Documentation of the Data Definition Language to extend the 3DCityDB for PostgreSQL/PostGIS

Deliverable D2.2

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Short Description:
This document explains the development and installation of data definition language (DDL) scripts of the newly proposed CityGML (v2.0) Food Water Energy – Application Domain Extension (FWE-ADE) using 3DCityDB (v4.0.3) PostgreSQL.
Keywords:
DDL, CityGML FWE ADE, 3DCityDB, PostgreSQL

History			
Version	Author(s)	Comment	Date
1.0	Rushikesh Padsala (Rushi)	First draft	27.01.21

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Abbreviated Terms

FWE	Food Water Energy
OGC	Open Geospatial Consortium
CityGML	City Geography Markup Language
ADE	Application Domain Extensions
UML	Unified Modeling Language
XML	Extensible Markup Language
XSD	XML Schema Definition
DDL	Data Definition Language

Scope

The Food Water Energy Application Domain Extension (FWE ADE) extends the CityGML data model to add several FWE and its nexus related objects and attributes which are particularly required to visualise the key performance indicators (KPIs) derived from the FWE nexus in a study area. Visualisation of such KPIs will help merge data silos into one common data model and help the stakeholders make critical decisions regarding city planning and adapting to the future climate and population changes. Estimating regional biomass potential, its conversion to available thermal and electricity demand, and its impact on water demand using CityGML landuse dataset is one such example of implementing FWE nexus calculations (Bao et al., 2020). Its exemplary KPI visualisation is available in the article by Bao et al., 2020. Such workflows have been the key motivation behind the development of the FWE ADE.

With the initial release[1] and development of the FWE ADE's UML diagrams and XML schema definition files within the IN-SOURCE consortium, there is a growing interest and need in having a database implementation of the FWE ADE. One major intension behind its database implementation is finding interfaces to different urban energy simulation software such as SimStadt (HfT Stuttgart)[2] and URBANICA (AIT)[3]. Since CityGML datasets are primary inputs to SimStadt and with the possibility of finding interface to PostgreSQL from URBANICA, extending the free and open-source 3D City Database (3DCityDB)[4] suits the purpose. Using Data Definition Language (DDL) scripts, ADE specific tables can be added, removed or modified within the database.

The current version (v4.2.3) of 3DCityDB Importer/Exporter[5] tool with its ADE manager plugin provides a generic and automated solution for 1) mapping between object-oriented model and relational-database model of PostgreSQL and Oracle and 2) generating and installing ADE specific DDL schemas and thus extending the PostgreSQL or Oracle (Yao and Kolbe, 2017). However, extending the 3DCityDB's importer/exporter tool to import or export ADE enriched CityGML datasets are still not automated and require coding to develop ADE specific java libraries. Further

[1] https://transfer.hft-stuttgart.de/gitlab/in-source/fwe-ade
[2] https://simstadt.hft-stuttgart.de/de/index.jsp
[3] https://www.ait.ac.at/themen/digital-resilient-cities/projects/urbanica/
[4] https://www.3dcitydb.org/3dcitydb/
[5] https://github.com/3dcitydb/importer-exporter

details on ADE specific java libraries' development is explained using a test ADE implementation available publicly via GitHub[6].

In the current state, the present document only explains the automated process to 1) generating FWE ADE's DDL statements for PostgreSQL and 2) its installation/registration with the 3DCityDB, both using the ADE manage plugin of the importer/exporter tool of 3DCityDB. More details on the FWE ADE UML diagram and its XSD files can be obtained from its website[7]. Information on installing the 3DCityDB with its importer/exporter tool and ADE manager plugin can be obtained from its documentation[8].

3DCityDB ADE Manager Plugin

As mentioned before, the ADE manager plugin to the importer/exporter tool of 3DCityDB helps to 1) generate FWE ADE DDL scripts and 2) install/register the DDL scripts with PostgreSQL of 3DCityDB. Figure 1, as below, shows the corresponding divisions of the ADE manager plugin. Panel 1 Transformation, will help generate DDL scripts from the FWE ADE XSD files and panel 2.

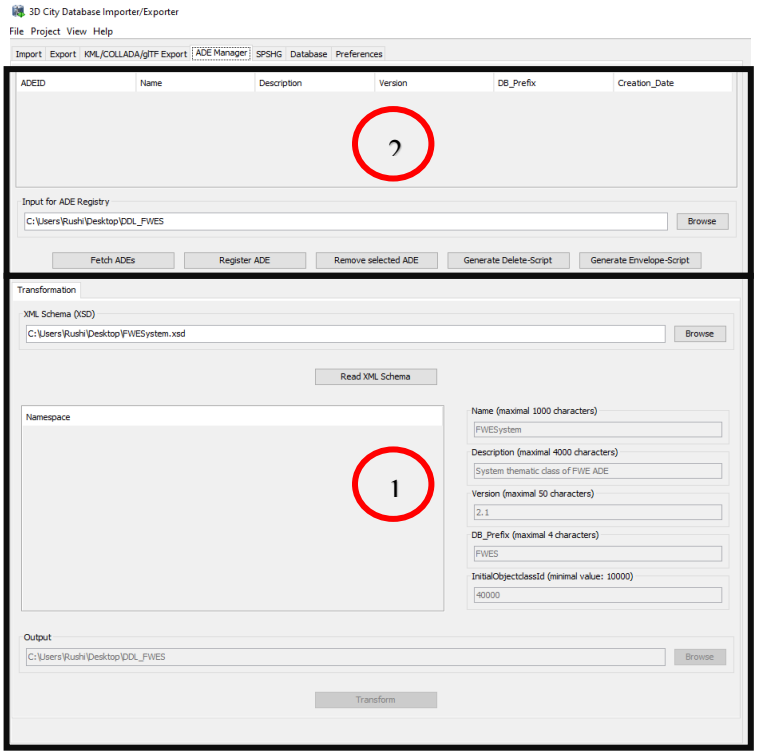

Figure 1: GUI panel of ADE manager plugin

[6] https://github.com/3dcitydb/extension-test-ade
[7] https://transfer.hft-stuttgart.de/pages/INsource/FWEADE.html
[8] https://www.3dcitydb.org/3dcitydb/fileadmin/downloaddata/3DCityDB_Documentation_v4.2.pdf

The XSD file for all the thematic modules of the FWE ADE was derived from its UML diagrams using a free java based tool ShapeChange[9].

For documentation purpose, the FWESystem module of the FWE ADE is used as an example to demonstrate the working of the ADE manager plugin. For the other thematic modules of the FWE ADE, the process remains the same. As a pre-requisite, a database instance of 3DCityDB running on PostgreSQL is pre-configured. Information on setting up a database instance in 3DCityDB can be obtained from the 3DCityDB documentation as referenced before (footnote 8).

1. Generating FWE ADE DDL Scripts

Generating FWE ADE DDL scripts is a three-step process, as shown below in figure 2.

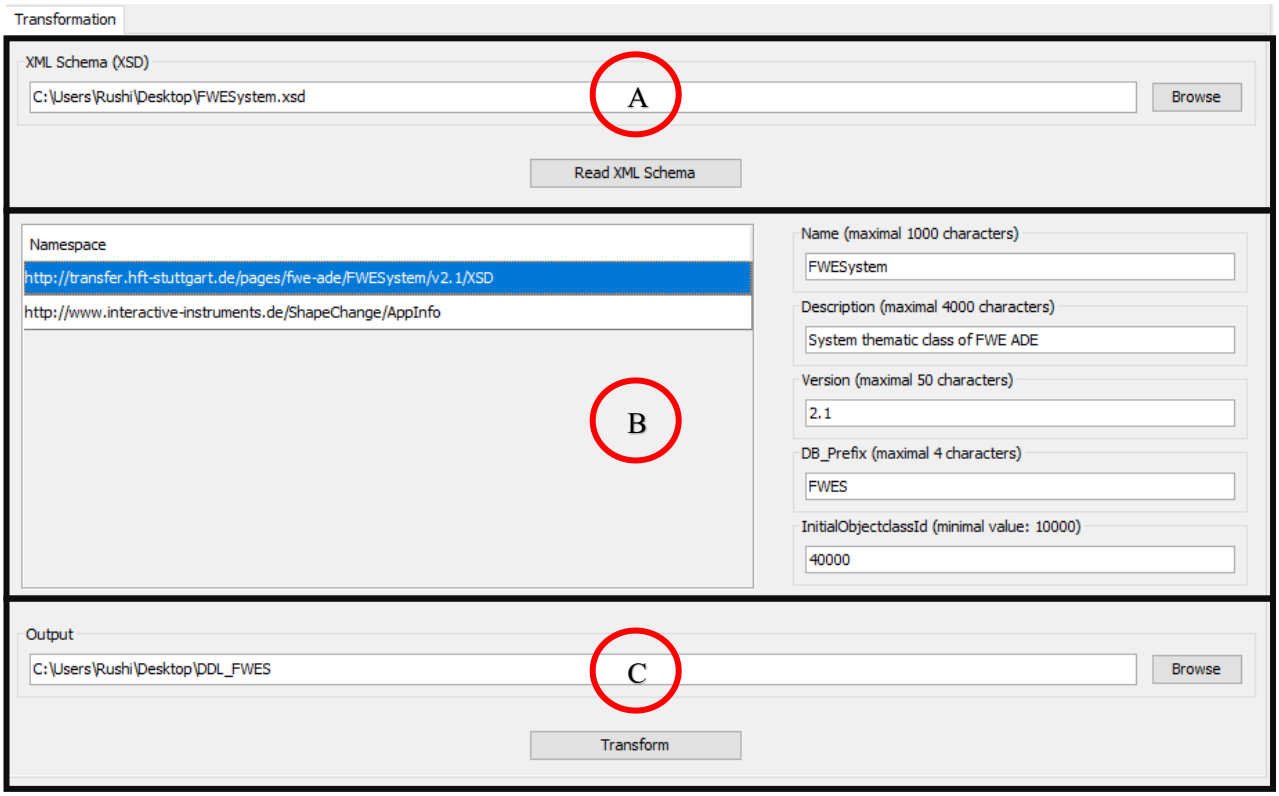

Figure 2: FWE ADE specific DDL generation

Step A requires the location of the FWESystem XSD file to read the XML schema. Step B requires input parameters such as a reference name, description, version, a unique database prefix to separate it from the original data model of CityGML and a unique object class ID. This together forms the ADE metadata that will be later required during the ADE installation/registration process. Finally, in step C, the

[9] https://shapechange.net/

output location is specified where all the generated DDL scripts will be stored. The transform button in step C will automatically create a mapping between the object-oriented model of the ADE and relational-database model of PostgreSQL and Oracle. The generated ADE specific schema mapping files and DDL scripts for both PostgreSQL and Oracle can be found in the output folder specified in step C. DDL scripts and schema mapping XML files for all the thematic modules of the FWE ADE are located on the following location.

FWE ADE Module	Location
Building	https://transfer.hft-stuttgart.de/gitlab/in-source/fwe-ade/-/tree/master/public/FWEBuilding/v2.1/DDL
Landuse	https://transfer.hft-stuttgart.de/gitlab/in-source/fwe-ade/-/tree/master/public/FWELanduse/v2.1/DDL
Area	https://transfer.hft-stuttgart.de/gitlab/in-source/fwe-ade/-/tree/master/public/FWEArea/v2.1/DDL
System	https://transfer.hft-stuttgart.de/gitlab/in-source/fwe-ade/-/tree/master/public/FWESystem/v2.1/DDL

Table 1: Location of FWE ADE DDL scripts

2. Installing FWE ADE DDL Scripts

Ones the ADE specific schema mapping files and DDL scripts are generated from step 1; they can be used to create new ADE specific tables and thus registered with the PostgreSQL using the "Register ADE" functionality of the ADE manager plugin.

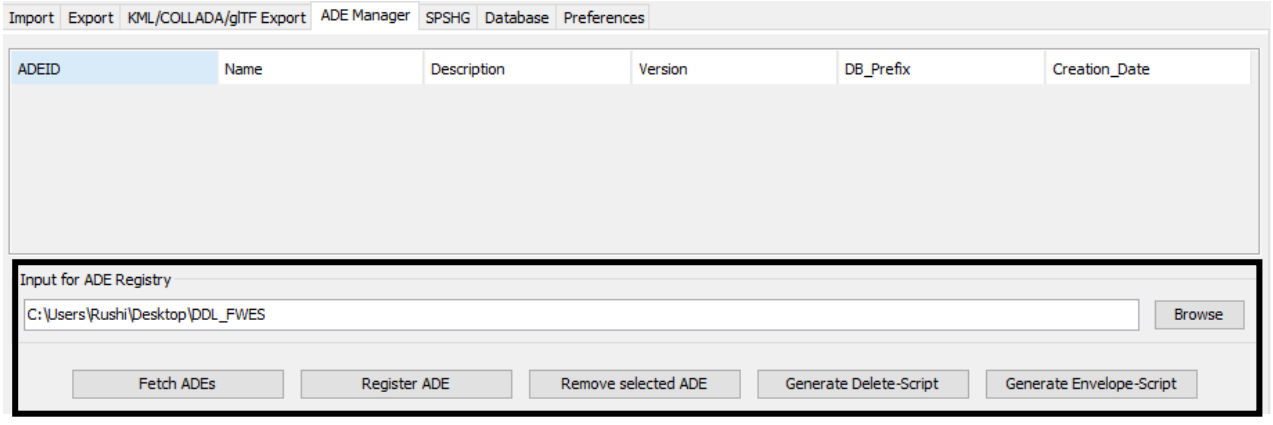

Figure 3: Registering FWE ADE with PostgreSQL

The output location mentioned in step 1 where ADE specific schema mapping file and DDL scripts were produced must be specified here as the input location. On

clicking Register ADE, schema mapping file and DDL script for PostgreSQL will be executed creating ADE specific tables in the database.

While performing the ADE registration process, the ADE database schema is first created, and the metadata information provided during step 1 is subsequently written to the 3DCityDB metadata tables. Additionally, the database stored functions and procedures, e.g. DELETE script and ENVELOPE script will also be newly generated. After the ADE has been successfully registered, a list of all ADEs registered in the 3DCityDB instance, and their relevant meta-information is shown in the ADE information panel. Figure 4, as below, shows the registration of all the thematic modules of FWE ADE.

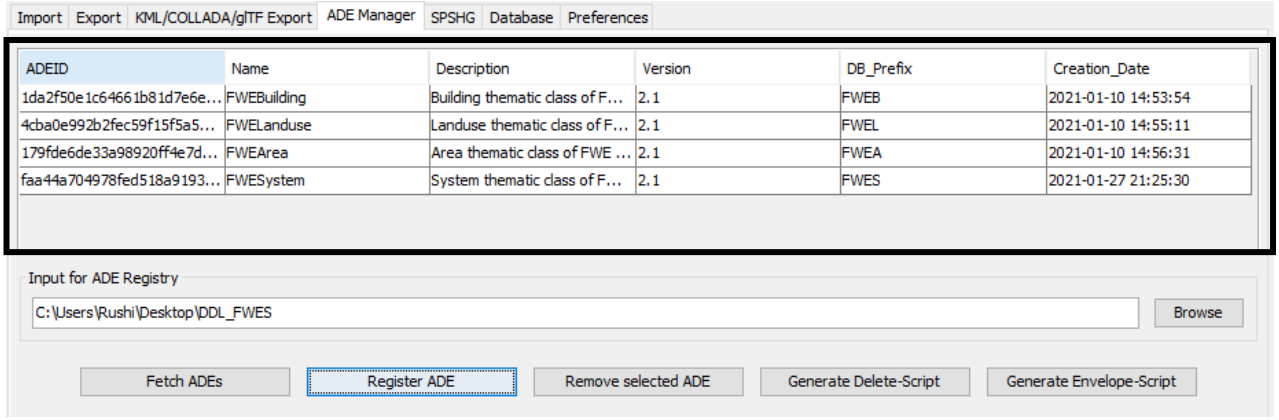

Figure 4: FWE ADE registered with PostgreSQL

Registration of the FWE ADE can also be confirmed using PgAdmin client for PostgreSQL. ADE specific tables are created with initials as specified in the DB_Prefix during step 1.

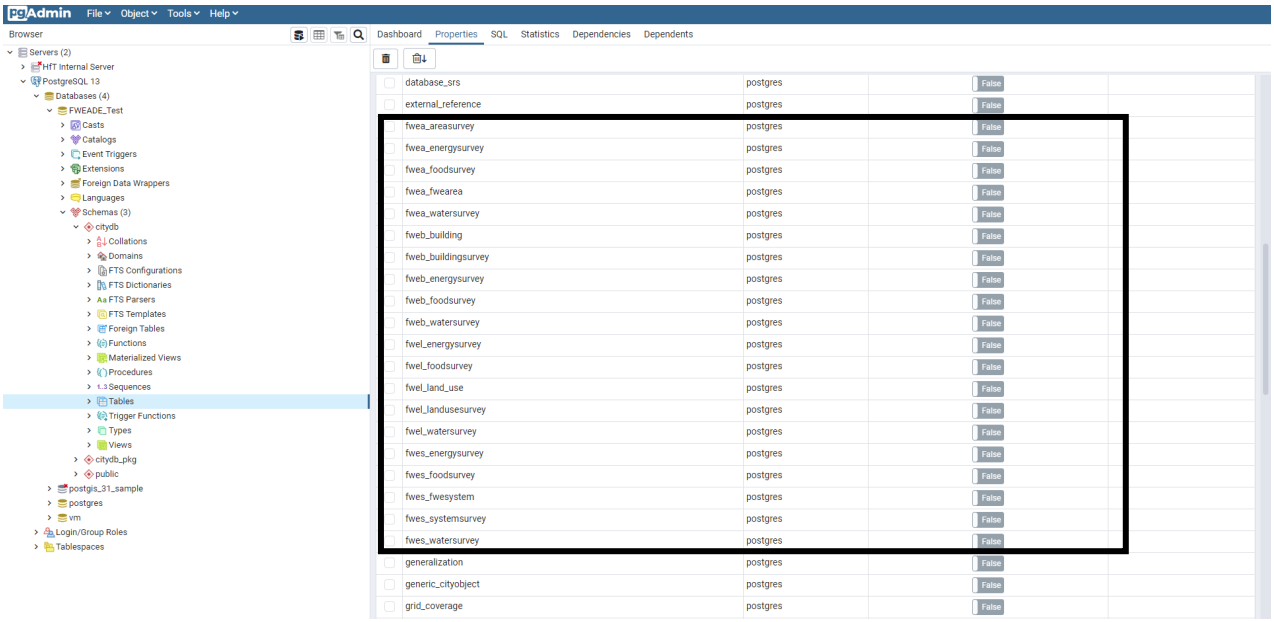

Figure 5: FWE ADE tables as seen using PgAdmin

References

- Bao, K., Padsala, R., Coors, V., Thrän, D., and Schröter, B. (2020). GIS-Based Assessment of Regional Biomass Potentials at the Example of Two Counties In Germany. 10.5071/28thEUBCE2020-1CV.4.15.
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