WP2: Energy / Carbon / IEQ Performance
Phase Development and Discussion

Borong LIN

Profossor, Asst. Dean

School of Architecture,

Tsinghua University

Task Description

- WP2 will address this need and also contribute to the assembly of a unique database relating to the interlinked total performance gaps.

- The initial monitoring work **(Phase 1a – Preliminary Monitoring Study)** will also allow us to identify the most suitable buildings for the next stage of the work **(Phase 1b – Detailed Monitoring Study).**

- **Phase 2** will integrate monitoring and modelling approaches.

- This phase of the work will develop semi-automated building assessment methods, technologies and tools to enable rapid characterisation of probable pathologies to determine the most cost-effective route to remedy the underlying root causes of energy/IEQ underperformance.

- These methods will be informed by the work being undertaken in the IEA Annexes led by the project team.

- ***<u>Phase 1 – Monitoring and Data collection</u>***
  - ***Phase 1a. Preliminary Monitoring Study (24 buildings)***
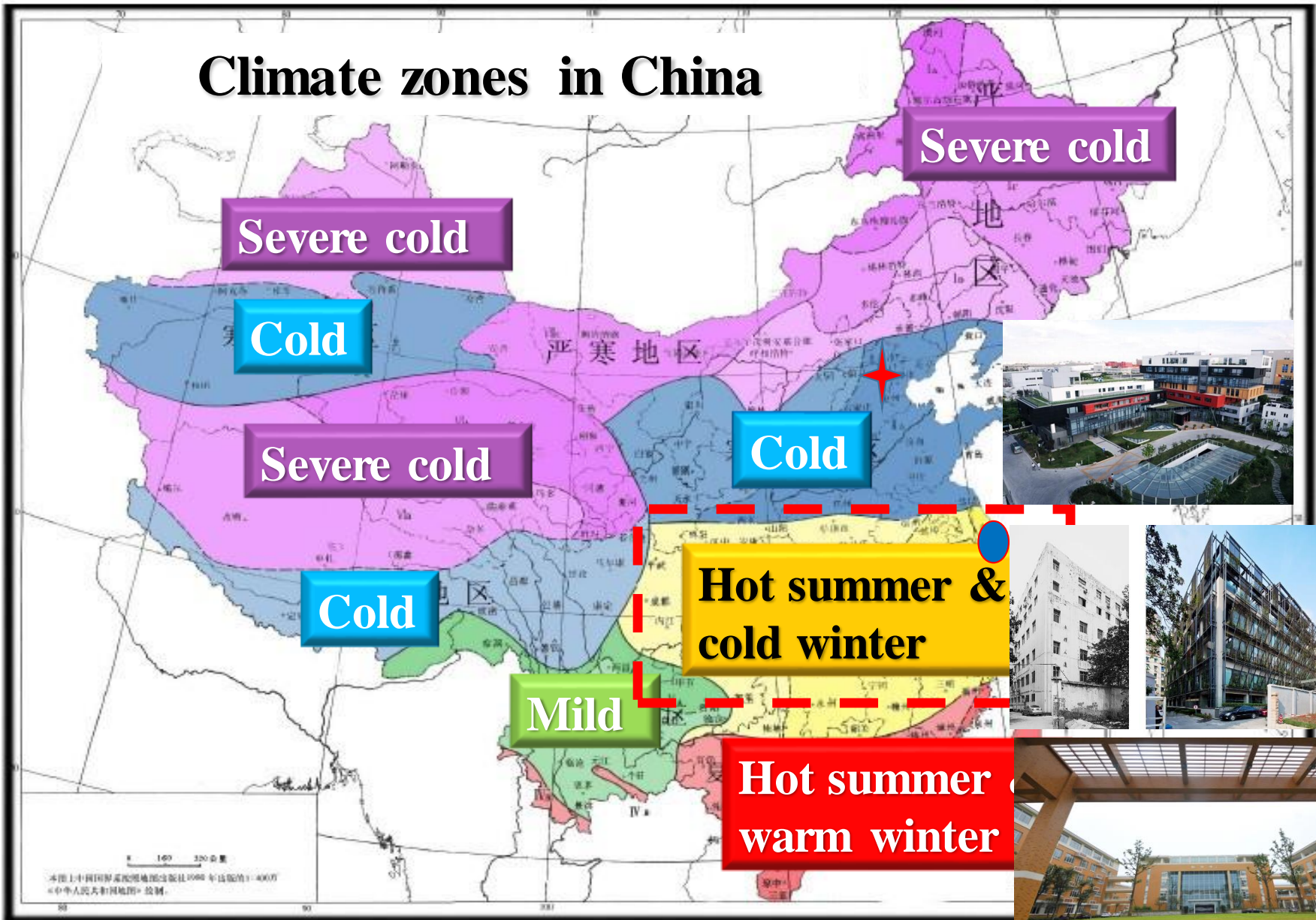 - ***Phase 1b. Detailed Monitoring Study (8 buildings)***

- ***<u>Phase 2 - Integration of Monitoring and Modelling</u>***
  - Phase 2 of WP2 will focus on the ***integration*** of monitoring and modelling work in order to develop semi-automated building assessment methods and tools, applicable to a wide range of non-domestic and large apartment buildings, enabling rapid characterisation of probable building systems pathologies and remedy the underlying root causes of underperformance

- Preliminary monitoring: should be done by Feb. 2017
- What have already been done for preliminary monitoring
  - Buildings are chosen, access to the investigated buildings has been built
  - Monitoring methodology has been developed, including: protocol, devices and questionnaire
  - Pre-test to validate the methodology has been done
- Nest step
  - Monitoring and survey

Year	2015				2016												2017												2018						
Month	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	2	3	4	5	6	7	8
WP2. ENERGY/CARBON/IEQ PERFORMANCE																																			
Phase 1a – Preliminary Monitoring																																			
Arrange details of access to monitored buildings																																			
Construct monitoring network																																			
Monitor buildings																																			
Questionnaire development																																			
Occupant Surveys																																			
Phase 1b – Detailed Monitoring																																			
Identify buildings to monitor in detail																																			
Implement new monitoring network																																			
Monitor buildings																																			
Occupant Surveys																																			
Phase 2 – Integration of monitoring and modelling																																			
Develop base building physics models																																			
Calibrate base models against monitored data																																			
Derive criteria for calbration success (long term monitoring)																																			
Develop key performance indicators																																			
Incorporate stochastic occupant behaviour into models																																			
Develop optimal automatic control strategies for indoor environment																																			

Part 1: Buildings to be investigated

Climate zones in China

Severe cold

Severe cold

Cold

Severe cold

Cold

Cold

Hot summer & cold winter

Mild

Hot summer & warm winter

Standardized Methodology

- Why we need a standardized monitoring methodology
- Comparable monitoring results between the UK and China
  - Able to be integrated into the following up modelling

- What should be included
  - Information needed to be collected
  - Monitoring methodology

Information to be collected

- Building information crucial to total performance of buildings
    - Location
    - Geometry
    - Function
    - Fabric
    - HVAC system

Information to be collected

- Energy consumption
  - Energy sources and consumption
    - Need to specify how the data is collected: energy bill/field measurement/simulation?
  - On-site renewables or CHPs
    - Mainly for residential in the UK and commercial buildings
  - Operating hours
    - An estimation only, do not need to be very accurate

- Indoor Environment Quality
  - Objective parameter -- field monitoring
  - Subjective response -- survey

- Monitoring parameters
  - *Thermal environment*: air temperature, globe temperature, humidity
  - *Acoustic*: external noise environment, internal acoustic environment
  - *Photometric*: illuminance on working level
  - *Air Quality*: concentration of CO_2, PM2.5, VOC
- Sampling duration and interval
  - Duration
    - No less than: one week in heating, cooling and transit seasons respectively.
  - Interval
    - Recommended: every 5 minutes
    - Maximum: every 10 minutes.

Monitoring methodology

- Sampling size
  - Minimal sampling size = min(f(Gross floor area), 10)

Table: f(Gross floor area)

	Residential (Apartment)	Office	School	Hospital
Air temperature	GFA/2000	GFA/2000	GFA/1000	GFA/1000
Humidity	GFA/2000	GFA/2000	GFA/1000	GFA/1000
Globe temperature	GFA/4000	GFA/4000	GFA/2000	GFA/2000
External acoustic	2	2	2	2
Internal acoustic	GFA/4000	GFA/4000	GFA/2000	GFA/2000
Illuminance	GFA/4000	GFA/2000	GFA/1000	GFA/2000
CO_2 Con.	GFA/2000	GFA/2000	GFA/1000	GFA/1000
PM2.5 Con.	GFA/2000	GFA/2000	GFA/1000	GFA/1000
VOC Con.	GFA/2000	GFA/2000	GFA/1000	GFA/1000

- Chosen of monitoring sites
  - Representative floors, orientations, function zones and HVAC zones should be monitored

Monitoring instruments

Environment sensors with WIFI

Measured parameter	Valid range	Uncertainty
Air temperature	-40 ~ 100 ^{Oc}	$\pm$ 0.5^{o}C
Air humidity	0 ~ 100%	$\pm$ 3%
luminance	0.01~20000lux	$\pm$ 3%
Noise intensity	30~130dB	$\pm$ 1.5dB
CO_2 concentration	0~5000ppm	$\pm$ 75ppm
Globe temperature	-20~80°C	$\pm$ 0.3^{o}C

Subjective survey _ questionnaire

Questionnaires

- **Occupants survey**
  - Office –staff
  - School-students
  - Hospital- patients
  - Residential –residents

- **Different season**
  - Spring/Summer/Autumn/Winter

- **Type of questionnaires**
  - Less than 4 page
  - Choice & scoring
  - Online / Paper

非常满意 👍　○ ○ ○ ○ ○ ○ ○ ○ 👎 非常不满意

0　　　　　　　　　　　　　　　　　**10**
Dissatisfied　　　　　　　　　　**Very Satisfied**

Questionnaires
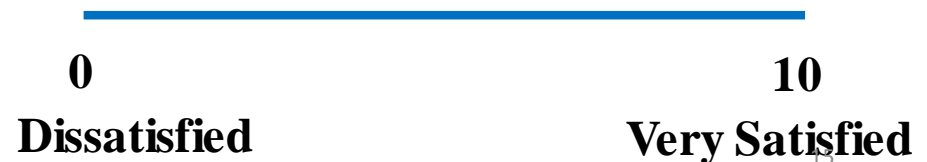
- Assessment contents (including but not limited)
  - Subjects' information
    - Age
    - Professional
    - Title
    - Occupied time
  - Physical environments' evaluation
    - Thermal
    - Luminous environment
    - Acoustic environment
    - Air quality
  - Service perception
    - Traffic convenience (elevator)
    - Cleanliness
  - Behavior performance
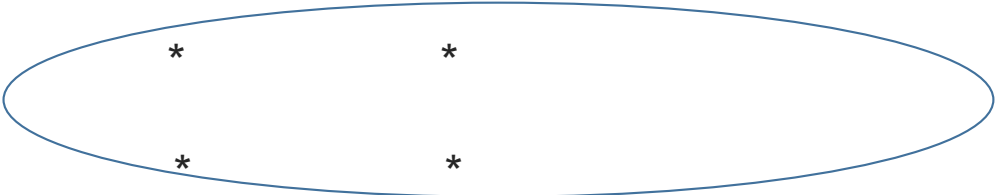   - Duration time
    - Adjustments

Pre-field Measurement

Geometry

HDD=1453

CDD=27

Gross Floor Area(m2)	20000	30000
Height(m)	60	80
Floor	22	27
Shape coefficient	*	*
Window to wall ratio	*	*

Get from designers

iBEM

Parameters：

Temperature，relative humidity，illumination，CO_2，PM2.5

To be discussed

- **Breakthroughs we are going to achieve in this research ?**

- **Which kind of conclusion can be drawn from this large scale monitoring?**

- **Why our research is unique and advanced compared with the previous research in the field of on-site monitoring of energy consumption and indoor environment quality?**

- **How to closely integrate our monitoring results with building performance modelling as well as system dynamic modelling ?**

- **Other types of buildings needs to be included?**
  - **Shopping Mall ?**
  - **……**
- **What kinds of the rooms should be investigated for different types of buildings?**
  - **Direction ?**
  - **Floors?**
  - **With or without opening windows?**
  - **……**

- **Which questionnaires to be used, Tsinghua or BUS?**

- **About occupants**
    - **Any other types of occupants need to be concluded?**
    - **One subjects survey for more times or one time ?**
    - **Assessments at the moment or at review ?**
    - **How to distinguish the occupants who knows the real IEQ and who not which might influence their assessments?**

- **How to combine (relate) the questionnaires used in WP2 with (to) the WP3 research?**

- **What the project really needs from the questionnaires survey ?**

Thank you for your attention!