CAMaRSEC

Climate-Adapted Material Research for the Socio-Economic Context of Vietnam

Enabling Research and Development for Sustainable Buildings in the socio-economic context of Vietnam

Climate-adapted Material Research for the Socio-economic Context in Vietnam

As a result of the rapid economic development in Vietnam, lifestyles and the needs of residents change in new building typologies with materials, constructions, and supply systems that were not previously common. This development leads to far-reaching issues with structures and building physics, especially under the demanding climatic conditions. This hinders the implementation of energy-efficient and sustainable construction practices in the local construction market. Consequently, the German-Vietnamese project CAMaRSEC supports the implementation and further development of energy-efficient, resource-efficient and sustainable construction practices.

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Climate-adapted Material Research for the Socio-economic Context in Vietnam

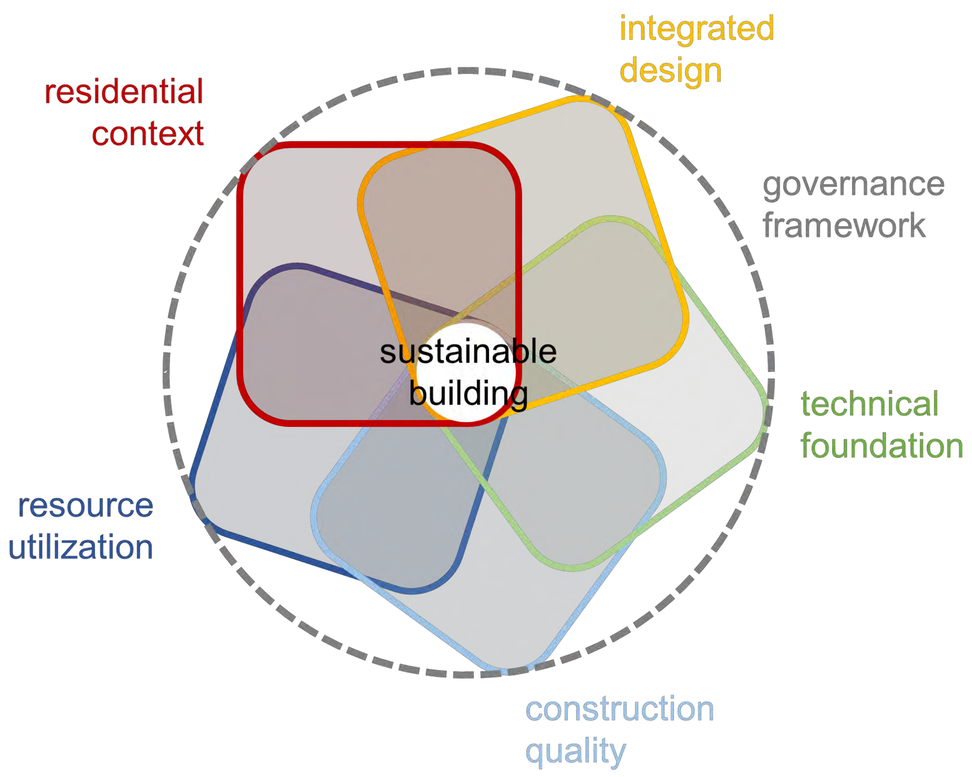
The effective application of energy- and resource-efficient construction tools and the successful implementation of the National Energy Code for the construction of residential high-rise buildings are currently hindered by a lack of facilities for building physics and materials research as well as by inadequate knowledge of user behaviour in modern residential buildings.

The aim of this project is to enable an energy-efficient and resource-saving construction practice through the strategic development of an infrastructure for research, characterization, training and the transfer of scientific results into the construction and planning practice, based on interdisciplinary problem analysis and basic research.

Project Scope

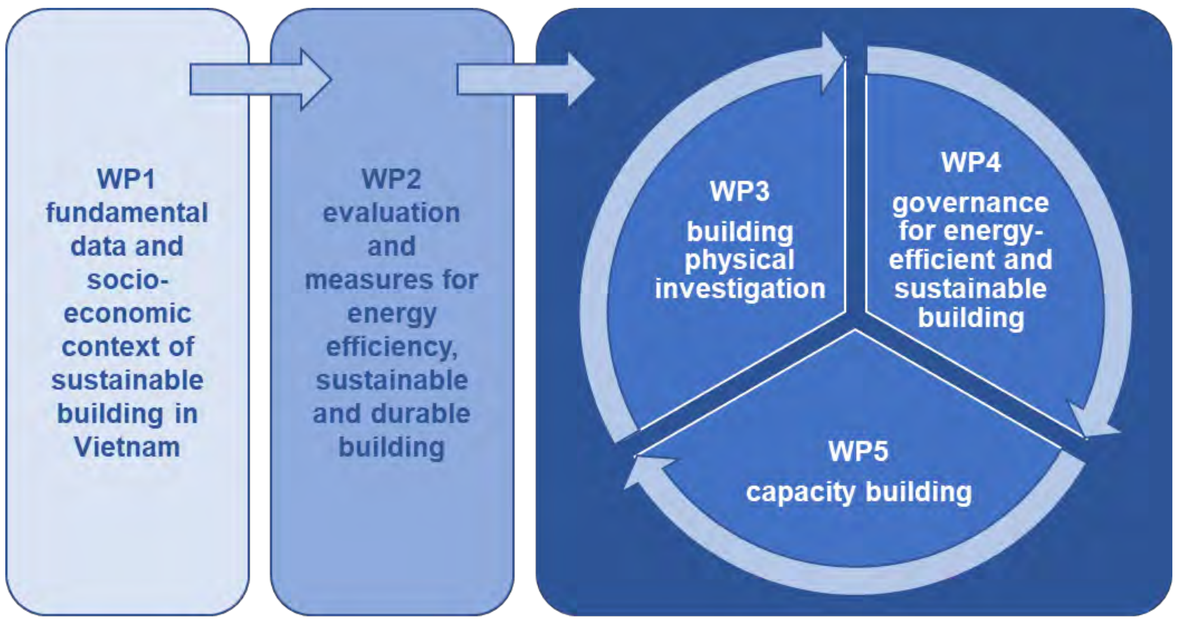
The CAMaRSEC project examines the current building practice in Vietnam from five perspectives, jointly illustrating the life cycle contexts of new residential buildings: living context, integrated design, technical fundamentals, quality of execution, and use of resources. All these topics are designed to establish an effective governance framework to promote sustainable construction in Vietnam. In order to achieve this, CAMaRSEC works with a transdisciplinary German-Vietnamese consortium.

CAMaRSEC will enable the research on materials and building systems as a basis for the application of the current energy standards, a damage-free and durable function of residential buildings and thus the long-term resource-saving construction. In addition to the initial installation of a pilot and research infrastructure, the introduction of an advanced regulatory framework and capacity-building measures will be pursued at the various stages of the building lifecycle.



Project Workplan

CAMaSEC is planned for a term of 36 months. It is organized in the following five work packages and supported through central management, dissemination and coordination activities:



Project Partner

The German partners are:

- University of Stuttgart (Stuttgart, Germany),
- Fraunhofer Institute for Building Physics (Stuttgart, Germany),
- University of Hamburg (Hamburg, Germany),
- Bau Bildung Sachsen e.V. (Leipzig, Germany), and
- TAURUS Instruments AG (Weimar, Germany).

The Vietnamese partners are:

- Vietnam Institute of Building Materials (Hanoi, Vietnam),
- National University of Civil Engineering (Hanoi, Vietnam),
- Ton Duc Thang University (HCMC, Vietnam), and
- College of Urban Works and Construction (Hanoi, Vietnam).

Funding

The CAMaRSEC project is funded within the CLIENT II programme “CLIENT II – International Partner- ships for Sustainable Innovations” by the German Ministry of Education and Research (BMBF) under the funding support code 01LZ1804.

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Subproject: technical aspects of engineering in the life cycle, project management

Subproject 1 brings together the work of the project consortium as part of the overall project management and ensures the integration of the results beyond the boundaries of specialist disciplines.

In technical terms, the focus of this subproject is on the technical and engineering aspects of building use and on the life cycle aspects of materials and buildings as well as on the evaluation of these aspects in a labelling system to be developed for building materials. Subproject 1 also prepares teaching materials for university teaching and publishes a textbook on energy-efficient and resource-efficient construction.

research questions

What are the environmental and physical parameters in modern residential high-rise buildings in Vietnam?

- How are the indoor environment parameters changing with the socio-economic conditions and what is the impact on the materials, building systems and the building performance?
- How can the implementation of energy-efficient and resource-efficient building practice in Vietnam be supported through professional information, capacity building and evidence-based governance interventions?

milestones and deliverables

- climate analysis for seven climate zones in Vietnam (WP1.4)
- simulation climate datasets for seven climate zones (WP1.4)
- measurement and building audits in apartments (WP1.5/3.2)
- development of a labelling and assessment system for construction materials and building systems (WP4.2)
- textbook for energy-efficient and resource-efficient building for students and professional stakeholders (WP5.6)

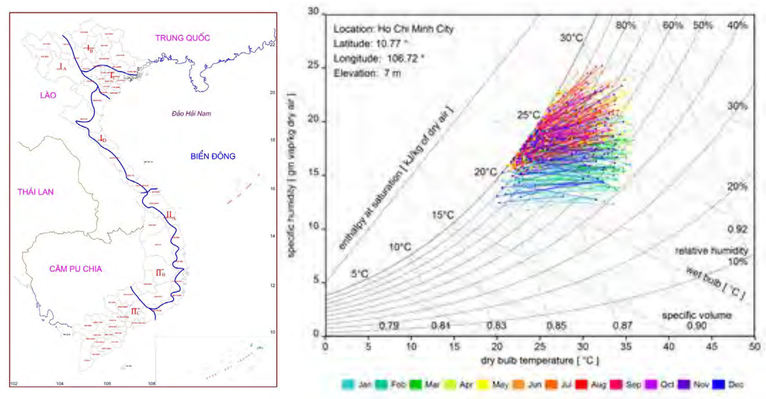

Figure 1: climate zone in Vietnam and climate analysis HCMC

WP1.4 Climate analysis

The climate of 7 cities (representative for the seven climate zones in Vietnam) is examined. For this purpose, long-term data series with the required set of parameters are purchased and evaluated. In addition, climate change scenarios are determined and applied to the datasets.

The climate items are selected for the analysis and the simulation with the simulation program WUFI for hygrothermal performance evaluation of building structures and rooms (see WP3.4).

The data is transformed in commonly used file formats such as epw-datasets for thermal building simulation or hry-datasets for hygrothermal simulations.

WP1.5 Building audit and basic measurements / WP3.2 Mobile test equipment and on-site measurements

Basic building audits and measurements are performed in 50 apartments in HCMC and 50 apartments in Hanoi. The questions of the household survey (WP1.3) and detailed questions on comfort and the individual assessment of the indoor environmental quality are asked to the occupants. The operation of the apartment, the conditions of the building structure and the building technology are audited. A even more detailed audit is conducted in a small number of apartments and the building performance is as assessed through measurement and walk-though auditing.

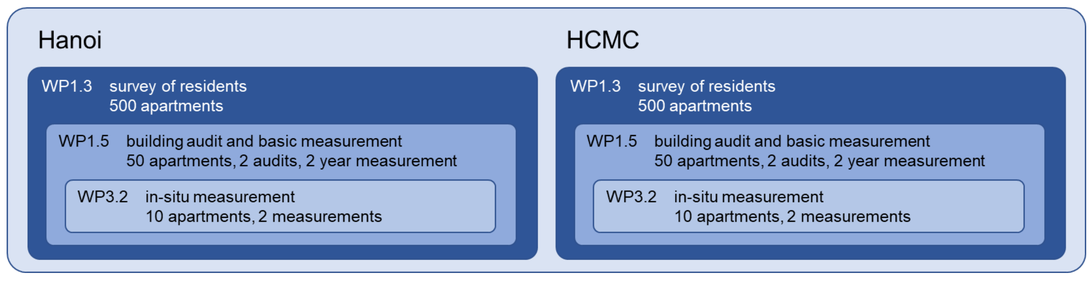

Figure 2: survey, audit and detailed measurement in apartments

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WP2.4 Life cycle evaluation of materials and material systems

Materials and material systems are evaluated for their life cycle impact. In this assessment the extraction of raw materials, the processing and production as well as the dismantling and disposal of the materials at the end of a building's lifetime is evaluated.

Recyclability of the materials and the use of recycled materials for the substitution of primary raw materials (sand and mineral aggregates) are considered.

A further topic of consideration is the effect on health in processing and dismantling and the health of the home during the use phase. The impact of materials on the local environment during installation, dismantling and during the use phase is also addressed.

life cycle phases for building assessment

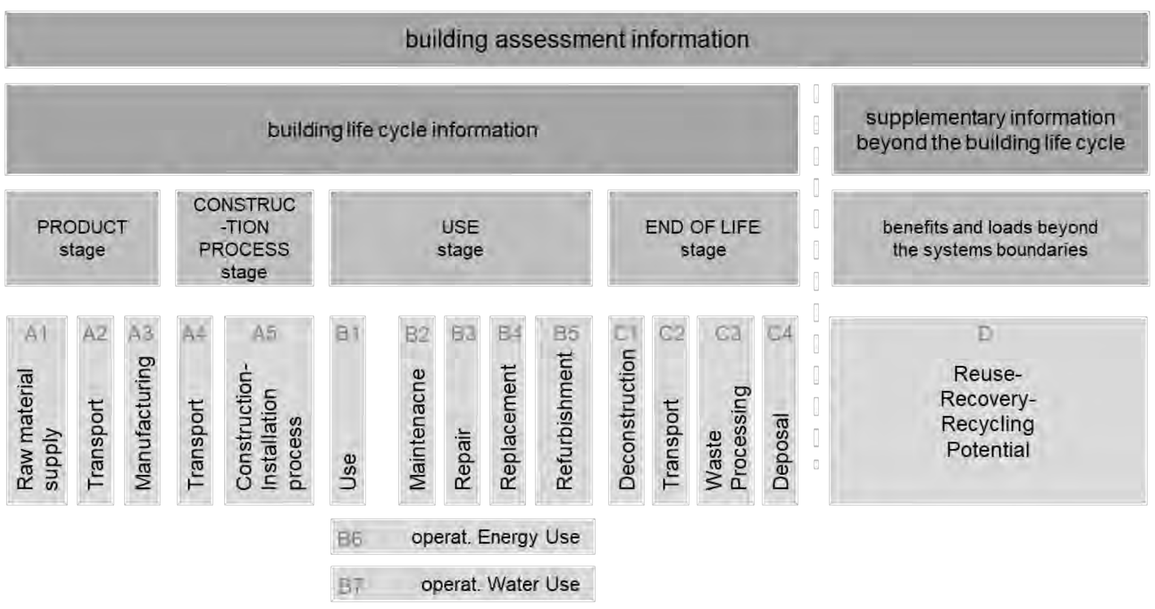
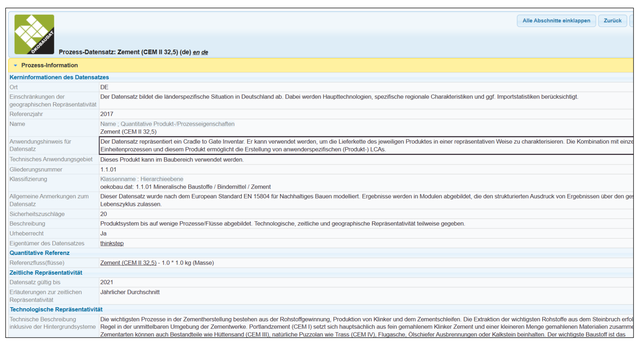


Figure 1: building life-cycle according to DIN EN 15804:2012-04

WP4.2 Concept and design of a labeling for building materials

Aligned with the current efforts of VIBM and the MoC, a concept for structured material specifications and a labeling system for building materials will be developed to help professionals and other practitioners in the performance-based material selection for energy-efficient and resource-efficient construction. While the current focus is on material properties to assess the material performance for energy saving, the approach shall be developed to include additional material parameters, such life-cycle performance, recyclability and health.



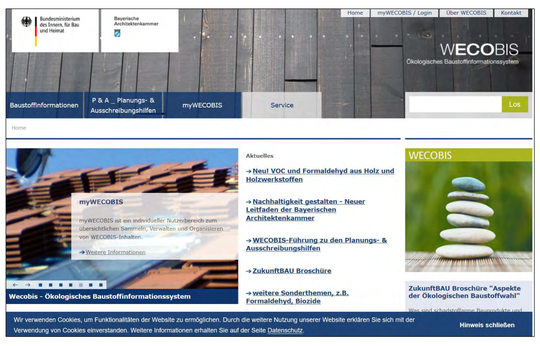
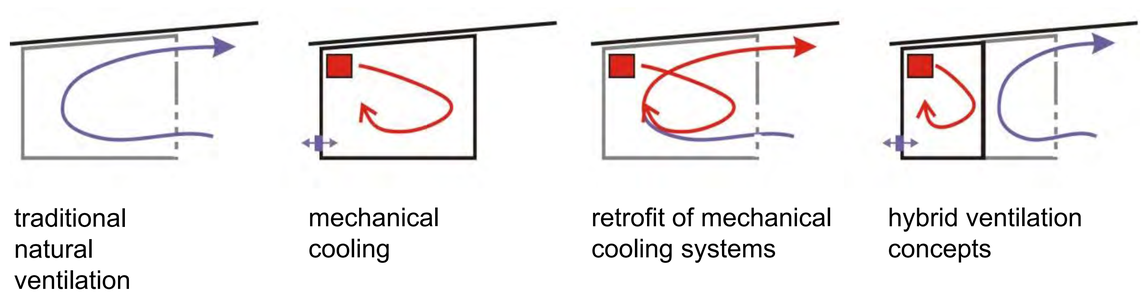


Figure 2: www.oekobaudat.de (left), www.wecobis.de (right)

WP5.2 Lecture documents for university education / WP5.6 Textbook for energy- and resource-efficient building

Lecture material and a textbook for university courses in architecture, civil engineering and materials science will be developed to be taught at the partner universities. On a scientific basis and results of the CAMaRSEC project, the teaching material will present basic and up-to-date contents of building physics, material science and building material science (durability, new materials, recycled material), technical building systems and energy-efficient and resource-efficient construction. It will be suitable for the university education of young engineers and technically oriented architects and shall also serve for the continuing education of the related occupational groups.

CAMaRSEC project content and visual representations (e.g. photos from the building audits, photos of experimental facilities, laboratory equipment) are used to illustrate and to enrich the content of the textbook.



traditional natural ventilation | mechanical cooling | retrofit of mechanical cooling systems | hybrid ventilation concepts

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Subproject: socio-economic dimension, governance, dissemination management

Introduction

In terms of academic work, Subproject 2 brings in the social, economic and political aspects of building use and the building's life cycle in Vietnam.

Theoretically, University of Hamburg follows a multi-level transition-towards-sustainability approach that contains two parts:

- The academic part: Collection of basic socio-economic information, representative data on the resident's perspective on Vietnamese high-rise buildings as well as the examination of stakeholder and governance structures in Vietnam's construction sector
- The outreach part: The establishment of the Competence Centre for Sustainable Building (CCSB-VN) at the National University of Civil Engineering, the conduction of stakeholder workshops, a Handbook for Green Living, Energy Efficiency, Durability and Health, as well as public conferences and a Vietnamese-German Scientific Advisory Board.

Figure 1: Source: Schulz in Waibel (2015)

WP 1.1 Basic Data: Society and Energy Policy in Vietnam

The objective of this WP is to create a consistent information and data basis for all WPs.

The database:

- supports the systematic analysis of literature, reports, media and statistical data.
- Collects data about the social and economic structure of Vietnam, energy tariffs, taxes, as well as available incentive instruments and the like is collected.
- Includes also expert interviews with key players from government agencies, developers, designers, engineers and NGO representatives.

Milestones and deliverables: Database on Society and Energy Policy in Vietnam; Status report

WP 1.2 Stakeholder and Governance Structures in Vietnam's Construction Sector

The objective of this WP is to create a consistent information basis for all WPs. In addition, it analyses usable governance-instruments and therefore prepares WP 2.1 and WP 4.1.

The main scientific tool is a SWOT analysis:

- Based on the existing participation structures and the legislative regulatory framework for energy- and resource-efficient construction; information about civil society and business-related initiatives in Vietnam
- Identifies working approaches and instruments for a successful governance framework for Vietnam through a comparative and empirical approach.

Milestones and deliverables: SWOT analysis

Figure 2: Analytical frame of a SWOT Analysis

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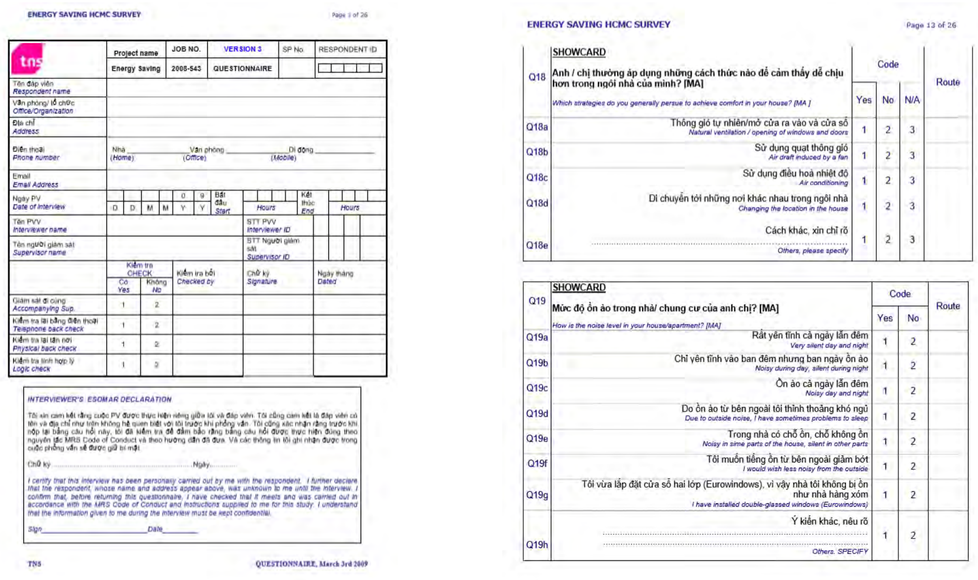
WP 1.3 Household Survey

The aim is to analyze the living context, living conditions and lifestyles in Vietnam's new residential high-rise buildings – a still rarely researched subject.


ENERGY SAVING HCMC SURVEY

tns — Project name: Energy Saving; JOB NO.: 2005-545; VERSION 3; QUESTIONNAIRE; SP No.; RESPONDENT ID

Tên điệp viên / Respondent name
Văn phòng/ tổ chức / Office/Organization
Địa chỉ / Address
Điện thoại / Phone number: Nhà (Home) Văn phòng (Office) Di động (Mobile)
Email / Email Address
Ngày PV / Date of interview: D D M M Y Y; Bắt đầu / Start; Hours; Kết thúc / End; Hours
Tên PVV / Interviewer name; STT PVV / Interviewer ID
Tên người giám sát / Supervisor name; STT Người giám sát / Supervisor ID

	Kiểm tra CHECK: Có Yes	Không No	Kiểm tra bởi / Checked by	Chữ ký / Signature	Ngày tháng / Dated
Giám sát đi cùng / Accompanying Sup.	1	2			
Kiểm tra lại bằng điện thoại / Telephone back check	1	2			
Kiểm tra lại tận nơi / Physical back check	1	2			
Kiểm tra tính hợp lý / Logic check	1	2			

INTERVIEWER'S ESOMAR DECLARATION

Tôi xin cam kết rằng cuộc PV được thực hiện riêng giữa tôi và đáp viên. Tôi cũng cam kết là đáp viên có tên và địa chỉ như trên không hề quen biết với tôi trước khi phỏng vấn. Tôi cũng xác nhận rằng trước khi hỏi tại bảng câu hỏi này, tôi đã kiểm tra để đảm bảo rằng bảng câu hỏi được thực hiện đúng theo nguyên tắc MRS Code of Conduct và theo hướng dẫn đã đưa. Và các thông tin tôi ghi nhận được trong cuộc phỏng vấn sẽ được giữ bí mật.

Chữ ký ..... Ngày.....

I certify that this interview has been personally carried out by me with the respondent. I further declare that the respondent, whose name and address appear above, was unknown to me until the interview. I confirm that, before returning this questionnaire, I have checked that it meets and was carried out in accordance with the MRS Code of Conduct and instructions supplied to me for this study. I understand that the information given to me during the interview must be kept confidential.

Sign..... Date.....

TNS — QUESTIONNAIRE, March 3rd 2009

ENERGY SAVING HCMC SURVEY — Page 13 of 26

	SHOWCARD: Anh / chị thường áp dụng những cách thức nào để cảm thấy dễ chịu hơn trong ngôi nhà của mình? [MA] / Which strategies do you generally persue to achieve comfort in your house? [MA]	Code: Yes	No	N/A	Route
Q18a	Thông gió tự nhiên/mở cửa ra vào và cửa sổ / Natural ventilation / opening of windows and doors	1	2	3	
Q18b	Sử dụng quạt thông gió / Air draft induced by a fan	1	2	3	
Q18c	Sử dụng điều hoà nhiệt độ / Air conditioning	1	2	3	
Q18d	Di chuyển tới những nơi khác nhau trong ngôi nhà / Changing the location in the house	1	2	3	
Q18e	Cách khác, xin chỉ rõ ..... / Others, please specify	1	2	3	

	SHOWCARD: Mức độ ồn ào trong nhà/ chung cư của anh chị? [MA] / How is the noise level in your house/apartment? [MA]	Code: Yes	No	Route
Q19a	Rất yên tĩnh cả ngày lẫn đêm / Very silent day and night	1	2	
Q19b	Chỉ yên tĩnh vào ban đêm nhưng ban ngày ồn ào / Noisy during day, silent during night	1	2	
Q19c	Ồn ào cả ngày lẫn đêm / Noisy day and night	1	2	
Q19d	Do ồn ào từ bên ngoài tôi thỉnh thoảng khó ngủ / Due to outside noise, I have sometimes problems to sleep	1	2	
Q19e	Trong nhà có chỗ ồn, chỗ không ồn / Noisy in some parts of the house, silent in other parts	1	2	
Q19f	Tôi muốn tiếng ồn từ bên ngoài giảm bớt / I would wish less noisy from the outside	1	2	
Q19g	Tôi vừa lắp đặt cửa sổ hai lớp (Eurowindows), vì vậy nhà tôi không bị ồn như nhà hàng xóm / I have installed double-glassed windows (Eurowindows)	1	2	
Q19h	Ý kiến khác, nêu rõ ..... / Others: SPECIFY	1	2	

Figure 1: Section of preceding household survey.

The household survey:

- is a representative quantitative household survey and the highest level of the study cascade together with WP 1.5 and WP 3.2
- is conducted among 400-500 households in Hanoi and among 400-500 households in HCMC
- covers demographic, social and economic data and the resident's behavioral patterns, their perception of the apartment and their awareness of sustainability issues

Milestones and deliverables: Household survey; raw data; Status report

Reference

Waibel, Michael (2009): Megacity Research Project TP. Ho Chi Minh / Vietnam, Work Package 9 Energy- and climate efficient housing typologies, Report.

WP 4.1 Instruments and Guidelines

The aim of this WP is to develop a concept for a holistic regulatory framework in the field of energy, resource-efficient and sustainable construction.

Based on the research carried out in WP1 and WP3, and in close consultation with local actors, recommendations for the further development of guidelines and standards in the field of energy, resource-efficient and sustainable construction are developed.

The recommendations for actions are tailored to the scope and development of the research facility planned in WP 3.1.

Milestones and deliverables: Roundtable workshops, concept paper

WP 4.3 Competence Center for Sustainable Construction

Knowledge about sustainable construction in Vietnam is still limited due to scattered expertise and, yet, not fully exploited synergies between science and industry.

The aim is to establish a Competence Center for Sustainable Construction in Vietnam (CCSB-VN) as a cross-sectoral institution at Vietnam's leading research institution in the field, the National University of Civil Engineering (NUCE) in Hanoi.

Figure 2: Sign of the CCSB-VN

Tasks of the Competence Center:

- It will bring together expertise from NUCE's relevant departments and other research institutions,
- it will disseminate the knowledge and products of CAMaRSEC.

Milestones and deliverables: Roundtable workshops, feasibility study; local project coordination office and National Competence Center for Sustainable Construction in Vietnam

´WP 5.4 Workshops for Stakeholder Engagement

This Package aims to link CAMaRSEC's activities to established key actors of civil society and businesses in Vietnam to disseminate the research outcome and products.

Workshop partners:

EUROCHAM · VGBC Vietnam Green Building Council / Hội đồng Công trình xanh Việt Nam · GreenID · GBA German Business Association

Milestones and deliverables: stakeholder workshops; PR video clips and press releases.

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WP 5.5 Handbook for Green Living, Energy Efficiency, Durability and Health

Figure 1: Preceding publications.

The objective of this WP is to communicate sustainability goals in the construction sector to a broader public.

The handbook, published in Vietnamese and English language, communicates in a comprehensive and accessible way to laymen.

Milestones and deliverables: Handbook

Figure 2: A look inside the Handbook for Green Housing

References

Waibel, M. (ed.) (2013): Handbook for Green Products. High-Quality Company Solutions towards Climate-Adapted Housing and Energy-Efficient Buildings in Vietnam, Edition 2: Technical Constructive Green Housing Products and Green Services. Transport Publishing House, Hanoi/Vietnam. 68 pages.

Hesse, C., Schwede D. & M. Waibel (eds.) (2011): Handbook for Green Housing: Climate-Adapted and Energy-Efficient Building Solutions for Ho Chi Minh City, Edition 1: Town Houses. Transport Publishing House, Hanoi/Vietnam. 68 pages.

K Public Conferences

The aim of this WP is to communicate the project and its goals to the general public and to facilitate exchange with experts.

There will be three major conferences with the target size of 120-160 persons:

- the inaugural conference at the National University of Civil Engineering (NUCE);
- the status conference at the Vietnamese Institute of Building Materials, that serves to present the empirical results, policy app-roaches and other project activities;
- the final conference at CCSB-VN will present the project results and show strategies for achieving lasting effects beyond the fun-ding period.

Milestones and deliverables: three conferences; press releases, PR video clips, Conference Proceedings

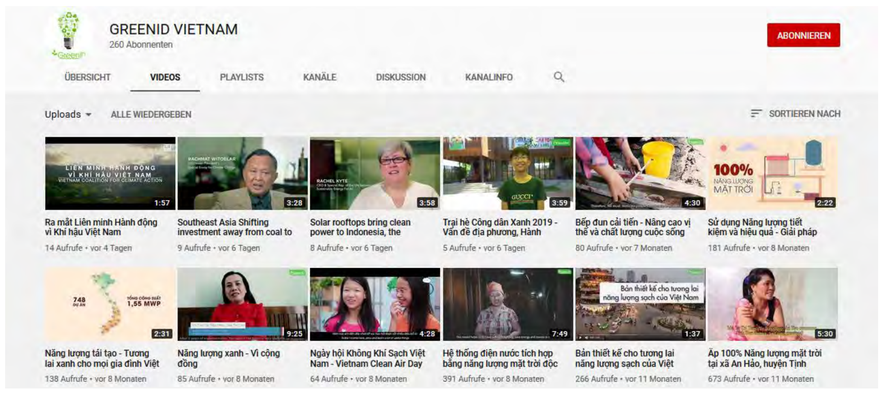

Figure 3: Youtube channel by GreenID

W Scientific Advisory Board

The aim of WP W is to ensure the scientific quality and relevance for local application.

A Scientific Advisory Board accompanies CAMaRSEC's research:

- It consists of six representatives from administration, industry and science, both from Vietnam and Germany.
- it is regularly informed about the project activities and the developed products, as well as on current issues,
- It advises in particular the implementation and utilization of the project's outcome and is invited to a short feedback report

Milestones and deliverables: Meet of the SAB; three feedback reports of the SAB

subproject leader

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Subproject: experiments and identification of **“hygrothermal properties"**

WP2: Assessment and measures for energy and resource efficiency and sustainable constructions

WP2.1 Material selection for constructions

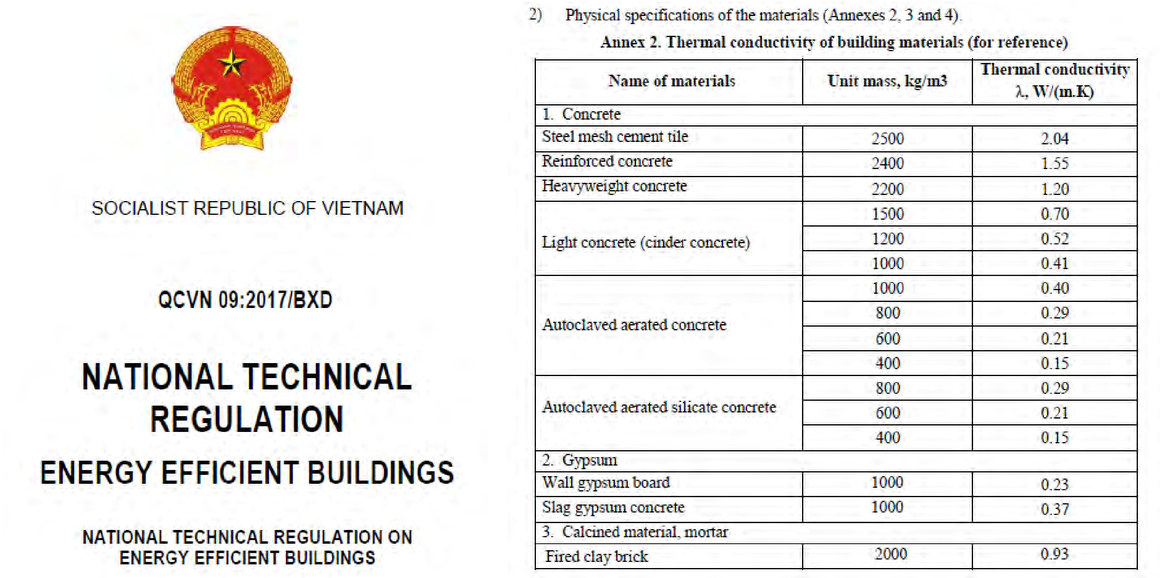
The process of selecting building materials is analysed. The criteria and material specifications in design practice are determined by an analysis of planning data and a survey among the relevant stakeholders. The result will be used as the basis for WP4.2 and as a starting point for the development of education and training in WP5. First, representative materials for the construction of exterior walls, in particular for the infill of the concrete skeleton construction most commonly used in Vietnam, are selected. While the properties of the bricks depend only on their production the properties of the masonry mortar and plaster systems are strongly influenced by the on-site mixing and preparation process and the prevailing weather conditions. Therefore, these factors must be taken into account when selecting the building materials to be examined. The result of the WP should be a list of building materials already used in Vietnam which can be further developed to be resistant to the Vietnamese climate and show improved energy savings and sustainability characteristics.

WP2.2 Functional requirement for the material selection

In this WP the required material parameters for heat and moisture control and for designing energy-efficient and durable residential buildings exposed to the prevailing climate (see WP1.4) are identified. The determination of the identified material parameters form the basis for the laboratory equipment concept to be developed in WP3.1. The envisaged material characterization allows more in-depth analysis of the energetic and hygrothermal performance of building envelope systems during application and based on the latter also a more detailed service life prediction. Thus, in addition to the thermally relevant material characteristics, such as thermal conductivity, density and specific heat storage capacity, moisture-related material parameters are of great importance because the hygrothermal analysis by computational simulation according to DIN EN 15026 or ANSI / ASHRAE 160 can be employed to prevent moisture penetration as well as material degradation or damage which will impair the material function. The objective of this WP is a material selection with regard to thermal and moisture control and durability, taking into account the external exposure and the desired indoor comfort conditions.

WP2.3 New materials and building technologies

WP2.3 goes beyond current building practice and specifies requirements for the use of alternative materials (including recycled or natural materials) and changed operation modes in modern dwellings. The results of such an analysis provide a framework for evaluation criteria for the development of new sustainable materials and systems. Since the currently mostly used fired bricks are problematic both from energetic and environmental (resource conservation) point of view, alternative materials should be investigated and if necessary developed, which represent a structurally adequate replacement without the above-mentioned disadvantages. For this purpose, the parameters of materials available in Vietnam are analysed and compared with the requirements. Based on these results, further material development goals may have to be defined. At the same time the international market is scanned for materials that already meet most of the requirements. In this WP climate adapted evaluation criteria for the development of new materials and systems shall be developed.



SOCIALIST REPUBLIC OF VIETNAM

QCVN 09:2017/BXD

NATIONAL TECHNICAL REGULATION

ENERGY EFFICIENT BUILDINGS

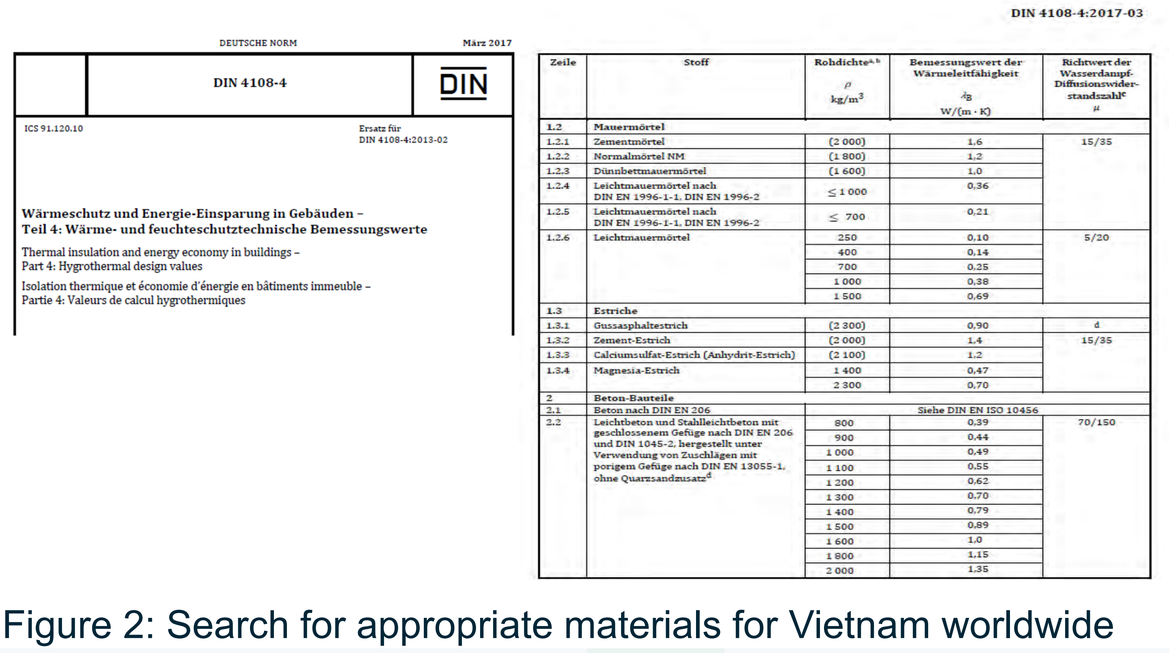
NATIONAL TECHNICAL REGULATION ON ENERGY EFFICIENT BUILDINGS

2) Physical specifications of the materials (Annexes 2, 3 and 4).

Annex 2. Thermal conductivity of building materials (for reference)

Name of materials	Unit mass, kg/m3	Thermal conductivity λ, W/(m.K)
1. Concrete		
Steel mesh cement tile	2500	2.04
Reinforced concrete	2400	1.55
Heavyweight concrete	2200	1.20
Light concrete (cinder concrete)	1500	0.70
	1200	0.52
	1000	0.41
Autoclaved aerated concrete	1000	0.40
	800	0.29
	600	0.21
	400	0.15
Autoclaved aerated silicate concrete	800	0.29
	600	0.21
	400	0.15
2. Gypsum		
Wall gypsum board	1000	0.23
Slag gypsum concrete	1000	0.37
3. Calcined material, mortar		
Fired clay brick	2000	0.93

Figure 1: Material selection according to Annex 2 of the National Technical Regulation for Energy Efficient Buildings



DEUTSCHE NORM März 2017

DIN 4108-4

DIN

ICS 91.120.10

Ersatz für DIN 4108-4:2013-02

Wärmeschutz und Energie-Einsparung in Gebäuden – Teil 4: Wärme- und feuchteschutztechnische Bemessungswerte

Thermal insulation and energy economy in buildings – Part 4: Hygrothermal design values

Isolation thermique et économie d'énergie en bâtiments immeuble – Partie 4: Valeurs de calcul hygrothermiques

DIN 4108-4:2017-03

Zeile	Stoff	Rohdichte[a,b] ρ kg/m³	Bemessungswert der Wärmeleitfähigkeit λB W/(m · K)	Richtwert der Wasserdampf-Diffusionswiderstandszahl[c] μ
1.2	Mauermörtel			
1.2.1	Zementmörtel	(2 000)	1,6	15/35
1.2.2	Normalmörtel NM	(1 800)	1,2	
1.2.3	Dünnbettmauermörtel	(1 600)	1,0	
1.2.4	Leichtmauermörtel nach DIN EN 1996-1-1, DIN EN 1996-2	≤ 1 000	0,36	
1.2.5	Leichtmauermörtel nach DIN EN 1996-1-1, DIN EN 1996-2	≤ 700	0,21	
1.2.6	Leichtmauermörtel	250	0,10	5/20
		400	0,14	
		700	0,25	
		1 000	0,38	
		1 500	0,69	
1.3	Estriche			
1.3.1	Gussasphaltestrich	(2 300)	0,90	d
1.3.2	Zement-Estrich	(2 000)	1,4	15/35
1.3.3	Calciumsulfat-Estrich (Anhydrit-Estrich)	(2 100)	1,2	
1.3.4	Magnesia-Estrich	1 400	0,47	
		2 300	0,70	
2	Beton-Bauteile			
2.1	Beton nach DIN EN 206		Siehe DIN EN ISO 10456	
2.2	Leichtbeton und Stahlleichtbeton mit geschlossenem Gefüge nach DIN EN 206 und DIN 1045-2, hergestellt unter Verwendung von Zuschlägen mit porigem Gefüge nach DIN EN 13055-1, ohne Quarzsandzusatz[d]	800	0,39	70/150
		900	0,44	
		1 000	0,49	
		1 100	0,55	
		1 200	0,62	
		1 300	0,70	
		1 400	0,79	
		1 500	0,89	
		1 600	1,0	
		1 800	1,15	
		2 000	1,35	

Figure 2: Search for appropriate materials for Vietnam worldwide

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WP3: Investigation of building material characteristics, systems und boundary conditions

In WP3, the capacity and necessary equipment for measuring boundary conditions and material parameters relevant for the prediction of the building envelope performance such as thermal resistance, thermal capacity, emissivity as well as hygrothermal properties are defined and the implementation plan is developed. In addition, an outdoor weathering test bench will be planned and set up with the Vietnamese partner VIBM at an early stage. Comparative investigations between the German and Vietnamese laboratories will validate the new test equipment in Vietnam. The field trial is accompanied by hygrothermal validation measurements in the climate simulator at the Fraunhofer IBP and computer modelling. Hygrothermal simulations are used to evaluate further components and room scenarios for different Vietnamese climate zones. In a feasibility study, the findings from the construction of two building physics laboratories in Vietnam are scaled up to a possible physical infrastructure for further testing and research in Vietnam and the way to implement such a facility is developed.

WP3.1 Plan for determination and research

Creation of a laboratory concept for characteristic value determination in accordance with Vietnamese energy standards and building physics material, component and building research.

WP3.3 Experimental and Research Facilities

Research institutes will be set up in this WP to investigate building physics issues identified in the CAMaRSEC definition phase.

a. laboratory facilities

Test equipment and test methods are to be defined here precisely, with application ranges, measurement accuracies, test boundary conditions and detailed installation plan. The implementation will be coordinated between the Fraunhofer IBP (scientific) and the industrial partner (technical) and VIBM. Properties for the Vietnamese energy efficiency standard and further relevant properties for the performance-oriented design (e.g. simulation studies, see WP3.4) shall be determined in the new Lab of VIBM. The services in this WP are supported by the industrial partner TAURUS.

Selection of parameters which shall be measured in the lab:

- Thermal properties: thermal conductivity, thermal resistance
- Air tightness, water tightness, air flow rate
- Water uptake, water vapour diffusion
- Reflectance, light transmittance, emissivity, solar heat gain

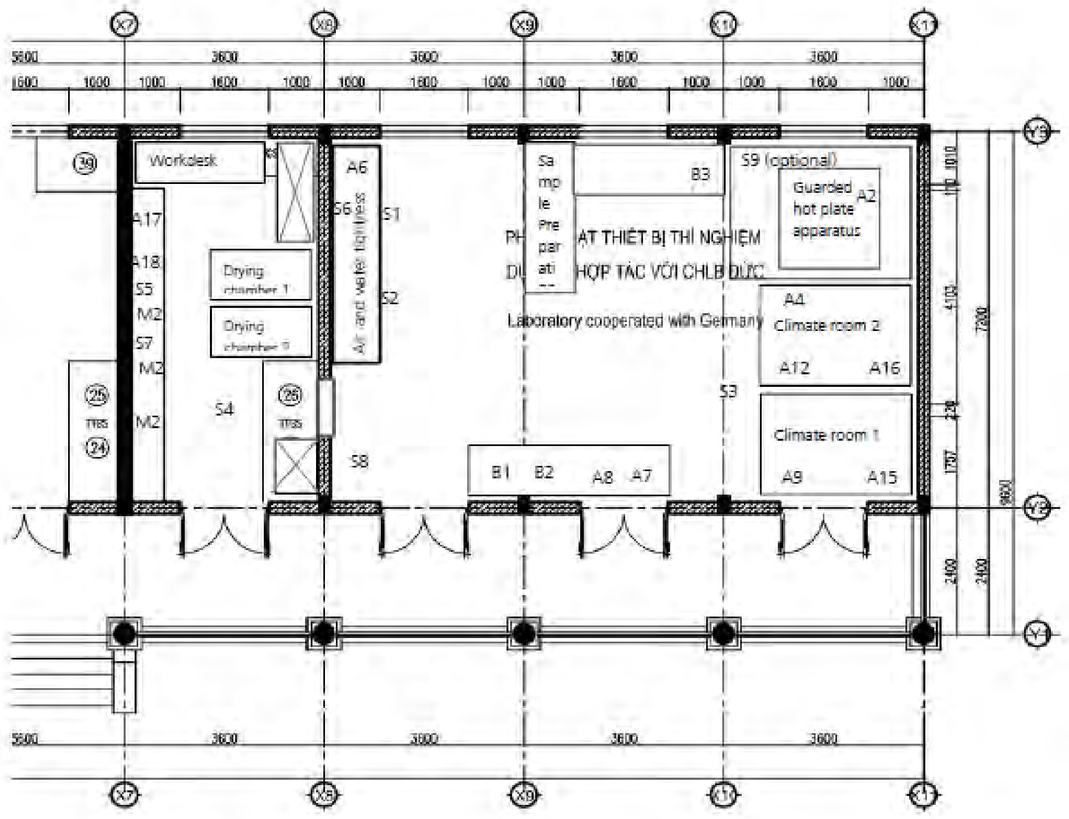

Figure 1: Draft of the new test lab with equipment

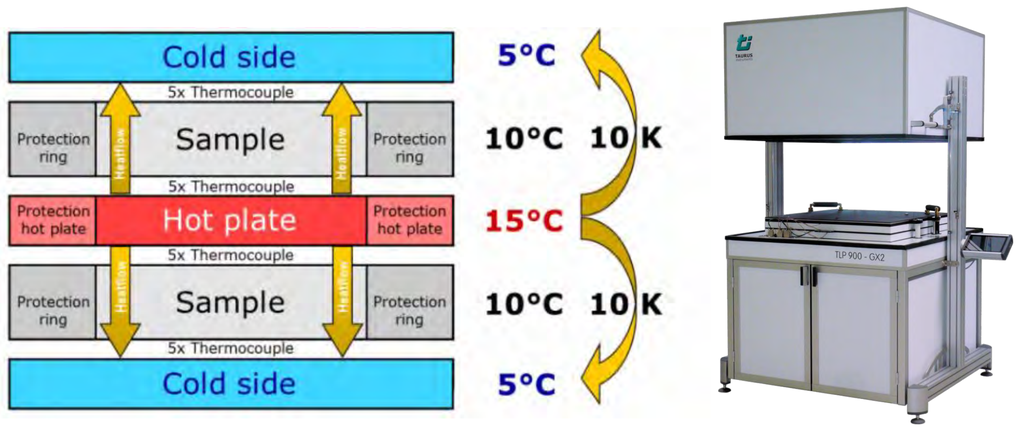

Figure 2: Measurement of thermal conductivity

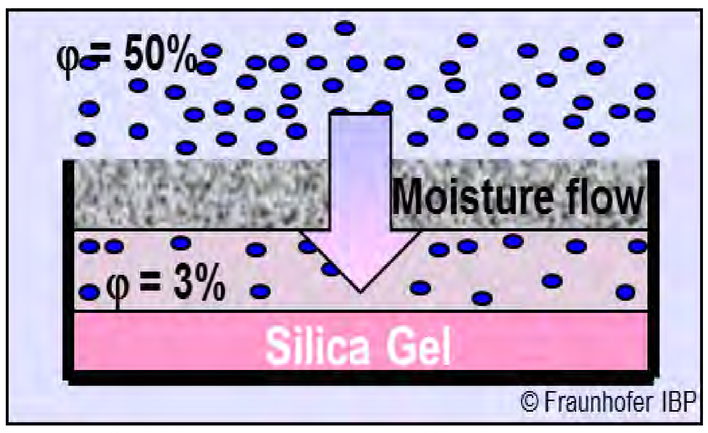

Figure 3: Water vapour diffusion test (cup-test)

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WP3.3 Experimental and Research Facilities

Research facilities will be set up in this WP to investigate building physics issues identified in the CAMaRSEC definition phase.

b. Free field weathering testing

An open-air test stand is set up at the VIBM Free Field Testing Center to evaluate the hygrothermal performance and durability of wall system samples. An air-conditioned test building is designed with the test facade oriented to a critical direction concerning the impacts of solar radiation and driving rain. Critical means that the environmental impact in these directions is at its peak, leading to faster degradation of facades exposed to that orientation. The building consists of a concrete skeleton with several sections each filled with different masonry types (e.g. lightweight concrete block, ACC) and as reference standard fired brick. At several positions of the wall sections, various sensors to monitor temperature and humidity distributions, moisture content and heat flux are installed and calibrated as a relevant pilot application in the new research facility. In the building, the indoor climate is controlled within a predefined comfort range. After calibration, the test bench is equipped with data acquisition systems to record and control the indoor conditions as well as the material and system performance of the tested wall elements. In this way, the performance of new wall systems can be compared directly with conventional wall structures.

- Verification of the durability of existing and new wall construction systems and their resistance to heat and vapour transfer as well their air and water (driving rain) tightness.

c. Comparative study of materials and systems

A number of materials and material systems are selected for comparative testing. These comparative tests should include all relevant parameters such as thermal conductivity, heat transfer coefficient, air permeability, water tightness (windows), compressive stress, water absorption, vapor diffusion resistance as well as special durability characteristics such as water absorption and compressive stress after exposure to natural climate. This is to ensure that standard quality standards are adhered to and that the results are internationally comparable. The selected materials are first tested in Vietnam and then sent to the Fraunhofer IBP, where the tests are repeated non-destructively on the same samples.

- Round robin tests for the determination of relevant material and system parameters between Vietnamese and German institutes as well as evaluation and assessment of the results obtained from testing the same samples.

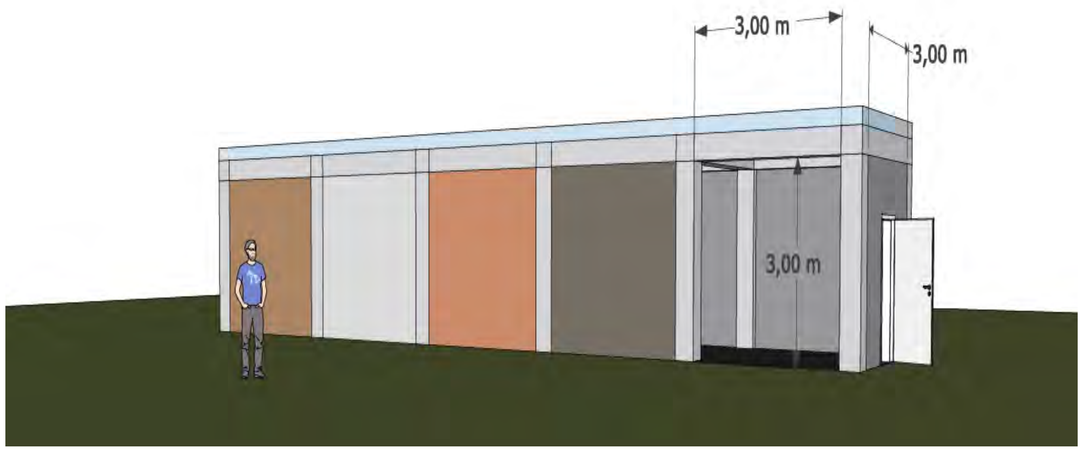

Figure 1: Draft of the new free field weathering test stand

Figure 2: Wall exposure hall at the Fraunhofer IBP test site

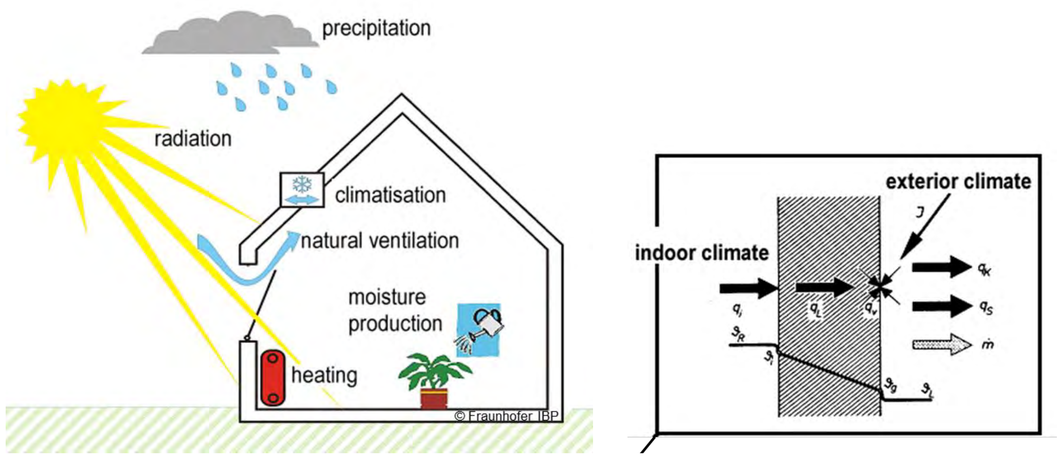

Figure 3: Heat and moisture transfer through the building envelope

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WP3.4 Hygrothermal simulation of building components and houses

In addition to the measurements in WP3.3a and parallel to the tests in WP3.3b and WP3.3c, simulation studies are carried out with the simulation programs WUFI® Pro and WUFI® Plus (developed by the Fraunhofer IBP). By comparing the experimental results with the simulation results, deviations and inaccuracies are detected and both experiment and simulation are reviewed and if necessary adapted. The researchers in Vietnam are trained to apply the simulation tool and to assess its results. The simulation studies will be extended to different scenarios e.g. to plan future material tests or to extrapolate results to predict the long-term behaviour of wall systems. At the same time, new material formulations can be developed and optimized by parameter studies with varying material characteristics in the simulation.

In this WP, five simulation workstations for research and teaching (see also WP5.2) will continue to be set up by the university partners NUCE and TDTU.

- The objective of using WUFI® to simulate the hygrothermal performance is threefold: analyse problems, develop improved systems and extrapolate system performance into the future to predict average service life and maintenance cycles.

What is WUFI®?
Hygrothermal component and whole building simulation

WUFI® is a family of software products that allow the simulation of the transient heat and moisture transfer processes in building materials, components and whole buildings exposed to natural weather. WUFI® is an acronym for **W**ärme **U**nd **F**euchte **I**nstationär—which, translated, means dynamic heat and moisture. WUFI® software uses the latest findings regarding vapor diffusion and liquid transport in building materials. The software has been validated by detailed comparison with measurements obtained in the laboratory and at IBP's outdoor testing field.

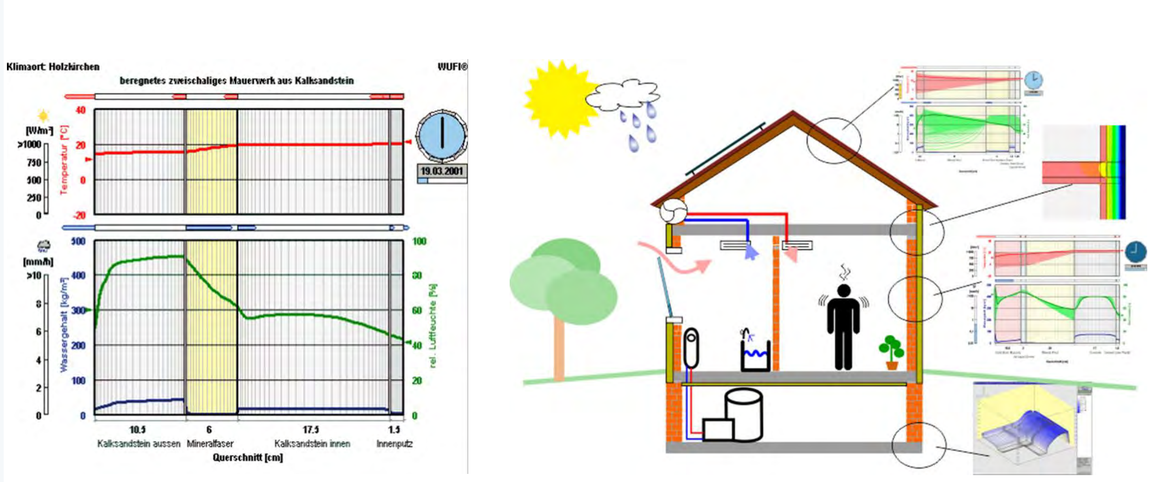

Figure 1: One- and multi-dimensional hygrothermal simulation

WP3.5 Feasibility study for test facilities in Vietnam

On the basis of WP3.3, a far-reaching feasibility study is being prepared for a testing and research infrastructure to determine material characteristics and to conduct applied building physics related material research. Beyond measuring basic characteristics (e.g. thermal conductivity, compressive stress, diffusion resistance, water absorption) which is done by many laboratories, the aim is to implement more advanced determination methods in Vietnam that only a few selected research institutions can perform due to their complexity and equipment costs (e.g. thermal resistance of large components, radiation characteristics, air permeability, driving rain and wind resistance, special hygrothermal material parameters). Here, the scientific and theoretical part of the work is provided by the Fraunhofer IBP, while the industry partner TAURUS gives priority to technology and application training. The actual planning takes place in Germany in cooperation with the local partners. The organizational structures of such a facility, the necessary financial resources and other factors (e.g. space requirements, skills of the staff and operating costs) are estimated. The plan will be discussed with the project partners VIBM, NUCE and TDTU, as well as with the scientific council and also with potential implementation partners (GIZ, KfW, UNDP, ifc, adb) and the ministries (MoC, MoST) in order to initiate the establishment of an appropriate research infrastructure.

WP5 Education, Training, Knowledge Transfer

WP5.1 Laboratory and research staff

The VIBM research and laboratory staff and research partners NUCE and TDTU focus on implementing test facilities in WP3.3. In the initial phase (possibly already before the construction of the test equipment), a research group will be trained in Germany at the locations of the Fraunhofer IBP (Stuttgart and Holzkirchen) and by the industrial partner TAURUS in Weimar (a leading supplier of laboratory equipment). The training includes theory behind the envisaged test method (Fraunhofer IBP), equipment engineering and pilot tests (TAURUS one to two days), joint execution of calibration measurements, test assignments, special applications of standards etc. (Fraunhofer IBP). The exchange of experiences, test protocols and the continuation of the trainings are carried out by two employees of the Fraunhofer IBP (scientific) and employees of the company TAURUS (technical problems).

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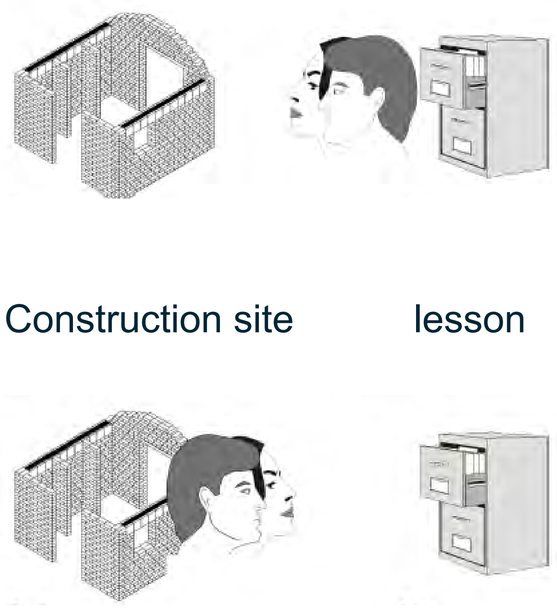
Subproject: Adaption of research results for Vocational Education and Training, Capacity Building

WP5.3 Local adapted trainings for construction workers

WP 5 will provide training, education and information at different levels of the building lifecycle and for different stakeholders.

In WP 5.3 research results are transferred and included in curricula for vocational education and training and further training courses of Vietnamese construction workers.

New training contents will be integrated into existing curricula when possible. Otherwise new curricula will be developed.



Construction site lesson

<u>traditional:</u>
View from theory to practice.
What should we teach and train that could be needed on the construction site …

<u>modern:</u>
View from practice to theory.
What is needed on site will be taught and trained, focusing real working tasks and working procedures …

Figure 1: VET – different points of view

Vietnamese teachers and trainers attend trainings of trainers (ToT) to get used to the curricula in theory and practice and to be qualified as national multipliers.

Then German and Vietnamese experts develop training materials and linked concepts for practical training sessions. In doing so, the research results are broken down to the requirements of construction practice. In coordination with the local trainers and lecturers, the results are evaluated and, if necessary, adjusted. In addition, appropriate practical training routes will be set up on site.

During the next phase the instructors of CUWC will be trained in trainings of trainers as multipliers for the new training contents. The multipliers are instructed to combine and convey theoretical and practical training contents in terms of action-orientation. Following this approach, the results of the work package can be applied both to initial training and to the further training of construction site personnel.

				DESIGN
			COMBINE	COMBINE
		ANALYSE AND SELECT	ANALYSE AND SELECT	ANALYSE AND SELECT
	ADAPT (MODIFY)	ADAPT	ADAPT	ADAPT
COMPREHEND (REPRODUCE)	COMPREHEND	COMPREHEND	COMPREHEND	COMPREHEND
Participants are able…				
… to reproduce given patterns of action.	**… to adapt given or known patterns of action to the existing conditions.**	**… to select a suitable pattern of action from known patterns of action based on the existing conditions.**	**… to develop a combination of known patterns of action based on existing conditions.**	**… to design their own patterns of action.**
The participants reproduce the patterns of action move in precisely-determined patterns of thinking and action	The participants use the specified patterns of action always move within the preset patterns of thinking and acting	The participants select one pattern of action presented by the teacher always move within the preset patterns of thinking and acting	The participants fall back on known knowledge and skills, and combine given or known patterns of action into a suitable pattern of action with which the problem can be identified and/or solved	The participants act independently without help from the instructor acquire the knowledge and skills required for identifying and/or solving the problem and develop their own patterns of action

Figure 2: VET qualification levels

Partners of the work package are Bau Bildung Sachsen e. V. from Germany and Hanoi based College of Urban Works Construction (CUWC).

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CUWC

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