Appendix I

List of learning targets

“Certified Passive House Designer"

PASSIVE HOUSE INSTITUTE
Dr. Wolfgang Feist
Rheinstr. 44
D-64283 Darmstadt
mail@passiv.de

This list of learning targets is based on the assumption that the aspiring Certified Passive House Designers are already familiar with the conventional practices of construction.

1. Definition of a Passive House

- Knowledge of the climate independent definition of a Passive House and the principles it is based on: The maximum heating load must not exceed the amount of heat that can be supplied to the building via the fresh air required for good indoor air quality. {p $p_{max,heat} \leq 10$ W/m² for residential buildings}
- Knowledge of the hygiene criteria, fresh air requirement per person, extract air volumes and minimum air change rates; understanding of the relationship between relative indoor air humidity and the effective air exchange; for cool temperate climates especially under cold weather conditions

2. Passive House criteria

Heating load	$p_{max,heat} \leq p_{supply\ air,max}$	{all climates}
Annual space heating demand	$q_{max,heat} \leq 15$ kWh/(m²a)	{climate dependent}
Annual space cooling demand	$q_{max,cool} \leq 15$ kWh/(m²a)	{climate dependent}
Airtightness Why is this a separate criterion?	$n_{50} \leq 0.6\ h^{-1}$	{all climates}
Annual primary energy demand	$e_{max,prim} \leq 120$ kWh/(m²a)	{all climates}

Which energy services are included in the defintion of $e_{max,prim}$?

Frequency of overheating	$t_{max,\vartheta>25°C} \leq 10\%\ t_{use}$	{all climates}

- Thorough understanding of the meaning and use of the terms heating load, annual space heating demand, n_{50}-value, primary energy, final energy, energy

services, frequency of overheating; understanding of the significance of the treated floor area $A_{TFA.}$ What is the definition of the reference area for a Passive House?

3. Basic principles of planning a Passive House

3.1 Thermal insulation – basics

- Understanding of the principle of thermal envelopes, including a good perception of the heat insulation qualities required for a Passive House in terms of both the insulation thickness and quality and the prevention of thermal bridges as well as the relationship between extensive and complex thermal envelopes and the respective building costs.
- Understanding of th link between U-values and internal surface temperatures
- Familiarity with typical U-values of opaque building structures for Passive Houses in cool temperate climates
- Knowledge of typical lightweight and solid structures suitable for Passive Houses in cool temperate climates
- Acquaintance with thermal bridge coefficients (exterior and interior dimensions) and qualitative analyses of building envelopes in terms of potential thermal bridges.
- Understanding of the principle of thermal bridge free construction.
- Quantitative evaluation of basic thermal bridges
- Knowledge of suitable insulating materials and their main characteristics.

3.2 Airtight envelopes – basics

- Understanding of the principle of a “single airtight envelope”; why is airtightness so important?
- Knowledge of suitable lightweight and solid structures in terms of airtightness;
- Knowledge of suitable airtight joints for lightweight, solid and mixed constructions
- Knowledge of suitable air sealing solutions in case of leakages at intersections
- Awareness of potential weak spots
- Awareness of the significance of the planning task “airtightness”
- Knowledge of test procedures (airtightness test) and requirements
- Understanding of basic leakages (e.g. holes from nails, power sockets, window connection joints, unrendered exterior wall surfaces, loose foil, unsealed openings, unsealed downpipes)
- Knowledge of permanent solutions for fixing simple leakages

- Assessment of difficult leakages (timber flooring in solid constructions, unrendered exterior walls behind interior linings (e.g. stairs), regular penetrations (e.g. continuous rafters))
- Knowledge of how problematic leakages can be avoided

3.3 Transparent exterior components – basics

3.3.1 Window U-values according to EN 10077

- Acquaintance with U_g, U_f, and Ψ_g values and the installation-based thermal bridge coefficient (Ψ_{mount})
- Difference between “Certified Passive House windows” and “approved (window) connection details”
- Understanding of the thermal quality parameters for curtain wall systems;
- Understanding of the comfort criterion (interior surface temperature of Passive House suitable windows)
- Estimation and determination of frame ratios
- Understanding of triple low-e glazing systems and knowledge of the main heat transfer mechanisms in windows. (Heat conduction through the filling gas, radiation of heat and low-e coating, convection)
- Understanding of the design and purpose of a window’s glass edge system
- Why is a thermally optimised glass edge system (warm-edge) important?
- What solutions are there for reducing the thermal bridge coefficient at the edge of the glazing? (warm-edge, deep glazing rebate)
- What properties are required for a Passive House window? (knowledge of all specific values, if necessary compensating radiators)
- Acquaintance with the PHPP window sheet

3.3.2 Heat gain through windows according to PHPP

- Knowledge of the g-value definition according to EN 410, g-values expressed to two significant figures
- What is the difference between the g-value and light transmittance (ISO 9050)?
- Knowledge of typical values for different types of glazing
- What other factors reduce the solar energy gain? (Angle of incidence, dirt, frame ratio, shading, reflection)
- Estimation and determination of frame ratios
- Simple examples of energy transmission through windows (cold day, heating period, summer)

- Knowledge of the energy criterion for glazing (U_g - 1.6 W/(m²K) · g ≤ 0) and its application;
- Knowledge of the influence of a building's orientation on the solar energy supply
- Knowledge of typical self-shading effects of buildings on their solar energy supply
- Acquaintance with the PHPP shading sheet

3.3.3 Impact on summer comfort

- Solar heat loads during summer months: why is this value so high?
- The connection between a building's orientation and solar heat loads during summer months (qualitative understanding)
- Effective ways to counter high heat loads (qualitative analysis)
- Knowledge of limitations for transparent surfaces without temporary shading
- Knowledge of the difference between internal and external temporary shading
- Acquaintance with the PHPP summer shading sheet

4. Ventilation in a Passive House – basics

4.1 Why is ventilation essential?

- Knowledge of the most important air contaminants in buildings
- Knowledge of the CO_2 criterion
- Determination of fresh air flow rates for adequate ventilation [Pfluger 2003]
- Relationship between the relative indoor air humidity and sources of humidity inside the building, the rate of fresh air supply and the external temperature
- Why does the air flow need to be limited even during winter? What can be done when higher ventilation rates are required for other urgent reasons?

4.2 Natural ventilation

- Understanding of driving forces of natural (non-mechanical) ventilation (qualitative understanding)
- Knowledge of types of natural ventilation: joints and cracks, tilted windows, open windows
- Understanding of factors that will influence natural ventilation effects; typical air change rates (qualitative understanding)
- Why is non-mechanical ventilation not suitable for Passive Houses located in regions with a considerable amount of heating degree days? (unreliability,

heat losses)

4.3 Exhaust systems

- Understanding of the general layout of an exhaust ventilation system (residential buildings): areas for air supply, air transfer and air extraction (ability to identify these zones in floor plans)
- Knowledge of essential components: air inlets, extract air outlets, exhaust air fan, filters
- Identification of advantages of air extraction devices over non-mechanical ventilation
- Why should air extraction devices not be used in Passive Houses in regions with a considerable amount of heating degree days? (heat losses)

4.4 Balanced supply and exhaust air systems with heat recovery

- Understanding of the general layout of a supply and extraction device (residential buildings): areas for air supply, air transfer and air extraction (ability to identify these zones in floor plans)
- Knowledge of essential components: supply air inlets, supply air ducts, air transfer openings, extract air outlet, extract air ducts, silencers, fresh and extract air filters, central unit (and its components)
- Knowledge of the typical dimensions of such ventilation devices [PHPP]
- Knowledge of air circulation effects: mixing of indoor air
- Knowledge of the Coanda effect
- Knowledge of the potential and limits of decentralised systems
- Knowledge and assessment of typical solutions
- Ability to mark supply and extraction points in floor plans
- Knowledge of the required filter qualities and why these are necessary
- Knowledge of the hygiene requirements for Passive House ventilation systems (no cooling, no active dehumidification and humidification, continuous/dry operation, upstream fresh air filter EU-class F7 or better) and reasons for these requirements; Literature: [AkkP 23]
- Exterior air inlets: what factors need to be taken into account? (filters, hygiene (location of the exterior air inlet), weather, condensation and frost protection, sound proofing)
- Knowledge of suitable duct systems. Basics of planning ducts (short pathways, smooth surfaces, fittings, typical cross sections, air-tightness)

- Under which conditions do ducts need to be insulated and how is it done properly? (generally: cold ducts in warm rooms, in case of reheating or recooling, protection from condensation)
- Knowledge of the requirements for Passive Houses suitable central ventilation units.
- Significance and calculation of effective (dry) heat recovery rates
- Significance and calculation of the specific electricity use
- Basic knowledge on how to set up central ventilation units
- Basic knowledge of noise protection principles
- Acquaintance with entering a ventilation unit in the PHPP
- Understanding of flow rate adjustment in ventilation systems; significance of balancing settings; how to adjust / balance a ventilation system?

5. Principles of heating systems for Passive Houses

- Knowledge of the heating load criterion; what is the difference between “heating load” and “space heating demand”?
- Knowledge of the 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? (ability to calculate a simplified example and make qualitative estimations)
- Why is thermal comfort in a Passive House largely independent of the means of heat/cold distribution?
- Knowledge of typical heating loads
- Knowledge of typical heat distribution systems suitable for Passive Houses
- Under what conditions are radiators required beneath windows?
- Ability to sketch a heat distribution system in the floor plan of a Passive House
- What factors need to be taken into account when considering air heater coils? (effective heating capacity based on the air flow rate; downstream duct insulation)
- Why can’t the supply air flow rate be increased?
- How does the PHPP deal with heating loads [Bisanz 1999]?
- What factors need to be taken into consideration when designing the heat distribution system and the central heat generator? (the total heating load must be accounted for)
- How and to what extent can temperature differences be achieved within a Passive House?

- To what extent is the maximum heating load influenced by the following factors: large leakages, constantly tilted windows, temporary opening of windows, opening of the front door
- Knowledge of the limitations of supply air heat distribution systems (disconnected rooms, extract rooms); solutions for these cases
- Correct positioning of a thermostat within a dwelling unit

6. Summer comfort – basics

- Knowledge of thermal comfort standards [ISO 7730]
- Understanding of comfort factors during the summer period (qualitative understanding):
    - Air exchange – assessment methods; how can it be increased?
    - Solar load: significance, dependence on the building's orientation and the transparent surfaces, shading, temporary shading, effectiveness of internal and external blinds
    - Impact of interior heat sources; how can they be reduced?
    - Impact of exterior colours [Kah 2005]
    - Impact of thermal insulation [Kah 2005]
    - Impact of thermal masses inside the building [Feist 1999]; what happens in the case of strongly fluctuating internal loads [Kah 2006]?

7. Electrical energy

- Characteristics of electric energy (versatile and effective, high primary energy input associated with its generation)
- Why is energy efficiency especially important when it comes to electrical energy?
- Typical electrical consumption of a Passive House's building services (auxiliary electricity)
- Energy efficiency requirements for auxiliary power consumption
- Typical electrical appliances in homes
- Improving the energy efficiency of domestic appliances
- Typical electrical appliances in offices (interior lighting, IT)
- Improving energy efficiency in offices; why is this such an important issue?

8. Principles of energy balancing (PHPP)

- Principles of energy balancing: volumes and dimensions for energy balances, equations
- Energy losses: transmission, ventilation
- Energy gains: internal heat sources, passive solar gains, heating
- Calculation of transmission and ventilation losses; estimating their significance
- Calculation of a window's U-value according to PHPP; calculation of solar heat gains, especially taking into account shading.
- Significance of internal heat sources.
- Calculation of the heating load according to PHPP: why calculate the heating load based on two different design days? [Bisanz 1999]
- Determining the required capacity of a ventilation system according to PHPP
- Heat dissipation of hot water pipes and storage tanks
- Compact building services units in the PHPP
- How to deal with products that are not certified (guarantee of accuracy of specified values, plausibility check)

9. Basics of economic efficiency calculation

- Payback period, present value method, annuity method [Feist 2005][VDI 2067], application of the annuity method to simple examples
- Correct determination of excess investment
- Life cycle assessment
- Cost-effective insulation levels [Feist 2005]
- Advantages of calculating the price of each kilowatt hour saved (independently of energy prices)

10. Invitations to tender and allocation

- Detailed specification of all services and products (specific values!) and categorisation based on types of services / trades
- Allocation of responsibilities
- Clarification of trades interfaces, especially for complex interfaces; what factors need to be taken into account (e.g. order of execution taking into account all trades involved)?
- Liabilities e.g. concerning the implementation of an airtight construction involving several trades

11. Construction site management and quality assurance

- Which trade sectors are concerned?
- Initial instructions for craftsmen
- Special requirements concerning the work itinerary (e.g. application of interior plaster before installation of building services, application of screed after internal plaster)
- Materials and services to be inspected and quality assurance methods:
    - Airtightness of surfaces and connection details / intersections
    - Thermal bridge free design, avoiding penetrations that do not figure in the plans
    - Window installation; frame and glazing qualities
    - Thermal insulation, thermal conductivity of insulation materials, elimination of joints, application without air gaps.
    - Air ducts: no leakages, layout / dimensions in accordance with plans, insulation, prevention of condensation and protection against construction dirt, antistatic
    - Ventilation unit: installation according to plans, flow rate check / adjustment
    - Space heating system: installation according to plans, complete insulation of heated pipes (including fixtures, pumps, etc.), running times of pumps, test run
    - Hot water system: installation according to plans, complete insulation of heated pipes (including fixtures, pumps, etc.), running times of pumps, test run
- Required quality assurance procedures (pressure test [appropriate timing], specific dates for the quality assurance for the window installation, airtight layer, insulation, air ducts, inspection of the ventilation unit)
- Handing over the building at an appropriate interior temperature (warm in winter and cool in summer periods).

12. Information and support for occupants

- What kind of information do occupants of Passive Houses need?
- Opening windows: effect during winter and summer periods.
- Temporary shading: effect during winter and summer periods.
- Ventilation unit: it is not an air conditioning system; maintenance requirements: changing filters; permanent use or shutdown with dry filters.
- How to avoid dry air in winter.

- Who do I ask if I have any questions?

13. Refurbishments using Passive House components

- Certification criteria for refurbishments with Passive House components (EnerPHit) for cool temperate climates
  - Annual space heating demand: $q_{max,heat} \leq 15$ kWh/(m²a)
  - OR: Components according to the cost optimum (life cycle based), standard values
  - Airtightness: target value: $n_{50} \leq 0.6\ h^{-1}$ | required value: $n_{50} \leq 1.0\ h^{-1}$
- Advantages of using Passive House components [AkkP 24]
- Examples of completed Passive House renovation projects
- Typical thermal bridges and effective solutions
- Special challenges concerning interior insulation (humidity) [AkkP 32]

14. Calculation, quantities, units

- Acquaintance with the metric system and decimals
- Acquaintance with standard symbols, quantities and units, in particular the consistent use of units throughout the calculation process
- Ability to make a clear distinction between different physical quantities such as work and power, or temperature and heat, etc.

15. Non-residential buildings

- Characteristics of common non-residential Passive House buildings such as offices and schools (intermittent use, significant internal heat loads from appliances and due to high occupation rates)

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www.passipedia.org – the Passive House resource