1. PROJECT SUMMARY

The initiative "Carrying heritage buildings as part of urban regions into a modern and energy-efficient society (CHARMS)" develops an integrated urban development strategy for improving the thermal comfort of historic houses and neighborhoods in the urban region of Chiang Mai. In the light of the planning paradigm of preservation through use, locally adapted, sustainable usage concepts for historic wooden houses are developed and their implementation prepared.

First, climate models of various urban climatic levels are developed. The climate analysis is enriched with the comparative analysis of the attitudes of urban and rural residents of historic districts on the subject of energy and resource efficient building renovation. The ecological and social effectiveness of the solutions developed in the project is assessed based on these climate and social structure models. The development of locally adapted solutions is based on innovation challenges, understood as short solution-oriented experimental projects that propose solutions from the perspective of building materials, the building structure, the urban microclimate, the municipal communication infrastructure and the standardization of municipal decision-making processes. This process is accompanied by the ASEAN-wide identification of social innovations to improve thermal comfort, as well as the ASEAN-wide implementation of capacity-development activities with universities from countries confronted with comparable challenges. The technical and social innovations are presented to an expert and to a community advisory board and adjusted according to their feedback. The focus of the last two project years is the political and scientific utilization of the project results and the preparation of the economically viable implementation of the integrated urban development strategy in the subsequent implementation phase based on an innovation strategy.

CHARMS contributes to the implementation of the green economy, *future city*, German *Energiewende* and links ecology with economy and social aspects. CHARMS operationalizes the national sustainability strategy (new edition 2016) and the German high-tech strategy. The project also makes a contribution to the implementation of the "Goals for Sustainable Development of the United Nations (SDGs)", especially Goal 7 (Energy for all), Goal 11 (Sustainable cities) and goal 17 (Global partnership for sustainable development)

2. PROBLEM ANALYSIS

Focal problem: Unhealthy and uncomfortable thermal environments provided by traditional, wooden buildings in Thailand impair local resident's wellbeing

Research conducted by the CHARMS team in 2019 shows that the use value that residents in Chiang Mai/Northern Thailand, attribute to wooden, traditional residential buildings is impaired by the unsatisfactory indoor comfort these buildings provide. This problem is further evidenced by a convenience-sample based pilot survey with 119 respondents from the pilot districts of Wat Lam Chang and Wat Ket conducted in 2020 (thereof 52 residents of wooden buildings). With future developments in mind it is important to note that the results indicate a generation split in terms of perceptions of the indoor comfort provided by traditional wooden building with the younger generation having a more negative view on this issue than the older generation (Fig 1). At the same time, the results indicate that the existence and future use of these buildings are of utmost importance for the sake of the cultural identity of the local inhabitants (with almost 80 percent approval among those respondents, who do not live in traditional wooden buildings).

Additional qualitative interviews with stakeholders indicate that thermal comfort, understood as “a condition of mind that expresses the subjective satisfaction with the thermal environment” (Kolokotsa et al. 2012), is the most important determinant of the cost-effective provision of an acceptable level of indoor comfort for local residents. As a result, the current performance of traditional wooden buildings in Chiang Mai do not meet the expectations of most residents. Those living in wooden buildings feel impaired by an either energy-costly (with air-conditioning) or for many uncomfortable (without air conditioning) thermal environment. Managing the indoor climate of traditional wooden buildings is not only a question of thermal comfort, but also a health issue. Air pollution in Chiang Mai has increased enormously compared to the times when the traditional wooden buildings were built, having led to the problem of haze pollution, especially during the dry season (January to April), when dust remains suspended in the atmosphere for a long time. Chiang Mai was ranked as having the worst air quality index score in the world in March 2019 (Sereenonchai et al, 2020). As a result of uncomfortable and unhealthy indoor conditions, the majority of Chiang Mai city’s historic residential buildings that are older than 80 years have been replaced by modern apartment buildings, resulting in a dwindling feeling of cultural identity and a decreasing quality of life, not only for the residents, but for the entire neighborhood. Furthermore, this urban development comes with a high level of resource-consumption due to mechanical ventilation and cooling. Thailand’s final energy consumption has been continuously increasing in the building sector, accounting for 57.9% of total electricity consumption in 2013 (Chaichaloempreecha et al., 2017). The COVID19 outbreak is adding to the relevance of a comfortable and healthy indoor environment in residential buildings since working from home has become the “new normal”.

Cause analysis: Identifying levers for change towards the reconciliation of energy savings, thermal comfort optimization and heritage values

The joint decision of the Thai-German team to focus R&D-activities on addressing the problem of uncomfortable and unhealthy traditional wooden residential buildings in Chiang Mai guided a deeper cause analysis conducted in 2020. The analysis resulted in the identification of four main causes that can be remediated within the resource and time-constraints of the FONA-program (Fig. 2).

Cause 1: Changing social demands on thermal comfort: As Thailand's economy is on the rise, individual demands for thermal comfort are increasing. Respondents of the survey in the pilot districts indicate that the inadequacy of thermal comfort partly results in the inability of wooden buildings to meet the expectations of *modern living.* In qualitative interviews conducted in 2019, interviewees related the term *modern* to changes in the functional use of residential buildings compared to the past, an increasing individualization in the Thai society resulting in individually differentiated and overall increasing (thermal) comfort expectations, as well as increasing awareness for the impact of indoor climate conditions on the physical wellbeing of residents.

Cause 2: Misfit of traditional cooling systems and urban climate: Chiang Mai's architecture has to accommodate three seasons: The rainy season from May to October (average temperatures of 28°C and 80% humidity), the dry season from November to February (average temperatures of 23°C) and the hot season from February to April/May (daytime temperatures above 40°C). The most effective adaption of traditional houses to the hot and humid climate in Chiang Mai was the use of raised floors and a loose-fit alignment of wooden beams for floors and walls to allow wind to pass through the building (Shimizu, 2018). However, in Thailand today it is a challenge to rely on natural ventilation as a passive cooling system in urban areas (Tantasavasdi et al, 2011), as the constantly changing environment has significant effects on the wind pattern, air pollution and disturbing noise, on top of the noticeable increase in overall temperatures due to the onset of climate change. Remote sensing images reveal that rapid urbanization causes urban heat islands in Chiang Mai (Srivanit and Hokao, 2012).

Cause 3: Investment-decisions favoring active cooling: Qualitative interviews conducted in 2019 with residents in the pilot districts of Wat Lam Chang and Wat Ket indicate that AC is considered the most effective means for cooling indoor space. A residential building without a central cooling system needs several AC systems to be able to cool the entire living area. As the economic burden to install a cooling system lies on the individual household, it is causing heat inequities between richer and poorer segments of society. This effect is further enhanced, as the exhaust air from AC contributes to the urban heat island effect and therefore reduces the thermal comfort for the poorer citizens further. The adoption of AC is occurring at a rapid pace, fostered by the spread of modern building practices in Chiang Mai and faith in modern technical solutions, in particular energy intensive air-condition, to achieve indoor comfort. Extra measures for improving the building envelope such as internal wall insulation, air tightening and other technical improvements or traditional passive systems that would save both energy and financial resources in the long run are rarely considered.

Cause 4: Lack of collective efficiency of urban development initiatives: Collaborative efforts of private sector, governmental, civil society and academic actors are at the center of promoting attractive and sustainable urban development. Over the course of the last two years, the CHARMS team identified numerous initiatives, such as SPARC, "Living City Learning Space" or the establishment of the social enterprise "Chiang Mai City Development, Co., Ltd". There is much talk of Chiang Mai becoming a UNESCO-City or a Creative City and the Thai Digital Economy Promotion Agency promotes the transformation to "Chiang Mai Smart City". In Chiang Mai, the collective efficiency of these initiatives, however, remains limited. As stated by one interviewee: "we are left wondering why basic problems such as the annual air pollution and transportation issues aren't being tackled, let alone solved". From a sociological perspective, this problem stems from the fact that progress towards smarter and more sustainable cities cannot only be about resource- and energy-efficient built environments and technical infrastructure. It stems from overcoming the lack of willingness and ability to cooperate in transdisciplinary, applied R&D-projects as transdisciplinary research questions and methodologies are often not eligible for acknowledged science funds, the rareness of transdisciplinary chairs and professorships in Southeast Asia, and the fact that a transdisciplinary record of accomplishment of local academics is usually not sufficient when applying for disciplinary full professorships.

3. STATE-OF-THE-ART IN SCIENCE AND TECHNOLOGY

Neither is the task of relieving urban structures from climatic pressure completely new, nor the strive for heritage preservation and vital heritage towns (Horayangkura 2017). However, the combination of relieving vernacular houses within an urban planning context of climatic pressure while limiting the use of primary energy AND maintaining the heritage value in the hot and humid climate of South Asian historic cities like Chiang Mai is new territory.

Sociological analysis of societal demands on thermal comfort: The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 55 describes thermal comfort as "the condition of mind which expresses satisfaction with the thermal environment" (Kolokotsa et al., 2012). From this perspective, thermal comfort is the satisfactory, stress-free thermal environment in buildings and, therefore, is a socially determined notion defined by norms and expectations (Nicol and Roaf, 2017). An acceptable level of thermal comfort meets a critical level of social demands, understood as the collective expectations on thermal comfort held by residents of heritage buildings. Empirical research indicates that there is large variation of social demands on indoor thermal comfort depending on different climates, times of year and culture (Nicol et al., 1999). In addition to the diversification of socially acceptable levels of comfort, increasing levels of income per capita come with higher expectations on thermal services. To anticipate the diverse and local nature of thermal comfort, social structure analysis can create a baseline model for the socially acceptable design as a space for thermal comfort improvements. The Sinus-Milieus are a prominent example for a milieu-based (see Bourdieu 1979) approach that identifies groups of like-minded people based on values and beliefs (SINUS 2020). However, SINUS is not problem-specific and methodologically non-transparent. Non-commercial approaches such as Otte's lifestyle typology (2004) offer more promising points of departure for developing a problem-centered social structuration analysis of urban and rural residents values and beliefs towards energy-efficient thermal comfort improvements of their historical buildings.

Adaptation of historic buildings and neighbourhoods: The arrangement and architecture of residential buildings have evolved over generations and have been adapted to the social and climatic conditions of the respective location (Punpairoj 2013). The most effective adaption of houses to the hot and humid climate in Chiang Mai was the use of raised floors and a loose-fit alignment of wooden beams for floors and walls to allow wind to pass through the house (Shimizu, 2018). Structural changes to historic buildings, such as a walled storage room under the raised first floor and a rain-tight roof, inhibit the air flow and thus the natural cooling effect of traditional houses nowadays. The perception of temperature depends strongly on the distribution of direct (solar) and indirect (surface) radiation as well as existing air movements. All these factors can be positively influenced by urban design measures (materials, greening, pathways, square design, water surfaces) and be combined with measures for climate protection (Lütke Daldrup 2011; Ahlhelm et al. 2016).

Passive Energy Saving Measures: Today, relying only on natural ventilation as a traditional passive cooling system in Thailand (Tantasavasdi et al, 2011) in urban areas is challenging, because the surroundings have a significant impact on the wind pattern and air pollution rendering this energy-efficient solution to cooling needs insufficient. The main advantage of passive measures is their continuous functionality without or only very little energy input. In traditional wooden buildings already equipped with modern energy-intensive AC, such measures could lead to considerable, even major energy savings and CO_2 reduction. In this context there are several different possible retrofit solutions that can be combined with each other. In hot and humid climates internal wall insulation is actual preferable to external insulation in order to keep the cool air inside. This offers the following advantages: It is easier and cheaper to install and would not change the (external) heritage look. It would offer inhabitants the possibility to create a "modern", individual living space inside a traditional wooden building. Moreover, it could be shown that the daily rainfalls during the rainy season could also be used for the reduction of the cooling load. Just by the application of a water buffering layer on the roof and the subsequent latent heat effect during the drying out of such a layer after rain events, the yearly energy demand of an example building could be reduced by approximately 35 %.

Strengthening collective efficiency of urban development projects: The willingness and ability to cooperate in transdisciplinary, applied R&D-projects is essential for the collective efficiency of these efforts. Kahneman and Tversky (1992) have shown that individuals are keener on avoiding losses than on achieving gains, *all else being equal*. This leads to the hypothesis that defending the common resource "Heritage city" is more effective for cooperation than promoting the transformation into a "Smart City". Results of the survey in the pilot districts indicate that about 80% of respondents are willing to engage in heritage preservation activities. Despite the potentially high engagement, the collective effectiveness of these efforts ultimately depends on horizontal (between initiatives) and vertical (between citizens and municipality) communication.

Horizontal communication: Upgrading transdisciplinary research capacities: While transdisciplinarity offers a way to tackle complex social-ecological challenges in Chiang Mai, transdisciplinary research has proven to be a challenging task in itself. The integration of research methods across academic disciplines, the collaboration between researchers and practitioners, and the need to balance societal and disciplinary academic impacts pose many difficulties even to experienced applied scientists (Jaeger-Erben et al., 2018). For the heritage sector, the UNESCO Bangkok concludes that there is a lack in transdisciplinary research capabilities. Capacity development for transdisciplinary cooperation should focus on early-career researchers and provide appropriate training, coaching, and mentoring, as well as arenas for interaction or institutional platforms that enable mutual social learning. In addition, projects can experiment with changes of arrangements and frameworks for transdisciplinary research at local universities.

Vertical communication: Community involvement in municipal communication infrastructure: Smart City planning can strengthen vertical communication by involving citizens in democratic decision-making, co-creating Smart city projects, and by proactively using the city's ICT infrastructure (Simonofski et al. 2019). Honoring the importance of citizens' participation, various technologies have been deployed in cities like Barcelona to enable communities to submit information regarding their needs, complaints, and interests, which in turn can be tied down to specific requests and actions. Furthermore, scientific reports describe the various aspects on how to strategically engage with the wider community of relevance in order to achieve the sustainable and collaborative concept identification and development of Smart City districts. Concepts such as urban design thinking put the citizen with her/his needs and requirements in the center of the developments and lay the ground for the development of enabling digital technologies.

Weighting conflicting goals in collective decision-making processes. To maintain the heritage value of buildings not all available energy-efficient technologies can be applied. Numerous research projects have already worked on gentle refurbishment and technology integration strategies for heritage buildings e.g. (Binder et al. 2014), (City of Quedlinburg 2014), (Entrop 2013). In Germany and in Europe the work of WTA (Wissenschaftlich-Technische Arbeitsgemeinschaft für Bauwerkserhaltung und Denkmalpflege e.V.) in the area of building conservation was groundbreaking to define standards and guidelines for best practice („Merkblätter") in balancing out the conflicting goals of heritage protection, energy-efficiency and comfort. Moreover, the technical committee CEN TC 346 Conservation of Cultural Property of the European standardization body CEN has developed the "Guidelines for improving the energy performance of historic buildings" that could be a blueprint for possible standards in Thailand. Table 1 provides an overview of the main activities carried out during the definition phase of CHARMS in 2019 and 2020 and the respective results as basis for the R&D phase of the proposed project.

Table 1: Main work conducted during the definition phase of CHARMS according to the main foci

Focus	Methods	Results
Energy planning and system integration	➔ Literature review of R&D projects ➔ Numerical description of a typology building ➔ GIS Mapping	➔ On-site analysis of the urban space ➔ Building typology analysis for first climate modeling ➔ Analysis of the deficiencies of the indoor climate ➔ District models

Sustainable heritage management	→ Mixed-method online study	→ Comparative study on different heritage management approaches of major Thai and German organization (15 respondents) → Summary of boundary conditions for sustainable heritage management
User behavior and innovation acceptance	→ Quantitative online-study (convenience sample for pilot data)	→ Pilot study on acceptance and social structures (119 respondents) → Community and expert feedback system
Bottom-up innovation and business models	→ Development of innovation catalogue → Case study development	→ Innovation catalogue summarizing 20 cases of bottom-up driven urban development projects from Thailand → Case studies on smart-city strategies of Phuket, Khon Kaen and Chiang Mai → Summary of boundary conditions for smart-city development in Thailand
Capacity development	→ Understanding capacity development needs	→ UNESCO included as a partner for CHARMS → First capacity development concept available → First workshop planned for end of July 2020
Long term cooperation structures	→ Establishing cooperation structures	→ Local project office established → Support structures established → Cooperation strategy with CMU SPP

4. GOALS AND OBJECTIVES

Main goal, mission and pilot districts of CHARMS

The main goal of CHARMS is to relieve vernacular houses of climatic pressure while limiting the use of primary energy and maintaining the heritage value in the hot and humid climate of Southeast Asian secondary cities

To meet this goal, the following 4 mission statements, jointly developed during the definition phase of CHARMS provide the strategic reference points for the design of activities and solutions. (1) Integration: We combine technical and social innovations for the development of an integrated urban development strategy for thermal improvements of historic buildings (2) Participation: We ensure social acceptance of the developed solutions by integrating the users into the R&D-process; (3) Holism: We compare urban and rural context and ensure transferability of R&D results all over Southeast Asia, (4) Impact orientation: We monitor environmental and social impacts and ensure the economically sustainable implementation of R&D results.

During the definition phase of CHARMS the project team identified the districts of Wat Lam Chang and Wat Ket as the most suitable locations for the R&D phase. Both districts have a significant proportion of traditional wooden buildings (Fig. 4) and a very active civil society. The latter is reflected in high level of engagement in heritage preservation activities (according to results of the pilot survey). However, the districts differ in their social structures, their urban thermal environment and potentially in their preservation status (due to the application for World Heritage status of the inner city, where Wat Lam Chang is located).

Objectives: Understand, jointly develop and integrate, capacitate, and change

Objective 1 is to establish a GIS-based baseline model against which any hypothetical impact of a set of recommended solutions to thermal comfort improvements can be evaluated. The baseline model consists of an integrated urban climate and micro-climate baseline model of urban space, a building climate baseline model of privately owned buildings with heritage value, and a social baseline model of the socially acceptable design space for energy-and resource efficient thermal comfort improvements of heritage buildings. **Objective 2** is to develop locally adaptable solutions for thermal comfort improvements in the form of short, experimental, solution-oriented R&D-sprints ("Innovation Challenges"). Each innovation challenge approaches the solution development process from a different perspective: (1) Material-based solutions for retrofitting historic buildings (2) indoor environment conditions of historic buildings, (3) outdoor environment conditions of historic buildings, (4) municipal communication infrastructures for community engagement, and (5) decision-making processes with a focus on weighting conflicting goals (heritage protection vs. thermal comfort vs. energy-efficiency). The two latter innovation challenges 4 and 5 are of a crosscutting nature and address thermal comfort improvements indirectly. The results of the innovation challenges are the main inputs for the development of an integrated urban development strategy. **Objective 3** is to capacitate academics from heritage preservation, business management and public policy with managerial capabilities needed to design and implement integrated, economically sustainable solutions for the preservation of traditional wooden buildings. First, a catalogue is developed describing social innovations for thermal comfort improvements of residential buildings and neighborhoods with heritage value from comparable social and thermal contexts in Southeast Asia. Second, the workshop concept "Sustainable value creation and heritage management" (developed in the definition phase) is implemented through an economically sustainable blended learning concept in universities in other Southeast Asian countries, namely Laos, Cambodia and the Philippines. Finally, the establishment of a web-based e-learning platform hosting a "digital heritage management institute" is prepared. **Objective 4** is to develop an integrated urban development strategy for thermal comfort improvements, the heart of CHARMS. The GIS-based, socio-climatic baseline-model is the basis for the development and comparison of different solutions. The project team pitches the integration strategy to the community and strategic advisory board to receive feedback on its local fit and economic sustainability. Based on the feedback, the integrated urban development strategy is further adapted. **Objective 5** is to ensure the strategic economic and political utilization of the R&D-results. Systematic economic utilization planning ensures the economically sustainable implementation of the R&D results. In addition, the learnings of the project are utilized to develop (1) policy guidelines for heritage conservations; (2) technical guidelines on improvement of indoor living condition of heritage buildings and (3) guidelines for urban plans that relieve urban heat islands around historic urban spaces. **Objective 6** is to ensure good project governance structure that steers the implementation of and decision-making in CHARMS.

Indicators for measuring project success

CHARMS developed a set of quantifiable criteria to measure project success. Seven quantitative and 1 qualitative indicator form the basis for measuring progress in terms of project implementation as well as for measuring the potential environmental and social impact of the developed R&D-solutions.

Table 2: Summary of indicators for measuring project success

Indicator	Related project outputs
1: Methodological tools *No. of new or improved methodological tools developed to address energy- and resource efficient retrofitting of residential buildings*	➔ One urban climate and microclimate model ➔ One numerical building climate model ➔ One social structure model on the attitudes towards energy-efficient thermal comfort improvements of heritage buildings
2: Institutionalized structures and processes *No. of new or improved German-Asian research networks and international research collaborations*	➔ Integration of at least 3 Thai and Fraunhofer researchers in the international Climate-Heritage-Network ➔ At least one permanent position of Fraunhofer-researchers at Chiang Mai University ➔ At least two new Asian members for the Morgenstadt-Network
3: Policy frameworks *No. of new or improved policy frameworks developed to address energy- and resource efficient retrofitting of residential buildings*	➔ At least one new policy guideline for heritage conservation ➔ At least one new technical guideline on improving indoor living condition of heritage buildings ➔ At least one guideline for urban plans that relieve urban heat islands around historic urban spaces ➔ Adaptation of at least one standard (WTA, CEN) to the Thai context
4: Publications *No. of scientific publications of high relevance*	➔ At least 5 publications with ISBN-number published ➔ At least 5 presentations at scientific conferences
5: Number of supported young researchers *No. of trained young scientists*	➔ At least 5 master-theses finalized ➔ At least 7 Ph.D. financially supported ➔ At least 2 Ph.Ds. finalized ➔ At least 2 research-stays of Thai researchers in Germany/year ➔ Cooperation agreement between the DAAD and SPP signed
6: Prototypes and solutions *No. of prototypes, demonstrators and feasibility studies developed during the project*	➔ At least 5 concepts for energy-efficient thermal comfort improvements developed ➔ One integrated urban development strategy for improving the thermal comfort of historic buildings
7. Private sector *No. of companies addressed by CHARMS and other private-sector relevant activities*	➔ At least 100 companies informed about project results ➔ One innovation strategy for urban development strategy ➔ At least 5 companies participating in the innovation strategy
8: Changes in attitudes of decision-makers *Narratives of urban decision-makers on energy-efficient thermal comfort improvements*	➔ Dominant narratives of 20 decision-makers on energy-efficient thermal comfort improvements of heritage buildings are more positively connoted

5. POLICY RELEVANCE

Research for sustainable development on a sociological, economic and ecological level is a key task for future-oriented policy. By developing energy-efficient and culturally sensitive solutions to increase indoor comfort in historic districts and buildings in Chiang Mai, CHARMS contributes to the creation of a knowledge base for the development of political options for the preservation of the livelihood for present and future generations and provides impulses for sustainable development in secondary Asian cities. The project also helps to make better use of the opportunities that environmental technologies offer the German economy and to deepen cooperation between science and industry. In line with the integrated focus of "FONA 3", CHARMS does not only consider the challenge of energy-efficient preservation of historic districts and buildings through private use, but is systematically linked to a focus on implementation through technical and social innovations. In this way, CHARMS contributes to the implementation of the green economy, *future city*, German *Energiewende* and links ecology with economy and social aspects. CHARMS operationalizes the national sustainability strategy (new edition 2016) and the high-tech strategy of the German federal government. The project contributes to the implementation of the "Goals for Sustainable Development of the United Nations (SDGs)", especially Goal 7 (Energy for all), Goal 11 (Sustainable cities) and goal 17 (Global partnership for sustainable development). Finally, the development of locally adapted solutions for energy and resource-efficient urban development promotes the German internationalization strategy and the "New Urban Agenda".

6. WORK PACKAGES

CHARMS interprets the 4-year R&D-phase as consisting of 2 main phases, each with its own R&D-purpose:

- **Phase 1:** Socio-climatic baseline model and experimentation with innovative solutions for energy-efficient, heritage-sensitive thermal comfort improvements.
- **Phase 2:** Development of an integrated urban development strategy for energy-efficient, heritage-sensitive thermal comfort improvements based on the results of phase 1 and the consolidation of all R&D-results through the development of policy guidelines and an innovation strategy.

WORK PACKAGE 1: SOCIO-CLIMATIC BASELINE MODEL

Nr.	Title	PMs	Timing	Scope
1.1	Urban climate and micro-climate model	9	1-15	Chiang Mai City
Lead: Fraunhofer IEE; **Partner**: INKEK - Institut für Klima- und Energiekonzepte GmbH (Subcontract)				
Historic buildings are important characterizing objects within the ensemble context in which they are located. To maintain their urban value and meaning, it is important to include surrounding buildings (of other ages) in the urban development approach and ensure that the ensemble is working as a unit of old and new. The main goal is to establish a baseline model of such an urban space against which any hypothetical impact of a set of recommended solutions is to be evaluated. The urban climate map (UCM) is the starting point to identify historical urban spaces (ensembles/neighborhoods) in urban heat islands within the communities of Wat Ket and Wat Lam Chang that subsequently will be translated into a numerical micro-climate model. This model of the specified urban space will be the center of the integrated solution concept that is to be developed. From this model, the major controllable factors that are adversely affecting the micro-climate of the neighborhood and, more specifically, on historic buildings will be identified and analyzed.				
Main steps				**Timing**
Step 1: Calculation of an urban climate map (UCM)				1 - 6
Step 2: Analysis of UCM, and identification of urban heat islands (UHI) coinciding with historical urban districts of Thai identity giving nature.				4 - 6
Step 3: Transfer and simulation of the microclimate around the historical urban area specified in Step 2.				5 - 14
Step 4: Identification of the major controllable factors adversely affecting the micro-climate of the neighborhood and specific historical buildings				14 – 15
Main outputs				
(1) Urban climate model, GIS, month 6, (2) Micro-climate model, (GIS), month 14; (3) Report on climate modeling, PDF, month 15; (4) Analysis of the microclimate and most prominent factors controlling the climate, PDF, month 15				

Nr.	Title	PMs	Timing	Scope
1.2	Numerical building climate model	9	1-15	Pilot Districts
Lead: Fraunhofer IEE; **Partner**: -				
To ensure long-term usability under changed urban climatic conditions and user requirements, the historic buildings have to be developed and technically improved. The work package is focused on the creation of a baseline building model for privately owned buildings with high heritage value to identify the most critical features of the indoor space. Critical features are those that adversely affect the indoor climate of the building that are a threat to the building fabric or are at risk to become a threat under refurbishing attempts. The priority is to maintain, preserve and restore the principles of vernacular architecture, heritage value and the existing building substance and character as much as circumstances allow. The conditions that are to be improved are foremost the indoor accumulation of pollutants and heat via natural ventilation and				

free/sustainable cooling. To improve the climatic conditions of the indoor space and to identify most feasible improvement solutions thermodynamic and air-flow baseline models of typical buildings are developed.	
Main steps	
Step 1: Analysis of typical heritage buildings representing the setting in the ensembles / neighborhoods. Characteristics of vernacular architecture for base-case modelling and typical alterations at the current time.	1 - 6
Step 2: Analysis of typical technological facilities within historic buildings at the current time, deficits of the technical equipment and risk or actual structural damage to historic building structures.	1 - 6
Step 3: Definition of evaluation criteria regarding indoor temperatures, air-quality, and ventilation with regard to modern usability and requirements as well as impact on global indicators as final-energy demand and CO2-emissions.	6 - 9
Step 4: Modelling of the indoor climate of typology buildings (status quo / base-case) as dynamic thermal simulation, heat and moisture transfer simulation, and analysis of air-flows.	4 – 15
Main outputs	
(1) Building typology domestic heritage buildings, XLS, month 15; (2) Evaluation matrix for measure evaluation, XLS, month 15; (3) Base case models for selected typologies, Trnsys, Trnflow (Wufi), month 15	

Nr.	Title	PMs	Timing	Scope
1.3	Social structure model	20	1 – 24	Thailand

Lead: Fraunhofer IMW; **Partner**: CMU SPP	
Actors are guided in their actions by cultural values and social norms. The term "social milieu" thus refers to groups of individuals with similar life goals and lifestyles and includes the mentality and attitude of the persons. The acceptability of proposed heritage management solutions differs between social milieus. Against the backdrop of these assumptions, the main goal of Task 1.3 is to develop a typology of groups of people in Thailand that display similarities in the way they act and think with regards to energy and resource efficient heritage preservation. A social structure analysis is conducted to (1) understand peoples' attitudes and orientations, values, lifestyles and life goals towards energy and resource efficient heritage preservation, (2) identify clusters of likeminded people (3) develop a thorough sense of preferences of each cluster, (3) compare clusters, (4) enable tailored communications and stakeholder-participation approaches on heritage management and urban development to a specific target cluster, and (5) to ensure acceptance of proposed solutions by specific target clusters	
Main steps	**Timing**
Step 1: Refinement of the conceptual approach developed during the definition phase	1 - 6
Step 2: Small scale application to validate the refined approach	6-12
Step 3: Adaptation and large-scale application of approach	12-21
Step 4: Analysis and publication of results	21-24
Main outputs	
(1) Validated, empirical social structuration approach, methodological tool, month 12; (2) Map of social structure based on attitudes on energy- and resource efficient retrofitting of traditional buildings, Journal paper, month 24; (3) Recommendations for milieu-sensitive heritage management, PPT, month 24	

WORK PACKAGE 2: INNOVATION CHALLENGES

Nr.	Title	PMs	Timing	Scope
2.1	Material-based retrofitting solutions	5.5	7-24	Chiang Mai

Lead: Fraunhofer IBP; **Partner**: CMU SPP	
The aim of this challenge to find solutions based on innovative materials, technology and constructions for wooden heritage building conservation. Possible solutions will be discussed and co-developed with local experts and stakeholders. Several ideas for hot and humid climate available from Fraunhofer IBP that have been already developed to a certain stage but have not yet been introduced into practice, should be discussed in terms of applicability, feasibility, sustainability, user acceptance and compatibility with heritage science and local regulations in Chiang Mai and Thailand. These ideas will include among others: (1) Internal insulation of walls for better indoor comfort and energy saving, (2) Use of moisture buffering materials, (3) Use of moisture storing materials for roofing and passive cooling, (4) Use of natural or renewable materials; (5) "House in House" solutions for retrofit	
Main steps	**Timing**
Step 1: Analysis and pre-selection of existing concepts and solutions	7-10
Step 2: Analysis of local implementation context within a workshop co-creation framework	10-12
Step 3: Selection of possible, adaptable retrofit solutions	12-15
Step 4: Pitch of the compiled retrofit concepts in front of the CHARMS boards	16-20
Step 5: Adjustment of the compiled retrofit concepts according to feedback of local stakeholders	20-24
Main outputs	
(1) state of the art on existing concepts and solutions, PDF, month 10; (2) Identification of possible material-based solutions for local energy retrofit in Chiang Mai and Thailand, Summary of Workshop, month 12; (3) Catalogue of possible adaptable retrofit solutions, Concept paper / PPT, month 18; (4) Feedback from local stakeholders and partners on conceptual ideas for retrofit, Summary of workshop, month 20; (5) Adjusted, integrated concept for energy retrofit of traditional buildings in Chiang Mai; PDF, month 24	

Nr.	Title	PMs	Timing	Scope
2.2	Solutions for indoor climate improvements	5.5	10-24	Chiang Mai

Lead: Fraunhofer IEE; **Partner**: CMU SPP	
The main goal of this task is to develop an integrated set of solutions to improve the indoor environment conditions of historic buildings identified in WP 1.2 to create improved indoor comfort conditions with regard to temperatures and air quality under preservation of the heritage value. To obtain locally developed sets of solutions, IEE cooperates with a local design team from Thai universities with strong architectural planning focus that are interested in heritage development under climate protection targets. It is also possible to involve local professionals (architects and urban planners) to take part / team up with student groups. Cooperation with local implementers (trade, industry, investors) is expressly desired in order to achieve the greatest possible practical relevance of the results. Identified parameters that have most potential to building on the results from Task 1.2, suggested solutions can be targeted to maximize feasibility and improvement for the historic building(s). The anticipated effects on the evaluation parameters of the most promising concept are described, modelled, and reviewed for their feasibility for the local community. Possible solutions could include: (1) overpressure ventilation (2) full climate control of single rooms (periodically), (3) support of natural ventilation through climate-controlled ventilation system, (4) high temperature surface cooling for single rooms, (5) shading of building facades by roof overhangs, porches (integrating technical objects e.g. pv , fans) to decrease heat load on buildings and harvest renewable energy, (6) changing of roofing material to decrease temperatures and increase natural ventilation, dismantling of components that hinder ventilation indoors and outdoors, integration of 'smart' natural / semi-natural ventilation (climate responsive window / façade openings)	
Main steps	**Timing**
Step 1: Summary of detailed solution alternatives to improve indoor conditions	10-12

Step 2: Thai-German teams working on detailed solutions	12-18
Step 3: Pitch of solutions in front of the CHARMS boards	18-20
Step 4: Adjustment of the compiled solutions according to feedback of local stakeholders	21-24
Main outputs	
(1) Challenge description and evaluation parameter definition, PDF, month 12; (2) Locally developed design plan(s) and technical description(s) from co-working phase, CAD + PDF, month 18; (3) Feedback results PDF, month 20; (4) Preparation and transfer of design plan, data, month 24	

Nr.	Title	PMs	Timing	Scope
2.3	Solutions to improve the urban micro-climate	5.5	10-24	Chiang Mai
Lead: Fraunhofer IEE; **Partner**: CMU SPP				

The primary goal of this task is to develop and promote an integrated set of solutions for the outdoor urban environment that both relieve the urban hot spot and the historic houses within of climatic stress due to accumulation of heat and air pollution. The evaluation parameters could include quantitative properties such as maximum temperatures and critical spots, air pollution, solar radiation, concentration of fine dust at certain measurement points, renewable energy production etc.; and a qualitative evaluation of the quality of stay and overall usability of the urban space. To obtain locally developed sets of solutions to the urban space to improve its condition, IEE cooperates with a local design team from Thai universities with strong urban planning / architectural planning focus that are interested in heritage development under climate protection targets. It is also possible to involve local professionals (architects and urban planners) to take part / team up with student groups. Cooperation with local implementers (trade, industry, investors) is expressly desired in order to achieve the greatest possible practical relevance of the results. Building on the results from task 1.1, suggested solutions can be targeted to maximize impact on the urban space and the historic building(s) within. The anticipated effects on the evaluation parameters of the most promising concept are described, potentially modelled, and reviewed for their feasibility for the local community Possible solutions in the urban space could include: (1) shading of building facades by trees (or technical objects e.g. 'pv-trees' or pergolas) to decrease heat load on the buildings, (2) unsealing of concrete and asphalt surfaces to reduce heat loads and fine dust in the building surroundings, (3) integrating water surfaces and fountains, (4) deconstruction of fences / walls / (unused) buildings to allow free-flow of air through the urban spaces and improve cooling by natural ventilation for historic buildings, (5) redirection of traffic-flows from sensitive heritage places and management of traffic and parking.

Main steps	**Timing**
Step 1: Summary of detailed solution alternatives to improve urban micro-climate	10-12
Step 2: Thai-German teams working on detailed solutions	12-18
Step 3: Pitch of solutions in front of the CHARMS boards	18-20
Step 4: Adjustment of the compiled solutions according to feedback of local stakeholders	21-24
Main outputs	
(1) Challenge description and evaluation parameter definition, PDF, month 12; (2) Locally developed design plan(s) and technical description(s) from co-working phase, GIS, PDF, month 18; (3) Feedback results, PDF, month 24	

Nr.	Title	PMs	Timing	Scope
2.4	IT-based solutions for citizen engagement	4.5	7-24	Chiang Mai
Lead: Fraunhofer FOKUS; **Partner**: CMU SPP, Digital Economy Promotion Agency (DEPA)				

As pointed out in the problem analysis, one of the main challenges in the context of long-term improvement of thermal comfort in Chiang Mai is related to communication/interaction between residents and the municipality. Thus, the objective of this innovation challenge is to define a communication infrastructure that enables the local municipalities to engage with citizens and other relevant stakeholders in a transparent and participatory way. This means that citizens will be enabled to participate during the initial exploration, problem definition, execution and evaluation of projects. For example, the citizens could help to define the actual problem, to provide ideas for solutions, or they could support the evaluation of proposed solutions. In general, core functionalities related to citizen engagement encompass among others: 1) provisioning of relevant information about ongoing and upcoming activities/projects, 2) consultation on planned projects and policies (including provisioning of feedback), 3) submission of new (project) ideas, 4) voting for ideas, 5) possibility to comment on ideas, 6) conduct of surveys, 7) a management dashboard, and 8) data analytics. User experience (UX) is another facet that will be considered in addition to the core functionalities. In the context of citizen engagement, it is of paramount importance to create a solution that is simple and intuitive to use yet powerful enough to offer the needed functionalities. Lastly, it is also planned that the concept will be based on open standards and interfaces thereby addressing the problem of vendor lock-in and ensuring that the envisioned solution will be replicable to other municipalities and cities.

Main steps	**Timing**
Step 1: Definition of a first concept of a municipal communication infrastructure	7-10
Step 2: Analysis of the implementation context in Thailand	10-12
Step 3: Refinement of the concept	12-15
Step 4: Pitch of the concept in front of the CHARMS boards	16-20
Step 5: Adjustment of the concept according to feedback of local stakeholders	21-24

Main outputs
(1) Draft of a first concept for a municipal communication infrastructure, PDF, month 10; (2) Summary of analysis of implementation context, PDF, month 12; (3) Refined Concept (based on Output 2), PDF, month 15; (4) Pitch presentation for refined Concept, PPT, month 20, (5) Final version of concept for the municipal communication infrastructure, PDF, month 24

Nr.	**Title**	**PMs**	**Timing**	**Scope**
2.5	Standardized urban decision making	5.5	7-24	Chiang Mai
Lead: Fraunhofer IBP; **Partner**: CMU SPP				
In energy retrofit of traditional houses a conflict of development goals can be observed worldwide. On the one hand, ambitious greenhouse saving targets are necessary to reach the Paris goals and being implemented in many countries (European New Green Deal). Here the building stock plays a decisive role. On the other hand, traditional buildings are a key factor to local and regional identity and important for the well-being of people. Of course, we can also learn a lot from them about history or traditional (low tech) ways of living. Against this background, the main goal of Task 2.5 is to adjust existing German and European best practice guidelines and standards such as “WTA Merkblätter” and CEN TC 346 to the ASEAN context.				

Main steps	**Timing**
Step 1: Identify relevant standards from Germany / Europe / countries in the tropics	7-10
Step 2: Analysis of local implementation context within a workshop co-creation framework	10-12
Step 3: Integration of relevant sources for possible approaches	12-15
Step 4: Pitch of the compiled approaches to weighing the conflicting goals in front of the boards	16-20
Step 5: Adjustment of the compiled approaches according to feedback of local stakeholders	20-24

Main objectives
(1) Report on standards for energy retrofit of traditional houses in hot and humid climate, PDF, month 10 (2) Identification of possible approaches to weigh conflicting goals in the local energy retrofit of traditional houses in Thailand, summary of workshop, month 12; (3) Catalogue of existing standards and ideas for their adjustment for use with the local stakeholders and partners in Chiang Mai, Concept paper / PPT, month 15; (4) Adjusted concept, PDF, month 24

WORK PACKAGE 3: CAPACITY DEVELOPMENT

Nr.	Title	PMs	Timing	Scope
3	Capacity development	16	4-42	ASEAN
Lead: Fraunhofer IMW, **Partner**: CMU SPP, UNESCO Bangkok, Universities in the Philippines, Laos and Cambodia, Fraunhofer Academy				
The main goal of WP3 is to capacitate academics from the heritage sector, business managers and public policy actors with managerial capabilities required to promote energy-efficient, heritage-sensitive and economically sustainable thermal comfort improvements. WP3 is of regional scope and addresses academics from universities from different ASEAN-countries. These universities are accessed by the *Cultural Heritage Alliance* managed by the Siam Society under Royal Patronage (see LOI). Though the participating universities are likely from Laos, Cambodia and the Philippines, a final decision on this matter is jointly taken in Q4 2020. The main implementation partner of WP3 is the UNESCO Bangkok. The WP starts with the collection of innovative practices and organizational models addressing thermal comfort. Geographically, this step is focusing on the partner universities' countries. The results are summarized as a "social innovation catalogue on thermal comfort improvements". In step 2, the concept of the pilot workshop "Sustainable value creation and heritage management", implemented in July 2020 in cooperation with the UNESCO and Chiang Mai University is advanced to a comprehensive blended learning concept. Based on a mix of digital and face-to-face workshops, the concept is than piloted with the partner universities and further adjusted based on the participants' feedback. In step 3, the blended-learning concept is complemented with a business model that allows the provision of workshops in Southeast Asia independently from public-funds. Key partner for the business model development is the Fraunhofer Academy (FA). The final step of WP3 is the conceptual preparation of a web-based e-learning platform. The FA supports this step by training technical and academic staff of one of the selected partner-universities (the university with the highest capability and willingness to host the platform) in the conceptual design of web-based e-learning platforms. The practically oriented workshops result in a concept for the establishment of the e-learning platform during the upcoming implementation phase.				

Main steps	Timing
Step 1: Identification of social innovations	4-30
Step 2: Development and application of a blended learning concept and	9-33
Step 3: Digital Management Academy	24-42
Main outputs	
(1) Social innovation catalogue, Working paper, month 18; (2) Blended learning concept, PPT, month 6; (3) Increased capacity (heritage management), Knowledge, month 24; (4) Business model, PPT, month 24; (5) Increased capacity (e-learning platform establishment), Knowledge, month 36	

WORK PACKAGE 4: INTEGRATED URBAN DEVELOPMENT STRATEGY

Nr.	Title	PMs	Timing	Scope
4	Integrated urban development strategy	32	25-39	Chiang Mai
Lead: CMU SPP **Partner**: All Fraunhofer and associated partners				

The goal of WP4 is the development of an integrated urban development for thermal comfort improvements in historic buildings and distrcits based on the results of the solution-development process (WP2), the identified social innovations (WP3), the socio-climatic baseline models (WP1) as well as the feedback structures (Task 6.3). In a first step, the solutions developed in the three technical innovations challenges are transferred into the socio-climatic baseline-model (WP1) to assess their long-term climatic impact and social acceptability. Based on an interdependency model of urban climatic impact on the indoor comfort conditions of heritage buildings, measures in the direct building environment are weighted against technical and structural measures on the building itself. This results in a set of different, technologically feasible and climatically beneficial measures (output 1). These measures are presented to the community board and the expert advisory board. Based on the feedback on the technological fit, social acceptability and economic feasibility, the measures are further adjusted (output 2). The set of adjusted technological measures are related to the identified social practices or organizational models ("social innovation catalogue") for thermal comfort improvements to develop a first, integrated strategy (output 3), which is pitched to the CHARMS boards to receive more feedback and further adjust the strategy. Finally, the results from the two cross-cutting innovation challenges are related to the adjusted, integrated urban development strategy to complement it with changes related to the local and national framework conditions for thermal comfort improvements. The outcome is the final, integrated urban development strategy for thermal comfort improvements that serves as an input for developing a sustainable business model for its successful introduction and diffusion in WP5.

Main steps	**Timing**
Step 1: Assess climatic and social impact of technical measures identified in challenge 1 - 3	25-28
Step 2: Proposal of a set of technologically feasible and climatically beneficial measures	28-30
Step 3: Pitch results of 4.2 to expert advisory and community board	31-33
Step 4: Integrate social innovations and non-technical measures with adjusted results of 4.2	33-36
Step 5: Pitch results of 4.4 to CHARMS boards and develop final integrated urban development strategy	36-39

Main outputs

(1) Inter-operative urban climate and adjacent building model, Code, month 28; (2) Integrated urban development strategy; PDF, month 36; (3) Synthesis report on the results of WP4, PDF, 39

WORK PACKAGE 5: CONSOLIDATION OF RESEARCH RESULTS

Nr.	Title	PMs	Timing	Scope
5.1	Innovation Strategy	14	25-45	Thailand/ASEAN

Lead: Fraunhofer IMW; **Partner**: CMU SPP, Thai and German private sector

The successful transfer of solutions from application-oriented basic research into innovative products and processes requires an integrated research and innovation management. The main goal of task 5.1 is to systematically analyze and evaluate the application potential of the integrated urban development strategy for thermal improvements of historic buildings. The development of an innovation strategy for the developed solutions support the economically sustainable implementation of CHARMS R&D-results in the implementation phase. As a first step, WP5 complements the work in WP4 with a critical reflection on the economic value creation potential of different strategic options. In the second step, the integrated urban development strategy is subject to a more a comprehensive analysis evaluation combining both market needs and technical solutions (technologies, process, know-how etc.). Within the scope of prioritizing application fields and solutions, the view beyond existing competencies is to be broadened in order to uncover the resources and competencies required for transfer along the value chain. This work is supported by environment analysis of relevant influencing factors and framework conditions (e.g. competition, markets, customers and regulations) to support the evaluation process. The set of integrated solutions will be jointly evaluated and ranked in terms of utility and feasibility. Finally, an innovation strategy and an

implementation roadmap will be developed documenting the most important development steps and transfer possibilities of the prioritized solution and its value architecture. The innovation strategy and implementation roadmap supports the development of a sustainable business model, which should enable the introduction and diffusion on the market after the development work.

Main steps	Timing
Step 1: Integrate market-perspective in WP4	25-28
Step 2: Define technical solution competencies and identify relevant fields of applications for the economically sustainable implementation of WP4 results	29-31
Step 3: Analyze relevant influencing factors and framework conditions supporting the transfer and economically sustainable implementation the WP4 results	32-36
Step 4: Evaluate and prioritize economically sustainable solutions of WP4 for the implementation of CHARMS R&D-results	37-40
Step 5: Develop an innovation strategy and implementation roadmap that supports the economically sustainable implementation of CHARMS R&D-results in the implementation phase	40-45

Main outputs
(1) Market-feedback integrated in WP4, PPT, month 28; (2) Application field search matrix, Excel, month 31, (3) Summary of relevant framework conditions, PDF, 36, (4) Innovation strategy, PDF, month 45).

Nr.	Title	PMs	Timing	Scope
5.2	Policy recommendations	15	31-48	Thailand

Lead: CMU SPP; **Partner**: FH IMW, FH IEE
There are currently no policies or regulations related to traditional residential buildings or guidelines available for upgrading traditional wooden buildings to meet modern living conditions. Moreover, the current regulatory process in Thailand is centralized with limited community participation, although the public policy formulation process includes opinions from community level to national government agency. Against this backdrop the main goal of Task 5.2 is to derive recommendations for improving urban planning policies, regulations and guidelines for energy-efficient and resource efficient retrofitting of historic buildings on national level and urban planning practices on local level, based on the results of Work Packages 1-4. CMU SPP is the predestined organization for this task as it is represented in various high-level expert networks on national level. For example, the director is consultant for the Thai Ministry of Commerce and a CMU SPP senior associate is responsible for the administration of public funds for the Thai Research Council in the field of sustainable urban development. Finally, in their urban development projects the SPP works very closely with the local communities. .

Main steps	Timing
Step 1: Re-Analysis of urban practices and relevant policies, regulations and guidelines	31-35
Step 2: Roundtables with political decision makers on local, provincial and national	35-44
Step 3: Derivation of policy recommendations	44-48

Main outputs
(1) Systematic overview of urban practices as well as current policies, regulations and guidelines for energy-efficient and resource efficient retrofitting of historic buildings, PDF, month 35; (2) Main results of the roundtable discussions, Minutes, month 44; (3) Policy Recommendations., PDF + PPT, month 48

WORK PACKAGE 6: PROJECT GOVERNANCE

Nr.	Title	PMs	Timing	Scope

6.1	Project Management	24	1-48	Overall

Lead: FH IMW; **Partner**: CMU SPP, Subcontractor for overall public communication (to be selected)

The main goal of Task 6.1 is to ensure the successful achievement of the project outputs according to the time schedule and budget allocation. An existing web-based communication and collaboration system hosted by Fraunhofer IMW (e.g. MS Teams) will be configured for CHARMS and access will be provided to the partners. In this way, all project data and documents can be easily stored and exchanged internally, and video calls can be easily arranged. Virtual German-Thai project meetings will be conducted at least once a month. Personal meetings are held at least twice a year, alternately in Germany and Thailand. The project will start with a Kick-Off-Meeting in Thailand to ensure that everyone has a common understanding of the project, their roles and the work plan. Fraunhofer IMW as project coordinator will manage (1) the project contract with the project agency (2) all contractual and financial issues with CMU SPP, (3) the preparation of the yearly technical interim reports and (4) the preparation of the final technical report. The financial reports are prepared by the Fraunhofer Headquarters. Project progress shall be monitored through quarterly internal summary progress reports presenting briefly the status of active tasks to allow easy follow-up with regard to scheduled implementation and/or deviations. In accordance with the regulations for safeguarding the good scientific practice of the Fraunhofer-Gesellschaft, all project data will be stored for at least 10 years. A data management plan will address the relevant aspects according to the FAIR principle. Several dissemination activities are complementing this task, in particular: (1) setup and maintenance of a project website, (2) project leaflets in Thai, German and English; (3) regular electronic newsletter (every 6 months). For these communication issues a subcontractor will be responsible for. In addition the project team will present project results at conferences and in scientific publications.

Main steps	Timing
Subtask 1: Project reporting	1-48
Subtask 2: Project meetings	1-48
Subtask 3: Legal and financial management	1-48
Subtask 4: Data management	1-48
Subtask 5: Project communication and dissemination	1-48

Main outputs

(1) Communication and Collaboration Platform ready for use, virtual rooms, month 1, (2) Contract with SPP signed, pdf, month 1, (3) Data management plan, excel sheet, month 3 (draft), month 48 (final version), (4) Dissemination plan, excel, month 3 (draft), month 44 (final version), (5) Project website, virtual, month 3; (6), project leaflet, in-design, month 4; (7) progress monitoring, one-pager (template), every three months, (8) interim and final technical reporting, report, once a year; (9) main results of virtual and personal project meetings, minutes, for each meeting; (10) newsletter, electronic; every 6 months, (10) Publications, pdf, ongoing

Nr.	Title	PMs	Timing	Scope
6.2	Impact Monitoring	8	1-48	Overall

Lead: FH IEE; **Partner**: FH IMW, Cognitive Edge (Subcontractor)

The main goal of Task 6.2 is to monitor the impact of the project measures according to the CHARMS indicators (see Table 2). For measuring changes in perceptions of decision-makers, SenseMaker®, a tool provided by Cognitive Edge will be used. Micronarratives on the topic of energy and resource efficient heritage preservation will be collected and respondents will be asked to convey the meaning of their shared stories by responding to a series of pre-defined analytical questions four times during the project. These narratives allow better access to contextualised knowledge and interpretation by enabling respondents to give meaning to their own stories. Finally, an integrated monitoring system will be developed to collect quantitative measurement data from the integrated concept (WP4). Measurable parameters include e.g. pollutant concentrations in the urban environment of the historic buildings, solar radiation, operative and

surface temperatures as well as air humidity and air flows. Within the building, the corresponding climatic boundary conditions at critical times of the year or weather conditions must be recorded by means of sensors. Global (non-measurable) impact indicators such as CO_2 emissions are derived from the measured data and can serve as reference values for extrapolations.

Main steps	Timing
Step 1: Testing and refinement of overall impact monitoring approach	1-6
Step 2: Data Collection	7-45
Step 3: Continuous analysis of results	9-47
Step 4: Developing and refining impact monitoring strategy for integrated solution measures	36-48
Main outputs	
(1) Final Impact monitoring approach, excel, month 6, (2) Narrative patterns of 20 decision makers of energy and resource efficient heritage preservation, knowledge, months 7, 21, 33, 45), (3) Final impact monitoring concept for integrated solution measures, pdf, month 48	

Nr.	Title	PMs	Timing	Scope
6.3	Expert and community feedback	9.5	1-48	Chiang Mai
Lead: CMU SPP; **Partner**: FH IMW				
The main goal of Task 6.3 is to establish and to make use of regular feedback structures, by (1) the local community and (2) an expert advisory board to reflect on the interim results and to make recommendations for the further direction of CHARMS. The expert advisory board will consist of 12 members from different areas of knowledge (energy efficiency, heritage preservation, urban planning, economics etc.) and from different sectors (research, politics/administration, business, civil society). The main task of this board will be to a) provide critical evaluation of project activities and outputs and b) give strategy advise with refining related future action (for members see Appendix). The community board will consist of the elected members of the community councils in Wat Lam Chang and Wat Ket and will reflect the interim results from the user´s point of view. The community board will meet at least twice a year, the expert advisory board at least once a year. The boards will play a central role in the evaluation process of the innovation challenges (WP2) and the integrated concept (WP4). All five German-Thai innovation teams will present and defend their solutions in a two-stage-competitive process. In the first stage, the expert advisory board act as a jury, who will assess the solutions of the innovation teams based on the following criteria: technical feasibility, economic viability, reduction of emissions and principal fit to the local context. In the second stage, the most promising solutions will be presented in front of the community board, who will finally decide.				

Main steps	Timing
Step 1: Establishment of the expert advisory board and the community board	1-3
Step 2: Regular Meetings of the expert advisory board and the community board	4-46
Step 3: Stage-Gate Selection Process for solutions from WP2 and WP4	16-36
Main outputs	
(1) Recommendations provided by the expert advisory board, Expert Knowledge; every 12 months, (2) Recommendations provided by the community board, User Knowledge; every 6 months	

7. COOPERATION STRUCTURE AND DIVISION OF WORK

The solution-oriented character of CHARMS requires a transdisciplinary approach. According to Jahn (2012) transdisciplinary research processes come in three phases: (1) Joint problem identification and structuring, (2) Generating new knowledge in an integrative manner (3) Economic and social valorization of results.

CHARMS follows this approach as it splits the R&D project in the latter two phases, while it builds on the results of the definition phase, where the focus was on problem identification and structuring. The transdisciplinary approach of CHARMS is also reflected in the composition of the project partners and the cooperation structure. The German-Thai core team consists of the Fraunhofer Center for International Management and Knowledge Economy IMW (coordination), the Fraunhofer Institute for Energy Economics and Energy System Technology IEE and the School of Public Policy SPP at Chiang Mai University (CMU SPP). They are sharing the responsibility of leading the six work packages of CHARMS (Fig. 6). In addition, the Fraunhofer Institute for Building Physics IBP and the Fraunhofer Institute for Open Communication Systems FOKUS will bring in their ideas and solutions for three of the five innovation challenges. Thereby the technical (Fh IEE, IBP, FOKUS) and socio-economic (Fh IMW) knowledge of applied research of Fraunhofer is combined with the expertise of CMU SPP, the first and so far only university institution in Thailand with an explicitly transdisciplinary character. The governance structure that steers the implementation of and decision-making in CHARMS includes not only the project management, but also the impact monitoring, as well as the systematic consultation of experts and the community (see WP6). Major potential conflicts among the project partners with implications on the entire project will be discussed and decided within the steering committee. It consists of the six Work Package Leaders plus their main counterparts within Fraunhofer and CMU SPP respectively. Thereby, an equal representation is ensured when establishing consensus. Details on conflict management will be set out in the cooperation contract.

Apart from the core project team, CHARMS will include a number of other key German and Thai dissemination and implementation partners in the project activities as follows:

Table 3: Implementation and dissemination partners

	Organization	Focus	Level
Implementation Partners	Chiang Mai Municipality and Pilot Districts	New heritage-sensitive urban planning practices, integrated urban development strategy	Local
	Chiang Mai Chamber of Commerce	Innovative solutions for retrofitting traditional wooden buildings	Local
	German-Thai Chamber of Commerce		National
	Morgenstadt		International
	Digital Economy Promotion Agency	Municipal communication infrastructure	Provincial and national
	UNESCO Bangkok – Asia and Pacific Regional Bureau of Education – Cultural Unit	New managerial capabilities for academics from the heritage sector, business management and public policy	ASEAN
	Siam Society		National
Dissemination partners	International Climate Heritage Network	Scientific results, innovative solutions and practical recommendations	International
	BABLE	Promotion of solutions for energy- and resource-efficient retrofit of traditional wooden buildings	International
	SCONTE	New knowledge on preservation of traditional wooden buildings	National
	DAAD Thailand	Scientific results and transdisciplinary research	International
	German Embasssy Singapore	Political recommendations and innovative solutions	ASEAN

The School of Public Policy understands itself as “pracademic” hub. Therefore, the SPP brings together academics and experts from the environment of Chiang Mai University with different backgrounds and expertise. CMU SPP will actively integrate affiliated researchers and their respective CMU faculties in the CHARMS activities, who are essential for the successful implementation of the project (such as Faculty of Architecture, Energy Research and Development Institute, Social Research Institute and Excellence Center for Urban Planning). The CMU SPP also has established its own interdisciplinary international PhD program, which attracts graduate students from all over the world and from the ASEAN region in particular. This contributes to CMU SPP's own understanding of being a problem and technology neutral knowledge integrator on public policy issues critical to sustainability. This makes the SPP a unique core Thai partner for Fraunhofer. In CHARMS, CMU SPP functions as technology neutral integrator of “knowledges” (academic knowledge from various disciplines, expert knowledge, local knowledge, etc.). As knowledge integration is key for achieving the project objectives a dedicated Work Package (WP4), led by CMU SPP takes care of this issue. The second role of SPP focuses on the development of political recommendations for improving heritage and urban planning policies at national level and urban planning practices at local level (Task 5.2).

UTILIZATION PLANNING

Economic prospects of success

To ensure that the developed R&D solutions are implemented in an economically viable manner, market-side requirements are taken into account in project planning and research work in an ongoing manner. For this purpose, the knowledge and technology transfer department of Fraunhofer IMW has developed a set of methods and instruments to support medium-sized companies and research institutions in developing strategic, long-term cooperative networks and in utilizing research results in a sustainable and goal-oriented manner. Fraunhofer IMW will rely on its model of economic utilization planning and will adapt it to the context of the utilization of energy and resource-efficient solutions for heritage buildings (Task 5.1). For this purpose, a broad support network (AHK Bangkok, Chamber of Commerce Chiang Mai, Morgenstadt and BABLE) will integrate relevant actors from the private-sector during the second half of the project. Moreover, R&D activities are implemented in an economically sustainable manner. In addition to the utilization planning for the integrated urban development strategy for thermal comfort improvements in historic buildings (WP4), the activities in WP3 are complemented by developing a business model for providing self-financed capacity building activities in the university context of Southeast Asia. The Fraunhofer Academy, the Fraunhofer Division for External Further Education, will consult the project team on this issue.

The overall economic prospects of success for CHARMS can be rated as high due to the extensive experience of Fraunhofer IMW in the utilization planning of R&D results in international cooperation projects, the flexible access to companies based on the broad support network and the systematic integration of the economic utilization planning into the project in WP5.

Scientific prospects of success

CHARMS contributes to the development of skills as well as scientific and technical development in a wide range of areas. The climate and social structure models (WP1) have not yet been integrated into an overall concept for energy and resource-efficient district development in the form proposed her and have not been evaluated in real use cases in South East Asia. We expect a paradigm shift here, away from the consideration of the climatic or social context in isolation towards socio-climatic analyses. This leads to broad scientific utilization options: Basic concepts and strategies can be presented in high-level scientific conferences and journals; and there are plenty of opportunities for follow-up research projects at national and international level. The structuring of CHARMS into a solution-oriented (month 1-24) and a utilization-oriented (month 25-48) phase can serve as a model for similar, transdisciplinary research projects. The customized solutions for increasing indoor thermal comfort developed as part of the five Innovation Challenges (WP2) will provide important impulses for further R&D in this area. Moreover, the innovation challenges minimize the project risk by diversifying the stakeholder structure as well as the perspectives on one and the same problem (energy-efficient, heritage-sensitive thermal comfort improvements). The project risk is further minimized through the consistent involvement and funding of local young scientists through CHARMS. The focus of the further education measure on blended learning and the establishment of a Digital Heritage Management Academy corresponds to the state-of-the-art of the international further education offer in times of COVID-19 and climate change. The policy guidelines (WP 5) will outline the need for further research on integrated urban development strategies for thermal comfort improvements of historic buildings in Thailand and Southeast Asia and will contribute to the future research agenda in this area. The overall scientific chances of success for CHARMS can be rated as high due to the risk-minimizing project structure, the successful piloting of R&D processes within the definition phase, the integration and funding of local junior researchers, the consistent use of digital R&D and further education concepts as well as the high level of trust among the project partners.

Scientific and economic connectivity

There is a wide range of application potential for the results of the project, both for Fraunhofer and CMU SPP as well as the associated partners. The climate and social structure models (WP1) serve to develop locally suitable solutions. The climate models can be used as a blueprint for assessing the ecological effectiveness of similar initiatives in Chiang Mai. The results of the social structure analysis enable a comparison of urban and rural attitudes and allow the broad impact of the developed solutions to be assessed. The locally adapted solutions (WP2) provide the starting point for the economically viable implementation of the approaches within the implementation phase, but also in comparable projects. The local application context is integrated into the R&D processes via the integration of the two advisory boards. Due to the specific nature and requirements of the local problem context as well as industry-specific and legal regulations, further adaptation is required for the prototype implementation of the integrated urban development strategy, which is ensured by a flexible design of the R&D-processes (WP4). The identified social innovations to address comparable problems in Southeast Asia enable the enrichment of socio-technical solutions with new practices and organizational models. The further training measures (WP3) can be made available in the implementation phase via an appropriate license fee. Scientific and economic connectivity of CHARMS can be rated as high due to the diversification of the stakeholder structure and solution approaches, the high transferability of the developed solutions, the consistent integration of local and expert feedback, the enrichment of socio-technical R&D solutions with social innovations from comparable problem-contexts in Southeast Asia as well as the standardized utilization planning,

8. FINANCIAL PLAN AND TIMETABLE

The planning for the implementation phase envisages the continuation of work with the established team over a period of 24 months. The cost estimate is based on current estimates and will amount to approximately EUR 1.0 million in total.

9. OWN CONTRIBUTION OF INTERNATIONAL PARTNERS

The financial contribution from Thai side for the R&D phase includes: half of the personal costs for the coordinating person at CMU SPP (69.600 €), two PhDs for two years each (40.000 €) and rent for the CHARMS project office, access to the university library, access to GIS and statistical databases (12.800 €) at CMU during the whole project duration incl. communication services as a central local anchor in order to accompany project management and to organize and control the implementation of local research processes. The total amount of co-funding from SPP for CHARMS would be 122.400 € for the 48 months duration of the project. The planned own resources provided by Thailand for the implementation phase include: 50% of the staff costs for coordination and non-personnel costs as indicated for the R&D phase. These services correspond to an own contribution of appr. 50.000 € for the implementation phase.

Hintergrund und Problemstellung

Der thermische Komfort in Wohnhäusern ist eine zentrale Determinante des häuslichen Wollbefindens in der tropischen Zone. Darüber hinaus beeinflusst die Art, wie thermischer Komfort sichergestellt wird, den Energieverbrauch der Gebäude erheblich. Die Akzeptanz des Raumklimas, mit den Faktoren thermische Behaglichkeit, Luftqualität, Lärm und Beleuchtung wird einerseits durch die Gesamtbehaglichkeit der Nutzer bestimmt. Andererseits können lokale Unbehaglichkeitsphänomene den thermischen Komfort beeinträchtigen.

Der aktuelle Nutzungswert, den die Bewohner von Chiang Mai traditionellen Holzwohnhäusern zuweisen, ist durch das Raumklima der Gebäude stark beeinträchtigt. Darauf weisen Erhebungen des CHARMS-Teams im Rahmen einer willkürlichen Stichprobe mit 119 Befragten aus den Pilotbezirken *Wat Lam Chang* und *Wat Ket* hin (davon 52 Bewohnern von traditionellen Holzhäusern). Aus dieser Pilotuntersuchung ergeben sich zudem Hinweise, dass vor allem die jüngere Generation das Raumklima der Holzhäuser kritisch sieht und dieses Problem vor allem auf den fehlenden thermischen Komfort dieser Gebäude zurückführt (Abb. 1). Gleichzeitig ist die Existenz und zukünftige Nutzung dieser Gebäude für die kulturelle Identität von rund 80 Prozent der Befragten von größter Bedeutung.

Das nachhaltige Management des thermischen Komforts historischer Holzhäuser ist nicht nur einer Frage des subjektiven Wohlbefindens, sondern auch eine Frage der öffentlichen Gesundheit. Chiang Mai liegt in einer von Bergen umgebenen Senke. Aufgrund von regelmäßigen und großflächigen Waldrodungen im Norden des Landes, sowie in den
angrenzenden Nachbarländern Laos und Myanmar hat Chiang Mai eine extrem schlechte Luftqualität und die höchste Lungenkrebsrate in ganz Thailand. Durch die Corona-Krise wird

die Herausforderung des gesunden und guten Lebens in historischen Holzhäusern in Chiang Mai weiter salient.

Übergeordnetes Projektziel

Vor diesem Hintergrund entwickelt das Vorhaben *Integration historischer Gebäudebestände urbaner Regionen in eine moderne und energie-effiziente Gesellschaft* (CHARMS) eine integrierte Strategie zur Erhöhung des thermischen Komforts historischer Wohnhäuser und Quartiere in der urbanen Region Chiang Mai. Im Lichte des Planungsparadigmas *Erhalt durch Nutzung* werden lokal angepasste, nachhaltige Nutzungskonzepte für historische Holzhäuser und Quartiere entwickelt und deren Implementierung vorbereitet.

Während der Definitionsphase von CHARMS identifizierte das Projektteam die Distrikte Wat Lam Chang und Wat Ket als die am besten geeigneten Standorte für die FuE-Phase. Beide Bezirke haben einen erheblichen Anteil an traditionellen Holzgebäuden (Abb. 2) und eine sehr aktive Zivilgesellschaft. Letzteres spiegelt sich in einem hohen Engagement für Aktivitäten zur Erhaltung des kulturellen Erbes wider (gemäß den Ergebnissen der Pilotumfrage). Die Bezirke unterscheiden sich jedoch in ihren sozialen Strukturen, ihrer urbanen thermischen Umgebung und möglicherweise in ihrem Schutzstatus (aufgrund der Beantragung des Welterbe-Status der Innenstadt, in der sich Wat Lam Chang befindet).

Identifikation technischer- und sozialer Lösungen

Dem Problem des fehlenden thermischen Komforts sowie der unzureichenden Luftqualität innerhalb der historischen Gebäude liegen verschiedene Ursachen zugrunde. Einerseits haben sich die Ansprüche der jüngeren, lokalen Bevölkerung an thermischen Komfort im

Vergleich zur Eltern- und Großelterngeneration geändert (Ursache 1). Diese Veränderung basiert auf einer Lebensstil-basierten veränderten Nutzung der Gebäude, einer generell höheren Erwartungshaltung an ein komfortables Leben sowie einem höheren Bewusstsein für die gesundheitliche Relevanz der thermischen Bedingungen und der Luftqualität in Holzwohnhäusern. Um ein breites Verständnis der lokalen Einstellungsmuster zu energie- und ressourceneffizienter Gebäudeertüchtigung im historischen Bestand zu entwickeln, wurde durch das Fraunhofer-Zentrum für Internationales Management und Wissensökonomie IMW in der Definitionsphase ein neuer Ansatz der problemzentrierten Sozialstrukturanalyse entwickelt. Der pilotierte Ansatz wird in der FuE-Phase weiterentwickelt und skaliert.

Investitionen zur Erzeugung und Aufrechterhaltung einer angenehmen Raumluft-Qualität konzentrieren sich heute in der Regel auf aktive Kühlsysteme, wie Klimaanlagen (Ursache 3). Einerseits wird dadurch der Energieverbrauch der Gebäude substantiell erhöht. Andererseits trägt die Abluft der Klimaanlagen potentiell zur Entstehung von Wärmeinseln bei. Zusätzliche Maßnahmen zur Verbesserung der Gebäudehülle wie Innenwanddämmung, Luftdichtheit und andere technische Verbesserungen oder traditionelle passive Systeme, die langfristig sowohl Energie als auch finanzielle Ressourcen sparen würden, werden selten in Betracht gezogen. Die Entwicklung material-basierter Maßnahmen zur Erhöhung des thermischen Komforts in Holzwohnhäusern wird durch das Fraunhofer-Institut für Bauphysik IBP eingebracht („*Innovation Challenge* 1").

In der Vergangenheit wurde ausreichend thermischer Komfort historischer Holzwohnhäuser durch passive, natürliche Kühlmaßnahmen sichergestellt. Der Innenraumkomfort der Gebäude basierte auf der Passfähigkeit von Architektur und urbanem (Mikro)-klima. Aufgrund der durch den Klimawandel gestiegenen Außentemperatur, der durch die Urbanisierung verursachten Veränderung des lokalen Mikroklimas, sowie der hohen Luftverschmutzung, wird durch die traditionellen Kühlungsmaßnahmen kein ausreichender Innenraumkomfort mehr sichergestellt (Ursache 2). Während der Definitionsphase wurde eine erste Analyse des lokalen Mikroklimas vorgenommen sowie der lokale Gebäudebestand erfasst und typologisiert. Auf dieser Basis werden durch das Fraunhofer-Institut für Energiewirtschaft und Energiesystemtechnik IEE Klimamodelle und Lösungsansätze auf Gebäude- („*Innovation Challenge* 2") und Umgebungsebene („*Innovation Challenge* 3") entwickelt und für die Identifizierung von Lösungen angewandt.

Weiterhin ist die kollektive Effizienz öffentlicher und privater Maßnahmen zur Erhöhung der Lebensqualität in historischen Quartieren und Gebäuden der Stadt Chiang Mai gering (Ursache 4). Als Gründe sind hier die fehlende Abstimmung der Initiativen untereinander, die unzureichende Kommunikation zwischen der Stadt Chiang Mai und den lokalen Anwohnern, sowie die unzureichende Befähigung von städtischen Entscheidungsträgern, Zielkonflikte zu managen, zu benennen. Chiang Mai soll staatlich gefördert zu einer „Smart City" weiterentwickelt werden. Die aktuelle Planung sieht keine systematische Integration von IT-basierten Mechanismen zur Interaktion zwischen Stadtverwaltung und lokalen Anwohnern vor. Das Fraunhofer-Institut für Offene Kommunikationssysteme FOKUS setzt an dieser Stelle an und entwickelt IT-basierte Konzepte zur Verbesserung der Kommunikation zwischen Anwohnern und Stadtverwaltung („*Innovation Challenge* 4“).

Zur Stärkung der Kommunikation zwischen einzelnen Initiativen hat das Fraunhofer IMW in der Definitionsphase ein Weiterbildungsprogramm entwickelt und pilotiert. In Kooperation mit der UNESCO Bangkok wird dieses in der FuE-Phase weiterentwickelt und ASEAN-weit skaliert. Zur Vorbereitung der Weiterbildungsaktivitäten identifiziert das IMW ASEAN-weit soziale Innovationen zur Verbesserung des thermischen Komforts. Dieser Katalog sozialer Innovationen baut auf einem in der Definitionsphase entwickelten Innovationskatalog auf und findet sowohl in den Weiterbildungsaktivitäten (als Good Practices) als auch in der Entwicklung einer technologisch-sozial integrierten Lösung zur Erhöhung des thermischen Komforts (als Praktiken und Organisationsformen) Anwendung.

Schließlich stärkt das Fraunhofer IBP die Standardisierung von Entscheidungsprozessen im Bereich der energieeffizienten Erhöhung des thermischen Komforts in historischen Gebäuden durch die Anpassung relevanter Merkblätter der Wissenschaftlich-Technischen Arbeitsgemeinschaft für Bauwerkserhaltung und Denkmalpflege e.V., sowie des europäischen CEN/TC 346-Standards zur „Erhaltung des kulturellen Erbes“ („*Innovation Challenge* 5“).

Integrativer Teil des Entwicklungsprozesses der benannten Lösungen ist das systematische Einholen von strategischem (auf Basis eines innerhalb der Definitionsphase etablierten Experten-Beirats) und lokalem (auf Basis eines Community Board) Feedback zur ökonomischen, ökologischen und sozialen Passfähigkeit der Lösungen.

Integration der Lösungsansätze und strategische Verwertungsplanung

Das Herzstück des Vorhabens CHARMS ist die Entwicklung einer integrierten urbanen Entwicklungsstrategie zur energie-effizienten, kulturell-sensiblen Erhöhung des thermischen Komforts von historischen Holzhäusern auf Basis der Ergebnisse der fünf *Innovation Challenges* und der identifizierten sozialen Innovationen zur Verbesserung des thermischen Komforts. In einem ersten Schritt werden die entwickelten Lösungen der drei Herausforderungen für technische Innovationen in das sozio-klimatische Basismodell übertragen, um deren langfristige klimatische Auswirkungen und soziale Akzeptanz zu bewerten. Basierend auf einem Interdependenzmodell der Auswirkungen des urbanen Klimas auf die Komfortbedingungen von historischen Gebäuden in Innenräumen werden Maßnahmen in der direkten Gebäudeumgebung gegen technische und strukturelle Maßnahmen am Gebäude selbst abgewogen. Dies führt zu einer Reihe verschiedener, technologisch machbarer und klimatisch vorteilhafter Maßnahmen. Diese Maßnahmen werden dem *Community Board* und dem Experten-Beirat vorgestellt. Basierend auf den Rückmeldungen zu technologischer Passform, sozialer Akzeptanz und wirtschaftlicher Tragfähigkeit werden die Maßnahmen weiter angepasst. Schließlich werden die angepassten technologischen Maßnahmen mit den identifizierten sozialen Praktiken und Organisationsmodellen angereichert, um eine erste integrierte Strategie zu entwickeln. Die Strategie wird wieder den beiden Beiräten vorgestellt, um sie über das erneute Feedback weiter anzupassen. Das Ergebnis wird im letzten Schritt mit den Ergebnissen der *Innovation Challenges* 4 und 5 angereichert (IT-basierte Kommunikation, Standards) und auf diese Weise mit Maßnahmen zur Verbesserung der lokalen und nationalen Rahmenbedingungen gekoppelt. Der Integrationsprozess wird durch die Universität Chiang Mai geleitet.

Das entwickelte Strategie dient als Input für die Verwertungsplanung der FuE-Ergebnisse. Um die wirtschaftlich nachhaltige Umsetzung der Forschungsergebnisse von CHARMS in der Implementierungsphase zu unterstützen wird ein Geschäftsmodell für deren Markteinführung und Skalierung sowie eine Roadmap für die Umsetzung der strategischen Planung entwickelt („Innovationsstrategie"). Hierfür nutzt CHARMS einen standardisierten Prozess für die Verwertungsplanung von FuE-Ergebnissen, der am Fraunhofer IMW im Rahmen einschlägiger Programme (z.B. BMBF „2+2"; BMWi – „Zentrales Innovationsprogram Mittelstand ZIM") entwickelt wurde. Die gesellschaftliche und politische Verwertung der FuE-Ergebnisse wird durch den thailändischen Projektpartner School of Public Policy an der Universität Chiang Mai geleitet und mündet in Empfehlungen zur Weiterentwicklung der thailändischen gesetzlichen Rahmenbedingungen und integrierten Entwicklungsstrategien im Bereich der energie- und ressourceneffizienten Ertüchtigung historischer Gebäude und Quartiere in Thailand.

Partnerstruktur

Die Implementierung des Vorhabens basiert auf einer umfassenden Partnerstruktur, bestehend aus Kernpartnern, Implementierungs- und Verbreitungspartnern

- Kernpartner: FH IMW (Konsortialführer), FH IEE, FH IBP, FH FOKUS School of Public Policy an der Universität Chiang Mai (CMU SPP)
- Umsetzungspartner: Vertreter der Pilotbezirke Wat Ket und Wat Lam Chang, Stadt Chiang Mai, DEPA – *Digital Economy Promotion Agency*, Morgenstadt-Netzwerk, Bable.de, AHK Bangkok, *Chamber of Commerce Chiang Mai*, UNESCO Bangkok, Siam Society
- Dissemination Partner: Deutsche Botschaft Singapur*, International Climate Heritage Network*, DAAD Thailand

Der thailändische Kernpartner CMU SPP ist die erste und bisher einzige universitäre Einrichtung in Thailand mit explizit transdisziplinärem Charakter. Sie wird die angegliederten Forscher der jeweiligen CMU-Fakultäten aktiv in die CHARMS-Aktivitäten einbinden, die für die erfolgreiche Umsetzung des Projekts von wesentlicher Bedeutung sind (u.a. Fakultät für Architektur, Institut für Energieforschung und -entwicklung, Institut für Sozialforschung und das Exzellenzzentrum für Stadtplanung).