

**ELITH: THAILAND PARTNER JGSEE/KMUTT:
SUMMARY OF PROJECT WORK PLANS, ACTIVITIES AND OUTPUTS**

Compiled from the quarterly reports by Chris Butters, Warwick, Sept. 2016

Editor's note: The core research objective of the Thai ELITH team has been to further the introduction of energy efficiency codes for the housing sector in Thailand. This has been based on extensive surveys and analysis of existing housing, traditional solutions and recent trends, household energy use and national trends; tests and pilot studies; evaluation of existing methodologies for buildings energy analysis and rating; studies of embodied energy and carbon; development of technical rating systems: and establishing contacts and cooperation with the responsible authorities and agencies for housing and energy on a national level.

Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi (KMUTT), 126 Prachauthit Rd., Bangmod, Tungkru, Bangkok 10140 Thailand.

ELITH – KMUTT, Thailand:

Project: Research Programme on Reducing Energy Consumption Cost and GHG Emissions for Tropical Low-income Housing: ELITH - - Funded by EPSRC, UK. The team (nb not all assistants are included here):

Prof. Dr. Surapong Chirarattananon Principal Investigator
Asst. Prof. Dr. Pattana Rakkwamsuk Co-investigator
Asst. Prof. Dr. Siriluk Chiarakorn Co-investigator
Dr. Pipat Chaiwiwatworakul Co-investigator
Dr. Surawut Chuangchote Co-investigator
Ms. Hathairat Loyprakhon Research Assistant
Mr. Preecha Tummum Research Associate

Summary of Project Activities

There are 3 individual work plans for this project.

Activities in Work Plan 1 "Operational Energy and Architectural/Urban Design" involves in (i) surveying the low income houses in Thailand, (ii) conducting several researches on technology improvement of the house envelope, daylight application in the houses, appropriate means for air-conditioning and ventilating to achieve comfort in the house, and (iii) developing an energy labeling scheme for low income houses in Thailand using research results and insight gained from activities (i) and activities (ii). Concepts of life cycle costing and total carbon emission are expected to be adopted for the labeling scheme to be developed.

In Work Plan 2 "Embodied Energy and Building Materials", research activities focus on embodied energy of the low income houses and how to reduce the embodied energy and GHG emission from the houses. The researches in Work Plan II are complementary with those in Work Plan I.

Activities in Work Plan 3 "Disseminating Good Energy Practice Relating to Tropical Housing" are disseminations of the results from the project. In the plan, the dissemination will be done through the project website, annual workshops among the project teams from Thailand and other partner countries that include Uganda, Tanzania, China, and the United Kingdom, presentations of project results in national and international conferences, publications in national and international journals, and training of personnel of project partners. Demonstration facilities developed from this project will continued to be utilized even after the project terminates.

Period: Oct - Dec 2013 and Jan - Mar 2014

This report provides a summary of activities undertaken during the first two quarters. The major activities are described in the following.

1. Review of Literatures on Features of and Patterns of Energy Use in Medium and Low Income Houses

In accordance to the work plan submitted in the previous progress report, a review of literatures on features of and patterns of energy use in medium and low income houses in Thailand would be submitted in the period of Oct – Dec 2013. A similar review for international situation was scheduled to be submitted in the following period. However, since the present report is submitted at the end of Jan-March 2014 period, the content of the report pertains also to international situation in the same report.

The present review report includes geographical and socio-economic information on Thailand, an examination of the notion of low income houses, recommended house designs for each region, an examination of features of low income houses constructed by a state enterprise, breakdowns of energy consumption in typical households, and a preliminary examination of carbon content of Thai housing stocks.

2. Other Activities

Other major activities are as follows.

2.1 Visit to the National Housing Authority of Thailand (NHA)

On January 14, 2014, the Thai project team met with 11 representatives from NHA at Building 2 in the NHA compound in Bangkok. Figure 1 shows a photograph taken during the meeting. The project team introduced team members, described the main objective of the project and work plan to the Director, the Vice-Director, and 10 researchers/staff of the Housing Development Department of NHA. The NHA representatives agreed to appoint a team to work on a collaboration research with the project team. The NHA representatives also asked for the knowledge transfer from the research team. The research team from KMUTT might give a lecture related to energy efficiency in buildings and also details of this project to NHA staffs. The research team agreed with the idea. A lecture or training will be carried out in the future at NHA. A formal letter of invitation to the director of NHA for collaborative research was later submitted and a formal letter of response was received. The NHA welcome the invitation and assigned a deputy director of Housing Development Department to work with the project team. Another round of meeting between the project team and the team from the NHA is planned to initiate the collaborative research, first to create a joint research plan, to assess training needs for NHA personnel, and to elaborate on methodology of research.

Figure 1 shows the first meeting between the project team and representatives of the Housing Development Department of NHA.



Figure 1 A meeting with representatives from NHA on January 14, 2014.

2.2 Preparation of Project Website

According to the work plan, a website of this project in Thailand will be created. The website content is being prepared. The portal is being designed and the basic design is primarily agreed on. It will have a link to the Building Energy Science and Technology (BEST), which is the host academic unit, website.

2.3 Preparation on the Demonstration House Model

According to the work plan, a model demonstration house will be used for training and demonstration of features of low energy house. A full-sized house model located on an experimental site of BEST in the Bangkhuntian campus of KMUTT is being retrofitted for use to serve this objective. Figure 2 shows the experimental model and Figure 3 shows its floor plan.

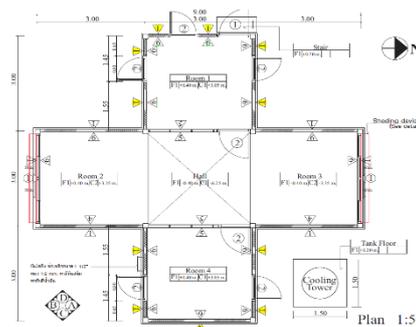


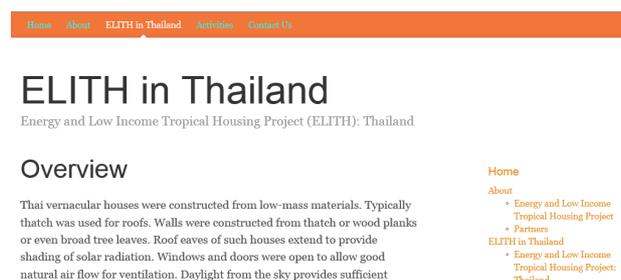
Figure 2. The experimental model house for demonstration of energy efficient technology.

Period: April-June 2014

This report provides a summary of activities undertaken during quarter 4 (April-June 2014) of the project. The major activities are described as follows.

1. ELITH-Thailand Website

ELITH-Thailand members created a website to introduce the project and also to disseminate the activities and results. The website can be reach via <http://low-e-housing.jgsee.kmutt.ac.th/>.



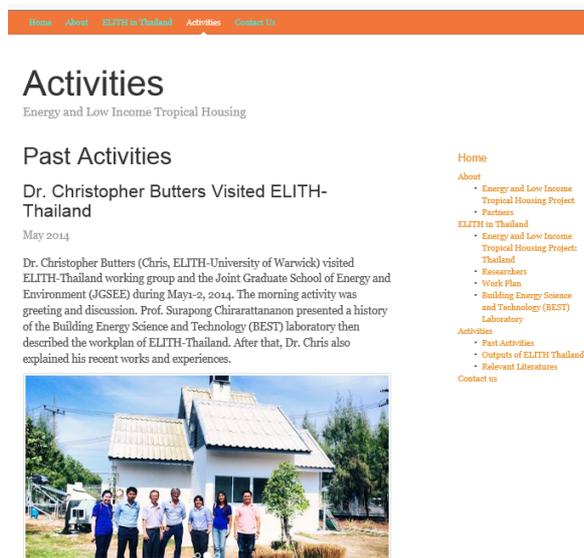


Fig. 1 Examples of pages in ELITH-Thailand website

There are 5 menus of ELITH-Thailand website, including: (1) Home; (2) About (ELITH and Partners); (3) ELITH in Thailand (Overview, Objective, Beneficiaries, Work Plan, and Project Team); (4) Activities (Past Activities, Outputs of ELITH Thailand, and Relevant Literatures); and (5) Contact Us. The most important part of this website is “Activities”, which is in the project plan (dissemination) of ELITH.

2. Visits of Partners

ELITH-Thailand is very pleasure to welcome partners to come to Thailand for meeting, discussion, and site visits. The meeting and discussion were held in Bangmod Campus of KMUTT, while visits of Building Energy Science and Technology (BEST) Laboratory were at Bang Khun Thian Campus.

2.1 Visit of Mr. Christopher Butters (May 1-2, 2014)

Mr. Christopher Butters (Chris, University of Warwick) visited ELITH-Thailand and The Joint Graduate School of Energy and Environment (JGSEE) during May 1-2, 2014. The morning activity was greeting and discussion. Prof. Surapong presented a history of the Building Energy Science and Technology (BEST) laboratory then described the work plan of ELITH-Thailand. After that, Chris also explained his recent works and experiences.



Fig. 2 Meeting of ELITH-Thailand and Mr. Chris

In the afternoon, ELITH-Thailand members (Prof. Surapong, Dr. Surawut, and students in BEST laboratory) invited Chris to visited BEST laboratory and facilities at Bang Khun Thian Campus of KMUTT. Prof. Surapong let the Master and PhD students presented their researches and experiments conducted in the laboratory such as ventilation stack, light pipes, desiccant wheel dehumidifier, effective shading devices, etc. The progress of renovation of the experimental house to support the experiments in the work plan of the ELITH projects was also presented.



Fig. 3 Mr. Chris visited facilities of BEST Laboratory

1.2 Visit of Mr. Alex Ndirwami and Mr. Mark Olweny (June 15-17, 2014)

Mr. Alex Ndirwami (Alex) and Mr. Mark Olweny (Mark) from Uganda Martyrs University, Uganda, came to KMUTT during June 15-17, 2014, before the annual group meeting of ELITH. Alex and Mark joined the weekly meeting of ELITH-Thailand and visited the facilities of BEST Laboratory. It was a good chance for ELITH-Thailand members to discuss with Alex and Mark about the possible collaboration between Thailand and Uganda. Common interests and housing survey methodology were discussed. Alex and Mark went to Ningbo, China, for ELITH annual group meeting on June 18, 2014.



Fig. 4 Visit of Mr. Alex and Mr. Mark

1.3 Visit of Dr. Terry and Dr. Heather (June 28, 2014)

On June 28, 2014, after the annual group meeting of ELITH, there was a follow-on meeting of ELITH-Thailand, and Dr. Terry Thomas (University of Warwick) and Dr. Heather Cruickshank (The University of Cambridge), at KMUTT, Bang Khun Thian Campus. Experiments, facilities, and all research works at JGSEE were described. Terry and Heather also shared their experiences to ELITH-Thailand members and JGSEE students.



Fig. 5 Visit of Dr. Terry and Dr. Heather

1.4 Site Visit of Dr. Terry (June 30, 2014)

In the morning of June 30, Dr. Terry attended the weekly meeting of ELITH-Thailand at Prof. Terry also shared his experience in the room of Dean of School of Energy, Environment and Materials (SEEM), KMUTT. Prof. Surapong, Dr. Pattana, Dr. Pipat, and Dr. Surawut presented on history, staffs, facilities, and

research works of BEST Laboratory. In the afternoon, a researcher on ELITH-Thailand accompanied Dr. Terry to visit the Environment Research and Training Center, Pratumthani Province, to see a research on biomass-burning furnace with the uses of interlocking brick. Dr. Nittaya, a researcher at Environment Research and Training Center, shared her experience and showed her experiments.



Fig. 6 Site visit of Dr. Terry

3. Annual Group Meeting at Ningbo, China

The annual group meeting of ELITH was held during June 19-26, 2014, at Ningbo, China. This meeting primarily comprised discussions, presentations, a visit to a demonstration zero emission building, and visits to rural mountain settlements in the Ningbo region. From ELITH-Thailand, Prof. Surapong (the principal investigator), Dr. Pattana, Dr. Pipat, and Dr. Surawut attended the meeting. Unfortunately, we were not able to attend until the final days. We had to leave early on June 22 because of research reasons.



Fig. 7 ELITH annual group meeting at Ningbo

4. Household Survey Designs and Plan

ELITH-Thailand planned to do the household survey to collect the data of electric appliances, building configurations and energy uses in household and establish the baseline for each household type. Thermal and visual comforts of each household type, building enveloped materials, and energy uses during building construction process will be surveyed also. This survey will be done with the collaboration of National Housing Authority (NHA), Thailand.

The survey questionnaire was developed. It was attached with this progress report. The details of household survey plan can be seen in the Working Paper entitled “Household Survey Plan for Low-Income Housing Study”.

Summary of Project Activities

Period: July - September 2014

This report provides a summary of activities undertaken during quarter 5 (July - September 2014) of the project. The major activities are described as follows.

1. Regular project meeting

Regular meetings were held every Monday morning at a meeting room in the school of energy, environment and materials building of KMUTT. Agendas of the meetings are as in Table 1.

Table 1 Meeting activities

Date Activity

7 July 2014 Follow up on the meeting NHA on 3 July 2014.

14 July 2014 Holiday

21 July 2014 Discussion on survey methodology; questionnaire, thermal and comfort lighting comfort, the use of measuring instrument during the surveys, test of methodology at Dr. Pattana's house.

28 July 2014 Discussion on improving survey methodology questionnaire based on experience during the survey at Dr. Pattana's house.

4 August 2014 Continued discussion on subjects previously discussed in the past week and setting up methodology for collecting thermal and lighting environment. And identification of power rating of household appliances.

11 August 2014 Holiday

18 August 2014 Discussion on tests of survey methodology and use of equipment for lighting and thermal environmental quality.

25 August 2014 Discussion on survey plans, budget, and in charge person for the surveys.

1 September 2014 Final discussion of survey preparations.

8 September 2014 Discussion on the survey results of the central region.

15 September 2014 Discussion on the survey results of the northern region.

22 September 2014 Discussion on the survey results of the north - eastern region.

29 September 2014 Discussion on the survey results of the southern region.

2. Activities with National Housing Authority (NHA), Thailand

2.1 Meeting with NHA for Household Survey Plan (July 3, 2014)

On July 3 (09:30 - 13:00), ELITH - Thailand (Prof. Surapong Chirattananon, Dr. Pattana Rakkwamsuk, Dr. Pipat Chaiwiwatworakul, Mr. Preecha Tumm, and Ms. Hathairat Loyprakhon) and NHA (7 representatives) held a meeting with NHA representatives to discuss about collaboration and household survey plans which is a part of ELITH work plan. Prof. Surapong described the overall plan of ELITH - Thailand and the tentative survey plans made by the team. NHA members also shared their experience and offered new locations of survey which are more convenient and effective for survey Thailand: Project Progress (July - September 2014) 3 purposes. The NHA team was headed by Mr. Noppadon Wongwiangchan; Director of Community Management Department.

Fig. 1 Meeting with NHA to discuss about household survey plan.

2.2 Seminar on Updating Housing Situation in ASEAN Countries (July 23 - 25, 2014)

NHA held a seminar entitled "Updating Housing Situation in ASEAN Countries: The Way Forward for ASEAN Community" on July 23 - 25, 2014 at Colonial Hall, Centara Grand Beach Resort and Villas, Hua Hin, Prachuap Khiri Khan Province. ELITH - Thailand was invited to attend this seminar.

Dr. Surawut was the representative of the team to attend it. He was able to share the experiences of Thailand - ELITH group with representatives from ASEAN countries. In this seminar representatives from housing authorities or related ministries from ASEAN countries reported the housing/land policies and situations.

Fig. 2 Seminar on updating housing situation in ASEAN countries, Hua Hin, Thailand.

3. Tests of Survey Methodology and use of equipment for lighting and thermal environmental quality

Before conducting household surveys in several parts of Thailand, tests of survey methodology and use of equipment for lighting and thermal environmental quality were carried out of four types of residential buildings built under the projects of NHA in Bangmod District, Bangkok, to verify the methodology, and also improve the skills of the survey teams.

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Fig.3 Tests of equipment.

4. Household Surveys

ELITH - Thailand with the collaboration of NHA carried out surveys in four major regions of Thailand during September 4 - 26, 2014, to collect data of electric appliances, building configurations, indoor environmental condition, thermal sensation, and energy uses in household and establish the baseline for each household type. Table 2 lists the survey sites.

Fig.4 Household surveys

Table 2 Survey sites for housing features and thermal comfort of medium and low income earners in Thailand.

Area	Project developer/Owner	Province	Survey date
Central	NHA houses	Phra Nakhon Si Ayutthaya	September 4, 2014
	Other detached houses	Pathum Thani	September 5, 2014
Northern	NHA houses	Chiang Mai	September 11, 2014
	Other detached houses	Chiang Mai	September 12, 2014
North - eastern	NHA houses	Ubon Ratchathani	September 18, 2014
	Other detached houses	Ubon Ratchathani	September 19, 2014
Southern	NHA houses	Phuket	September 25, 2014
	Other detached houses	Phang Nga	September 26, 2014

Remarks: NHA houses: Residential buildings built under the projects of NHA
Other detached houses: Other houses apart from NHA houses

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5. Outputs of activities in the 5th quarter

The outputs of the 5th quarter comprise a preliminary report of household surveys and conference papers for SEE2014 conference. For the household survey report, housing features and thermal comfort of four main regions of Thailand were studied. The results indicate that house configurations of each region are different depending on their local cultures, climates and annual climatological events such as storms and floods. Thermal comfort levels of people of each region are also different due to their habit. Moreover, trends of materials used in house constructions in the future are concrete which lead to increase CO2 emission from embodied energy. The preliminary results of the surveys can be seen in the paper entitled "A Survey of Housing Features and Thermal Comfort of Medium and Low Income Earners in Thailand". Apart from that there is a report on overview of ELITH - Thailand project in a paper topic of "Reducing Energy Consumption Cost and

Greenhouse Gas Emission for Tropical Low - income Housing: Thailand Contribution” and current situation including forecast of energy uses and CO₂ emission of residential sector in Thailand are also described in a paper entitled “Energy Consumption and GHG Emission of Thailand’s Residential Sector”. For CO₂ emission from embodied energy of Thai residential houses, calculation method are presented in a paper topic of “Evaluation of Greenhouse Gas Emission from Residential Buildings in Thailand” and results of embodied energy CO₂ emission of NHA houses are shown in a paper entitled “Greenhouse Gas Emission from Low Income House Construction: Case study in Baan Eua - Arthorn Project in Thailand”. The papers mentioned are in APPENDIX.

Summary of Project Activities

Period: October - December 2014

This report provides a summary of activities undertaken during quarter 6 (October - December 2014) of the project. The major activities are described as follows.

1. Regular Project Meeting

Regular meetings were held every Monday morning. The meeting place was change from a meeting room in the School of Energy, Environment and Materials building to the meeting room of The Joint Graduate School of Energy and Environment. Agendas of the meetings are as in Table 1.

Table 1. Meeting activities.

Date Activity

6 October 2014 Discussion on the research outputs that are ready for disseminations in ELITH session in the 5th International Conference on Sustainable Energy and Environment (SEE 2014)

13 October 2014 Discussion on the invitation of representatives from NHA to attend ELITH session in SEE 2014

20 October 2014 Draft of the outline of the report entitled "A Survey of Housing Features and Thermal Comfort of Medium and Low Income Earners in Thailand"

27 October 2014 Selection of the survey data of housing features as the representative of each region for reliability and separation of NHA data from all surveys

3 November 2014 Discussion on the progress of the report

10 November 2014 Discussion on the papers that will be presented in SEE 2014

17 November 2014 Discussion on the special ELITH session in SEE 2014

24 November 2014 Discussion on the survey results of the central region after data analysis energy uses and carbon emission

1 December 2014 Discussion on the survey results of the northern region after data analysis energy uses and carbon emission

8 December 2014 Discussion on the survey results of the north - eastern region after data analysis energy uses and carbon emission

15 December 2014 Discussion on the survey results of the southern region after data analysis energy uses and carbon emission

22 December 2014 Continued discussion on the preparation of progress report

2. Disseminations of Project Outputs in ELITH Session

in the 5th International Conference on

Sustainable Energy and Environment (SEE 2014)

There are 270 people attended SEE 2014. The technical papers were divided between the 7 headings: (A) Energy systems and policy, (B) Bioenergy and biofuels, (C) Renewable energy, (D) Energy efficiency, (E) Energy conversion technology, (F) Climate policy, (G) Environmental and climate science and mitigation technology. ELITH session was in topic D. The session was conducted on November 20 - 21, 2014.

There were totally 10 presentations in the session. On the first day, Dr. Terry Thomas (University of Warwick), the principal investigator of ELITH Project, was firstly presented about general information of ELITH and some results from the half way of the project. Dr. Ali Cheshmehzangi (The University of Nottingham, Ningbo China) also presented his work on urban cooling improvement. Thailand - ELITH members also presented their works in this session, Dr. Surawut Chuangchote, Dr. Pipat Chaiwiwatworakul, and Dr. Siriluk Chiarakorn presented on work plan of ELITH - Thailand, energy use in residential sector of Thailand, and greenhouse gas emission of example Thai commercial buildings, respectively. On the second day, the presentations of Thai housing features and thermal comforts, embodied energy of houses under NHA project, and the use of daylighting through fenestration system of Thailand were presented by research assistants of the project.

Figure 1. ELITH session in SEE 2014.

The proceedings, including ELITH session, have been issued as a CD, given an ISSB number (978 - 616 - 92228 - 1 - 1) and were mounted at website: <http://see2014.com/>. A link to the downloadable database with DOI will be also posted by National Research Council of Thailand (NRCT).

3. Special ELITH Member Meeting (Bangkok, Thailand)

After SEE 2014, the ELITH group meeting was carried out at a common room of SEE2014. Dr. Terry, Dr. Ali and Thailand - ELITH members attended this meeting. Ongoing works and next plans were discussed during the meeting.

Concerning that AGM we agreed not to hold a 2015 AGM but instead to encourage one - to - one contact between members. Our two AGM's to date were perhaps necessary but were expensive in time and money out of proportion to their contribution to our research output. We have spent considerable time on planning collaboration, but not in carrying it out. By next year we ought to be well past 'planning' and into the discussion of findings that is best done face - to - face or by telecoms.

Figure 2. Special ELITH member meeting in Bangkok.

We agreed it was time our work was geared directly to the Phase III dissemination activities in our 3rd year. So each partner should by now have decided: (1) Who are the primary targets/customers (e.g. builders, developers, regulators, architects, manufacturers, fellow - academics) for the new knowledge we are generating; (2) What is that new knowledge (findings and recommendations); and (3) How do we propose to deliver it (e.g. training, reports, publications, demonstrations, private and public meetings).

4. Outputs of Activities in the 6 th Quarter

To establishment of current baselines of housing features, energy uses and CO₂ emissions of low and middle income earners, has being studied. A report entitled "A Survey of Housing Features and Thermal Comfort of Medium and Low Income Earners in Thailand" has been written. In the report, the first part is the background of the survey. Purposes, scope, and methodology of the survey are discussed. In the next parts, survey results of northern, central, north - eastern and southern regions of Thailand will be reported and discussed. The survey results from residential building under NHA will be discussed separately for ease to make the recommendation to NHA after the project. In this progress report, only the first and second chapters are shown, i.e. background and detailed survey results of northern Thailand, respectively. The full reported will be completed and submitted in the next quarter. The results of the survey is planned to be submitted to

international peer - reviewed journals for publications (1 - 3 papers).

Summary of Project Activities

Period: January - March 2015

This report provides a summary of activities undertaken during quarter 7 (January - March 2015) of the project. The major activities are described as follows.

1. Regular Project Meeting

Regular project meetings were planned to be held every week. The meeting day was changed from Monday morning to Friday morning. The agendas of the meetings are shown in Table 1.

Table 1. Meeting activities.

Date Activity

16 January 2015 Discussion on the progress of project

23 January 2015 Meeting with NHA

2 February 2015 Discussion on (1) the 2nd survey in central area (targets in agricultures) and (2) topics for presentations in NHA seminar

13 February 2015 Discussion on (1) conclusions of the 2nd survey in central area and (2) contents for the ELITH project progress report (#7)

20 February 2015 Decision on the contents for presentations in NHA seminar

27 February 2015 Discussion on the progress of project

12 March 2015 Meeting with Ali (The University of Nottingham Ningbo China)

20 March 2015 Drafting of presentations for NHA seminar

27 March 2015 Final revision of presentations for NHA seminar

2. Meeting with NHA

On January 23, 2015, a meeting with NHA was held. Members of ELITH Thailand reported the project progress to the NHA partners. NHA and ELITH Thailand planned to have project dissemination in an academic seminar which will be held by NHA on April 3, 2015.

3. Meeting with Ali

Dr. Ali Cheshmehzangi from The University of Nottingham, Ningbo, China, visited ELITH Thailand. For Thai partners, Prof. Surapong Chirarattananon, Dr. Pattana Rakkwamsuk, Dr. Pipat Chaiwiwatworakul, Dr. Surawut Chuangchote, Mr. Preecha Tumm, Ms. Hathairat Loyprakhon, and Mr. Bupphapan Puangbuppha joined the meeting.

Prof. Surapong showed an outline of working plan of Thai project team, that the original plan was being followed. The Thai project team presented that household surveys for 4 regions of Thailand were carried out. The Thai project team will spend the next 2 quarters to analyze the results, identify criteria and developing scheme for rating energy and carbon performance of residential houses. It is hoped that the scheme would be used by National Housing Authority (NHA) of Thailand in the development of new houses and apartment units.

Dr. Ali commenced by inviting the Thai partner to cooperate in a comparative study of energy performance of residential houses in Thailand and China that could lead to development and Thailand: Project Progress (January - March 2015) 3

implementation of residential building energy code and subsequent deployment and dissemination. He also expressed his interest in urban planning. He also mentioned his visit and organization of workshops on urban planning in universities in Cambodia.

Finally, the following proposals were tentatively agreed between Dr. Ali and Thai project team.

(1) A comparative study of energy and carbon performance of Chinese and Thai residential

households that is expected to be developed into a scheme for rating energy and carbon performance or building energy code.

(2) Joint organization of a symposium for information dissemination will be held. It was felt that if there were sufficient interested by other partners, it could be expanded to include participation from interested persons other than the ELITH partners.

The minutes of this meeting is attached at the end of this report (Attachment 1).

Figure 1. Meeting of Ali and ELITH Thailand

4. Outputs of Activities in the 7th Quarter

To establishment of current baselines of housing features, energy uses and CO₂ emissions of low and middle income earners, has being studied. A report entitled "A Survey of Housing Features and Thermal Comfort of Medium and Low Income Earners in Thailand" has been written. In the report, the first part is the background of the survey. Purposes, scope, and methodology of the survey are discussed. In the next parts, survey results of northern, central, north - eastern and southern regions of Thailand were reported and discussed. In this progress report, final report is presented. The results of the survey is planned to be submitted to international peer - reviewed journals for publications (2 - 3 papers). Now one paper was submitted already.

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(Attachment 1)

Energy and Low - income Tropical Housing

Minute of a Meeting between Ali Cheshmehzangi and Thai Project Partner

Thursday 12 March 2015

10.45 - 12.30

Reading Room, the Joint Graduate School of Energy and Environment

Present

Ali Cheshmehzangi University of Nottingham at Ningbo

Surapong Chirarattananon KMUTT

Pattana Rugkwamsuk KMUTT

Pipat Chaiwiwatworakul KMUTT

Surawut Chuanfchote KMUTT

Preecha Tummua KMUTT

Hathairat Loyprakone KMUTT

Bupphapan Puangbuppha KMUTT

Greetings

Surapong introduced Ali to all Thai members. There were exchanges of greetings.

Introduction by the Thai Project Team

Surapong made an outline of the plan of work of the Thai Project Team, that the original plan was being followed. After the conduct of surveys of detached households and of the 4 types of housing units of the National Housing Authority (NHA) in September 2014, and another short round during 5 - 6 February 2015, the survey team led by Preecha has completed writing the reports. The reports were to be submitted as a part of the progress report for the 7th quarter ending in March 2015. The first paper on the survey results for the Northern Region intended for submission to international journal had been completed. The plan of the Thai project team was to spend the next two quarters (8th and 9th) to analyze the results, identify criteria and developing scheme for rating energy and carbon performance of residential houses. It was hoped that the scheme would be used by NHA in the development of new houses and apartment units. Surapong also mentioned involvement of NHA with its counterparts in 6 other ASEAN countries in mission similar to that of NHA.

Presentation by Ali Cheshmehzangi

Ali commenced by inviting the Thai Partner to cooperate in a comparative study of energy performance of residential houses in Thailand and China that could lead to development and implementation of residential building energy code and subsequent deployment and dissemination. Also potential housing prototyping were discussed for both contexts. He also expressed his interest in urban planning. He mentioned his participation in a research project called 'Toolkit for Resilient Cities' supported by Siemens. The project aimed to raise awareness among decision makers for town and city planning to create resiliency in infrastructures to be able to respond to sudden large scale events. He related his experiences in exchanges of information in town planning with Chinese officials, developers, and community leaders. He also discussed the possibilities for contextualized green community development toolkits, similar to BREEAM community and LEED - ND.

He expressed his impression that there seemed to be no plan in China for coordinated rural housing and community development. Each community was seemed to be left to find its own direction. He described social development in rural China that there were large dwellings occupied by elderly

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people who were unable to mend and improve them. Their offspring worked and lived in cities and went back for occasional visits. Similar scenarios and conditions between China and Thailand were discussed. He also mentioned his visit and organization of workshops on urban planning in universities in Cambodia. He also discussed the level of education in countries like Laos and Cambodia, and the need to have impact on such matter out of the project.

Ali discussed his proposal on publication of brochures, one of which will be developed between Ali and Chris (on Urban Green Infrastructure), while he will be going to China for a visit. Ali proposed to have dual language brochures, including one in Chinese and English, and possibly a similar one in Thai and English. As the starting point, the focus will be on the existing proposal for a joint brochure between UNNC and Warwick. The proposal is to reach a wider audience, including key targeted groups of urban planners, policy makers and the local governments. Some of these works can happen jointly for a wider dissemination. This will be in parallel to our conference and journal papers, and will include different type of end - users.

Ali also discussed possibilities for having a symposium as part of next year's dissemination plan. This was discussed in his meeting with Terry and Chris at Warwick University in February 2015. He discussed about the Asian side of the programme and to develop possibilities of having direct impact on low - income and regional Asian countries, such as Laos, Cambodia and Myanmar. Also possibilities of a joint workshop or involvement with Thailand's National Housing Authority were discussed, since Thailand may have interest in Green Urban Planning agenda.

A comparative case of rural and urban housing between Thailand and China were discussed to define possibilities of doing a joint comparative study. China's current and future housing reform and housing plans were discussed. Ali also discussed the role of Thailand as a model in the region and how we can expand the project outcomes further. Two examples were the symposium and brochures.

Discussions and Agreements

The following proposals were tentatively agreed between Ali and Thai Project Team:

- a) a comparative study of energy and carbon performance of Chinese and Thai residential households that is expected to be developed into a scheme for rating energy and carbon performance or building energy code, and
- b) joint organization of a symposium for information dissemination.

It was felt that if there were sufficient interested by other partners it could be expanded to include participation from interested persons other than the ELITH partners.

The following proposal would be explored for financial support:

a workshop to disseminate the results in a) to participants from Cambodia and other nearby countries.

The Thai Project Team will explore possible involvement and support from the NHA to its ASEAN counterparts for such proposal.

Summary of Project Activities

Period: April - June 2015

This report provides a summary of activities undertaken during quarter 8 (April - June 2015) of the project. The major activities are described as follows.

1. Regular Project Meeting

Regular project meetings were held every week. The meeting day was Friday morning. The agendas of the meetings during April - June 2015 are shown in Table 1.

Table 1. Meeting activities.

Date Activity

8 April 2015 Discussion on method to define energy performance indicators for residential buildings

20 April 2015 Discussion on progress of dissemination of project results in ELITH - Thailand website

24 April 2015 Follow - up progress discussion on ELITH - Thailand website

1 May 2015 Discussion on energy performance indicators for building envelope, lighting system, ventilation, and others

8 May 2015 Setting of persons in charge of the website updating and discussion on energy performance indicators for houses.

15 May 2015 Discussion on guideline of energy performance development of building envelope

5 June 2015 Discussion on "Newsletter" from Dr.Terry and discussion on criteria of GHG emission rating

12 June 2015 Discussion on results of development of building performance indicators for residential building envelope

19 June 2015 Discussion on progress report preparation

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2. Dissemination of Project Outputs in a NHA seminar (April 3, 2015)

On April 3, 2015, ELITH - Thailand gave 4 presentations in a seminar held by National Housing Authority, Thailand (NHA). Prof. Dr. Surapong Chirarattananon, Asst. Prof. Dr. Siriluk Chiarakorn, Dr. Pipat Chaiwiwatworakul, and Mr. Preecha Tummu presented outputs of ELITH - Thailand, i.e. survey results, low - income housing models, embedded energy, and green - house gas emissions.

3. Output of Activities I - Development of Energy Performance Indicators

In this quarter, energy performance indicators for residential building envelope were developed as planned. The details of the indicators are shown in the attached report entitled "Development of Energy Performance Indicators for Residential Building Envelope".

4. Output of Activities II - Alternative Building Models for Low - income Housing

Alternative building models for low - income housing with their bill of quantities (BOQ), embedded energy, and green - house gas emissions are reported in another attachment.

The past report (January - March) presented survey results on baseline of energy use, material use, and GHG emissions of representative houses in rural and suburban area of each region of Thailand. The representative houses of each region were selected based on designs of existing and near future house which are mostly concrete houses. In the present report, the rest of the

houses found during the surveys is shown to illustrate the change, and impacts on energy use and GHG emissions.

Summary of Project Activities

Period: July - September 2015

This report provides a summary of activities undertaken during quarter 9 (July - September 2015) of the project. The major activities are described as follows.

1. Regular Project Meeting

Regular project meetings were held every week. The meeting day in this period was mainly on Friday morning or Tuesday afternoon. The agendas of the meetings during July - September 2015 are shown in Table 1.

Table 1. Meeting activities.

Date Activity

10 July 2015 Discussion on draft of the 8 th progress report of ELITH-Thailand.

17 July 2015 Discussion on concept of energy and GHG emission rating criteria for low income housing in Thailand.

24 July 2015 Discussion on final draft of the 8 th progress report.

4 August 2015 Meeting with Dr. Ali for collaboration between ELITH-Thailand and China.

7 August 2015 Discussion on concept of development of energy performance of residential building envelope enclosing air-conditioned and non-air-conditioned spaces.

14 August 2015 Discussion on revising a paper entitled "Energy Use and Carbon Emission of Low-income Houses in Northern Thailand" before resubmitting.

21 August 2015 Discussion on setting in charged persons of components of energy and GHG emission rating method.

25 August 2015 Discussion on progress of development of energy and GHG emission rating method.

1 September 2015 Discussion on progress of development of energy and GHG emission rating method.

8 September 2015 Discussion on a draft of framework outline of energy and GHG emission rating scheme.

15 September 2015 Discussion on preparing ELITH-Thailand progress report before meeting with Chris and Ali

22 September 2015 Meeting with Chris and Ali for collaboration of ELITH-Thailand, China, and UK.

29 September 2015 Discussion on progress of development of energy and GHG emission rating method.

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2. Meeting with Ali for collaboration between ELITH - Thailand and China

On August 4, 2015, Dr. Surapong, Dr. Pipat, Dr. Surawut, and Mr. Preecha met with Dr. Ali to discuss about the collaboration of ELITH - Thailand and China (Figure 1). A joint dissemination and translation of a book (written by Ali and Chris) are ones of the concreted collaboration.

Figure 1. Meeting with Ali.

3. Meeting with Chris and Ali for collaboration of ELITH - Thailand, China, and UK

On September, 2015, Chris and Ali come to Thailand to meet ELITH - Thailand team (Figure 2).

Follows are minutes of meeting noted by Chris.

3.1 Status

Brief exchange of status and summary of contents of work going on.

3.2 Proposed seminar/symposium

- Suggested date: March.
- Format: two days, but important guests are likely to attend for only a half day, so the program must be planned accordingly. Second day to be mainly workshops in smaller subgroups.
- Budget: funds will be needed if many from outside are to be paid for travel etc.
- Target audience: partly for logistical and language reasons, the main focus should be Thailand dissemination: the NHA, Bangkok Metropolitan Authority BMA, the Electricity Authority EGAT, city planners and authorities; other ministries (Energy, Public Works), if possible Real Estate Institute or Developers; maybe other academic/research contacts? From outside: if possible a few important MECON contacts; perhaps a couple from Ningbo and Uganda. Also, send invitations to UN Habitat, ASEAN and many similar important authorities who cover their own costs. Limiting this seminar to mainly Thailand dissemination makes things simpler, and still very useful.
- Contents: Housing issues related to energy and climate, trends, and policy directions, including: steps towards rating/certification schemes, focus on community qualities as well Thailand: Project Progress (July - September 2015) 4 as energy, the importance of urban (meso) scale not only individual buildings, and processes towards sustainability: from guidelines to regulations, European experiences, etc
- Allies: primarily the NHA (get them involved in planning the March seminar?). Also the Nat.Envir. and Energy Office (name??). ASEAN have worked with ISO and appliance certification for 20 years, get their interest to extend this to buildings, as in OECD countries.

3.3 (a) Embodied energy

Siriluk presented the Thai regional studies, with embodied energy and carbon figures and considerations of alternative materials – brick, as well as lightweight options such as fibre cement panels. Traditional houses have very low EE/EC. So do earth houses in Africa (and China). This argues in favour of simpler materials.

Pipat and Pattana discussed the 150m² test house which is being built.

Chris presented typical figures from European experience, including a very low EE Norwegian house, and intends to produce a comparative paper discussing trends and what can be done in hot climates – in collaboration with Siriluk hopefully. To include a hot – dry climate example if possible. It seems that in all climates, we can and should achieve figures of well under 100 kg CO₂ e/m² in modern sustainable housing.

We are both using ICE. Chris has added an analysis of the minor items and fixed interior fittings – tiles, sanitary, paints, ironmongery etc– assumed as standard in all house models being compared, this adds 10 – 15% to the EE/EC which is worth noting.

We also discussed the operational energy (OE/OC) and how the trend is similar in all climates, covering the remaining low OE needs with PV roofs (integrated PVs). With similar figures for energy needs in hot and cold climates! With a very rough estimate, the 10kW capacity of PVs on the KMUTT test house means its annual energy need is around 80kWh/m², which is similar to typical passivhaus European houses.

Please check this? And how much of that is for the space cooling – what comfort levels (indoor temperatures) are you taking as baseline? The passivhaus norm is around 15kWh/m² for space heating and the rest for hot water + electrical appliances.

Chris also presented two topics for papers, one about how LCA accounting methodology of post use energy/carbon is incomplete, and one on the large EE/EC impact of the site works and infrastructures.

We also discussed materials. Cement and steel are the “main” EE/EC problems. Chris noted

the growing potential of biomaterials and how this could be a very big topic to focus in hot climates in future. There is a lot of official EU and industry interest. These include hemp, and a large range of plant materials are available in tropical countries, many of which have been researched but for other purposes not for building materials.

3.3 (b) Urban housing blocks

Ali – discussion on China urban housing blocks. Interest to find examples in Bangkok to study and do a comparative analysis between models in China and Thailand.

Interest of the older 6 - storey housing model. “Practical guidance and policies for Green Cities” – quite many such documents are available from UK and other cities.

We discussed the fact that one can achieve equally high density of population without high rise - with low rise cities, and that these may have several other advantages, both energy/carbon as Thailand: Project Progress (July - September 2015) 5

well as social. And probably especially relevant for lower income developments. This is to be one main theme for the March event.

Also that it is better and more economical to solve some things on the urban level rather than in individual buildings. For example district cooling - which is also the only way to reduce the heat island effect produced by air conditioning. Chris is doing a project on that topic.

3.4 Certification

Presentation of the KMUTT work - to propose a system for Thailand, hopefully to be implemented by NHA, in the direction of future guidelines and building regulations too. This is relevant for us all.

NHA are also interested in the social/community aspects of sustainability. This ties in very well with our goal of a holistic approach. The community qualities should be a theme for discussion at the March seminar. European eco - districts like Vauban are almost all low to medium rise.

We discussed in particular, the necessary processes to take place over time. For example, the Ningbo infrastructure brochure (see below) aims to influence developers (and city planners) in a simple way. If the NHA can test out a rating system then it can slowly be improved, become effective and be accepted. It would be useful to bring in European experience of these processes, including mistakes made and ways NOT to do this!

This focus on processes and experiences should also be a feature of the March seminar, maybe presented by Chris (has already written a working paper on "the Dynamics of Change"). Identify the interested parties who can be allies. There is little public interest so far, or from developers, but there are green designers as well as national policy/climate objectives. Also cities have sustainability goals. And the NHA is an excellent starting point.

3.5 General

We did not much discuss limitations, progress and how we might approach the final stages of the project. Such as, structuring final project meetings, workshops and dissemination.

3.6 Green infrastructure document

Preparation for Thai translation and coordination for dissemination of the document in Thailand. This document was finalized and released in August 2015 in a dual language format (English and Chinese).

3.7 Other notes from the meeting

KMUTT informed about the MECON project. There are some interesting contact persons who would be good to get to the March meeting.

The KMUTT test house should be seen as an important dissemination output.

Solar thermal, which is higher efficiency, to improve efficiency of absorption chillers (Surapong)

NHA is also interested in the issue of ageing population in houses, especially in suburban and rural areas. Need for “generation housing” design, as in Scandinavia?

Urban resilience, flooding etc – green roofs are mandatory in some European cities – to

reduce/delay storm water flow - also good for energy, biodiversity, and heat island, even more in hot climates.

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Siam Cement Group is a key contact if one can get them interested ... we are not only “the enemy” of cement, but are very interested in their improvements. Chris offers contacts to the very advanced Norwegian cement company.

Received from KMUTT: draft papers on (a) Rating System for housing energy and carbon, and (b) the regional houses energy surveys.

KMUTT will try to organize a meeting including Ali with NHA in approx. November.

Figure 2. Meeting with Chris and Ali.

4. Output in This Quarter I - Embodied Energy and Embodied Carbon of Low Income Houses in Thailand

The past report (April - June) presented alternative building models, their BOQ, embedded energy, and GHG emissions of the rest of the houses found during the surveys to illustrate the change, and the impact on energy use and GHG emissions. The representative houses of each region were selected based on designs of existing and near future house which are mostly concrete houses. In this quarter, the report presents embodied energy and embodied carbon of the houses found during the surveys to illustrate the change, and the impact on energy use and GHG emissions.

5. Output in This Quarter II - Framework Outline for an Energy and Carbon Rating Scheme for Design of a Residential House

The objective of another work during this period is to develop building energy rating scheme for residential buildings. The report presents framework outline for an energy and carbon rating scheme for design of a residential house. The scheme covers energy use and carbon emission from construction materials used and scheduled operational occupancy of a house based on house design,

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scheduled cooling and lighting. A certified house must meet thermal comfort, light quality, and potential natural ventilation requirements. The scheme rates a house design into four levels: certified, distinct, highly distinct, and excellent.

Summary of Project Activities

Period: October - December 2015

This report provides a summary of activities undertaken during quarter 10 (October - December 2015) of the project. The major activities are described as follows.

1. Regular Project Meeting

Regular project meetings were held every week. The meeting day in this period was mainly on Tuesday afternoon. The agendas of the meetings during October - December 2015 are shown in Table 1.

Table 1. Meeting activities.

Date Activity

6 October 2015 Discussion on development of building envelope performance indicators of bedrooms and a study on results of natural air flow through residential houses.

19 October 2015 Discussion on development of building envelope performance indicators of living rooms and preparations for meeting with NHA on November 2015.

27 October 2015 Discussion on preparation of meeting with NHA on November 2015

(Continued).

6 November 2015 Discussion on preparation of the presentation files for meeting with NHA.
13 November 2015 Discussion on preparation of ELITH seminar on March 2016 and details of energy and carbon rating scheme of residential houses.
20 November 2015 Discussion on preparation of the presentation files for meeting with NHA and details of energy and carbon rating scheme of residential houses.
27 November 2015 Meeting with NHA at NHA office.
8 December 2015 Discussion on preparation of ELITH seminar on March 2016.
15 December 2015 Discussion on details of energy and carbon rating scheme of residential houses.
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2. Meeting with NHA Staffs at NHA Office (November 27, 2015)

On November 27, 2015, ELITH - Thailand members had a meeting with NHA staffs. The discussion is for Asia dissemination seminar during March 23 - 25, 2016.

Figure 1. Meeting of ELITH - Thailand and NHA Staffs at NHA Office (November 27, 2015)

3. Output in This Quarter

An output report entitled "Detail of an Energy and Carbon Rating Scheme for Design of a Residential House" is attached with this progress report. In that report, overall concepts and details of an energy and carbon rating scheme for design of a residential house are presented. The authors utilize the procedure and data used in the construction of performance indices of the three major building systems in the new building energy code for identification of the performance of corresponding systems of a target building. Three levels of energy performance are adopted for each system. The regression equation used similar to the code is modified for use in the rating scheme. It is used to calculate energy consumption of reference buildings, each building equipped with each major system of a performance level. When billed energy consumption of the target building falls within the range of energy consumption of the reference building of a given level of energy performance, the target building is adjudged to possess the given level of energy performance.

Summary of Project Activities

Period: January - March 2016

This report provides a summary of activities undertaken during quarter 11 (January - March 2016) of the project. The major activities are described as follows.

1. Regular Project Meeting

Regular project meetings were held every week. The meeting day in this period was same as previous period, mainly on Tuesday afternoon. The agendas of the meetings during January - March 2016 are shown in Table 1.

Table 1. Meeting activities.

Date Activity

5 January 2016 Discussion on details of the energy and carbon rating scheme of residential houses.

12 January 2016 Discussion on housing model to be used to evaluate the energy and carbon rating scheme of residential houses.

19 January 2016 Discussion on preparations of the dissemination seminar on 23 - 24 March 2016.

2 February 2016 Discussion on preparations of the dissemination seminar on 23 - 24 March 2016 and potential assessment method of the developed energy and carbon

rating scheme.

9 February 2016 Discussion on preparations and detailed schedule of the dissemination seminar on 23 - 24 March 2016.

17 February 2016 Discussion on the potential assessment method of the developed energy and carbon rating scheme and preparations and detailed schedule of the dissemination seminar on 23 - 24 March 2016.

23 February 2016 Discussion on name list of participants and the invitation letters.

9 March 2016 Discussion on the potential assessment method of the developed energy and carbon rating scheme.

15 March 2016 Discussion on presentation preparations of the dissemination seminar on 23 - 24 March 2016.

21 March 2016 Discussion on presentation preparations of the dissemination seminar on 23 - 24 March 2016.

23 March 2016 ELITH partner meeting.

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24 March 2016 ELITH dissemination seminar.

29 March 2016 Discussion on summary report of the dissemination seminar.

2. ELITH Partner Meeting

(March 23, 2016) (Detail is in the attached file entitled "Output 1 - ELITH Partner Meeting".)

3. ELITH Dissemination Seminar

(March 24, 2016) (Detail is in the attached file entitled "Output 2 - ELITH Dissemination Seminar".)

SEE "PROCEEDINGS" FOLDER