Urban Development 2050

Planning resource-efficient cities

MIA -Metabolic Impact Assessment

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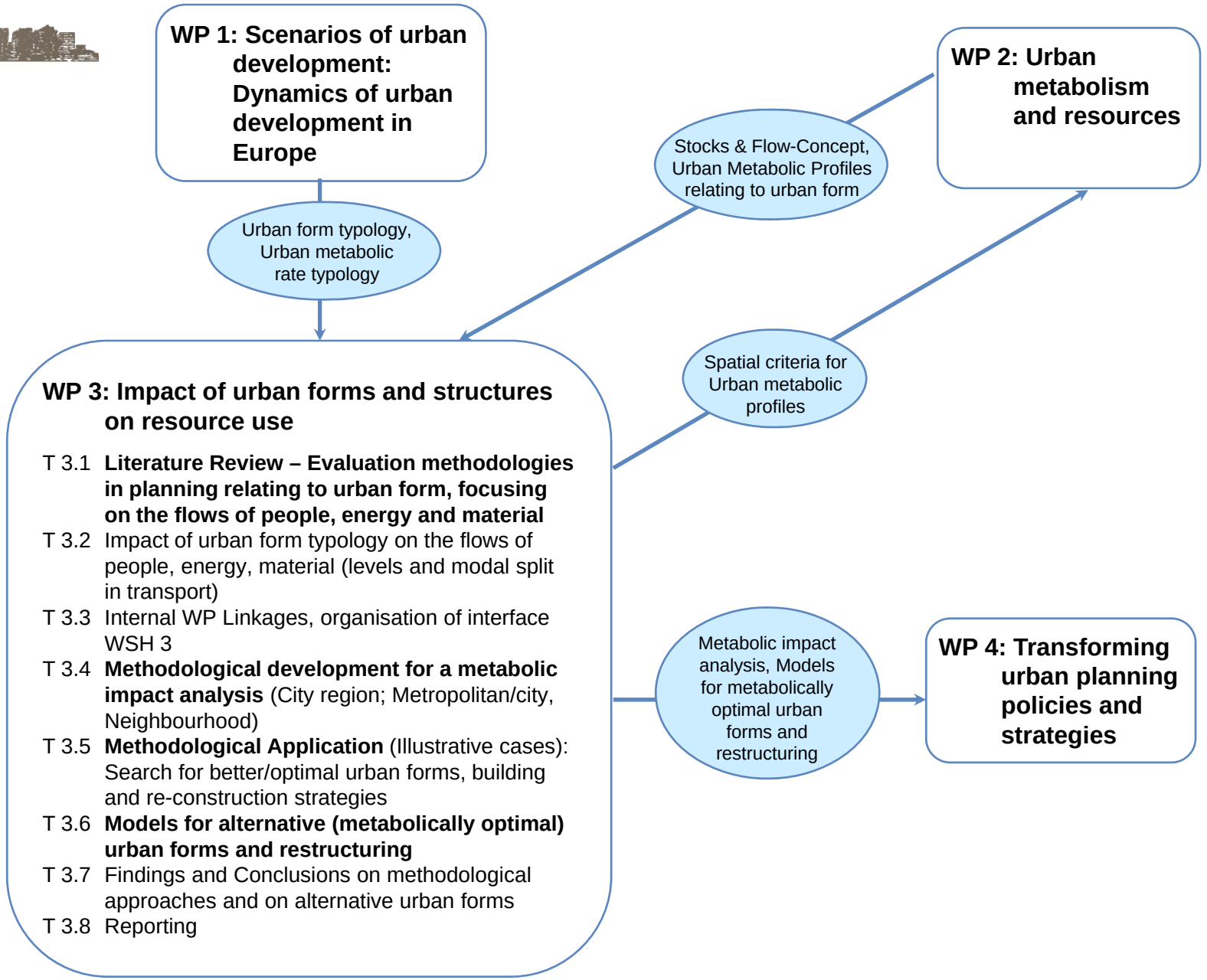

WP 1: Scenarios of urban development: Dynamics of urban development in Europe
Urban form typology, Urban metabolic rate typology
Stocks & Flow-Concept, Urban Metabolic Profiles relating to urban form
WP 2: Urban metabolism and resources
Spatial criteria for Urban metabolic profiles
WP 3: Impact of urban forms and structures on resource use
T 3.1 Literature Review – Evaluation methodologies in planning relating to urban form, focusing on the flows of people, energy and material
T 3.2 Impact of urban form typology on the flows of people, energy, material (levels and modal split in transport)
T 3.3 Internal WP Linkages, organisation of interface WSH 3
T 3.4 Methodological development for a metabolic impact analysis (City region; Metropolitan/city, Neighbourhood)
T 3.5 Methodological Application (Illustrative cases): Search for better/optimal urban forms, building and re-construction strategies
T 3.6 Models for alternative (metabolically optimal) urban forms and restructuring
T 3.7 Findings and Conclusions on methodological approaches and on alternative urban forms
T 3.8 Reporting
Metabolic impact analysis, Models for metabolically optimal urban forms and restructuring
WP 4: Transforming urban planning policies and strategies

MIA – METABOLIC IMPACT ANALYSIS

Main objective

- This methodology provides an operational instrument to assess the overall impact of a particular development proposal on the existing urban metabolism performance of a given city, metropolis or city region.

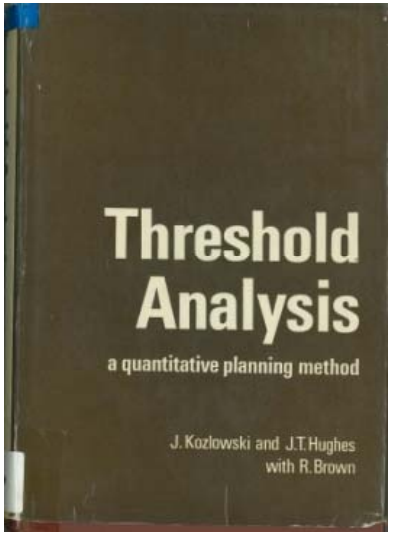
Influences

- MIA draws on the EIA & SEA methodologies. MIA provides an embracing and holistic perspective based on the urban metabolism concept, with some resemblances to the Sustainability Appraisal approach in which the sustainability concept offers the glue to integrate the different analysis topics.

Influences (continuation)

- **MIA has been influenced by the *Threshold Analysis*. The idea of selecting directions for expansion areas in accordance to cost minimizing solutions as far as the existing provision of infrastructures and public equipments are concerned has some similarities to MIA.**

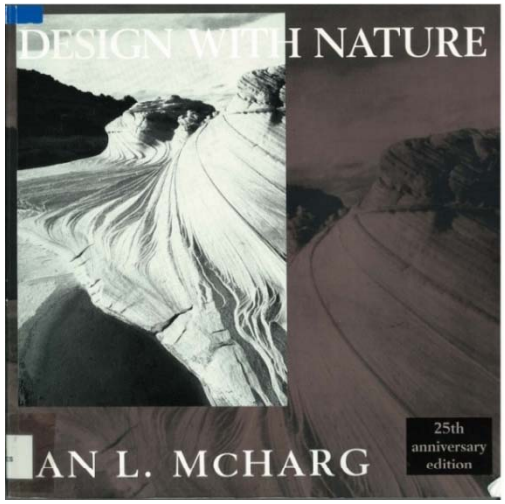
- **MIA is able to explore the installed urban metabolism capacities and natural capital across the complex urban fabrics that constitute the contemporary city.**



Influences (continuation)

-MIA has also been influenced by McHarg's *Design with Nature* (1970) in respect to the systematic use of layers of environmental information and to the application of the environmental sensitivity concept.

Contrary to the mainstream application of the urban metabolism concept that simply ignores the spatial dimension of development processes and of the sustainability concept, MIA explores this spatial dimension and attempts to take the best use of GIS techniques.



MIA's general purposes

1 – It evaluates the urban development process, from a metabolic perspective.

2 – It focuses on plans and projects as fundamental drivers of the urban development process.

3 – It assesses the city wide metabolic impact of the proposals included in plans and projects.

4 – It explores the spatial dimension of alternative development processes.

5 – It may address different temporal scales but is better suited to short and medium term assessments.

6 – It deals with the environment in an integrated way.

Differences between MIA and EIA/SEA

MIA	EIA/SEA
The study area is not defined by the intervention area of the urban project under analysis, instead coincides with the city or metropolis boundaries for which the urban metabolic model is available or has to be built (in case is not available).	The geographical scale of the study area tends to be predefined by the characteristics of the PPPP under analysis and may vary slightly in accordance to the environmental component under consideration (watershed, airshed, etc)
Application to specific Plans and Projects. It can also be applied to Policies and Programmes, however this application will be far more complex and demanding	EIA – Projects SEA - Policies, Programmes, Plans
The environment is dealt with in an integrated way (based on the notion of urban metabolism)	The environment tends to be artificially fragmented into several components
The evaluation rationale is provided by the city or metropolis territory	The evaluation is structured around the object of assessment
Evaluation can be ex-ante and ex-post and is better suited to short to medium term analysis	Evaluation can adopt longer time frameworks but is essentially an ex-ante exercise
It is unlikely to ever have a specific legal or regulatory support, but it can be informally articulated with the planning process	Has a specific legal basis and is usually integrated in the development control process (according to specific screening procedures)

MIA Application

Stage 1. STUDY AREA, SCOPING AND THE DEFINITION OF THE INTERVENTION AREA

1 - Checking the existence of an urban metabolism model

2 – General characterization of the planning proposal

3 – Definition of the study area

4 – Definition of the intervention area

5 – Scoping / definition of the components (and sub-components) of urban metabolism

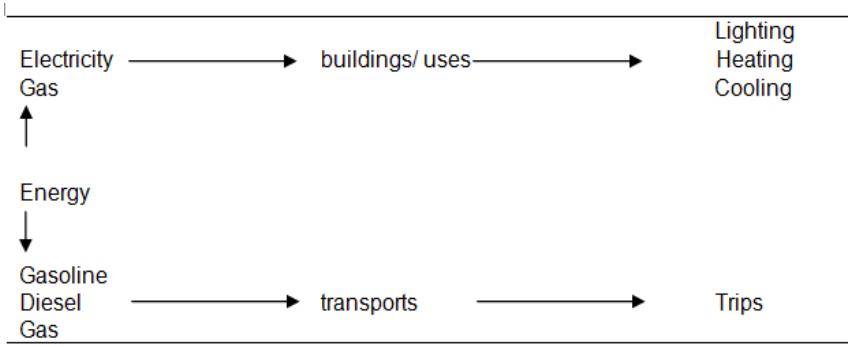
Stage 2. METABOLIC CHARACTERIZATION OF THE STUDY AREA(S)

A baseline characterization of the study area, from a metabolic point of view, is needed at this stage. This characterization shall take advantage of the study area urban metabolism model to describe the main inputs, throughputs and outputs, in terms of flows and stocks of energy (transports and buildings), land use, water and materials.

Stage 3. METABOLIC CHARACTERIZATION OF THE PLANNING PROPOSAL

The planning proposal – the object of analysis – shall also be characterised from a metabolic perspective and on the basis of the intervention area previously defined. A description of the likely inputs, throughputs and outputs associated to the planning proposal, in terms of flows and stocks of energy, land uses, water and materials have to be estimated.

1 - Energy



For a better understanding of the metabolic consequences of the proposal under analysis, buildings and transports are treated separately.

a) buildings

The estimation of the buildings' energy consumption should be specified per final use (heating, cooling, and lighting) and on an yearly basis.

The calculations of energy consumption should be based on building types and can be estimated with the use of the *MIT Design Advisor* software (Smith, 2004), or similar software available.

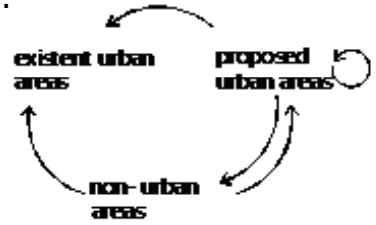
b) transports

The assessment of energy consumption by transports involves the use of a Traffic Assignment Model which reproduces the conditions of traffic in the road network of the case study area. This model should be able to provide travel distances within the case study and consequently, the energy consumption from transportation.

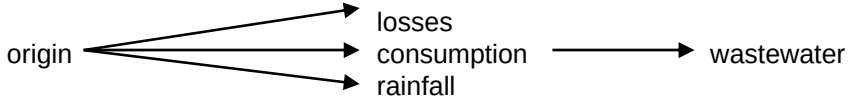
If this model it is not available, the use of a simplified evaluation procedure based on a O/D matrix (origin / destination matrix) should be considered.

2 – Land use

After the characterization of the city and the definition of the existing urban areas, proposed new urban areas, and non-urbanised areas, an analysis and quantification of the potential variation between these three categories has to be carried out, as well as an assessment of the variation of permeable and sealed areas and the final consumption of land associated to the proposal under analysis.



3 - Water



Calculation of the new water consumption associated to the planning proposal implementation. Wastewaters must not be disregarded, as they represent an important environmental issue (metabolically speaking they are outputs of the urban water cycle).

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4 - Materials

Calculation of the amount of materials entering the study area (city scale) and the intervention area (planning proposal), and the amount of material that is stored (as built-up components). Simultaneously, in order to consider the outputs, construction and demolition wastes should be quantified. This is a component with several information constraints in practice.

input materials → stocks → output materials

Stage 4. IDENTIFICATION AND CHARACTERIZATION OF THE IMPACTS

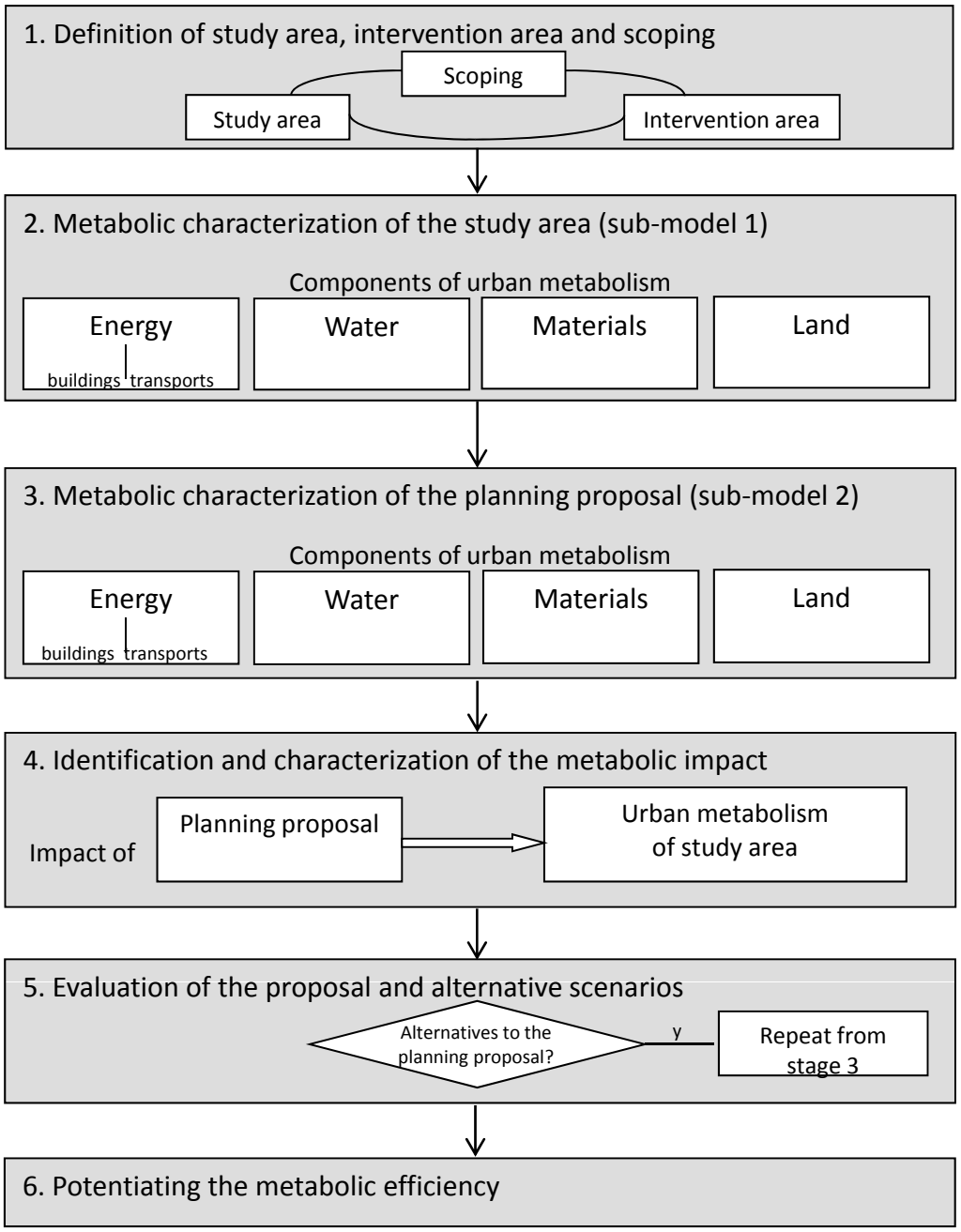
In order to identify and characterize the metabolic impacts of the planning proposal under analysis the two sub models developed in stages 2 (study area) and 3 (planning proposal - intervention area) have to come together.

Stage 5. EVALUATION OF THE PROPOSAL AND ALTERNATIVE SCENARIOS

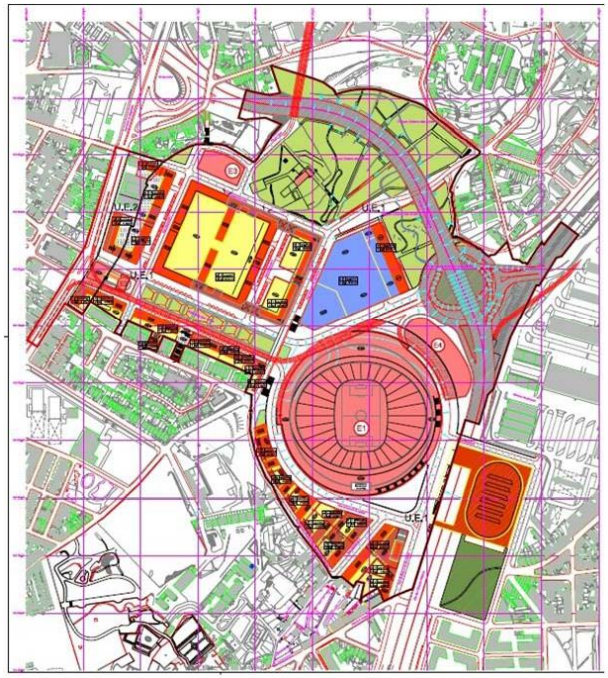
The metabolic impact of the proposal and/or alternatives, positive or negative, have now to be considered in a wider perspective of the general dynamics and transformation goals set before for the city.

Stage 6. POTENTIATING THE METABOLIC EFFICIENCY

The final results are likely to incorporate a number of recommendations to change and/or adapt the development proposal, the plan or the urban project to the particular circumstances of the city or metropolitan area, in order to improve the metabolic performance of both the proposal and the city at large.


1. Definition of study area, intervention area and scoping
Scoping
Study area
Intervention area
2. Metabolic characterization of the study area (sub-model 1)
Components of urban metabolism
Energy
buildings
transports
Water
Materials
Land
3. Metabolic characterization of the planning proposal (sub-model 2)
Components of urban metabolism
Energy
buildings
transports
Water
Materials
Land
4. Identification and characterization of the metabolic impact
Impact of
Planning proposal
Urban metabolism of study area
5. Evaluation of the proposal and alternative scenarios
Alternatives to the planning proposal?
y
Repeat from stage 3
6. Potentiating the metabolic efficiency

MIA application to Oporto



MIA application to Oporto

Stage 1. STUDY AREA, SCOPING AND THE DEFINITION OF THE INTERVENTION AREA

Selection of study area:

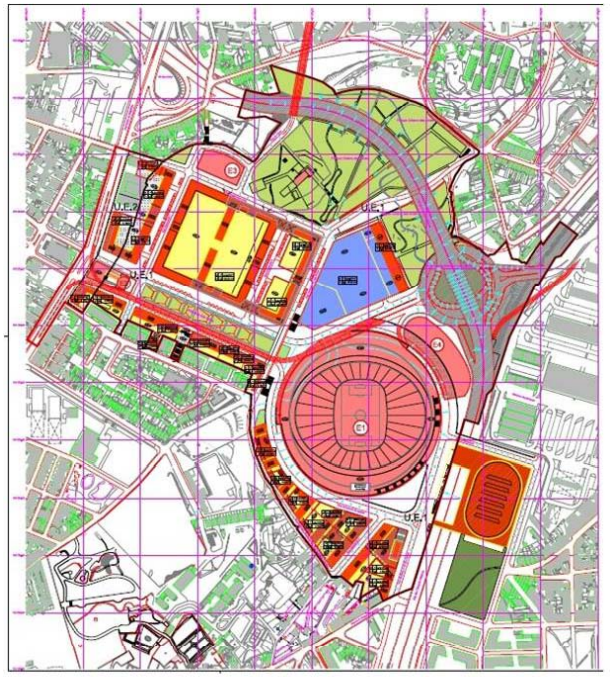
- given the size of this planning proposal it is most adequate to carry out the analysis at the city scale

Selection of intervention area

- Delimitation of the planning proposal area – detailed plan

Description of layout	Area
area of the plan (41,3ha)	413 000 m^2
Street system	168 940m^2
Green areas (public)	100 000m^2
Residential (building coverage)	286 104m^2
Commerce and services	95 002m^2
Total gross floor area (residential+commerce+services)	381 106m^2

The PPA was mainly characterized by the construction of the new *Dragão* Stadium, and the demolition of the old *Antas* Stadium, taking into account the then upcoming Euro 2004 and the redevelopment of the whole surrounding area.

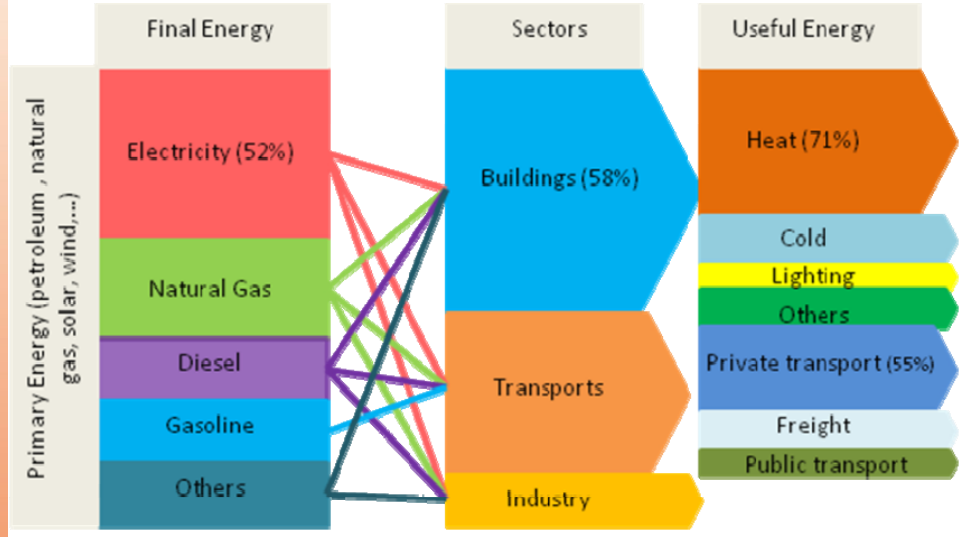


Groundfloor map of the detailed plan

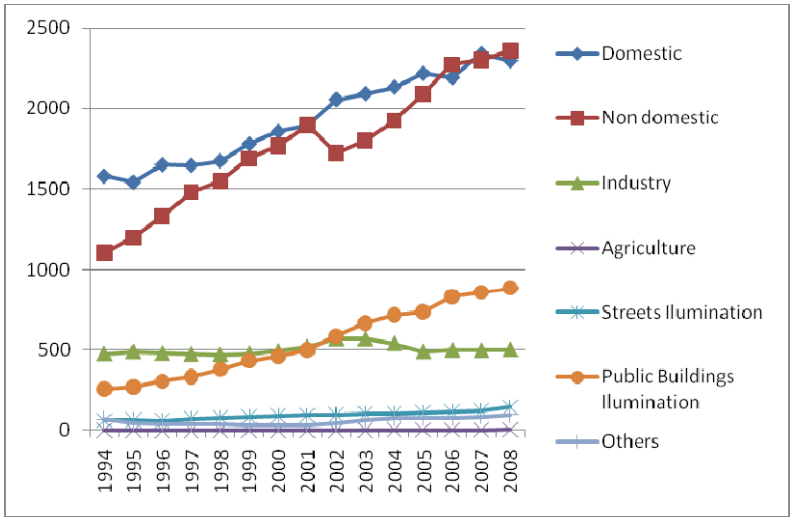
Stage 2. METABOLIC CHARACTERIZATION OF THE STUDY AREA

1- Energy

Energy matrix of Oporto (2004)



Energy Consumption (kWh) per sector, per capita in Oporto



- **Electricity (52%)** as main source of energy demand, while the national average was 44%

- In this **area buildings stand out as large energy users** (26% residential and 32% services).

- End uses of energy for residential buildings on a yearly basis: **71% for heat production** (of which 24% corresponds to the heating of sanitary water, 24% for meals preparation and 23% for domestic heating), 14% for domestic cold, 10% for specific electricity and 5% for artificial lighting.

1- Energy - buildings

Energy consumption for each building type: use of the ***MIT Design Advisor*** software

The input data to this software was adopted based on the urban typologies considered and used to calculate the energy consumption (kWh/m2) in Oporto per final use. The choices made for each simulation group were based on a representative building of each type.

Table - Urban tissues, building types and energy consumption (Example)

Types of urban tissues	Characterization
T1_Historical areas	
	2. occupancy and equipment **– residential and retail** 3. ventilation system **– natural or mechanical** 4. thermal mass - **low mass: lightweight or obstructed floor** 5. building geometry **- single zone: two facades** 6. roof description - **traditional roof** 7. room dimensions (width, depth, height) – **2,5x4,00x3,00** 8. window description – **30%** 9. wall description – **residential low insulation**
T4_Single-Family Housing Areas	
	2. occupancy and equipment **– residential** 3. ventilation system **- natural or mechanical** 4. thermal mass - **low mass: lightweight or obstructed floor** 5. building geometry **- 4 facades with well-mixed air between zones** 6. roof description – **traditional roof or modified bitumen roof** 7. room dimensions (width, depth, height) – **3,00x4,00x3,00** 8. window description – **30%** 9. wall description - **high insulation**

1- Energy

a) buildings

Types of urban tissues

T1 - Historical areas

T2 - Areas of Continuous Building Frontages and Largely Replete Plots

T3 -Areas of Continuous Building Frontages and Plots in the Process of Repletion

T4 -Single-Family Housing Areas

T5 -Areas of Isolated Buildings

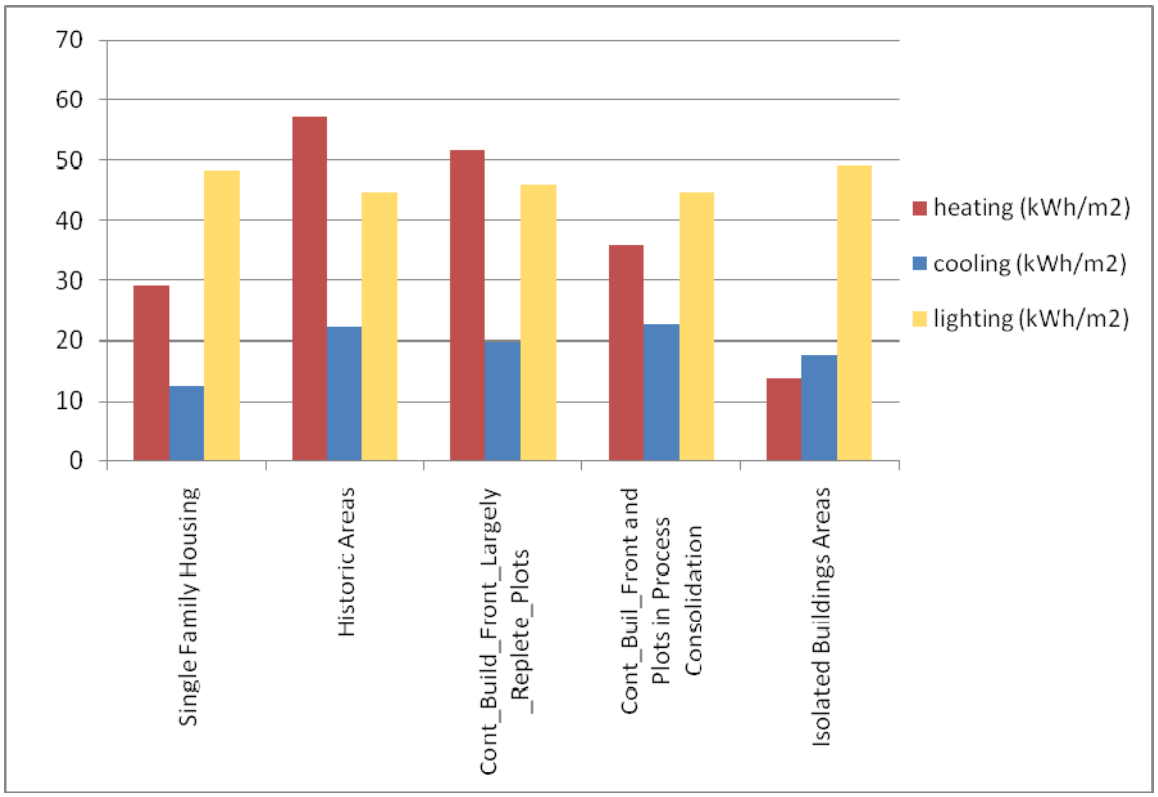
T6 -Areas of Public Services

T7 -Business Park

T8 -Special Urban Development Areas

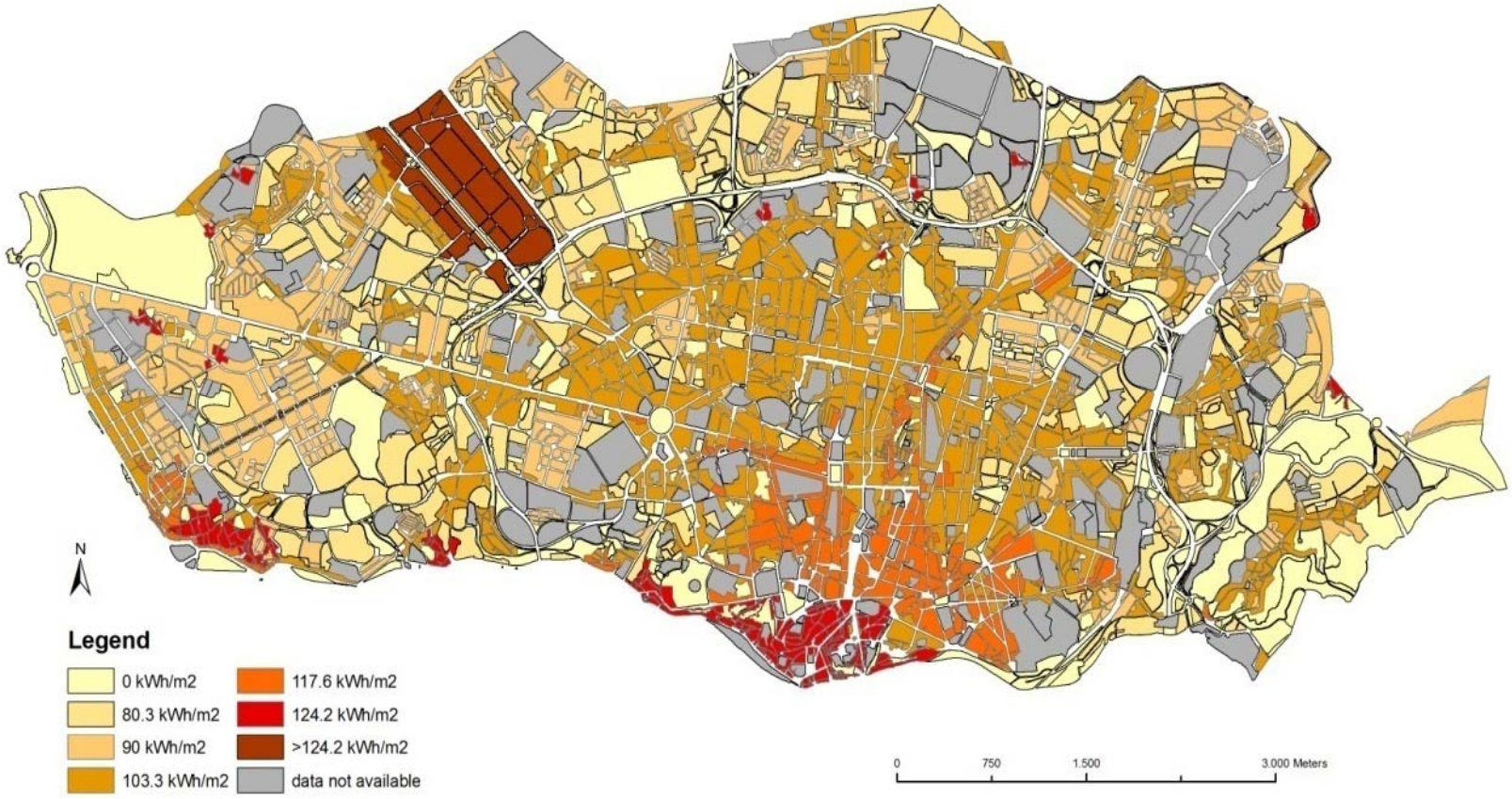
T9 -Green Areas

T10 -Transport Areas



Map – representation of the total yearly consumption of energy for each building type

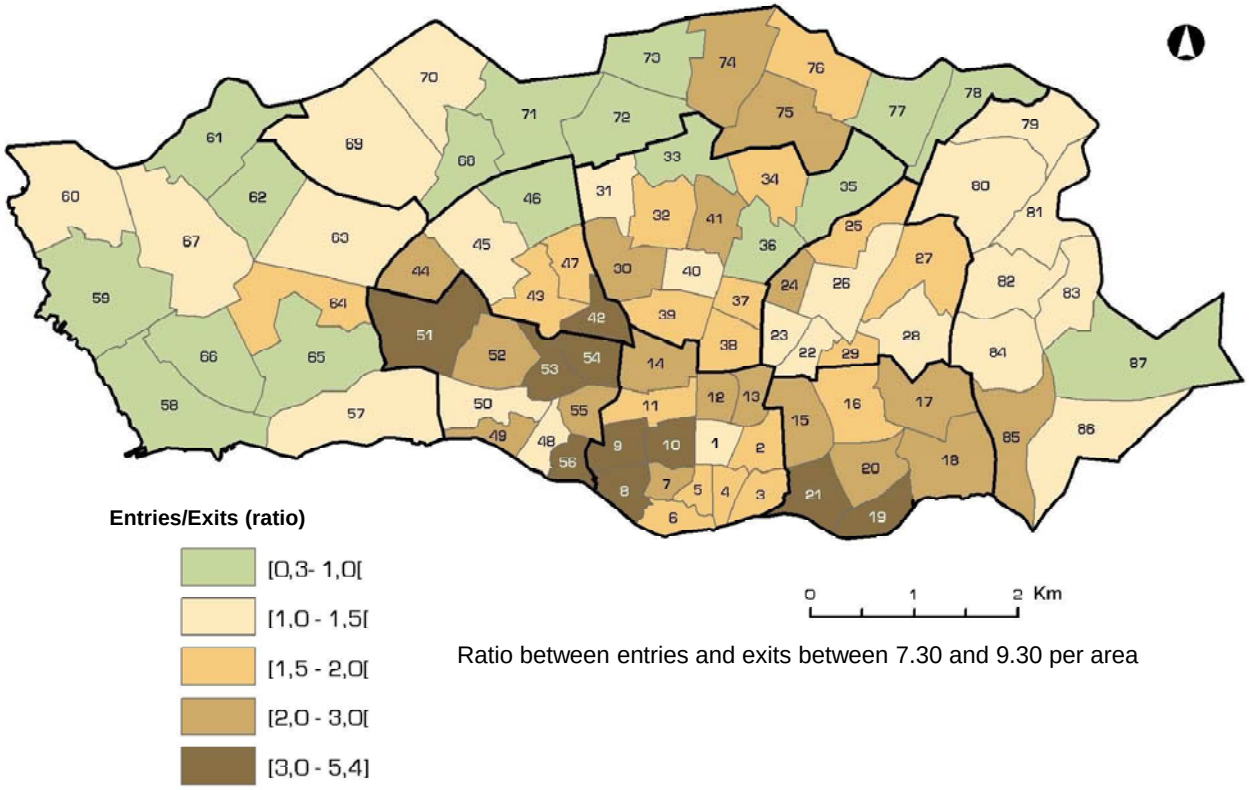
- Within the city centre, as we get closer to the city core, energy efficiency decreases.
- Outside the centre, energy consumption is more heterogeneous but, generally speaking, more efficient.



1- Energy - Transports

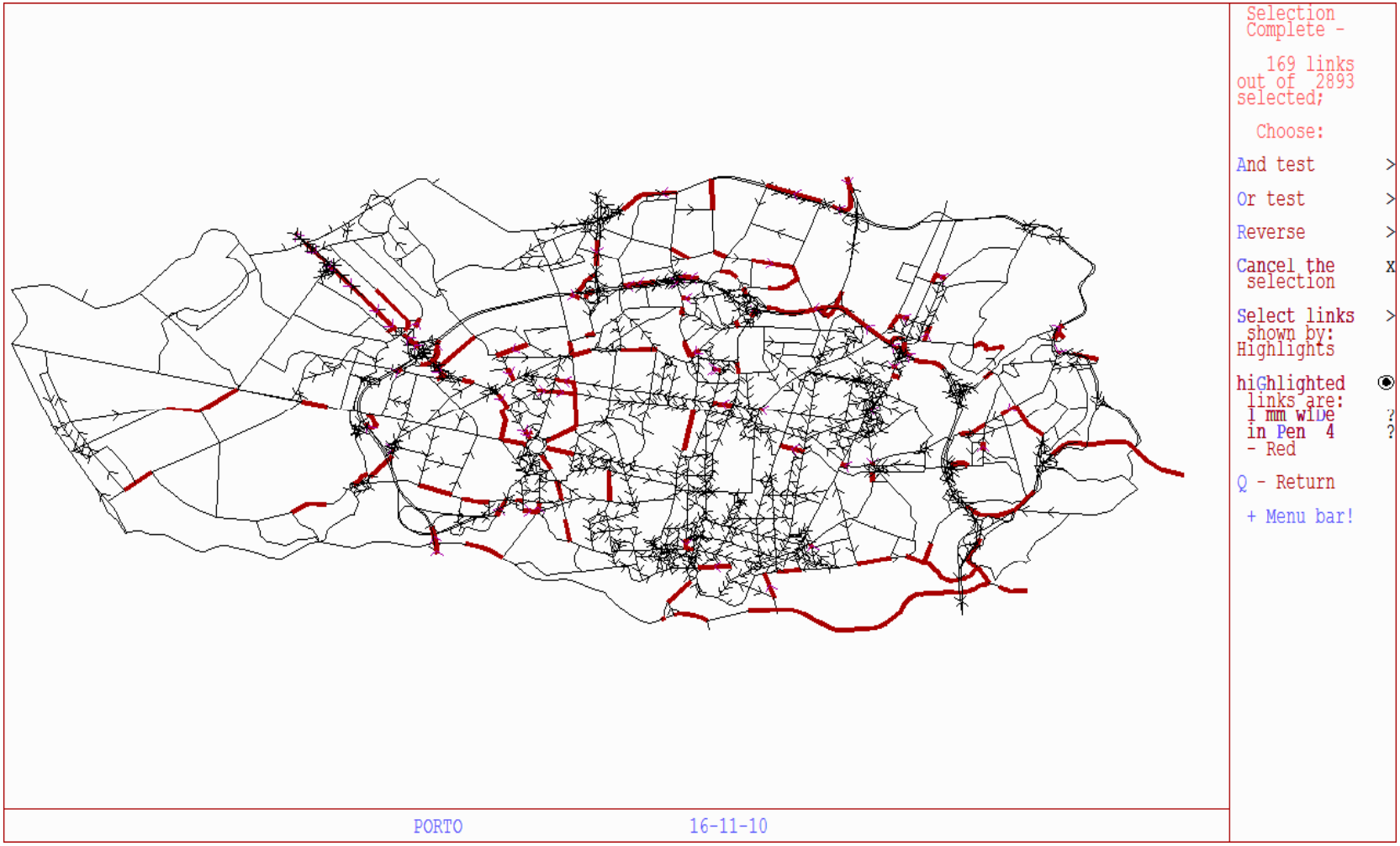
About 130 000 trips are estimated in weekdays (between 7:30 to 9:30 a.m.).

- 32.7% (42,523 trips) to the city, from other municipalities
- 9.7% (12 621 trips) from the city
- 29.2% (37 991 trips) within the city a
- 28.4%, (36,884 trips) "crossing over"



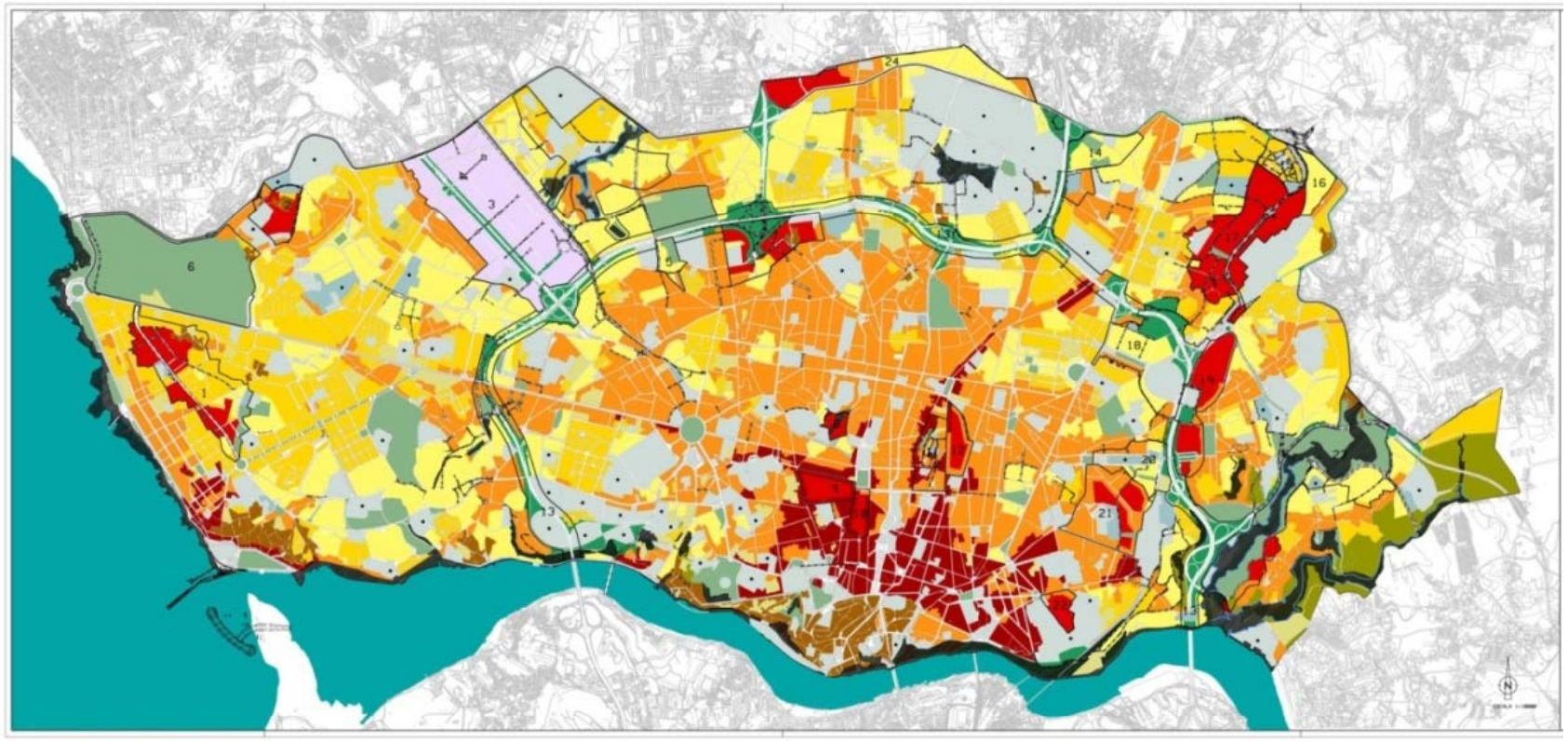
Ratio between entries and exits between 7.30 and 9.30 per area

1- Energy - Transports



(base scenario) Saturation rate > 90%

2- Land use



2006 PDMP

2- Land use

Land Cover Types	Nº Units (blocks)	Area (m2)	Area (ha)	Percentage %	Sealed Surfaces%	Sealed Surfaces (m2)	Sealed Surfaces (ha)
Historic Areas	212	719908,03	71,99	1,7	100	719908,0313	71,99
Continuous Building Frontages and Largely Replete Plots	240	1436449,82	143,64	3,5	85	1220982,347	122,10
Continuous Building Frontages and Plots in the process of repletion	834	7340612,15	734,06	17,8	70	5138428,505	513,84
Single Family Housing	574	4264304,58	426,43	10,3	60	2558582,751	255,86
Areas of isolated buildings	329	5576787,07	557,68	13,5	65	3624911,595	362,49
Business Park	27	786302,64	78,63	1,9	100	786302,6412	78,63
Special Urban Development Areas	53	1306734,84	130,67	3,2	100	1306734,84	130,67
Areas of Public Services - existent	255	5357083,82	535,71	13,0	75	4017812,868	401,78
Areas of Public Services - proposed	33	386654,13	38,67	0,9	75	289990,5977	29,00
Green Areas	512	5638508,39	563,85	13,7	0	0	0,00
Transport Areas	n.a.	8473900	847,39	20,5	100	8473900	847,39
Total		**41287245,48**	**4128,72**	**100**	**75**	**28137554,18**	**2813,76**

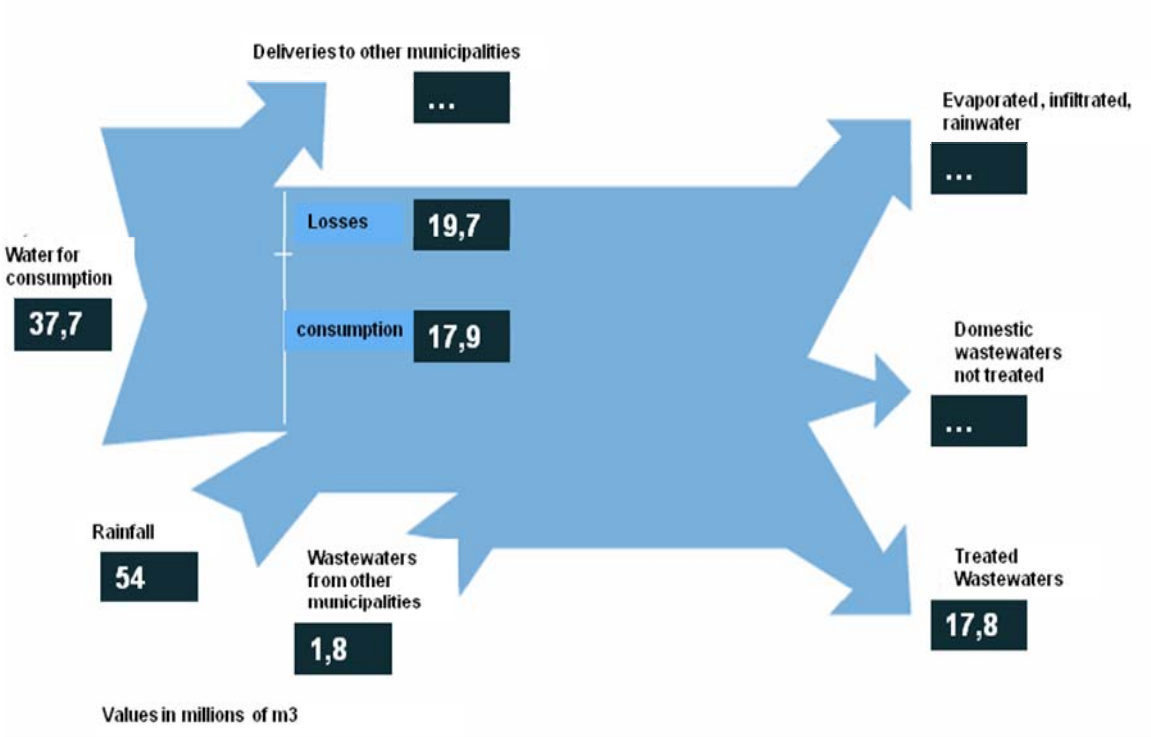
The sum of the total area for each land use type of the PDMP was calculated.

The plan establishes a maximum percentage of sealed surfaces according to the land uses.

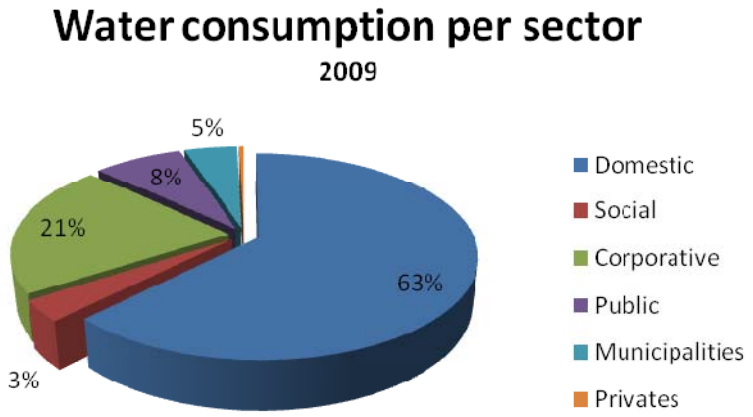
This information enabled the estimation of the total city sealed surface.

3 - Water

Water Matrix of Oporto



The domestic sector is the one that most influences the city's water footprint.



4 - Materials

Considering SUME`s input-output perspective, we should be able to assess construction materials entering the city, and construction and demolition waste (CDW) generated within its boundaries.

Despite the current legal framework, data on waste production, particularly in CDW, is not available.

Stage 3. METABOLIC CHARACTERIZATION OF THE PLANNING PROPOSAL

The Detailed Plan of *Antas*, was approved and published in **2002**.

The main reasons for this intervention and for the local plan were the need felt by *Futebol Clube do Porto* to build a new football stadium, coupled with the organization of the UEFA European Football championship 2004.

In the context of the Municipal Master Plan, the Detailed Plan of *Antas* was included in a mixed uses area (density 2), providing each plot with a building capacity based on an index of 2.1m²/m² applicable to the area of the building located on a strip with 30m deep along the streets, and 1.05m²/m² applicable to the remaining area.

1- Energy

a) buildings

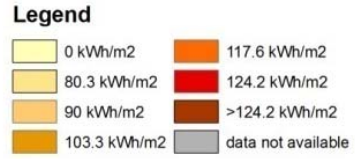
Given the total yearly consumption for each of the building types, a *zoom* into the area of the PPA, revealed that energy consumption is relatively efficient in relation to the city centre.

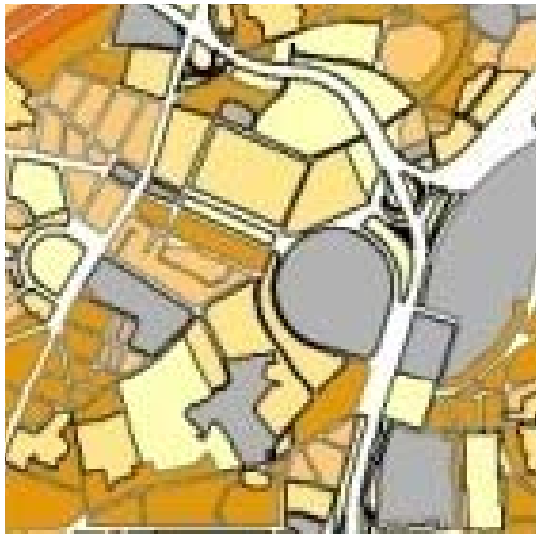
For the PPA (only 2 typologies):

Energy consumption for “Isolated Building Areas” will amount to 17,854.383,8 kWh

“Continuous building frontages and plots in the process of consolidation” , will consume on a yearly basis 9.188.948, 2 kWh

(area x consumption/m2 = total consumption)





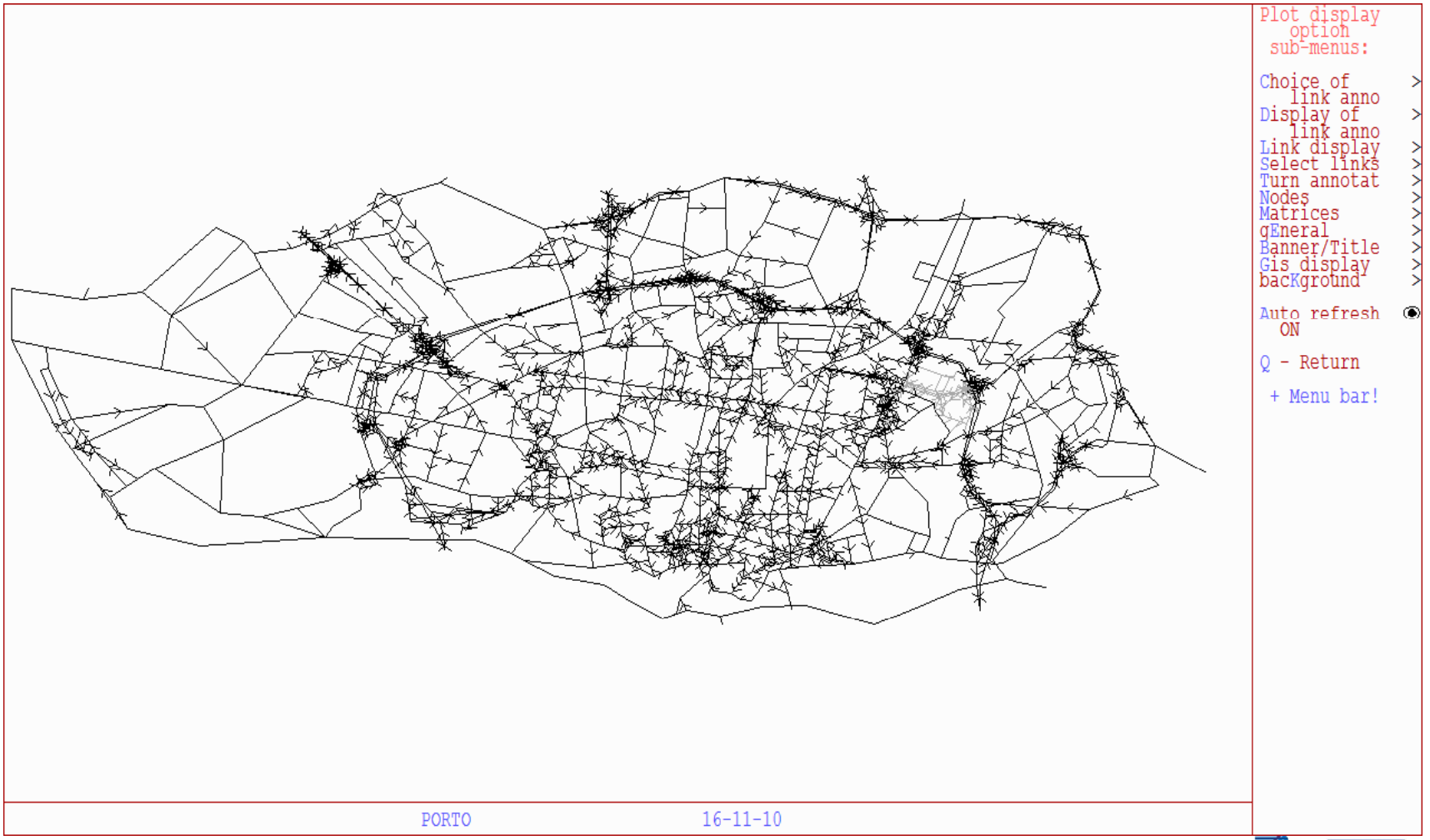
b) transports

Estimation of trip generation for each type of land occupation (first individually and in the end, for the whole area of the plan).

	Entries (nº trips)	Exits (nº trips)	Total
Shopping	231	148	379
Apartment	216	1940	2156
Hotel	35	24	59
Office Building	278	38	316
Light rail transit station with parking	390	43	433
School	67	57	124
Clinic	56	56	112
Bank	13	13	26
Health Club	49	36	85
Total	1335	2355	3690
Data corresponding to the a.m. peak hour (from 07.30 a.m. to 09.30 a.m.)			

b) transports

Changes in the network



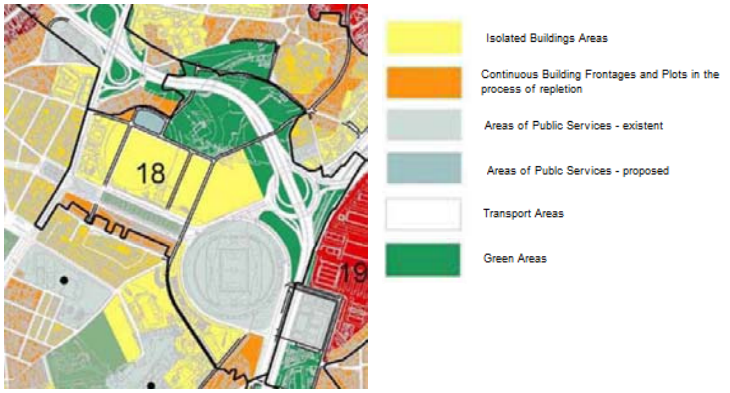
b) transports

Different assumptions

- Consideration of population moving from other parts of the city
- Effect of a new metro line within the intervention area

		Additional Trips	Fuel Consumption
		%	%
0	scenario without PPA		
1	*scenario with PPA*		
1.1	without reduction in the number of trips from other parts of the city	5,3	10
1.2	reduction of 50% of exits/ 0% of entries, in other parts (cells) of the city	4,3	8,6
1.3	reduction of 50% of exits/ 20% of entries, in other parts (cells) of the city	3,8	6,8
2	*scenario with PPA, reduction due to the effect of the metro (23,6% of users of private car changed to the metro)*		
2.1	without reduction in other trips from other parts of the city	4	7,1
2.2	reduction of 50% of exits / 0% of entries, in other parts (cells) of the city	3,1	5,5
2.3	reduction of 50% of exits/ 20% of entries, in other parts (cells) of the city	2,5	4,6

2- Land use



2 types of land uses contemplated in the detailed plan of *Antas*.

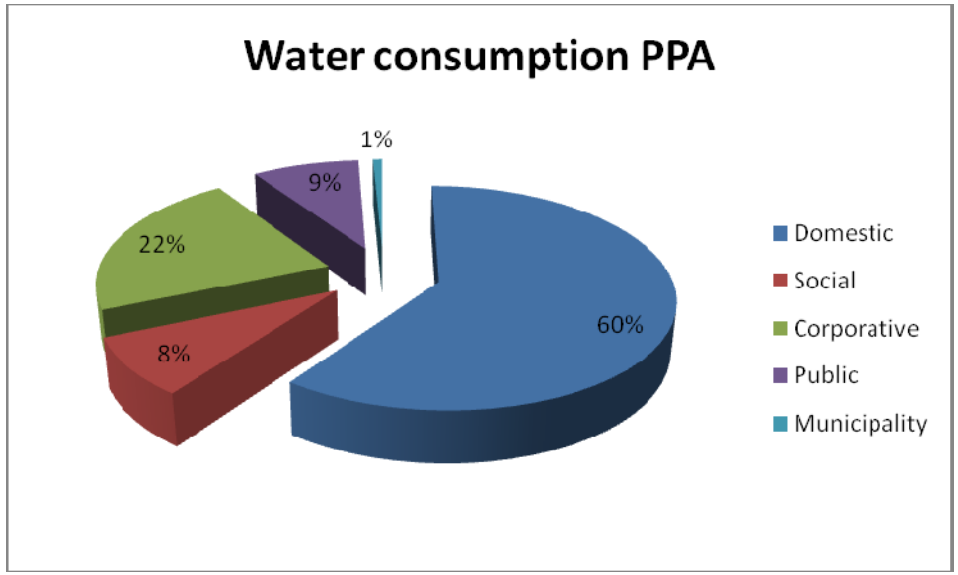
- *Continuous building frontages and plots in the process of repletion*
- *Areas of isolated buildings*.

Land Cover Types	Nº Units (blocks)	Area (m2)	Area (ha)	Percentage %	Sealed Surface%	Sealed Surface (m2)	Sealed Surface (ha)
Historic Areas	0	0	0,00	0	n.a	n.a	n.a
Continuous Building Frontages and Largely Replete Plots	0	0	0,00	0	n.a	n.a	n.a
Continuous Building Frontages and Plots in the process of repletion	3	18.032	1,80	4	70	12622	1,26
Single Family Housing	0	0	0,00	0	n.a	n.a	n.a
Areas of isolated buildings	5	79.045	7,90	20	65	51379	5,14
Business Park	0	0	0,00	0	n.a	n.a	n.a
Special Urban Development Areas	0	0	0,00	0	n.a	n.a	n.a
Areas of Public Services - existent	3	71.900	7,19	17	75	53925	5,39
Areas of Public Services - proposed	1	600	0,06	0	75	450	0,05
Green Areas	2	100.000	10,00	24	0	0	0
Transport Areas	n.a.	143.523	14,35	35	100	143.523	14,35
Total	14	413100	41,31	100	64,2	261899,65	26,19

3 – Water

- **Domestic consumption** with the largest water demand, and perspectives of further increase in the future (project is not yet fully implemented and also because, a significant part of the dwellings already built are not yet occupied).

- **The service sector** is also an important water consumer (in particular the shopping mall and the *Dragão* stadium).



Considering the average domestic water consumption per capita in Portugal of **150 litters/day**

The total residential consumption, for a fully-implemented plan = **450 000m³** (on a yearly basis)

4 - Materials

- **main inputs** are the construction materials for buildings and infrastructures (roads, pipes...)

- **main outputs** from the demolition of the existing stadium and land movements.

material	**inputs**	**outputs**
concrete	Unkown	Unkown
stone	Unkown	unkown
steel & iron	Unkown	1050 tons
plastic	Unkown	60 tons
woods	unkown	44 tons

Stage 4. IDENTIFICATION AND CHARACTERIZATION OF THE IMPACTS

1 – Energy

a) buildings

-the **planning proposal represents 2,66%** of the total annual energy consumption of the municipality.

- the PPA represents only **1%** of the **municipality area.**

- However the PPA presents a much **lower per capita consumption** when compared to the city, 4437,6 kWh/cap against 6285 kWh/cap.

Energy - b) transports

Different assumptions

Scenarios		Additional Trips	Fuel Consumption
		%	%
0	scenario without PPA		
1	*scenario with PPA*		
1.1	without reduction in the number of trips from other parts of the city	5,3	10
1.2	reduction of 50% of exits/ 0% of entries, in other parts (cells) of the city	4,3	8,6
1.3	reduction of 50% of exits/ 20% of entries, in other parts (cells) of the city	3,8	6,8
2	*scenario with PPA, reduction due to the effect of the metro (23,6% of users of private car changed to the metro)*		
2.1	without reduction in other trips from other parts of the city	4	7,1
2.2	reduction of 50% of exits / 0% of entries, in other parts (cells) of the city	3,1	5,5
2.3	reduction of 50% of exits/ 20% of entries, in other parts (cells) of the city	**2,5**	**4,6**

The PPA is responsible for a negative impact with the **increase in the number of trips and in fuel consumption**

However, the **new metro line** counteracts some of the impacts (reducing some of the previous and the new trips from/to the area by car).

Without PPA

With PPA

saturation rate > 90%

2 – Land use

Sealed surfaces

- in the whole **municipality = 68.2%** (regarding the municipal plan´s maximum built-up area per plot),
- in the **PPA = 63.4%** of sealed surfaces.

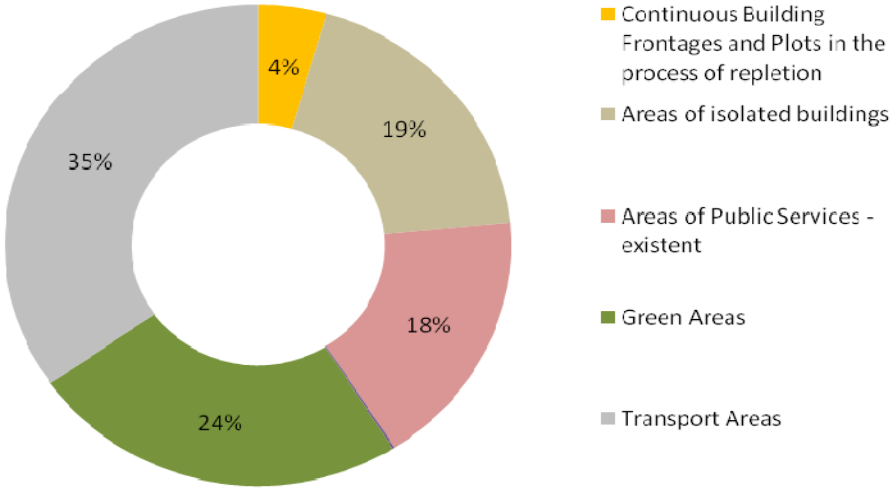
Oporto municipality has a total of **154,8m²/cap**, when the same variable for the PPA is significantly different : **37, 8 m²**

The intervention area shows much better results in terms of land use efficiency per capita, in comparison to the city performance.

Green public spaces

- 12m2/inhabitant in the city
- 12,1m2/inhabitant in PPA

Land uses within the planning proposal



3 – Water

In the PPA

Domestic water consumption
- in the planning proposal = 36, 5 m^3/cap to 65, 7 m^3/cap.

Total water demand for that area
= 60, 3 m^3/cap to 109, 5 m^3/cap. (considering that the domestic sector is 60% of the total demand)

In the city
-Total water demand = 46 m^3/cap/year (in the year 2007)

Knowing that the planning proposal area is 1% of the city's total area, then we can conclude that this new development plan will have a significant role in terms of water consumption.

4 – Materials

- This particular project had a **significant amount of material outputs** due to the previous stadium demolition and massive excavations

- There is scarce information about **inputs** to conclude about final impacts

A - description of the impacts of the project		B - evaluation techniques
variation of consumption (material)	→	statistical analysis
variation of production of waste	→	statistical analysis

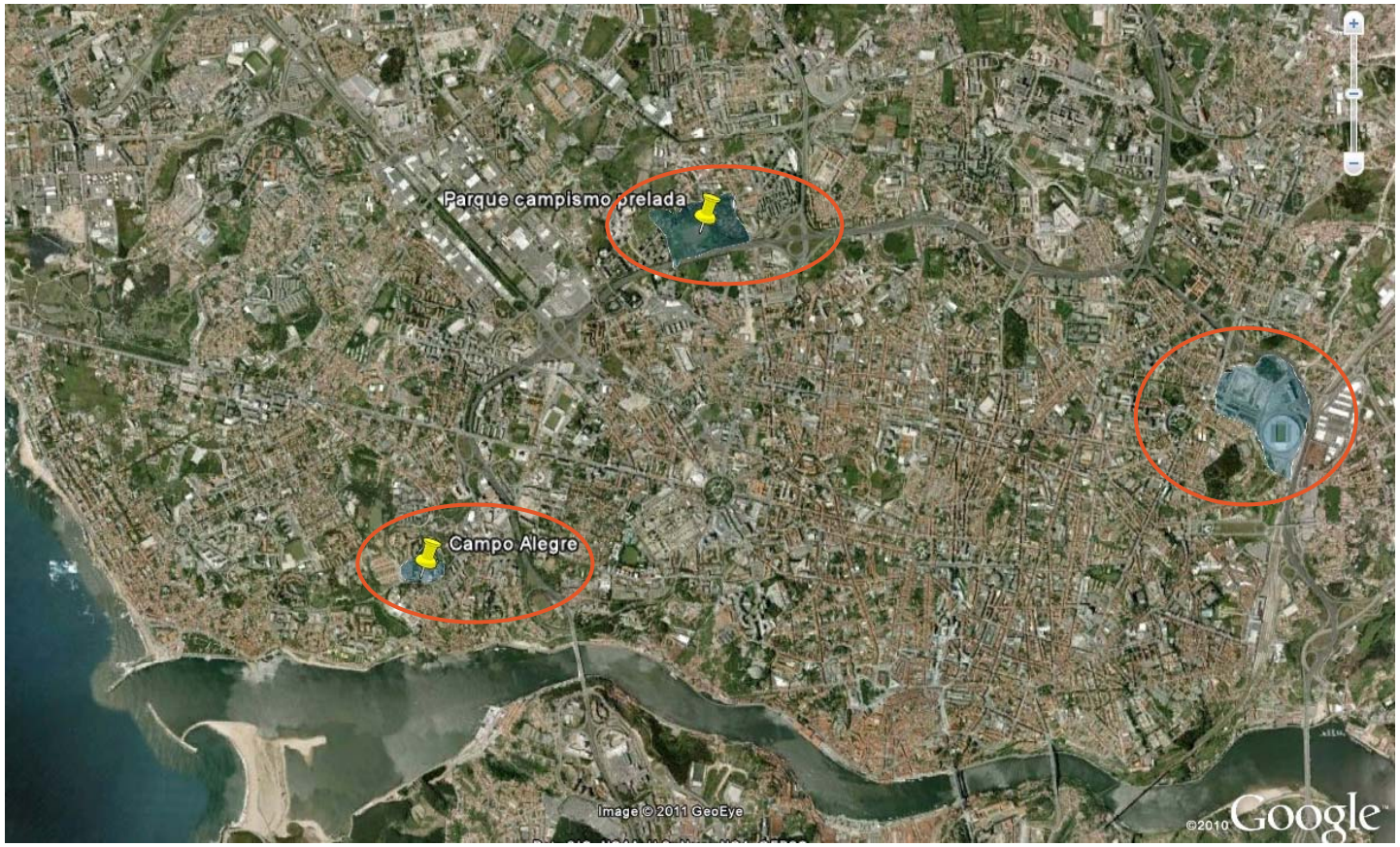
1- Evaluation of the proposal - indicators and benchmarking

	Indicator	Oporto study area	Oporto planning proposal	Benchmark data	Impact
Energy - buildings	**Energy consumption per capita**	**22 kWh/cap/day**	**Over 11 kWh/cap/day**	**EU27 - 15.7 kWh/cap/day**	**++**
	Energy consumption per built-up area	63 kWh/m^2/yr	81 kWh/m^2/yr	n.a.	-
	Energy consumption per sector	Final Energy: **Buildings 47%** Transports 45% Industry 8%	**Buildings – 59,9%** Transports – 40,1% Industry – 0%	EU Final Energy: **Buildings – 35,9%** Transports – 32,6% Industry – 27,9%	**Buildings --**
	% of renewable sources of energy in the total energy consumption	13%	n.a	EU27 – 15,6% Portugal – 30,1%	n.a.
Energy - transports	Percentage of journeys to work by car	45%	assumed to be the same (transport model)	EU15 – 57,8% EU27 – 55,2%	n.a.
	Modal split of passenger transport	Private transport: 52% Light rail: 13,8% Other public transports: 26,6% By foot: 7,6%	assumed to be the same (transport model)		n.a.
	Length of tram network	**60,00km**	**1 station within the plan**	**EU average 94.1 km**	**+-**
	Passenger car density	450 cars /1000 inhab.	assumed to be the same (transport model)	EU15 – 425,6 EU27 – 410,9	n.a.
	Number of park and ride parking spaces per 1000 cap.	**3.62 (yr 2004)**	**104.96**	**EU15 – 4.56** **EU27 – 4.95**	**++**

Land use	Population density	52,3 cap/ha	199,7 cap/ha	EU average 113.1 cap/km^2	++
	Land use mix index population+jobs /km^2	**7615,35**	**32082,32**	**n.a.**	**+**
	Number of households	12449400 dwellings	2750 dwellings	EU15: 19894022 EU27: 18037792 (average)	Not ranked
	Density of green public areas	**12 m^2/cap**	**12 m^2/cap**	**European average: 42,1m2/cap**	**=-**
	Urbanized (sealed) area per capita	154,8 m^2/cap	37,8 m^2/cap	n.a	+
	% of sealed surfaces	**68,2%**	**63,4%**	**EU (at country level) 8,6%**	**+-**
Water	**Water consumption per capita**	**136 l/cap/day (Neves, 2003)**	**201.6 l/cap/day**	**EU 15 – 226,6 l/cap/day; EU 27 – 187,6 l/cap/day**	**--**
	Water consumption as a function of built-up area - l/m^2 /day	1.74 l/m^2/day	From 6.35 l/m^2/day	n.a	-
	Water consumption by residential sector	**63% 11.331.000 m^3/yr**	**60% 189.924 m^3/yr**	**Ranges from 6, 5% to 50% (in average: less than 18%)**	**-+**
	Wastewater production per capita	**109 l/cap/day**	**161 l/cap/day**	**n.a**	**-**
	Population connected to WWTP	100%	100%	EU15 - 94.6% EU27 - 93.8%	=+
Materials	Collected CDW	n.a	Concrete and stone - n.a Steel & iron – 1050 t Plastics - 60 t Wood - 44 t	EU – d.n.a Portugal – 7170 millions of tones	n.a.
	Collected CDW per capita	n.a	n.a	Portugal – 674 t/yr/cap	n.a
	Reused or recycled CDW materials	**n.a**	**More than 50%**	**U.K. about 45% Portugal less than 5%**	**+**

2- Alternative Scenarios

Hypothetical alternative locations for the detailed plan (map below)
→ study component - Transports Energy



2- Alternative Scenarios

Increase on fuel consumption in all alternatives, comparing the Oporto baseline situation with each alternative

Locations	Oporto with PPA	Oporto with PPA and the Metro	PPA in Campo Alegre	PPA in Prelada
Increase in Fuel Consumption (%)	10	4,6	7,5	6

- **Only transports** have being considered;

- Other factors would also be important, e.g. the **land use component**, regarding the *Parque de Campismo da Prelada,* would result in a **very negative impact**, since almost all the area is unsealed.

Stage 6. POTENTIATING THE METABOLIC EFFICIENCY

Buildings sub-component: Consensual **design improvements**

-**Building orientation** can be optimized, privileging the south side of the building

-**Insulation** level improvement (walls and roof with continuous thermal insulation)

-**Solar panels** installed on the buildings' roofs for heating water

-Adoption of **crossed ventilation** inside the dwellings, natural whenever possible

-**External solar protection** of glazed windows in the south facades

Transports sub-component: non-motorized means of transport should be promoted

-the implementation of **bike-stations** and bike corridors could stimulate the use of bicycles in the surrounding areas

-**Taxation,** e.g. in existing **parking** spaces to encourage people to leave private cars

-**Privilege accessibility policies instead of mobility policies**

Land use component :

-**preservation of green areas**, and if possible, their enlargement. The same should happen with the unsealed surfaces within the building plots.

-when **basements and garages** are built below supposed **green areas** within the plots, they can no longer be considered unsealed surfaces. In order to potentiate the effects of unsealed surfaces, **construction in depth should be better considered and evaluated**.

Water component

-**recycled waters** can be used for the **irrigation of green spaces**

-**rain sensors** can be installed so that the system will not run when it's raining

-lower water **pressures** in the **distribution network** can help reduce the amounts of water used

-raising water **tariffs**

Materials component

-reusing most of the **wastes** material

FINAL REMARKS

The contribution of MIA to the **urban metabolism** field

- MIA seems able to provide the **spatial dimension** that is absent from current urban metabolism models. This spatial dimension is essential to urban planning purposes.
- MIA provides an operational tool designed **to analyse changes and transformations** occurring in our cities rather then, simply, their overall metabolic performance. As such, its application may **provide a deeper understanding of the nature of different and contrasting development processes**, in particular when it comes to their contribution to the existing stocks and flows of energy, land and materials.

The contribution of MIA to the **evaluation** field also seems relevant.

- MIA is able to **provide a more integrated analysis** taking advantage of the potentials of the urban metabolism concept to provide a comprehensive perspective of the consequences of current urban development processes.
- Finally, **the design of the methodology is open** to public scrutiny and participation.