

Tackling energy-related data interoperability from the CityGML Energy ADE point of view

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CitiEnGov final conference

Ferrara, 3 April 2019



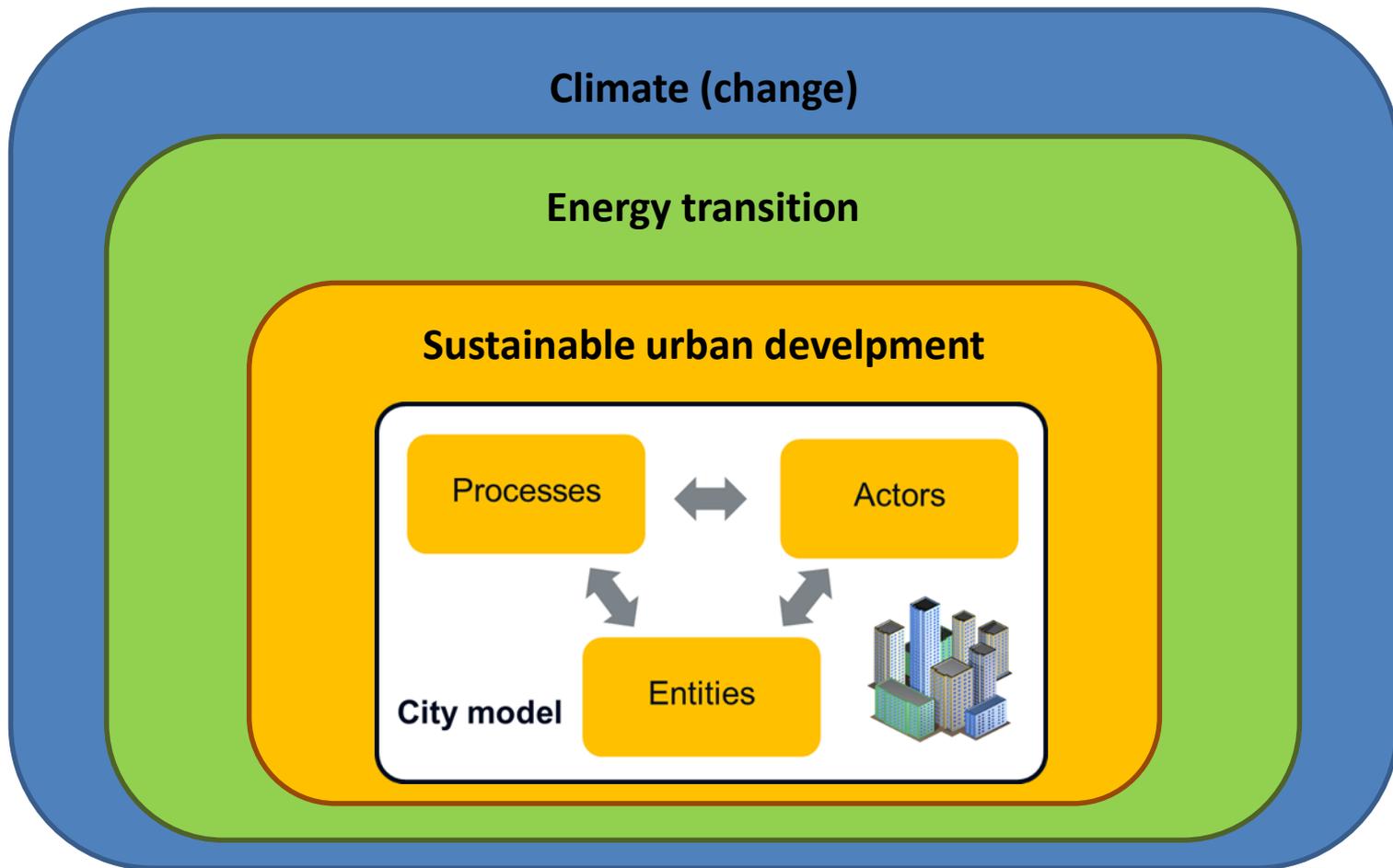
Energy & cities

City models

- Standards
- CityGML
- Energy ADE
- Examples

Conclusions

References



Energy and cities

Cities consume $\approx 70\%$ of the produced energy (and $\approx 40\%$ only for heating)

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- Where are inefficient buildings?
- How to increase their efficiency?
- How to simulate different scenarios according to different energy policies?

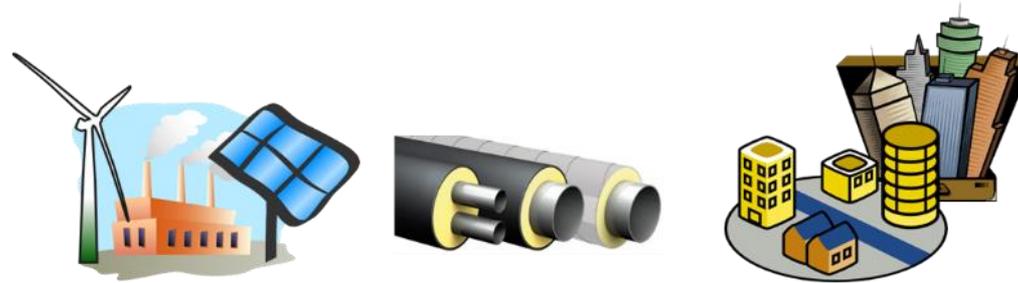


- How to evaluate the energy performance of a district (or city)?
- How to deal with existing and future infrastructures?
- How to choose between different types of energy production and distribution technologies?

**SEMANTIC 3D CITY MODELS AS INFORMATION HUB
FOR ENERGY-RELATED APPLICATIONS?**

Energy and cities

Cities consume $\approx 70\%$ of the produced energy (and $\approx 40\%$ only for heating)



- Fossils
- Renewables
- Industrial processes
- Nuclear

- Electrical
- Gas
- District Heating & cooling
- Waste water
- Steam
- Oil

- Housing
- Industrial
- Tertiary

**SEMANTIC 3D CITY MODELS AS INFORMATION HUB
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City models as information hub

Semantic 3D city models help **reducing complexity** and facilitating cooperation and **exchange of information** among city departments, companies, cities and citizens, etc.

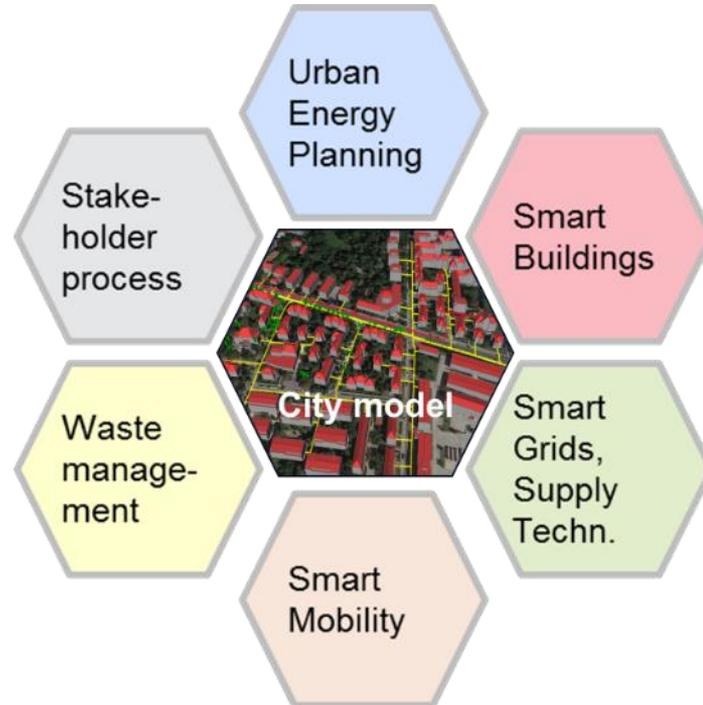
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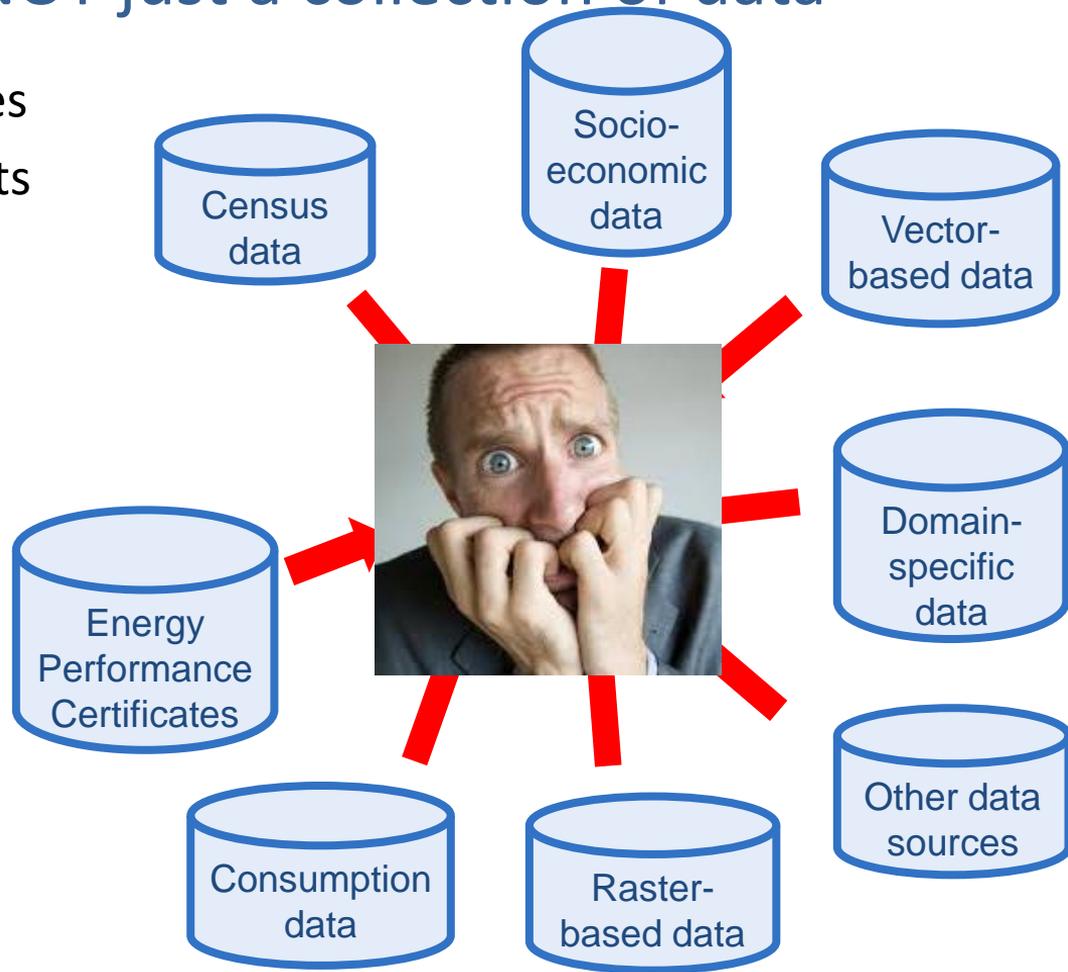
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A city model is NOT just a collection of data

- Different data sources
- Different data formats
- Different semantics
- Different scales
- Different accuracies
- ...



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A city model as «living» information hub

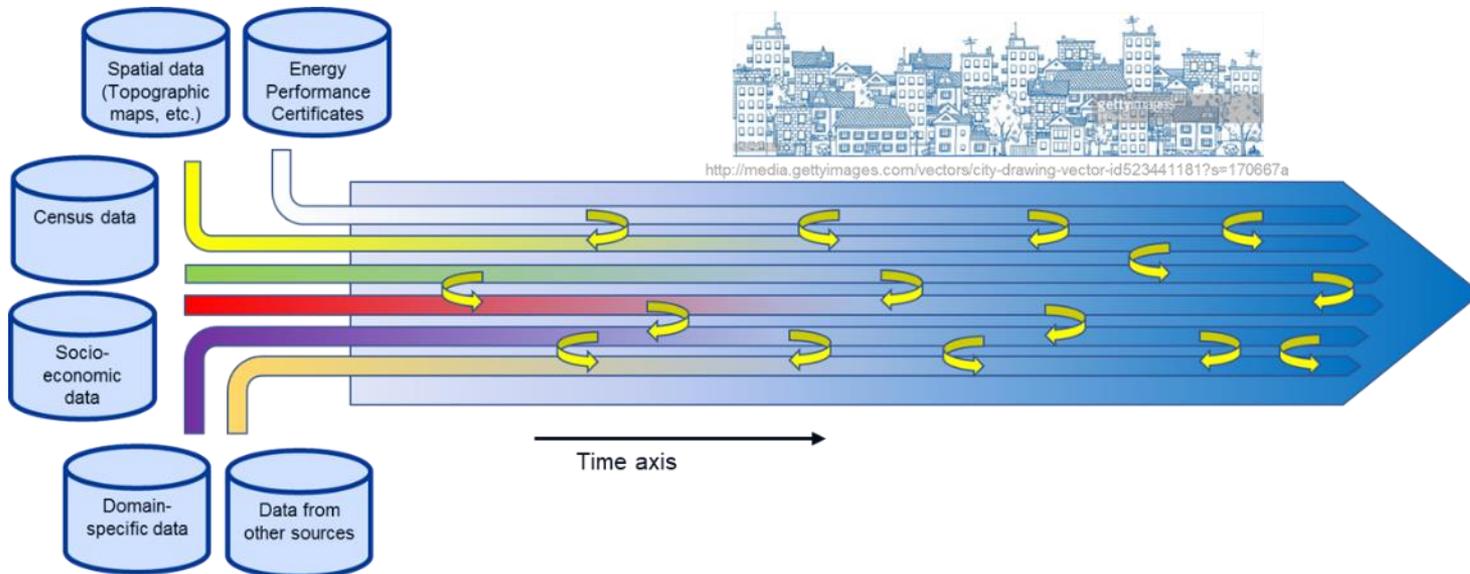
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A city model as «living» information hub

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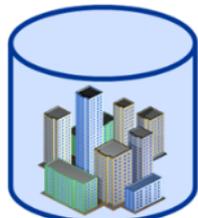
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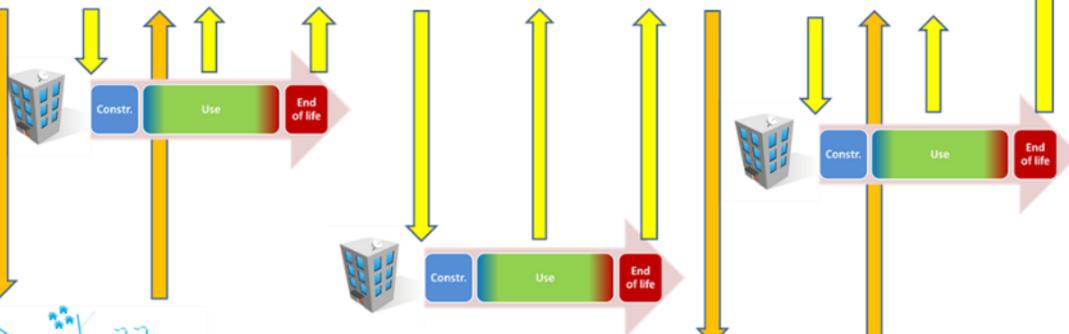
Urban
Information
Model



<http://media.gettyimages.com/vectors/city-drawing-vector-id523441181?s=170667a>



Building
Information
Models



Network
Information
Models



www.aqualinksystem.com

What about *international* (geo-spatial) standards?

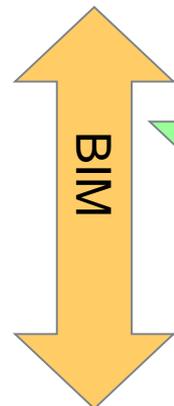
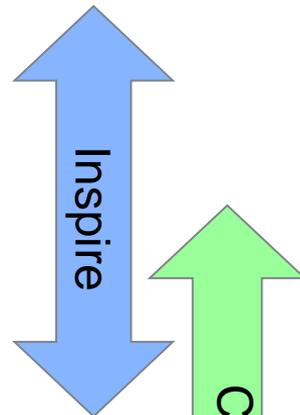
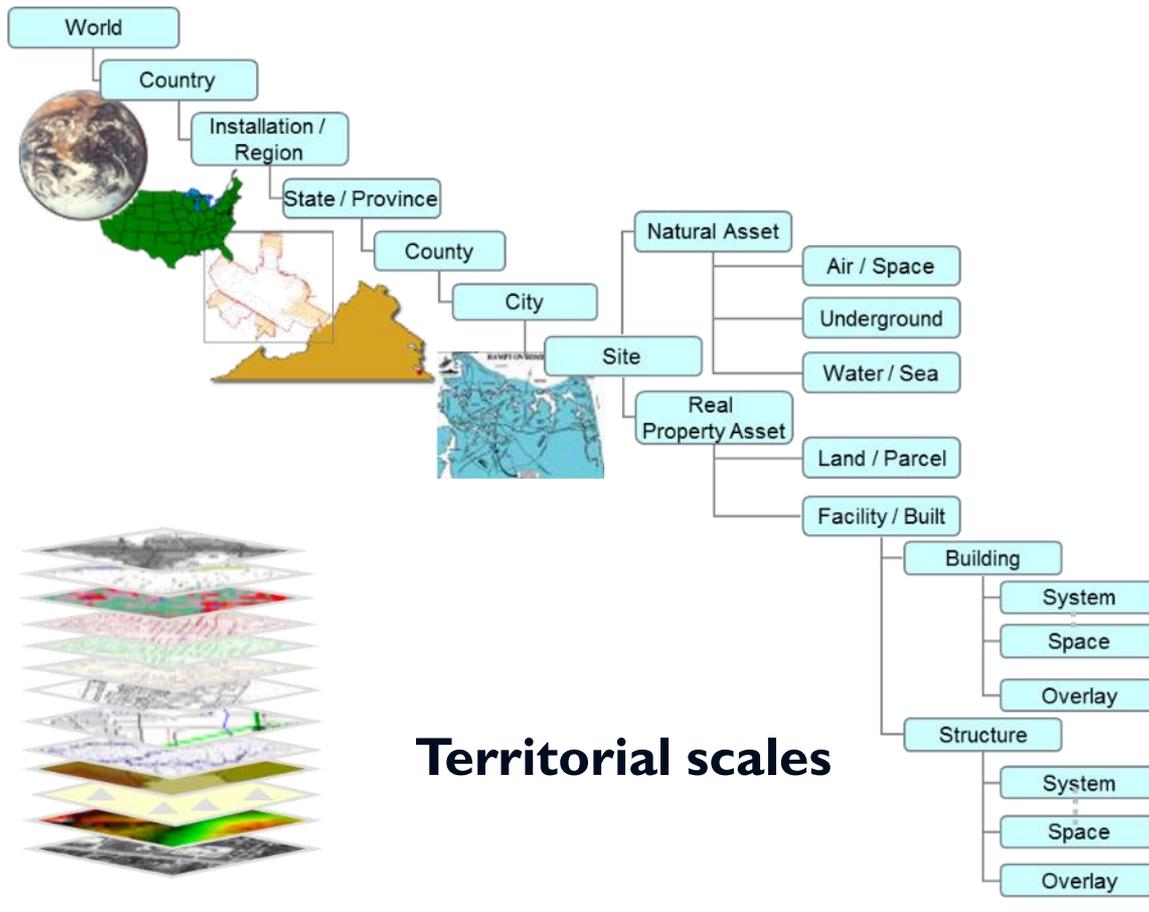
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Territorial scales

What about *international* standards for energy?

- BIM:
 - Availability of some standards (*gbXML, IFC*)
 - In general, the focus is the *new* building/object



- INSPIRE :
 - *Data Specification on Buildings*: Lack of or too few attributes/classes usable for energy simulations



- CityGML
 - A bit better than INSPIRE, but still not enough
 - But: **extensibility through ADEs** (Application Domain Extensions)



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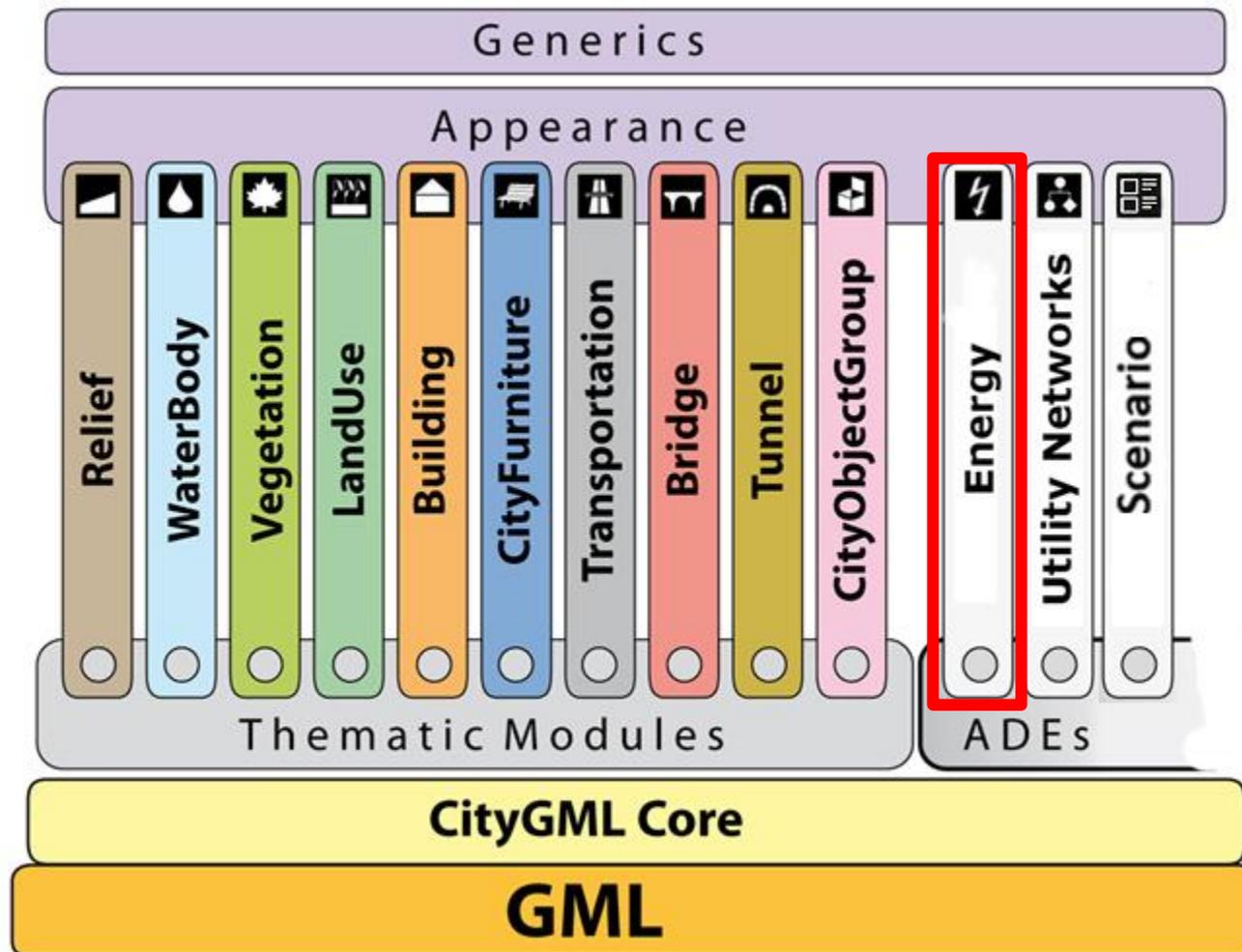
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What about *international* standards for energy?

CityGML Energy ADE: goals

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- Ease data interoperability for Urban Energy Modelling
 - Among heterogeneous software tools and stakeholders
- Define relevant energy-related data in a standard, open, urban data model
 - Allow for multi-scale energy simulation (from single building to whole city)
 - Both top-down and bottom-up approaches



Energy ADE

Modular structure

- Core module
 - Shared classes, enumerations and codelists
- Building Physics module
 - Thermal zones, thermal boundaries
- Material and Construction module
- Occupant's Behaviour module
 - Building usage
- Energy Systems module
- Supporting classes
 - Weather data, time series, etc.

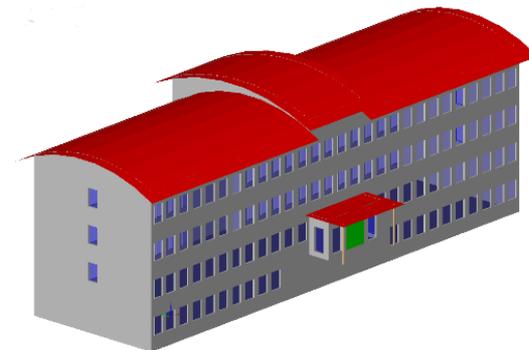
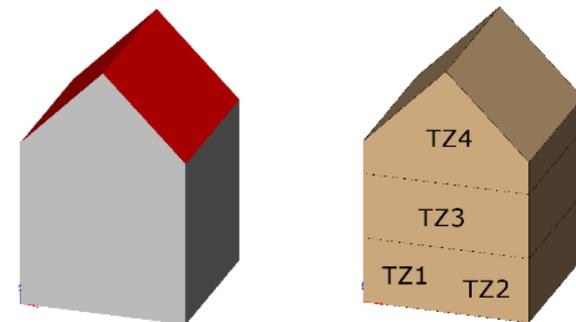


Image source: Courtesy of KIT



Partitioning of a building into thermal zones (example)

Details:

Agugiaro, G., Benner, J., Cipriano, P., Nouvel, R., 2018

The Energy Application Domain Extension for CityGML: Enhancing interoperability for urban energy simulations.

Open Geospatial Data, Software and Standards 2018 3:2

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Energy ADE

- International consortium started in 2014
 - Ca. 20 institutions, 11+ countries (as of 2019)
 - Open, consensus-based development
 - Wiki: http://en.wiki.energy.sig3d.org/index.php/Main_Page
 - GIT: <https://git.rwth-aachen.de/energyade/citygml-energy>

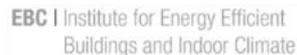
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CityGML + Energy ADE

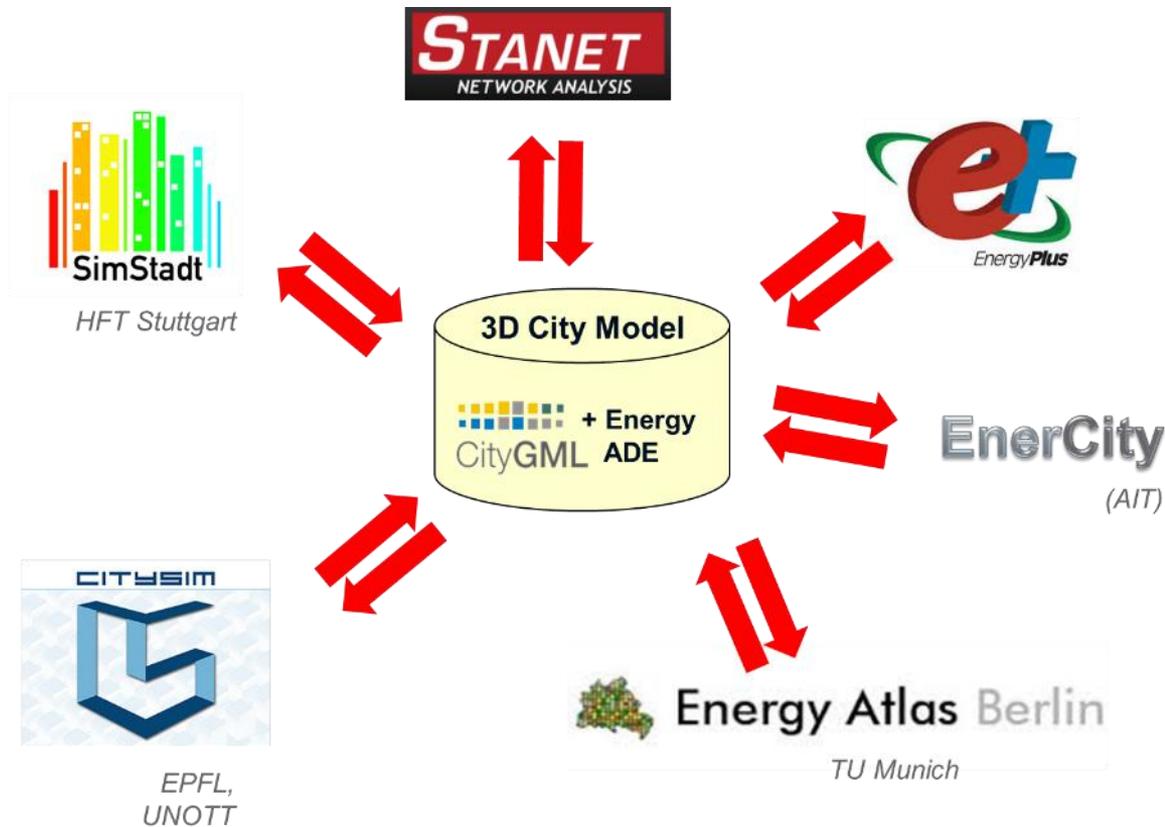
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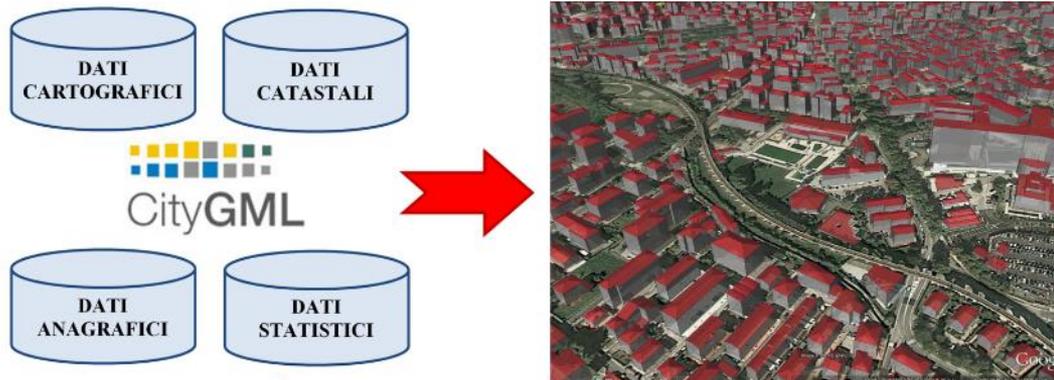
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Energy ADE: some experiences



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- **Examples**

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Energy ADE: some experiences

- Definition of refurbishment scenarios
- Comparison with regards to national and European legislation
- Cost-benefit analysis up to block/district scale

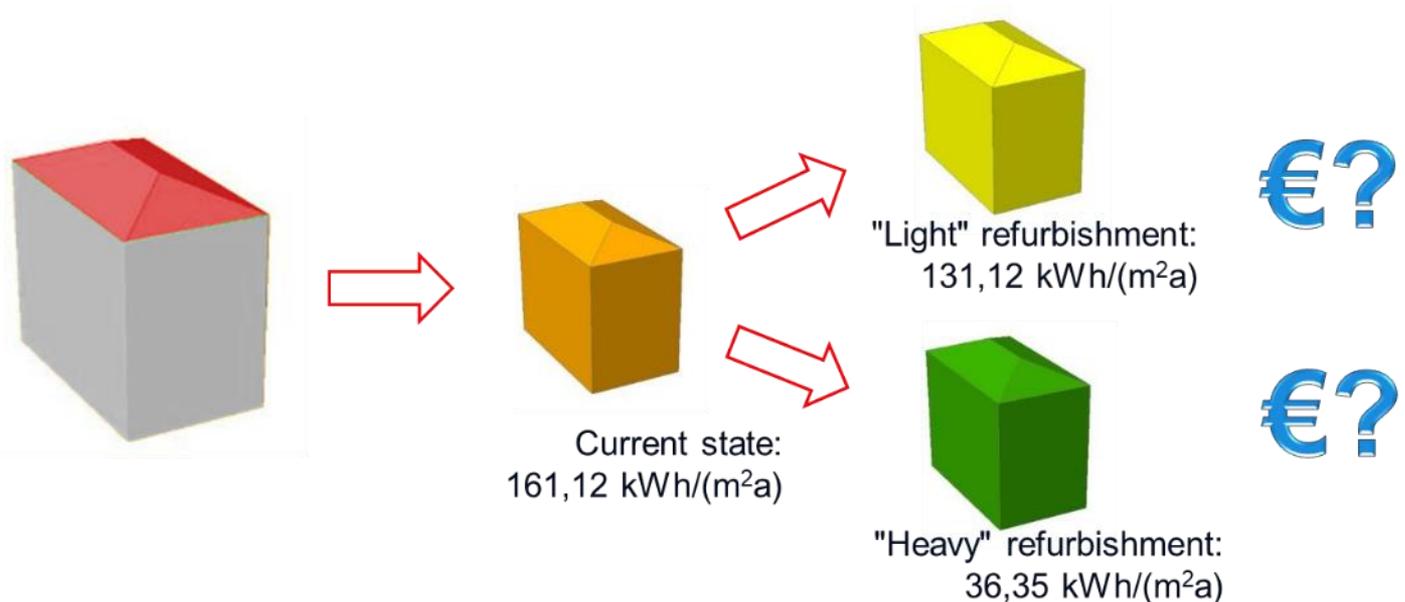
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Some experiences: Trento

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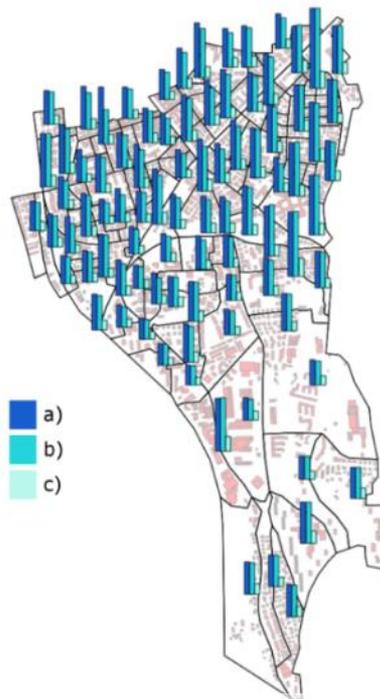
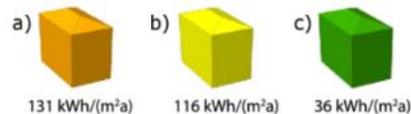
City models

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- **Examples**

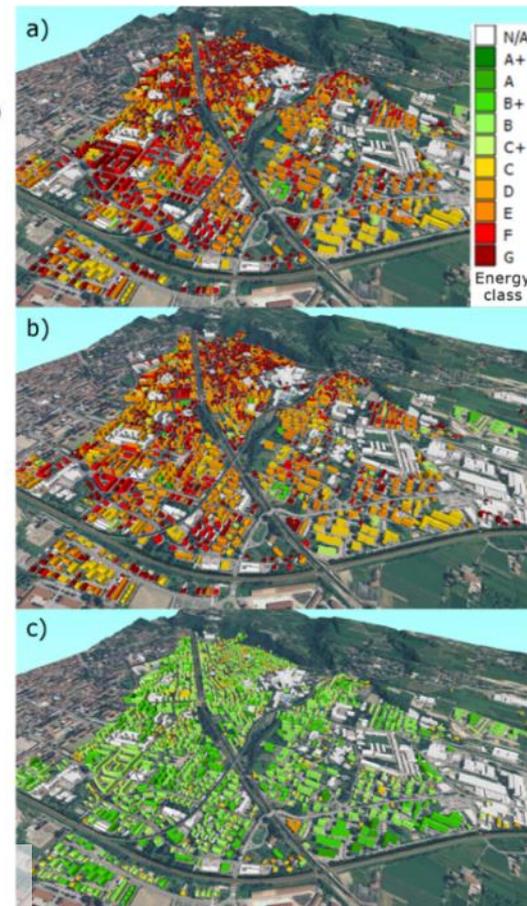
Conclusions

References

Primary energy demand computed according to the Italian UNI TS 11300 norms



Energy scenarios:
 a) Original state
 b) Current state
 c) Refurbished state



Mode details:

Agugiaro, G., 2016

Energy planning tools and CityGML-based 3D virtual city models. Experiences from Trento (Italy)

Applied Geomatics, 8(1), pp. 41-56, Springer Berlin Heidelberg, ISSN: 1866-928X

Some experiences: Vienna

Semi-automatically identify errors & reduce inconsistencies

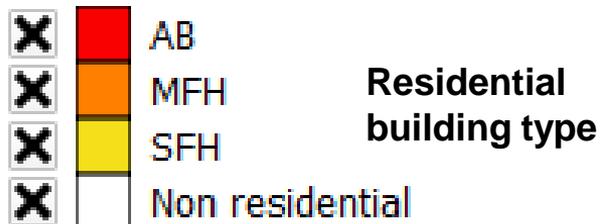
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Church as residential building



Office & industrial buildings as residential buildings



Some experiences: Vienna

Estimate energy demand + scenarios

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Some experiences: Gavardo (Brescia)

- Evaluation of existing data available to (all) Italian municipalities
 - Topographic data
 - Cadastral data
 - Census data (ISTAT)
 - Addresses
 - Energy Certificates
 - Gas consumption data
 -



Example of topographic map vs cadastral map

- Definition of data harmonisation and integration strategies
- Target: CityGML + Energy ADE

Mode details:

Pasquinelli, A., Agugiario, G., Tagliabue, L.C., Scaioni, M., Guzzetti, F., 2019,

Exploiting the potential of integrated public building data: Energy performance assessment of the building stock in a case study in northern Italy. ISPRS Int. Journal of Geo-Information, 2019, 8(1), 27 Agugiario, G., 2016

Some experiences: Gavardo (Brescia)

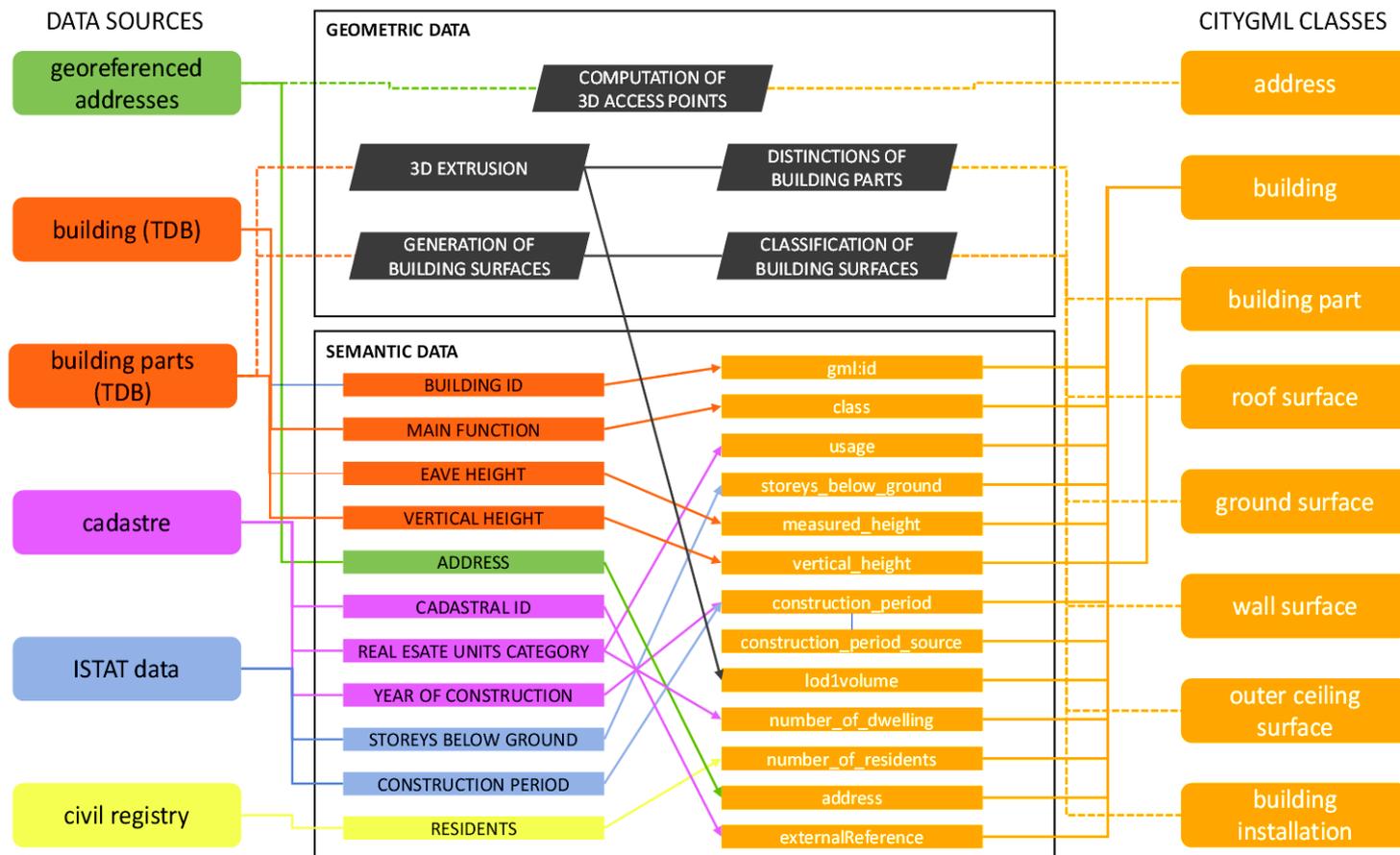


Image source: Pasquinelli et al. (2018)

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Some experiences: Gavardo (Brescia)

- Estimation of heating energy demand, gas consumption, refurbishment scenarios

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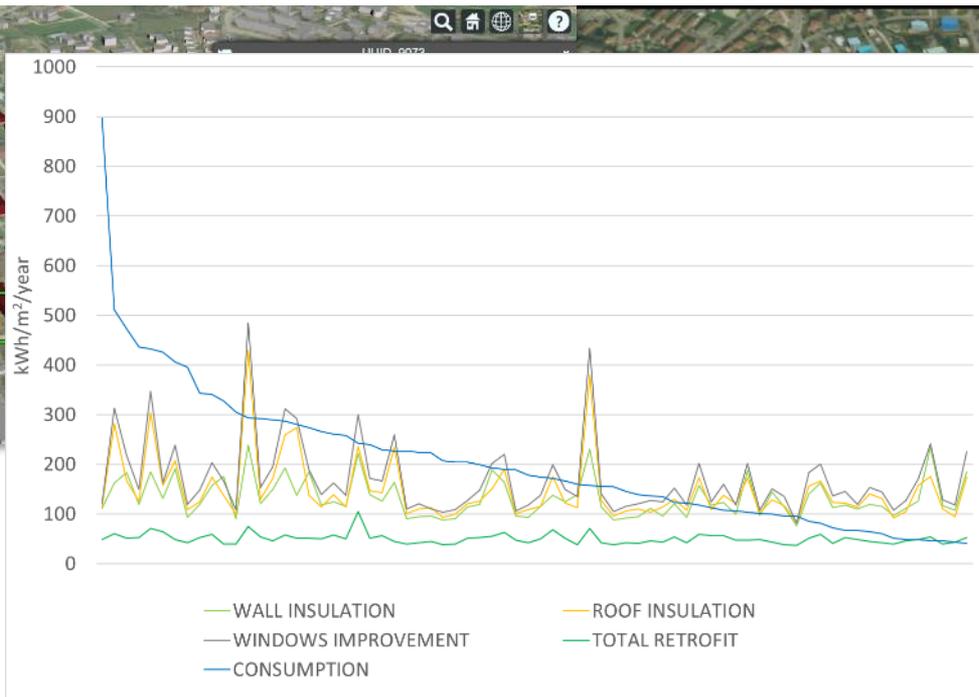
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Heating energy demand



Comparison of retrofitting scenarios



Gas consumption

Some experiences: Amsterdam

- First tests for generation/enrichment of a CityGML + Energy ADE model starting in April 2019

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- **Examples**

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Some experiences: Project IntegrCiTy

Geneva, Stockholm, Vevey: Energy networks in cities are still planned, built, operated and optimized in silo-like fashion

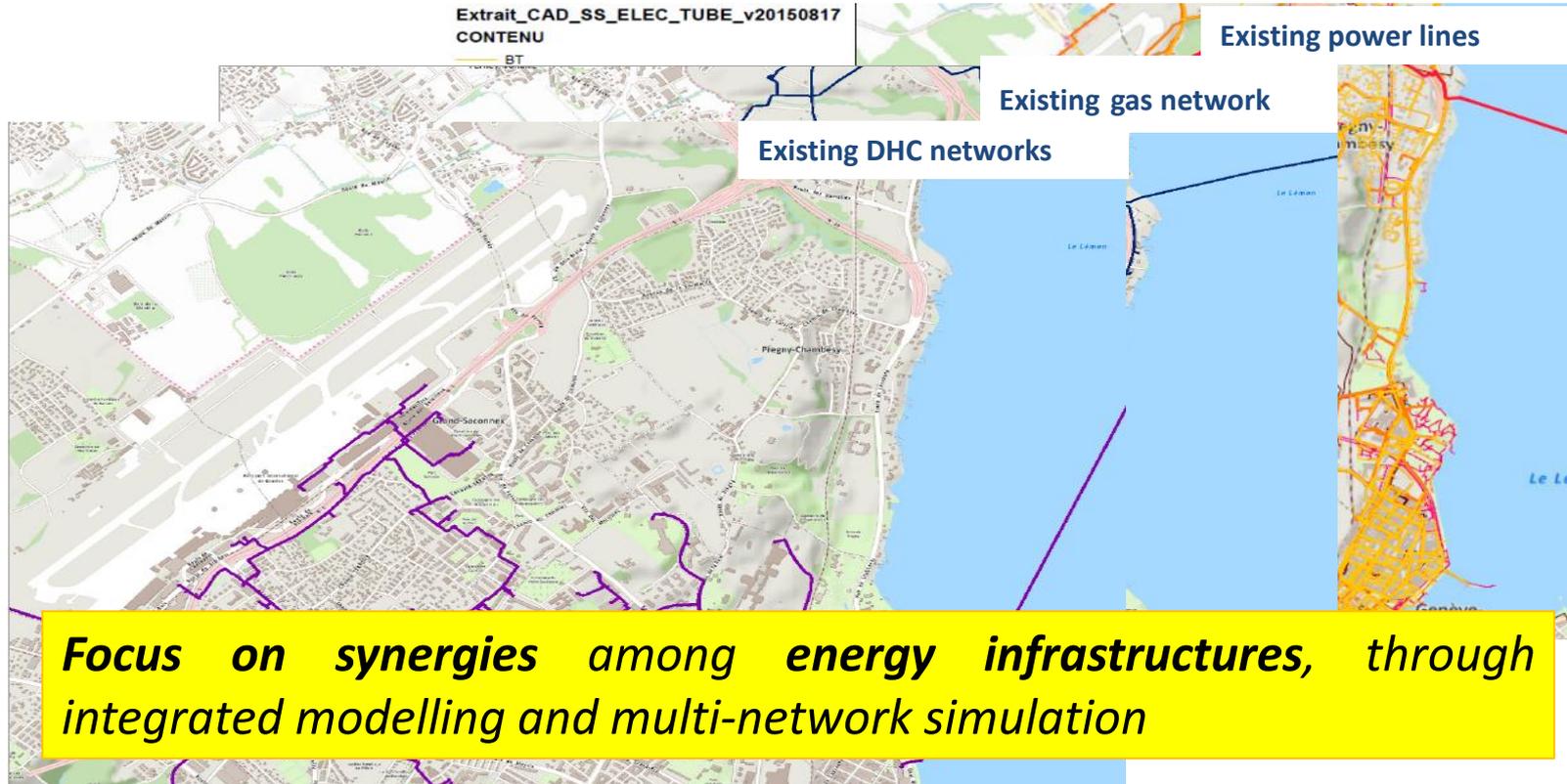
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Focus on synergies among energy infrastructures, through integrated modelling and multi-network simulation

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- District heating network
- **Electrical network**



Air HP



Geothermal HP

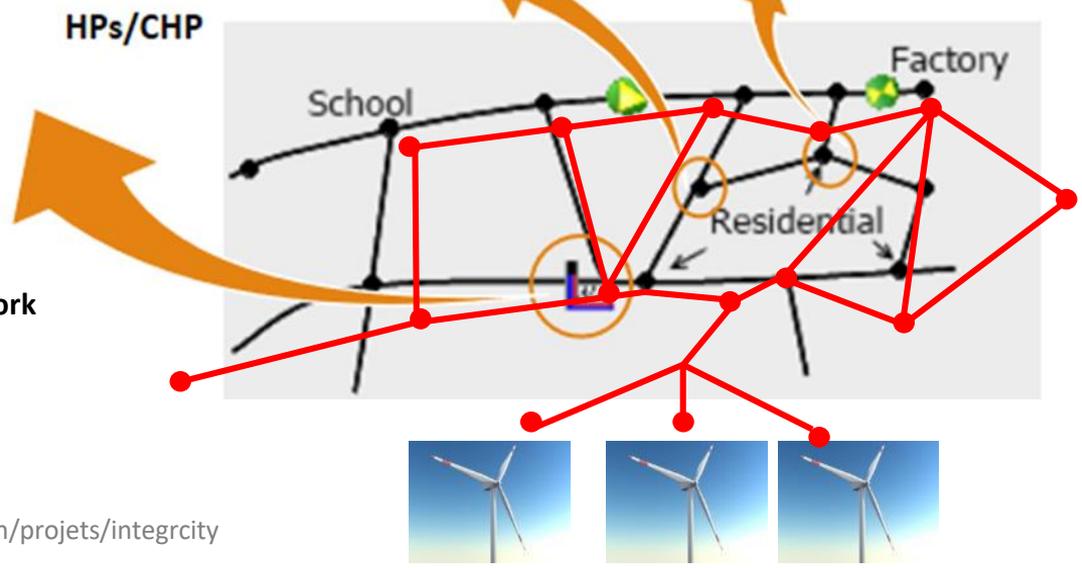
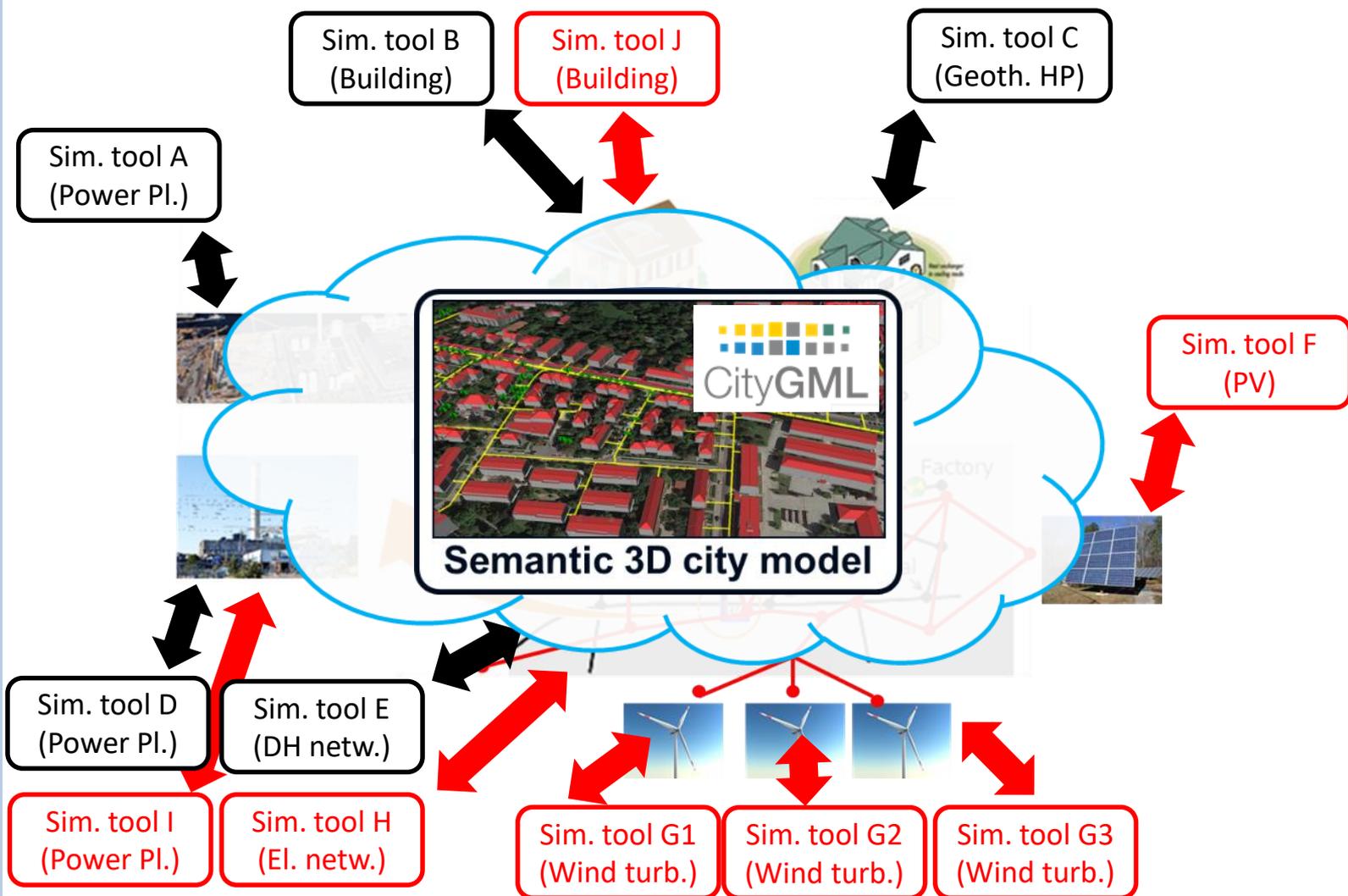


Image: <http://iese.heig-vd.ch/projets/integrcty>

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Standard-based 3D city models for...

Sustainable urban planning and transformation

Micro-climate
(e.g. heat islands)

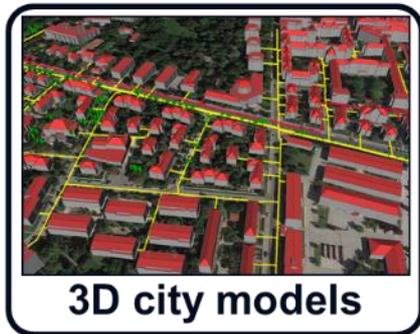
Air quality

Solar analyses
(e.g. for PV)

Noise

Urban nature-
based solutions

Participatory
planning



Energy

Mobility

Relation to BIM

Relation to supply
networks

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- Climate change is a complex problem, intimately tied to the energy transition and sustainable urban development
 - Cities are among the main energy consumers, but also represent the largest potentials for energy savings
- Standard-based **semantic 3D city models** represent a powerful and useful **information hub** for city-wide applications
 - Data integration is always time-consuming, so: **Do once, use many!**
- **Energy ADE** extends CityGML for energy-related topics
 - So far, only existing open data model for Urban Energy Modelling, i.e. “*between BIM and INSPIRE scales*”

Energy ADE: Some other projects

(Some) national / international projects adopting / using the Energy ADE

Energy & cities

- Project **GeoSmartCity**:
<http://www.geosmartcity.eu>



City models

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- Project **Energy Atlas Berlin**:
<http://energyatlas.energie.tu-berlin.de/en>



- Project **CI-ENERGY**:
<http://www.ci-nergy.eu>



Conclusions

- Project **IntegrCiTy**:
<http://iese.heig-vd.ch/projets/integracity>



References

- Project **IN-SOURCE**:
<https://jpi-urbaneurope.eu/project/in-source/>



Selected bibliography (since 2016)

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<http://www.ibpsa.org/proceedings/BSO2016/p1047.pdf>

Thank you for your attention



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