D4.4 Prototype 3-D GIS city model of Vejle with GHG emissions from installed sensors

Carbon Track and Trace (CTT2.0)

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Contents

1. Introduction

This document describes the deliverable D.4 in WP4 of CTT2.0. First an overview about the used data and its integration into the system is given, followed by a system diagram. In addition, a link between CTT2.0 and 3DGPC, which is another LoCaL project, is made.

The collaboration within this task of the CTT project was designed to understand initial technical challenges and develop a prototypical integration as a possible visualization for cities to interact with the CTT measurement data.

The implemented prototype shows the capabilities of integrating (live) sensor measurements such as GHG emissions into virtual 3D city models. Thus, the prototype informs about the sensor locations together with their measurements in the city. If the sensors are installed in different heights, then the third dimension of the visualization may be utilized. In addition, the sensor measurements may be visualized in 3D, e.g. by a three-dimensional bar at the sensor location.

2. Data & Data Integration

Description of Data

As input data for the 3D prototype both the virtual 3D city model and a digital terrain model (DTM) of the City of Vejle were available. Both datasets are available as open-data[1,2] from city and national repositories and thus can be used for free. The DTM was provided as ESRI ASCII grids, a well-known raster GIS file format. The city model was provided as a Microsoft Access database, which then in turn contains the actual city model of individual buildings. The city model covers the centre (midtby) of Vejle (Figure 1) and contains 3614 buildings. The model describes the buildings' outer geometry (LOD2, Level of Detail 2, meaning a simplified outer shell) without any further subdivision of the buildings or any additional attribute information or metadata on type of buildings etc. The sensor data was available via access to the database storing the Vejle sensor measurements, provided by NTNU.

[1] http://download.kortforsyningen.dk/content/dhm-2007terr%C3%A6n-16-m-grid
[2] http://data.vejle.dk/dataset/3d-bymodel-af-vejle-og-centerbyer

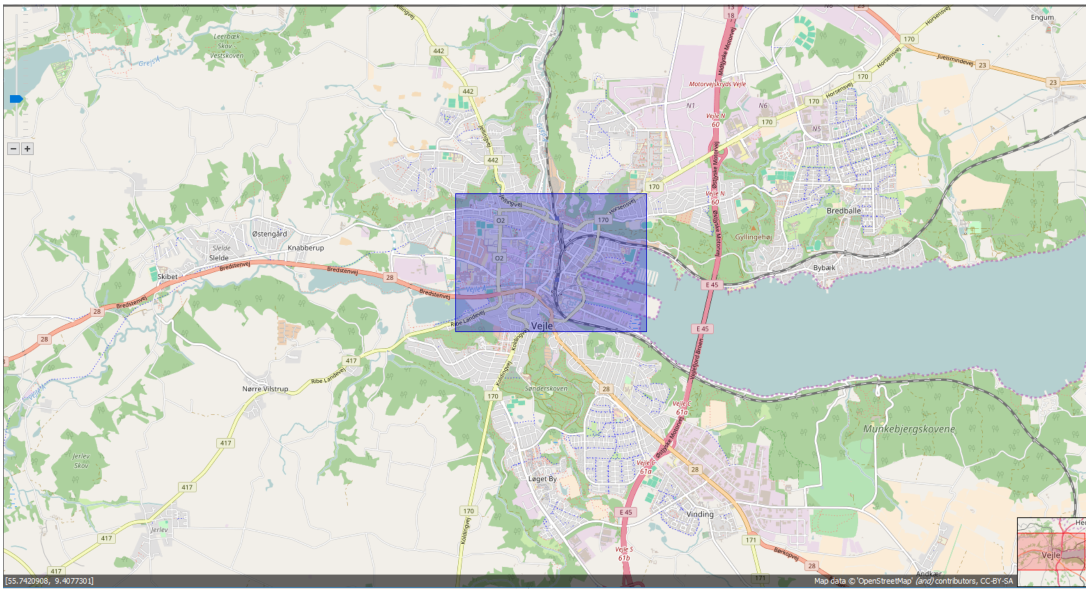

Figure 1. Coverage of the provided city model (blue rectangle).

Data Integration

In order to integrate the data (city model and terrain) into the software solutions of virtualcitySYSTEMS, both spatial datasets needed to be transformed to CityGML (a main open standard to describe 3D city models[3]). For visualization purposes within a web browser, the datasets needed to be additionally transformed into streaming formats supported by the virtual web-globe Cesium.

In order to transform the city model into the streaming format, the model was transformed to standard-compliant CityGML first through an automated process that needed to be set up and then imported into the virtualcityDATABASE. Based on this internal database the city model was transformed into the streaming format to be used for the web-based visualization. Both datasets were compiled into the specific virtualcityMAP CTT_Sensor_Demo_Vejle application, which is a web-based application that combines 3D geo-portals with application-specific features (Figure 2). As can be seen in the figure, it combines the shaped and coloured terrain model with the buildings from the city model that are set on the ground. The application further defines the integration and visualization of sensor values by providing for access to the sensor locations in the 3D model and to the actual measurements.

[3] http://www.opengeospatial.org/standards/citygml

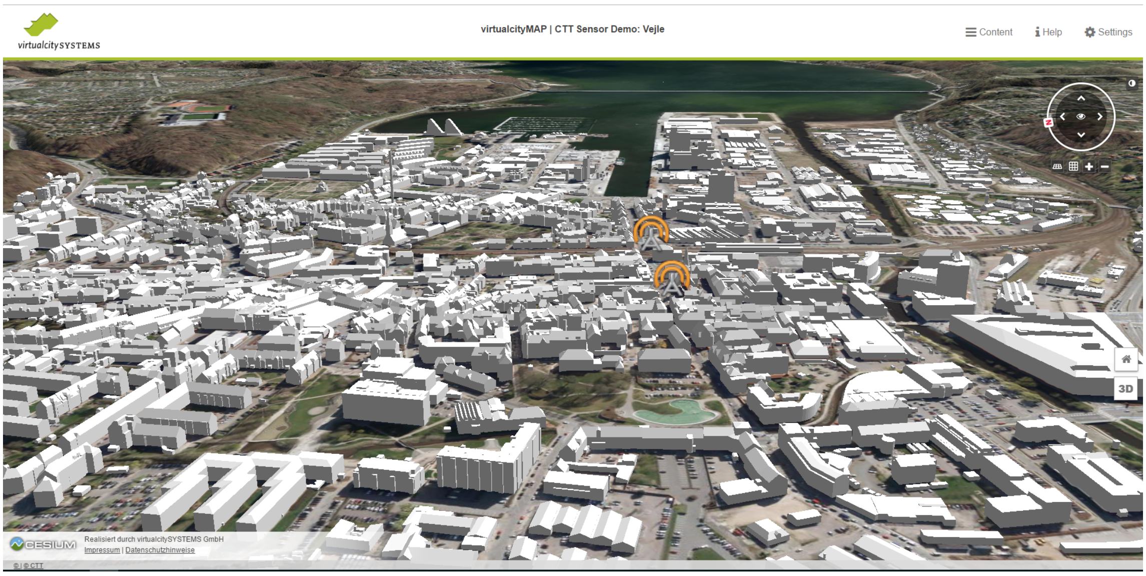

Figure 2. virtualcityMAP visualizing the 3D city model and the sensor locations.

The sensor measurements are integrated into the application on the fly. For that, a web-service, which queries and returns the sensor locations and the measurements aggregated over the last 24 hours from the database, was developed and set up. This web-service is queried by the virtualcityMAP application, which visualizes the measurements by line-graph as shown in figure 3.

The prototype is available at:

http://hosting.virtualcitysystems.de/demos/vejle-sensor-demo/

Figure 3. By clicking a sensor symbol its measurements are visualized in a graph.

Figure 4 visualizes the system architecture of the prototype. It shows the transformation steps needed to create the virtualcityMAP application as well as the queries in order to fetch the sensor information.

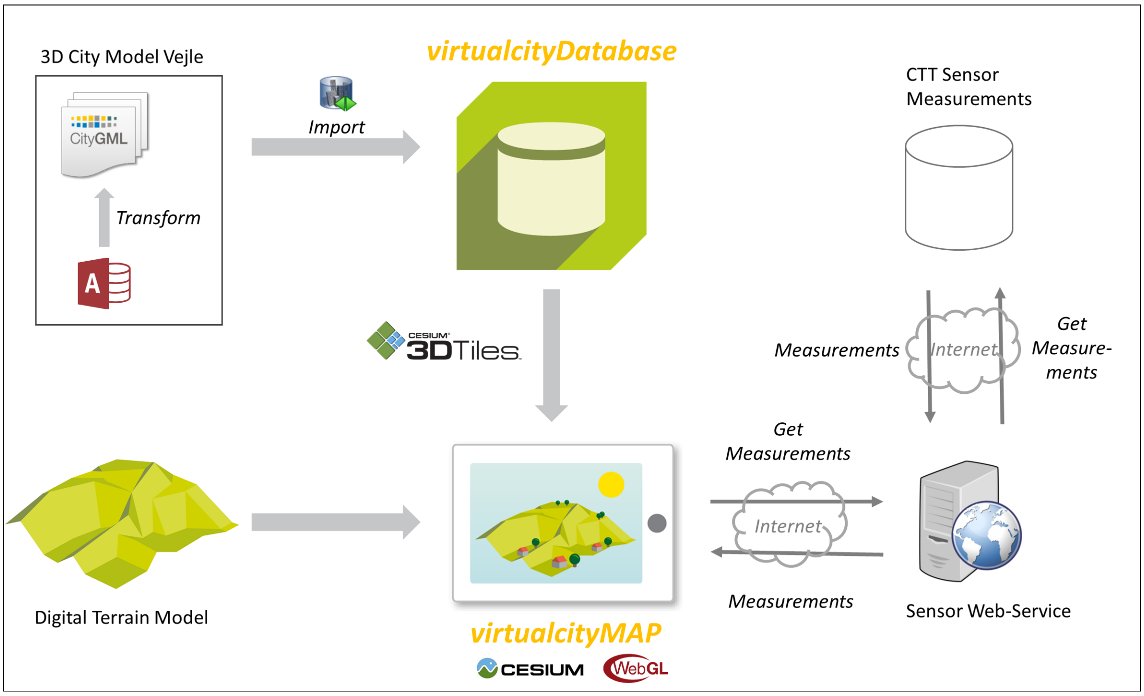

Figure 4. System architecture of the prototype.

Trondheim City Model

For the prototypical deliverable we focused on the City of Vejle instead of Trondheim. Although both cities provide a virtual 3D model, the one provided by the City Trondheim[4] cannot be transformed to CityGML easily. The model is based on 3ds Max and there are no known complete transformation tools to CityGML, so this would mean a lot more development time and effort that was available within this task. On the other hand, the transformation of the Vejle city model could mostly use existing transformations and needed only little manual intervention. Hence, to spend not too much time in transforming the models, we focused on the model of Vejle. Figure 5 shows a visualization of the Trondheim model.

Figure 5. The virtual 3D city model of Trondheim. (http://trondheim2030.no/2015/11/09/ny-tredimensjonal-modell-av-trondheim-gjor-det-enklere-a-planlegge-framtidas-by/)

4. Reference to 3DGPC

This prototype has some links to the LoCaL project 3DGPC. 3DGPC developed a prototype that provides energy information of public buildings in the City of Helsinki. For that, Helsinki provided a CityGML based virtual 3D city model and energy performance data of public buildings (mostly schools). In addition, the demonstrator is able to calculate a GHG report (GPC) based on this data. Thus, it is possible to get information about single buildings as well as the whole city (resp. the city owned buildings) (Figure 6 and 7). Thus, both demonstrators show environmental information in cities over time. In addition, the demonstrators' architectures share some similarities.

[4] https://data.norge.no/data/trondheim-kommune/digital-3d-bymodell-deler-av-trondheim-kommune

In future research, it may be of interest to combine the two prototypes in order to show 'live' information of GHG measurements (for instance inside buildings and on the streets) as well as aggregated information over several years. Based on this it may be possible to develop emission reduction plans based on historical data and better monitor the decisions made and their implications by live sensor information.

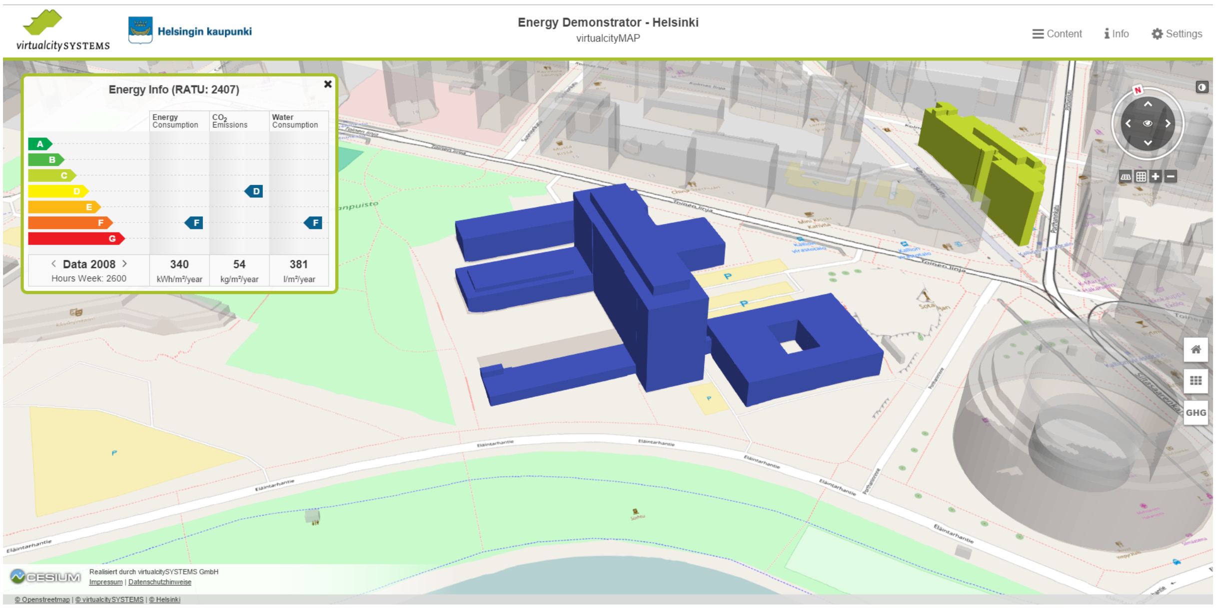

Figure 6. Energy performance (energy, CO2, water) of a single building. It is possible to browse through different years.

Figure 7. A GPC report calculated based on the CO2 emission data of public buildings.

5. Scalability and Future Extensions

If certain preconditions are met, the demonstrator can be scaled to other cities. First, the virtual 3D city model of a candidate city need to be available in the international OGC standard CityGML or in a format which can be transformed to CityGML easily. Based on this, virtualcitySYSTEMS offers mature tools for the creation of web-applications (virtualcityMAP). The integration of additional information such as sensor measurements is straightforward, if the information is encoded in GeoJSON (e.g. via a web-service). If energy information is available on the building level, it is even possible to combine this demonstrator with the one developed in 3DGPC.

The current model visualizes point-based measurements. With work in CTT going forward, future models developed there may yield GHG mapping that could be overlaid into the 3D city model and show real-time calculated GHG maps, with the possibility to interact with it to get the original raw measurements as in the current prototype.

There further exists the option to test different visualizations, both static and dynamic, for the visualization and finally for the use of cities within planning processes in combination with other data visualization tools. A possibility would also to include traffic data that is initially explored in D3.2, once the analyses generated there are more robust and real-time-enabled.

As noted above, the integration of sensor-based measurements and building energy characteristics could be a beneficial combined visualization. Another approach would be to combine different datasources to add metadata to the buildings, to better estimate their energy use and emissions, for example by type of building, type of industry, or number of dwelling units.

With more sensor data becoming available, the prototype can be extended to include additional locations easily, with the extension to scaling to larger cities in line with the CTT development.