FP 7 Project SUME: Sustainable Urban Metabolism for Europe

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SUME Project Partners & Case study cities

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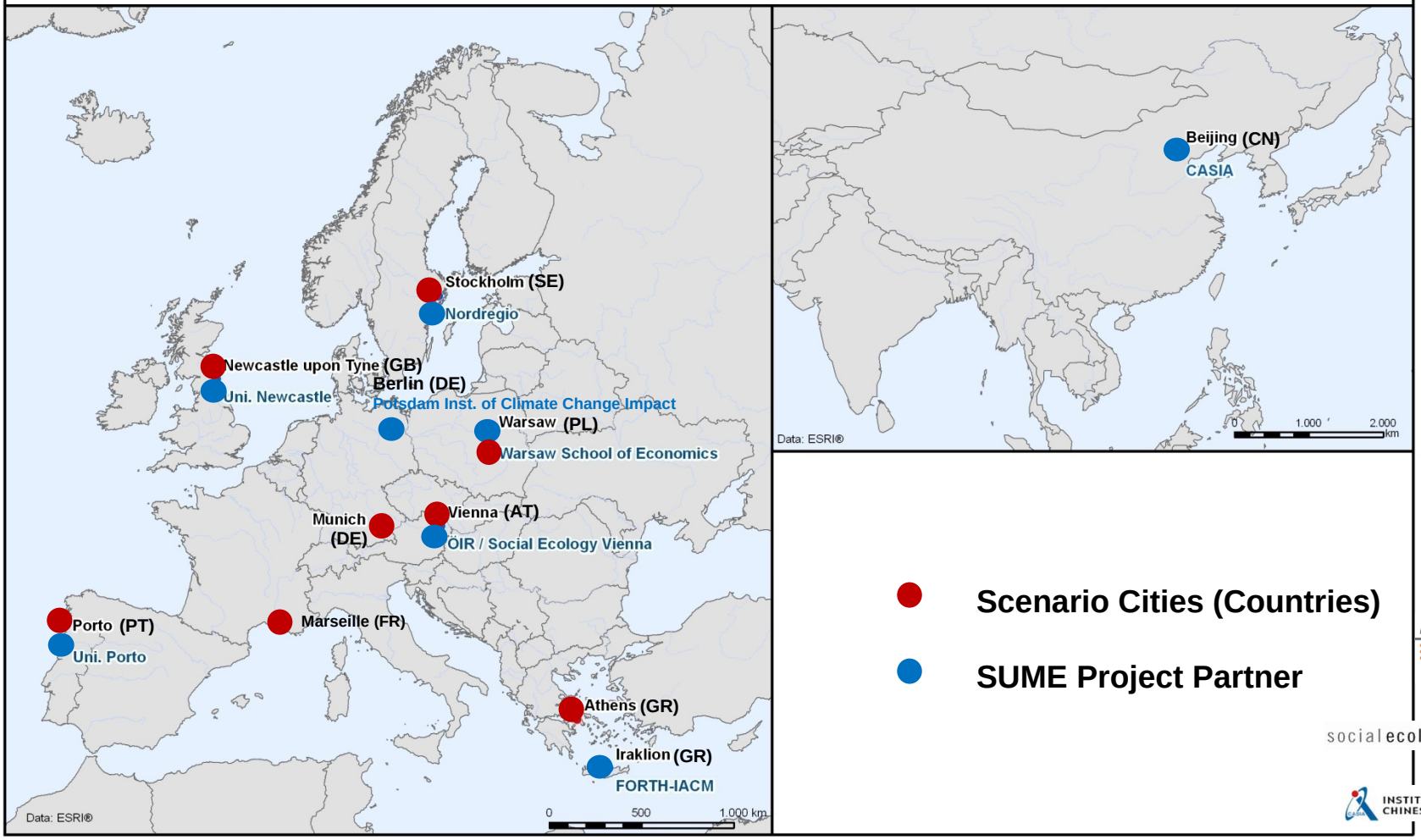


FP 7 Call and project partners

- Collaborative Research Project - Area 6.2.1.5 Urban development ENV.2007.2.1.5.1 Urban metabolism and resource optimisation in the urban fabric, 11/2008 – 10/2011

01	Austrian Institute for Regional Studies and Spatial Planning (OIR, coordinator))	AT
02	University of Porto, Faculty of Engineering (CITTA – FEUP)	PT
03	Nordic Centre for Spatial Development (Nordregio)	SE
04	Foundation for Research and Technology – Hellas (FORTH)	GR
05	University of Newcastle upon Tyne (UNEW)	UK
06	Delft University of Technology (TU Delft)	NL
07	Klagenfurt University, Faculty for Interdisciplinary Studies (UNI-KLU)	AT
08	Potsdam Institute of Climate Change Research (PIK)	DE
09	Chinese Academy of Sciences (CASIA)	CN
10	Warsaw School of Economics (SGH)	PL

The first challenge: Resource efficiency

Challenge :

- **How can future urban growth** (population, income) on a world wide scale be accommodated with the **Climate Change Agenda** (CO2 reduction objectives) ?

- With the scenario-, modelling- and evaluation approach, **SUME shows the options cities have** for transforming into future, more energy-resource-efficient forms (time horizon: 2050)

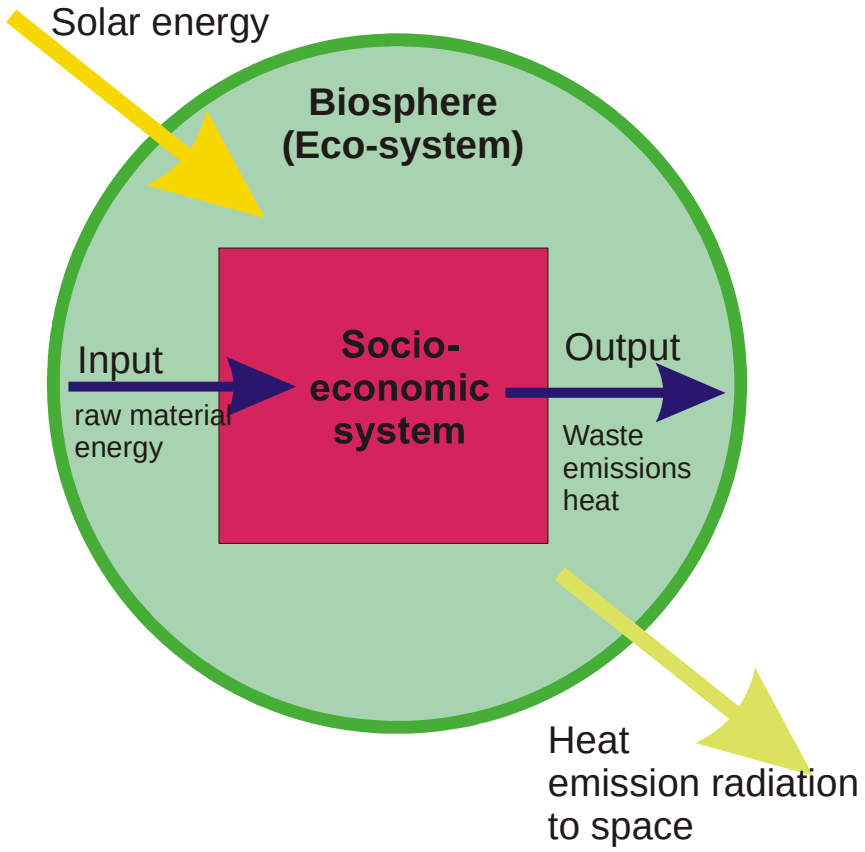
Urban development and the metabolism approach

Challenges for urban development, viewed by an urban metabolism approach

- What is the **urban metabolic performance** of the various (existing) urban structures/urban forms –
  in terms of energy use, land use, material input-output balance ?
  (→ GHG, Climate Change)?
- What does **urban restructuring** mean for a potential future improvement of the energy-material balance ?
- Are there consistently **better urban structures/urban forms** ?
- What is the result of a comprehensive, **metabolic appraisal** of urban restructuring:
  What are the material/energy costs of a forced restructuring/rebuilding compared with the use of existing structures ?

Background: Social Metabolism

- Social systems as thermodynamically open
- Energy and material flows into socio-economic system
- Internal energy and material flows
- Energy and material flows back to nature
- Main operationalizations
  - Material and energy flows
  - LCA
  - Stocks and flows dynamics



The SUME approach – questioning the future

The SUME approach will be evaluated and tested in a number of case study cities:

- Vienna (AT), Munich (DE), Porto (PT), Newcastle (GB), Stockholm (SE), Athens (GR), Marseille (FR), Warsaw (PL)
- With scenario and modelling methods applicable for all cities in Europe (and beyond)
- with a project and policy assessment method

SUME provides **tools for sustainable planning and decision-making**, which have to be tailord to a great variety of urban development situations, esp. for cities which may be

- growing or declining,
- with high or low densities,
- which have different public transportation systems,
- in varying environmental and climate conditions

Questions to be answered:

- How do various (existing**) urban forms** influence the use of energy, land, materials ?

  E.g. Athens (GR) pop. 3,5 mill – 352 km2
  Brussels (BE) pop. 3,6 mill – 1.990 km2

- How can urban forms be changed in expanding cities ?

  E.g. Vienna (AT) 2000-2050: pop. + 35%

- How can restructuring of urban forms be done in stable or shrinking cities?

  E.g. Porto (PT) 2000-2050: pop. -4%

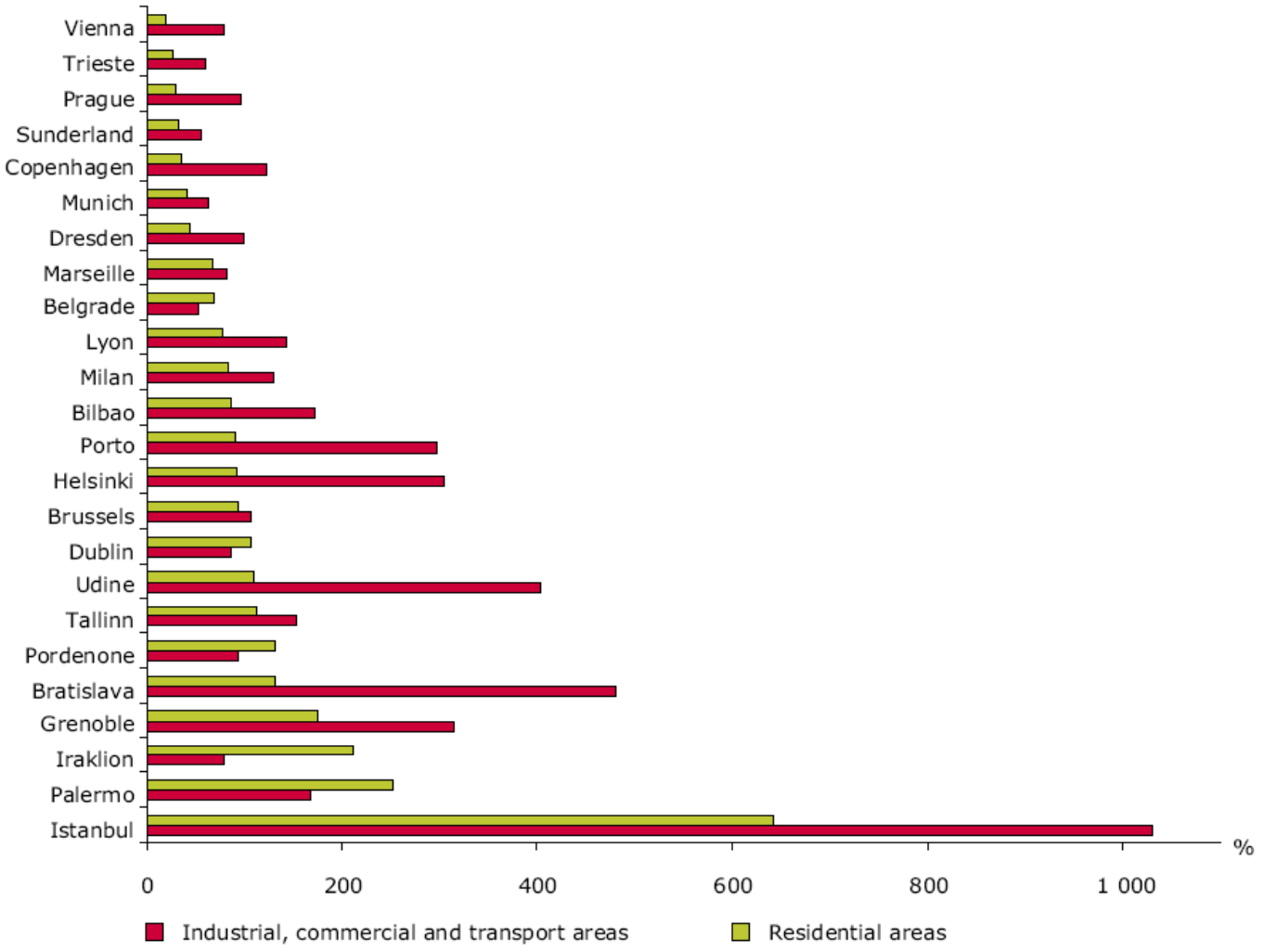
- How do urban forms influence the use of motorized vehicles ?

  E.g. Cologne (DE) 65% of daily trips by car
  Vienna (AT) 36% of daily trips by car

  → concluding impacts on energy use ?

Challenges from the past: Urban growth

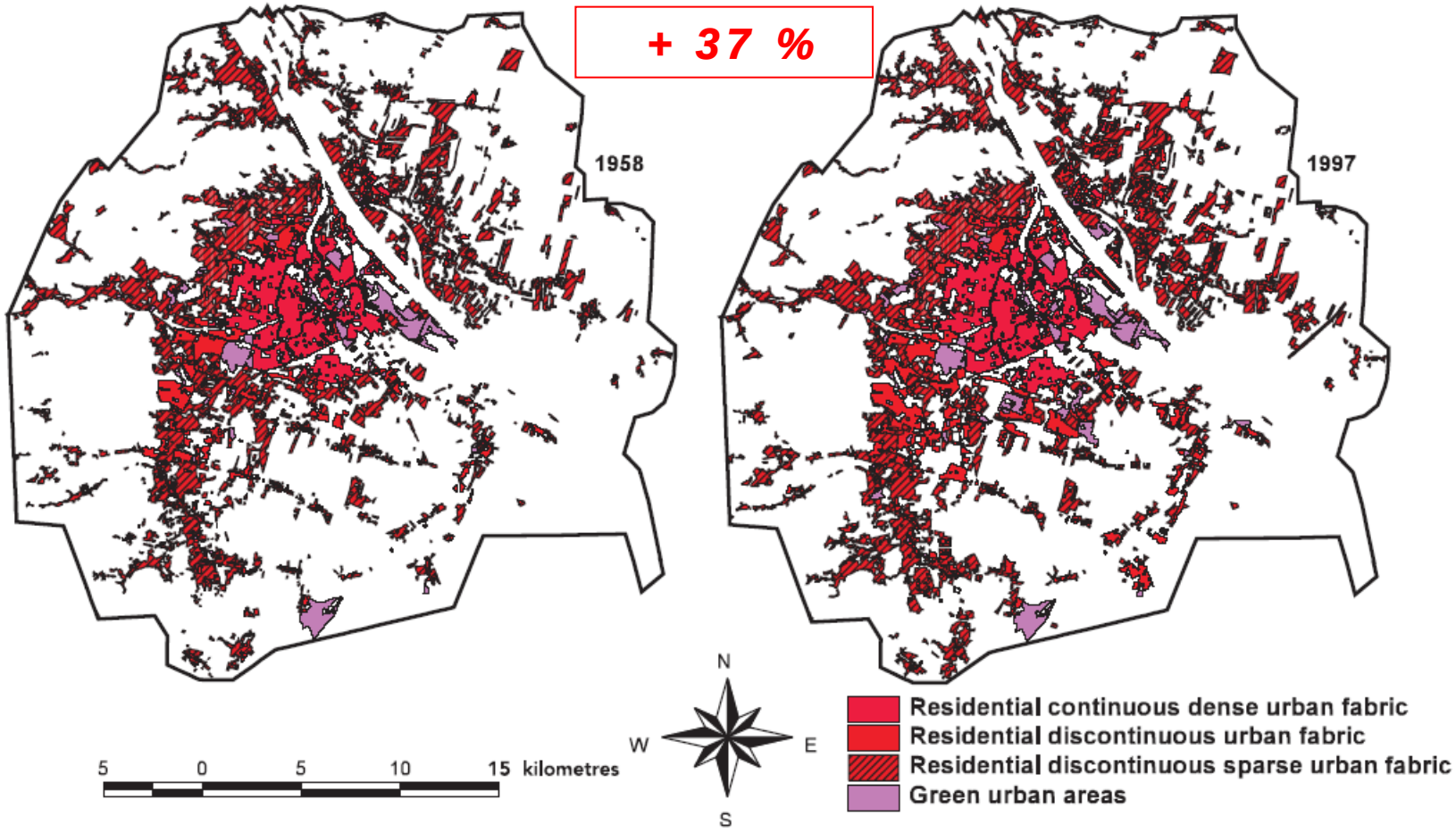
Growth rates of residential areas and industrial, commercial and transport areas from the mid-1950s to the end 1990s), selected European cities



Source: MOLAND (JRC) and Kasanko *et al.*, 2006

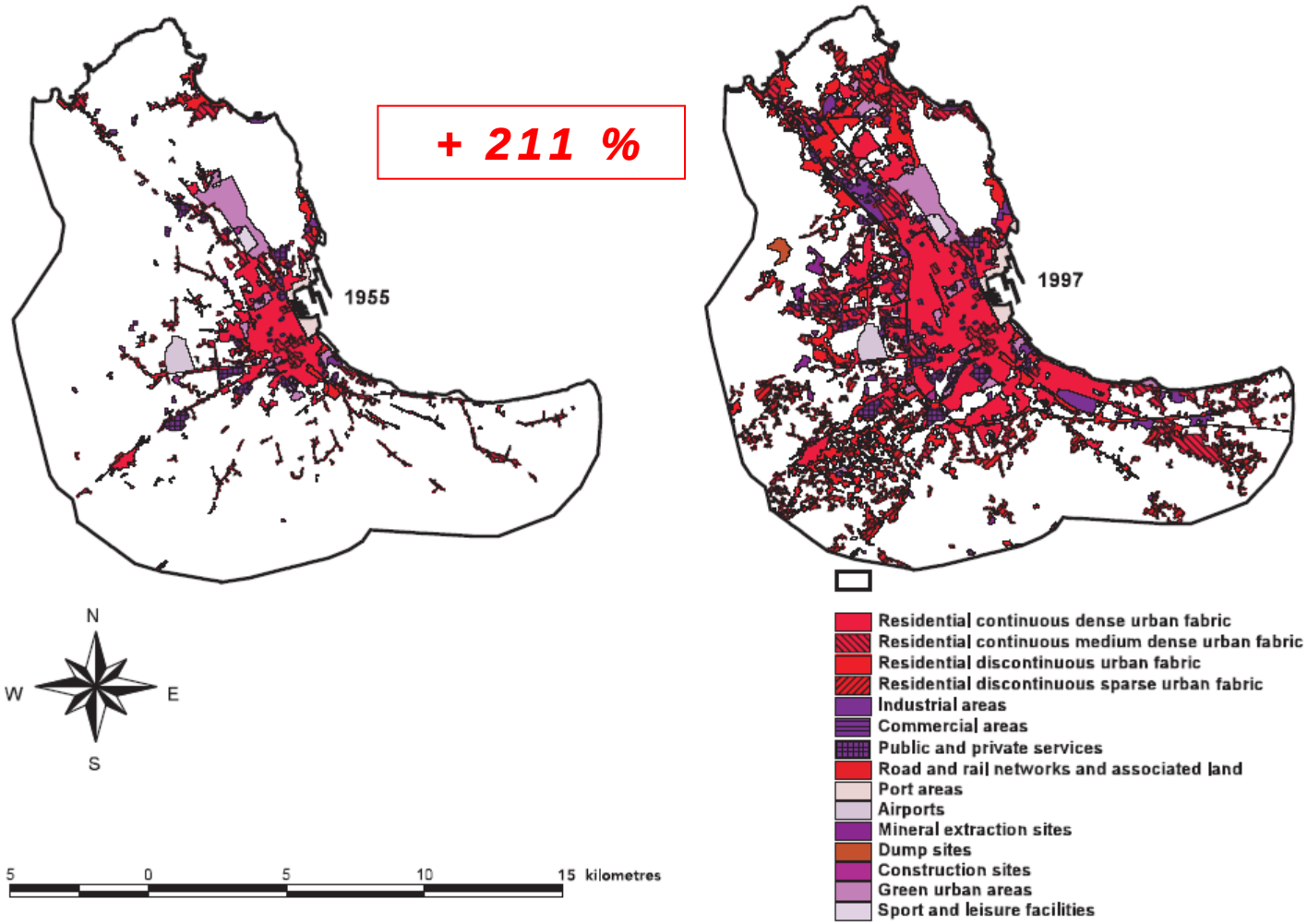
Challenge from the past: Vienna

Correlation between the growth of residential and green areas in Vienna (Austria) from 1958 (left) to 1997



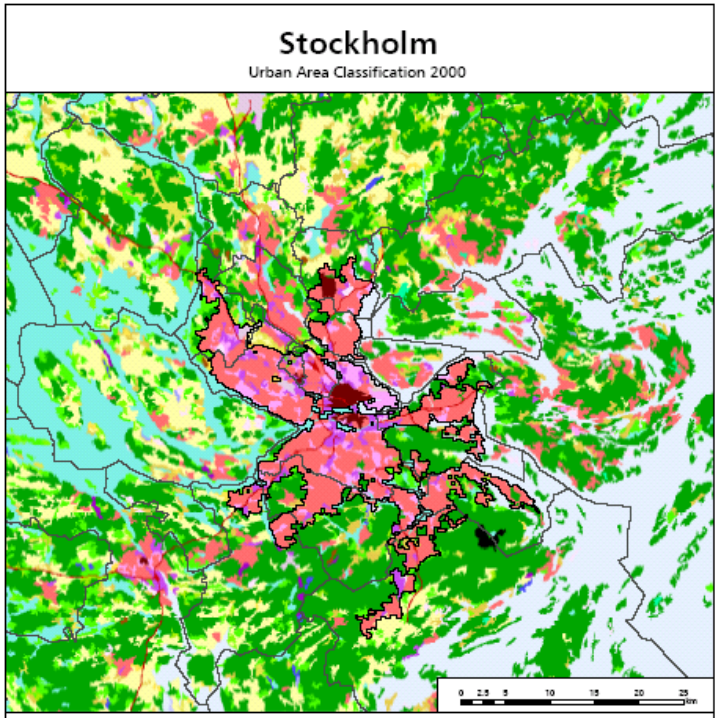
Challenge from the past: Palermo

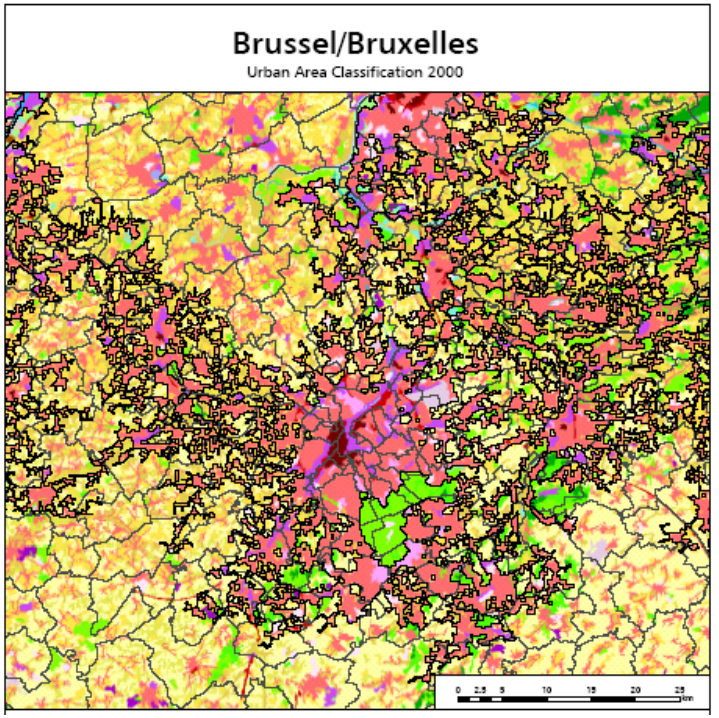
Urban sprawl in Palermo (Italy) from 1955 (left) to 1997.
only artificial surfaces (class 1 of the Murbandy/Moland legend) are depicted.

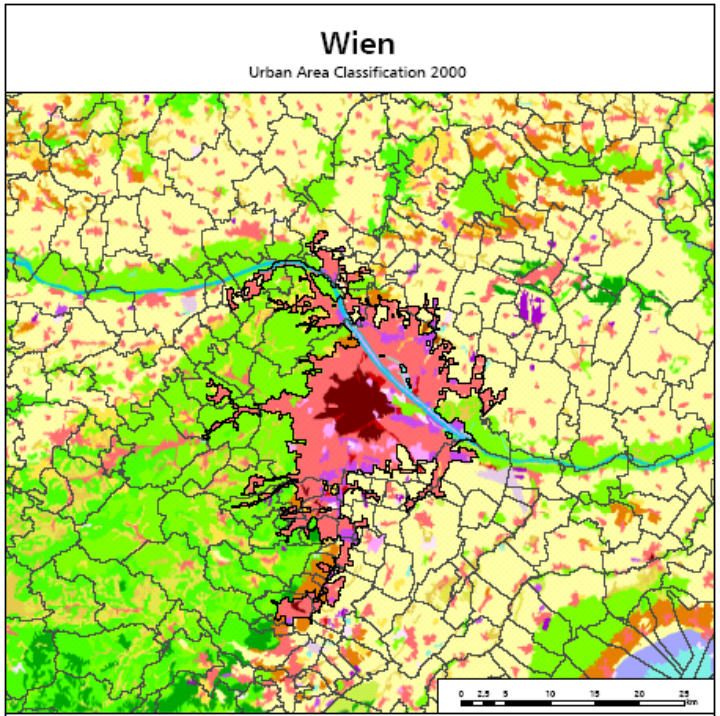


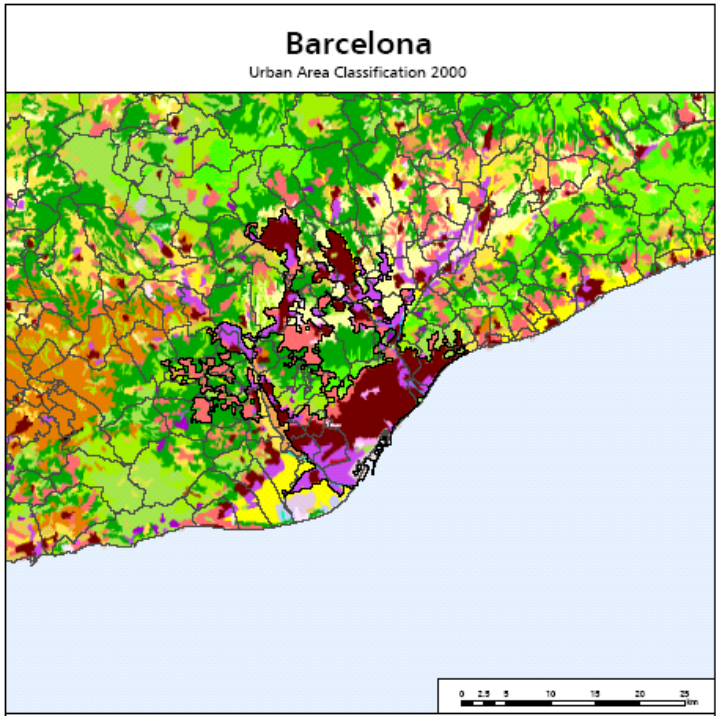
Urban Form: densities and spatial configurations

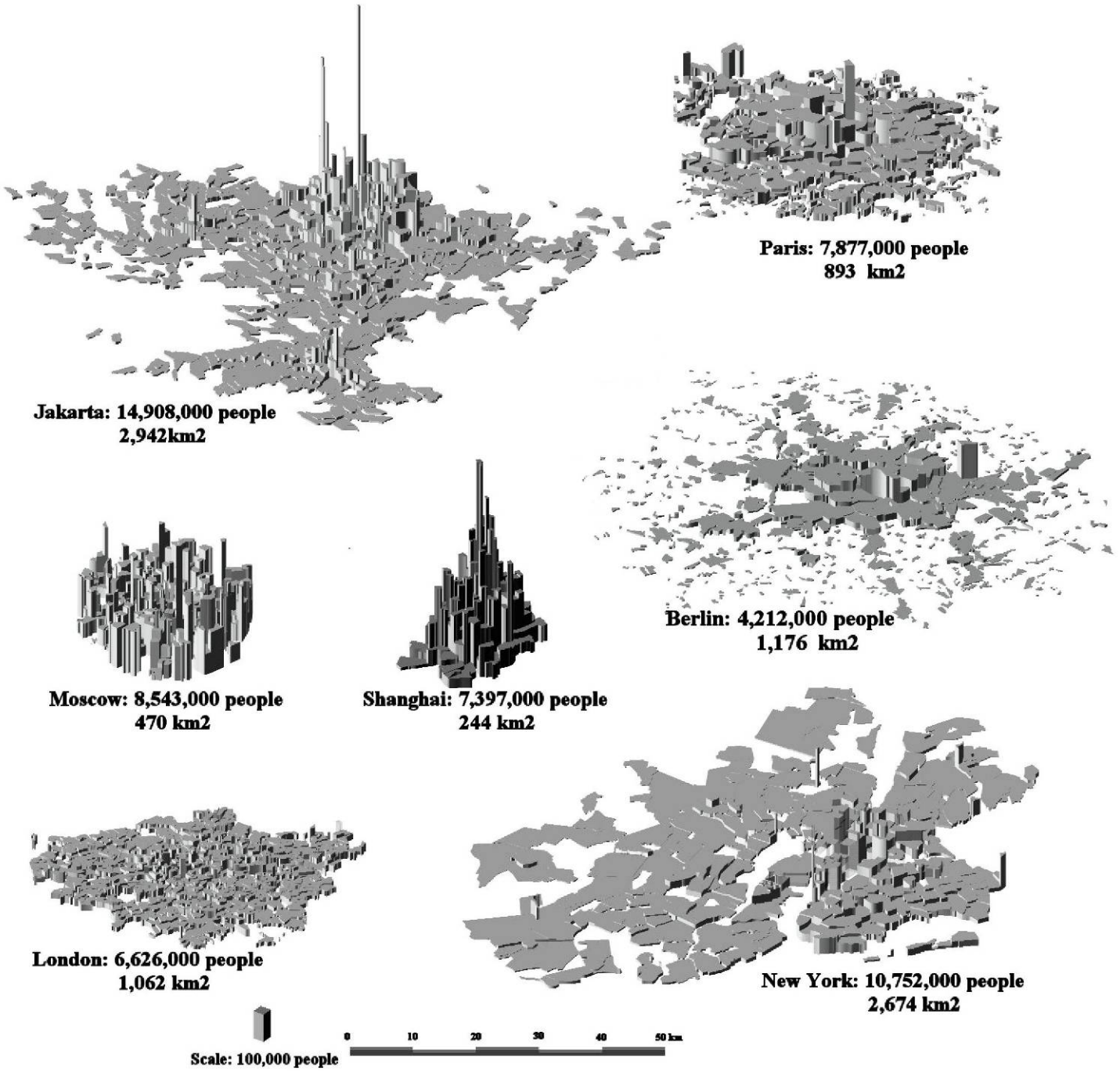
Urban Morphological Zones (UN Habitat definition)







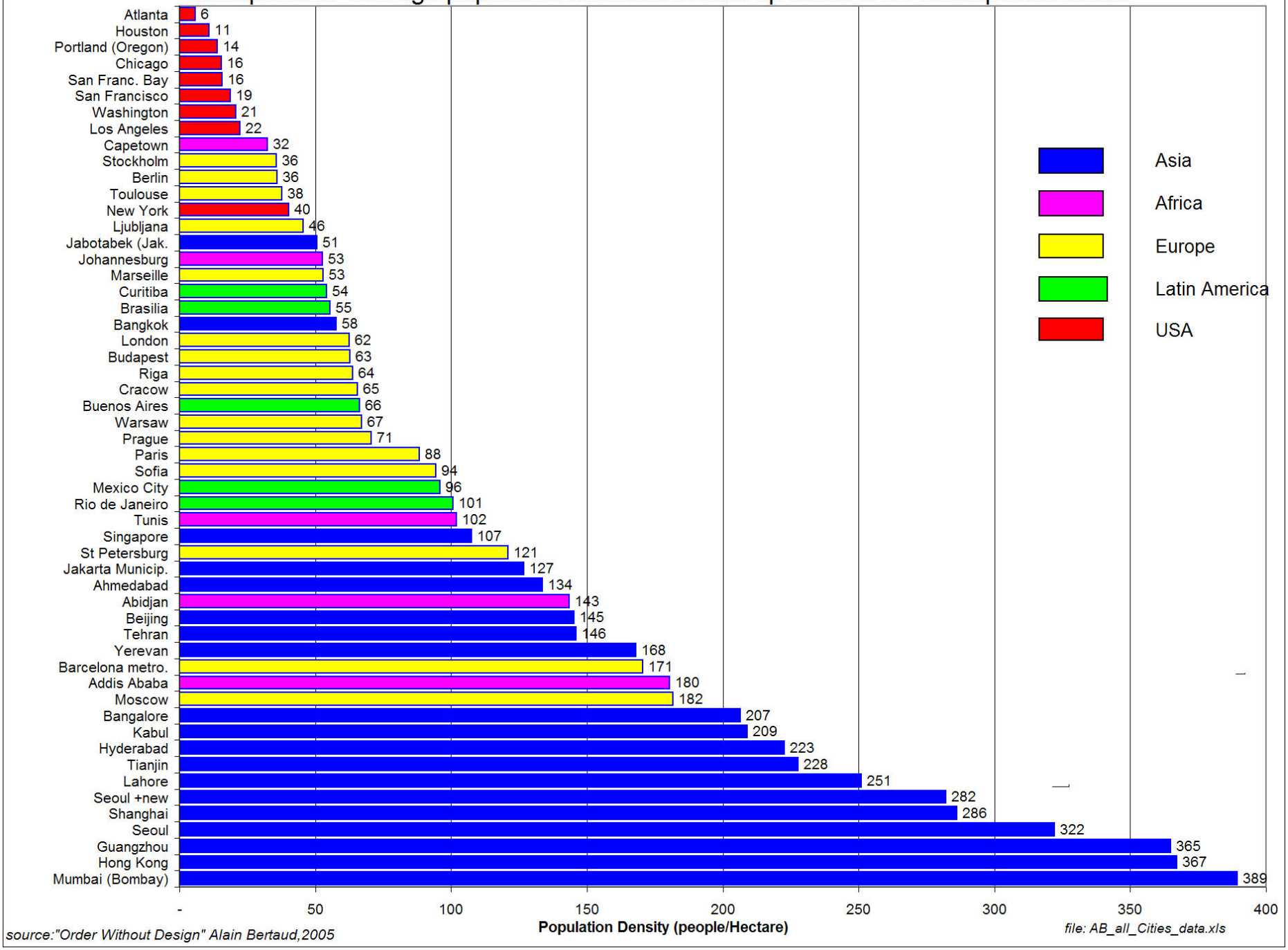




3D representation of the spatial distribution of population in 7 metropolis represented at the same scale

Source:
A. Bertaud

Comparative average population densities in built-up areas in 51 metropolitan areas



source:"Order Without Design" Alain Bertaud,2005

file: AB_all_Cities_data.xls

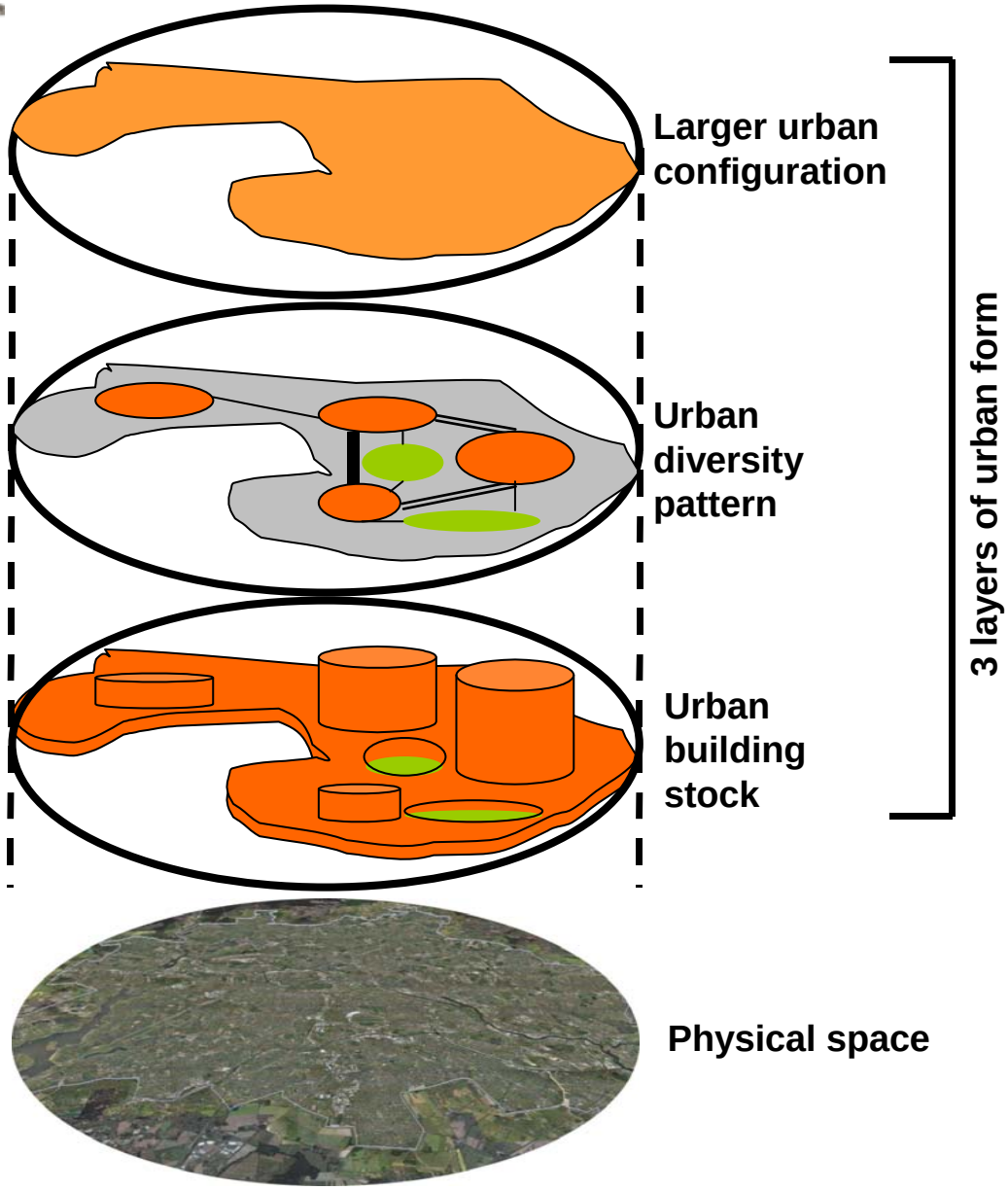
SUME approach on urban form and metabolic impact

The interrelationship between urban form and resource consumption

3 layers of urban form:

- larger urban configuration (overall density, shape, transport distances) → consumption of space
- urban diversity pattern (distribution of densities) → potential for public transport
- urban building stock (construction periods, building types) → potential to reduce residential energy consumption

→ *To be analyzed for the entire **U**rban **M**orphological **Z**one (UMZ, UN Habitat definition, based on Corine data)*



3 Layers of urban form

SUME scenario approach

Urban development scenarios: Guiding Principles

- Spatial development paths for different cities, 2000 – 2050
- Main drivers: population and job change, living space per capita
- BASE scenario as the continuation of current spatial trends (densities, configurations)
- SUME scenario as a path of sustainable spatial planning – focusing on the interrelations between urban form and metabolic performance

Urban development scenarios: Analysis and strategy relevance

- Comparison of long-term development of cities with different
  -- development dynamics,
  -- location in Europe,
  -- urban form parameters
  (density, fragmentation, transportation systems)
- Scenario outputs - major impacts on:
  land use, transportation, building energy
- Comparative analysis allows to detect spatially relevant key factors in general and for individual cities:

  Key parameters are densities, housing types, floor space/cap., access to high-level transport, land use restrictions, building age

→ Basis for tailored, sustainable urban development strategies

Working Steps

STEP 1

Allocation of local and regional population projections to the UMZ → new population (incl. ‚dwelling searchers') /jobs (UMZ) until 2050

Level of cells within the UMZ

STEP 2

Allocation of new population and jobs within/outside of UMZ, 2001 and 2050

- **2a – Major urban development projects**
- **2b – Development corridors and areas**
- **2c – City-typical densification**
- **2d – Allocation outside the UMZ**

Larger Urban Configuration
→distribution of population and jobs to cells
→space demand outside of UMZ – LUC extension

STEP 3

Calculation of population and jobs within high level public transport, density distribution 2001 and 2050

Urban Diversity Pattern
→population and jobs in the range of public transport
→urban centres and density distribution

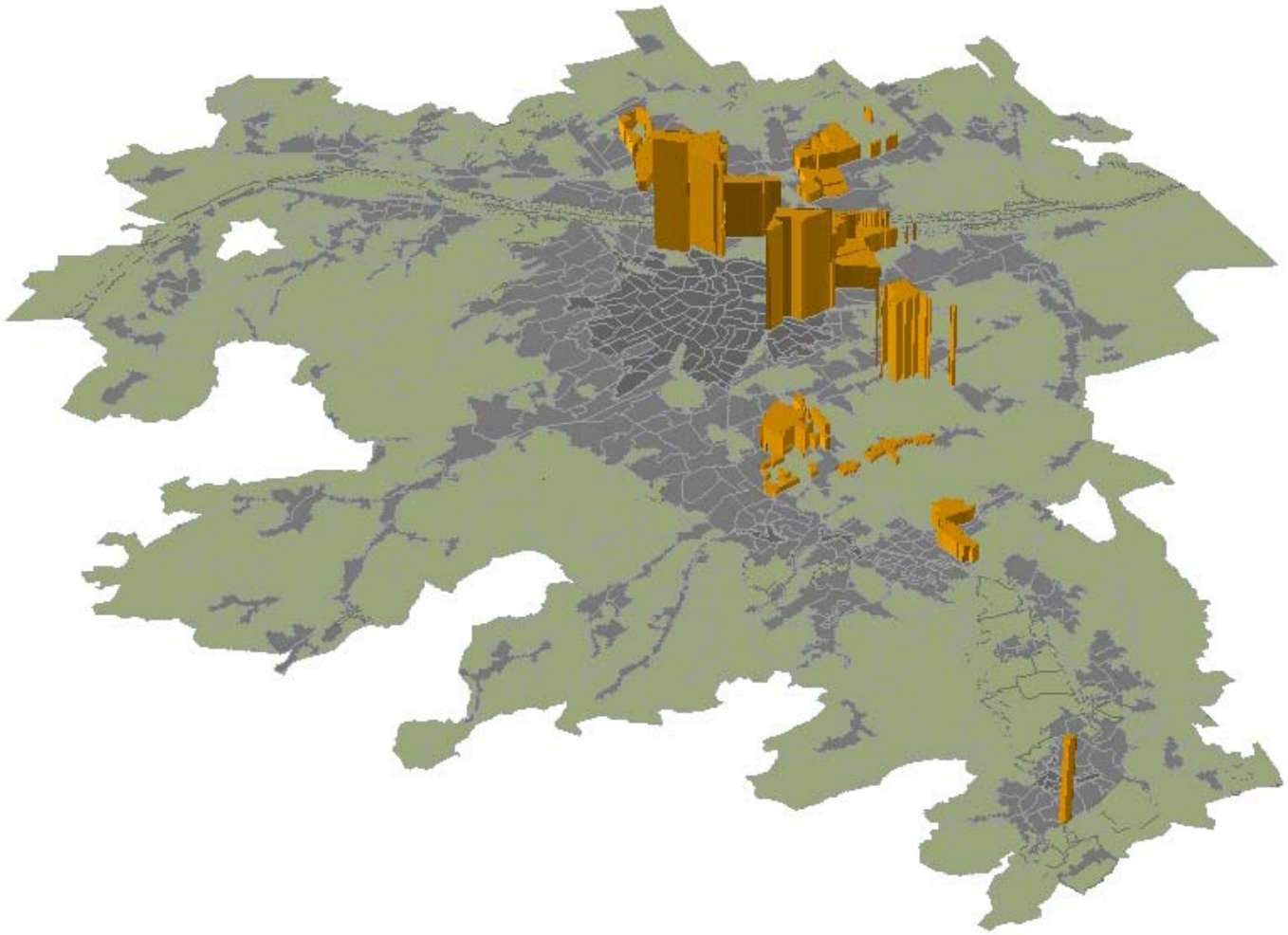
STEP 4

Calculation of age structure and transformation of housing stock → energy demand 2001 – 2050

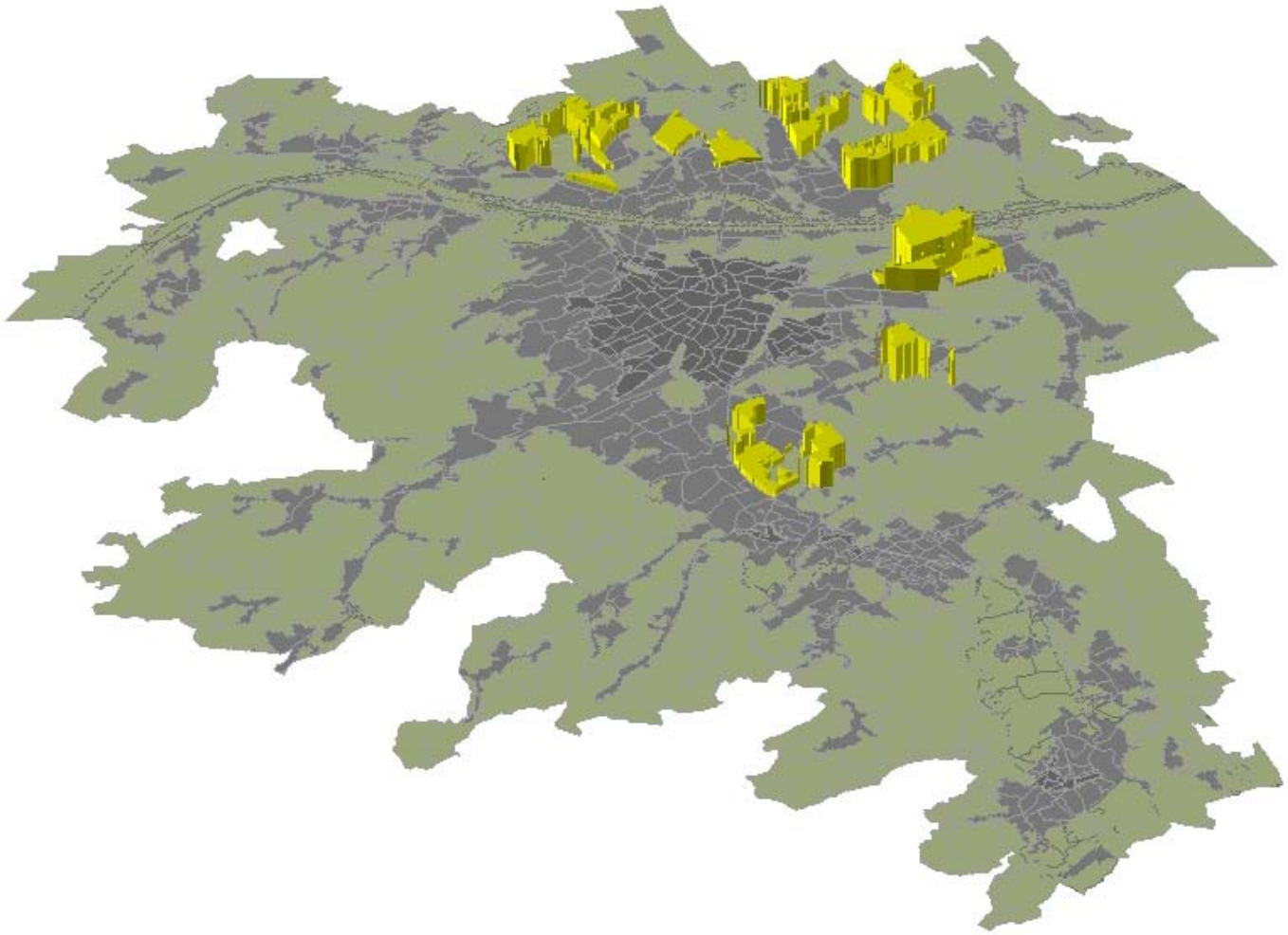
Urban Building Stock
→age structure development of the housing stock
→housing stock related energy demand

Example:
Base Scenario Vienna – scenario steps a, b, c, d

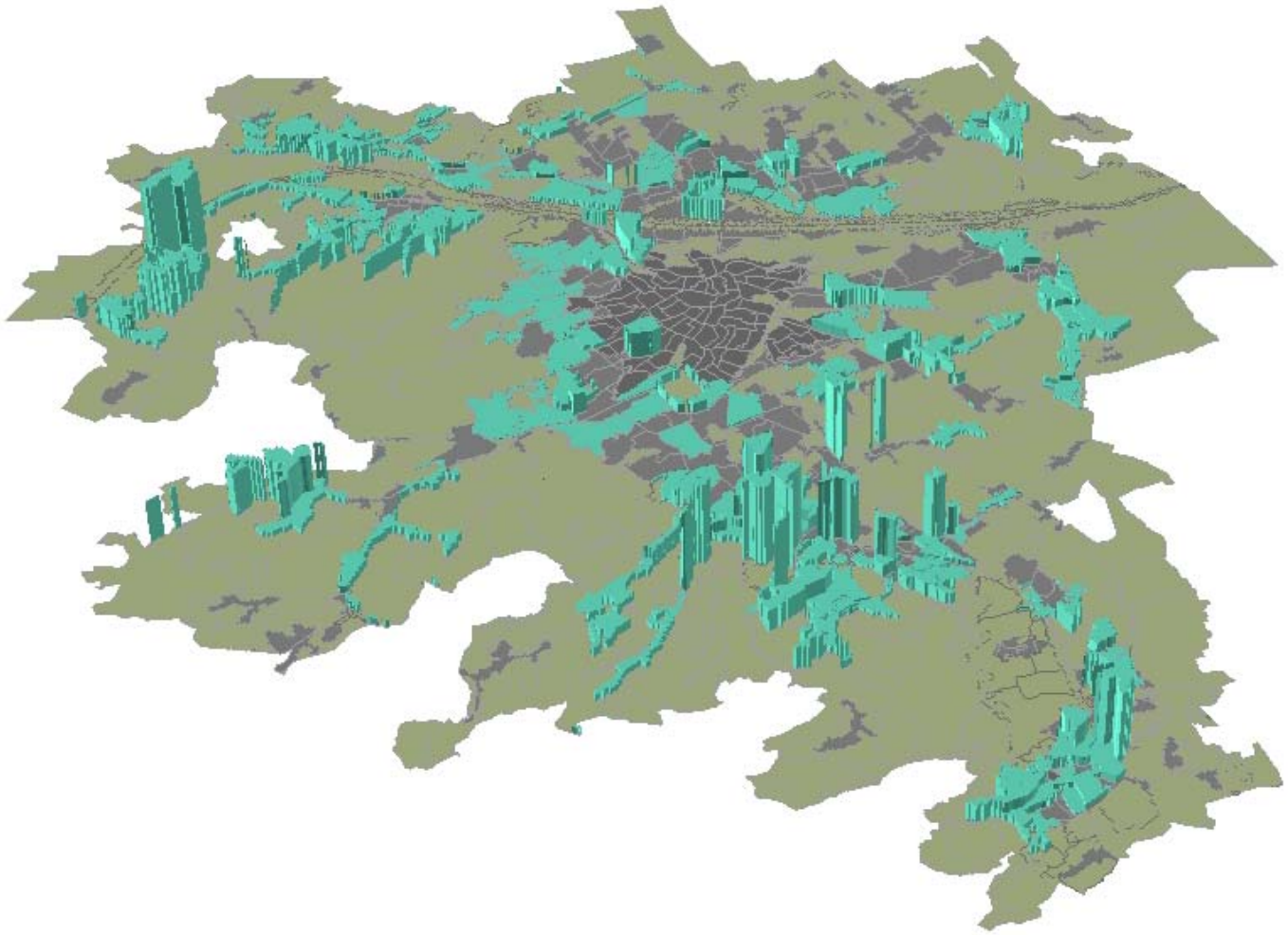
Vienna - Allocation of population
Step 2a: Large scale projects



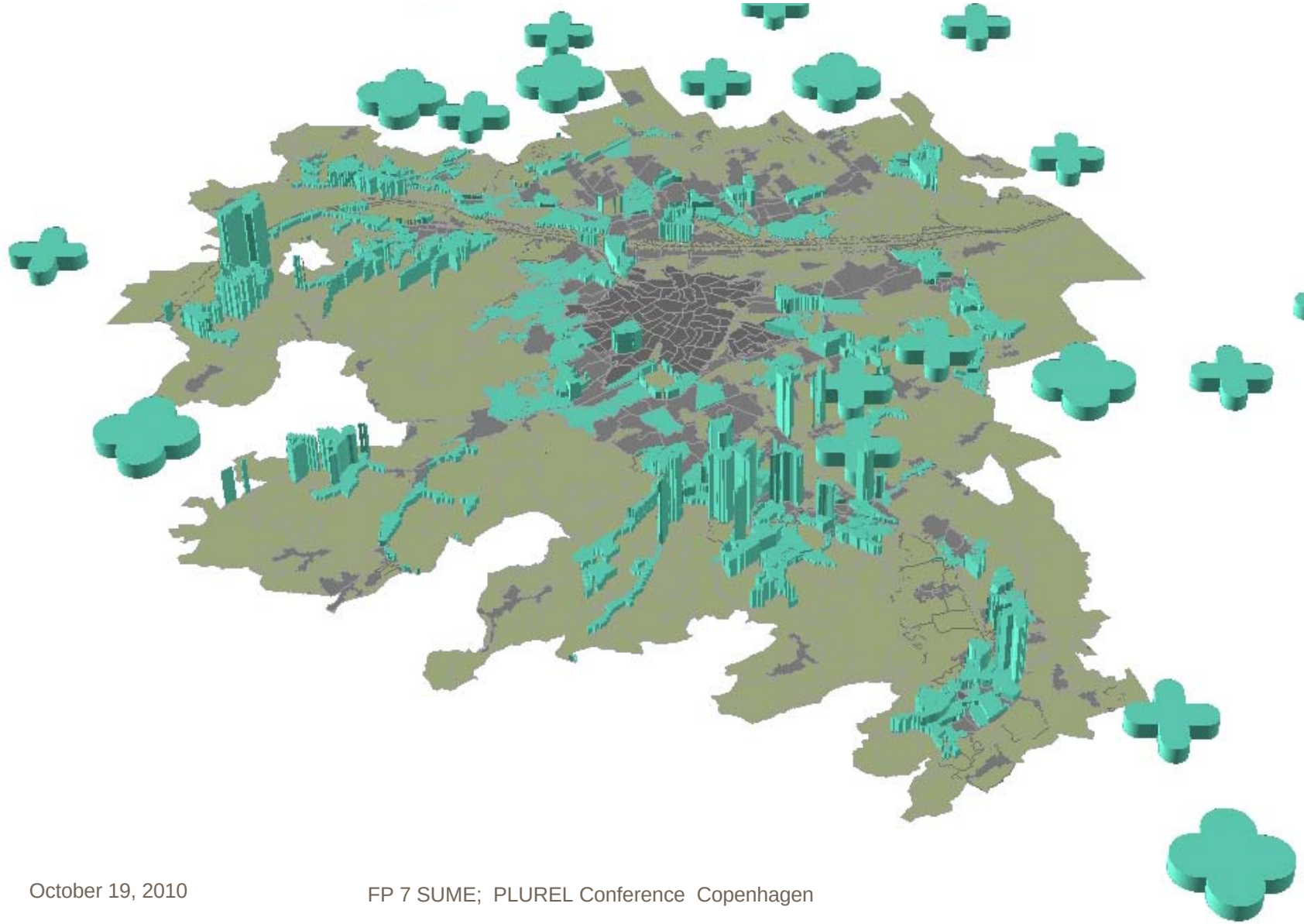
Vienna - Allocation of population
Step 2b: Project development



Vienna - Allocation of population
Step 2c: Filling up and densification



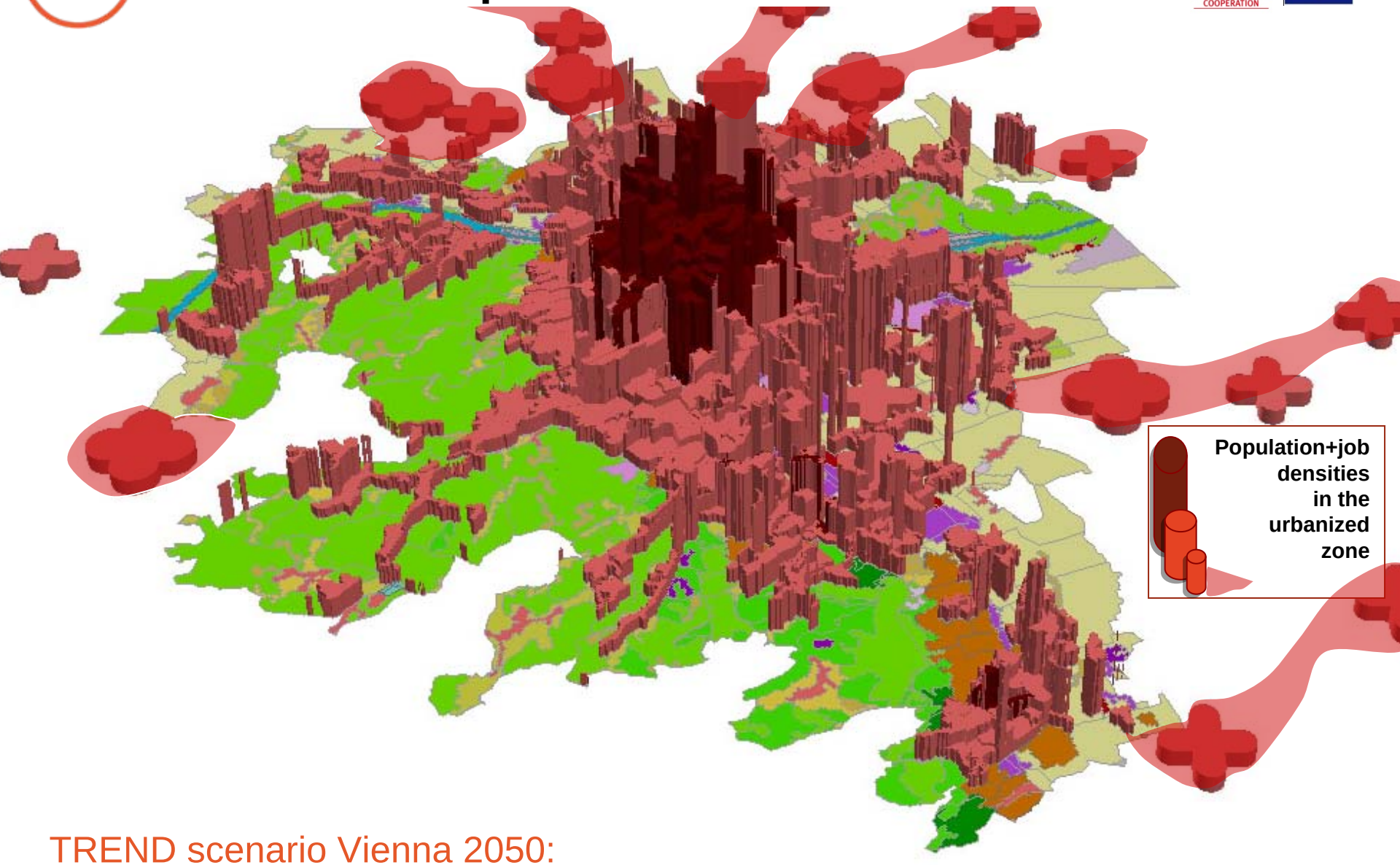
Vienna - Allocation of population
Step (2c +) 2d: Expansion of urbanized zone



Scenario results for the city of Vienna

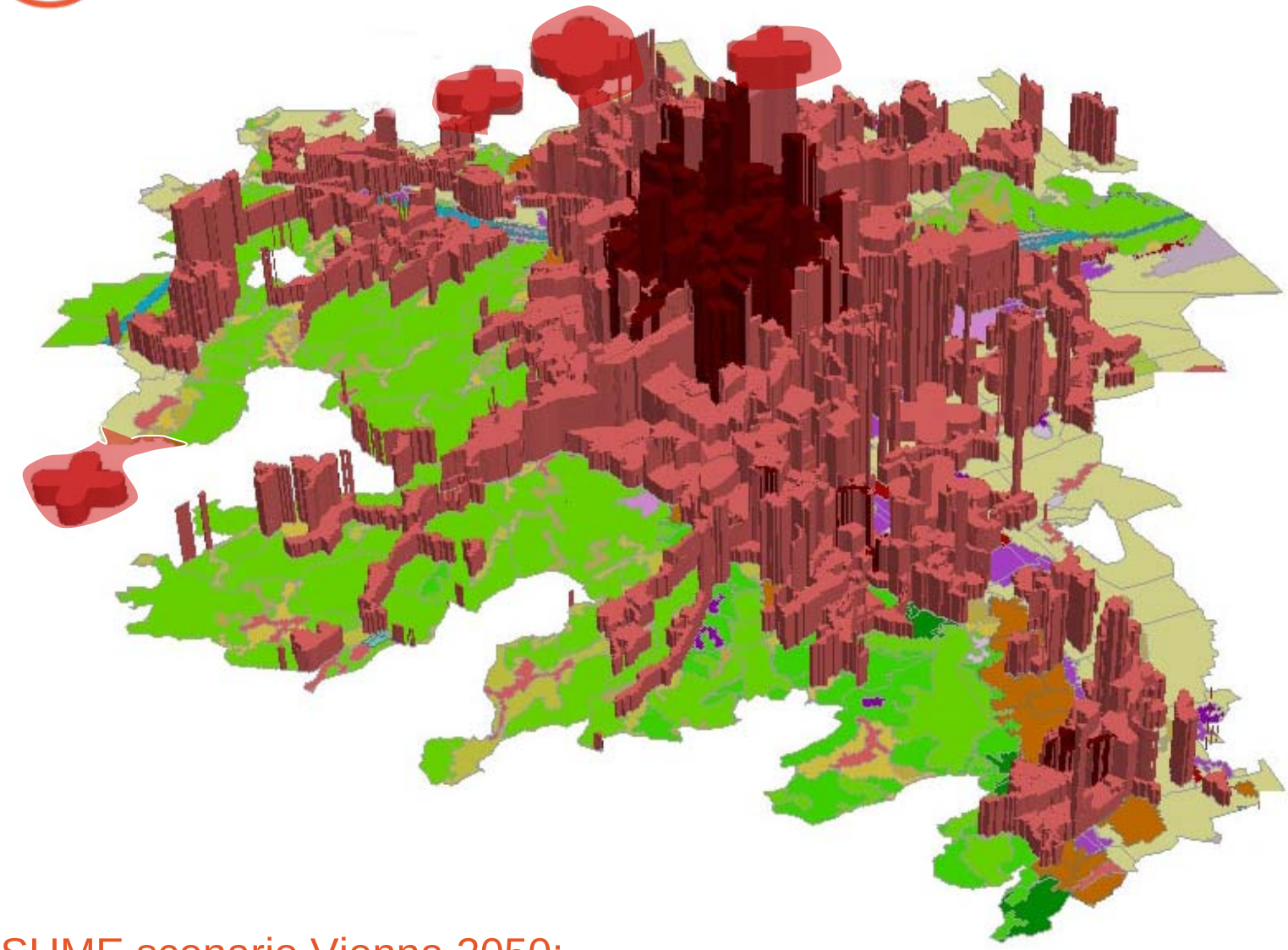
- 2 a projects with metro or other high level public transport
- High potential for 2b projects in high quality public access
- General densification (step 2c) in the SUME scenario is an essential development potential
- High potential to concentrate development near existing and new high-level public transport infrastructure (accessibility), also in step 2c
- High share of taboo-zones within core city
(for both scenarios)

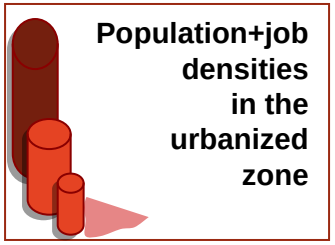
Vienna (AT): BASE spatial development scenario 2000 - 2050



TREND scenario Vienna 2050:
Dispersed urban development leads to expansion of the urbanized zone by **+54%**

Vienna (AT): SUME spatial development scenario 2000 - 2050





SUME scenario Vienna 2050:
Densification strategy reduces the expansion of the urbanized zone to only **+14%**

SUME scenario comparisons

Scenario input: Population development, densities and floor space

	population in UMZ 2000 (Mio.)	pop./km2 urban fabric 2000	share of urban fabric of total UMZ (2000)	floor space/ inhabitant (m2) 2000 - 2050
Vienna	1.8	5 789	75%	40 – 46
Munich	1.7	7 240	72%	40 - 46
Porto	1.3	5 557	74%	40 - 44
Stockholm	1.2	4 150	67%	40 - 45
Athens	3.4	15 551	78%	40 - 44

BASE vs. SUME scenarios: Growth of urbanized zones 2000 – 2050

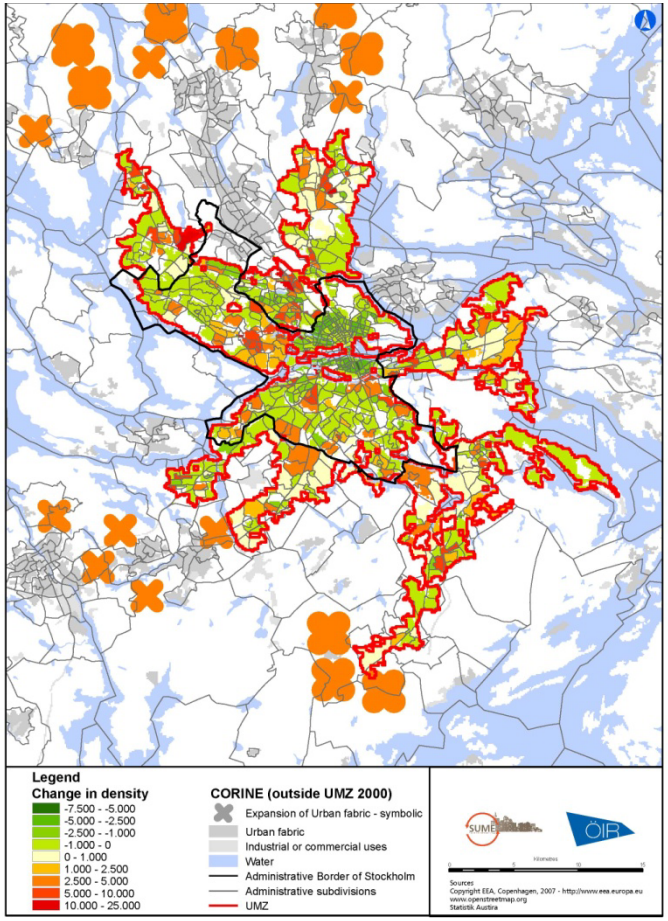
	Density: pop.+jobs/ km2 urban fabric 2000	population in urba-nized zone 2050 (Mio.)	population change 2000-2050	Area growth of urbanized zone in % 2000 - 2050 BASE	SUME
Vienna	7.251	2.4	+35%	+54%	+14%
Munich	8.759	2.0	+17%	+41%	+18%
Stockholm	5.278	1.8	+44%	+38%	+20%
Porto	5.403	1.3	- 4%	0%	0%
Athens	18.584	3.7	+9%	+24%	0%

Conclusion:

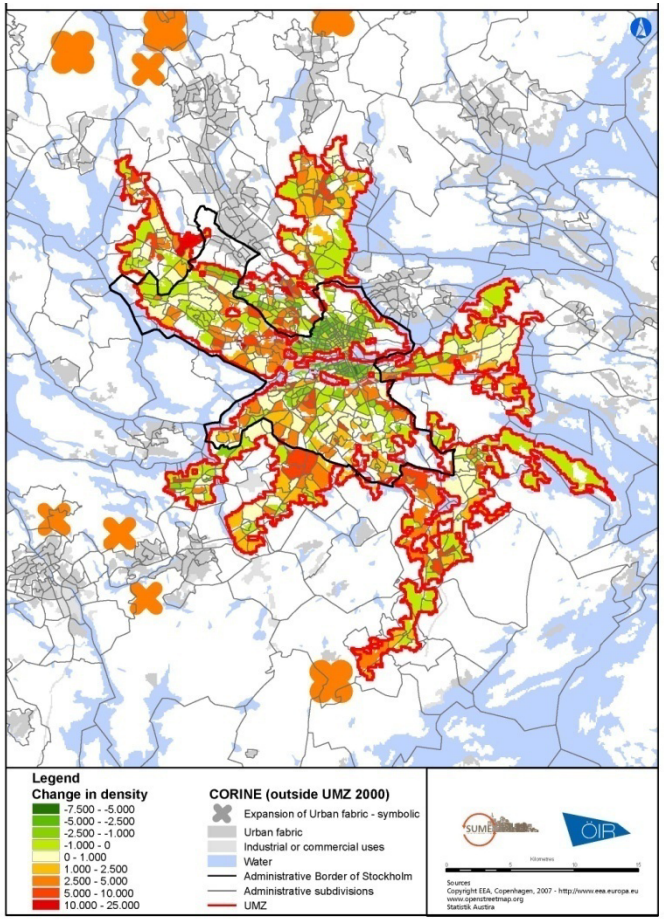
Urban development can be made more compact and sustainable, if SUME-type spatial development strategies are applied

Example: Density changes 2001 - 2050

Stockholm - BASE

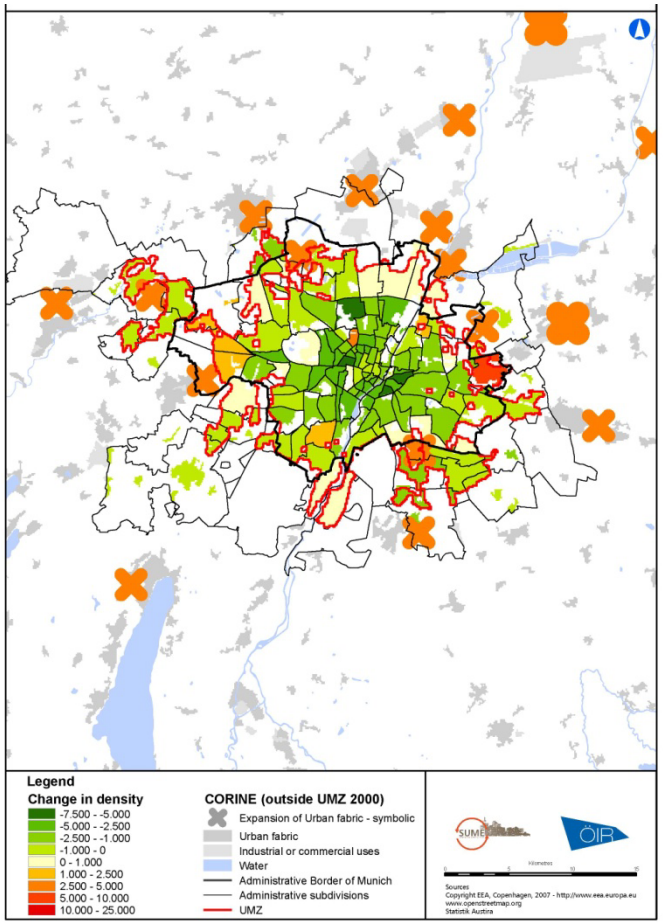


Stockholm - SUME

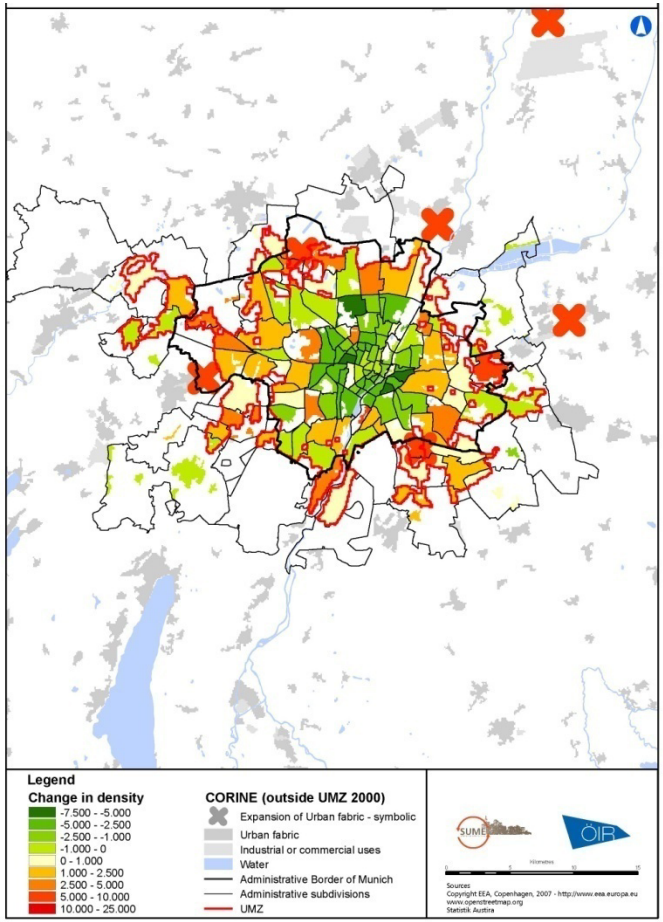


Example: Density changes 2001 - 2050

Munich - BASE



Munich - SUME

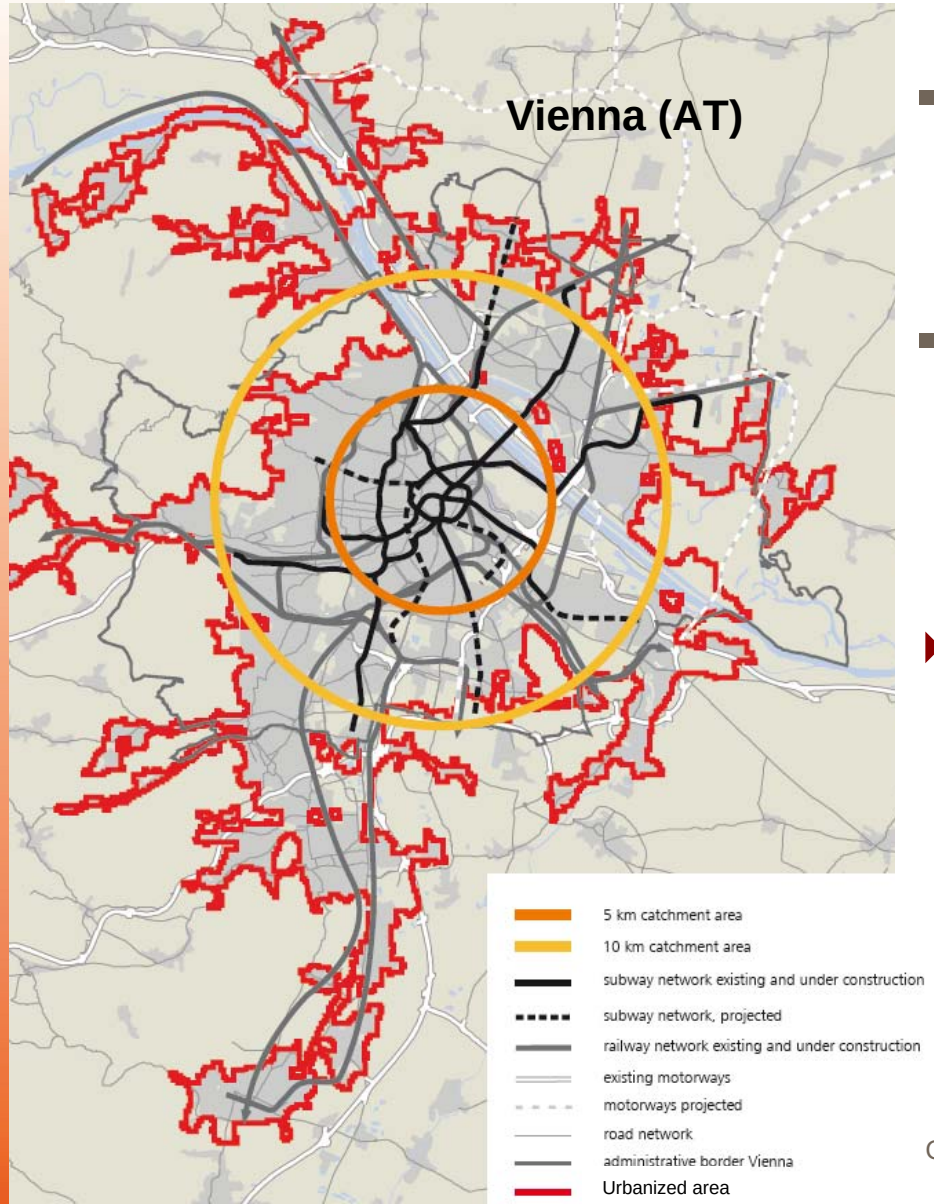


Conclusions:
Spatial development – urban form

- Fast growing cities with increasing floor space demand will show massive growth of their urban fabric (land use)
- They also have the greatest potential to spatially focus development, use inner-city re-densification and orient to public transport lines
- Cities with low densities and high fragmentation of the UMZ need a new approach towards spatial planning and urban restructuring with a high focus on public transport
- High density situations like in Athens raise the question for an alternative strategy: sustainability also needs open (green) space, and lower average densities

Urban form:
Impact on transport (→ energy)

The second challenge: Transport

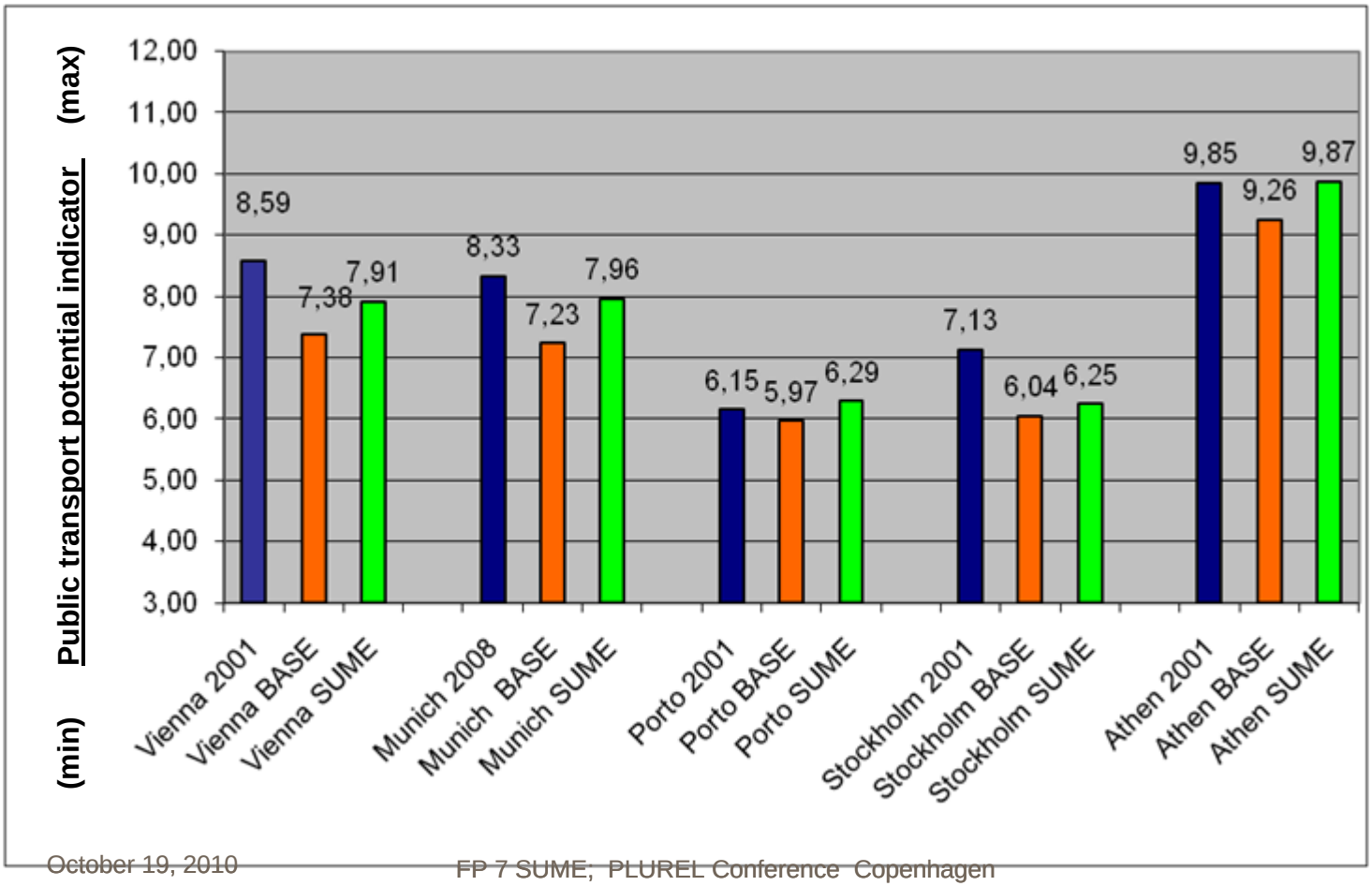


- The share of car use for daily trips is influenced by the accessibility of good quality public transport
- Growing cities tend to expand spatially, they loose in compactness and access to public transport lines

⏩ But: Urban spatial development scenarios show the trends, SUME scenarios show the potential to improve accessibility

The potential to use public transportation, depending on spatial development 2000 - 2050: BASE and SUME scenarios for Vienna, Munich, Porto

Integrated public transport potential indicator: 12 = max., 3 = min.



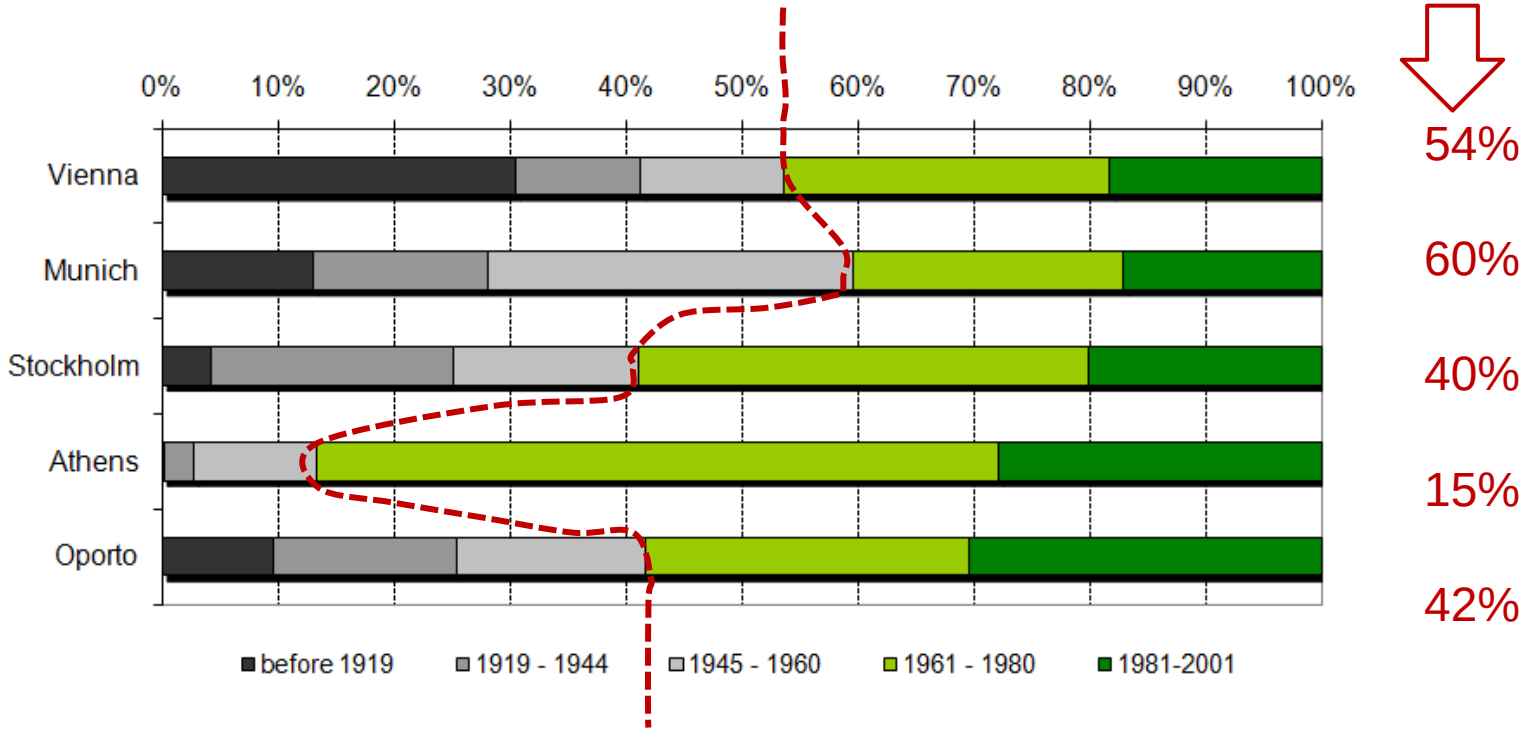
Changes of the urban diversity patterns (UDP-indicator) → transport/energy

- The BASE scenarios indicate a substantial decline of urban form factors contributing to a sustainable transport system (decline of UDP indicators), although expansions of the public transport system are included
- A SUME development strategy, including densification and a focus an good access to high-level public transport, shows a relevant improvement of the UDP indicator
- In growing cities with rising standards of floor space it will be necessary to implement intensified SUME-strategies in order to maintain today´s UDP-standards
- Cities with high densities but low public transport quality have a great potential to improve their UDP levels

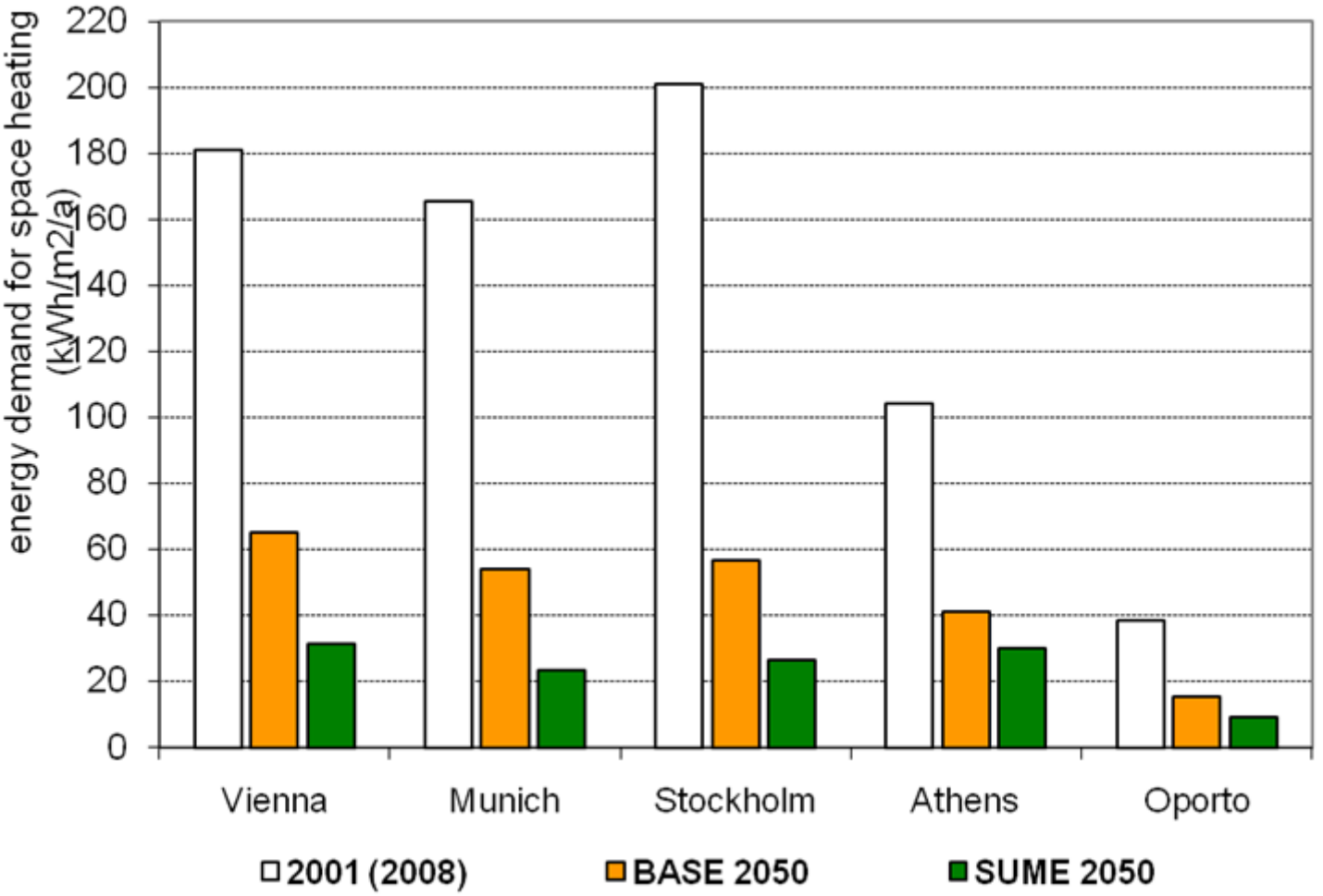
Urban building structures: Future options to reduce energy consumption for heating/cooling

The third challenge: Transforming the building stock to reduce energy consumption

- Cities have different building age structures (and corresponding technical standards), which are decisive for the potential to reduce their energy consumption for heating
- If buildings are being replaced after 80 years:
  → the option for putting in zero-energy housing until 2050 in % of total is



How energy demand for space heating can be reduced 2001 - 2050: Scenarios BASE and SUME



Scenario conclusions for energy demand

- The specific energy demand for space heating is decreasing generally substantially (per m2)
- Options for energy saving by transforming the existing housing stock are considerable
- For space heating, the savings within the transformed housing stock (2001-2050) range between:
  13 – 24% (BASE) and 34 - 49% (SUME scenarios)
- The higher relevance of space-heating demand in cities of cold-moderate climate justifies enforced transformation of buildings
- Attention to total energy demand (incl. construction, renovation and demolition) is needed, especially in warm climate cities
- Total energy demand (construction, reconstruction, heating) for the transformed housing stock ranges from
  +5% to –15% (BASE) and from –3/-8% to –35% (SUME)
- If energy demand for cooling is included,
  building quality is of greater relevance in warm climate cities

Urban development scenarios: Conclusions

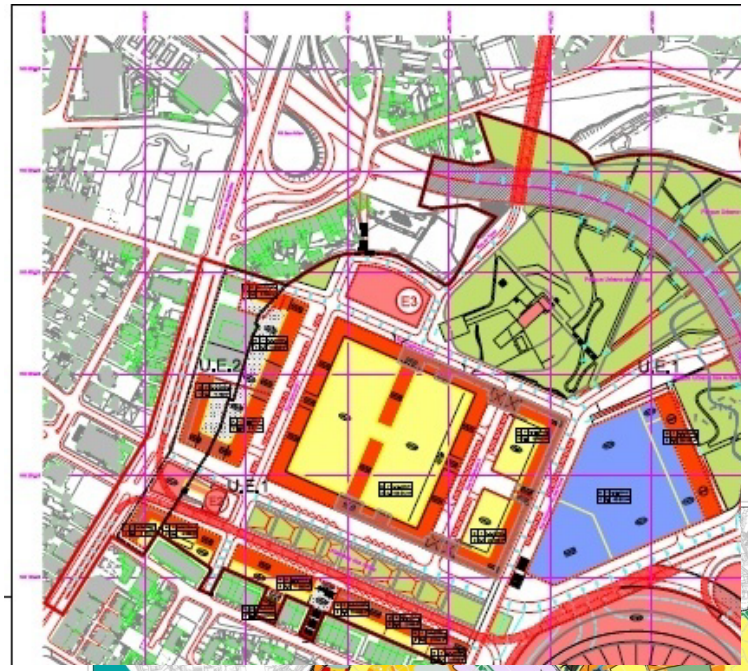
Urban development perspectives:

- The urban growth and spatial expansion of the past is continuing – how can it be strategically steered towards a more sustainable way ?
- Fast growing cities have the greatest potential to save (material) resources and energy, depending on their planning policies (urban form & transport system) – with a great spread between BASE and SUME scenarios
- They also have the greatest opportunity to improve energy consumption for heating and cooling - through accelerated increase of zero-energy buildings and renovation
- Slow growing cities have little potential to change their urban form; they need to focus their building potential wisely (restructuring existing quarters), expand public transport systems and accelerate building renovation

Spatial re-development as key strategy

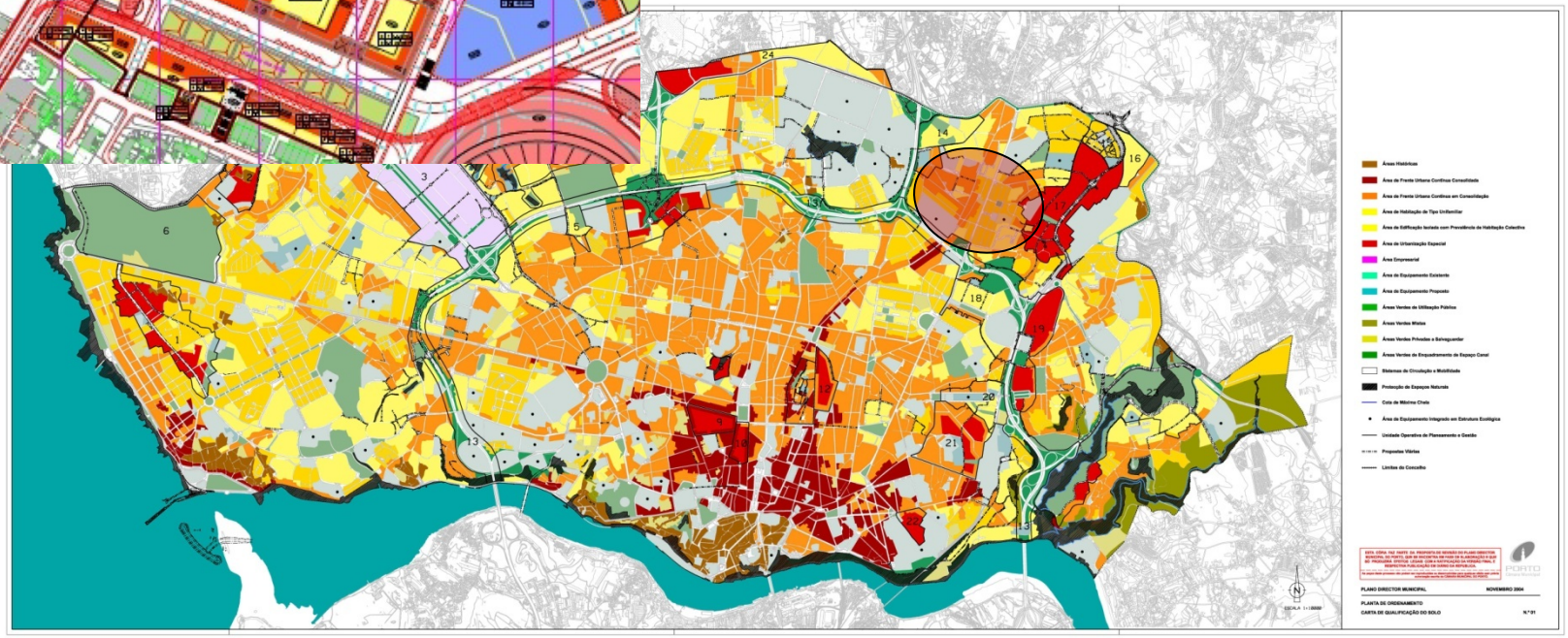
- Public-transport accessible urban fabric with currently low densities is the key to avoid large-scale future expansion of cities
- The potential to transform existing low-density sections of a city is great, but a challenge for urban development policies and planning instruments:
  A new policy-set beyond brown-field development is needed
- Building-oriented renovation strategies in such areas should be combined with densification strategies – both policies can gain from it
- Integrating large scale development projects, forming new centers an nodes of transport can be a strategy to improve the urban diversity pattern and given an impulse to densification

Key project integration: City of Oporto case study



- Integrating large scale development projects in existing urban fabric:

  Change of densities in the urban fabric, impact on neighbouring quarters, improvement of the transport system



SUME:
Urban development and the metabolism approach

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