

CityGML Energy ADE: Latest news!

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Outline

1) What has been going on recently?

- Memory refresher: Energy ADE in a nutshell
- Recent updates: Software, Datasets, Projects
- 2) Where are we heading to?
 - Ongoing research
 - First steps towards Energy ADE 2.0
 - Energy ADE and CityGML 3.0
- 3) Conclusions

Energy ADE in a nutshell

- Extension to the CityGML 2.0 standard
- Uses the Application Domain Extension (ADE) mechanism
 - Extends existing classes
 - Adds new classes and attributes
- Modular structure
 - Core module
 - Building physics module
 - Material and construction module
 - Occupant's behaviour module
 - Energy systems module
 - Supporting classes



https://www.citygml.org/ade/

Further 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. <u>https://opengeospatialdata.springeropen.com/articles/10.1186/s40965-018-0042-y</u> (open access)

Energy ADE

Updates

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions

Energy ADE in a nutshell

- Open, consensus-based development
 - GitLab: <u>https://git.rwth-aachen.de/energyade/citygml-energy</u>
 - Wiki: <u>http://en.wiki.energy.sig3d.org</u>
 - Version 1.0 released in June 2018
- International consortium started in 2014
 - Over the years, participation of up to ca. 20 institutions, 11+ countries



Energy ADE

- Updates
- Software
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- Projects
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- Energy ADE 2.0
- CityGML 3.0
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Energy ADE in a nutshell

- Eases data interoperability for Urban Energy Modelling
 - Between different software tools
 - Between different stakeholders
- Defines (and stores) energy-related data in a standard, open, urban data model
 - Allow for multi-scale energy modelling
- Based on multidisciplinary cooperation between CityGML users, data producers, software vendors, ..., and scientists





Energy ADE

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- Energy ADE 2.0
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- Conclusions







Further details:

Malhotra, A., Shamovich, M., Frisch, J., van Treeck, C., 2019

Parametric Study of different Levels of Detail of CityGML and Energy-ADE Information for Energy Performance Simulations. Proc. of the 16th IBPSA Int. Conf. http://www.ibpsa.org/proceedings/BS2019/BS2019_210607.pdf (open access)

• Builds upon CitySim solver (EPFL, 2004-2013)

CitySim Pro

• **CitySim Pro**: GUI for import, visualization, dynamic simulation and export



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Energy ADE

Software

Datasets Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions



Energy ADE

- Updates
- Software
- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0

Conclusions

- Works with CityGML LoD2 or LoD3 models
- Geometry checking
- Model enrichment:
 - Physical parameters
 - Usage parameters and schedules
- Exports data as CityGML + Energy ADE model

🔬 GML Toolbox			Imple	emen	itati		
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http://en.wiki.energy.sig3d.org/images/upload/20181206_12_Benner_Energy_ADE_Sim.pdf

3DCityDB



- Given (any) ADE xsd schema, automatic generation of the <u>database schema</u> "on top" of the normal 3DCityDB
 - Supported from withing the Importer/Exporter tool 4.x
 - Free and open source



- Module to import/export ADE data from/to the extended 3DCityDB
 - Closed-source implementation already done for the Energy ADE
 - Release as open source envisioned (tbd)

Energy ADE

Updates

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions

FME 2020.1 (beta)

• Able to deal with CityGML and ADEs since "ages", but...

Energy ADE	FME 2020.1 "What's New"
Updates	FME 2020.1.0.0 b20568 20200529
Software	Snowflake: Add Role as optional connection parameter
Datasets	CityGML, add local EnergyADE v1 0 schemas
Projects	Citygent. and local Energympt vito Schemas,
Research news	Snapefile Reader: Fix issue with duplicate feature returned when using an envelope / spatial index shape sbn
Energy ADE 2.0	AttributeValueMapper: Fix operation when default value contains non-ASCII characters.
CityGML 3.0	
Conclusions	File Home Share View



Con



CityJSON & extensions



- Energy ADE
- Updates
- Software
- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

• CityJSON: JSON-based encoding of CityGML



- CityJSON extension ≈ CityGML ADE
 - JSON file documenting how the core data model can be extended
- Energy extension
 - In principle, done, but requires testing

Further details: https://www.cityjson.org https://www.cityjson.org/extensions



Example: Montréal 3D city model modified and enriched with (some) energy objects/properties

Sample datasets (open data)



Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions



https://gitlab.com/volkercoors/neqmodplus-steinbeis

HFT campus CityGML 2.0 (LoD2) + Energy ADE 1.0

Several datasets by KIT

Please Note!					
These examples are examples for public Angewandte Informa	e made by the Institute for Automation and Applied Co ations, please provide the following source: Institute httl: / Karlsruher Institut für Technologie.	mputer Science (IAI) at the Karlsruhe Institute of Technology (KIT), and are for for Automation and Applied Computer Science (IAI) / Karlsruhe Institute of Techr	r unrestricted use. If you use these tology (KIT) or institut für Automation und		
Karlsruhe Institute of Technology (KIT), Institute for Automation and Applied Computer Science (Campus North) CityGML 2.0 Energy ADE Version 1.0 sample files					
Name	Downloads	Originating System / Organization	Snapshot		
FZKHouse LoD2	Pure CityGML model # Energy ADE model # Energy ADE model with simulation resultsd?	GML-Toulou "ChyGML to EnergyADE" enhancement EnergyPlus			
FZKHouse LoD3	Pure CityGML models# Energy ADE models# Energy ADE model with simulation results#	GML-Toolbox "ChyGML to EnergyADE" enhancement EnergyPus			
Bau445 LoD2	Pure CityGML models? Energy ADE models? Energy ADE model with simulation results?	GML-Toolbox "ChyCML to EnergyADE" enhancement EnergyPlus			
Bau445 LoD3	Pure CityGML model# Energy ADE model# Energy ADE model with simulation results#	GML-Toobor "CiryGML to Energy40E" enhancement Energy4Na			
Weather Data	Weather data in CSV-formate? Weather data in EnergyPlus EPW-formate?	Deutscher Wetterdienst (DWD) Climate Data Center (CDC)@			

http://www.citygmlwiki.org/index.php?title=KIT_Sample_files_Energy_ADE

IBPSA Project 1



Energy ADE

Updates

- Software
- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

Goals:

- Consolidate the development ranging from system representations of the data (BIM/GIS) and their dynamic behaviors
- Provide stable, well-tested, validated and documented code for energy simulations
- Demonstrate the applications capabilities which can be enabled using Modelica





Federal Ministry for Economic Affairs and Energy

Further details: https://www.e3d.rwth-aachen.de/go/id/gwiuq

Project SmartQuart

Goal:

Development of a modular blueprint for a decentralised energy and heat transfer at district level



Energy ADE

Software

Updates

Energy ADE 2.0

CityGML 3.0

Conclusions



Rotterdam

Project currently in development



http://steinbeis-3dps.eu/rotterdam/Apps/Rotterdam/Rotterdam Cesium Viewer.html

Energy ADE

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions

Energy ADE Updates Software Datasets Projects

- Research news
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

Helsinki

Project currently in development







CityDBEnergyADEWriter

Co SimStadtModels: 0

27.0.0.1		
elsinkiDB		
432		
ostgres		
writeYearlyHeatDemandDHW		
4		

0

Base

Net Zero Gowanus 2050 (Brooklyn)



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Federal Ministry of Education and Research

Energy ADE Updates Software Datasets Projects Research news Energy ADE 2.0 CityGML 3.0 Conclusions

18



Further details: https://sites.google.com/nyit.edu/insource-fwe/consortium http://gowanusbydesign.org



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730254.







Geneva: Eaux-Vives district



- Impact of trees on daylight and photovoltaic production
- Adequacy between photovoltaic production, daylight penetration (comfort and electrical production), consumption and storage
- Data/Results to be shared on GitLab as open data





Energy ADE

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions

Gavardo (Italy)



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



Energy ADE

Software

Datasets

Projects

CityGML 3.0

Conclusions

Ongoing research



- Energy ADE
- Updates
- Software
- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

• Web based, combines multiple tools

- CityATB: CityGML Analysis Toolbox
- *CityGTV*: CityGML Geometrical Transformation and Validation
- CityEnrich: CityGML Enrichment using Energy ADE
- TEASER+: dynamic urban scale simulations



RNTHA

Image source: PhD thesis A. Malhotra (2020)



Modelling

(CFD)

+ Analysis

viewing/editing, rad viewer)

(heat island, future climate)

Image source: https://i.ytimg.com/vi/qHFEhD2SsDA/maxresdefault.jpg

Energy ADE

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions



Ongoing research

Coupling CityGML + Energy ADE with ENVI_MET (for micro-climate simulations)



Energy ADE

Updates

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions

Ongoing research



CityGML + Energy ADE model of Amsterdam for urban planning (semi-automatic design of new districts)

Q # × []]? **Buildings Usage Zones** (Residential, commercial, education, ...)

Image source: Agugiaro et al. (2020)

Updates Software

Energy ADE

- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

Energy ADE 2.0

- Energy ADE
- Updates
- Software
- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

- In early development (see GitLab)
 - Change requests due to experiences so far
 - Reduce complexity in certain modules
 - Revise the Energy System module
 - Too large and complex when compared to real-life use cases

Further details: http://en.wiki.energy.sig3d.org/images/upload/Benner_EnergySyste msModel.pdf

₩.	Projects Groups Snippets Help	Q 🕜 🗸 Sign in
c	energyade > citygml-energy > Issues	
۵	New issue	
Ð	Open 25 Closed 134 All 159	
D	Recent searches V Search or filter results	
Ľ	Created date v \$	
≡* Ø	Provisional removal of the energy source model from the Energy ADE 2.0 #172 · opened 7 months ago by Alexandru Nichersu	🙊 0 updated 7 months ago
©	Heating and Cooling system availability schedules #171 · opened 8 months ago by Joachim Benner Building occupants	🗪 1 updated 7 months ago
8	New Time Series type MonthlyTimeSeries #170 - opened 8 months ago by Joachim Benner Supporting Classes	오 1 updated 7 months ago
	ThermalZone should have isVentilated #169 - opened 9 months ago by Peter Remmen Building Physics	👷 2 updated 7 months ago
ж 84	How to model multiple Buildings supplied by one EnergyConversionSystem #168 - opened 10 months ago by Peter Remmen (ADE core) (Energy systems)	🙊 2 updated 9 months ago
	Possibly rename HeightAboveGround? #167 - opened 1 year ago by Giorgio Agugiaro (ADE core)	🙊 2 updated 7 months ago
	Link SystemOperation to AbstractEnergySystem? #166 - opened 1 year ago by Giorgio Agugiaro (inegy system)	updated 9 months ago

https://git.rwth-aachen.de/energyade/citygml-energy

- Tighter integration/harmonisation with the Utility Network ADE
 - E.g. the respective construction/material modules already harmonised

Image source: <u>https://github.com/opengeospatial/CityGML-</u> 3.0CM/blob/master/Conceptual%20Model/CityGML_3.0_UML-Diagrams.pdf

Energy ADE and CityGML 3.0

- CityGML 3.0 core becomes more complex, but...
 - ...will allow to reduce/simplify the Energy ADE modules AbstractFeature Building partitions (ThermalZones, UsageZones, etc.) \rightarrow Spaces torminationDate: DateTime (0.1 aldFrom DateTime 10.1 validTo: DateTime IO 5 ade/XRoba/EachaniNHi Joscov A/E/XRoba/EachaniNHi Joscov 10 COMMAN Alabar City China diment of «Property: engineeringCRS: EngineeringCRS.ID relativeToTomain RelativeToTomain 80. adi/OR/Model ADEOR/Model (0 relativeTcWater RelativeTcWater (0. 1) abOlibitatOliObiet ACCOMMINGCE/Obied I +bounds Propertion Abstraction AbetractSpaceBoundar Property Occerto. spaceType: SpaceType (0. 1) adeONotracticon/loandary ADEONIstracticanel volume: Qualified/Jolume 10.1 ana Qualifedàrea ID.* deCMastracticace: ADECMastracticace ID AbstractThematicSurfac area: Qualified/vea [0.1 adeON/otracThomaticSurface ACEON/otracT AbstractPhysicalSpace Abstract, opical Space «Propertica Pronto Concentration adeOVbstractLopicalSpace ADEOVAbstractLopicalSpace [0. adeORestractPhysicalSpace: ADEOREstractF adeOtOceanSurface ADEOtOceanSu AbstractOccupiedSpac Abstract Incounted Inco Pronty shoot adeORestractOccupiedReaser ADEORestractOccupiedReases 10 adrONbitrad Incorport/lease ADEONbitrad Incorport/lease
 - - ThermalBoundaries \rightarrow SpaceBoundaries
 - Timeseries \rightarrow Dynamizers (?)
 - ...still no module for Constructions/materials

Beware:

Energy ADE Construction **#** CityGML 3.0 Construction!

Further details:

Kutzner et al. (2020)

CityGML 3.0: New functions open up new applications. Journal of Photogrammetry, Remote Sensing and Geoinformation Science volume 88(43–61) https://link.springer.com/article/10.1007/s41064-020-00095-z (open access)

Energy ADE

Software

Datasets

Projects

Research news

Energy ADE 2.0

CityGML 3.0

Conclusions

Conclusions

- Energy ADE
- Updates
- Software
- Datasets
- Projects
- **Research news**
- Energy ADE 2.0
- CityGML 3.0
- Conclusions

- Energy ADE greatly enhances the modelling capabilities of CityGML wrt. energy
 - So far, the only existing open data model "between BIM and INSPIRE scales"
 - Has reached version 1.0, number of tools is growing
 - Is already used for different applications at urban scale
- Near future plans
 - Add Energy ADE *reading* capabilities to the tools
 - Extend/complete 3DCityDB support
 - Apply for further projects and funding to continue development
 - Consider submission as OGC Community standard
- (Less) near future plans
 - Energy ADE (3.0?) for CityGML 3.0
 - ...tbd...







Thank you for your attention



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