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Further Development of the CityGML Energy Application Domain Extension 3.0

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Abstract

The CityGML Energy Application Domain Extension (ADE) is an open and standardised data model to facilitate multi-scale cross-sectoral Urban Energy Modelling applications. It is based on the international standard CityGML (version 2.0), and was first released in 2018. Since 2024, the data model has been undergoing a major revision to align it with recent developments in CityGML, address feedback from its user community, and better support emerging data and interoperability requirements. The Energy ADE 3.0 beta 7 has been released in autumn 2025. Since its release, several ideas and suggestions for improvement have been collected. This paper presents an overview of some of the most relevant change requests that have been evaluated and eventually implemented, leading to the current beta 8, and the rationale behind these changes. Attention is paid to the modules that have been more affected by such changes, namely the Core module, and the new Building module. Finally, the results of tests with synthetic and real data are provided, confirming the soundness of the updated data model and highlighting no major implementation issues. These results reflect the continued development of the Energy ADE towards its future alignment with CityGML 3.0. At the same time, ideas and feedback dealing with the request to add support for scenario management have lead to start and branch off a new and, currently separate research work focusing on a new and domain-agnostic extension, namely the Scenario ADE.

1. Introduction

Semantic 3D city models have established themselves as one of the relevant components of any Urban Digital Twin. Standards facilitate the adoption of semantic 3D city models and, as a result, the development of applications based on them. To this extent, CityGML represents the most relevant international standard. CityGML 1.0 and CityGML 2.0 have been published in 2008 and 2012 (OGC, 2008; OGC, 2012), respectively, while the latest version, CityGML 3.0, has been published in 2021 (OGC, 2021). Currently, CityGML 2.0 is still the most widely used version, however the latter is going to be adopted more and more as it contains several enhancements. Regardless of the version, CityGML can be extended by means of so-called Application Domain Extensions (ADEs). They allow to enrich the modelling capabilities of CityGML for specific domains.

In the context of Urban Energy Modelling (Zhou et al., 2025), preliminary work to extend CityGML for energy-related applications goes back to the beginning of the 2010s, with work carried out at TU Berlin (Krüger and Kolbe, 2012) and the Stuttgart University of Applied Sciences (HFT), in Germany.
Starting from 2014, an international, open, consensus-based consortium was founded, that took over the development of the Energy ADE. The first version, Energy ADE 1.0[1]) was released in 2018 (Agugiaro *et al.*, 2018), followed in 2019 by a minor update (version 2.0) in 2019. Since its release, the Energy ADE has been used in several national and international projects and implemented at different levels of completeness in different software tools.

The experiences collected since 2018 have contributed to forging new ideas. Therefore, in 2024, TU Delft, in the Netherlands, and the Stuttgart University of Applied Sciences joined forces and started to develop a new version of the Energy ADE, version 3.0, within the European project DigiTwins4PEDs[2] (Padsala *et al.*, 2025).

The development of the Energy ADE 3.0 is still based on CityGML 2.0 and, like the previous versions, is driven by two main objectives:

a) to store and manage energy-relevant data collected at urban scale,
b) to provide harmonised data to assess the energy performance of buildings using heterogeneous approaches and software tools (e.g. standard-based energy balance, dynamic simulations).

Additionally, two more goals have been envisioned:

c) to update the data model based on the experiences collected since the previous releases
d) to design and improve the data model in order to avoid future conversion issues when porting it to CityGML 3.0.

The reason for developing on CityGML 2.0 instead of the more recent CityGML 3.0 resides in the availability of well-established approaches to model ADEs (Van den Brink *et al.*, 2013) and existing software solutions that can already use the developed ADE, *in primis* the CityGML 3D City Database 4.x (or, in short, 3DCityDB) (Yao *et al.*, 2018), which is one of the core technologies within the DigiTwins4PEDs project. As a matter of fact, as the development of the Energy ADE 3.0 started, the 3DCityDB 5.x (Yao *et al.*, 2025), which supports CityGML 3.0, had not been released yet. Furthermore, as of today (June 2026), it still lacks documented support for ADEs. Nevertheless, the Energy ADE 1.0, although initially developed for CityGML 2.0, has been recently mapped to CityGML 3.0. The operation has provided valuable insights that have been incorporated into the design of the Energy ADE 3.0 in order to facilitate its future porting to CityGML 3.0. Further details can be found in Bachert *et al.* (2024).

After approximately one year of development, the new Energy ADE (beta 7) has been published in GitHub[3] and is now freely available for testing and evaluation since autumn 2025. Additionally, the development is now carried out again in an open, consensus-based approach, with contributions and ideas from heterogeneous international partners.

[1] https://www.citygmlwiki.org/index.php/CityGML_Energy_ADE
[2] http://digitwins4peds.eu
[3] https://github.com/tudelft3d/Energy_ADE

It is worth mentioning that the currently available Energy ADE 3.0 (beta 7) does not only consist of the data model (as UML diagrams), but also of technical specifications, some modelling guidelines, sample datasets, a database schema for the CityGML 3D City Database 4.x, and still-in-development but partially released Java libraries for a tighter support with the existing Java-based CityGML tools. A first overview of the new Energy ADE (as of beta 6) was published in (Agugiaro and Padsala, 2025) and has been partially implemented (Padsala *et al.*, 2026).

This paper focuses on the major changes implemented up to now (June 2026) in the latest beta 8. Such changes result from the evaluations, tests and experiences carried out not only in the already mentioned DigiTwins4PEDs project, but also in new initiatives such as the European project FlexPED[4], and the Dutch project RenoDAT[5]. FlexPED builds upon DigiTwins4PEDs, however the goal is to develop an open energy data management and flexibility framework for city districts, using an Urban Digital Twin (UDT) platform integrated with AI-powered agent-based simulation. In the case of RenoDAT, the project plans to develop a reliable data infrastructure to improve building renovation quality, streamline processes, and help meet critical climate and societal well-being goals in the Netherlands. Within the RenoDAT project, CityGML 2.0, coupled with the Energy ADE 3.0, are being tested as a possible open data model to accommodate the data requirements of the Building Renovation Passport, as indicated by the revised European Directive on Energy Performance of Buildings (EU/2024/1275, EPBD) (EU Parliament, 2024). More details can be found in (Schlosser *et al.*, 2026). Additionally, interviews and discussion between the main developers and several experts have been conducted since summer 2025, the most recent one being during the International Energy ADE Workshop[6] held in Delft in June 2026.

2. Methodology

The Energy ADE 3.0 is developed following the approach described and published by (Van den Brink *et al.*, 2013) and already used in other ADEs. Since this approach is well-known, documented and established, it will be only briefly summarised here. More space will be instead given to the new ideas and feedback gathered from the projects and interviews with stakeholders, as these have been the starting point to update the Energy ADE 3.0 to the current version (beta 8, as of June 2026).

2.1 Data modelling

Once the data model of the Energy ADE 3.0 is described at the conceptual level in terms of necessary classes, properties, and relationships, UML is used as the modelling language. Afterwards, the transfer format is defined. In our case, the target is GML, so a XSD (XML Schema Definition) file is created. The third step consists in creating test datasets, which are used to test the conversion tools developed successively. Finally, Java libraries are developed to load and save XML-based CityGML files with Energy ADE 3.0 content, and to convert such XML-based files to a SQL-based encoding (in our case, the 3DCityDB 4.x). Further details will be provided in section 4.

2.2 New ideas to improve the Energy ADE 3.0

Since the release of the Energy ADE 3.0 beta 7 in autumn 2025, the previously mentioned FlexPED and RenoDAT projects have started. This has allowed the Energy ADE 3.0 to be further evaluated from new perspectives in terms of data requirements. Additionally, from late summer 2025 till today several interviews have been conducted with experts in order to collect constructive feedback and new ideas on how to improve the data model. Given the extent and heterogeneity of the proposed changes, they have been grouped (as far as possible) into the following points and then, once deemed relevant, they have been used to update the data model accordingly, as described in section 3.

1) In CityGML 3.0, all objects derived from *gml:AbstractFeature* are distinguished using two main types of identifiers: the obligatory *featureID* (corresponding to the *gml:id*) for internal linking and XML document validation, and an optional *identifier* used to persistently track real-world objects across multiple model versions (OGC, 2021). Providing globally unique and stable identifiers for the *identifier* attribute is recommended. This means these identifiers should remain stable over the lifetime of the real-world object. Additionally, CityGML 3.0 class *AbstractFeatureWithLifeSpan* adds the concept of time validity (properties *validFrom* and *validTo*) which plays a relevant role when dealing with the real-world lifespan of a specific version of an object. They track exactly when a feature (such as a building, a bridge, but also an energy performance certificate!) comes into existence and when it ceases to be valid.
2) The Energy ADE 3.0 reworks and extends the classes of *QualifiedHeight*, *QualifiedArea*, and *QualifiedVolume*, in that not only a *value* and its *unit of measure*, but also a *type* (expressed via a codelist) and some simple metadata in terms of data *source* and *description* are provided. This is particularly useful when, as it happens very often, such values are merged from heterogeneous datasets (e.g. the gross floor area computed from the CityGML model, and the net floor area imported from cadastral data). In line with this concept, it was requested to add like-wise "some" metadata to all objects, in order to be able to characterise them in terms of provenance and quality.
3) A common request asked for the possibility to have *generic attributes* and *external references* for all classes derived from *gml:Feature*, not only for those subclassed from *_CityObject*. The reason is that this would allow more flexibility in case of special, country-specific attributes, as well as the added value of linking the created data to external resources. A good example for this change request are classes *EnergyPerformanceCertificate* and *UtilityNetworkConnection*. Additionally, a way to model generic KPIs (Key Performance Indicators) would be preferable to generic attributes, as KPIs should be provided with some additional properties (such as a scope, or a standardised name).
4) A request was made to generalize the concept of *RefurbishmentMeasure*, because regular maintenance interventions could also contribute to the overall energy performance of a building (or building unit). This is particularly relevant if one considers the historical series of interventions that are carried out in a building(unit), also considering what a Building Renovation Passport should contain. Additionally, for any of these interventions it should be possible to clearly indicate (or link) which building element was addressed.
5) From several building energy simulation experts, a major request came to rework and unify the Energy ADE's *Building physics* and the *Occupancy modules* (which, in essence, had been existing since version 1.0). One reason is that the logical

[4] https://flexped.eu
[5] https://www.nwo.nl/en/projects/xqbeg97133
[6] https://3d.bk.tudelft.nl/events/energy2026/

https://doi.org/10.5194/isprs-archives-L-4-W2-2026-1-2026

subdivision of thermal properties (in class *ThermalZone* of module *Building Physics*) and the occupancy properties of class *UsageZone* (in module *Occupancy*) were hard to map to current software packages (e.g. EnergyPlus, CitySim, SimStadt). Additionally, the fact that a *ThermalZone* contains 0..* *UsageZones* goes against the common modelling practices in which a multi-zone building (e.g. shops in the ground floor, offices in the first floor and residential in the remaining floors) is generally divided i.e. *first* based on its usage zones and only *then* the thermal zones are defined.

6) Regarding the *Building physics* module, another series of comments targeted the modelling of the thermal boundaries in the Energy ADE beta 7 by simply adding a few new classes (*BasementCeilingSurface*, *IntermediateFloorSurface*, *AtticFloorSurface*, *PartyWallSurface*) and reusing the existing ones for (Building) *WallSurface*, *RoofSurface*, etc. First, the mixed usage of the thematics surface classes for both the building envelope and the thermal zone was considered to be confusing. A clear distinction between classes for building and classes for thermal zones would be preferred and make the selection of the classes more clear. Additionally, it was suggested to extend the concept of shared walls (class *PartyWallSurface*) as not only walls could be adjacent, but also other surfaces (e.g. in case of building with very irregular geometries).
7) Although it is known that CityGML 2.0 is a predominantly static data model, while CityGML 3.0 that has added several time-related modules to account for slow (Versioning module) and fast changes (Dynamizer module) in a city and its city object members, few additional requests were made when it comes to time-dependent features and properties. First and foremost, it was asked to add back the *irregular time series* to the *TimeSeries* module. Additionally, it was suggested to add classes to support *monthly* time series as a special case of irregular time series, given their relevance and frequent usage in urban applications. It must be noted that support for monthly time series was indeed introduced also in the Energy ADE 2.0 in 2019.
8) A last major request focused on a major overarching aspect of many urban applications: the possibility to deal with *scenarios*, i.e. the possibility to define different targets, different contexts, and – ideally – use different simulation tools, to collect and compare different results for different what-if alternatives. Although this request goes a bit beyond the goal of the Energy ADE 3.0, some thoughts will be shared later on and in the conclusions.

3. Updated conceptual data model

The consolidated list of change requests presented in the previous section was further analysed in detail and forms the basis of the changes to the Energy ADE 3.0 data model that are going to be described in this section. For practical reasons, the changes are grouped into the corresponding Energy ADE module.

In this paper, only the most relevant changes will be discussed, as well as the accompanying UML diagrams. Due to space constraints, and in order to facilitate the comparison and comprehension of such changes, the reader is invited to download and have the UML diagrams of both beta 7[7] and beta 8[8] at hand. They can be freely downloaded from the GitHub repository.

3.1 Core module

Following the suggestions and change requests listed in points 1), 2) of the previous section, the updated *Core* module of the Energy ADE 3.0 is depicted in Figure 1 and has been redesigned as follows:

- By means of the ADE-hook mechanism, the *_CityObject* class obtains a series of new attributes. Attributes *identifier*, *validFrom*, *validTo* are basically backported from CityGML 3.0 and allow to introduce the concepts of unique and stable identifier, as well as life-span time boundaries.
- Attribute *indicator* adds the possibility to store generic KPIs in case no other alternatives are available in the current data model. The class *Indicator* provides some additional properties to better describe what the KPI is for.
- Attribute *metadata* allows to store a (small) selection of metadata information (via class *Metadata*). It must be however highlighted that this is a first, oversimplified iteration, and further reasoning is necessary after additional testing. Other, much more consistent and complex ADEs have been proposed to add metadata to CityGML (e.g. Labetski *et al.*, 2018), and providing complete and extensive metadata support is out of the scope of the Energy ADE. The current implementation tries to accommodate the first very simple requirements in terms of metadata.

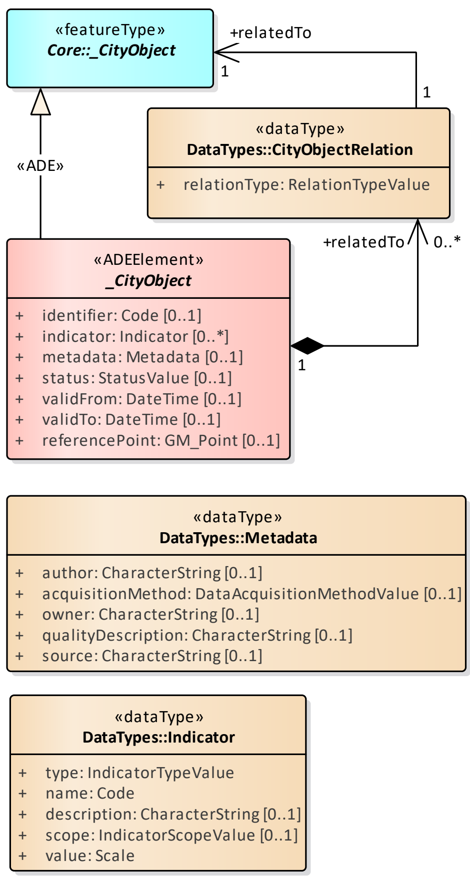

Figure 1. Excerpt of the Core module of the Energy ADE 3.0 beta 8 depicting the original *_CityObject* class (in azure) and its extended class via the ADE-hook mechanism (in pink). Additional classes are depicted in orange.

[7] https://github.com/tudelft3d/Energy_ADE/tree/3.0beta7/documentation

[8] https://github.com/tudelft3d/Energy_ADE/tree/3.0beta8/documentation

https://doi.org/10.5194/isprs-archives-L-4-W2-2026-1-2026

Regarding point 3), the changes are not depicted in this paper but can be seen in the full UML diagrams. In short: all classes that were previously derived from *gml:_Feature* (e.g. *UtilityNetworkConnection*, *EnergyPerformanceCertificate*, *AbstractSchedule*, *WeatherData*, etc.) are now derived from *_CityObject*. This means that they inherit all properties of *_CityObject*, including the possibility to have *generic attributes* and *external references* (and the additional ADE properties described before). This design decision was preferred to creating an in-between abstract feature class (e.g. *AbstractADEFeature*) containing CityGML 2.0's *generic attributes* and *external references*, and then to derive the feature classes (e.g. *UtilityNetworkConnection*) from this *AbstractADEFeature*. The reason is that this would lead to an encoding "asymmetry" in XML which might be perceived as confusing. The reason is that all ADE classes follow the GML standard encoding way, in that all properties of a feature must be wrapped in a specific *property* element which itself contains the element or the child element. However, CityGML 2.0 deviates from the standard specifically only for *generic attributes* and *external references*, as they are written as direct in-line elements of the parent object in XML. In order to avoid such situation, it was preferred to allow for the "wrong", but coherent encoding of CityGML 2.0 for consistency reasons. Fortunately, this problem will not occur once the Energy ADE 3.0 is mapped to CityGML 3.0, as the latest version is fully compliant with the GML encoding rules for XML.

Regarding point 4), the *RefurbishmentMeasure* class was generalised to an *Intervention* class. The attributes of class *Intervention* allow for example to define its type and action. The *Intervention* class and its ancillary codelists are depicted in Figure 2.

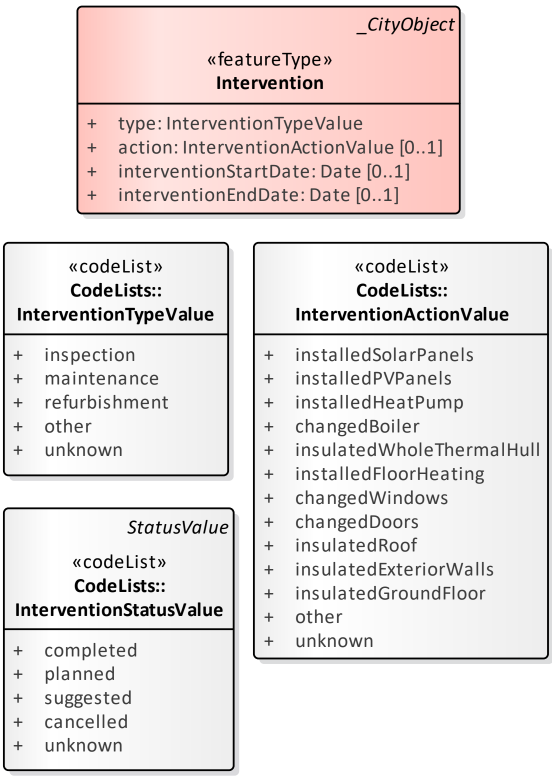

Figure 2. The new *Intervention* class and the associate codelists *InterventionTypeValue*, *InterventionActionValue*, and *InterventionStatusValue*. The last one is to be used with property *status* of the parent *_CityObject* class.

3.2 Building module

When it comes to point 5) and 6), the new *Building* module was designed from the integration of the former *Building physics* and *Occupancy* modules. The UML diagram is depicted in Figure 4. First of all, the new class *AbstractZone* merges the previous *ThermalZone* and *UsageZone* classes. From the former it keeps a number of attributes regarding the thermal properties of the zone (e.g. *infiltrationRate*, *isHeated*, *isCooled*), while from the latter it adds properties regarding the internal gains and the possibility to link to *BuildingUnits* and to have *Occupancy* objects (not depicted, inherited from class *AbstractBuildingSpace*). An *AbstractZone* is further specialized into a *Zone* class, which itself can optionally be composed of *ZoneParts*. The design pattern is the same as in CityGML 3.0 in that a *Zone* object can be decomposed into *ZonePart* objects, but *ZonePart* objects cannot be further decomposed into sub-parts. Finally, the *ZonePart* class reflects a possibility given also in EnergyPlus to decompose thermal zone into smaller *spaces* (the name is different, but the concept is the same). Finally, although this has not changed since beta 7, it is useful to remind that *Zone* (and *ZonePart*) objects can be modelled in different LoDs by means of solid geometries: LoD1, LoD2 and LoD3 are allowed, while there is no LoD4 (which is also in line with CityGML 3.0). An example is provided in Figure 3 (left). The remaining classes of the *Occupancy* module (*Occupants*, *BuildingUnit)* have been adapted and moved to the new *Building* module.

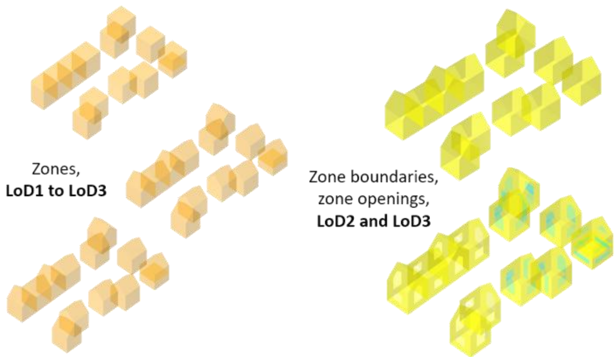

Figure 3. [Left] Example of *Zone* objects in different LoDs (from top to bottom). [Right] Visual example of zone boundaries and openings, modelled in LoD2 and LoD3.

When it comes to the boundary surfaces of the *AbstractZone*, they have been redesigned. From class *AbstractZoneBoundarySurface* a series of specific zone boundary classes have been defined, that are exclusively meant to be used for *Zone* and *ZonePart* objects. Although they are indeed derived from the (Building) *_BoundarySurface*, and they inherit all attributes defined in the ADE-extended *_BoundarySurface*, they offer semantically different classes and avoid confusion when modelling the thematic surfaces of *Zone* and *ZonePart* objects. While the meaning of most of the classes can be guessed from their name and their equivalent class in CityGML, a couple of energy-simulation relevant classes have been kept from beta 7 and simply adapted to the new data model. Finally, the *PartyWallSurface* class has been dropped. The concept is *shared surfaces*, can now be modelled for *any* thematic surface using the Boolean attribute *isShared* in class ADE *_BoundarySurface*. A similar approach has been followed for the openings, leading to the definition of classes *ZoneWindow* and *ZoneDoor*. For both the new thematic surfaces and openings, only LoD2 and LoD3 are allowed, while LoD4 is not, similarly to the solids of the *AbstractZone*. An example is provided in Figure 3 (right).

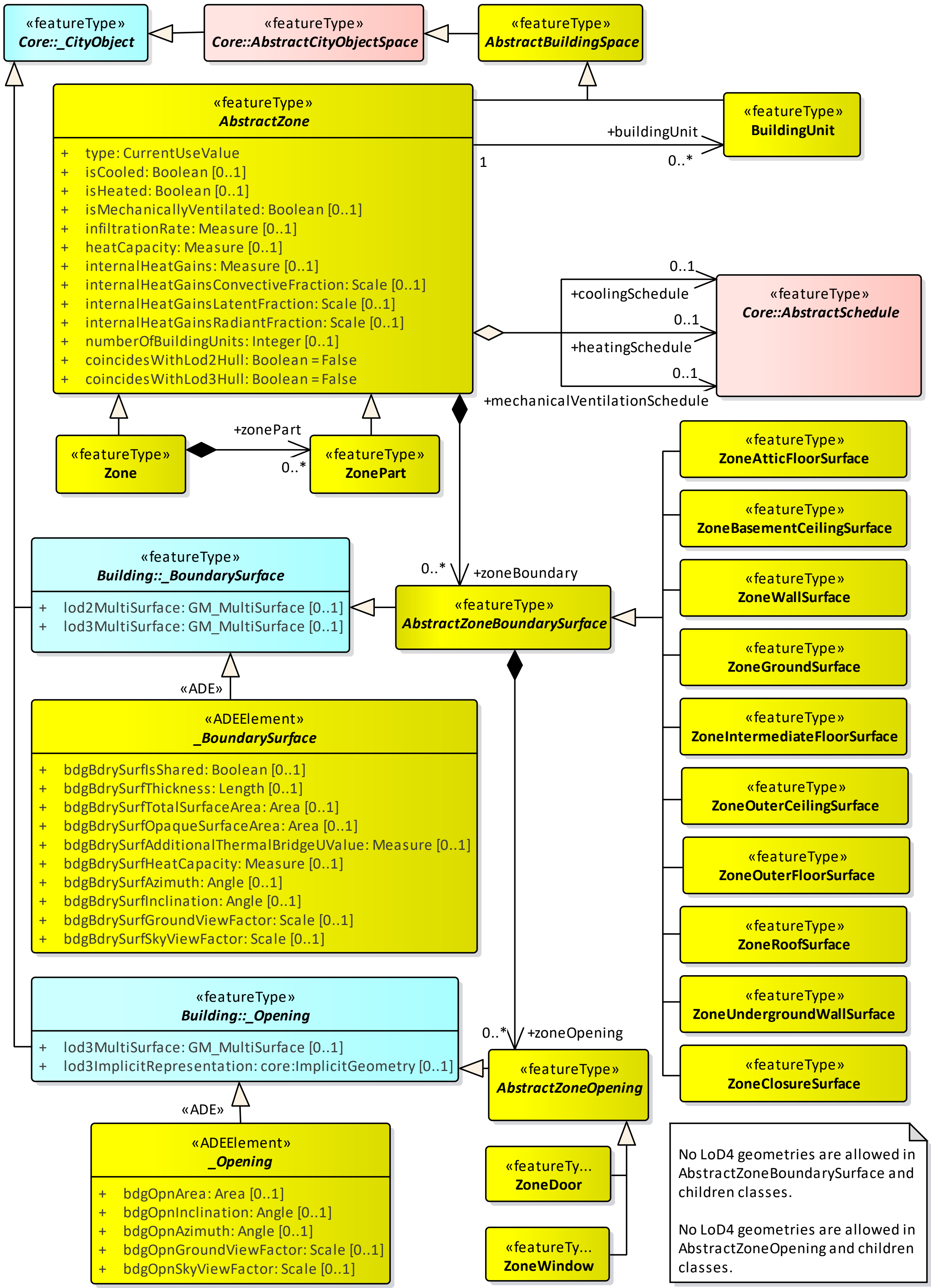

Figure 4. Excerpt of the UML diagram taken from the *Building* module of the Energy ADE 3.0 beta 8. The *AbstractZone* class is specialized in *Zone* and *ZonePart* classes. They can be represented, in LoD2 and LoD3, by means of zone boundary surfaces (*ZoneGroundSurface*, *ZoneWallSurface*, etc.) and zone openings (*ZoneWindow* and *ZoneDoor*). The CityGML 2.0 classes are represented in azure, while in pink the classes from the Energy ADE 3.0 Core module are depicted.

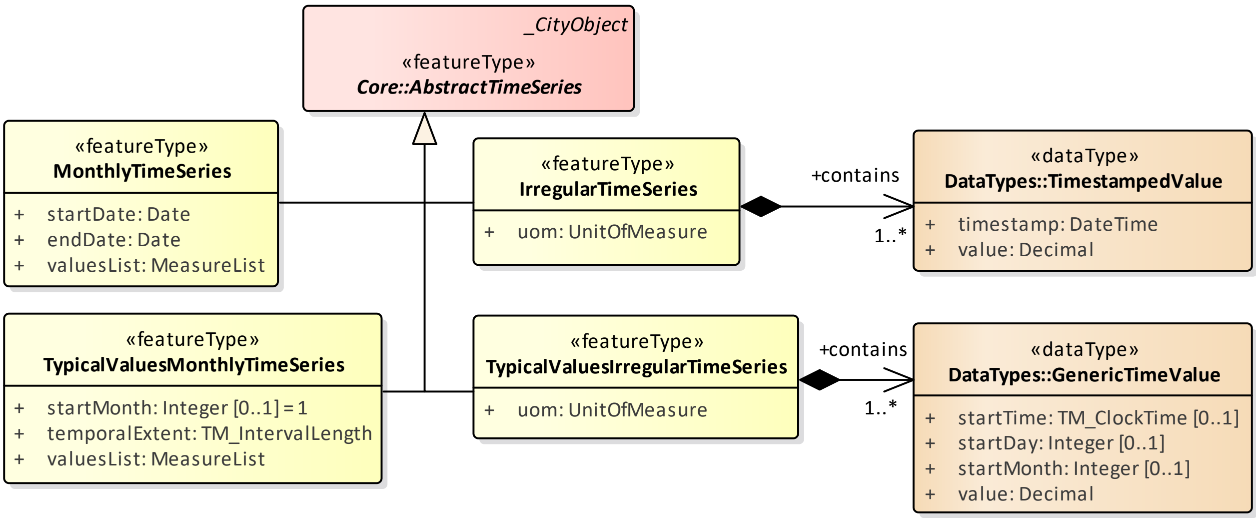

Figure 5. Excerpt of the UML diagram taken from the *TimeSeries* module of the Energy ADE 3.0 beta 8. The *AbstractTimeSeries* class is specialized in *MonthlyTimeSeries* and *IrregularTimeSeries* (left). For the latter, the actual values are modelled using the *TimestampedValue* class. For both *MonthlyTimeSeries* and *IrregularTimeSeries* classes, there is an "equivalent" class which is designed for typical values (right).

3.3 TimeSeries module

When it comes to point 9), the *TimeSeries* module was revised by adding a set of new classes in order to be able to model *irregular* time series, but also, as special case, *monthly values*. Additionally, for both type of classes, it is now possible to model *typical values* time series, which is in line with the already existing modelling capabilities for regular time series. An excerpt from the UML diagram is depicted in Figure 5.

3.4 Scenarios

Concerning the last point 9) on scenarios, no changes were implemented into the current data model. The feedback and the suggestions from the interviews was used as a starting point for a deeper reasoning on what a scenario should be, and what this would imply in terms of data modelling, not only for the Energy ADE, but also more in general within the CityGML "universe". First and foremost, the first finding was that there is no clear definition of what a scenario is, as the word is used in several different contexts and has different meaning depending on the domain. Therefore, it was decided to keep the further investigation on a separate track with respect to the Energy ADE, at least as long as a better conceptualisation and formalization have been carried out. The first results were made available by (Auer, 2026) and (Auer *et al.*, 2026) and provide first a definition of what a scenario is and what its components should be, and then a first conceptual model, presented as Scenario ADE. Currently, the Scenario ADE, also developed for CityGML 2.0, is meant to be domain-agnostic, takes inspiration from and further elaborates the *Versioning* module of CityGML 3.0.

4. Implementation and testing

Similarly to what has been done with the Energy ADE 3.0 beta 7, different follow-up development and testing steps have been carried out as soon as the beta 8 has reached a sufficient level of stability. Due to the iterative nature of Energy ADE 3.0 development, all software resources must be considered as still work in progress. Nevertheless, the valuable feedback collected so far is based also on the experiences collected using these additional resources, and not only evaluating the conceptual data model.

4.1 Additional software resources

First of all, the XSD file was obtained using ShapeChange[9] 3.10. The resulting XSD file was carefully checked also manually to ensure the correctness of the classes and properties. Additionally, the XSD file was then used in FME and in the KIT ModelViewer[10] for testing purposes, to generate and visualise test datasets. Finally, using the ADE Manager plugin of the 3D City Database Suite (Yao *et al.*, 2018), database DDL scripts were generated automatically to extend the 3D City Database. The generated DDL scripts were manually edited to carry out a further optimisation that allows to reduce the number of newly generated tables inside the 3DCityDB. Additionally, table and column names were adjusted to make them more similar to the original names in the data model (due to the automatic generation process, some names may be less intelligible). As a temporary solution while the Java-libraries for the 3DCityDB Importer Exporter are not yet available, an FME workbench has been developed: it allows to import Energy ADE 3.0 beta 8 into the 3DCityDB 4.x – which must have been previously extended using the above-mentioned DDL scripts. All software resources mentioned in this section are available in the GitHub repository of the Energy ADE 3.0.

4.2 Synthetic test data

Safe Software's FME Form 2025, together with the XSD file of the Energy ADE 3.0 beta 8, was used to generate a test dataset. The dataset, which has been progressively enriched with different Energy ADE 3.0 beta 8 data, is a set of fictitious buildings, trees and a DTM, belonging to the fictional dataset "Alderaan", which is already available as open (test) data (Figure 6). The dataset uses the Amersfoort / RD New coordinate system (EPSG: 28992) for the horizontal datum, and the Normaal Amsterdams Peil (NAP) height (EPSG:5109) for the vertical datum. If visualised in the real world, it ends up being in the middle of a small pond nearby Delft, the Netherlands.

[9] https://shapechange.github.io/ShapeChange

[10] https://www.iai.kit.edu/english/4561.php

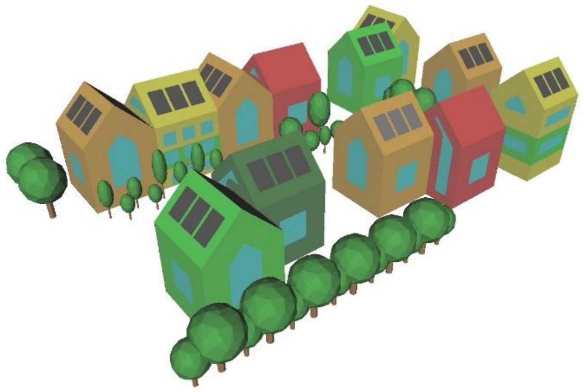

Figure 6. Excerpt of the test dataset "Alderaan" containing an example of nearly every class of the Energy ADE 3.0 beta 8.

4.3 Tests with real-world data

In the context of a MSc thesis embedded within the RenoDAT project in the Netherlands, the Energy ADE 3.0 beta 8 has been tested with several datasets. First, a single building was modelled integrating all available data and "simulating" the data acquired or surveyed on-site for the purpose of the computation of the Energy Performance Certificate. Additionally, several open datasets were integrated at municipality level (Figure 7), or even up to whole cities (Delft, Groningen, and Zwolle, for a total of circa 94000 buildings). More details are provided in (Schlosser, 2026a) and (Schlosser *et al.*, 2026). In all test cases, no major issues were encountered.

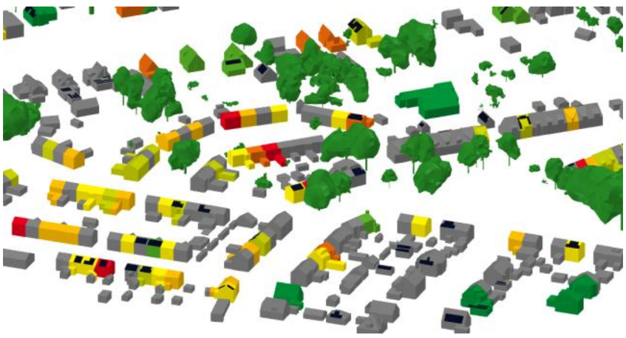

Figure 7. Example of a dataset containing CityGML 2.0 and Energy ADE 3.0 beta 8 data in the Emmer-Compascuum municipality, the Netherlands. Image source: (Schlosser, 2026a).

5. Conclusions

This paper has presented an overview of some of the major changes that have been implemented to the Energy ADE 3.0 since beta 7, and the rationale behind these changes. Most of the changes are the result of the experiences and new ideas collected in the past months using the previous beta 7, as well as interviews carried out by the authors of this paper to several experts in the period from summer 2025 to spring 2026. Although not all changes have been described in this paper (the full list is however available in the documentation published in GitHub), the paper has given an overview of the most relevant ones, namely those affecting the *Core* module, and class *_CityObject* in particular, as well as the design of the new *Buildings* module, which incorporates and merges the previous *Building physics* and *Occupancy* modules. All in all, the new version of the Energy ADE 3.0 goes one step closer to CityGML 3.0, *de facto* making its future porting even easier. At the same time, some gaps have been filled, e.g. in terms of support for monthly values and, more in general, irregular timeseries. Besides the changes to the conceptual model, the available resources in terms of XSD data, DDL scripts, and test datasets have already allowed a first series of tests. Additionally, the current beta 8 has been tested with several datasets in the Netherlands, which have provided a good testing ground to integrate multiple heterogeneous datasets.

Results so far are very encouraging. A series of interviews to heterogeneous stakeholders (users, software developers, municipalities, etc.) carried out in the Netherlands in spring 2026 in the context of a MSc thesis dealing with the Dutch Building Renovation Passport (Schlosser, 2026b) have confirmed the validity of the current data model as of beta 8. Additionally, preliminary findings from the RenoDAT project also indicate that the Energy ADE 3.0 beta 8 is able to fulfil the majority of the data requirements for the Building Renovation Passport (which implies the necessity to store energy-relevant data and, possibly, to compute the energy performance based on the collected values) (Schlosser *et al*., 2026).

5.1 Next steps

The development of Java-based libraries is planned to begin in autumn 2026 to ensure that the 3D City Database and its Importer/Exporter plugin completely support the Energy ADE 3.0. At the same time, another last review of the beta 8 data model is being carried out by the members of the Energy ADE 3.0 consortium, in order to eliminate last-minute possible inconsistencies and errors. Despite the current maturity of the current version, only its use and further testing in the coming months will show whether another set of changes or refinements is required (e.g. in the case of metadata), or not. Nevertheless, the open nature of the consortium makes the review process rather agile and transparent.

Looking ahead, once the data model will be sufficiently tested and mature to "freeze" its development and finalise it, we are already planning some additional steps. For example, besides finally porting the Energy ADE 3.0 to CityGML 3.0, it will be worth also moving from the 3DCityDB 4.x to 3DCityDB 5.x, and the additional implementation of the OGC API – Features.
Last, but not least, it is planned to evaluate how Energy ADE 3.0 data can be mapped to gbXML. Preliminary results to this extent are very promising, as mentioned in (Roman *et al*., 2025)

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