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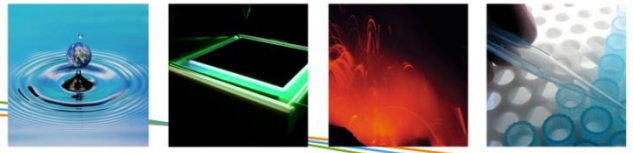

18/07/2013

Spatial mapping of future renewable energy potential in Flanders

Combining CA-based land use modelling and GIS

Lien Poelmans[a], Guy Engelen[a], Pieter Lodewijks[b]

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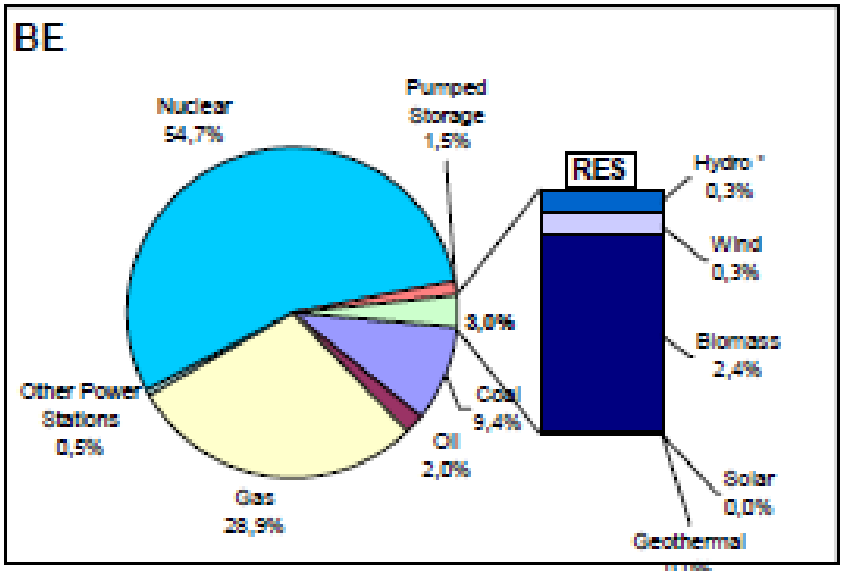
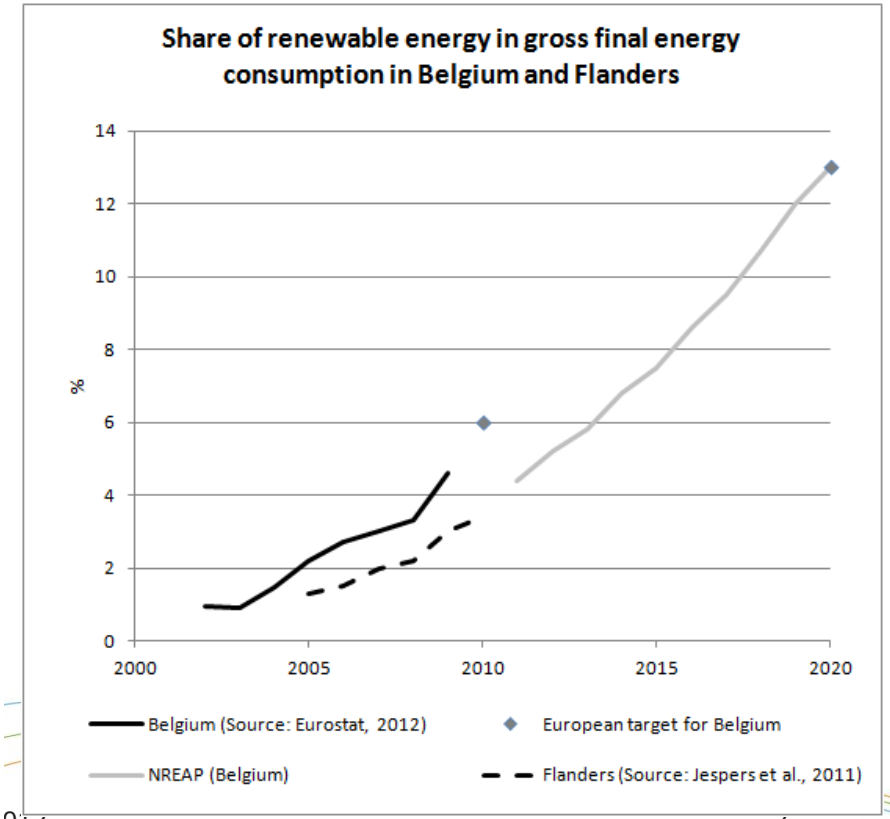
European Directive on renewable energy

- 20% RE of the total gross energy consumption by 2020
  - Belgium: 13% (4.6% in 2009!)
    - 20.9% RES-E (6% in 2009)
    - 11.9% RES-H&C
    - 10.1% RES-T (3.3% in 2009)

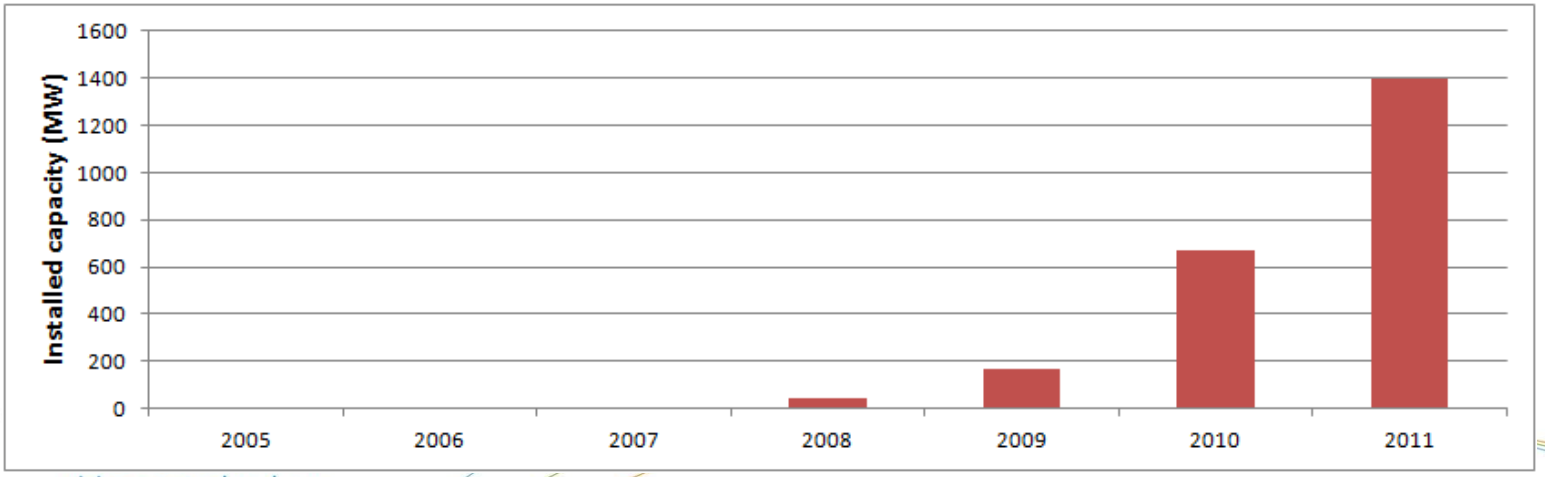
Gross Electricity Generation by fuel (2005)





Objectives

- Develop geographically explicit projections of renewable energy in Flanders in 2020
- Focus:
  - Onshore wind energy: NREAP target of 4320 MW onshore/offshore wind energy (currently: ± 1750 MW installed capacity in Belgium)
  - Solar energy (photovoltaic electricity): NREAP target of 1300 MW (currently: ± 1400 MW installed capacity in Flanders)



Objectives

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  - Solar energy (photovoltaic electricity): NREAP target of 1300 MW (currently: ± 1400 MW installed capacity in Flanders)
- Develop SDSS by coupling a CA-based land-use model for Flanders with a GIS-based approach

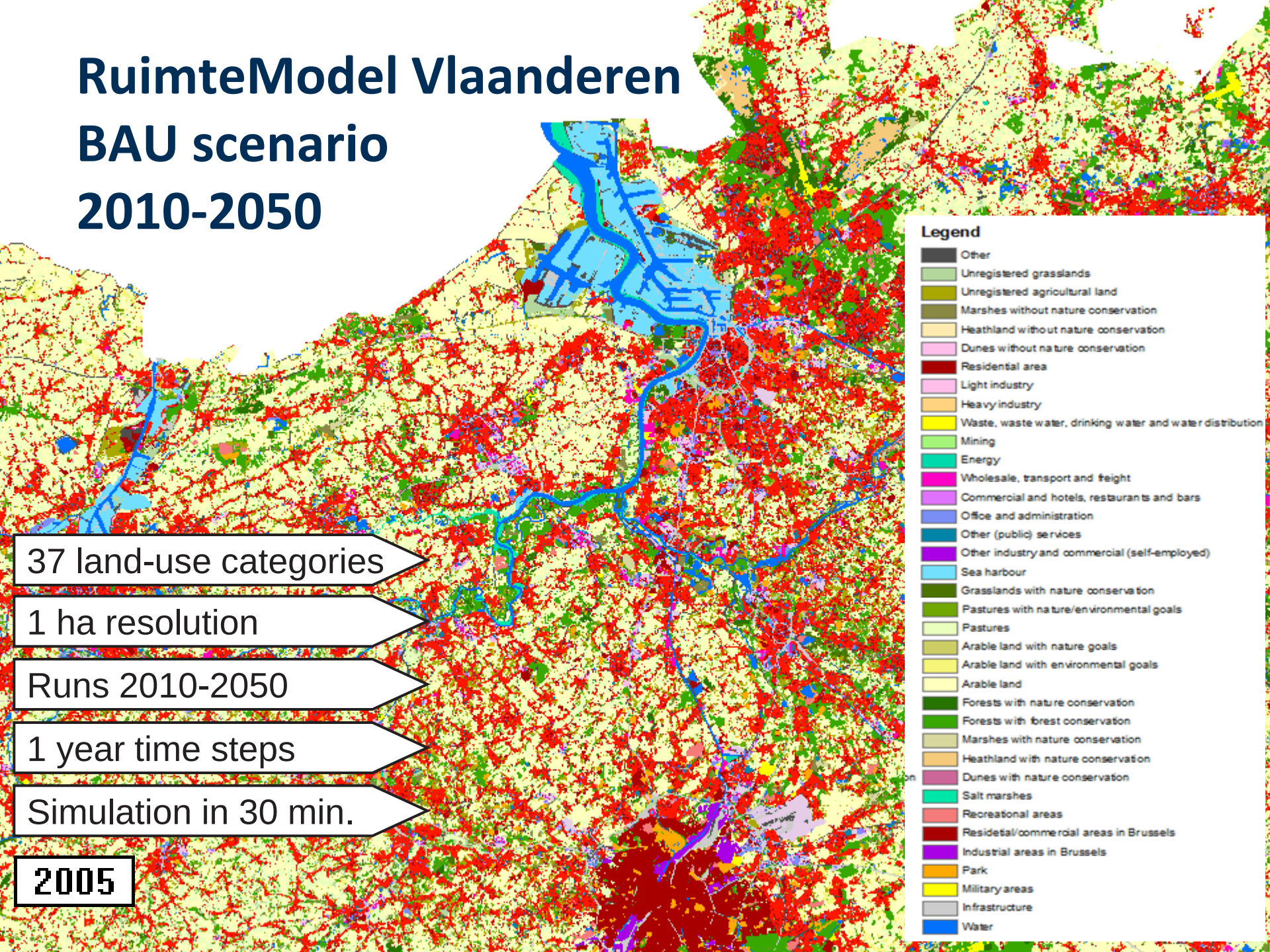
Land-use change projections

- Constrained Cellular Automata model for Flanders (RuimteModel Vlaanderen)

Land-use change projections

- Constrained Cellular Automata model for Flanders (RuimteModel Vlaanderen)
- Implemented and calibrated to run simulations covering the period 2010 until 2020
- Business-as-usual scenario
- Model output at the local level: land-use map for 2010-2020, showing the 37 simulated land-use classes at a resolution of 1 ha

RuimteModel Vlaanderen
BAU scenario
2010-2050



- 37 land-use categories
- 1 ha resolution
- Runs 2010-2050
- 1 year time steps
- Simulation in 30 min.

2005

RuimteModel Vlaanderen – BAU scenario

Land-use category	2010 (ha)	2020 (ha)	Difference (ha)	Daily difference (ha/day)
Residential	244.947	266.968	22.021	+6,0
Industrial/commercial	126.144	128.936	2.792	+0,8
Open space	929.892	905.174	-24.718	-6,8

Urban expansion in the surroundings of already urbanised cells, both in highly urbanised regions (around city centres) and in more or less 'rurban' regions in Flanders

→ Highly dispersed RE production and consumption

→ Limited space for placing wind turbines

Land-use change projections

- Constrained Cellular Automata model for Flanders (RuimteModel Vlaanderen)
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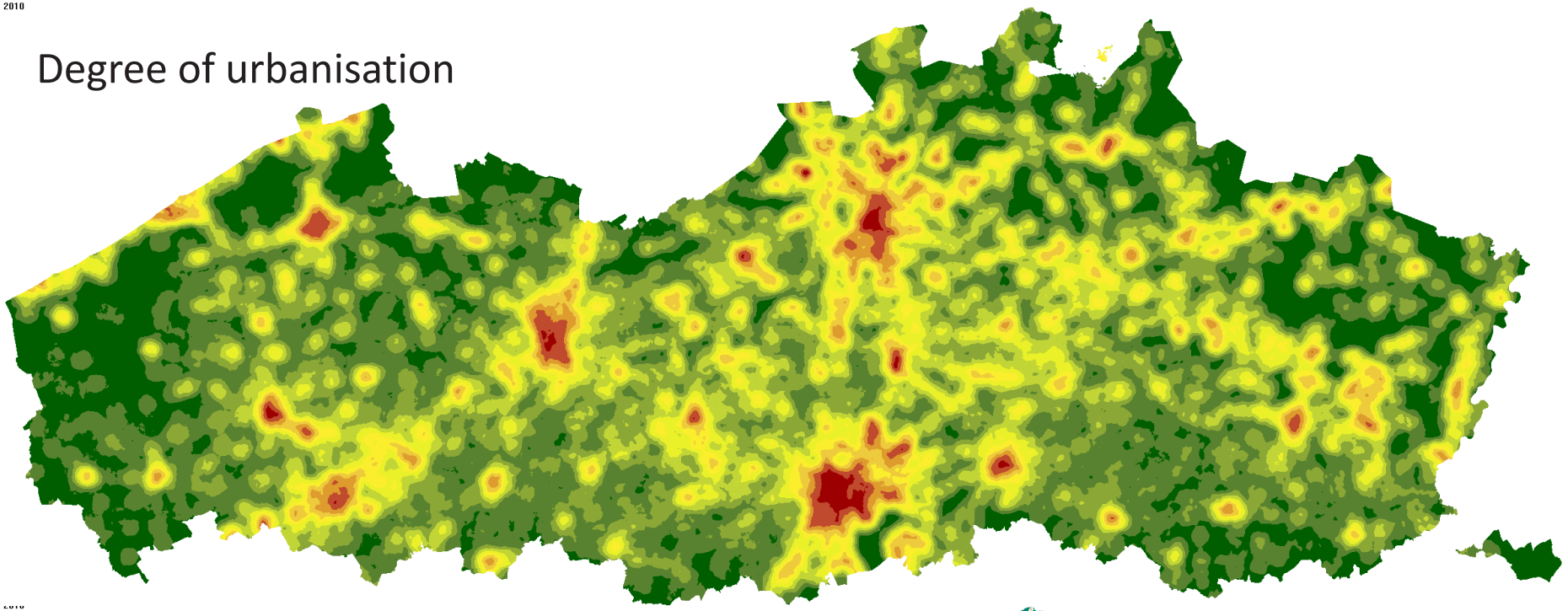
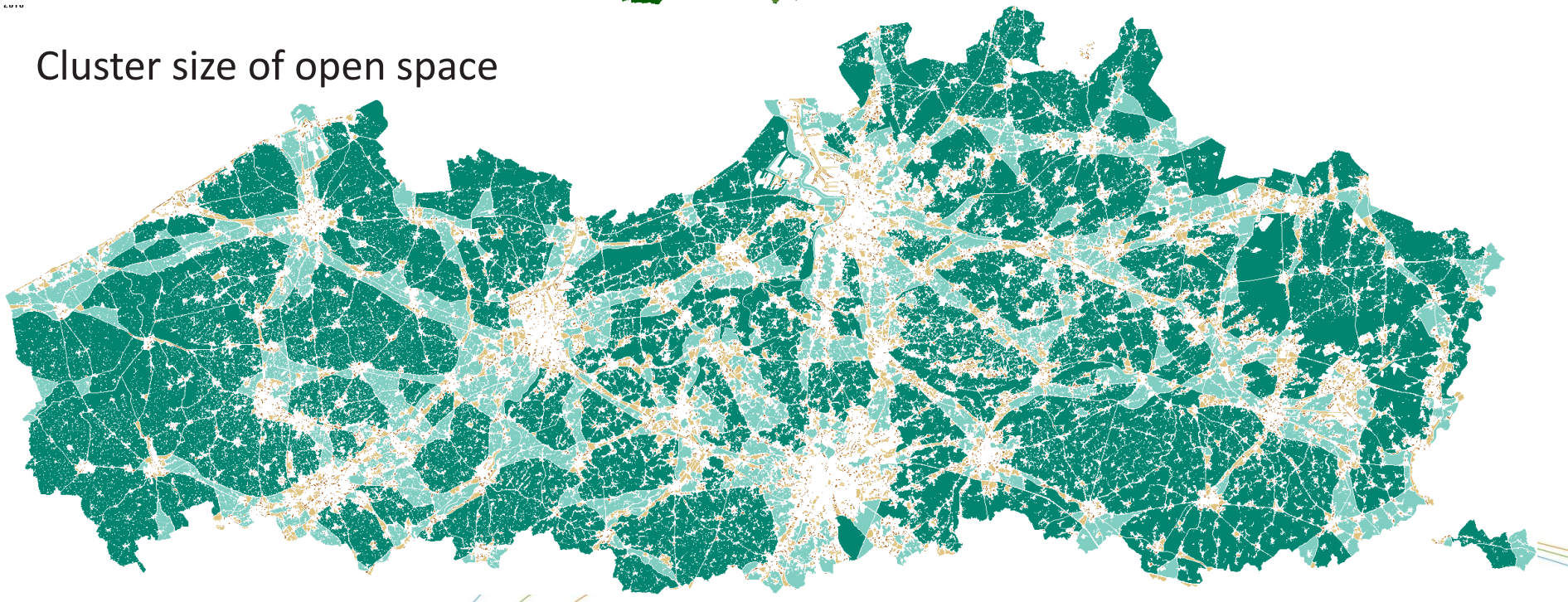
- Business-as-usual scenario
- Model output at the local level: land-use map for 2010-2020, showing the 37 simulated land-use classes at a resolution of 1 ha
- 2 spatial indicators:
  - Degree of urbanisation
  - Cluster size of the open space (natural, agricultural, recreational land use, water, parks)

2010

Degree of urbanisation

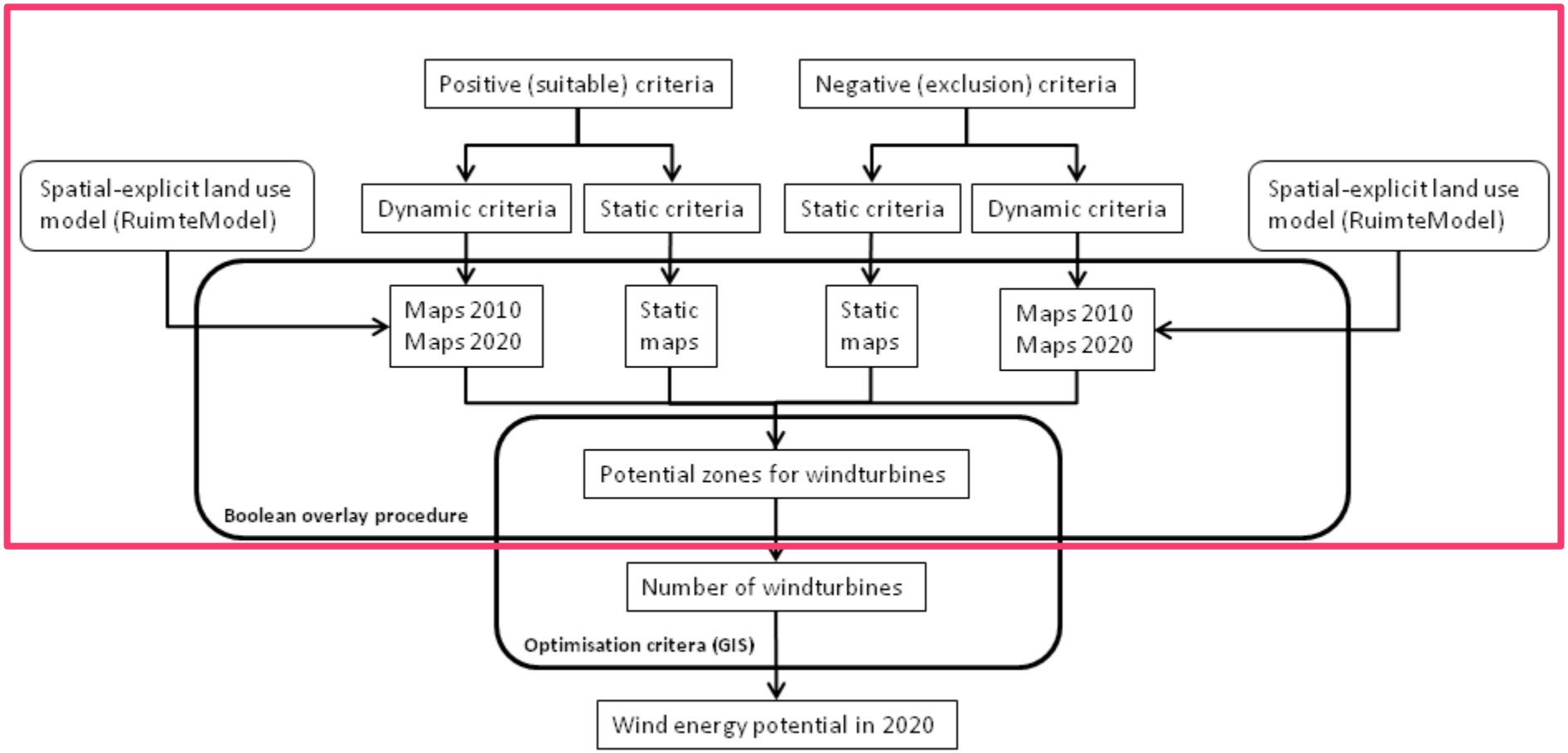


Cluster size of open space



Wind energy potential - Methodology

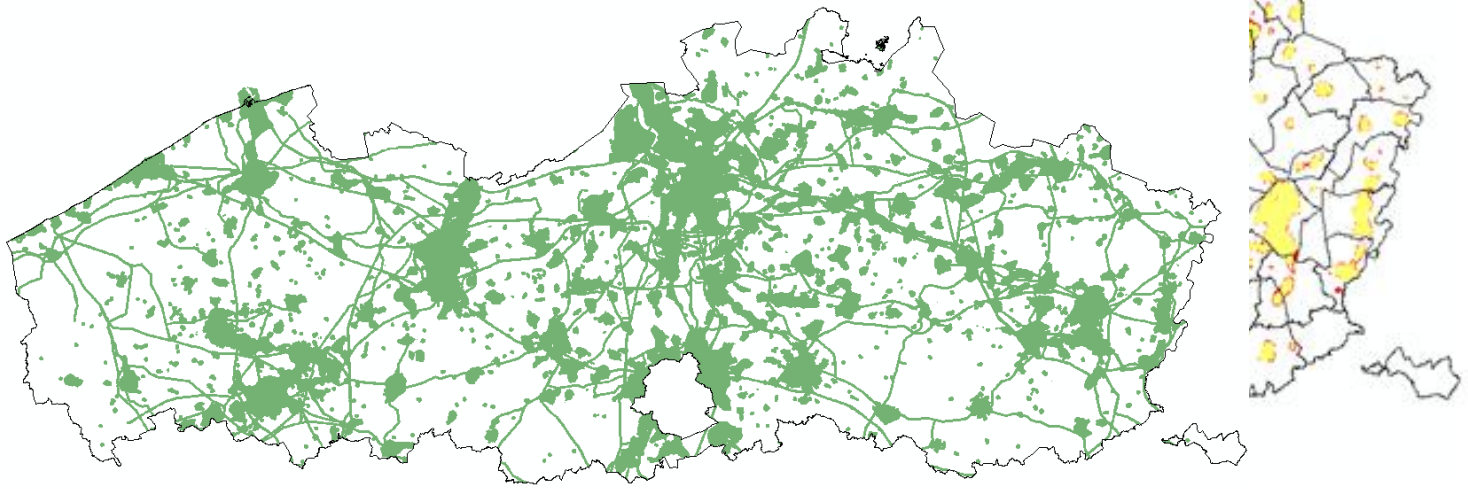
- Bottom-up approach
- 2 step procedure

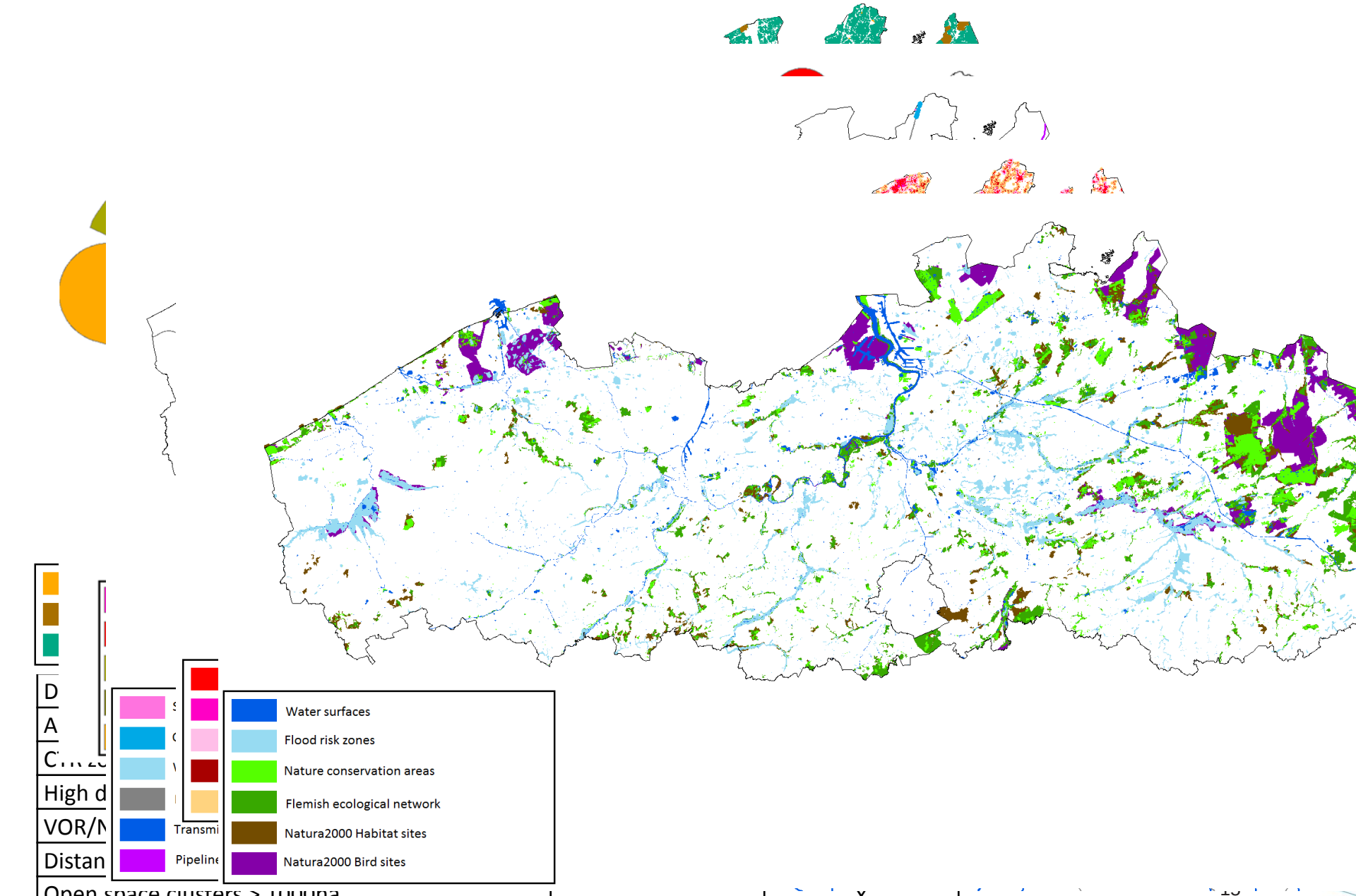


Positive criteria

Positive criteria	Buffer distance	Output of RuimteModel (dynamic)
Industrial areas (zoning plans)	250m	
Industrial land uses	250m	x
Distance to roads	250m	
Distance to transmission lines	250m	
Distance to main canals	250m	
Degree of urbanisation > 50%		x

2010	2020	Difference 2020-2010
444484.1 ha (±33%)	467344.8 ha (±35%)	22860.7 ha (+5.1%)




Water surfaces
Flood risk zones
Nature conservation areas
Flemish ecological network
Natura2000 Habitat sites
Natura2000 Bird sites
Transmi
Pipeline
High d
VOR/N
Distan
Open space clusters > 1000ha
X
© 2011, VITO NV

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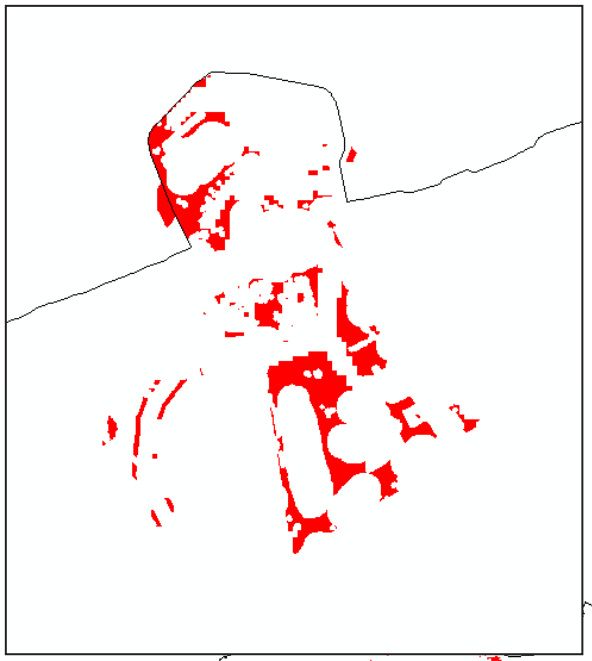
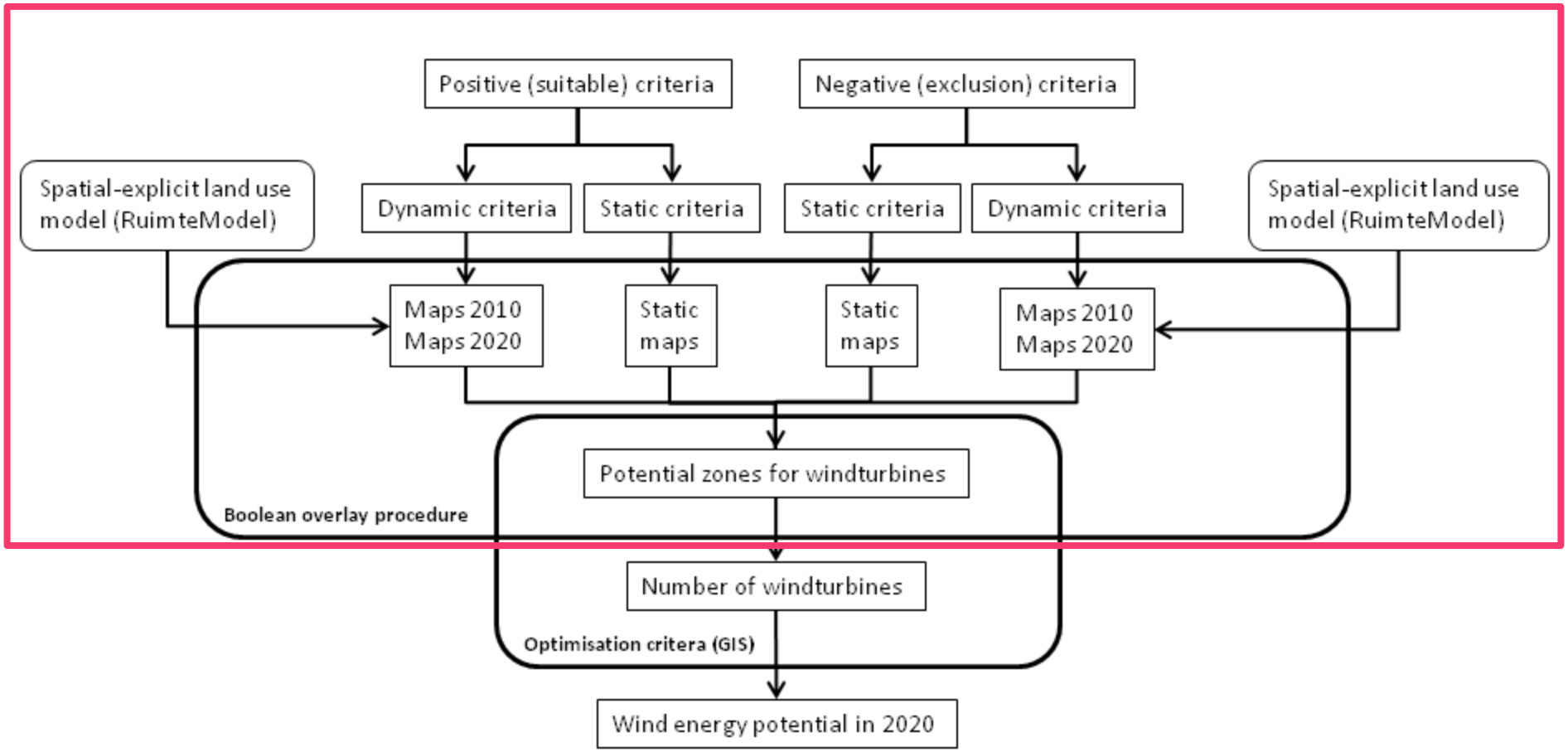


Estimating the wind energy potential



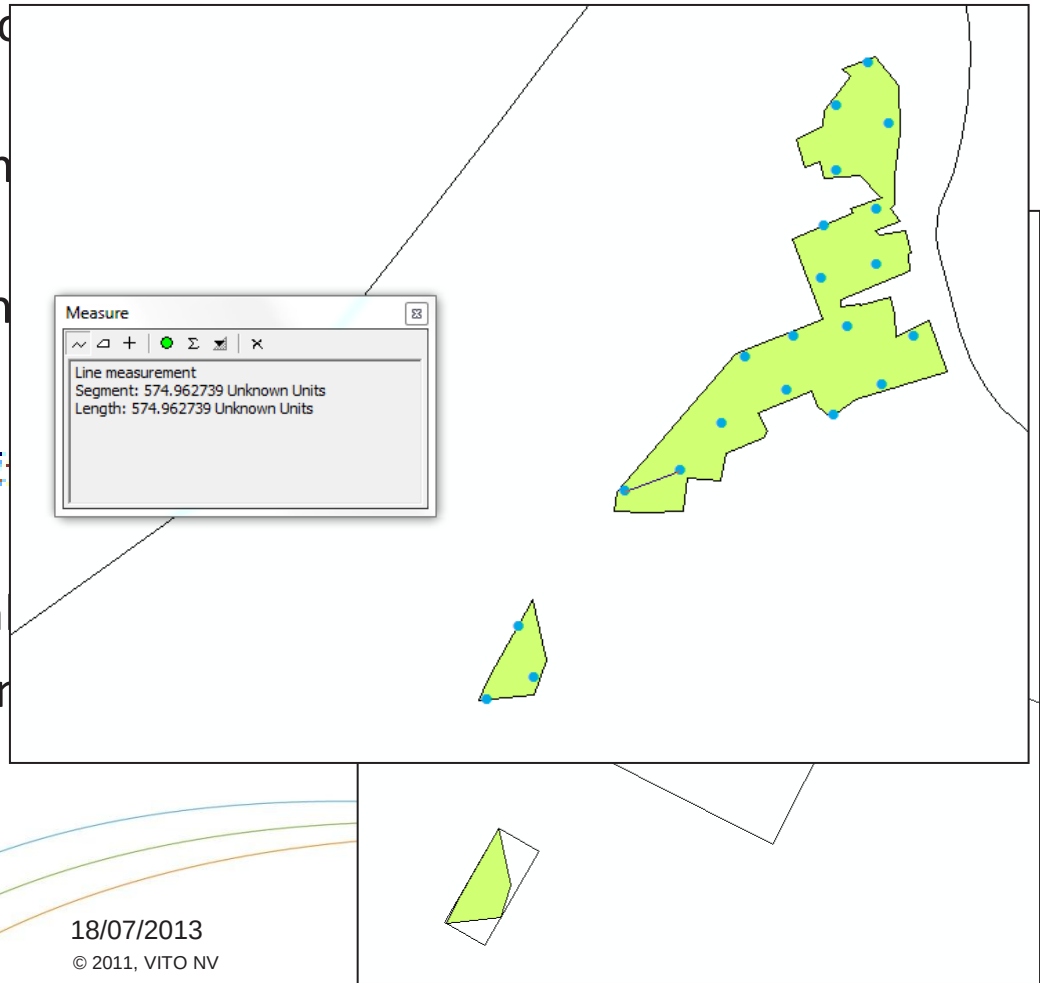
Allocate wind turbines inside suitable zones

GIS-based optimization procedure

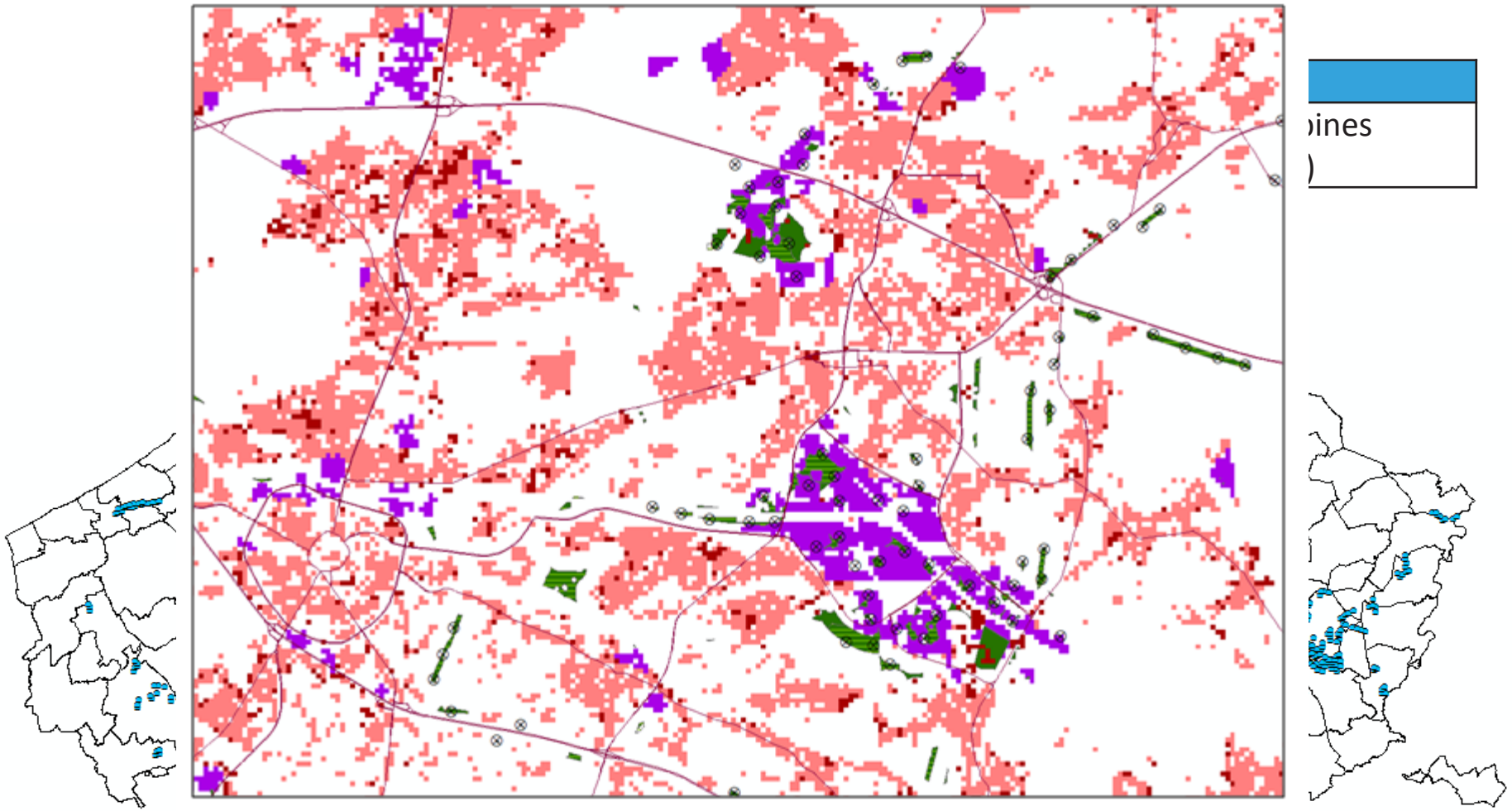
1. Remove polygons that are to
   radius)
2. Define *Bounding box (*minim
   polygon
3. Calculate the number of win

$$N = \frac{Area_{polygon}}{Area_{br}} \left[i \right.$$

4. Allocate the calculated num
5. Remove isolated wind turbir

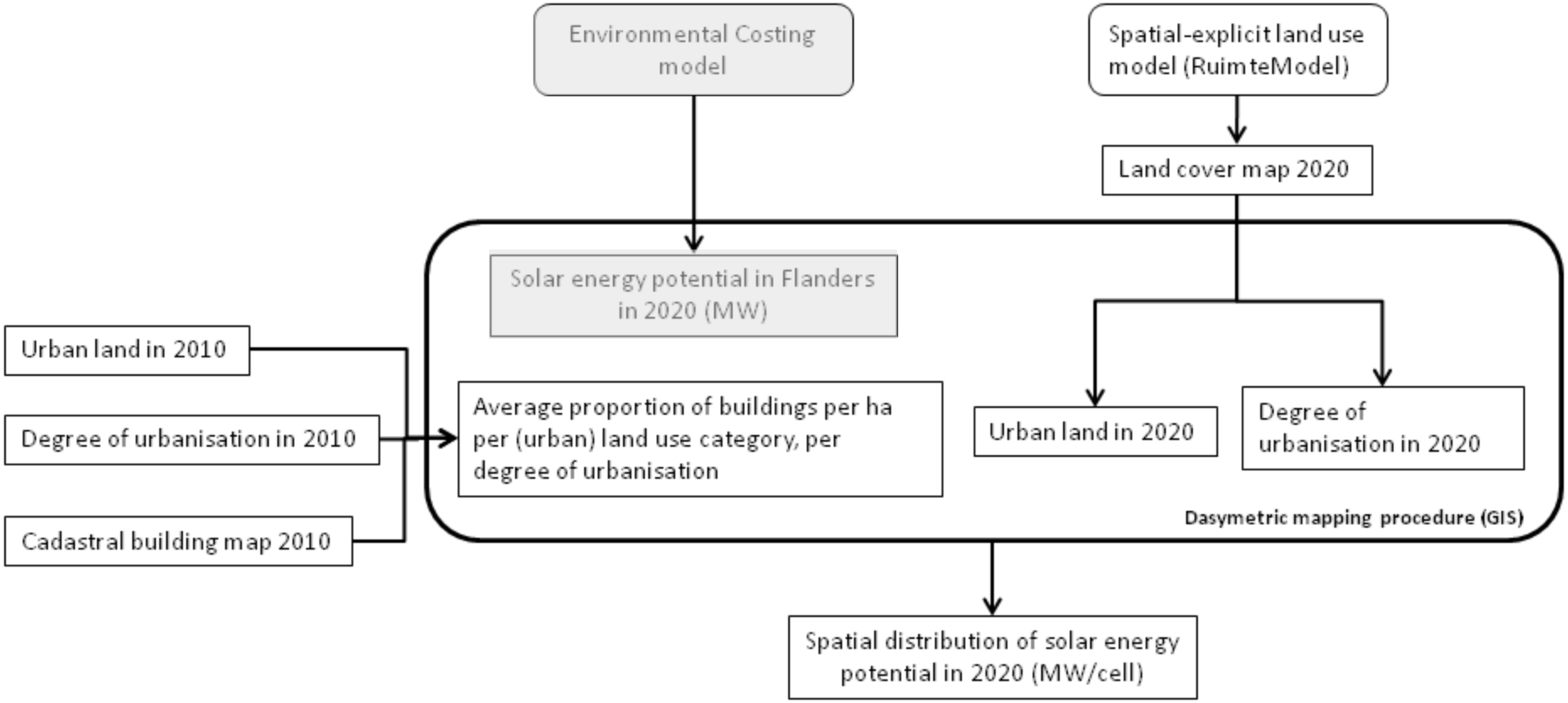


Estimated potential for wind turbines



Solar energy potential - Methodology

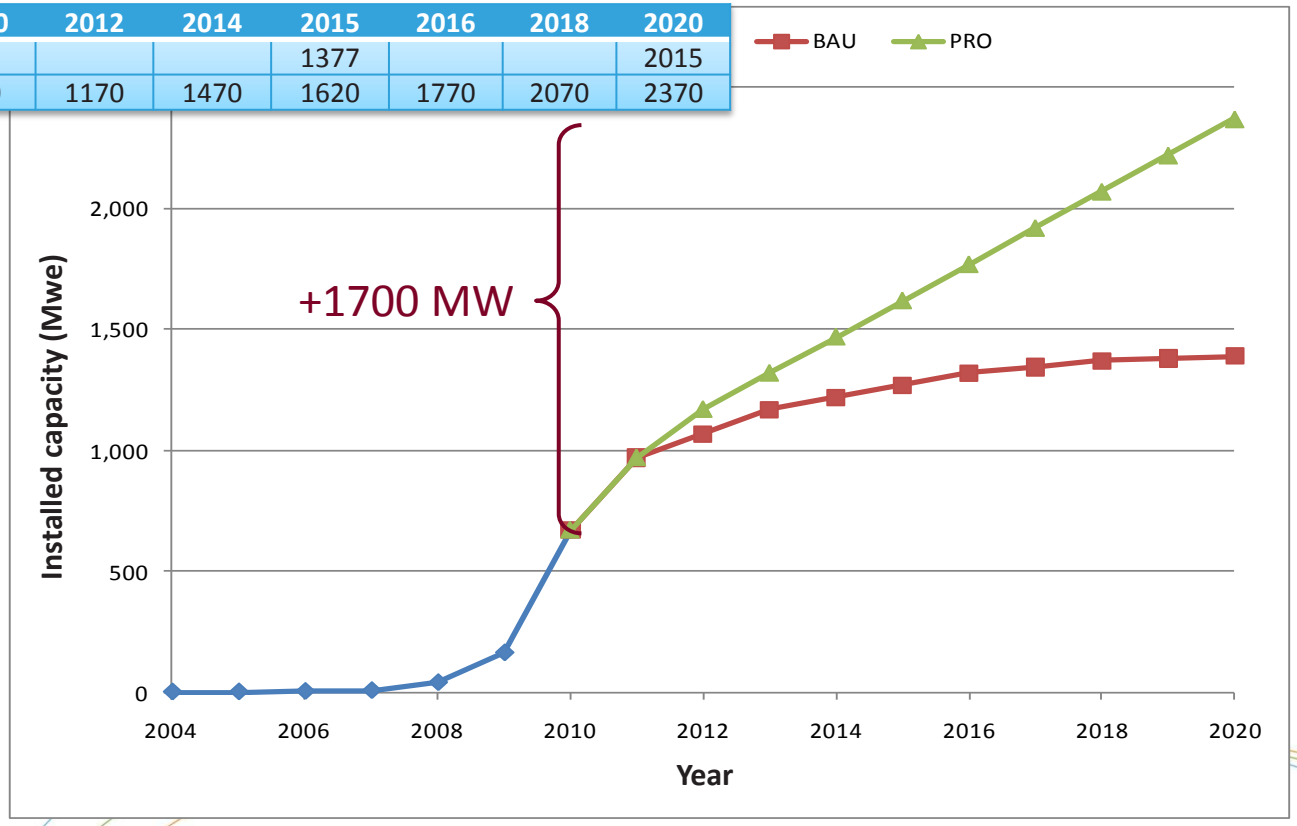
» Top-down approach



1. Estimating the solar energy potential in Flanders

- Environmental Costing Model
  - Technical-economic Markal-based model
- BAU-scenario vs. PRO-scenario 2020 for Flanders

PRO scenario	2008	2010	2012	2014	2015	2016	2018	2020
PV [GWh]	34	440			1377			2015
PV [MWe]	40	670	1170	1470	1620	1770	2070	2370



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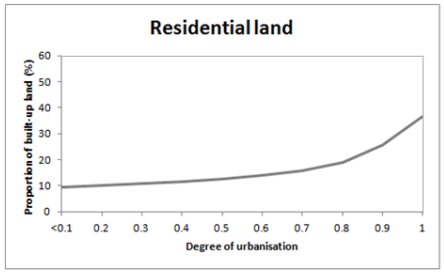
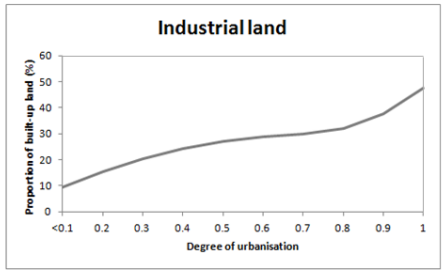
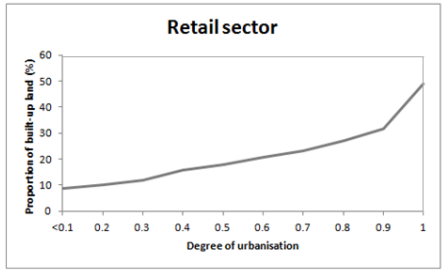
2. Allocating the solar energy potential

» Dasymetric mapping technique based on the results of the land-use change model

Allocating the solar energy potential

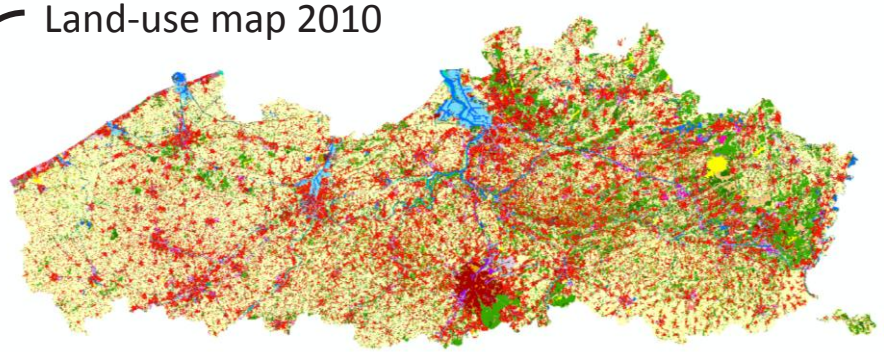




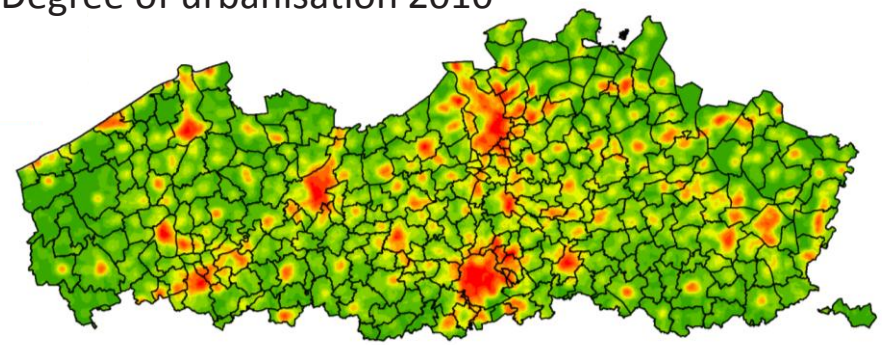


Fraction of 1ha cells for different land-use categories and degree of urbanisation that is built-up

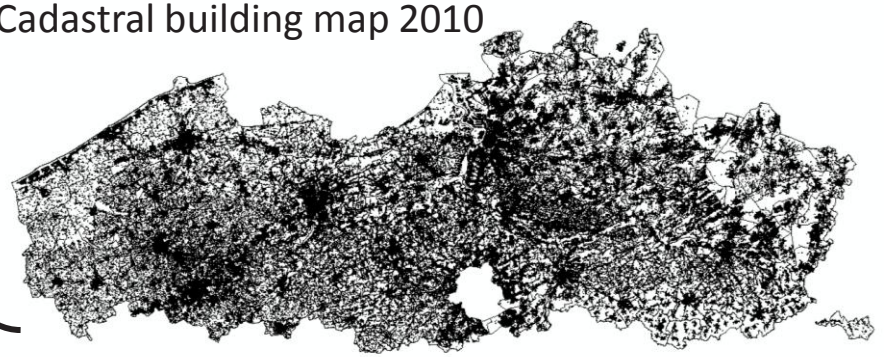
Land-use map 2010



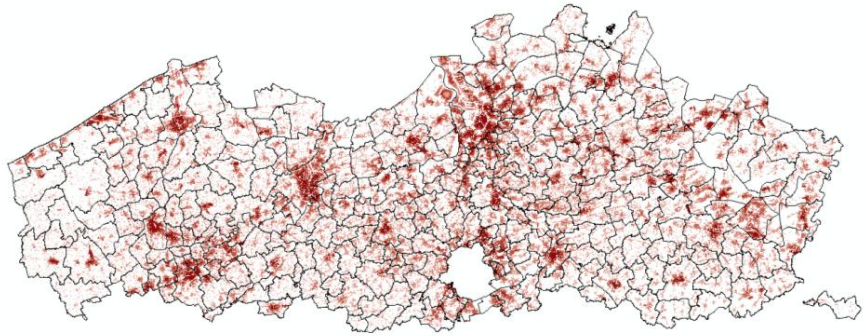
Degree of urbanisation 2010



Cadastral building map 2010

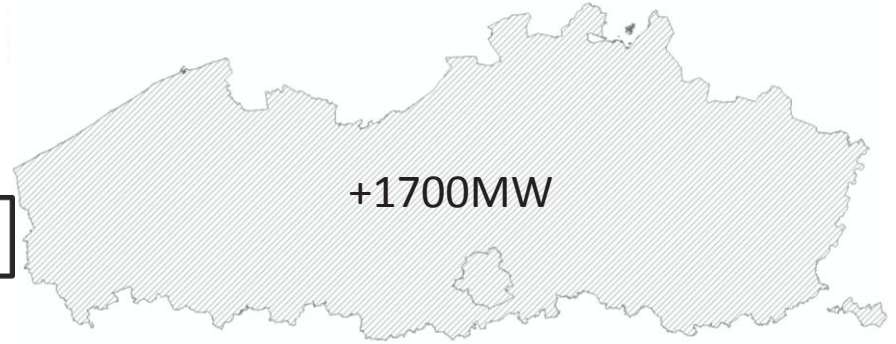


Average rooftop area per (1 ha) cell



Allocating the solar energy potential

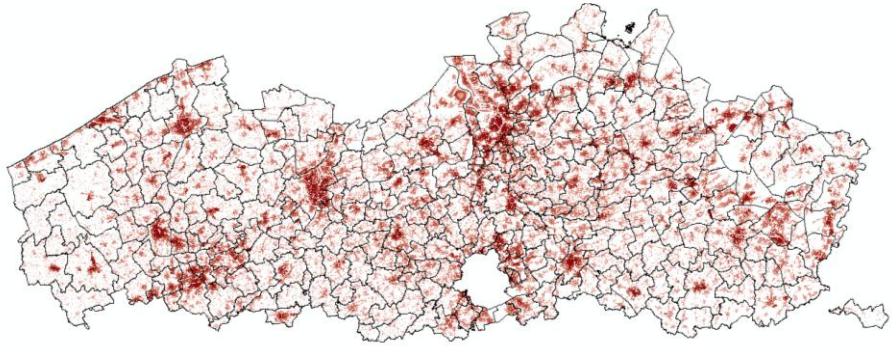
Estimated capacity in 2020 (for Flanders)



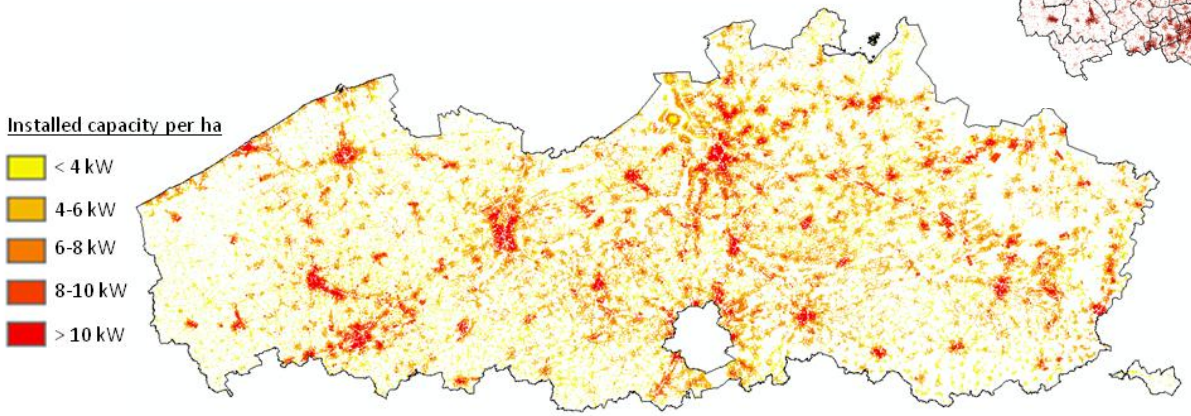
2020

Dasymetric mapping

Average rooftop area per cell



On average: 9.5 W/m² total rooftop area



Conclusions

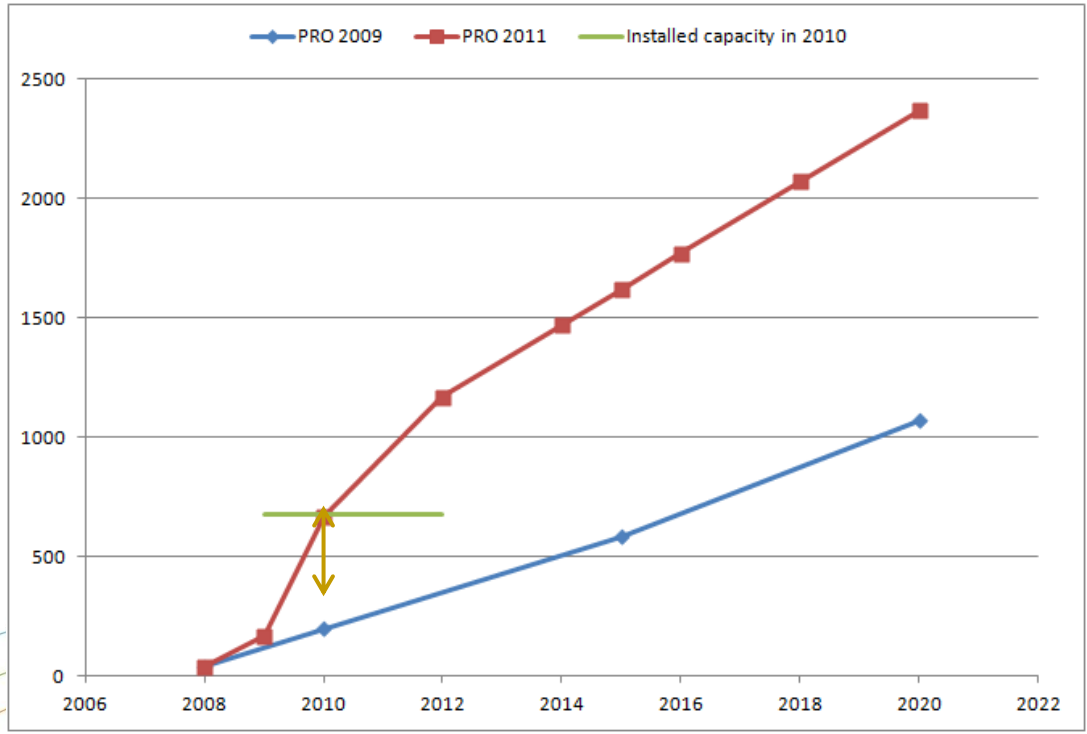
- Geographically-based potential for wind energy in Flanders: 3300MW by 2020
  - Well above the target for wind energy put forward in the Belgian NREAP!
  - However! Market conditions in the near future and the legal/administrative/political situation in Flanders will have the largest influence on the real market-technical potential for wind energy in the future
  - Moreover, the methodology makes abstraction of the specific terrain conditions and the onshore wind resources → the indicated suitable zones might not be the most optimal locations regarding wind speed and wind intensity and thus power output

Conclusions

- Total peak-capacity of installed PV in 2020: 2.4 GW
  - Well above the 1.3 GW that was mentioned in the NREAP
  - However! Highly dependent on changing policies related to the system of 'green certificates' (GCS) and the investment costs

Prognosis 2009	2008	2010	2012	2015	2020
Zon [GWh]	34	174	308	508	935
Zon [MWe]		200		583	1072

Prognosis 2011	2008	2010	2012	2015	2020
Zon [GWh]	34	440		1377	2015
Zon [MWe]	40	670	1170	1620	2370



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Conclusions

- Results have shown the applicability of a CA-based land-use change model for making estimates about future renewable energy production in a spatially-explicit and dynamic way
- SDSS should incorporate land-use models in order to get a more complete/correct view of the future potential for renewable energy
- These coupled systems should help grid operators in their effort to develop energy- and cost-effective energy systems within a spatial context of expanding urban regions
- Beyond this, the method supports a more integrated approach to spatial planning in that it can inform spatial planners about the unwanted effects of the diffuse urbanization patterns that are taking place in Flanders