IWEC:
  0 stations

PHPP climate data:

Up to date climate data for certification of Passive House projects in Latvia is being generated on a demand basis for the respective site location. The current version of the PHPP V.8 does not contain any standard datasets for this country. The closest datasets integrated into the PHPP are Tartu in Estonia and Vilnius in Lithuania.

PassREg beacons:

Within PassREg climate data from the following three main sources was compared and analysed: The national regulation LBN 003-01, weather stations of Meteonorm, satellite data downloaded from Passipedia, long-term WMO measurements and the 9th series (1991-2000) monthly averages of the World Weather Records.

Depending on the reference period of the climate data the average temperatures during winter (Dec-Feb) varied quite significantly. When looking at the development of temperatures over time (see Figure 7) it becomes evident that the reference period of 1961-1990 featured much lower temperatures than in more recent years. Though cold winters have also occurred during recent years it appears to pessimistic to use the cold temperatures as design boundary conditions. It was therefore decided to use a more recent time period for the PHPP climate data.

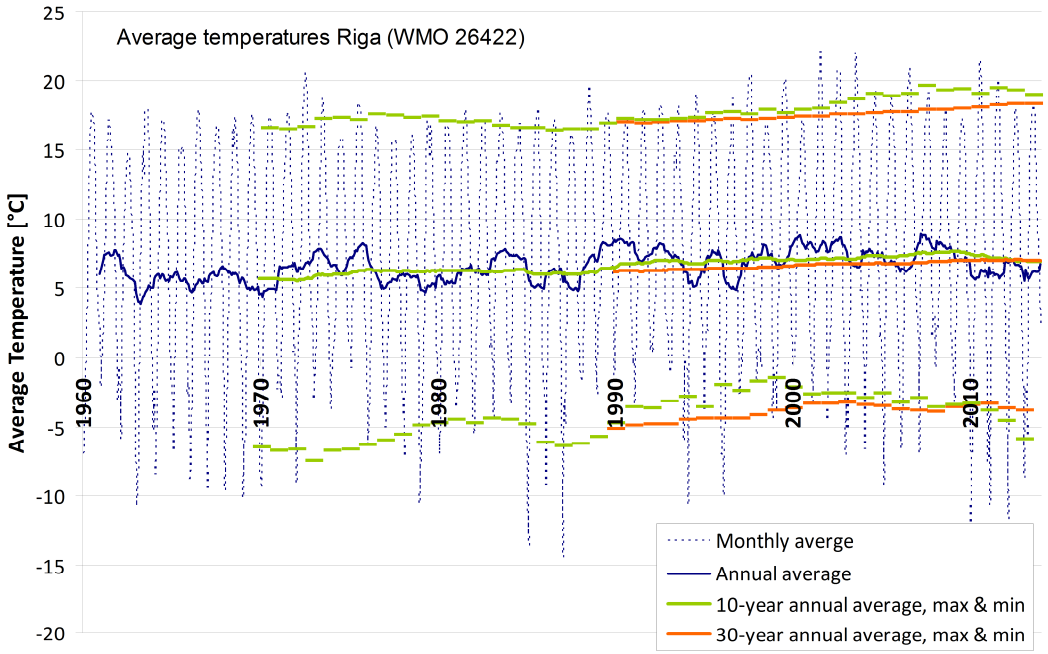

Figure 7: Average temperature trends in Riga since 1960.

Locally measured data could not be accessed for either of the beacon locations. The data comparison however indicates that significant microclimatic effects are not to be expected and therefore representative climate data from nearby locations can be used. The climate varies from East to West with milder temperatures at the coastal locations and colder conditions inland, towards the East.

For both beacon projects in **Tiskadi/Rēzekne** and in **Ērgļi** the data comparison lead to the conclusion that a climate dataset from Dougavpils, which is located a little further south, can used. Meteonorm temperature data is in good agreement with the 9th series World Weather Series, and radiation data with the EOSWEB satellite data. Meteonorm was therefore used as a data source.

An additional PHPP dataset was generated for the capital city, Riga.

4.9 NETHERLANDS

National Meteorological Organisation:

Royal Netherlands Meteorological Institute (www.knmi.nl)

In Dutch: Koninklijk Nederlands Meteorologisch Instituut (KNMI)

Data availability for energy calculations:

- Climate data is available free of charge from the KNMI for stations shown in the map below (Figure 8). Temperature data, global horizontal radiation and humidity as monthly or even hourly values.
- IWEC:
  3 stations (Amsterdam, Beek, Groningen), all category I

Figure 8: Network of weather stations in the Netherlands. Source. KNMI 2009

PHPP climate data:

The PHPP version 8 contains 5 climate data sets for the Netherlands. They are based on the old WMO reference period 1961-1990.

PassREg beacons:

Vroomshoop lies in the very East, close to the Border of Germany. The closets KNMI weather stations are Heino, Hoogeveen and Twente. The KNMI data from all stations is very similar for the reference period 1980-2009; Twente was selected as a reference station. A new PHPP climate data set was generated based on KNMI data, supplemented with data from Meteonorm 7 and satellite data.

The closest KNMI weather station to **Oosterhout** is Gilze-Rijen. Comparison the data from De Bilt showed that the climate hardly differs and that De Bilt can therefore be used as a reference station. The existing PHPP climate data set from De Bilt was updated with the KNMI data from the period 1980-2009 and Meteonorm 7.

4.10 United Kingdom

National Meteorological Organisation:

Met Office (www.metoffice.gov.uk)

Climate data:

- Original climate data from the existing weather station network, as well as climate summaries are available in different formats through the Met Office website. Main parameters: Temperature (min/max), days of frost, sunshine hours, rainfall and wind speed.
- TRY data can be purchased from the Chartered Institution of Building Services Engineers (CIBSE) for 14 locations within the UK
- IWEC: 10 stations
  Category I: 9
  Category II: 1

PHPP climate data:

Climate data for use in the PHPP was generated by the British Research Establishment (BRE) and the PHI in 2011/2012. The data has been integrated into the PHPP and is also available for download on the BRE website. The datasets are each representative for a climate zone / region. The data source is Meteonorm and the monthly values were checked for plausibility in the corresponding climate regions. There is still a need to verify/improve the load data of all UK climate data sets.

PassREg beacons:

Llanelli is at the coast, bordering two climate zones according to BRE (regions Severn & Wales). The applicability of the existing data set was evaluated for the specific site based on additional data research and comparisons with Met Office data. With an altitude correction, the climate data file for the region Wales (Sennybridge) should be used for the project location.