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Appendix I

Catalogue of Learning targets

"Certified Passive House Designer"

Learning targets covered

in the E-learning course

"Passive House Fundamentals" (04/2016)

Valid as of 01 May 2016

1 Introductory remarks

This catalogue of learning targets assumes that examination participants are already familiar with the rules of (conventional) construction and elementary principles of building physics relating to heat and moisture. Its purpose is to provide a substantiated additional qualification with reference to the planning and construction of Passive House buildings which also comprises some features of proper building operation and user instructions.

Some fundamental observations are made below which are generally applicable for the "Certified Passive House Designer" further training programme. The aim is to keep the description of the learning targets simple and uncluttered.

Presentation of the learning content based on the example of a cool, temperate climate with warm summers has proven to be successful and constitutes a multifaceted starting point as almost all important features of Passive House buildings can be presented here. Against this background, it is easy to translate knowledge to other climates. Moreover, basic knowledge of the consequences that various climatic boundary conditions would have for a Passive House building form a part of the learning targets.

In this knowledge transfer, an emphasis on residential use has proven to be just as successful. The main issues encountered during the planning and construction of Passive House buildings can be elaborated quite well here with almost constant indoor conditions; this includes fundamental features of large buildings, such as those occurring as a result of higher loads of the supporting structure and unheated adjacent areas. Basic knowledge should also be conveyed regarding the special requirements and boundary conditions for common non-residential uses (e.g. offices, schools, kindergartens).

The initial focus of the training is on new construction, as this is usually a more straightforward approach. In addition, principles for retrofitting buildings with Passive House components (EnerPHit), specific challenges, similarities and differences to the approach for new construction also belong to the essential contents of this training.

All of the subject areas are always directly linked to the balancing of the respective influences using the Passive House Planning Package (PHPP). Competent and proficient use of this important planning tool is a core objective of this training; all sub-tasks come together in this calculation model and become effective with diverse interactions. Targeted optimisation of the design and the construction – and thus also construction costs – can only take place if all these things are considered together as a whole. This includes gaining an insight into the balancing methodology as well as an understanding of elementary calculation methods (e.g. the makeup of the monthly balance, energy balances of individual components [e.g. windows, ventilation systems, thermal bridges], assessing the effects of errors and of changes to important input). Every course participant must work closely with this tool and become familiar with its use.

Testing of the acquired knowledge generally takes place through tasks which must be solved by selecting predefined elements, stating learnt knowledge, own calculation, sketches, and explanations.

Please note the red text indicates learning targets which are covered in depth in the e-learning course while orange text indicates learning targets which are partly covered. Purple text indicates subjects that will be addressed in the future e-learning course on retrofits.

2 Passive House definition

- Understanding of the climate-independent Passive House definition and its derivation:

  > "A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air".

See **1.1 What is a Passive House**

The limit of 10W/m² is explained in the slide "Heating via ventilation system" in **8.2 Heat storage and distribution**

- Understanding of the requirements for hygienic air, fresh air quantity that is necessary per person, extract air demand, minimum air change rate.

See **7.1 Why do we need to ventilate** and **7.2 Ventilation concepts for a Passive House**

- Understanding of the relationship between relative indoor air humidity and effective air exchange.

See **2.2 Humidity basics** and **2.3 Moisture in the building**

- Basic principles of the methodology for evaluation of thermal comfort based on ISO 7730.

3 Passive House criteria

- Understanding of the certification criteria for Passive House buildings and retrofits using Passive House components (EnerPHit).

Certification criteria for Passive House buildings are listed in **1.1 What is a Passive House |** Certification criteria for retrofits will be addressed in the e-learning about retrofits

- Knowledge of the key parameters (e.g. in the Verification worksheet of the PHPP) heating load, cooling load, annual heating demand, annual cooling and dehumidification demand, n_{50} value, primary energy (non-renewable and renewable PER), final energy,

See **8.1 Heat supply and DHW** for heating, **9.1 Passive House in summer** for cooling, **7.1 Why do we need to ventilate** for dehumidification, **6.3 Airtightness testing basics for n_{50}** value, **10.3 PER** energy services, frequency of overheating.

- Definition and influence of the reference areas and volumes used in Passive House design and certification.
- Basic understanding of the issue of assessing sustainability of the energy demand of buildings in the context of a changing energy supply system.

and classes for Primary energy, **10.2 Renewables** for final energy.

See Further material in the subunit **10.1 Energy balancing with PHPP** for the Treated Floor Area, Further material in the subunit **10.3 PER and classes** for the Projected Building Footprint, **6.3 Airtightness testing basics** for V and V_{50}.

See **10.3 PER and classes**

4 Basic principles of Passive House planning

4.1 Basic principles for the thermally insulating envelope

- The principle behind the thermal envelope. Quality of thermal protection for a Passive House with reference to insulation thicknesses/quality and avoidance of thermal bridges. Relationship between complex thermal envelopes and the construction costs.

See **3.1 Continuous insulation layer**

- Relationship between the U-value and interior surface temperature.
- Typical U-values of opaque building components for Passive House envelopes.

See **3.1 Continuous insulation layer**

- Typical assemblies/structures in lightweight and solid construction which are suitable for Passive House buildings.
- Acquaintance with thermal bridge coefficients (exterior and interior dimensions) and qualitative analyses of building envelopes with regard to potential thermal bridges.

See **5.1 What is a thermal bridge**

- Understanding of the principle of thermal bridge free design. Approach to be used for cases where a completely thermal bridge free solution is not feasible.

- Quantitative estimation of simple thermal bridges.

- Knowledge of suitable insulating materials and their main characteristics.

See **3.2 Insulation materials**

- Moisture transport mechanisms in building components and their scale, occurrence of moisture-related structural damage caused by convection, also diffusion where applicable. Appraisal of interior insulation, challenges, prerequisites for its use, build-ups, limitations to its use, and the level of efficiency that is achievable.

See **2.3 Moisture in the building**

Interior insulation will be addressed in the e-learning about retrofits

4.2 Basic principles for the airtight building envelope

- The principle behind an airtight building envelope. Importance of airtightness in buildings, e.g. with reference to energy demand, heating load, thermal comfort and structural integrity.

See **6.1 Importance of airtightness**

- Knowledge of airtight envelope designs in solid construction and lightweight construction.

See **6.2 Airtightness implementation basics**

- Knowledge of suitable airtight building component connections for lightweight, solid and mixed construction.

See **6.2 Airtightness implementation basics**

- Knowledge of suitable airtight sealing methods for penetrations.

See **6.2 Airtightness implementation basics**

- Awareness of potential weak spots.

See **6.3 Airtightness testing basics**

- Understanding of the planning task "airtightness".

See **6.2 Airtightness implementation basics**

- Knowledge of test procedures for the airtightness measurement and requirements. Determination of the reference volume, carrying out a measurement, understanding of the contents of the measurement report, quality assurance.

See **6.3 Airtightness testing basics**

- The appropriate time for the measurement.

See **6.3 Airtightness testing basics**

- Assessment of basic leakages (e.g. holes from nails, power sockets, window connection joints, unplastered exterior wall surfaces, sheeting that has come loose, penetrations that have not been airtightly sealed, open downpipes).

- Knowledge of methods for permanent fixing of simple leaks.

- Assessment of serious leakages (ends of wooden beams in masonry construction, unplastered exterior walls behind interior cladding (e.g. stairs), regularly occurring penetrations (e.g. due to continuous rafters)

- Knowledge of methods for avoiding serious leaks.

4.3 Basic principles for transparent exterior components

4.3.1 Heat losses from transparent building components

- Calculation of window U-values in accordance with EN 10077-1

See **4.1 PH windows and installation**

- Basic understanding of how specific values of frames can be reliably determined in accordance with EN 10077-2 through *calculation*. The importance of this approach for comparability and significance of the determined values.

- Understanding of the significance, composition and function of thermally favourable glazing spacers, interaction with the window frame (glazing rebate).

See **4.1 PH windows and installation**

- Familiarity with the values U_g, U_f and Ψ_g and the installation thermal bridge coefficient $\Psi_{install.}$ Difference between a "Certified Passive House window frame" and an "Approved (window) connection detail".

See **4.1 PH windows and installation**

- Understanding of the influences on the thermal quality of mullion-transom facades, the important effects in the case of sloping or horizontal glazing.

- Understanding of the thermal comfort requirements (interior surface temperature criterion) for Passive House suitable windows and the hygiene requirement in this regard.

- Estimation and determination of frame ratios.

- Build-up of triple low-e glazing systems and knowledge of the main heat transfer mechanisms in windows (heat conduction in the filling gas, heat radiation and low-e coating, convection).

See **4.1 PH windows and installation** and **2.1 Heat transfer**

- What properties are necessary for a window in a Passive House building? (Knowledge of all specific values, any compensating heating surfaces that are necessary).

See **4.1 PH windows and installation**

4.3.2 Heat gains through transparent building components

- Knowledge of the g-value according to EN 410. Importance of giving the value to two decimal places. Difference from light transmittance (ISO 9050). Knowledge of typical values for different

See **4.1 PH windows and installation**

types of glazing.

- What other factors influence the solar energy gains? (Angle of incidence, dirt, frame ratio, shading, reflection).

  See **4.1 PH windows and installation**

- Estimation and determination of frame ratios.

- Simple cases of energy flows from windows (cold day, heating period, hot day).

- Knowledge of the energy criterion for glazing:
  U_g - 1,6 W/(m²K) · g ≤ 0 and its application (e.g. efficiency classes for windows).

- Understanding of the influence of orientation on the availability of solar energy.

- Understanding of the influence of typical shading on the solar energy gains caused by the building itself.

4.3.3 Influence of transparent building components on thermal comfort under summer conditions

- Solar heat loads under summer conditions: why is it so high?

- Dependence of solar heat loads on orientation under summer conditions (qualitatively).

- Effective ways to counteract high solar heat loads (qualitative understanding).

  See **9.1 Passive House in summer**

- Awareness of the limit for transparent areas without temporary shading.

- Knowledge of characteristics and differences of internal and external temporary shading.

5 Basic principles of Passive House ventilation

5.1 Why is ventilation essential?

- Knowledge of the most important indoor air contaminants. Knowledge of the CO_2 criterion. Resultant fresh air volume flows for hygienically adequate ventilation.

See **7.1 Why do we need to ventilate**

- Relationship between relative indoor air humidity and sources of humidity inside the building, fresh air supply rate, and external temperature. Risks relating to high air change rates at low external temperatures. What can be done if this cannot be avoided for some important reason?

See **7.1 Why do we need to ventilate** and **2.3 Moisture in the building**

5.2 Natural ventilation

- Driving forces of natural ventilation (qualitative understanding).

See **7.2 Ventilation concepts for a Passive House**

- Types of natural ventilation: joints and cracks, tilted windows, intensive ventilation through windows).

See **7.1 Why do we need to ventilate** and **7.2 Ventilation concepts for a Passive House**

- Influences on natural ventilation: typical air change rates (qualitative understanding).

- Why is natural ventilation unsuitable for Passive Houses in regions with significant temperature differences between the inside and outside? (Unreliableness, heat loss).

See **7.2 Ventilation concepts for a Passive House**

5.3 Extract air systems

- Basic structure of an extract air ventilation system. Supply air zone, air transfer zone, extract air zone (ability to identify these in a floor plan). Fresh air inlets, extract air outlets, filters, exhaust air fan.

See **7.3 MVHR anatomy and certification**

- Aspects relating to comfort (preheating of air at the fresh air inlet, prevention of draughts).

See **7.2 Ventilation concepts for a Passive House**

- Advantages of extract air systems over natural ventilation.

See **7.2 Ventilation concepts for a Passive House**

- Why are extract air systems unsuitable for Passive Houses in regions with significant temperature differences between the inside and outside? (Heat loss).

See **7.2 Ventilation concepts for a Passive House**

- Rough estimation of the costs for a technically functioning extract air system compared with a balanced supply and extract air system with heat recovery.

5.4 Balanced supply and extract air system with heat recovery

- Zoning in a floor plan: supply air zone, air transfer zone, extract air zone. Possibilities and limitations of simplified approaches for saving expenditure for ductwork (e.g. advanced cascade ventilation, single-room ventilation).

See **7.2 Ventilation concepts for a Passive House**

- Knowledge of the essential components: supply air inlet, supply air ductwork, air transfer openings, extract air outlet, extract air ductwork, sound attenuators, fresh air filter extract air filter, central unit, penetration through the exterior wall, condensate drain.

See **7.3 MVHR anatomy and certification**

- Knowledge of typical dimensioning of such systems for Passive House buildings.

- Knowledge of air flow conditions in the room: mixed air ventilation. Understanding of the Coanda effect.

  See **7.3 MVHR anatomy and certification**

- Possible solutions and limitations of decentral systems. Typical solutions and their assessment.

- Knowledge of required filter qualities and the reasons for these.

  See **7.3 MVHR anatomy and certification**

- Knowledge of the hygiene requirements for a Passive House ventilation system (no cooling, no active dehumidification, continuous/reliably dry operation, filter class F7 or better for the fresh air filter at the front).

  See **7.3 MVHR anatomy and certification**

- Outdoor air intake openings and positioning, protection from the effects of weather, condensation and frost, noise protection).

  See **7.3 MVHR anatomy and certification**

- Knowledge about suitable duct systems. Basic principles for planning of ducts (short lines, smooth surfaces, fittings, typical air velocities and cross-sections, airtightness). Influence of duct pressure losses on energy demand for air transport and operating costs.

  See **7.3 MVHR anatomy and certification**

- Necessity and suitable implementation of thermal insulation of ventilation ducts (cold duct in warm room, warm duct in cold room, with post-heating).

  See **8.2 Heat storage and distribution**

- Planning for penetrations in the building envelope by ventilation ducts (airtightness, thermal insulation, if necessary diffusion resistance).

  See **7.3 MVHR anatomy and certification**

- Recuperative and regenerative heat recovery, principles and common implementations.

- Knowledge of requirements for central ventilation units that are suitable for Passive House buildings. Which features influence the efficiency of heat recovery (qualitative understanding: heat flows through the casing, internal/external leakages, type and dimensioning of heat exchangers) and the overall device (qualitative understanding: fans and motors, control unit, filters and fixtures), significance and determination of the effective dry heat recovery rate, significance and determination of the specific electricity consumption.

- Fundamental characteristics, potentials and limitations of moisture recovery in the ventilation system.

- Appropriate positioning of the central units. Basic principles of noise protection, hygiene, maintenance.

- Commissioning and flow rate adjustment of the ventilation system. Influence of balance settings. Regulation of planned flows in rooms. Achieved pressure losses compared with calculation for ductwork.

6 Knowledge of the heat supply system

- Knowledge of the heating load criterion. Differences between the heating load and the space heating demand.

See **8.1 Heat supply and DHW**

- Knowledge of thermal comfort requirements [ISO 7730]. What is the operative temperature? How significant are draughts? What is the maximum difference between the air temperature and average surface temperature in a Passive House building? (Ability to calculate a simplified example and provide qualitative estimations).

- Why is thermal comfort in a Passive House building in summer and in winter largely independent of the way of heat supply/extraction? Knowledge of typical heating/cooling loads.

- Knowledge of typical heat supply systems for Passive House buildings. Under what conditions are radiators required beneath windows?

See **8.1 Heat supply and DHW**

- Ability to sketch a heat supply system in the floor plan of a Passive House building.

- What needs to be kept in mind in the case of air heater coils and supply air heating? (E.g. dependence of the available heating capacity on volume flow, insulation of the duct downstream of the heater coil).

- Why can't one simply increase the fresh air flow rate?

- Determination of the heating load for Passive House buildings. Reason for the two-day method.

- What needs to be kept in mind when dimensioning the heat distribution system and the central heat generator? (It must also be possible to meet the overall heating load)

- How and to what extent can temperature differences be achieved in a Passive House building?

- What effects do the following have on the maximum heating load (qualitative understanding): large leaks, constantly tilted windows, temporary opening of windows, opening of entrance doors?

- Knowledge of the limitations of the central supply air post-heating (disconnected rooms, extract air rooms). Solutions for such cases.

- Correct positioning of a thermostat inside a home.

7 Hot water generation

- Comparison of the space heating load with the power requirement for hot water provision. Conclusions for designing the hot water generation system.

See **8.1 Heat supply and DHW**

- Temporal correlation of the energy demand for space heating and hot water generation with renewable energy supply.

- Typical hot water demand per person and the scope of the anticipated user dependence. The main applications for hot water, quantitatively.

- Requirements for an energy efficient hot water system, insulation levels for the storage cylinder, pipes and fittings, principle of absence of thermal bridges.

See **8.2 Heat storage and distribution**

- Significance of hot water circulation pipes for heat losses of the hot water system and approaches for optimisation.

- Optimisation possibilities of fittings with reduced water flow and heat recovery.

8 Summer comfort and space cooling

- Knowledge of summer thermal comfort standards [ISO 7730]
- Solar load: significance, dependence on orientation, dependence on the size of the transparent areas, shading, temporary shading, effectiveness of shading devices on the inside and outside. Colour of the façade/surface (also: cool colours), influence of thermal insulation.
- Influence of internal heat gains. Reduction potential?

See **9.1 Passive House in summer**

- Influence of the internal thermal mass (qualitative understanding).
- Influences on summer comfort (qualitative understanding) in case of mainly passive heat removal: air exchange – how can this be estimated? What possibilities exist for increasing this?
- Qualitative understanding: special characteristics in case of strongly fluctuating internal loads (e.g. school, meeting room).
- Assessment of PHPP results for expected frequency of overheating.
- Limitations of free cooling, possibility of heat removal through coupling with the ground by means of a circulating medium (e.g. concrete core activation).

See **9.1 Passive House in summer**

- Energy efficient and cost-effective cooling solutions for Passive House buildings, including distribution systems.

See **9.1 Passive House in summer**

- Specific values for cooling devices available on the market and their meaning in terms of energy efficiency rating.
- Temporal correlation of energy demand for space cooling with

renewable energy supply.

- Fundamental relationships of cooling and dehumidification, when is dehumidification necessary, approaches for energy efficient solutions.

9 Electrical energy

- Characteristics of electrical energy (versatile and high quality, increased use of primary energy from non-renewable sources when produced conventionally, problem of storage). Why is energy efficiency of particular importance in the case of electrical energy?

- Typical electricity applications for Passive House building services (auxiliary electricity), energy efficiency criteria for auxiliary electricity consumption.

- Typical electricity applications of domestic electricity. Improved energy efficiency for domestic electricity uses, typical values for conventional and efficient appliances.

- Typical electricity uses for office applications (lighting, IT) improved energy efficiency for office applications and special significance of these due to the avoided cooling demand.

- Production of renewable energy on/near the building, potentials and limitations. Evaluation system and reference value for the produced energy. Structure of a photovoltaic system and basic points to be considered for installation of the individual

See **10.2 Renewables** and **10.3 PER and classes**

components.

- Potential of energy generation on the building/on site during the course of the year, dependence on the location and shading.
- Potentials and limitations of electrical energy storage over different time periods.

10 Energy balancing

- Basic principles of energy balancing: balance boundary, balance envelope, balance equation.

See **10.1 Energy balancing with PHPP**

- Contributions to heat loss: transmission if applicable, ventilation/infiltration, cooling if applicable.

See **10.1 Energy balancing with PHPP**

- Contributions to heat gains: transmission if applicable, internal heat gains, passive solar gains, heating if applicable.

See **10.1 Energy balancing with PHPP**

- Calculation of transmission and ventilation heat flows. Estimation of amounts.
- Calculation of solar heat gains through windows taking into account any shading.

See **4.1 PH windows and installation_2016**

- Significance of internal heat gains
- Sustainability evaluation in the context of the overall energy supply system (primary energy non-renewable/primary energy renewable PER).

See **10.3 PER and classes**

11 Economic efficiency calculation

- Understanding of the payback period, present value method, annuity method.
- Which calculation approaches make sense for determining the economic efficiency of energy efficiency measures for buildings and why?

See **1.3 Economics, life cycle cost**

- Applying the annuity method in simple cases. Correct determination of extra investments (costs incurred anyway). Life cycle analysis, residual value. Economically effective level of insulation.
- Advantage of calculating an equivalent price for each kilowatt hour saved (independently of energy prices). Calculation of this value.

12 Invitation to tender, construction management and quality assurance

- Special necessity for exact specification of services and products (specific values!) and clear allocation based on individual specifications of services/trade disciplines.
- Clear specification of accountabilities and responsibilities.
- Clarification where trades overlap, particularly at complicated connection points. Special features of construction time planning (e.g. interior plaster before technical installations, screed after interior plaster)

- Which trade disciplines are affected with reference to airtightness and avoidance of thermal bridges? Necessary communications during meetings with craftsmen before the start of construction work.

- Checking of material deliveries and results, procedures.

- Typical defects in airtightness of standard surfaces and building connection details/ penetrations.

- Absence of thermal bridges in accordance with the planning, avoidance of unplanned penetrations.

- Window installations, checking of specific values of frames and glazing.

- Thermal insulation, thermal conductivities of the used insulation materials, avoidance of gaps, application of insulation without any air flow behind it,

- Air ducts: airtight, in accordance with plans, insulation, protection against condensation, protection against dirt on-site, anti-static, decoupling of structure-borne sound, sound attenuators.

- Ventilation system: in accordance with plans, checking of volume flows.

- Space heating system: in accordance with plans, full insulation of heat-carrying pipes (including fittings, pumps etc.), running times of pumps, test run.

- Hot water system: in accordance with plans, complete insulation of heat-carrying pipes (including fixtures, pumps etc.), running times of pumps, test run.

- Which quality assurance measures must be performed? Pressurisation test, specific dates for quality assurance for window installation, for implementation of the airtight envelope, for carrying out insulation work, work for the air distribution system, final inspection of the ventilation system.

- Handing over of the building in the warm state (cold external temperatures) or in the cool state (warm external temperatures).

13 User information and support

- Information for users of Passive House buildings:

  - Opening windows: effect during summer and during winter.

  - Temporary shading: effect in winter and in summer.

  - Ventilation system: is not an air conditioning system; replacing of filters; continuous operation or shut-down with dry filters. How to operate. How to avoid dry air during low external temperatures.

  - Heating: night-time setback barely effective as a rule, small heating power supplied without interruption.

  - Significance of efficient electrical appliances.

  - Cooling: no peak loads; small, almost constant demand.

- Who to contact in case of questions.

14 Retrofitting with Passive House components (EnerPHit)

- Advantages of retrofitting with PH components.
- Dangers of using mediocre quality of building components in retrofits of existing buildings. Microeconomic, economic, ecological.
- Certification criteria for retrofitting of existing buildings using Passive House components.
- Knowledge of examples of implemented retrofits.
- Solutions for typical challenges arising during later creation of an airtight layer.
- Knowledge of typical thermal bridge situations and suitable measures for dealing with these.
- Awareness of the special challenges arising with interior insulation with regard to building physics (protection against moisture), suitable solutions.
- Basic principles for step-by-step implementation of retrofitting measures in accordance with an overall plan.

This will be addressed in the e-learning about retrofits

15 Calculations, quantities, units

- Familiarity with the metric system and decimal units.
- Acquaintance with standard symbols, quantities and units, in particular the consistent use of units throughout the calculation process for the purpose of self-monitoring.

See **the whole course**

- Making a clear distinction between different physical quantities such as work and power, or temperature and heat etc.

See **8.1 Heat supply and DHW**