

Computing Residential Heat Demand in Urban Space using QGIS. A Case Study for Shumen, Bulgaria

Ivan Dochev

(BSc (Master Student), HafenCity University, Überseeallee 16, 20457 Hamburg,
ivan.dochev@hcu-hamburg.de)

Introduction

Smart City -> Smart Decisions -> Informed Decisions/Planning



Heat Energy in the
domestic sector

-> Informed Planning

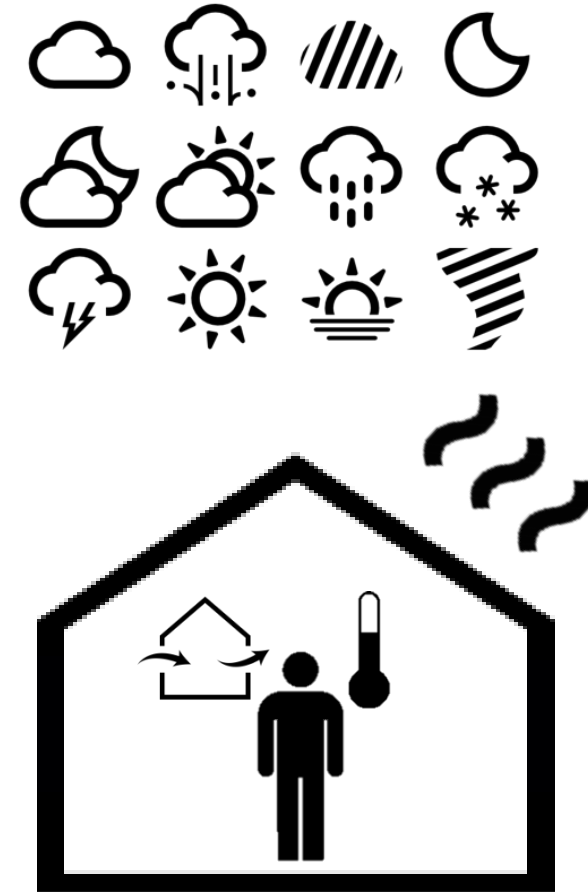
- ✓ STATUS QUO
- ✓ Scenarios
- ✓ ...

Heat Demand

Monthly Static
Heat Balancing
Calculation
DIN 4106
(German)



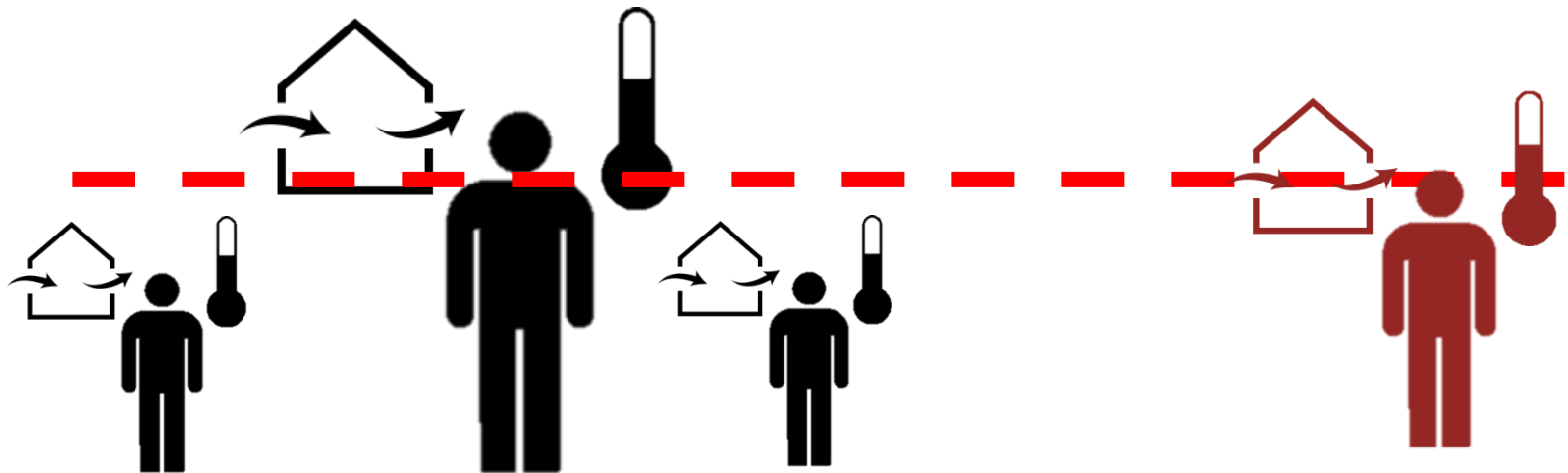
MWh/annum
MWh/month
kWh/m²*annum



City Scale?

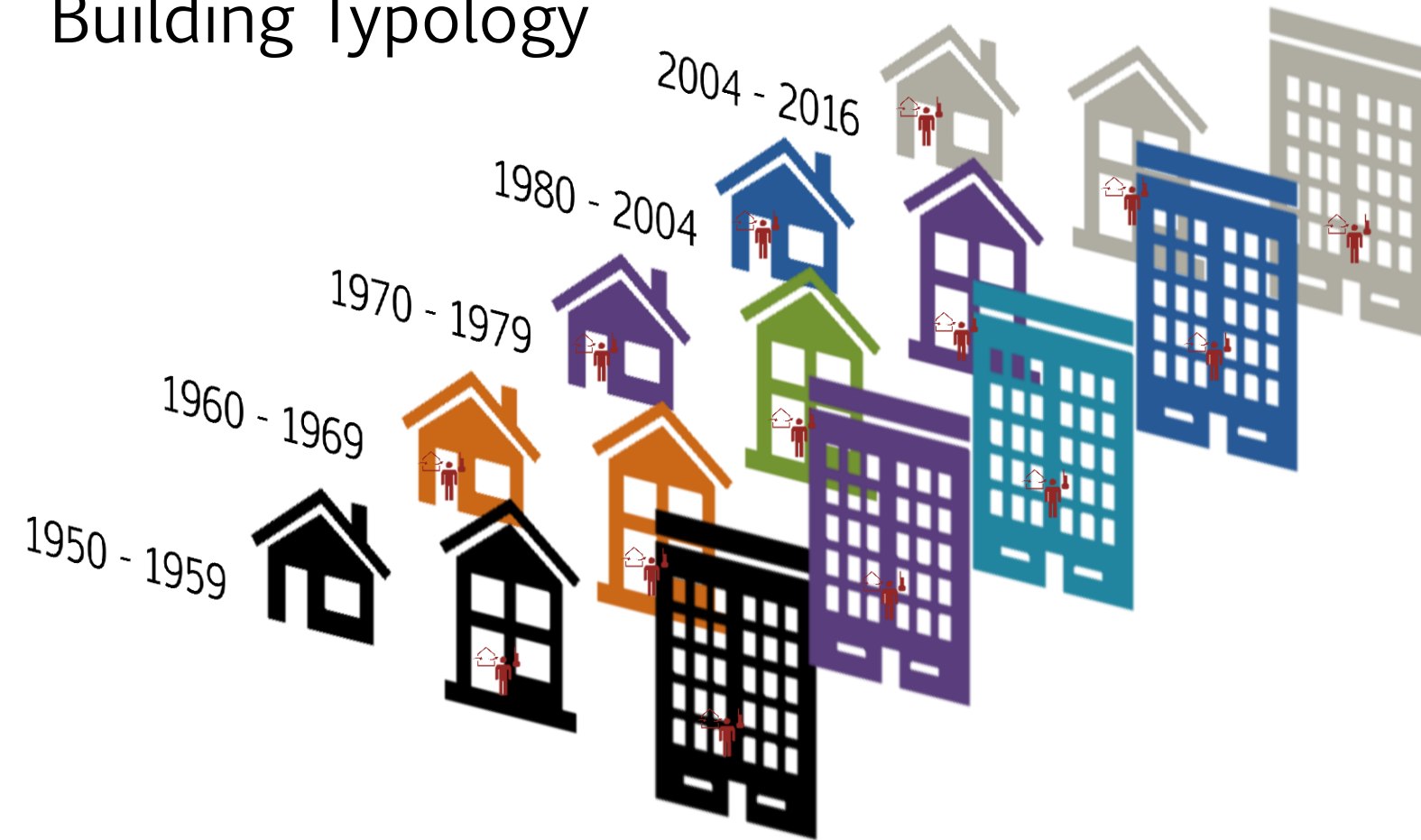


Average User



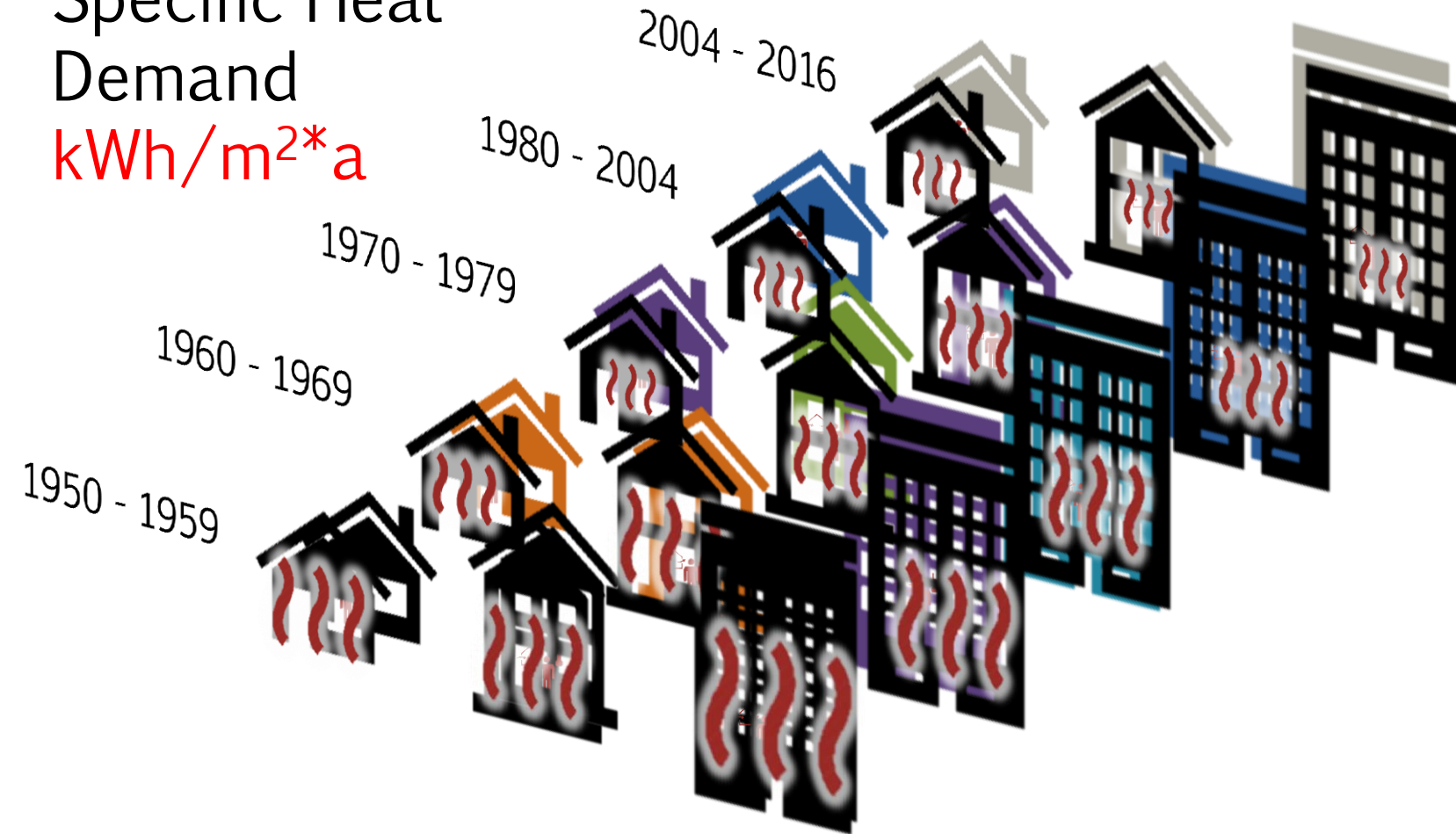
Internal Temp: 20⁰
Air Change Rate: 0.6h⁻¹

Building Typology

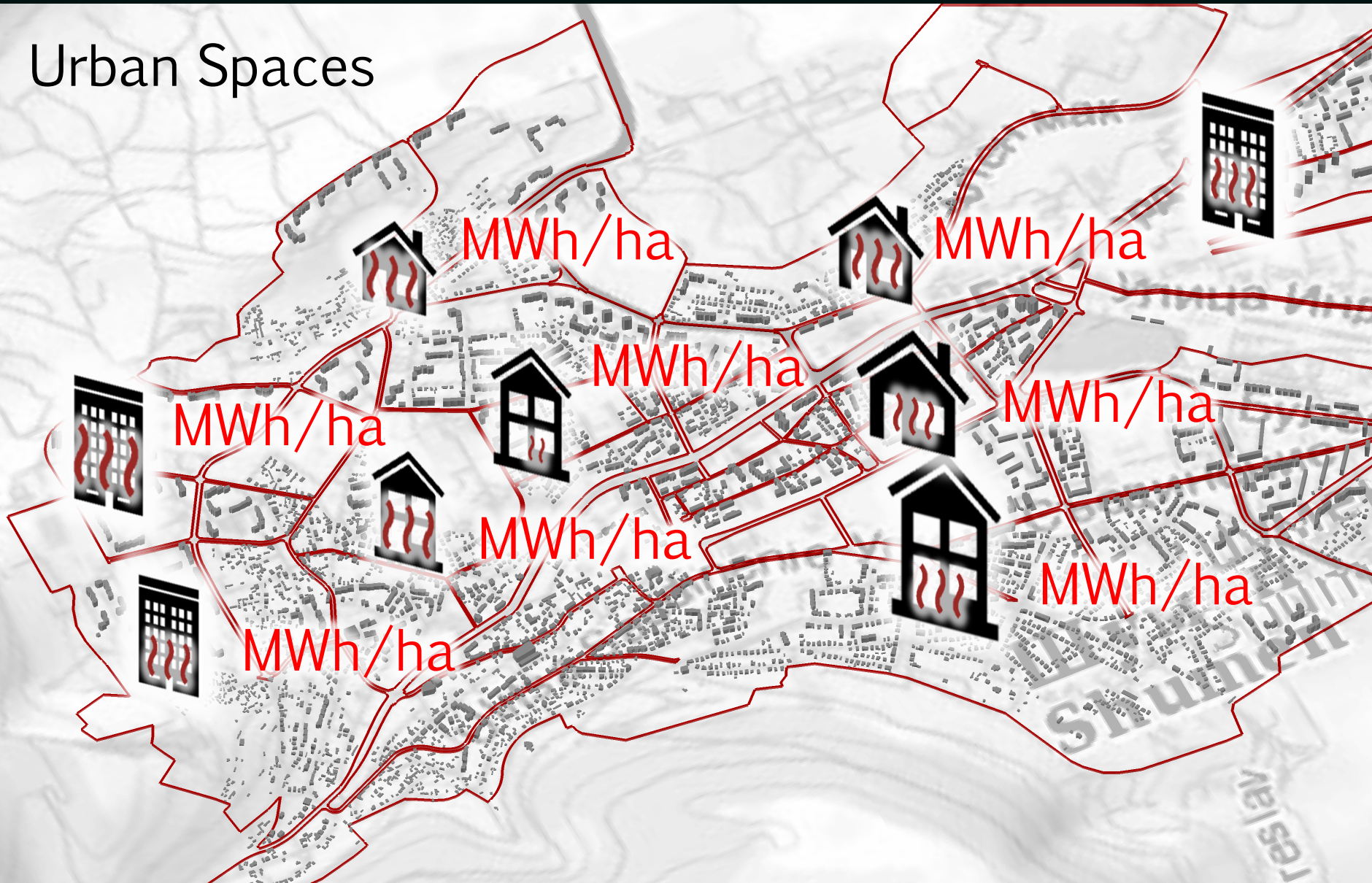


Specific Heat Demand

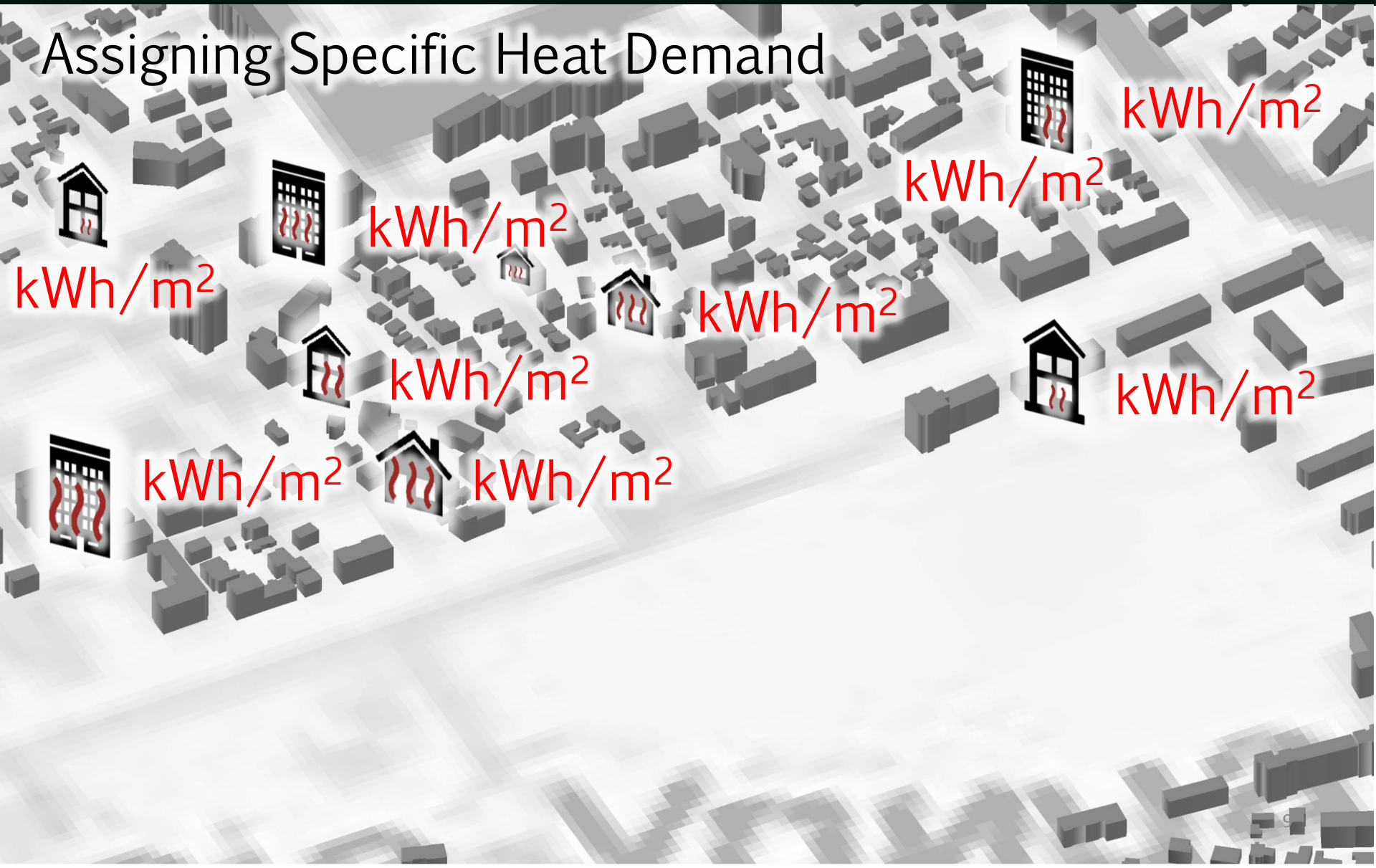
$\text{kWh}/\text{m}^2 \cdot \text{a}$



Urban Spaces



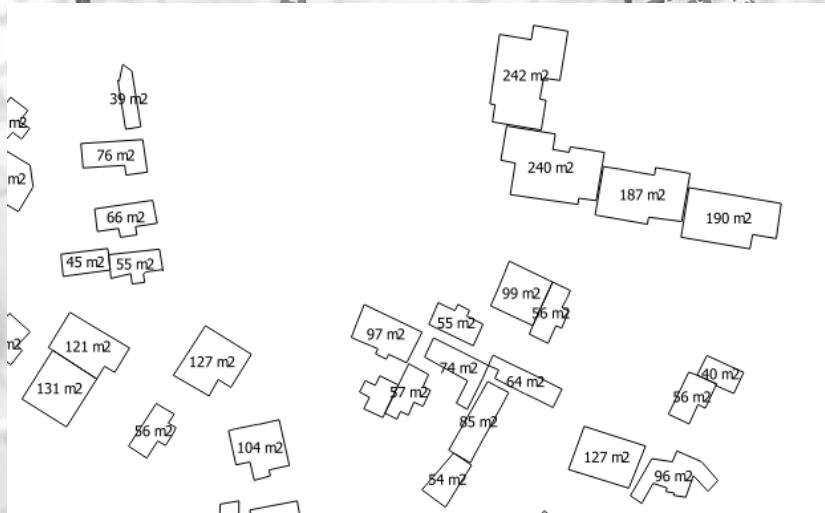
Assigning Specific Heat Demand



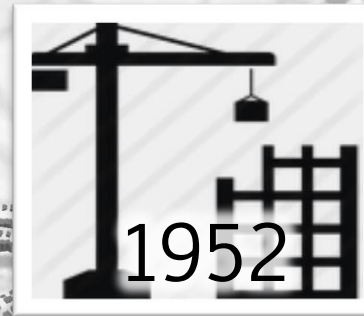
City of Shumen, Bulgaria

70 000 inhabitants
5500 residential buildings

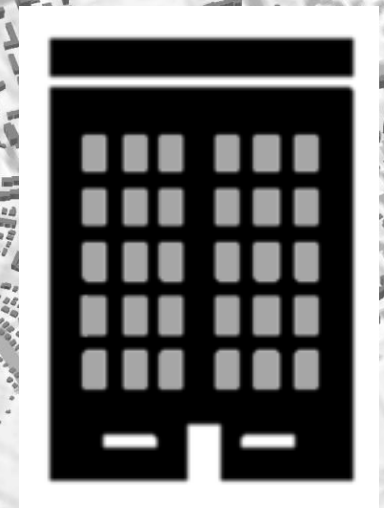
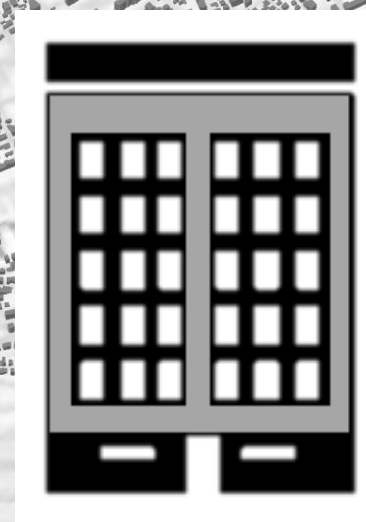
Cadastral Data:



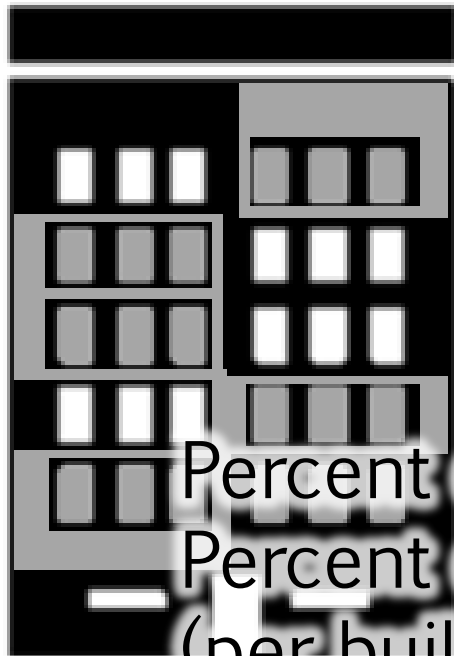
Census Data:



Construction
Year

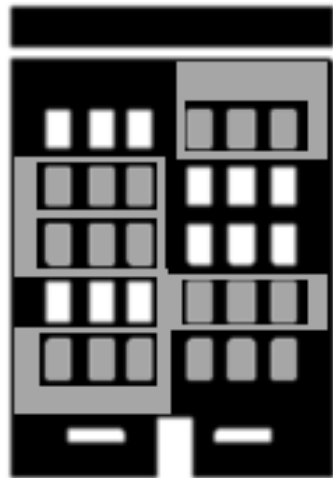


“Patchwork” Retrofit

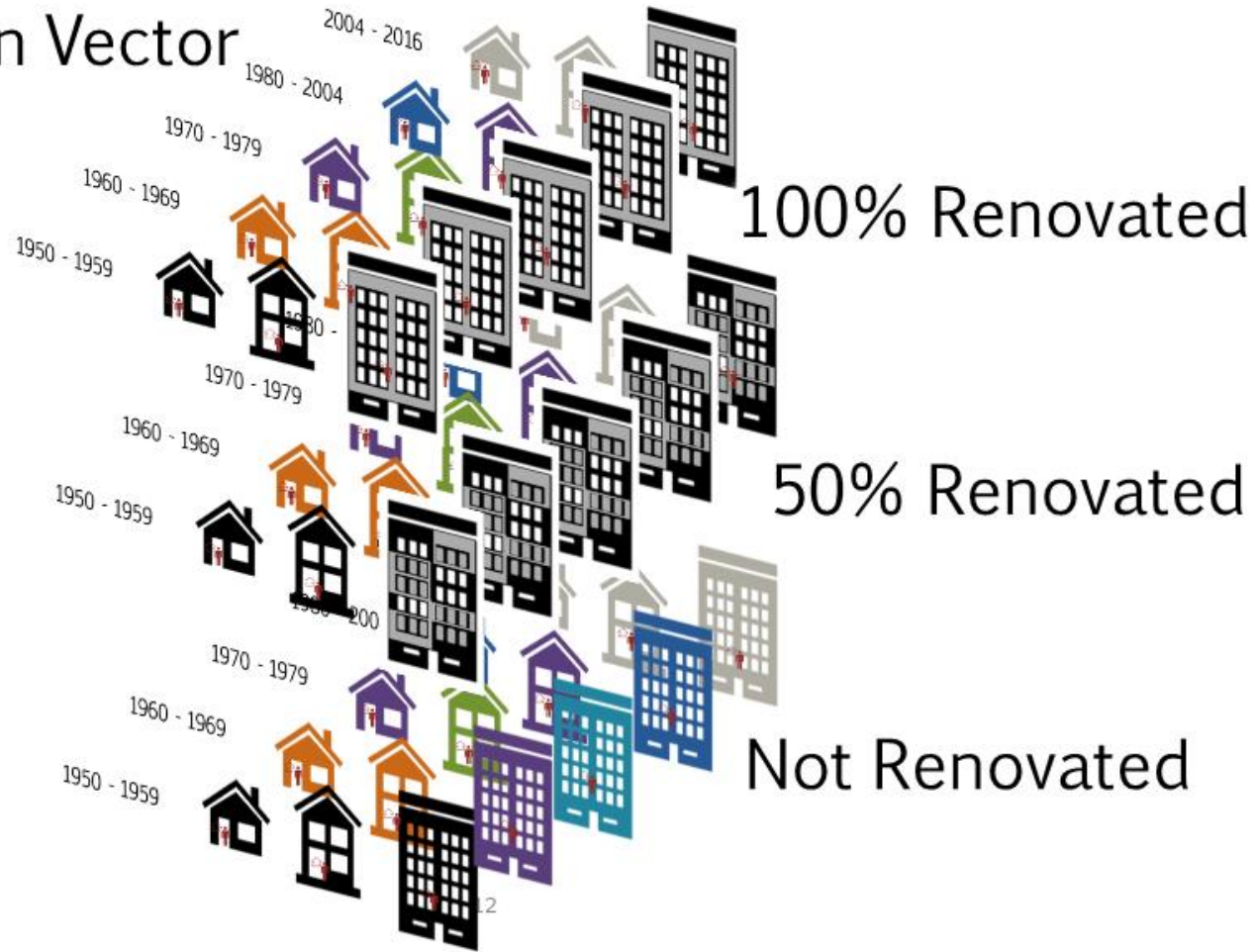


Percent of dwellings with Insulation
Percent of dwellings with EE Windows
(per building)

Renovation Vector



25% Renovated
+ Internal Temp
22°C ?



Assign Attributes

DIN 4106 Calculation

+Percent Renovated

Air Change Rate

U values

Internal Temperature

Modified TABULA
residential typology
For Bulgaria

QGIS – Open Source Geographic Information System

The screenshot displays the QGIS 2.18.0 interface. The main map area shows a street view with buildings highlighted in various colors (green, red, yellow). On the left, the 'Layers' panel shows a legend for 'Total Annual Heat Demand in kWh' with a color scale from 39-114 (green) to 240-499 (red). Below the legend, other layers like 'Map_Mask', 'OCM Landscape', and 'Google Physical' are visible. The 'Python Console' on the right shows a script named 'StaticHeatBalanceCode10_Report.py' with the following code:

```

46
47 #Field-map-initialization, change here for specifics of the shapefile
48 OBJECTID = 'OBJECTID'
49 Height = 'HEIGHT'
50 Floors = 'Floors'
51 Area = 'BuildArea'
52 Perimeter = 'BuildPerim'
53 Temperature = 'InsideTemp'
54 WallU = 'Walls'
55 WindowU = 'Windows'
56 RoofU = 'Roofs'
57 BaseU = 'Base'
58 EnEfWallsU = 'Walls_Renov'
59 EnEfWindowsU = 'Windows_Re'
60 EnEfRoofU = 'Roof_Renov' # Not-used-in-algorithm-yet
61 EnEfBaseU = 'Base_Renov' #Not-used-in-algorithm-yet
62 WinWallRatio = 'WinWallPer'
63 Inhabitants = 'Inhabitant'
64 PerIns = 'PerIns'
65 PerEnEfWin = 'PerEnEfWin'
66 RoofType = 'RoofType'
67 TotalAnnualHeatDemand = 'KWhAnnum'
    
```

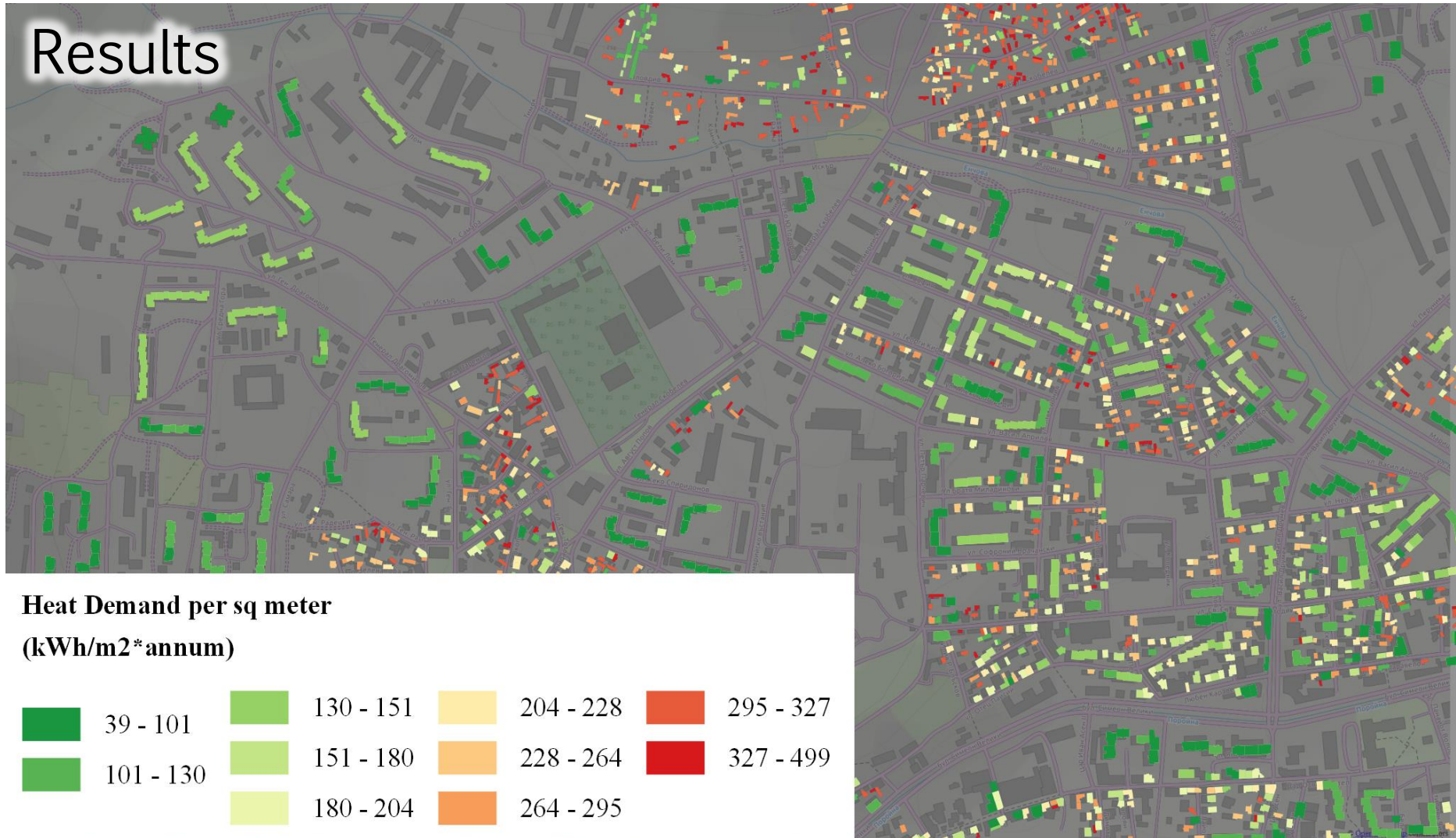
In the center, a report window titled '105 BUILDING REPORT FOR OBJECTID: 4628' displays the following data:

```

106 MONTH:6
107 LOSSES:-----
108 Transmission Losses - Outer Walls: 1627 W/K
109 Transmission Losses - Unheated Spaces (Hu): 187 W/K
110 Transmission Losses - Thermal Bridges (Htb): 173 W/K
111 Ventilation Losses (Hv): 693 W/K
112 Total Hm (Ht+Hv): 2680 W/K
113 Total Heat Losses(Qlm): 38495 kWh/month
114 GAINS:-----
115 Solar Gains Facades: 3129 W
116 Solar Gains Roof: 0 W
117 Internal Gains: 4248 W
118 Total Gains: 7377 W
119 Total Gains kWh/month(Qgm): 5488 kWh/month
120 -----
121 Utilization Factor for the month: 0.999992086936
122 -----
123 Total Heat Demand for the month: 33006
124 -----
125 -----
126 Heat Demand per annum: 149106 kWh/Annum
127 Demand Per Square Meter: 105 kWh/Annum*m2
    
```

At the bottom of the interface, the status bar indicates '1 feature(s) selected on layer Total Annual Heat Demand in kWh.' and shows the coordinate '492543.7,4791227.7', scale '1:3 140', and projection 'EPSG:32635'.

Results



Thank you for your attention

References

Arbeitsgemeinschaft für zeitgemäßes Bauen e.V, 2009. Unsere alten Häuser sind besser als ihr Ruf
Verbrauchsdatenauswertung – Wohngebäude; Untersuchung zur Ermittlung und Bewertung von
Energieverbräuchen im Gebäudebestand. Kiel: s.n.

Arbeitsgemeinschaft für zeitgemäßes Bauen e.V, 2012. Gebäudetypologie Schleswig-Holstein / Leitfaden für
wirtschaftliche und energieeffiziente Sanierungen verschiedener Baualtersklassen, Kiel: s.n.

Blesl, M., 2002. Räumlich hoch aufgelöste Modellierung leitungsgebundener Energieversorgungssysteme zur
Deckung des Niedertemperaturwärmebedarfs. [Online]
Available at: <http://dx.doi.org/10.18419/opus-1569>
[Accessed 2016].

Bulgarian Ministry of Economics, Energy and Tourism, 2009. Наредба № РД-16-1058 от 10 Декември
2009г. за показателите за разход на енергия и енергийните характеристики на сградите, София: s.n.
[in Bulgarian]

Everding, D., 2007. Solarer Städtebau. Stuttgart: Kohlhammer

Ecofys Germany GmbH, 2011. Flächendeckende Erhebung und Kartierung des energetischen Zustandes des
Hamburger Gebäudebestandes. [Online]
Available at: <http://www.ecofys.com/files/files/ecofys-2014-gebaeudeerhebung-hamburg.pdf>
[Accessed 12 8 2015].

Energieatlas: Zukunftskonzept Erneuerbares Wilhelmsburg (2010). Hrsg. von IBA Hamburg GmbH,
Umweltbundesamt, TU Darmstadt. Jovis Verlag. Dezember 2010.

Episcope/TABULA/Intelligent Energy Europe, 2009-2012. Joint EPISCOPE and TABULA Website. [Online]
Available at: <http://episcope.eu/welcome/>
[Accessed 20 8 2015].

Episcope, n.d. TABULA WebTool. [Online]
Available at: <http://webtool.building-typology.eu/#pdfes>
[Accessed 1 4 2016].

Hegger, M., Dettmar, J., Drebes, C., Greiner, M., Kern, T., Meinberg, T., ..., Wagner, C. 2014. Energetische Stadtraumtypen. Stuttgart: Fraunhofer IRB Verlag.

Hochschule für Technik Stuttgart, M.O.S.S., GEF Ingenieur AG, 2015. SimStadt: Presentation & goals of the project. [Online]
Available at: <http://www.simstadt.eu/en/index.html>
[Accessed 1 4 2015].

Institut Wohnen und Umwelt, 2005. Deutsche Gebäudetypologie - Systematik und Datensätze. [Online]
Available at:
http://www.iwu.de/fileadmin/user_upload/dateien/energie/klima_altbau/Gebaeudetypologie_Deutschland.pdf
[Accessed 7 4 2016].

Institut Wohnen und Umwelt, 2011. Deutsche Gebäudetypologie Beispielhafte Maßnahmen zur Verbesserung der Energieeffizienz von typischen Wohngebäuden, [Online]
Available at:
http://episcope.eu/fileadmin/tabula/public/docs/brochure/DE_TABULA_TypologyBrochure_IWU.pdf
[Accessed 7 4 2016].

Muñoz Hidalgo, M. E. & Peters, I., 2015. Allocating heat consumption of residential buildings in space with help of a filter array to determinate the building type in a digital cadaster. Hamburg (Germany): Unpublished manuscript.

SOFENA, 2012. TABULA Residential Building Typology for Bulgaria. [Online]
Available at:
http://episcope.eu/fileadmin/tabula/public/docs/brochure/BG_TABULA_TypologyBrochure_SOFENA.pdf
[Accessed 20 9 2015].