1 M-DAB2: THE PROJECT

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M-DAB2: Material intensity of inward development – resource assessment and localization of urban development potentials

Annual land consumption in Austria is currently 47 km², clearly superseding the target of 9 km² per year, which the current government program aims at for the year 2030 (Umweltbundesamt 2021 and Bundeskanzleramt 2020). Continued urban sprawl leads to a significant overconsumption of land and primary resources (new infrastructure for traffic, supply and disposal) . A targeted development of an existing urban environment („inward development", Grams 2015) leads to a reduction in annual land use and has huge potential for reducing the use of primary resources.

The project aims at localization, quantification and qualification of inward development potentials and will, for the first time ever, account for material intensities in inward development (amount of primary material) in the context of different development scenarios. Elaboration of criteria and verification using GIS-based automated context analysis will allow for a comparison between different development scenarios (1. demolition and new construction, 2. renovation/attic expansion, 3. annex construction or retrofitting) under consideration of the urban context in which this development happens. It will furthermore allow for a more systematic approach to location planning using different views. Building on the extended data basis of the previous project M-DAB (FFG Nr. 873569), five archetypal potential profiles (for different building and location types – e.g. building period, usage, construction class, environment) are created (AP2, Fig. 1). In the next step, development pathways for each of these potential profiles are assessed with special regard for minimal resource utilization (AP3, Fig. 3). In a final step, this project employs digital methods (e.g. Machine Learning) to identify similar potential development patterns within the urban fabric.

M-DAB2 develops a reliable digital model of material intensity which helps with the assessment of inward development potentials using an interactive visualization offering different views. In combination with the database of the previous project M-DAB, this project offers unprecedented insights into attainable saving potentials in primary resource use and landfill volumes (comparison of development scenarios) and an assessment of the city-wide potential and impacts of a best-practice method with regard to resource utilization.

Fig. 1: Archetypical Potential Profiles (own illustration)

ARCHETYPICAL POTENTIAL PROFILES AND DEVELOPMENT VARIANTS

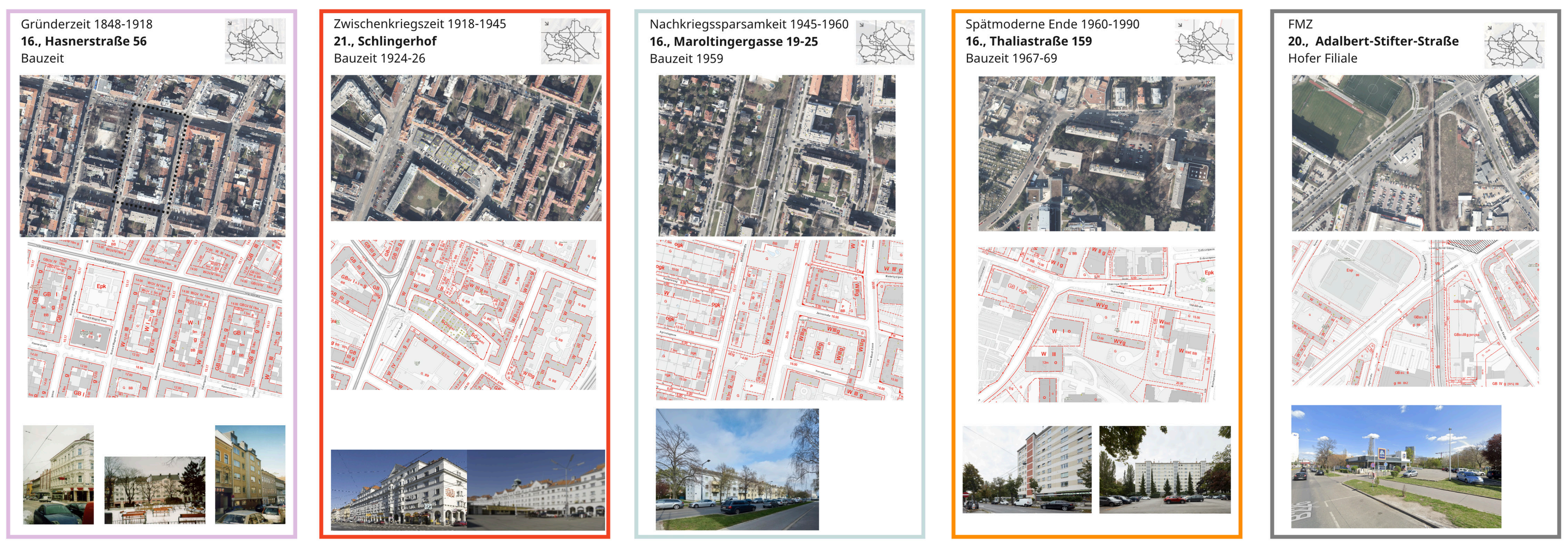

Fig. 2: Classification of Potential Profiles (own illustration, Basemap: Stadt Wien – ViennaGIS)

For identification and qualification of „potential profiles" in the city, one has to assess a variety of aspects (e.g. location within the city, building densities, capacities and qualities of existing infrastructure). The procedure is tested in the project using five different spatial situations (archetypal for Vienna) (Fig. 2). In order to determine land and usage potentials in these „profiles", each of these potentials is tested using three development variants through concrete test designs. These tests show specific options for action in urban planning regarding inward development for specific existing areas. The required components and materials can be determined from the resulting BIM models and thus subjected to an ecological and economic evaluation (WP4).

Based on the indicators, which are converted into potential profiles through qualitative and quantitative analyzes of specific potential areas (potential prototypes including development variants), similar potentials in the city can be automatically localized and quantified using digital methods (WP5).

With the help of an interactive visualization, the potentials are made visible using different filtering and weighting criteria (WP6), whereby the results are also to be presented and examined under the aspects of different target groups.

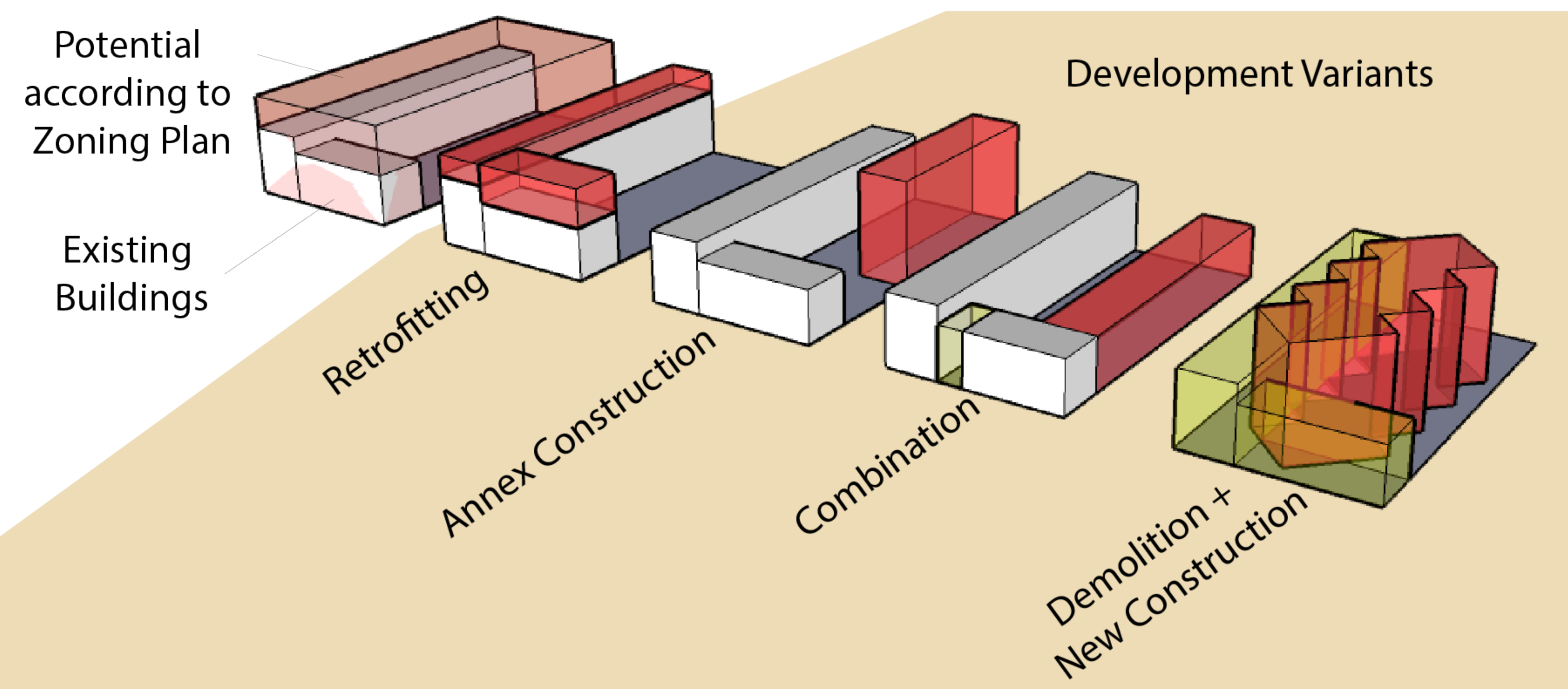

Fig. 3: Development Variants (own illustration)

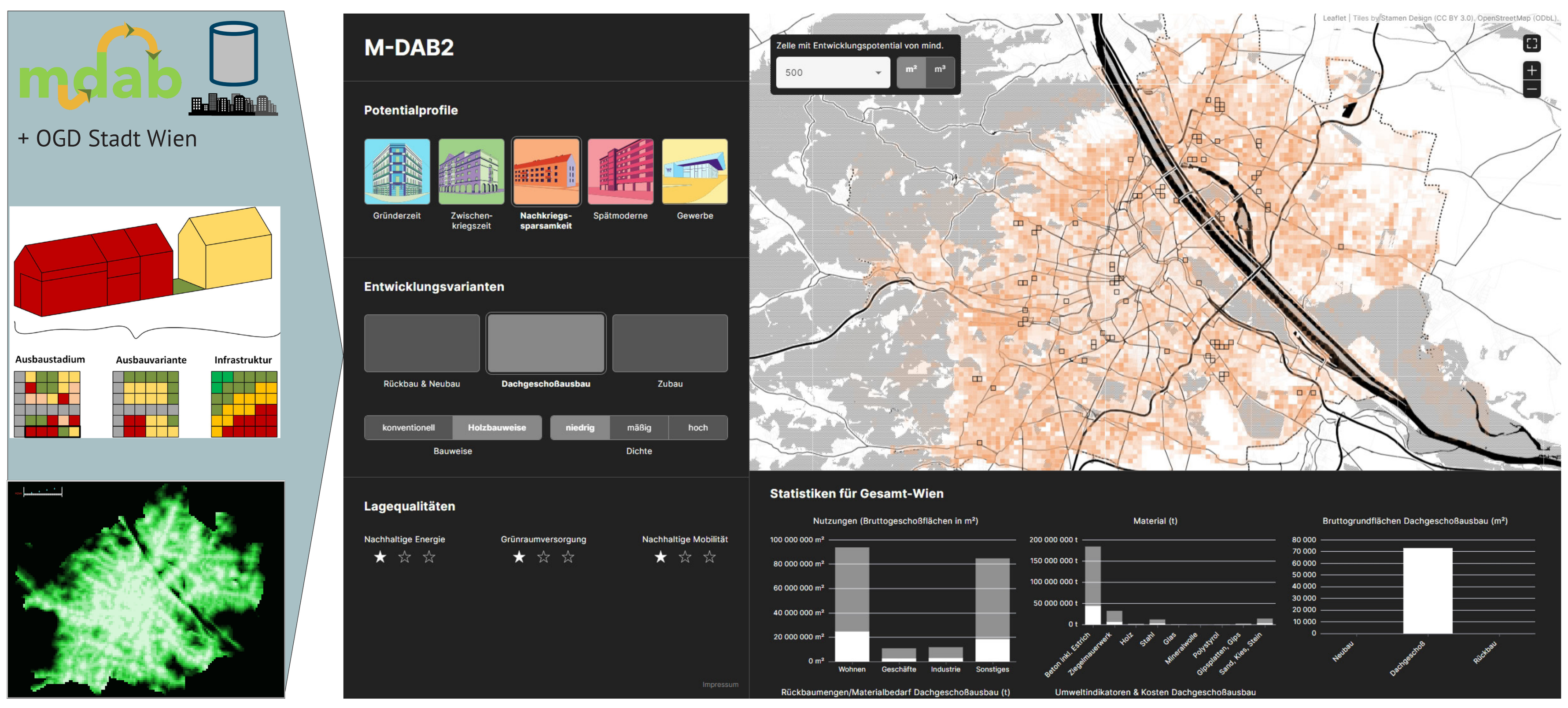

Fig. 4: Parameterization, Quantifying and Visualization (Prototype, own illustration)

METHODOLOGICAL INNOVATION BEHIND THE PROJECT

In the interdisciplinary research project, the individual work packages, such as the development of the qualitative profiles, the determination of indicators and attributes for the conversion and renovation variants or the ecological assessment, already make a contribution to sustainable inward development. Only by combining the different methods and by extrapolating the data – incorporated into intelligent, interactive visualizations – can a more holistic, clearer picture of the urban strategies of the environmentally and economically sustainable development of Vienna be drawn. Spatial planning and urban development intertwined with densification and sustainable development make it possible to recognize unused spatial and material potentials and to promote densification while preserving existing buildings.

With the developed material intensity model, planners and real estate developers can generate development scenarios for construction projects beyond the „common practice" (demolition and new construction) and, taking these into account, develop optimized concepts for land and material resources.

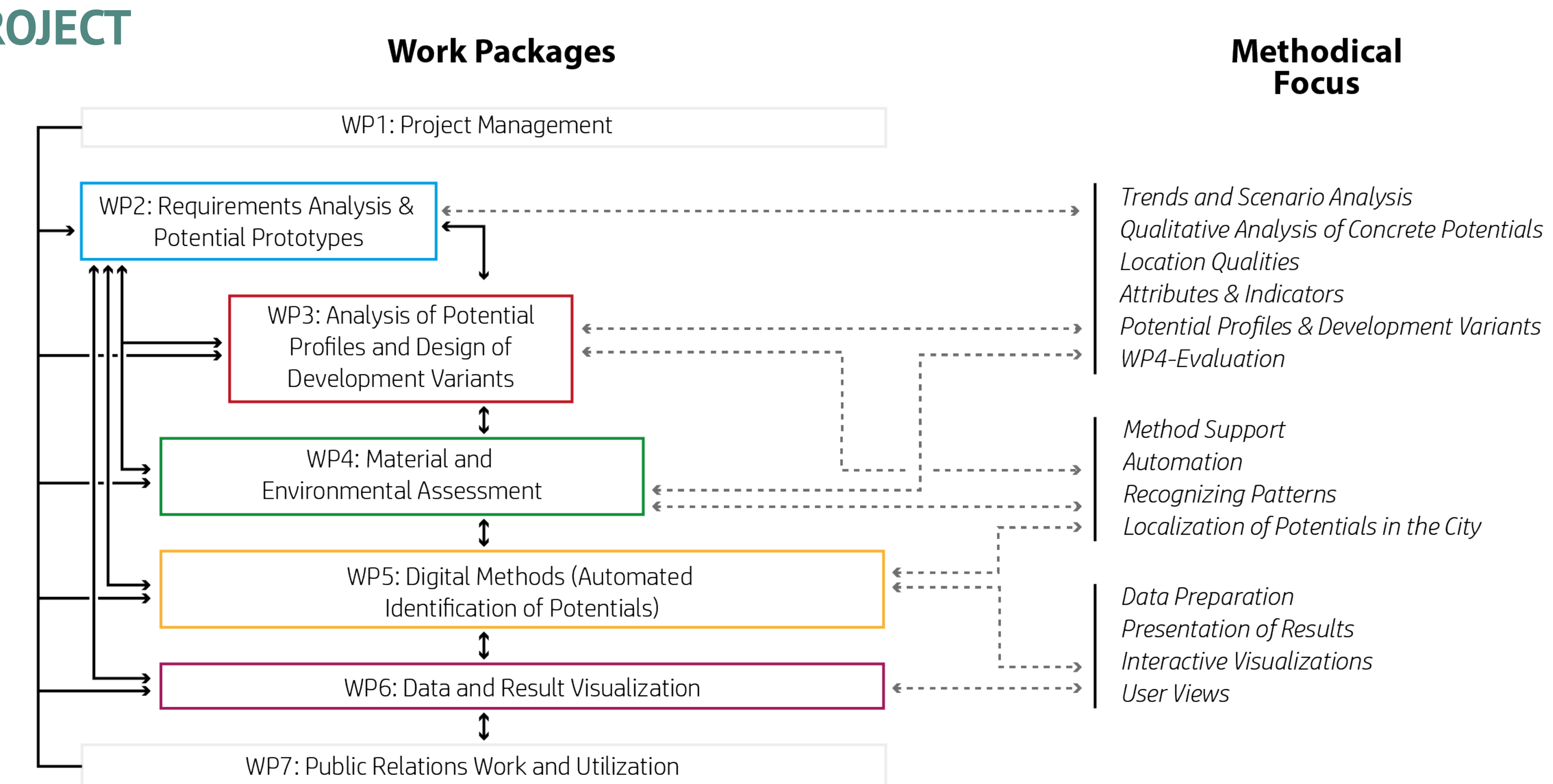

Fig. 5: Interaction of the Work Packages in M-DAB2 (own illustration)

LITERATURE

- Bundeskanzleramt, (2020): Aus Verantwortung für Österreich. Regierungsprogramm 2020 – 2024
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M-DAB2-Consortium:
TU Wien
- Institute of Spatial Planning (Local Planning / Spatial Simulation Lab (Simlab))
- Institute of Water Quality and Resource Management (Waste and Resource Management)
- Institute of Architectural Sciences (Digital Architecture and Planning)
Rhomberg Bau GmbH
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5 Material intensity of inward development

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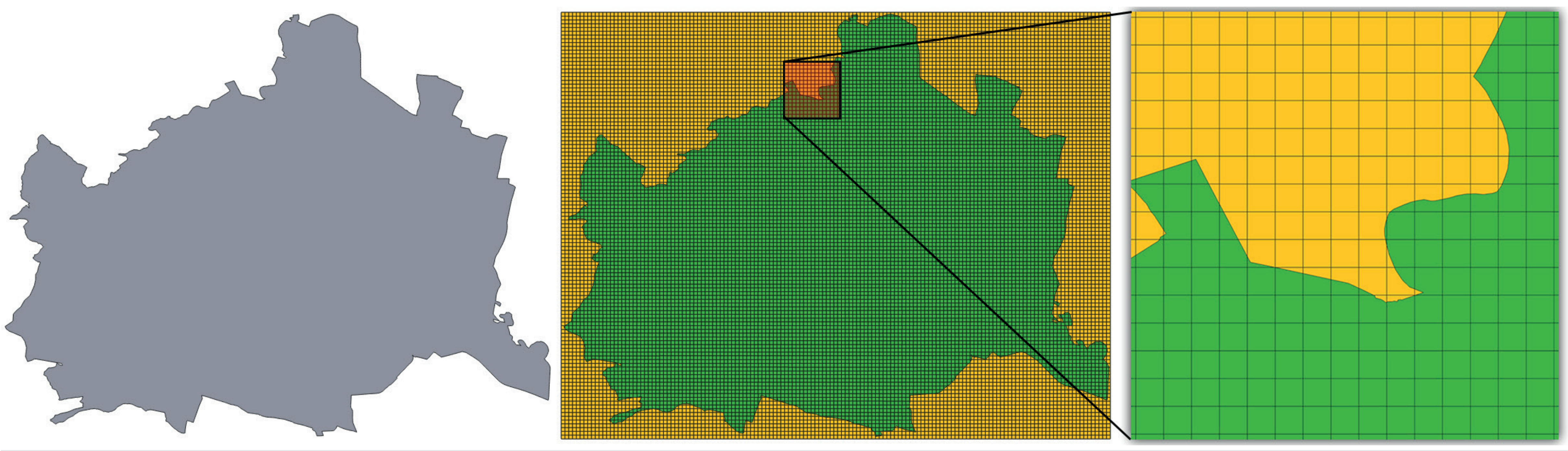


Fig. 1: QGIS model with grid (cells); left: borderline of Vienna; center: overlayed grid; right: detail (own illustration).

DEFINITION OF THE CELL SIZE

The information obtained from the GIS data, provided by the city of Vienna, is transferred to a city-wide grid; i.e. thematic information is localized and processed in cell data. Accordingly, the choice of cell size is crucial for the result (similar to the application of the box-counting method in architecture; see Lorenz 2013) since it can lead to over- or under-representation (high data density or high degree of aggregation).

The final cell size is defined according to Zoom Level 17 (level of detail). This corresponds, for example, to a displayed area of the urban building block or a park (see OpenStreetMap Wiki contributors, ‚Zoom levels').

ARCHETYPICAL POTENTIAL PROFILES

Five characteristic „archetypical potential profiles" based on multiple vector layer attributes and a material mix typical for each building type were defined. Specifically, these are calculated from three groups:

1. Cell-related values (area percentages of total area): Key values are compared with data from the zoning plan.
2. Block-related values (block of houses per site): Key values are compared with data from M-DAB (predecessor project).
3. Typical material mix [in t/m3]: Key values concerning typical material composition is compared with data from M-DAB (precursor project), aggregated and updated on the cells.
4. The probability of assignment to each of the five pre-defined potential profiles is calculated from these relations. The correspondence according to which a certain cell fulfills the specifications of the respective profiles as a result of the aggregated values is hereby calculated as the Euclidean vector distance.

THE POSITION FILTER

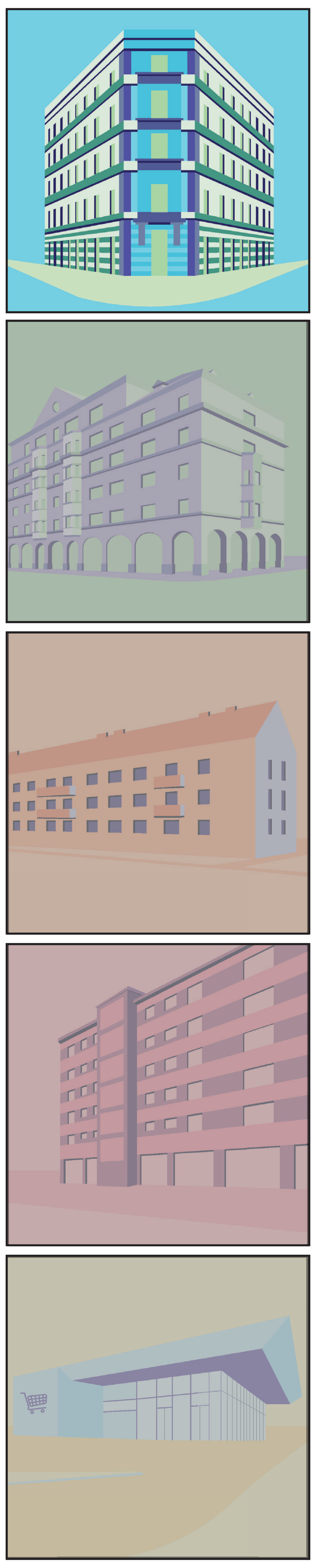
In the present model, three position filters are available to specify a cell's „percentage match" with the selected profile:

1. energy filter,
2. mobility filter,
3. green space filter.

These filters are composed of static and dynamic data. The first group includes data from QGIS, such as whether or not a district heating connection exists in a cell. The second group includes data calculated from simulations in NetLogo (Wilensky, 1999), such as distances of a cell to the nearest cell containing a subway station.

VERIFICATION OF THE DATA

The first step is to verify the data representation using a model in the multi-agent programming language NetLogo, where the discrete division of the world into cells accommodates the visualization for verification. Each cell contains the static data from the previous analysis in QGIS. In addition, a dynamic calculation of data (e.g., distance to a subway station) is performed, which, when combined with the static data, produces a property vector. This vector is then used to calculate the similarities between the cells.



Percentage of total area (on the scale of a block)	
Portion of traffic area e.g. **28,57%**	Traffic area **per cell** (zoning plan: classes 21-39)
Proportion of gross floor area e.g. **42,48%**	Building area **per cell** (zoning plan: classes 11 & 19)
Portion of remaining area (green area, parking, etc.) e.g. **28,95%**	Green area, yard area, ... **per cell** (zoning plan: classes 52-58)
Block of houses/plot of land	Predecessor project M-DAB: Building and/or site
Gross floor area (GFA) **17,271.00m²**	Gross floor area **per building block**
Average number of plots **16 pieces**	Average number of plots **per building block**
Key value: GFA per block area **2.39875**	Key value: GFA per block area **per building block**
Typical material mix	
Material intensities for Material groups 1-9 **X.XX t/m³**	Material intensities for Material groups 1-9 **per cell**

Fig. 2: Summary of the calculation of the percentage match with a selected potential profile [%] (own illustration).

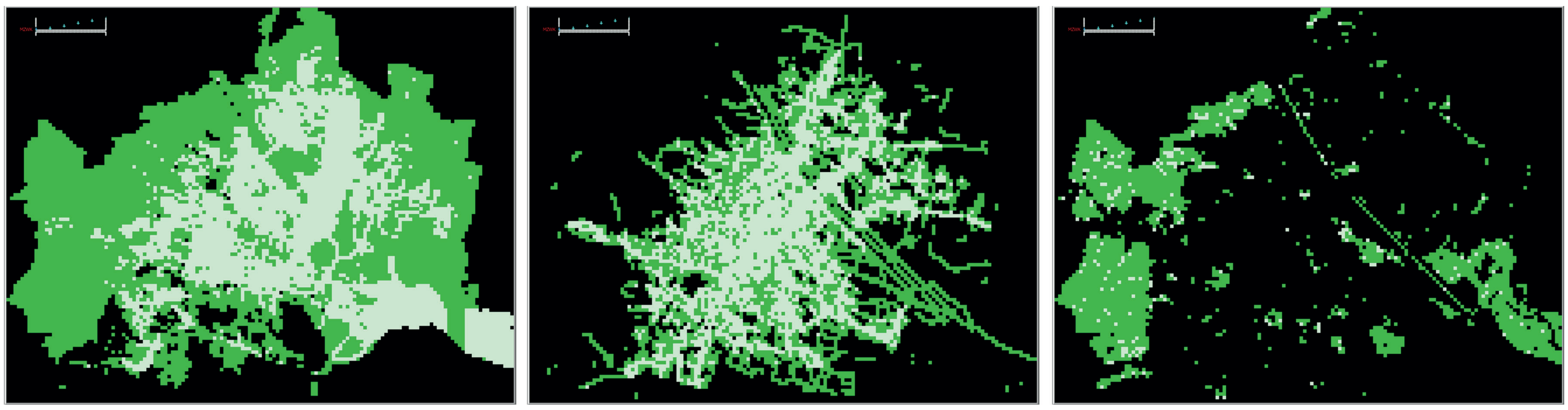


Fig. 3: Visualization of the energy filter (left), the mobility filter (center), and the green space filter (right); the coloring in the NetLogo model shows the three possible states (black = 0, medium green = 1, light green = 2) (screenshot from QGIS, own illustration).

LITERATURE

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