An integrated and “participatory” sustainable urban-energy planning methodology for the city of Cesena

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E4SMA

InSMART in 1 slide

- Brings together cities, scientific and industrial organizations.
- Establish and implement a comprehensive methodology for enhancing sustainable planning (focusing on energy).
- Integrative and multidisciplinary planning approach.
  - Specialized tools and models:
    - Comprehensive GIS energy database
    - Building simulator
    - Transport simulator
    - Technology explicit planning model (cost-optimal mix of measures)
    - Multi-criteria decision making method

Outputs:

- integrated analysis of the mid-term measures,
- applicable mid-term implementation plan (the necessary steps, required resources and monitoring procedures) at city level.

Key words: *integrative / participatory / multi-model*

InSMART cities

Key elements of novelty

	Existing SEAP approach (Cesena)	INSMART approach (Cesena)
Approach	Top-down. Downscaling of national targets, policies and measures.	Bottom-up. Driven by urban specific needs and integrated with the urban planning.
Sectors (coverage)	Residential, Commercial, Public Administration (very limited analysis of agriculture and industry). Transport is not included.	Residential, Transport, Public Administration.
Emissions (location)	Direct (within the urban area) and indirect (e.g. due to the generation of electricity consumed in the urban area).	Direct (within the system). All the emissions "directly" generated by the players of the system (e.g. households) are taken into consideration.
Emissions (type)	CO2, CH4, N2O	CO2, particulate
Measures	Simulation. Cost-benefit analysis of individual stand-alone measures.	Optimisation/Simulation (what-if analysis). Integrated system approach.

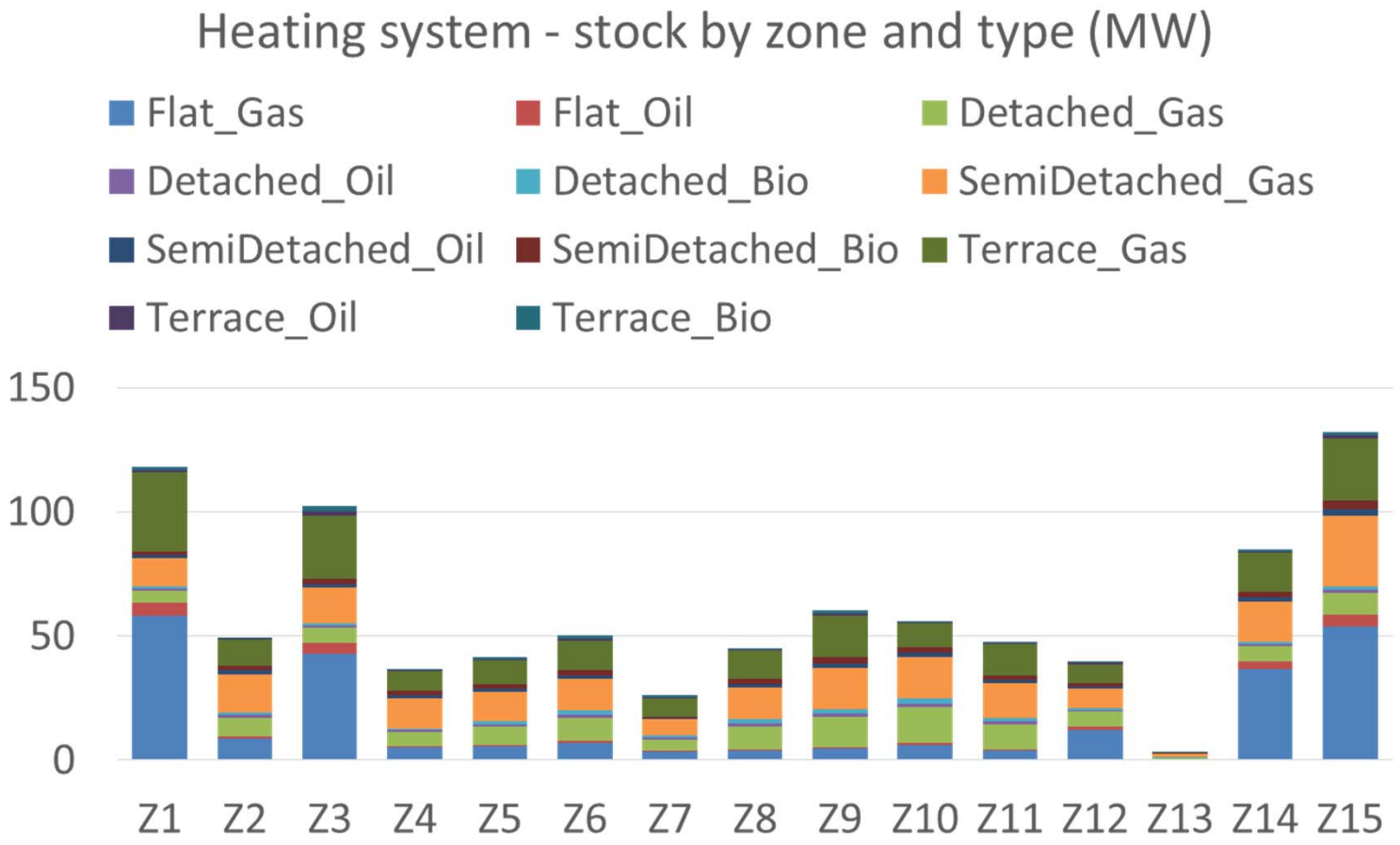
An application of the **innovative city planning method**, developed within the EU FP7 project InSMART, is applied to the municipality of Cesena (Italy).

A "*multi-model*" approach is used to explore and rank alternative plans (combinations of actions and measures) towards the sustainable development of the municipality, with a particular focus on the residential and transport sectors.

A "*technology-explicit model*" of the city is designed to be used as a test bed for exploring the evolution of energy-environmental variables in the urban area. A reference projection of the local system is calculated and then modified through six combinations of actions and measures aiming at representing six alternative sustainable planning hypotheses.

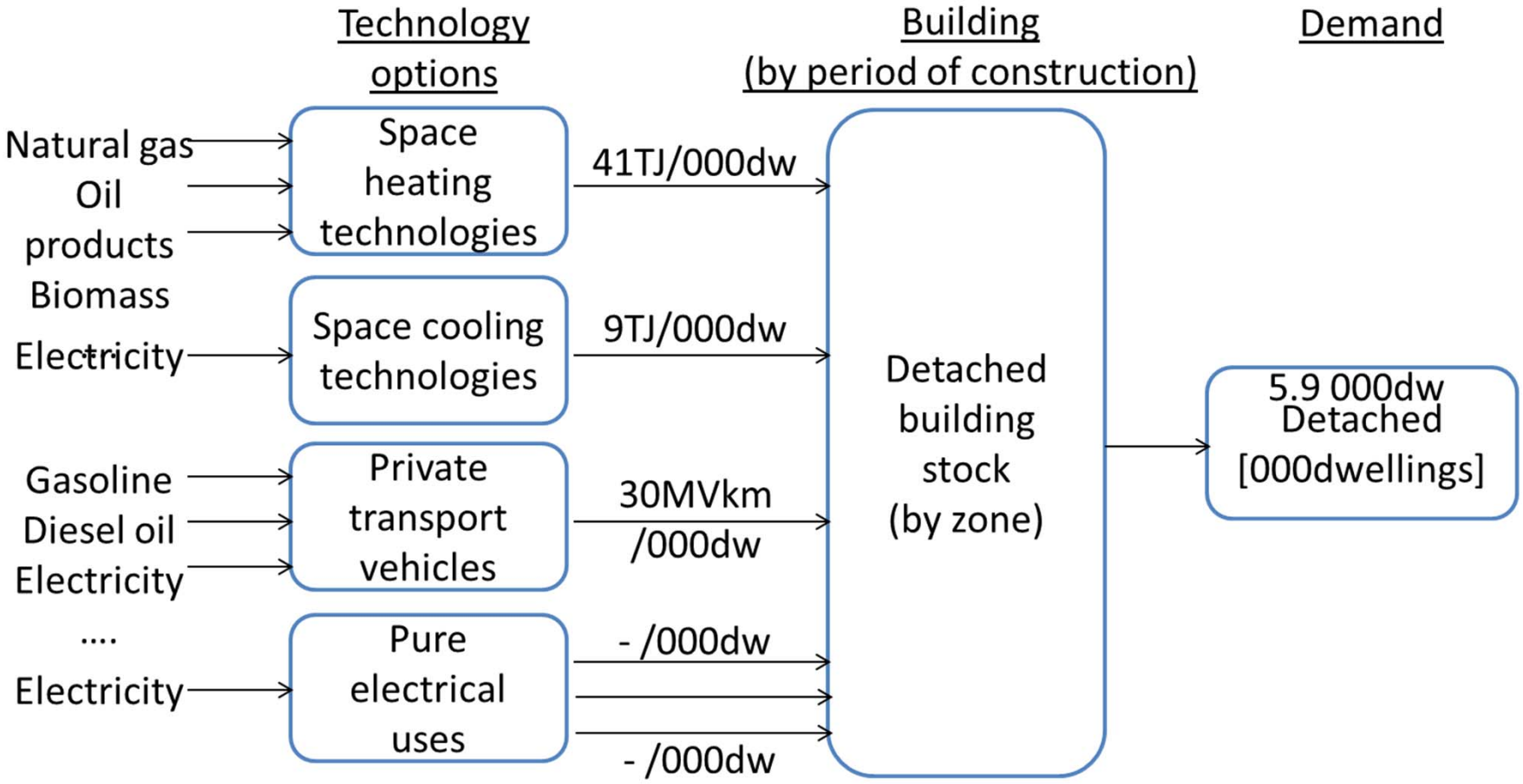
Making use of the dynamic responses of the urban system model (results per each alternative), **a "*multi-criteria method*" is used to determine the ranking** of the alternative options, evaluated against a set of elements (technological, social, environmental, economic).

Local energy system - 1



4 main building forms (thermal needs depend on the period of construction).
Gas technologies take the largest share in the base year.

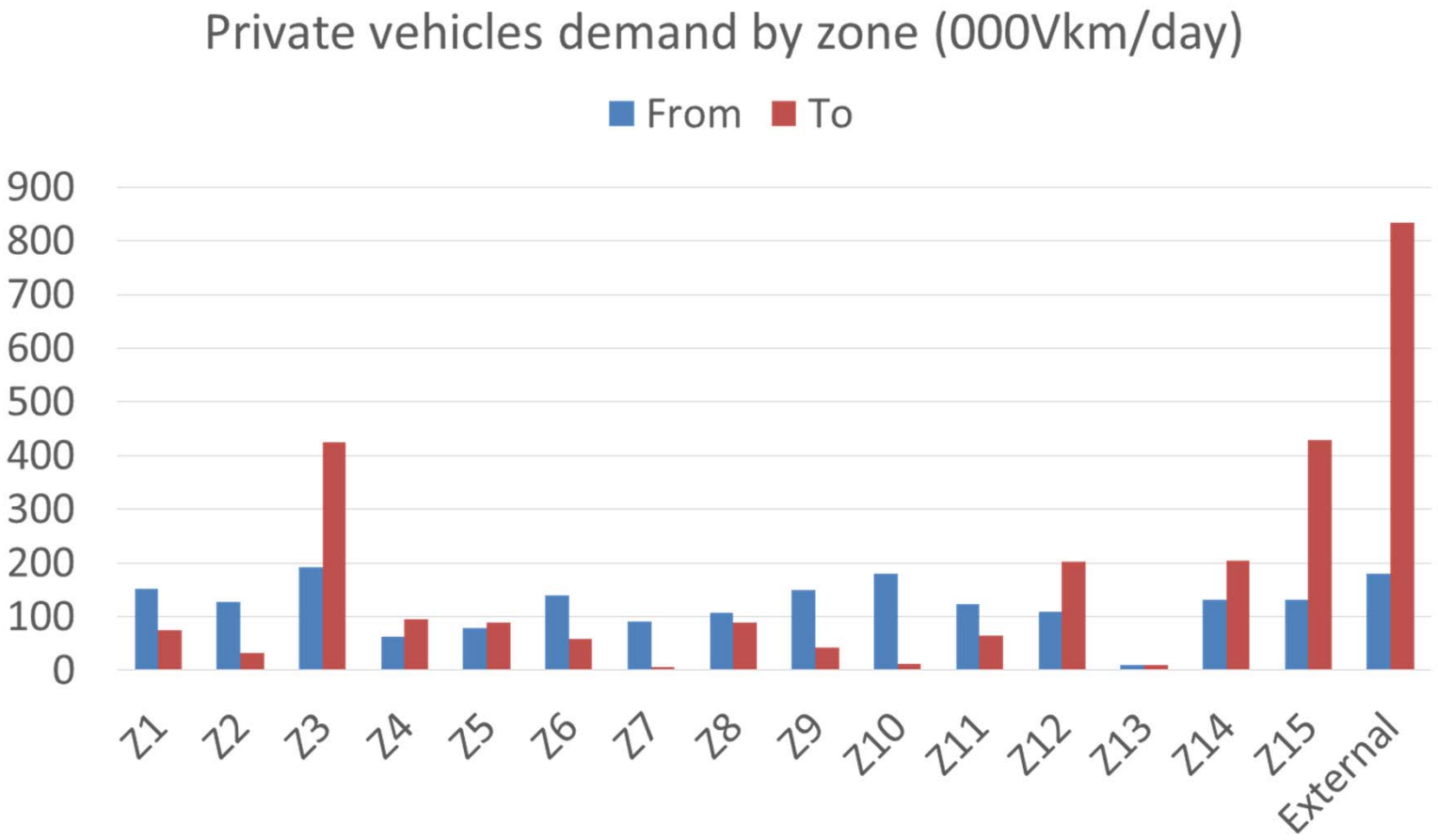
Local energy system - 2



Many “services” are demanded by the agent (responsible of investment decisions) placed in the dwelling (dw).

A budget constraint (per household) can be modelled.

Local energy system - 3



City is divided in 15 zones (+ 1 external area).
Z3 and Z15 are frequent destinations (shops and entertainment areas).

Stakeholders engagement

Modes of Governance in the energy sector

- Regulator and planner
- Consumer

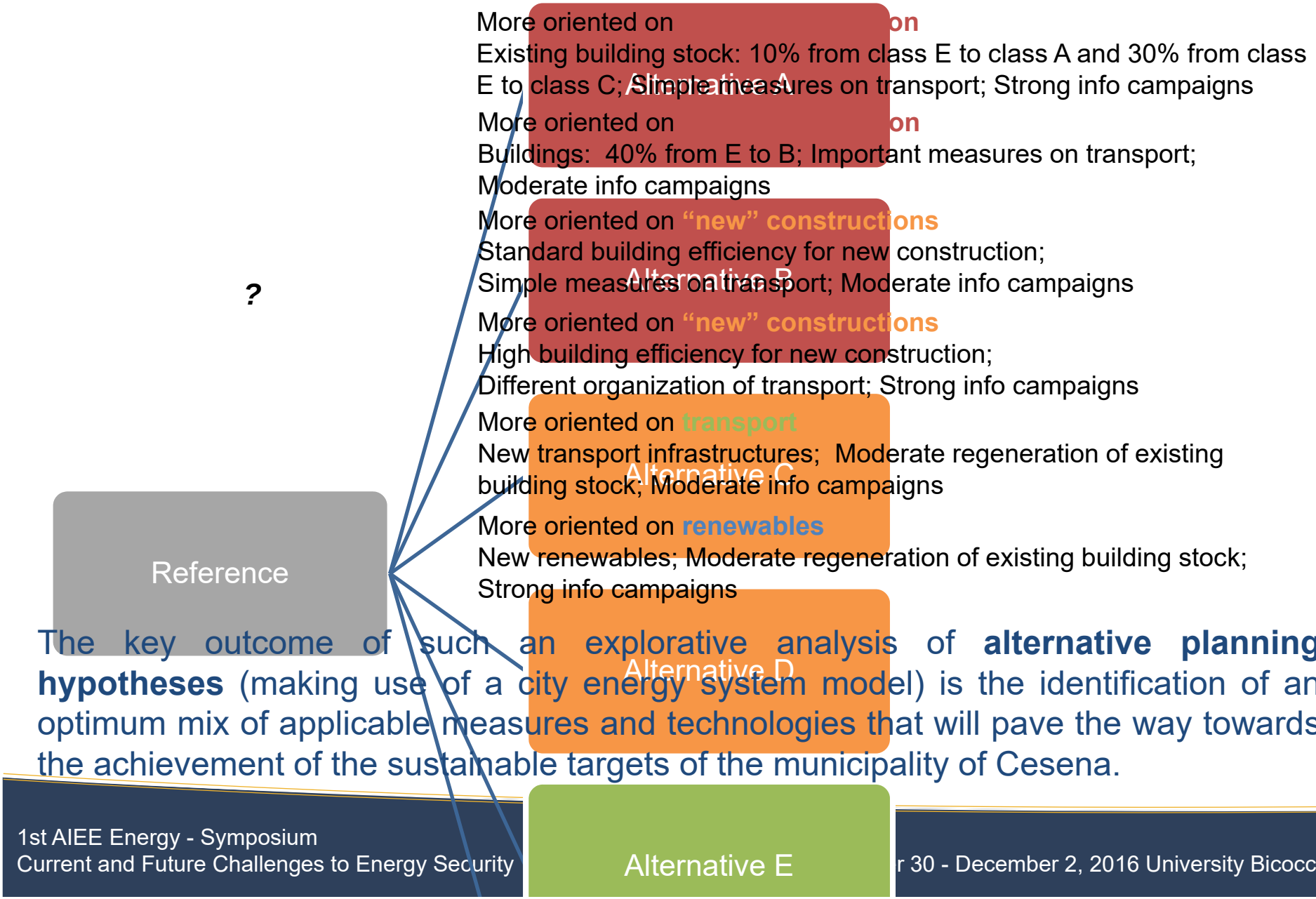
(behaviour of the municipal administration)

- Supplier of energy (and services)
- Support and information

- New district in the city (all buildings in class B + district heating)
- Standards on refurbishment measures in the building sector
- Production / Consumption of a certain fraction of electricity from RES
- Development of new bike lanes
- Creation of new bus stops / and new bus between zone “y” and zone “k”
- Reorganization of school schedule
- 10% of work from home for Municipality workers
- Communication campaigns on efficiency and renewable development
- ……..

→ different combinations of actions generate “**Alternative planning hypotheses**”

Stakeholders engagement (1st step)



The key outcome of such an explorative analysis of **alternative planning hypotheses** (making use of a city energy system model) is the identification of an optimum mix of applicable measures and technologies that will pave the way towards the achievement of the sustainable targets of the municipality of Cesena.

Stakeholders engagement (2nd step): criteria

Quantitative

C1: Energy consumption in the building sector in 2030. (TJ). MIN. Energy.

C2: Total CO_2 emissions in 2030. (t). MIN. Environment.

C3: Total particulate emissions in 2030 (kg). MIN. Environment.

C4: Investments (and maintenance) costs (until 2030). (kEuro). MIN. Economy.

C5: Onsite renewable production of energy in 2030. (TJ). MAX. Energy.

C6: Indicator of private vehicles (cars, moto) dependency in 2030. (Mpass-km). MIN. Social.

Qualitative

C7: Aesthetics/architectonic integration of technologies and infrastructures. (5-points scale). MAX. Environment.

C8: Easiness of implementation of the strategy. (5-points scale). MAX. Social.

C9: Local development. (5-points scale). MAX. Social.

Six Alternatives, nine criteria (quantitative and qualitative) - Hinkle's method for estimating criterion importance ranking ("resistance to change grid").

Evaluation Table

	C1	C2	C3	C4	C5	C6
Scenario	Unit: TJ	Unit: t	Unit: kg	Unit: kEuro	Unit: TJ	Unit: Mpass-km
Ref	1,965	273,868	11,296	2,353,204	1,358	1.168
ScenA	1,809	255,730	10,924	2,471,972	1,358	1.123
ScenB	1,828	272,480	12,324	2,787,580	1,358	1.165
ScenC	1,877	254,160	9,542	2,228,977	1,361	1.151
ScenD	1,874	305,136	13,055	2,846,468	1,358	1.198
ScenE	1,886	227,719	6,901	2,118,472	1,358	1.076
ScenF	1,838	246,819	9,624	2,381,794	1,673	1.168

Quantitative (determined by running the bottom-up model)

	C7	C8	C9
Scenario	Qualitative	Qualitative	Qualitative
Ref	Average	Very good	Very bad
ScenA	Good	Average	Good
ScenB	Good	Average	Good
ScenC	Bad	Good	Average
ScenD	Bad	Average	Very good
ScenE	Very bad	Very bad	Bad
ScenF	Average	Average	Good

Qualitative
(determined in collaboration with an independent group of technicians of the municipality and experts

Stakeholders engagement (3rd step): weights

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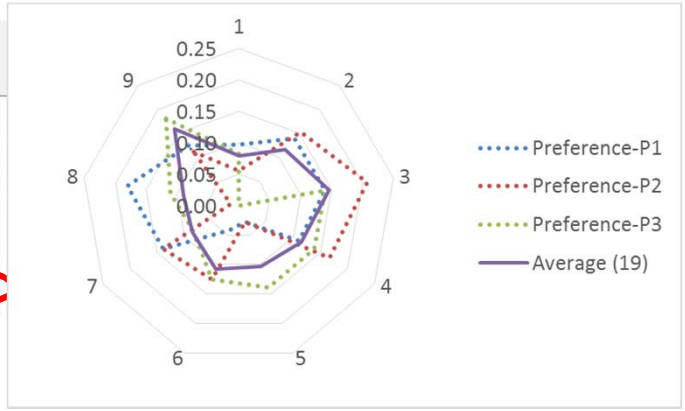
InSMART - Ce...	Energy c...	Total CO...	Total par...	Investm...	Onsite pr...	Indicator...	Aesthetic...	Easiness...	Local de...
Unit	TJ	tonnes	tonnes	kEuro	unit	unit	5-point	5-point	5-point
Cluster/Group									
Preferences									
Min/Max	min	min	min	min	max	min	max	max	max
Weight	0.08	0.12	0.15	0.12	0.10	0.11	0.08	0.09	0.16



Individual preferences, and stakeholder groups (average) preferences, across the nine criteria.

Qualitative (SG1)=0.33 - Qualitative (SG2)=0.27

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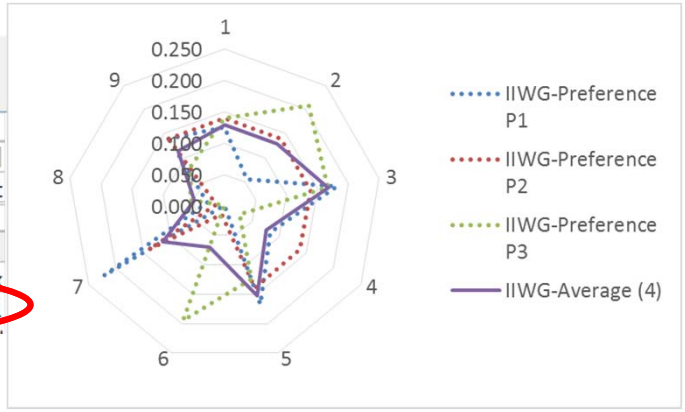
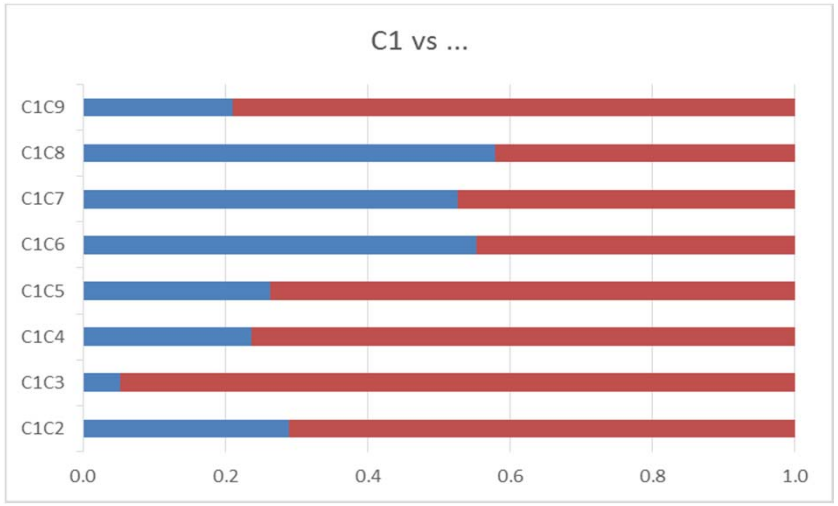
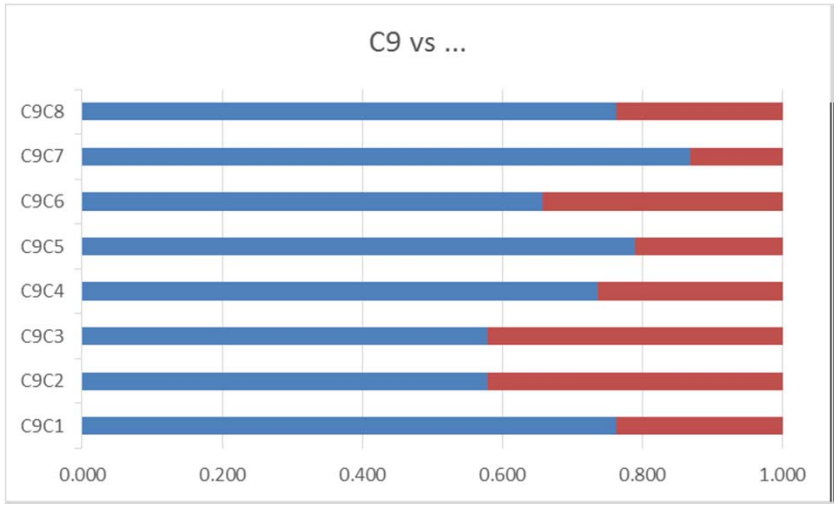
InSMART - Ce...	Energy c...	Total CO...	Total par...	Investm...	Onsite pr...	Indicator...	Aesthetic...	Easiness...	Local de...
Unit	TJ	tonnes	tonnes	kEuro	unit	unit	5-point	5-point	5-point
Cluster/Group									
Preferences									
Min/Max	min	min	min	min	max	min	max	max	max
Weight	0.13	0.13	0.17	0.08	0.15	0.07	0.11	0.05	0.11

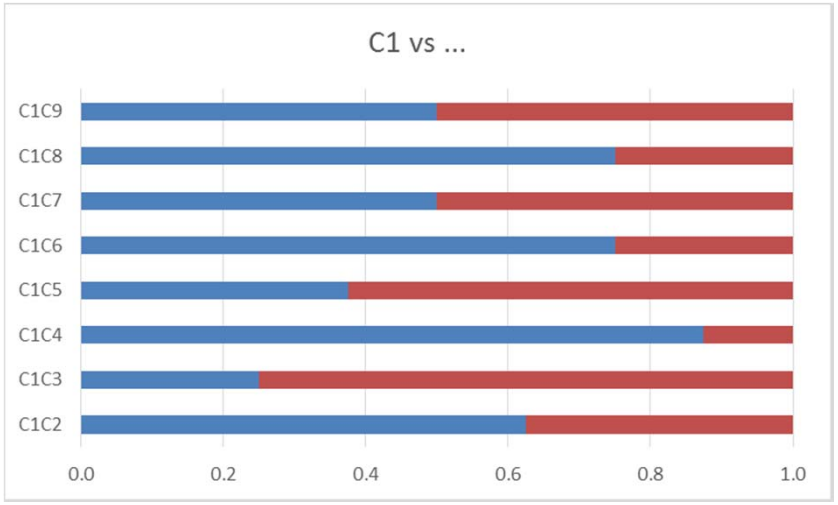


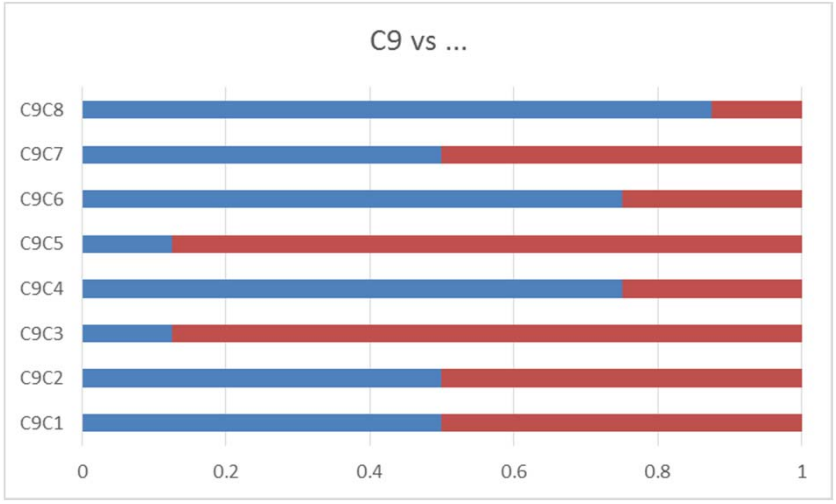
Stakeholders engagement (3rd step): weights





Examples of pair-wise comparison - SG1(top), SG2(bottom)





Results of the MCDA: selection of the alternatives

Software: Visual Promethee
Method: Outranking relation from pairwise comparison of the alternatives

→ Generation of “flows of preference”

Ranking	Alternative planning hypotheses	Phi	Phi+	Phi-
1	**Alternative F**	**0.2871**	0.4777	0.1906
2	**Alternative A**	**0.1986**	0.381	0.1824
3	Alternative C	0.0455	0.3863	0.3408
4	Alternative B	-0.0338	0.2729	0.3066
5	Alternative E	-0.1552	0.3121	0.4674
6	Alternative D	-0.3421	0.1986	0.5407

Ranking	Alternative planning hypotheses	Results / Decisions
1	**Alternative F**	**Shortlisted**
2	**Alternative A**	**Shortlisted**
3	Alternative C	Below the threshold
4	Alternative B	Likely not of interest
5	Alternative E	Likely not of interest
6	Alternative D	Discarded

Results of the MCDA: selection of the alternatives

Ranking	Alternative planning hypotheses	Phi	Phi+	Phi-	Delta
1	Alternative F	0.2195	0.4128	0.1933	=
2	Alternative A	0.1698	0.3567	0.1869	=
3	Alternative C	0.081	0.3988	0.3179	=
4	Alternative B	-0.0816	0.2382	0.3198	=
5	Alternative E	-0.1033	0.3502	0.4535	=
6	Alternative D	-0.2853	0.2257	0.511	=

S1

Ranking	Alternative planning hypotheses	Phi	Phi+	Phi-	Delta
1	Alternative F	0.334	0.4893	0.1553	=
2	Alternative E	0.1697	0.4322	0.2625	+3
3	Alternative C	0.1543	0.4041	0.2498	=
4	Alternative A	0.1163	0.3237	0.2074	-2
5	Alternative B	-0.2054	0.174	0.3794	-1
6	Alternative D	-0.5689	0.0712	0.64	=

S2

Ranking	Alternative planning hypotheses	Phi	Phi+	Phi-	Delta
1	Alternative A	0.3065	0.4497	0.1432	+1
2	Alternative F	0.1585	0.3835	0.225	-1
3	Alternative B	0.0323	0.3221	0.2898	+1
4	Alternative C	-0.0545	0.3117	0.3662	-1
5	Alternative E	-0.1111	0.3684	0.4795	=
6	Alternative D	-0.3317	0.2344	0.5661	=

S3

Sensitivity 1: a different stakeholder group
Sensitivity 2: no “qualitative” criteria
Sensitivity 3: no criterion on renewable (onsite) generation

Conclusions

- *The specific strategies identified by the "planning tool" (F, A) will form the technical basis of the city's Sustainable Energy Action Plan.*

- *Urban planning and energy planning are carried out **together** in an integrative manner, making use of ad-hoc models.*

- *Participation of the Municipalities and of a broad stakeholder group is the "key".*

Thank you!

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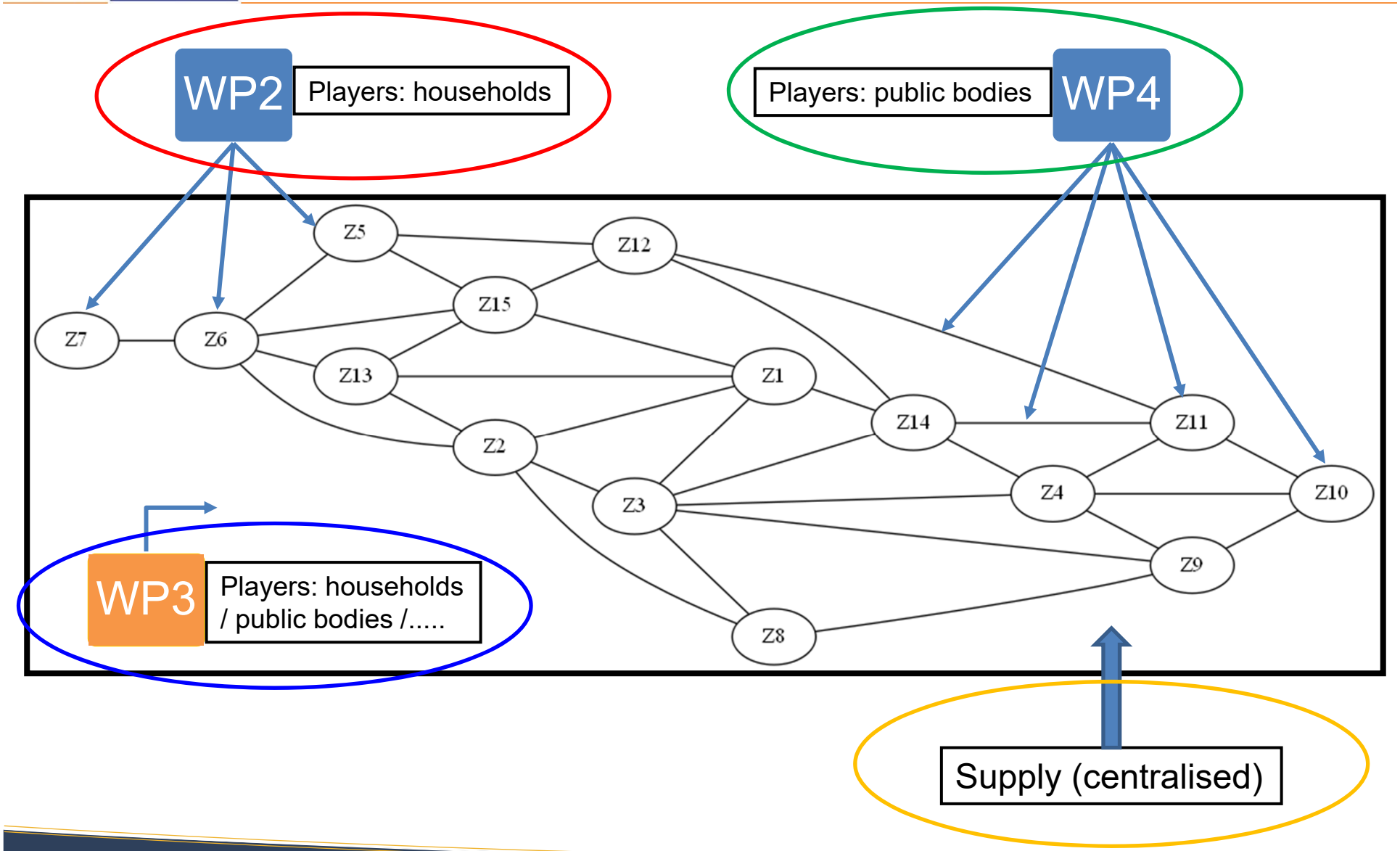
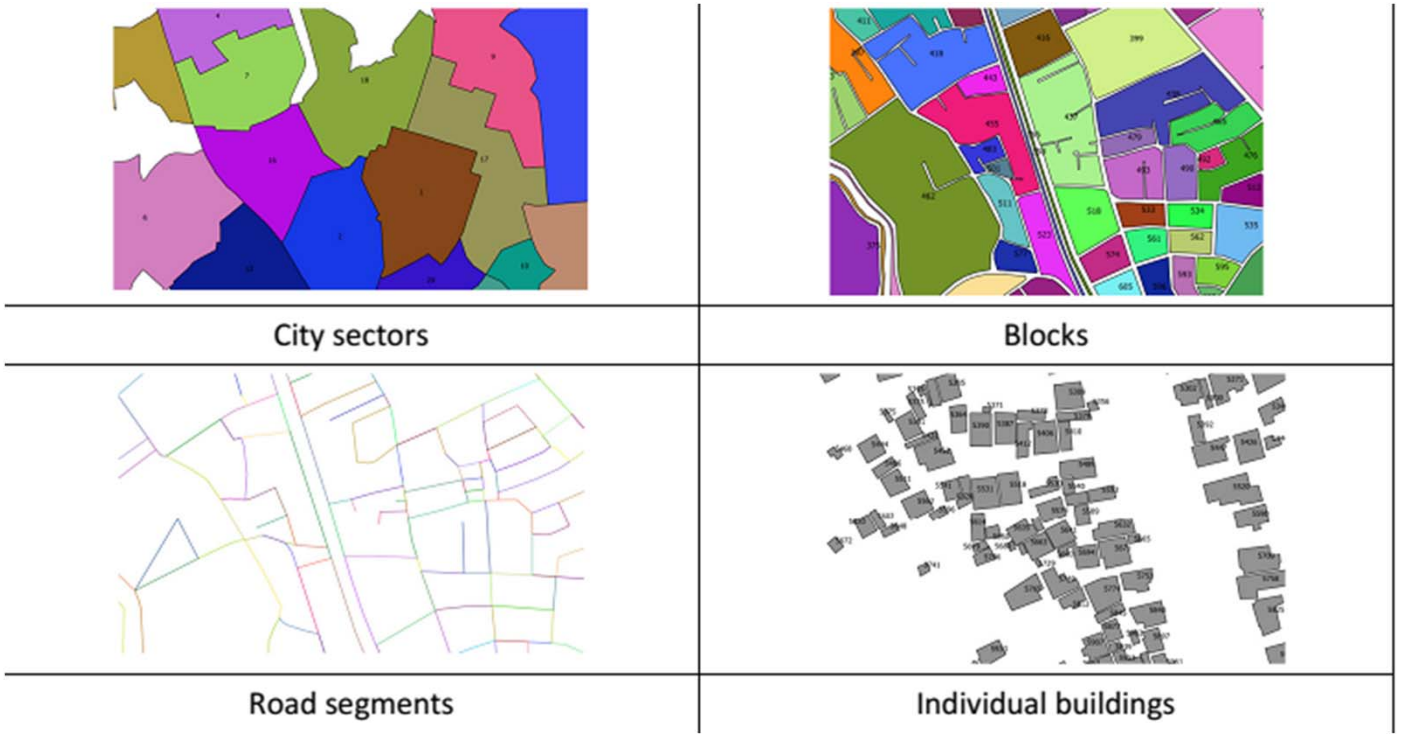
Authors acknowledge the Municipalities of Cesena and, in specific, all the people directly and indirectly involved in the project, as they all contributed to the development of this work.

Comune di Cesena

City: geographical representation



City: geographical representation



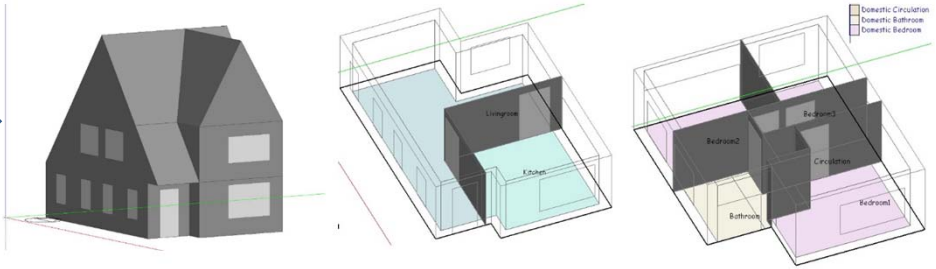
This platform is used to supply all the thematic models that are developed for the participating cities and to visualize and analyse the results.

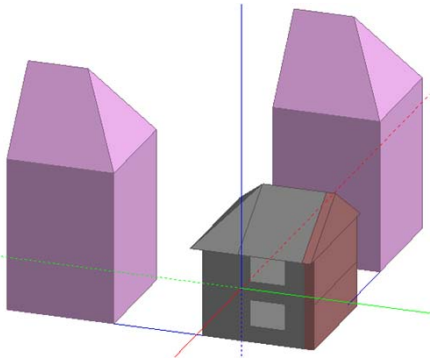
Key: identification of the basic geographical entities zones that may represent the geographical distribution of the information (according to the planning criteria).

Building analysis

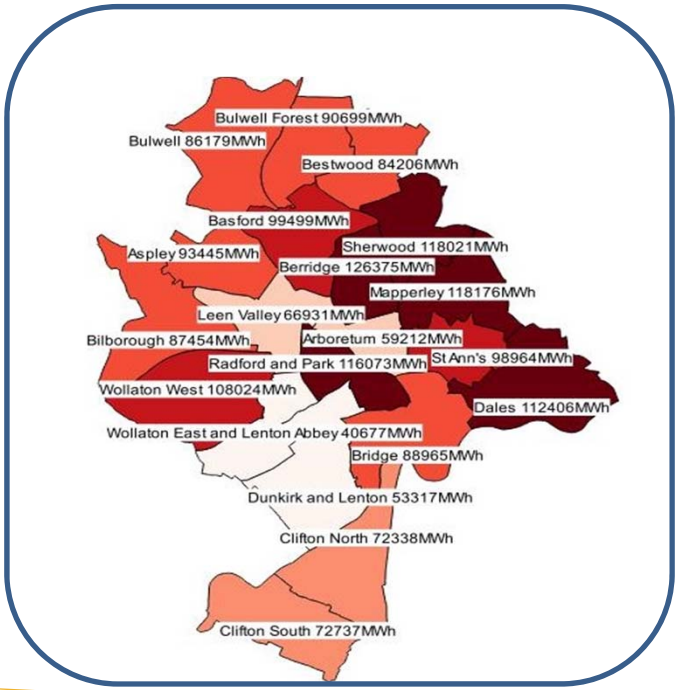
Survey/ Analysis

Simulation



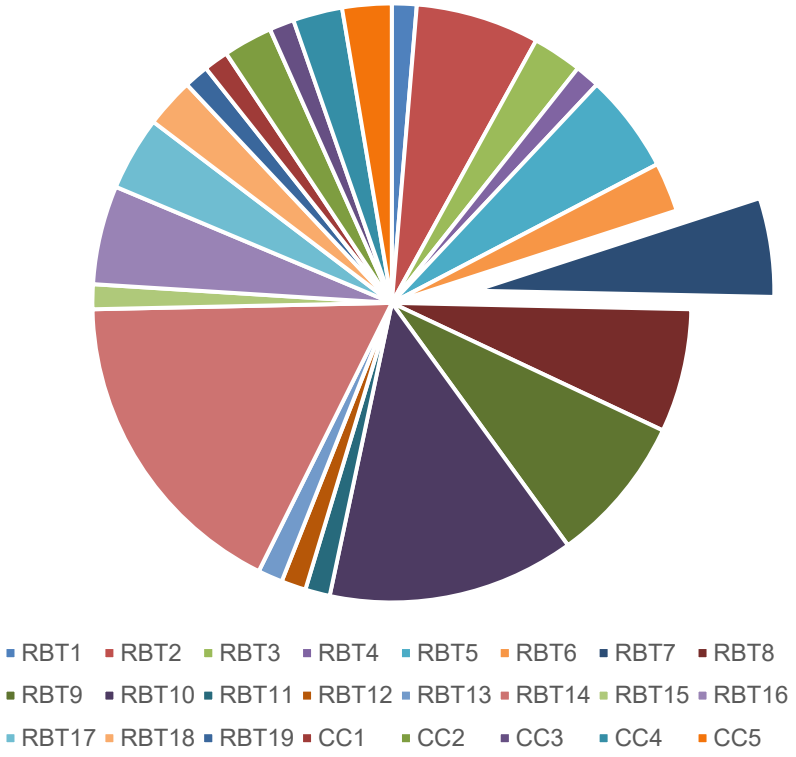


Synthetic stock

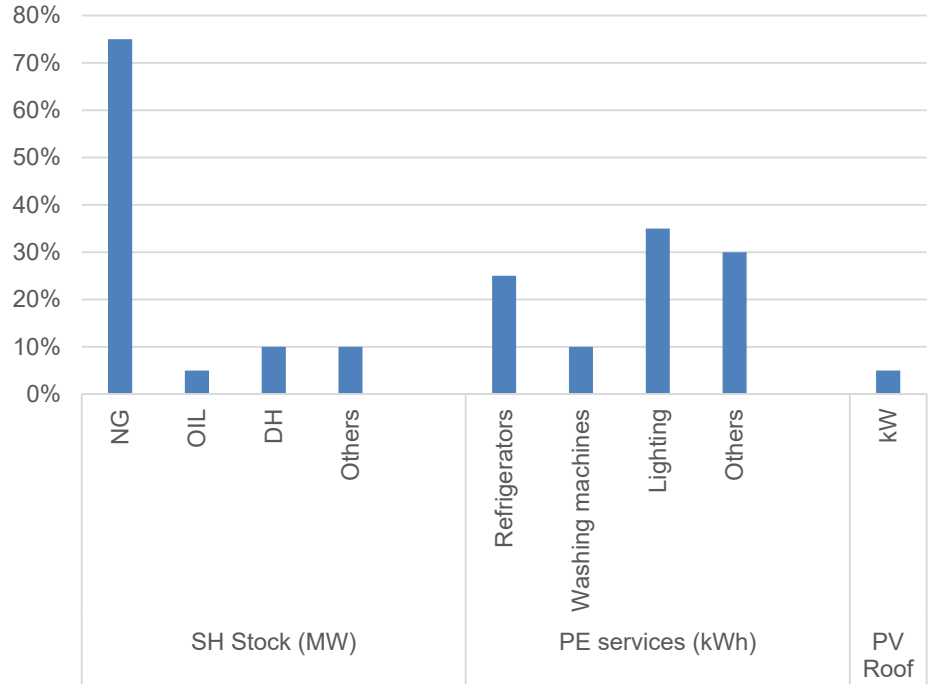


Zone (i) – Node of the graph

Fraction of occupied surface (m2) by "actor"

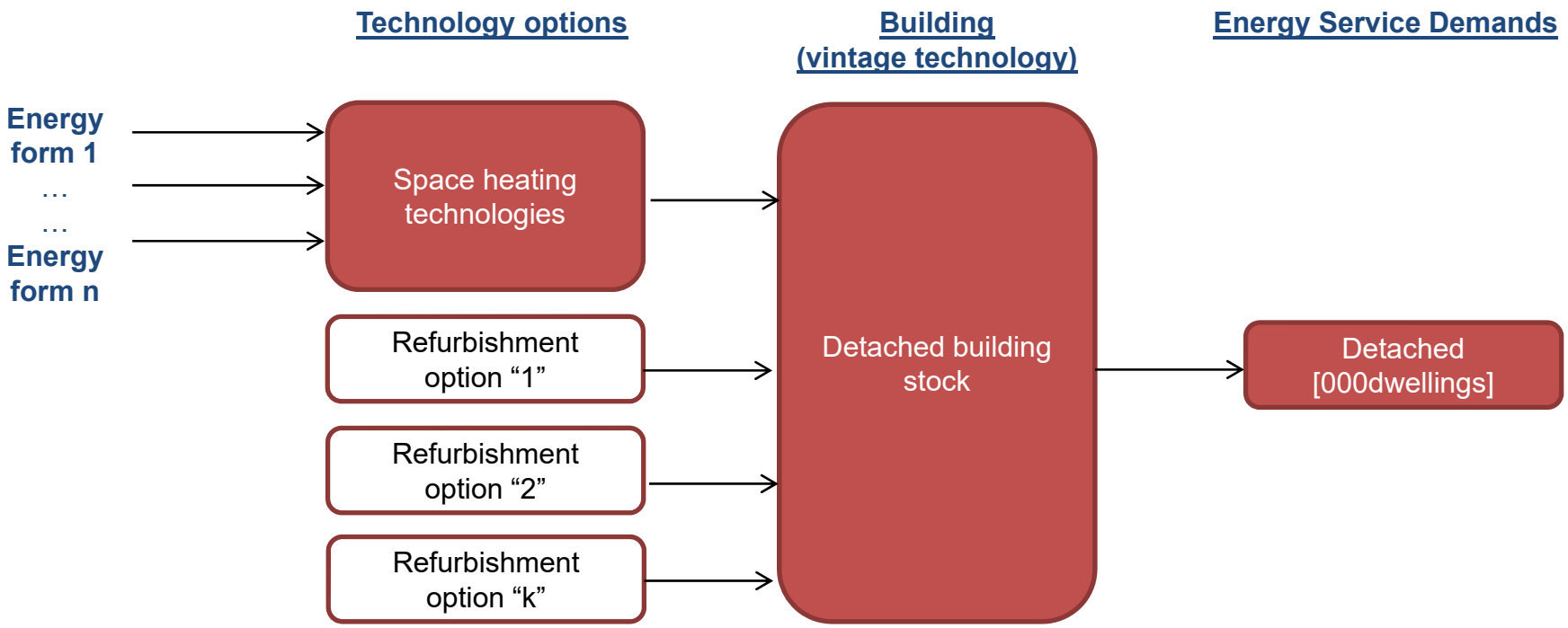


Share of space heaters by type, share of electricity consumption by service, share of PV over the total PV stock



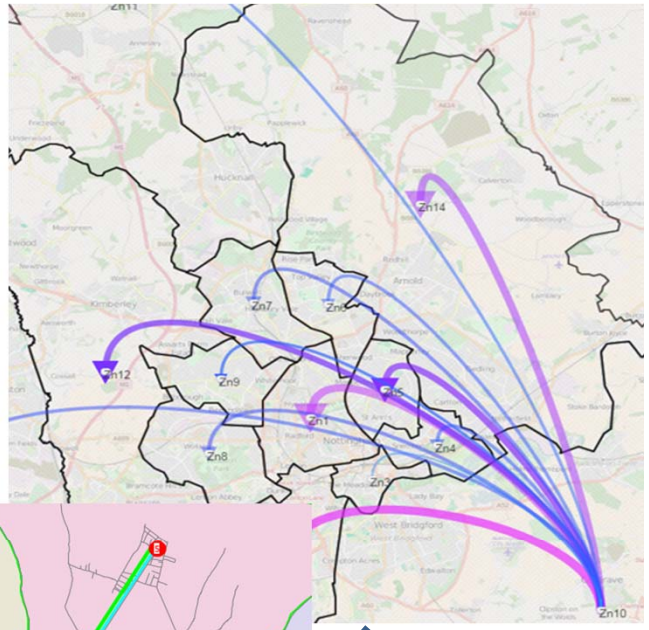
$$X_{Zone_i} = \sum_{actor=1}^{n} X_{actor}$$

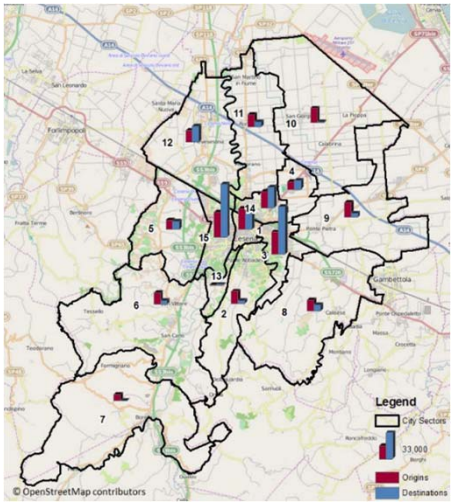
Residential building stock



Retrofitting scenarios in order to calculate the potential energy saving were examined for each typology (roof, external walls, windows)

Transport analysis





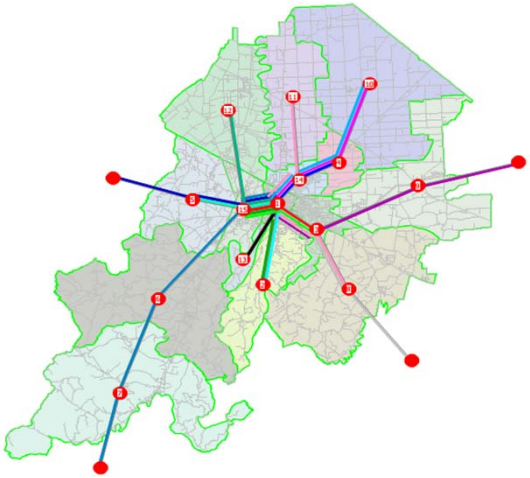
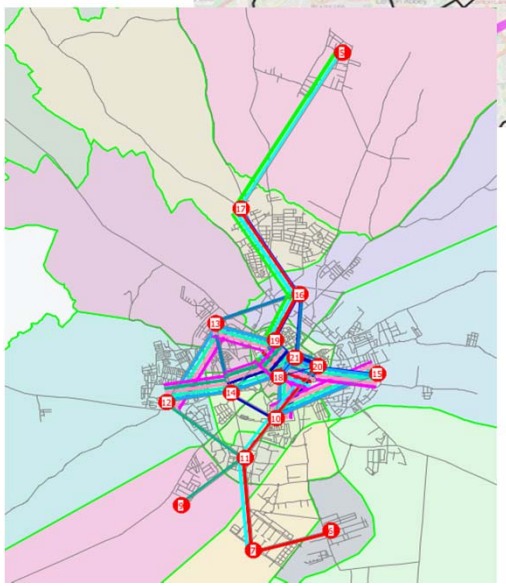


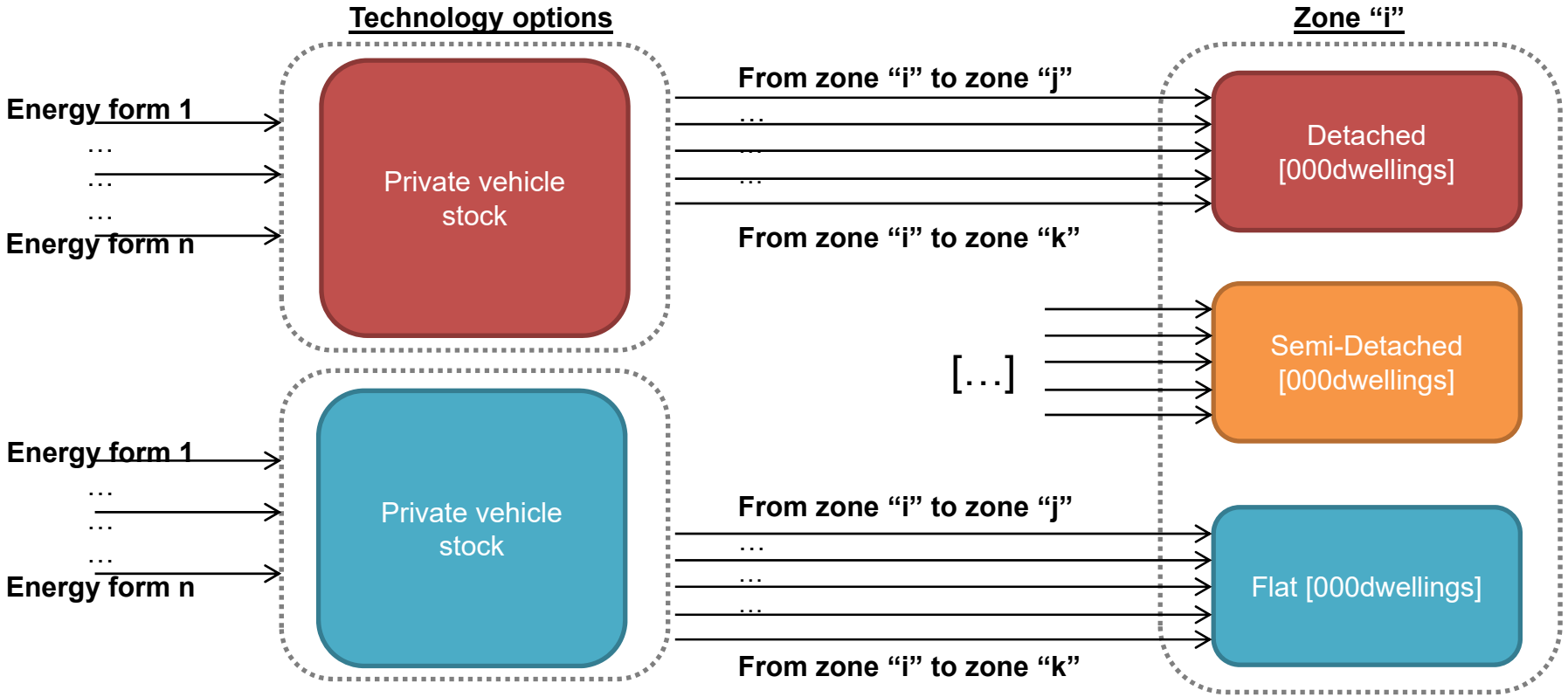
Figure 6. Public Transport Routes



Movements between model zones

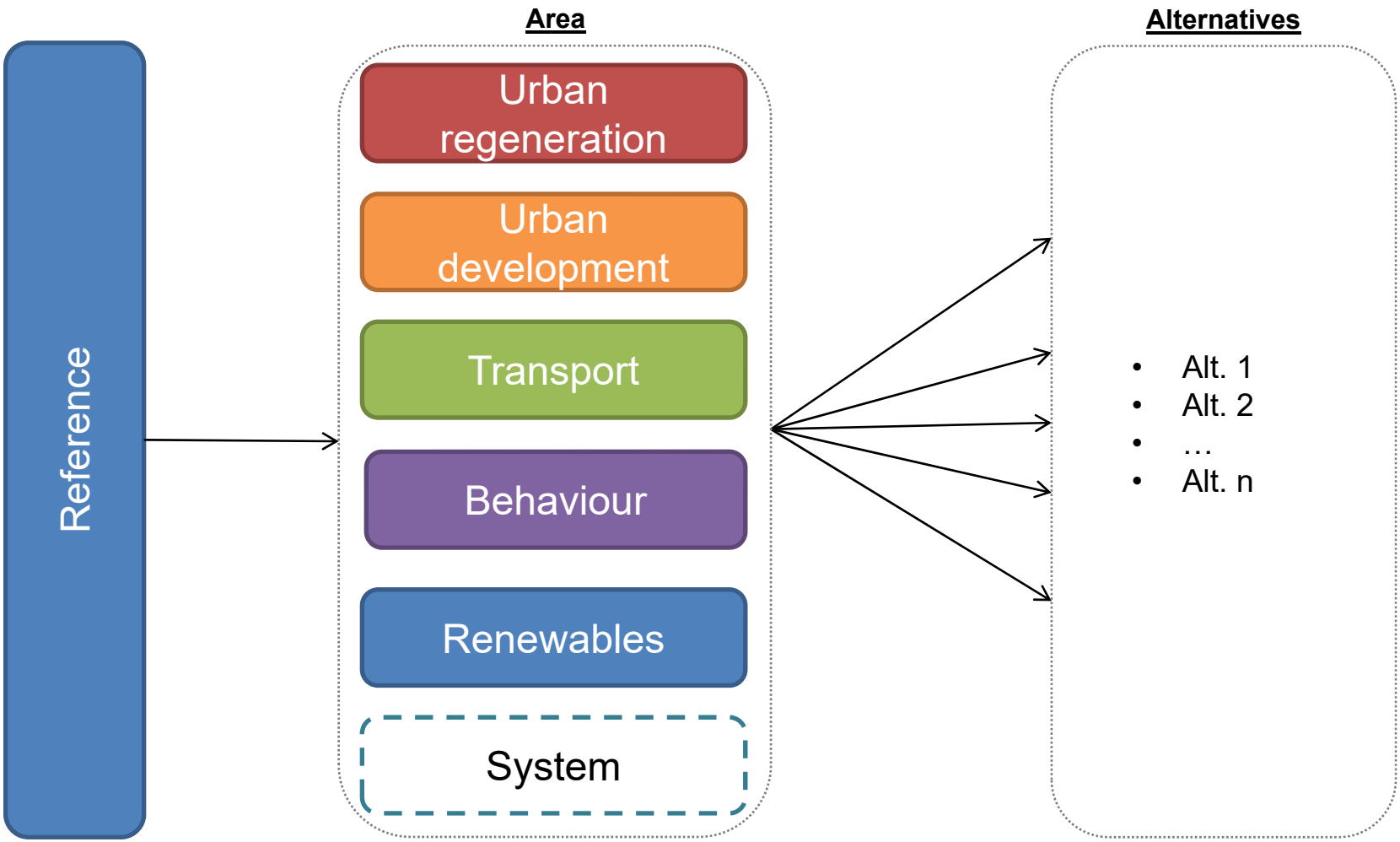
		1	3	14	15	2	4	5	11	12	13	6	7	8	9	10	16		
	All Purposes	Centro Urban 2	Fiorenzuola	Cervese Sud 2	Oltre Savio 2	Cesuola	Cervese Sud 1	Oltre Savio1	Ravennate	Dismano	Centro Urban 1	Valle Savio	Borello	Rubicone	Al Mare	Cervese Nord	External	Total	Origin Splits
1	Centro Urban 2	7979	4900	1403	5538	251	334	493	236	687	44	100	0	158	65	12	2604	24804	10%
3	Fiorenzuola	454	12877	2593	2192	167	1300	417	411	1392	22	131	0	1051	242	44	2732	26025	11%
14	Cervese Sud 2	373	4310	4564	2674	133	1309	327	378	1040	17	70	0	261	114	31	1830	17432	7%
15	Oltre Savio 2	872	1917	1420	16403	247	337	1196	303	1326	259	206	1	189	31	15	2899	27621	11%
2	Cesuola	372	2264	1245	2459	656	461	496	350	1196	126	287	1	510	97	30	1237	11787	5%
4	Cervese Sud 1	169	2245	1323	861	58	1370	57	158	437	7	19	0	124	96	31	816	7772	3%
5	Oltre Savio1	351	815	556	4586	115	85	1785	153	993	78	154	1	110	33	7	1152	10975	5%
11	Ravennate	609	2925	1033	3516	293	344	437	706	1112	40	69	1	149	115	76	1340	12767	5%
12	Dismano	442	1320	960	2880	126	308	773	470	3694	55	118	1	139	55	21	1332	12693	5%
13	Centro Urban 1	41	92	99	201	11	32	39	28	95	90	49	0	20	3	2	94	894	0%
6	Valle Savio	597	1103	560	4557	375	139	1051	212	1026	325	1608	26	176	65	13	1388	13222	5%
7	Borello	366	701	318	2104	204	93	494	133	604	161	763	250	121	47	10	747	7115	3%
8	Rubicone	631	4727	727	1287	266	289	249	226	440	24	67	1	2433	241	20	1364	12991	5%
9	Al Mare	537	6274	1325	1209	253	809	362	285	855	26	110	1	814	2472	96	1809	17236	7%
10	Cervese Nord	580	3697	1835	2295	259	1457	369	1107	1783	39	131	1	516	647	419	1775	16909	7%
16	External	1686	5883	2341	6188	400	1016	1002	605	1956	154	455	33	794	507	97	0	23119	9%
	Total	16060	56048	22301	58949	3814	9681	9547	5761	18638	1468	4337	317	7566	4830	923	23119	243360	
	Destination Splits	7%	23%	9%	24%	2%	4%	4%	2%	8%	1%	2%	0%	3%	2%	0%	9%		

Transport analysis



→ Cross-sectoral integration!

Stakeholders engagement (1st step)



Model allows the exploration of a set of alternative planning hypotheses, with an explicit representation (till 2030) of energy flows, technology and measures, costs, and emissions.

City ESM – Results (examples)