12.1 GENERATING URBAN-SCALE BUILDING DATA TO SUPPORT CLIMATE MODELING

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1. INTRODUCTION

The World Urban Database and Access Portal Tool (WUDAPT) project is a community-led initiative to acquire detailed data on cities that are relevant for urban climate studies. WUDAPT data is organised into three levels based on the precision of the data.

At the lowest level (L0) the local climate zone (LCZ) scheme is used to categorise an urban landscape into different neighbourhood types. Each type is associated with a set of parameter values that describe aspects of the form and function of the landscape, such as sky view factor, anthropogenic heat flux, etc. These data provide a way of assigning urban canopy parameter values (UCPs) that can be used in urban climate models. This approach has allowed the application of models in cities where there is little data currently available. However, L0 data does not meet the needs of many in the scientific community who require more precise spatial and attribute information. WUDAPT Level 1&2 data are designed to meet these needs.

In this presentation, the authors outline a potential path to getting information for buildings at an urban scale using a typology approach. These data should include information on building location, dimensions and fabric. Ideally, it should also include building use and energy information. At an urban scale, these data can be used to generate detailed geographic data on thermal admittance, surface roughness, albedo, etc. for urban climate models (UCM). They can also be used to run Urban Building Energy Models (UBEM) which have emerged as a tool for examining energy demand at urban scales and evaluating policy options (Monteiro et al, 2018; Reinhart and Davila, 2016). Much of the data needed by UBEMs corresponds to that needed by UCMs. Here, building scale data acquired for a case study city (Dublin) is presented and these are used to run an Urban Building Energy Model (UBEM) for a selected neighbourhood.

2. DATA ACQUISITION

In Europe, the Typology Approach for Building Stock Energy Assessment (Tabula) project has developed a database of residential building types for 21 countries (www.episcope.eu). This database identifies common building types with attributes on age of construction, building (wall, window, floor and roof) materials, insulation properties and HVAC systems. The information sheets for each archetype also includes estimated energy consumption (kWh/m²/yr) and retrofit options (Tabula, 2014).

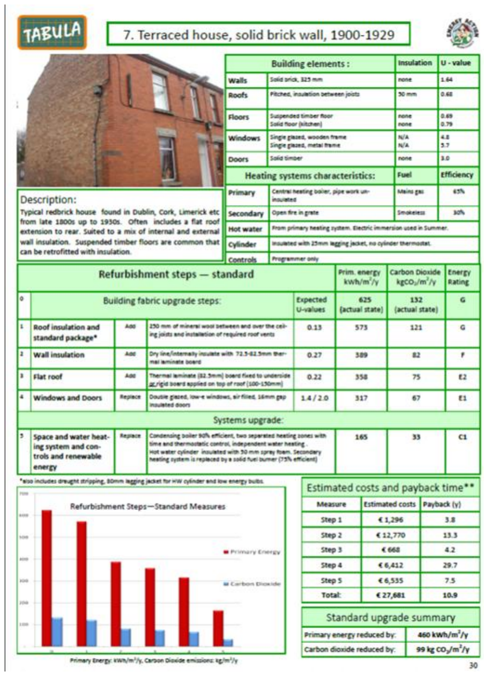

Figure 1. An example of the information sheet that links a photograph of the building to its attribute.

The database for Dublin was created using: a digital map of building footprints and heights; Census data that record household characteristics for areas; the Tabula classification of building types; available imagery from Google Earth Pro (GEP) and Street View (GSV). This information is managed within Quantum GIS, an open source geographic information system. These tools were used to visually classify over 30,000 buildings in Dublin city centre into types (Figure 2).

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Each building type is linked to Tabula information. For example, type 3 above is a terraced house constructed prior to 1900; it has uninsulated brick wall (325/225 mm thick), a roof that is front pitched with little insulation and single glazed windows with wooden frames. As built originally it has an energy rating (based on standard occupation patterns) of 352 kWh/yr.

Figure 2. The most common residential building types in the study area.

3. URBAN BUILDING ENERGY MODEL

The UBEM used here is the Urban Modelling Interface (UMI), which is designed by the Sustainable Design Lab in Massachusetts Institute of Technology (MIT) for simulating environmental performances of buildings at urban scales. Davila et al. (2016) used UMI to simulate the energy demand across Boston (US) using a GIS building database and customised library of building archetypes. UMI uses Rhinoceros Computer-Aided Design programme (Rhino) to integrate building information which is coupled to a building energy model (DOE's EnergyPlus). The results were compared with US national energy consumption surveys and demonstrated the potential of UBEMs to identify policy and renewable technology interventions at the building/neighbourhood scale. This approach can be replicated where suitable building typologies are available.

Here, we evaluated the potential for integrating Tabula-derived building data into UMI. The selected neighbourhood (Stoneybatter, Figure 3) is comprised of working-class housing built in the early 20th century. The typical houses are cottages and two-storey houses arranged in terraces. According to Tabula, these houses were constructed between 1900 and 1929; the envelope consist of uninsulated brick 325 mm thick, the pitched roof has 50 mm of mineral wool and the windows are single glazed. As a result, the energy rating estimates an annual demand of 350-480 kWh/m²/yr. This type of building makes up 37% of the overall housing stock in the city centre and pose a particular difficulty for retrofit as the wall is a solid construction.

Figure 3. The Stoneybatter neighbourhood in Dublin.

Each building in the study area was decomposed into individual facets to which the fabric attributes were assigned (Figure 4). The HVAC system of the dwelling and standard occupancy rates were applied to simulate energy use in the context of Dublin's climate. Hourly simulations can be performed but here we present the annual energy demand in kilowatt hours per square metre (kWh/m²/yr). This was done to allow comparison with the available energy data.

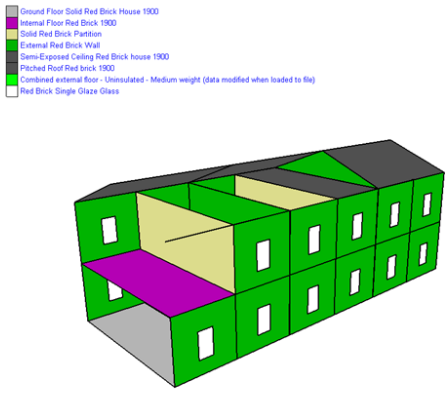

Figure 4. A cross section of a set of terraced buildings in the study area. Each facet is assigned the fabric attributes for that building type.

4. RESULTS

There is no energy data available at a household level and no information on detailed occupancy. In the UMI simulations, we used standard residential occupancy patterns to derive an annual energy demand (kWh/m²/yr). These simulations are comparable to building energy rating (BER) values that are assigned to households that are rented or sold (CSO, 2018). These BER data are available for census areas.

Table 2 shows the observed and simulated energy ratings for Stoneybatter and the nine census areas that comprise the study area. The UMI simulations are generally within 20 kWh/m^2/yr of the observed value and the largest difference is 70. Overall, the rating for the building stock is estimated at 390 kWh/m^2/yr and the UMI simulation was 393. The results indicate that for a significant proportion of the building stock in Dublin built in the early 20th century remains intact as energy inefficient neighbourhoods, despite policy initiatives over the last two decades.

Rating		UMI	
kWh/m^2/yr	kgCO2m^2/yr	kWh/m^2/yr	kgCO2m^2/yr
377	104.2	372	102.8
480	132.6	410	113.3
369	102	396	109.4
382	105.6	398	110
350	96.7	388	107.2
366	101.1	383	105.8
384	106.1	409	113
425	117.4	399	110.2
377	104.2	383	105.8

Table 1. A comparison of the energy rating data (based data gathered when a property is rented or sold) and the UMI simulations in the Stoneybatter case-study area.

5. **DISCUSSION & CONCLUSIONS**

Ching et al. (2019) outlined an approach to generating higher level data within the WUDAPT framework. Part of this strategy described a typology approach to acquiring information at a building scale in cities globally. Implementing this would require an international set of archetypes that could be used to classify individual buildings into types with associated geographical, dimensional, material and occupational attributes. Given the scope of what is proposed, the WUDAPT strategy is to sample urban landscapes strategically, perhaps using the LCZ (Level 0) maps as a suitable frame. This strategy would rely on citizens to generate information on building stock and on experts to create suitable typologies (similar to Tabula) that link attributes to types. WUDAPT is working to develop simple tools that can be used to make these links. The evidence presented here indicates that this is a viable means of gathering building level data on form and function for climate.

Knowledge of building form and function is needed for both urban climate/meteorology (outdoor) and building energy (indoor) applications. Traditionally, the research communities associated with the outdoors and indoors have evolved independently and employ different techniques to express energy exchanges that are common to each. The development of both UBEMs and the improved spatial precision of UCMs provides an opportunity to co-ordinate data gathering around a common set of attributes. These data would be sufficient to both: simulate neighbourhood scale climate and building energy demand, anthropogenic heating, CO_2 emissions, etc.

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