

# CityBEM: Monthly Heating and Cooling Energy Needs for 3D Buildings in Cities



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**Syed Monjur Murshed**  
*European Institute for Energy Research, Germany*

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| CityBEM: Monthly building heating and cooling energy needs in cities





- Research background
- Objectives
- Application of CityBEM
- Methodology
- Results and validation
- Conclusion



- In the context of **smart and low carbon cities**, increasing energy efficiency, reducing GHG emission, etc. play an important role
  
- **Buildings** are responsible for 40% of energy consumption and 36% of CO<sub>2</sub> emissions in the EU (EU 2011)
  
- **Building Energy Models** (BEM) can help to investigate detailed measures e.g., refurbishment plans, etc.
  - > several such **models** (statistical vs. engineering), **standards**, **tools/software** exist to calculate energy (heating and cooling) needs
  - > models are prepared and applied at different **spatial** and **temporal** extents and/or scales
  - > one of the widely used standard is **ISO 13790:2008** (ISO 2008)



## ISO 13790:2008 using non-GIS data

- + Widely used standard, applied in different countries (Vollaro et al. 2014, Vatières et al. 2013, Kim et al. 2013, etc.)
- + Internal validation of model

- Considers single building
- Cannot perform citywide calculation

## ISO 13790:2008 using 3D city models

- + With the availability of 3D city models and different LODs, ISO standard is applied (Eicker et al. 2012, Nouvel et al. 2015, Agugiaro 2016) in many cities

- Only heating energy demand is calculated
- Mostly on residential districts
- Robust validation is missing



- Implement the **ISO 13790:2008 standard** using the 3D city models to calculate the monthly building **heating and cooling energy needs in cities => CityBEM**
- Use open source and mostly publicly available datasets, tools and software to develop the CityBEM
- Perform a **quick and robust calculation** at a city scale
- Perform a 3-step **validation** of the CityBEM model

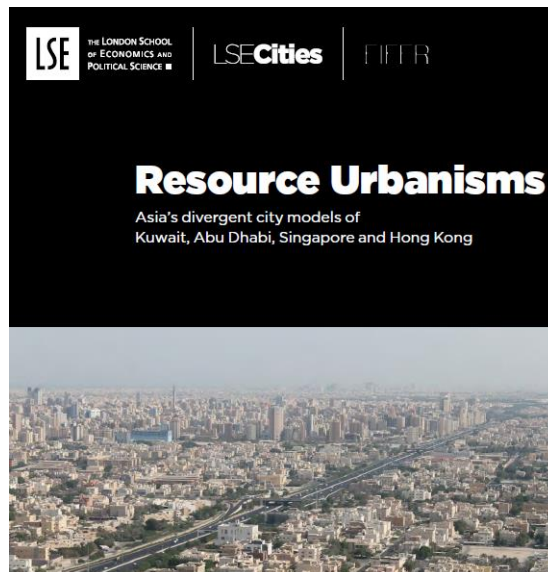


This contribution has been peer-reviewed. The double-blind peer-review was conducted on the basis of the full paper.  
<https://doi.org/10.5194/isprs-annals-IV-4-W5-83-2017> | © Authors 2017. CC BY 4.0 License.

## **CITYBEM: AN OPEN SOURCE IMPLEMENTATION AND VALIDATION OF MONTHLY HEATING AND COOLING ENERGY NEEDS FOR 3D BUILDINGS IN CITIES**

Karlsruhe

Murshed, S. M., Picard, S., Koch, A. (2017). "CITYBEM: AN OPEN SOURCE IMPLEMENTATION AND VALIDATION OF MONTHLY HEATING AND COOLING ENERGY NEEDS FOR 3D BUILDINGS IN CITIES." ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci. IV-4/W5: 83-90.



Kuwait

Abu Dhabi

Singapore

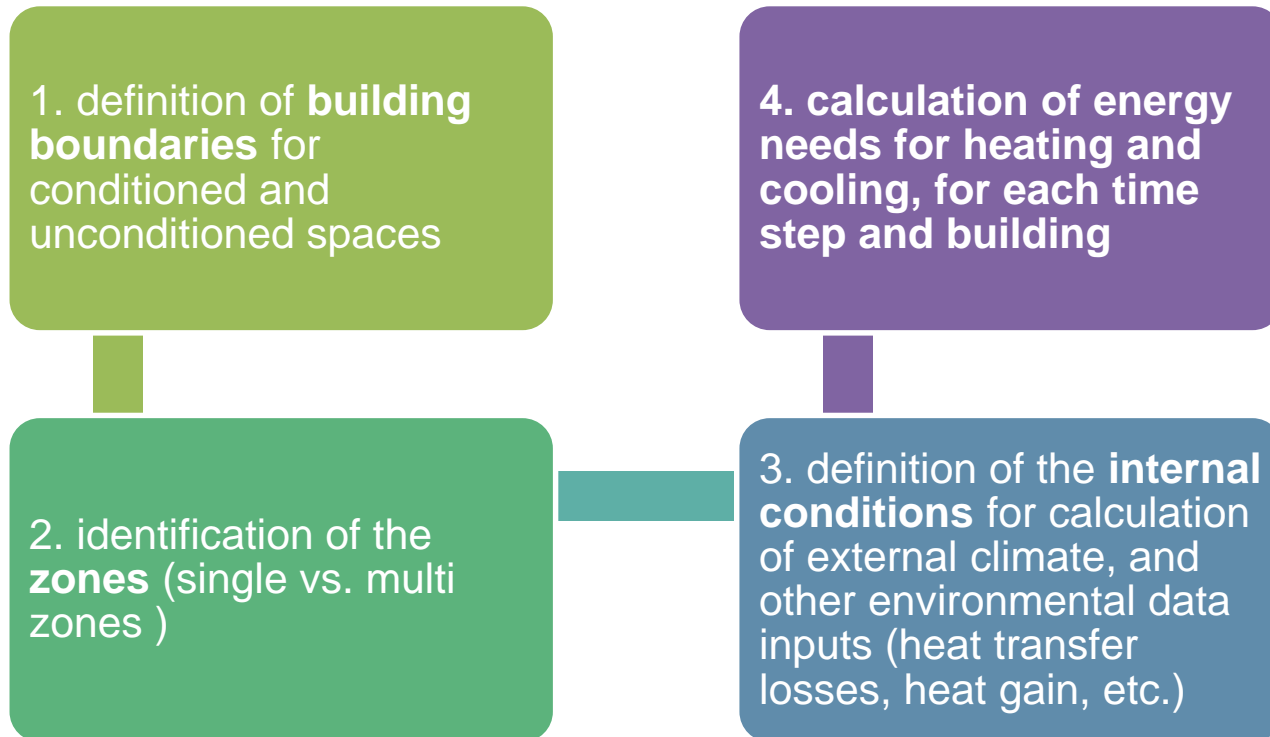
Hong Kong

Rode, P., A. Gomes-Peca, M. Adeel, S. M. Murshed, A. Koch, Wendel, J., Duval A. (2017). Resource Urbanisms: Asia's divergent city models of Kuwait, Abu Dhabi, Singapore and Hong Kong. London, United Kingdom, LSE Cities, London School of Economics and Political Science: London 71.

<https://lsecities.net/objects/research-projects/resource-urbanisms>



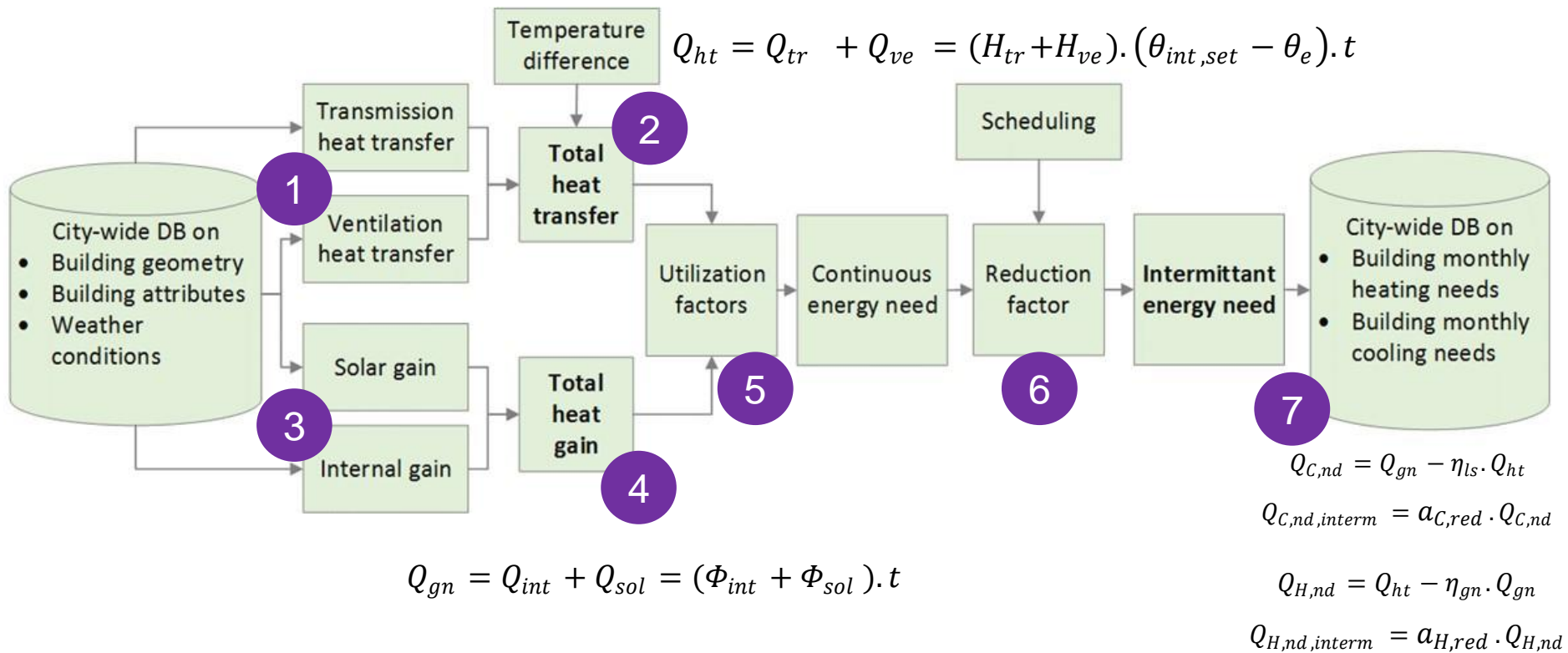
ISO standard is structured into 4 main blocks:





## 4. calculation of energy needs for heating and cooling, for each time step and building

7 main calculation steps:







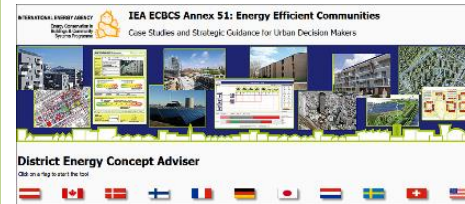
## Building geometry

- Wall area N, S, E, W
- Volume
- Floor area



## Building typology

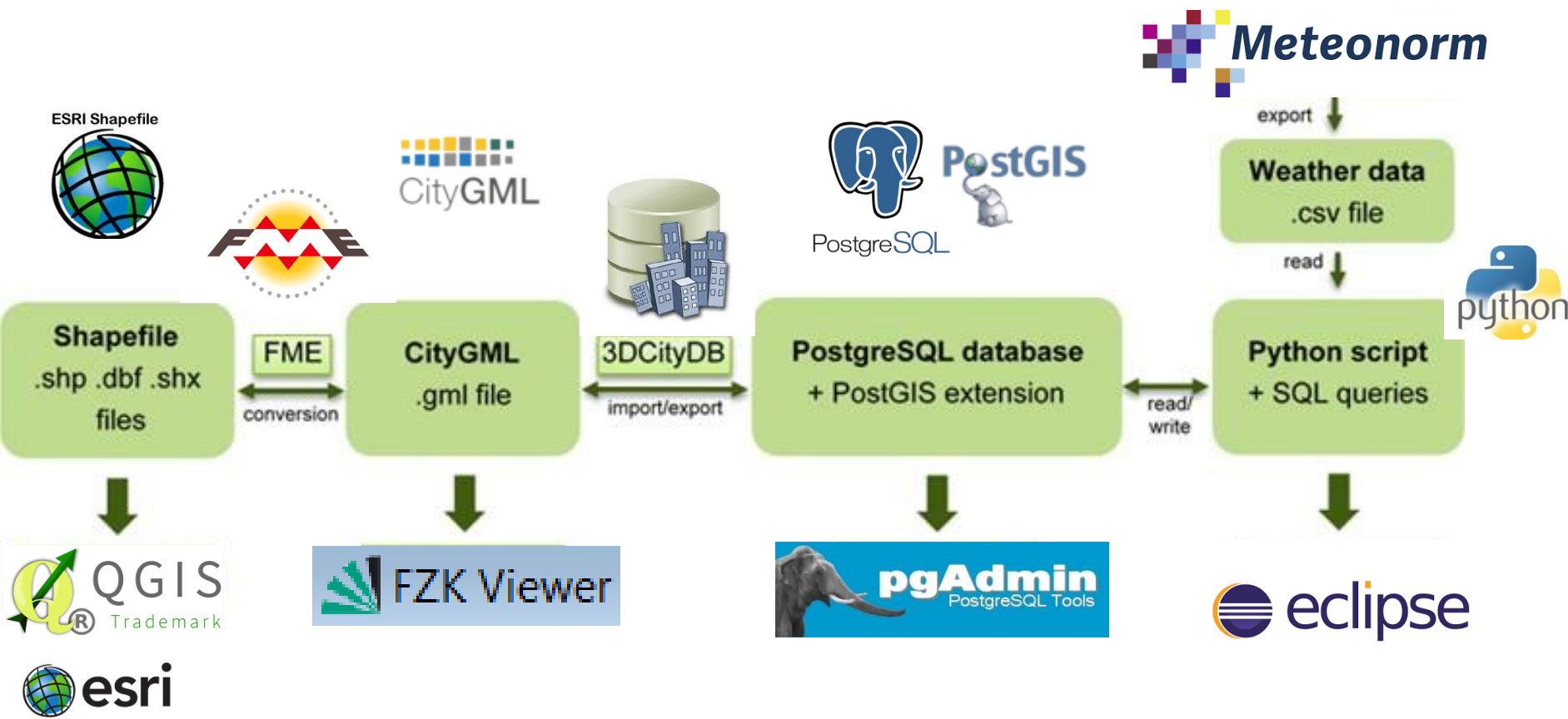
- Window area N, S, E, W
- U values wall, roof, window, ground
- G values window
- Thermal bridges
- Infiltration
- Ventilation
- Internal gain

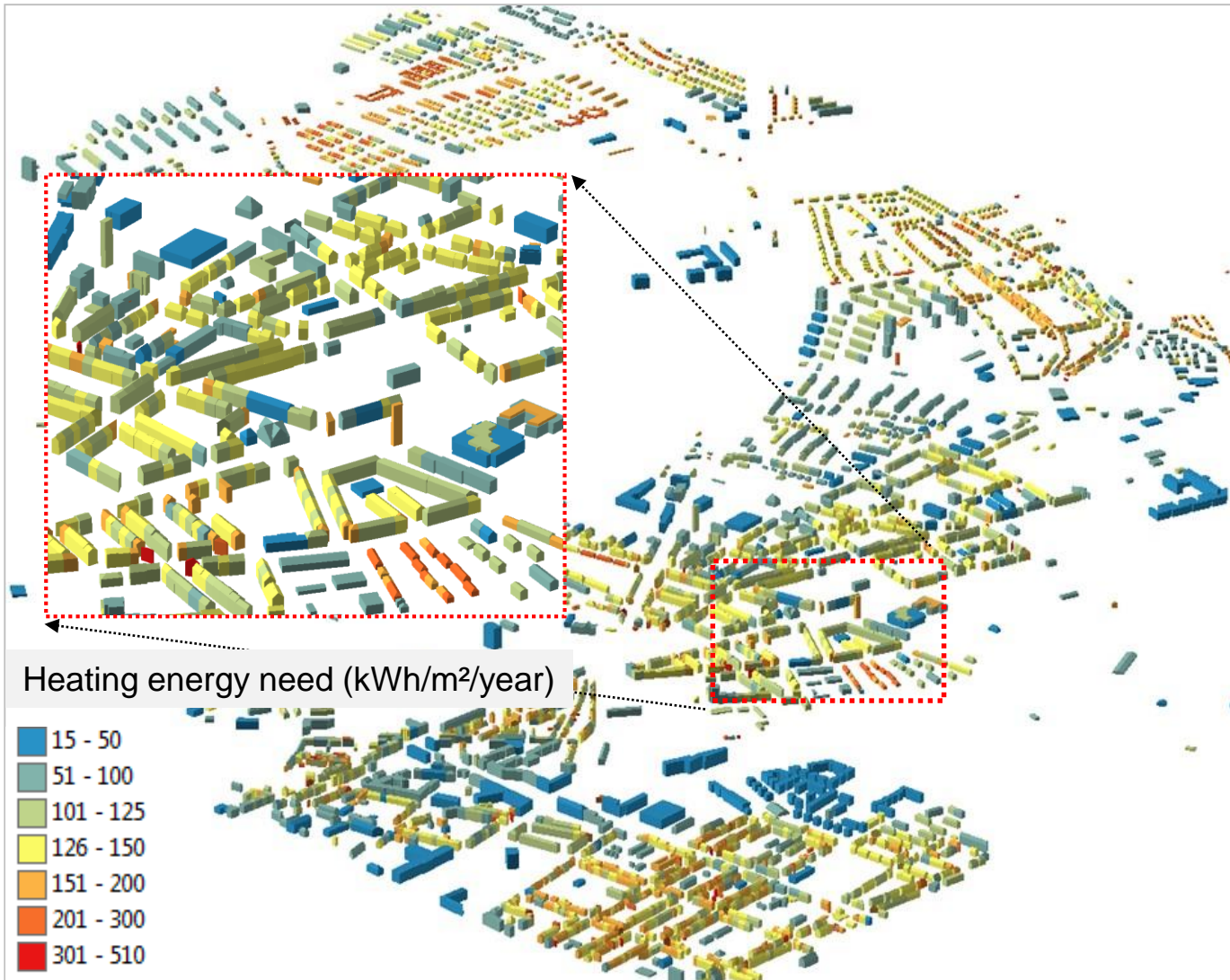


## Weather conditions

- Monthly temperature
- Monthly wind speed
- Monthly solar irradiance







Heating energy need in 4300 buildings in Karlsruhe Oststadt



Abdullah AlSalem



Jleeb



Sharq

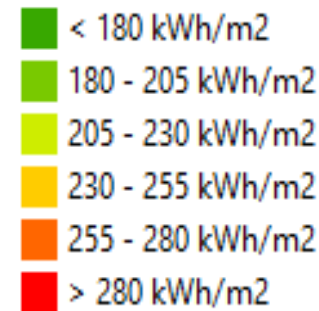


NWSulaibikhat

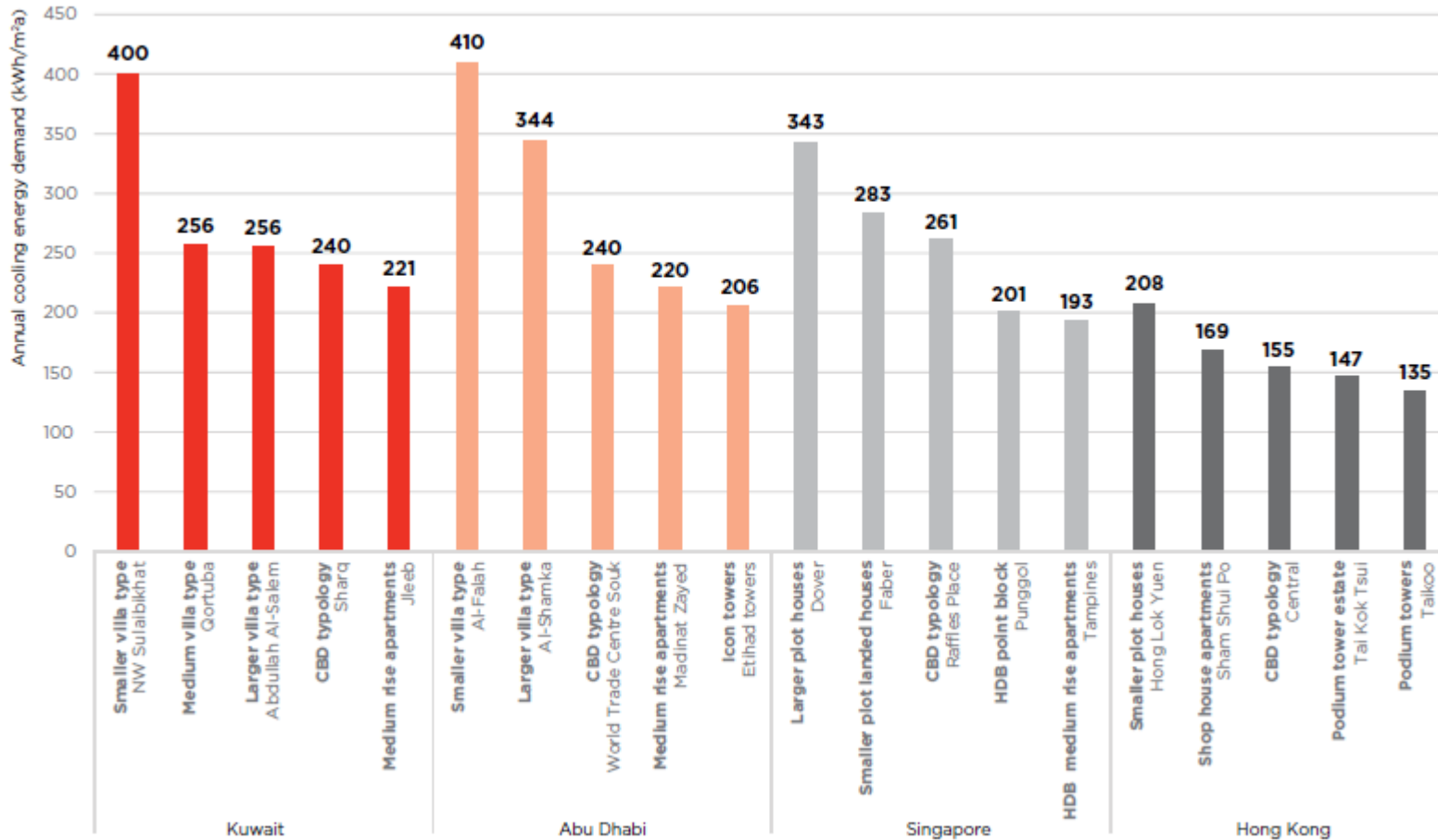


Qortuba

Annual cooling energy needs



## Annual cooling energy needs in the buildings in 5 building typologies in Kuwait



## Annual cooling energy demand in the 20 typologies



## A 3 steps validation was performed

- > Compare results with that in literature
- > Compare with ISO 13790:2008 appendix values
- > **Compare with a simulation software**



TRNSYS: TRaNsient SYstems Simulation



## Performance/test

- The CityBEM monthly model is **tested** in several European and Asian urban cities, with varying number of buildings in both LOD1 and LOD2 data
- The model proves **very efficient** and **quick** in displaying results in the virtual machine
  - > around 3 minutes to run on about 4300 LOD2 buildings, 8 minutes on 12000 LOD2 buildings, 28 seconds on 600 LOD1 buildings, etc.

## Limitation

- CityBEM requires a **geometrically and topologically correct** CityGML dataset
- User and their behavior are assumed **constant in all buildings**



## Ongoing research

- Calculation of energy use, considering the heating, cooling and ventilation system (HVAC)
- Hourly or seasonal energy need /use
- Sensitivity of the critical model input parameters
- Simulation of energy saving potential or building refurbishment plans, through a Graphic User Interface (GUI)
- More realistic representation of building using LOD3 or LOD4 models (multi-zone building)
- **Integration/Testing of CityBEM with EnergyADE 0.8 DB schema (next presentation!)**





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# Thank you!

Contact: [murshed@eifer.org](mailto:murshed@eifer.org)  
European Institute for Energy Research

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