Energy System Planning Models for cities

On limits of existent models and a new approach for models tailored to the needs of developing countries

Outline

- What are we talking about and why?
- Existent ESPM – Limits in city
- ESPM for city – New approach
- Way forward

What are we talking about and why?

68 computer-based modeling tools, Connelly et al. (2009)

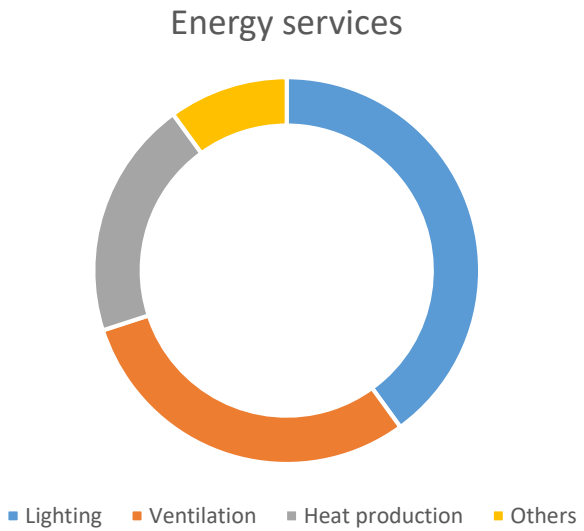
Contribution to post-2015 Development Agenda:

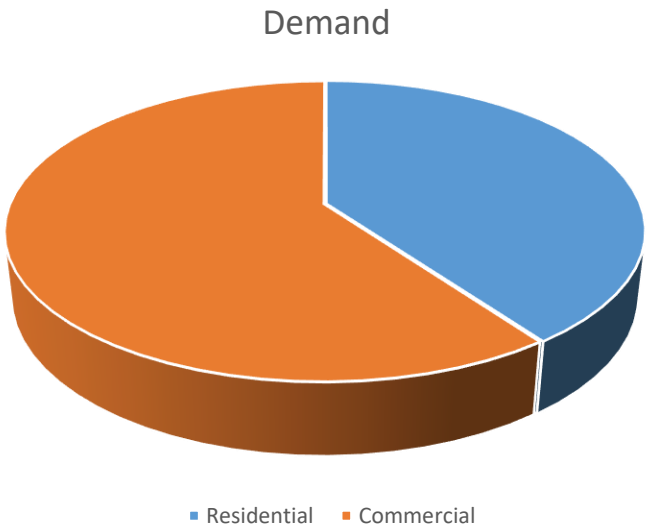
40 used in developing countries

12 focus on energy systems Urban et al. (2007)

What are we talking about and why? - 2

Cities are complex systems (Allen, 1997); (Amaral and Ottino, 2004) ; (Batty, 2005).





What should look like the system future energy demand?

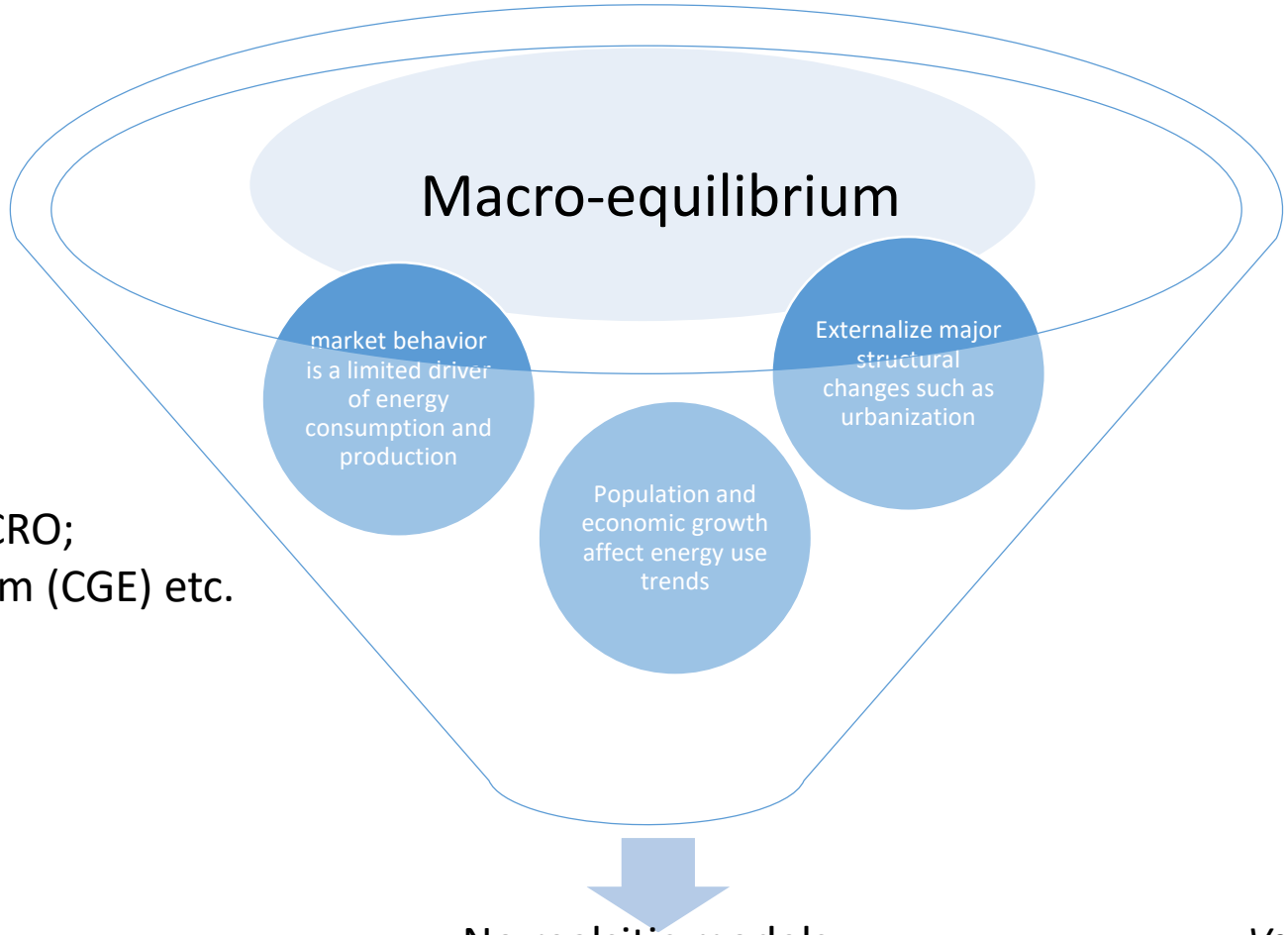
What is the system future demand?

What are the supply options?

Existent ESPM – Limits in city

No replication – No adaptation

Top – down approach – Market biases

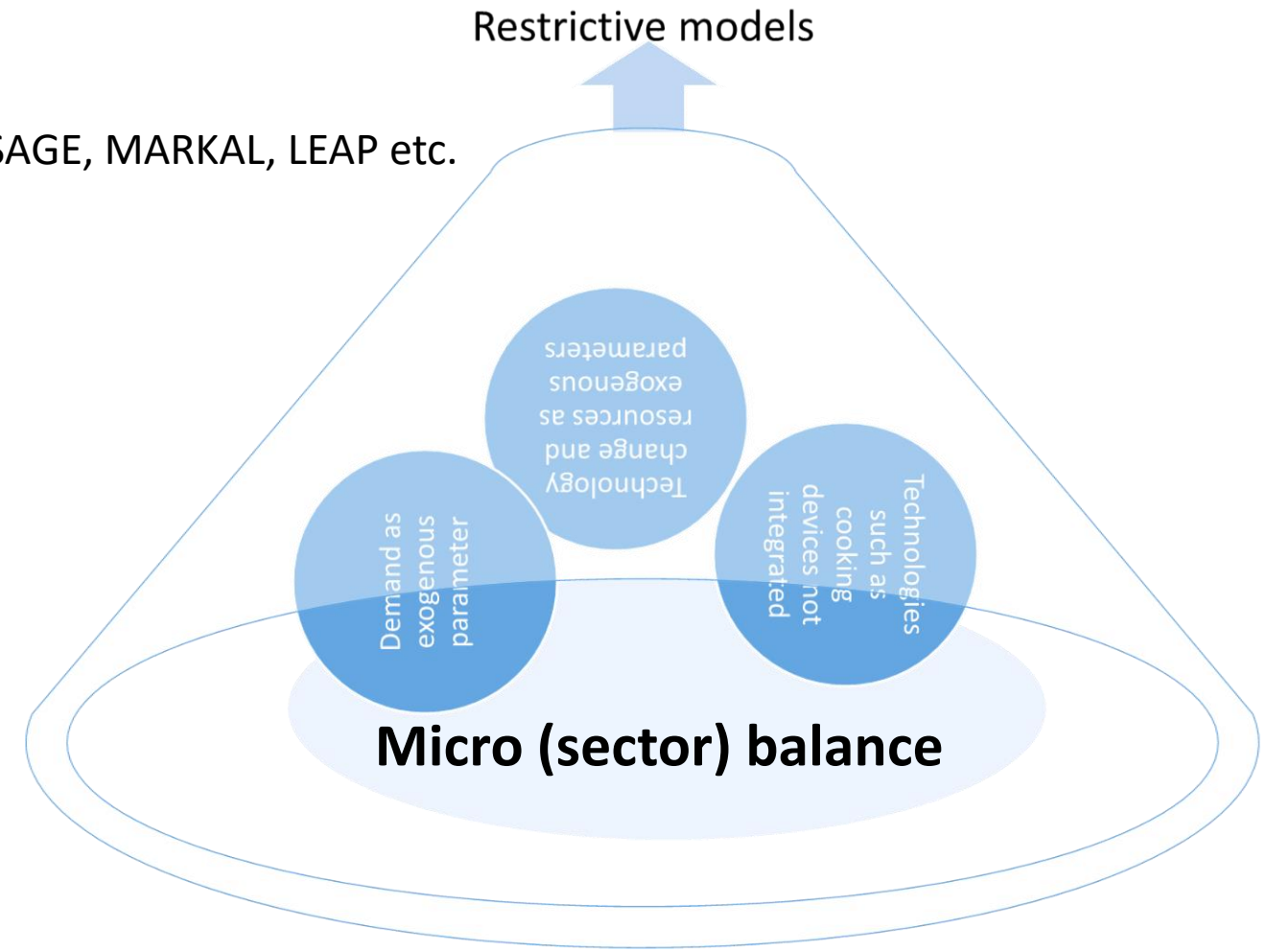


Models in this category: ETA-MACRO; Computational General Equilibrium (CGE) etc.

Van Beeck (1999)

Bottom – up approach – Sector characteristics biases

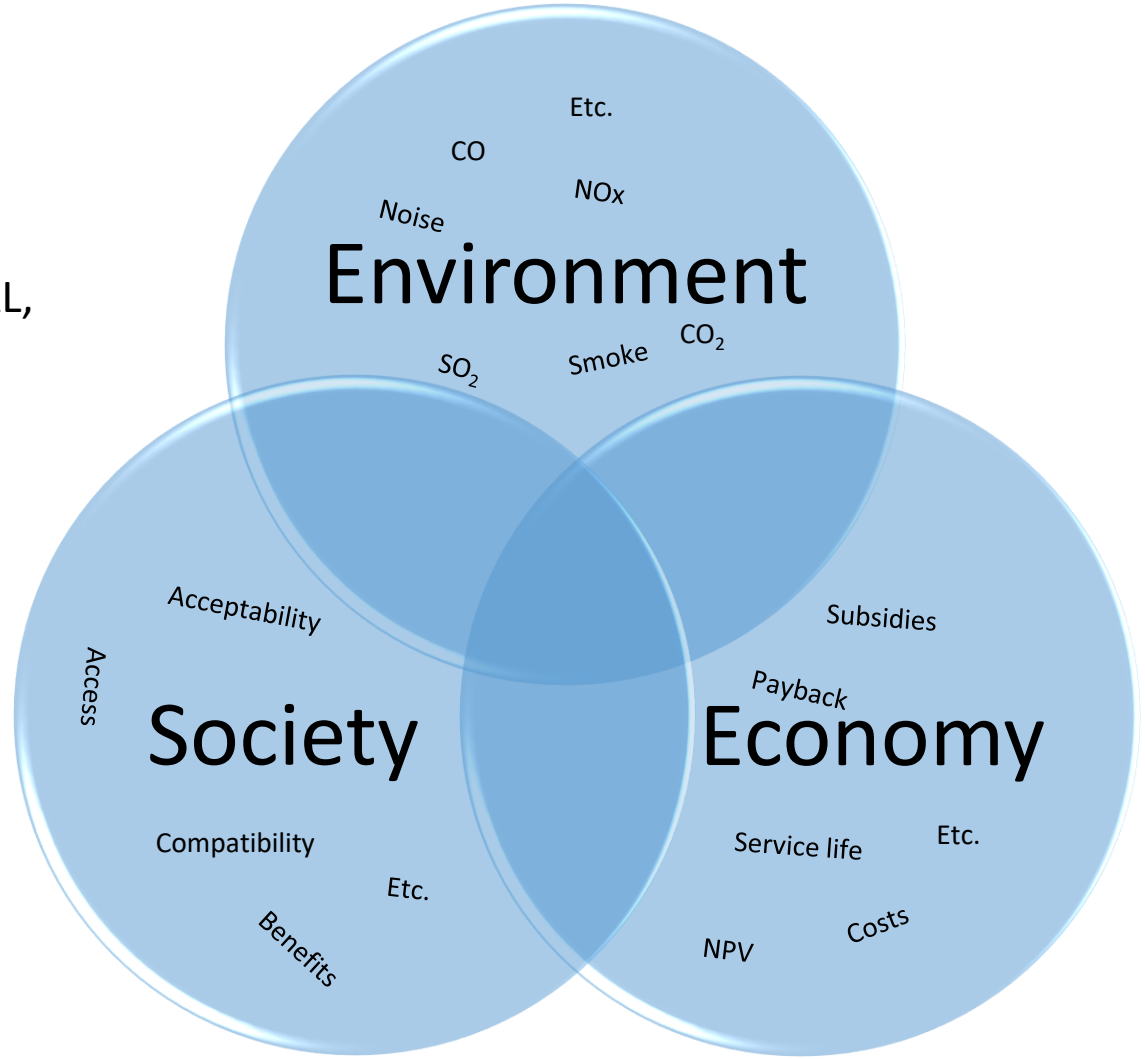
Models in this category: MESSAGE, MARKAL, LEAP etc.



Urban et al. (2007)

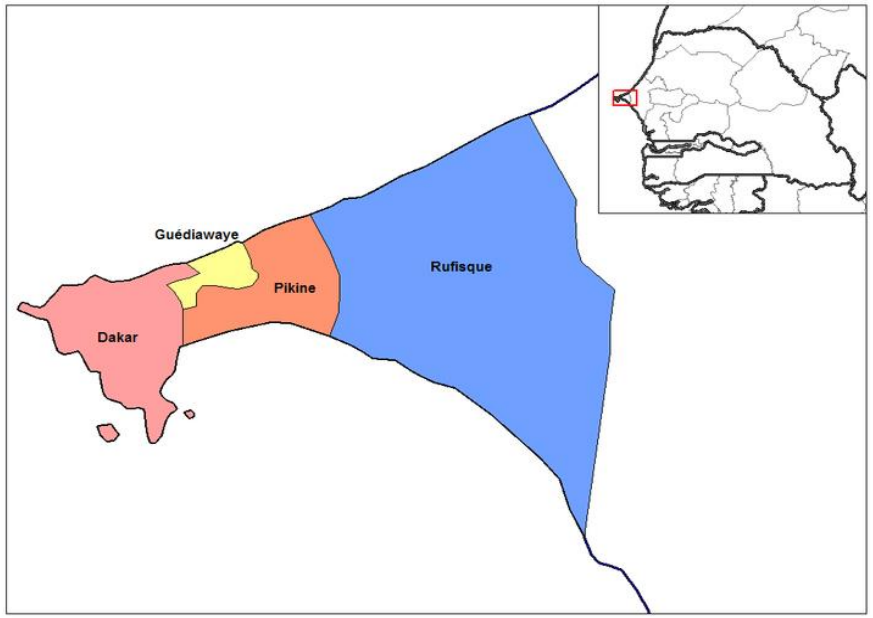
Sustainability dimensions in optimization models

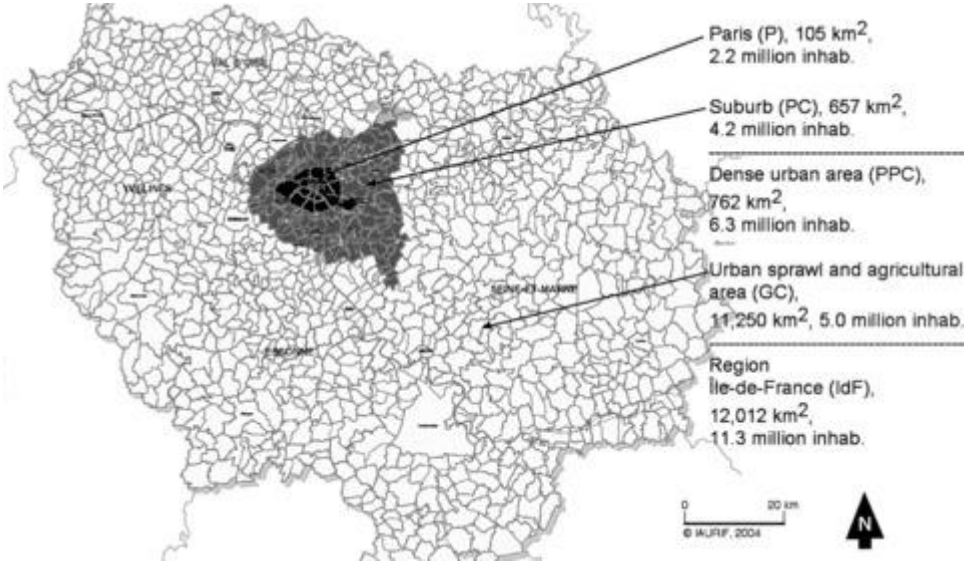
Models in this category: MARKAL, MESSAGE, LEAP, MAED etc.



Existent ESPM – City boundaries?

Two production accounting methods of city energy flows: (1) Final energy; (2) Regional energy metabolism





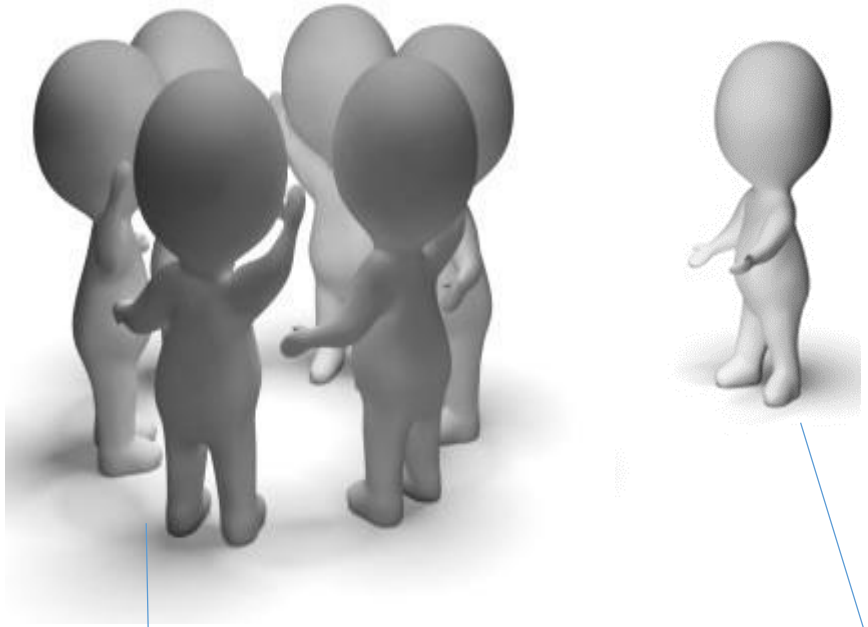
Sabine Barles (2009)

Metadata: Domestic fossil fuel consumption (2003, tonnes per capita)

- Paris (P): 1.8
- Paris suburbs (PC): 2.2
- Paris + suburbs (PPC): 2.1
- Urban Sprawl & Agricultural area: 2.6
- Ile de France: 2.3

Existent ESPM – City Economy Metric?

- Gross Regional Economic Product (GRP) to apply the two consumption accounting methods
  - Regional economic activity (Dhakal, 2009)
  - I-O extended tables ((Pachauri, 2007), (Cohen et al., 2005), (Lenzen et al., 2004), and (Dey et al., 2007)



City GRP

Informal economy

40% in developing countries
17% in OECD countries (Schneider, 2005)

Utility curves exclude citizens without access and informal sector

Existent ESPM – Limits on validity

Were we in the field of literature, many of us would be serious candidates to authorship of fantastic novels. *Renato flores (2008) about CGE models*

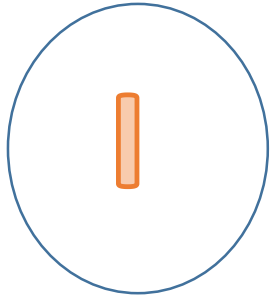
The predictive capability of models formulating controlled man-made systems (incl. optimization models) is irrelevant, even if it is often overestimated *(schrattenholzer, 1981)*

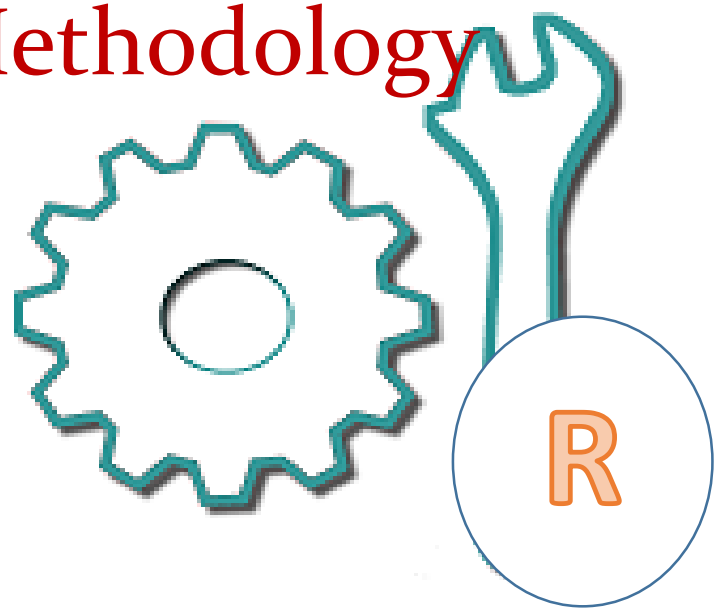
ESPM for City

New approach

ESPM Emerging city - Methodology

1. Multi-criteria decision making (MCDM) methods





Method has to be **Adapted** to needs of the target system by integrating characteristics of the system such as: access limit, biomass for cooking etc.

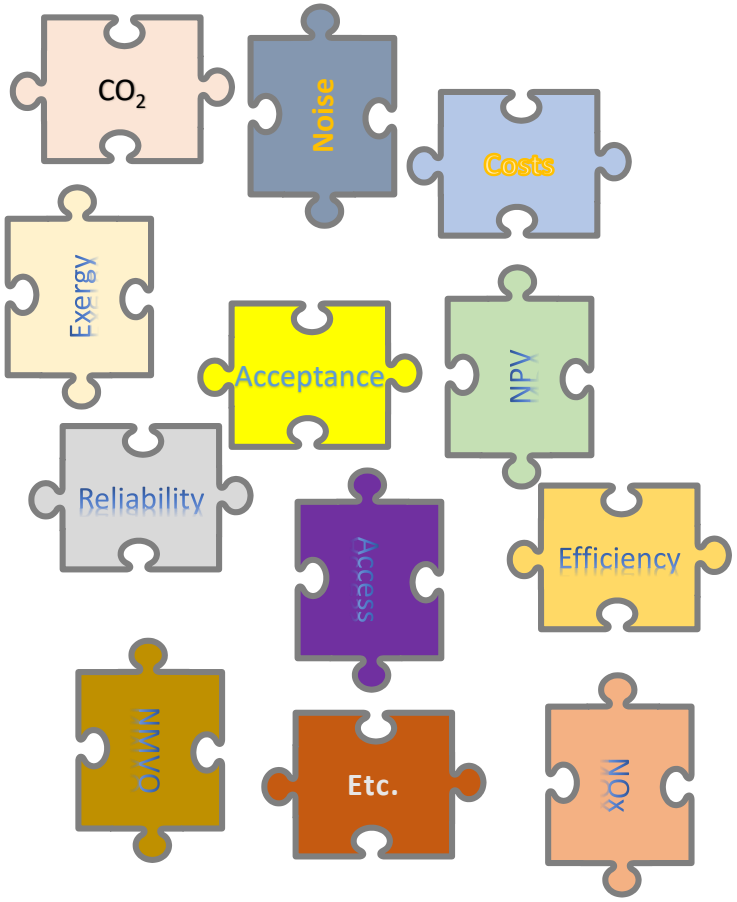
Method has to be **Inclusive** with an agent-based modeling approach that includes agents in informal sector

Method has to be **reproducible** with “Black box” for automation of computations and replication of results

2. Energy landscaping to balance supply-demand

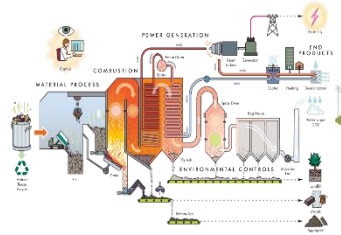
3. Mechanism design for scenario simulation

MCDM Methods – Step 1 Identification

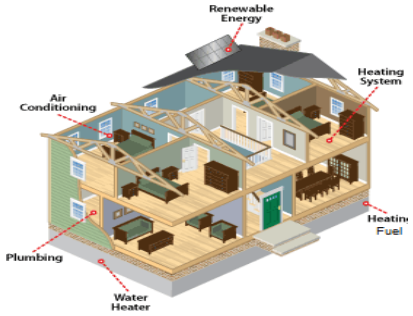


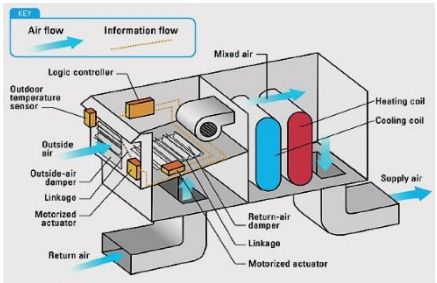
Supply options





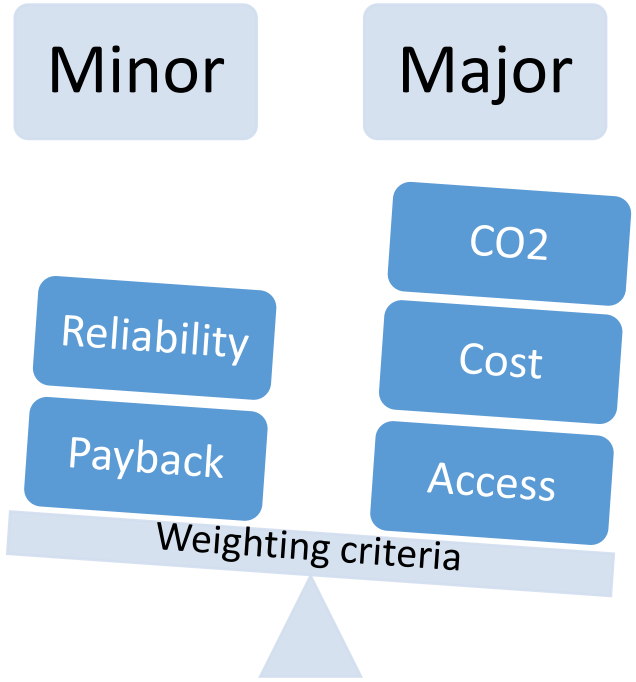

Demand options

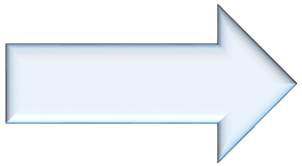


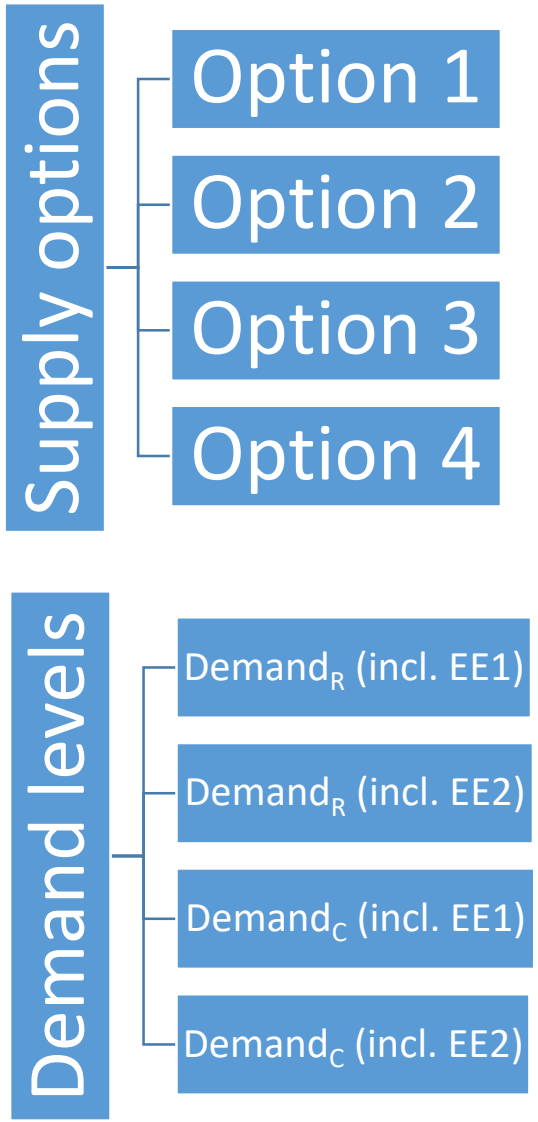


Consider multi-dimensions criteria of energy sustainability

MCDM Methods – Steps 2 (Weighting) & 3 (Selection)







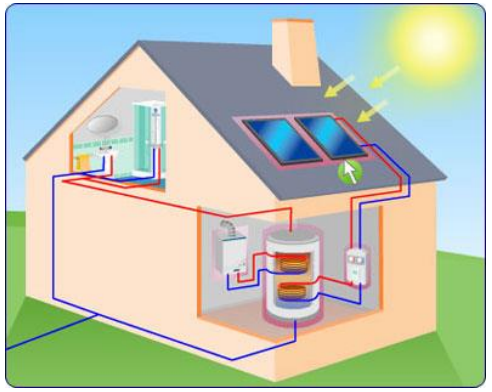
Weighting methods:

- Analytic Hierarchy Process (AHP)
- Entropy

ESPM City – Balance Supply/ Demand

Sustainable Energy Landscaping

New energy infrastructure requires a paradigm shift from “energy for space to “energy from space” (Scheffran et al., 2015)



Optimal location of the demand (Biberacher and Gadocha, 2009)

Minimum distance between demand and supply (Masurowski et al., 2015)

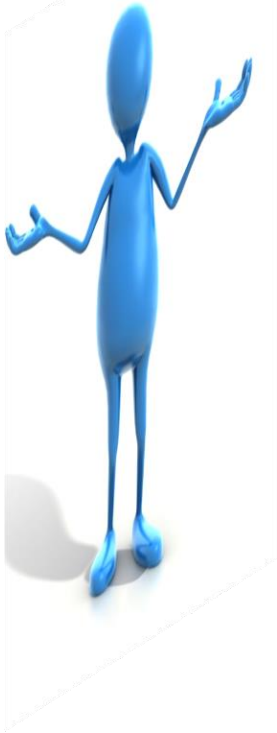
Participatory planning (Petit et al., 2007) with tools

- 3D extensions (e.g ESRI's *ArcScene)*
- 3D Globe products (e.g NASA’s World Wind)
- Open Source languages (e.g Virtual Reality Markup Language (VRML) and Extensible 3D (X3D) etc.

Scenarii analysis – Mechanism design

Mechanism Design is based on the concept of social choice that is simply an aggregation of the preferences of different agents having different objectives toward a single collective decision (Bistarelli et al., 2016)

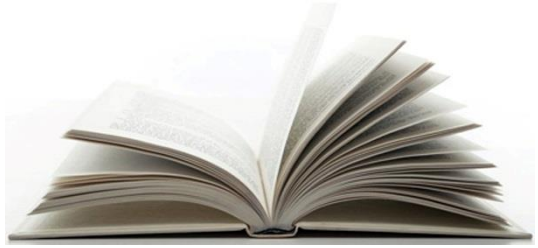
Scenario 1: Aggregate supply (1) and N demands
Bistarelli et al. (2016)



Scenario 2: Aggregate demand (1) and N supplies

ESPM Emerging City – Way forward

Experimental validation
Field application (Dakar, Senegal)



Scientific validation
Theory foundations
of the approach

Automation
Computing black box incl. formulae

Thank you for attention!

Questions and contributions are welcome

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