Workshop on 3D City Models and Urban Simulation

V. Coors, Hyderabad, 21.-22.12.2022

One of the most important tasks of the future is the development of city concepts that are sustainable, energy-efficient and make living in cities worthwhile

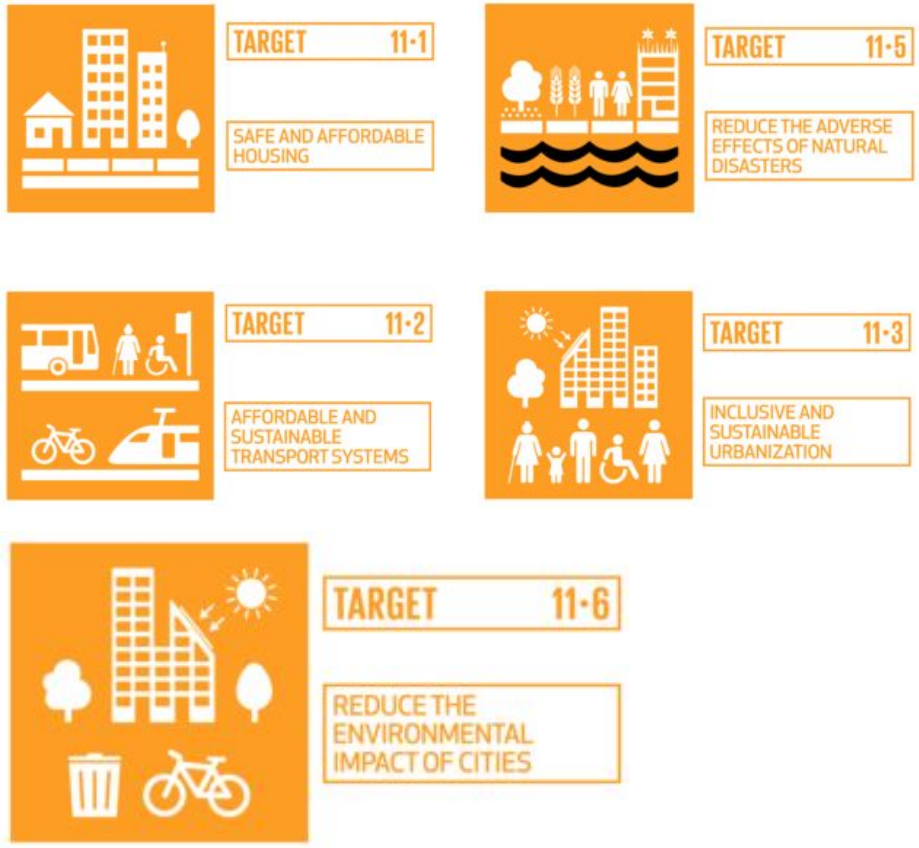
Trend 1: CITY

- Cities account for 75% of the CO_2 emissions
- further trend towards urbanization in the metropolitan regions world wide
- 2050: 70% of the world population will live in cities
- SDG 11: Make cities inclusive, safe, resilient and sustainable

Trend 2: TECHNOLOGY

- digital transformation, IoT (Internet of Things), electro-mobility, decentralized energy supply

- A sustainable urbanization (*trend 1*) can be developed successfully through new technologies (*trend 2*).
- This results in new business models for industry and commerce and further improving the development of climate protection activities at the same time.



SDG 11 has an impact on many other SDGs

> If we want to have a chance of achieving the SDGs, we need to get our cities right.
> – Maimunah Mohd Sharif (2018), Executive Director of UN-Habitat

JPI Urban Europe: Driving Urban Transitions

The 15-minute City Transition Pathway (15mC)

The Positive Energy Districts Transition Pathway (PED)

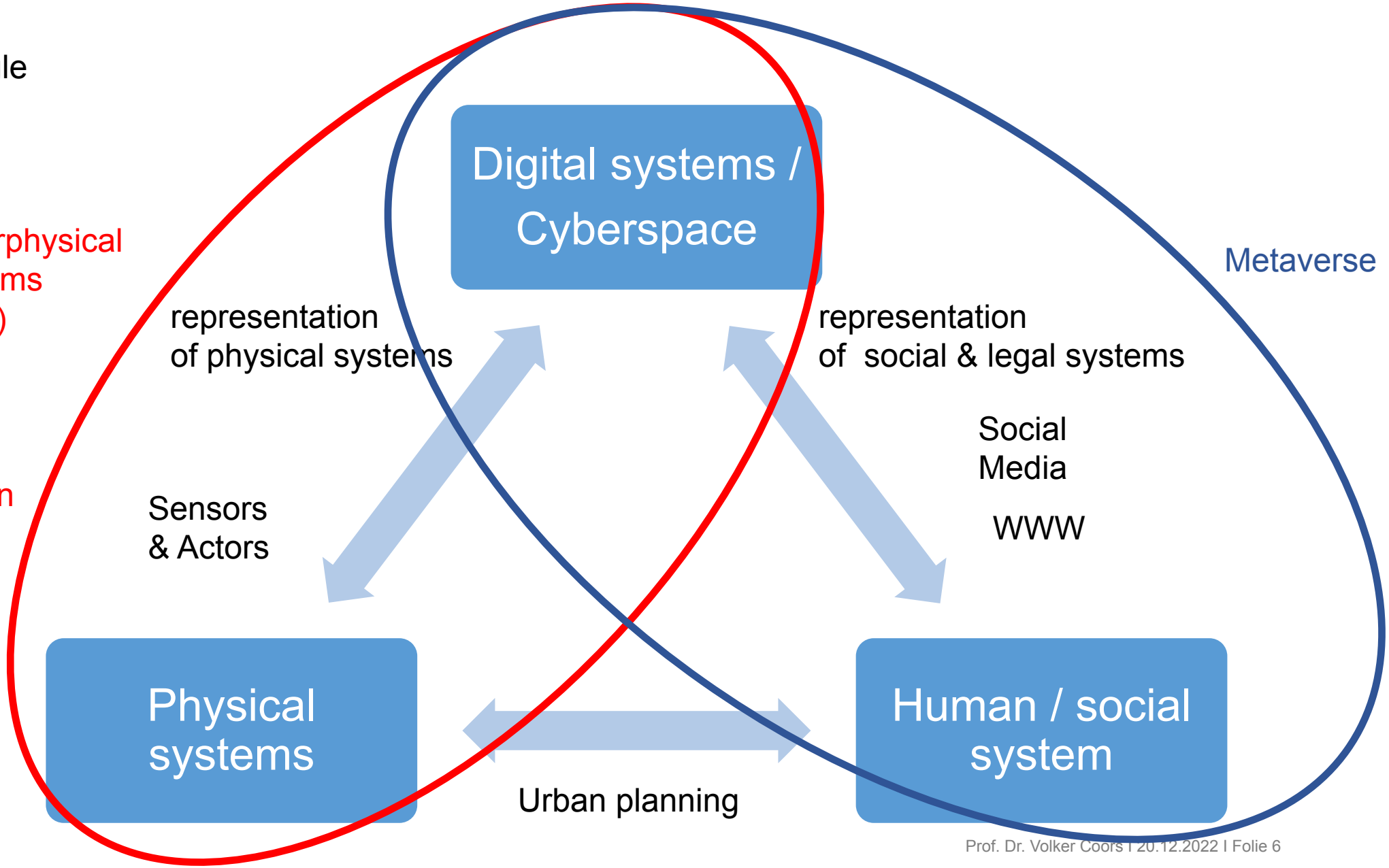
The Circular Urban Economies Transition Pathway (CUE)

https://dutpartnership.eu/

https://jpi-urbaneurope.eu/

Our contribution: Urban Digital Twin

Smart City Triangle



Digital Twins at Urban Scale

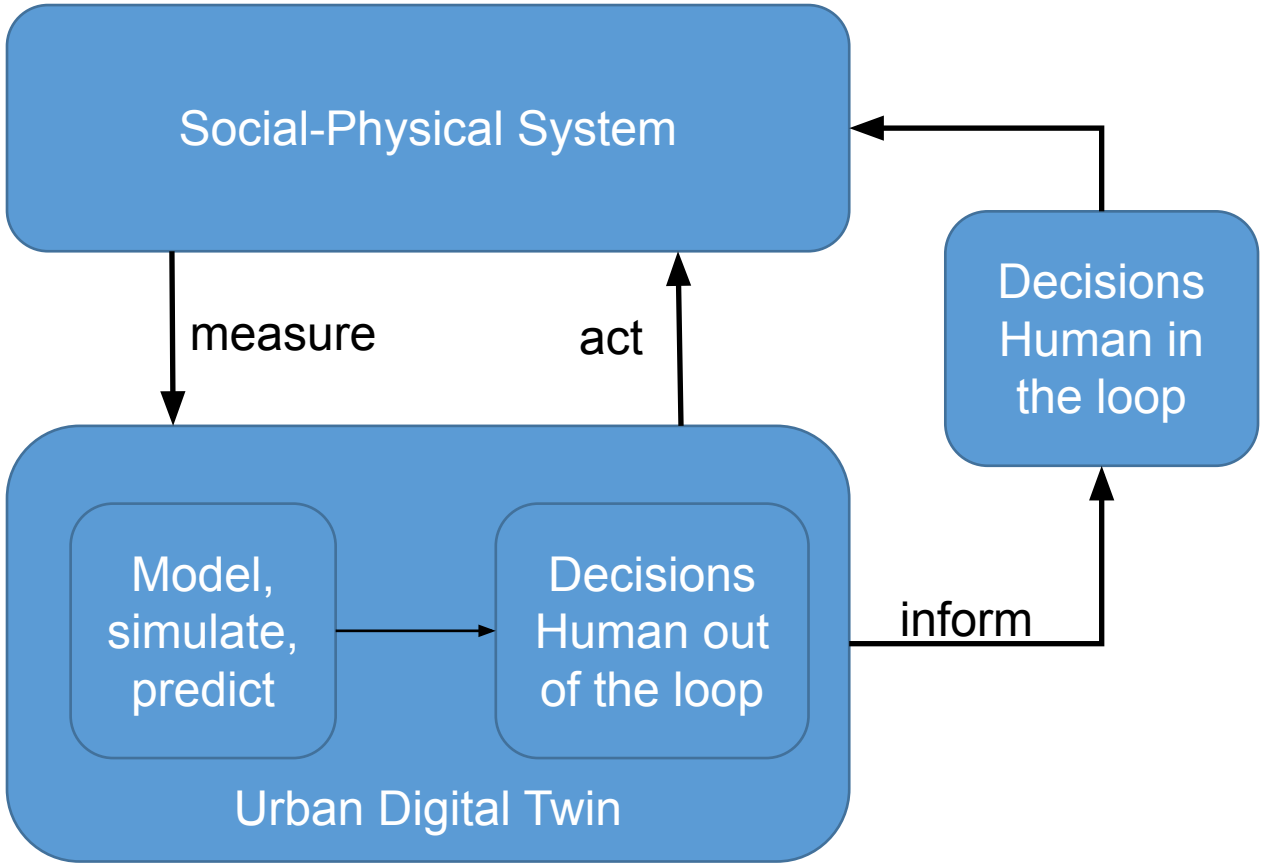
Digital twins are digital representations of things from the real world. Urban Digital Twins (UDT) focus on the representation of the built environment at urban scale.

They describe both physical objects and non-physical things such as processes by providing all relevant information and services through a unified interface. For the urban digital twin, it is irrelevant whether the counterpart already exists or will exist in the real world.

The purpose of UDTs is to improve the planning and management to achieve more inclusive, safe, resilient and sustainable urban environments.

Digital Twins at Urban Scale

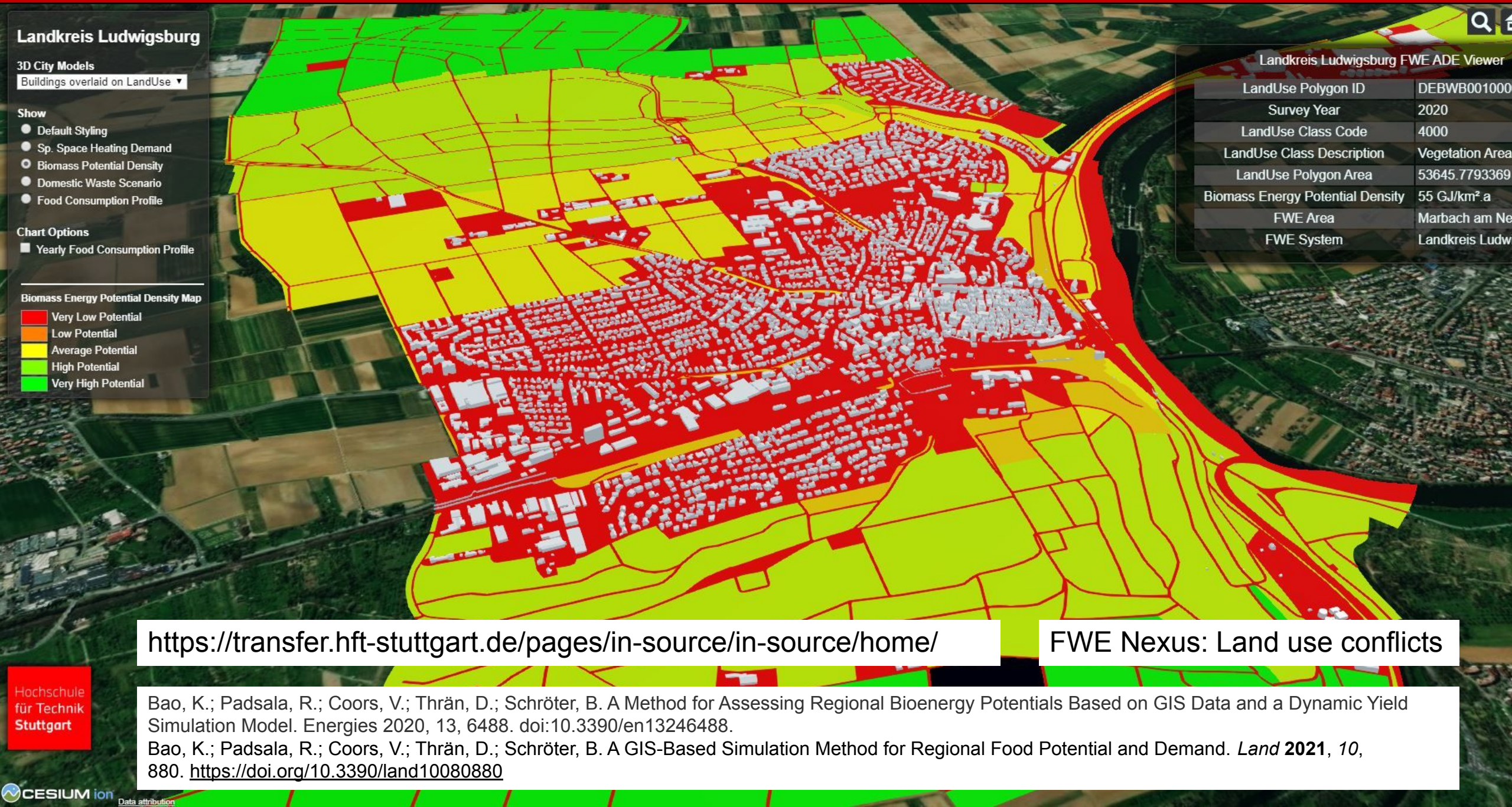
- Geospatial Technology
  - City Information Model
  - Spatial data analytics
    - Visual analytics
    - AI, predictive
- Sector specific UDTs
  - Energy, Water, Mobility
- Integration of UDTs
  - System of Systems approach



Based on J. Morley, Ordnance Survey, UK (extended)

CityGML as City Information Model

- CityGML 3.0: Conceptual model
  - Lingua franca of UDTs
- Covers most relevant features of the urban environment
- Domain specific extensions
  - Example: CityGML Energy ADE
- Encoding depends on the overall system architecture
  - CityGML XML encoding
  - CityJSON (JSON encoding)



https://transfer.hft-stuttgart.de/pages/in-source/in-source/home/

FWE Nexus: Land use conflicts

Hochschule für Technik Stuttgart

Bao, K.; Padsala, R.; Coors, V.; Thrän, D.; Schröter, B. A Method for Assessing Regional Bioenergy Potentials Based on GIS Data and a Dynamic Yield Simulation Model. Energies 2020, 13, 6488. doi:10.3390/en13246488.

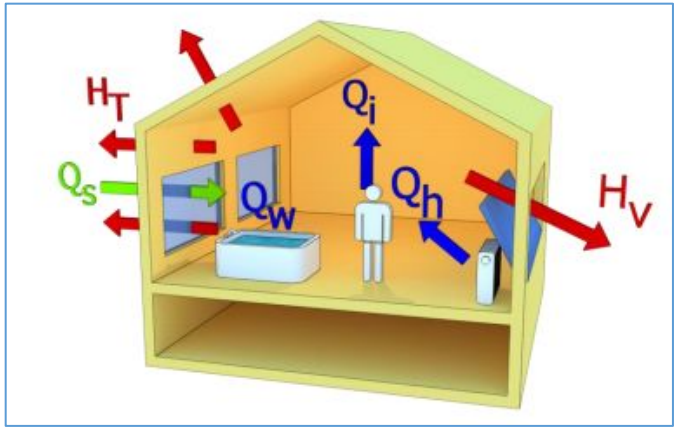
Bao, K.; Padsala, R.; Coors, V.; Thrän, D.; Schröter, B. A GIS-Based Simulation Method for Regional Food Potential and Demand. *Land* **2021**, *10*, 880. https://doi.org/10.3390/land10080880

Urban Energy Simulation

SimStadt

- Input Data:
  - CityGML Model ++
    - Building and Land use
  - Building Typology
  - Weather / Climate model

- Output
  - Heating / Cooling demand per building
  - District heating layout
  - CO_2 emissions based on Energy System
  - Potential of renewable energy
    - Photovoltaik, Biomass, Domestic hot water
  - New workflows such as food demand can be added



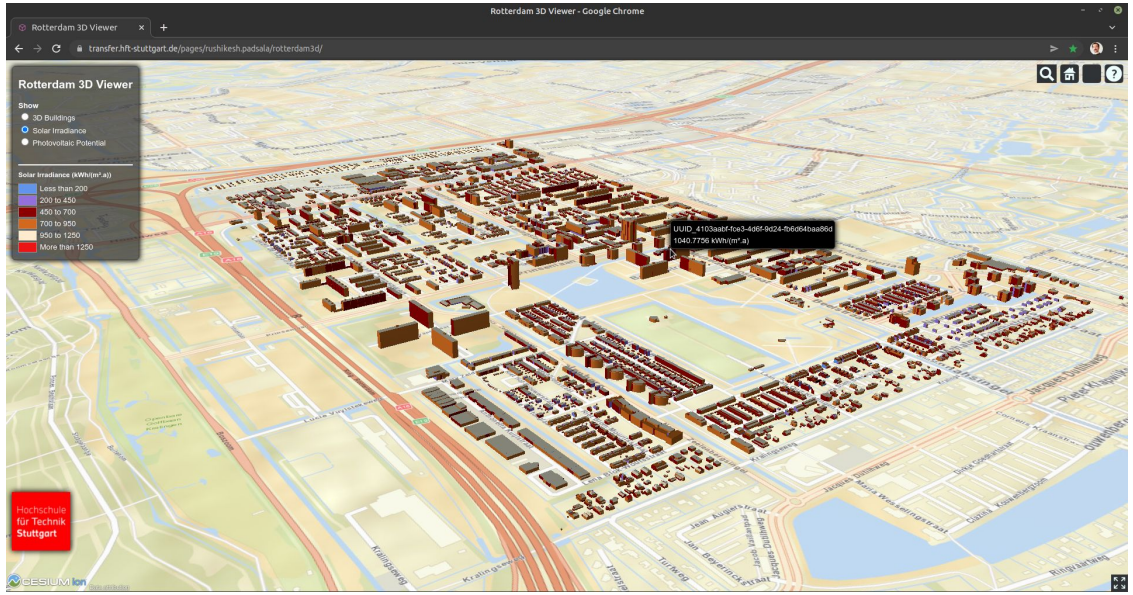
http://simstadt.hft-stuttgart.de

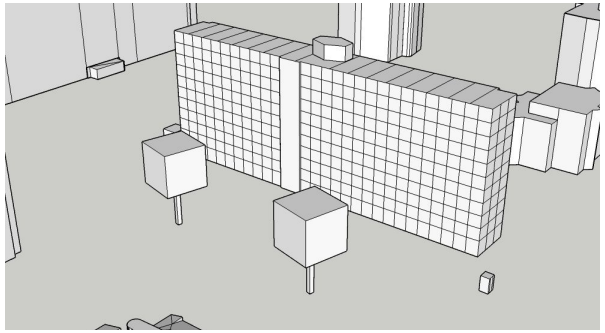
Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

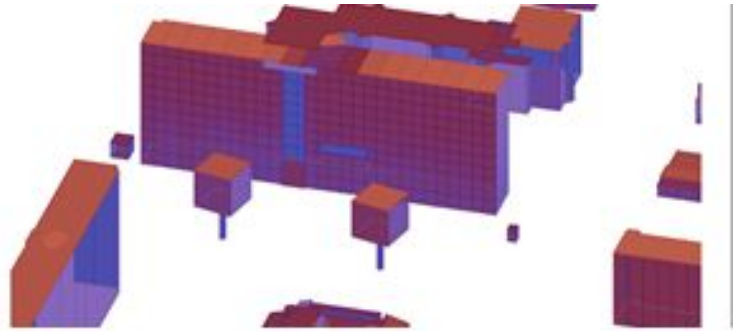

Rosensteinviertel 3D Viewer
Show
3D Buildings
Solar Irradiance
D3_02_15__facade3_136_8_5
824 kWh/(m².a)
Hochschule
für Technik
Stuttgart
https://transfer.hft-stuttgart.de/pages/rushikesh.padsala/rosensteinviertel3d/
Solar Irradiance (kWh/(m².a))
0
200
400
800
1000
>1200

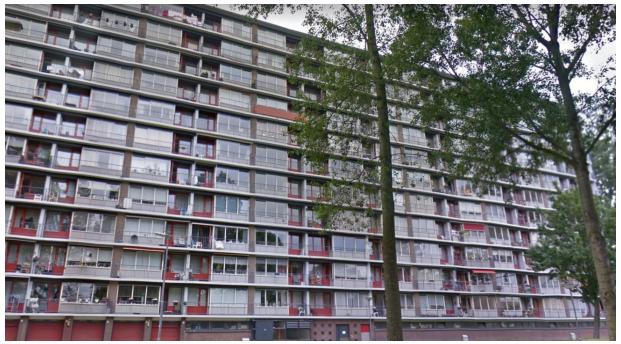
Rotterdam Solar (rooftop & facades)

Rooftop: point clouds (SAGA GIS)
Facades: 3D Building Geometry



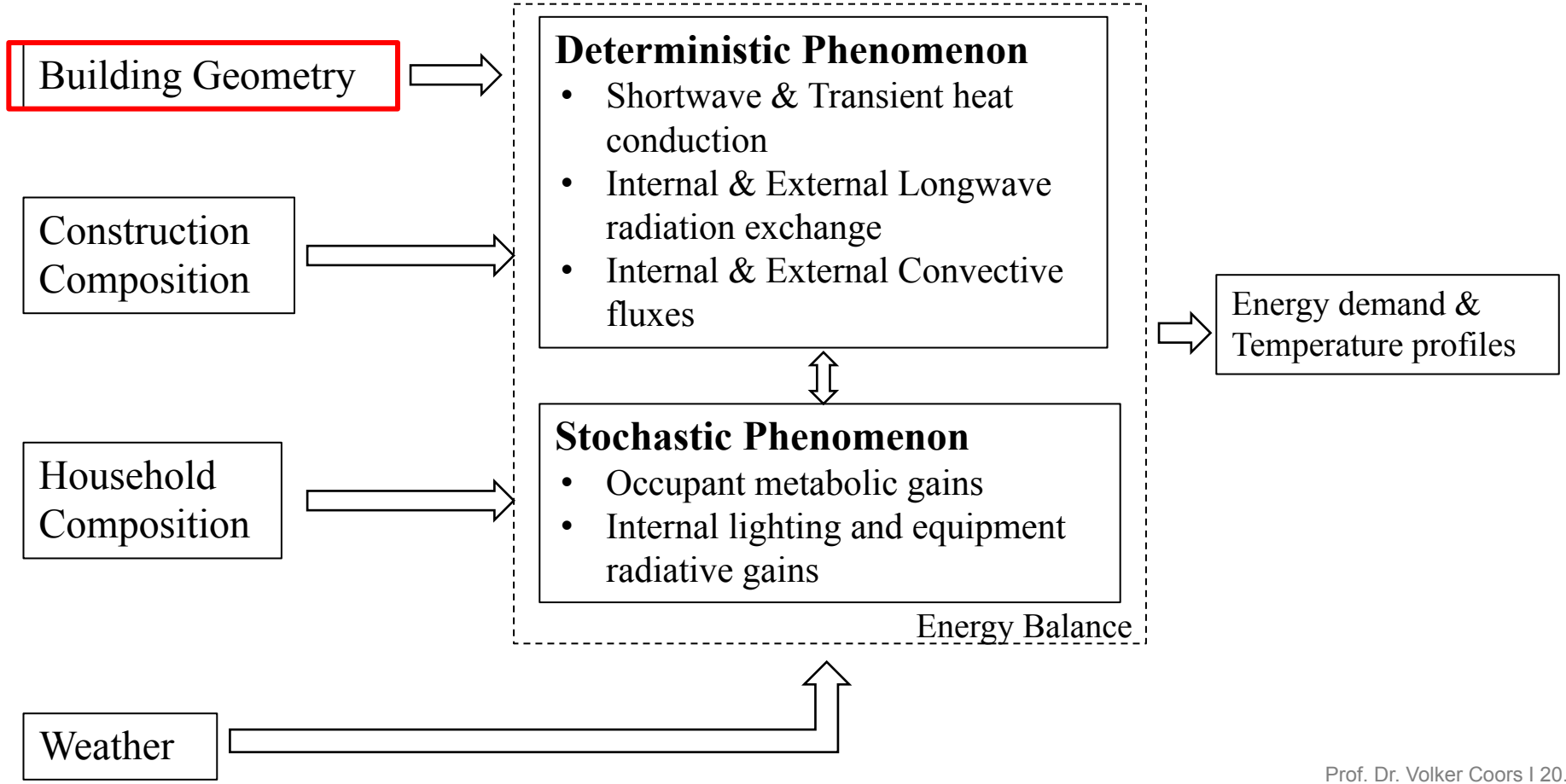


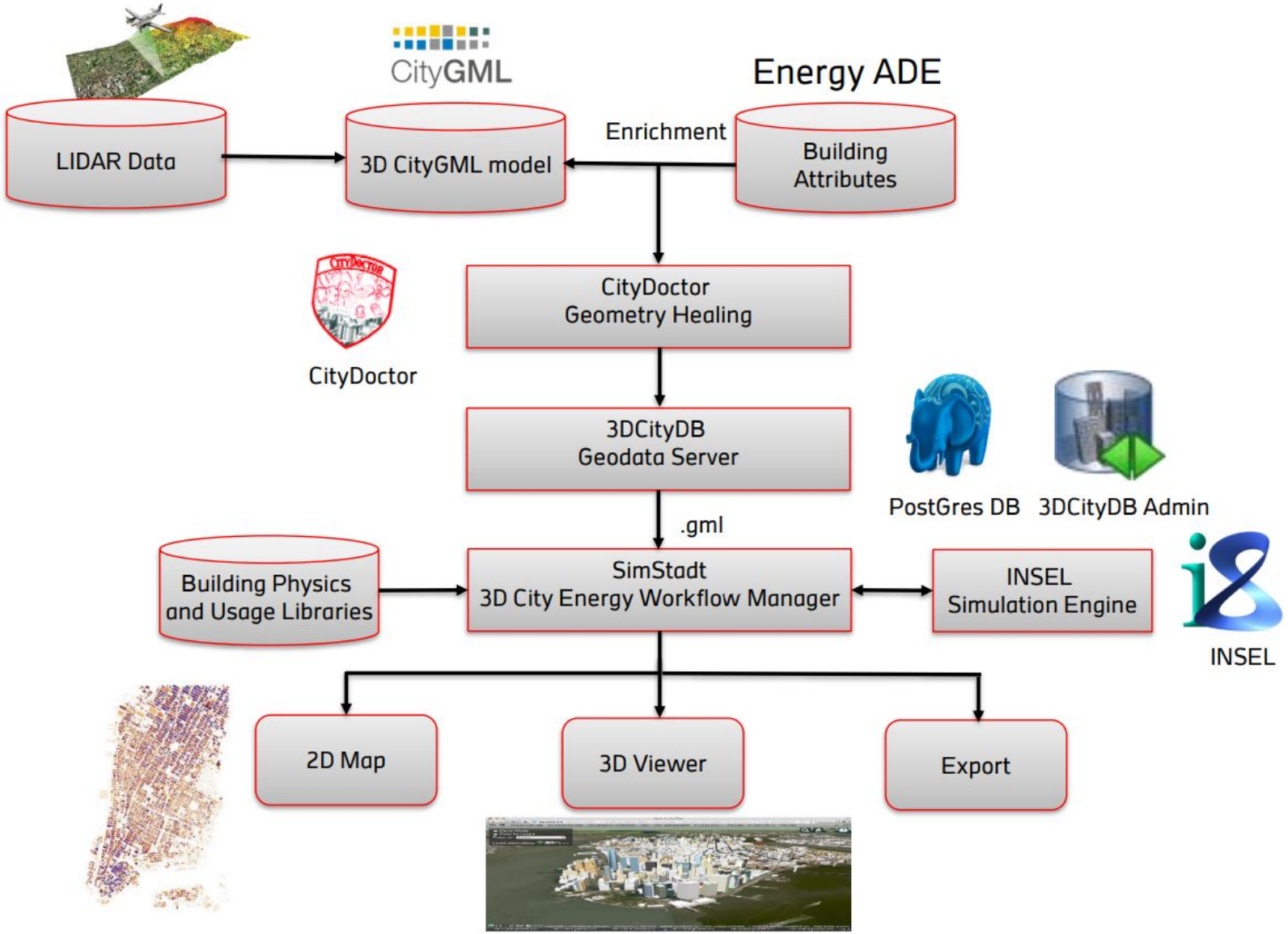




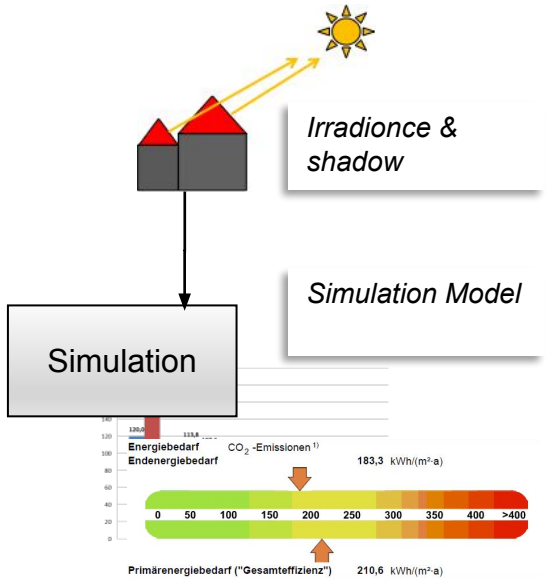
https://transfer.hft-stuttgart.de/pages/rushikesh.padsala/rotterdam3d/

Heating / Cooling demand




LIDAR Data
CityGML
3D CityGML model
Enrichment
Energy ADE
Building Attributes
CityDoctor
CityDoctor Geometry Healing
3DCityDB Geodata Server
PostGres DB
3DCityDB Admin
.gml
Building Physics and Usage Libraries
SimStadt 3D City Energy Workflow Manager
INSEL Simulation Engine
INSEL
2D Map
3D Viewer
Export

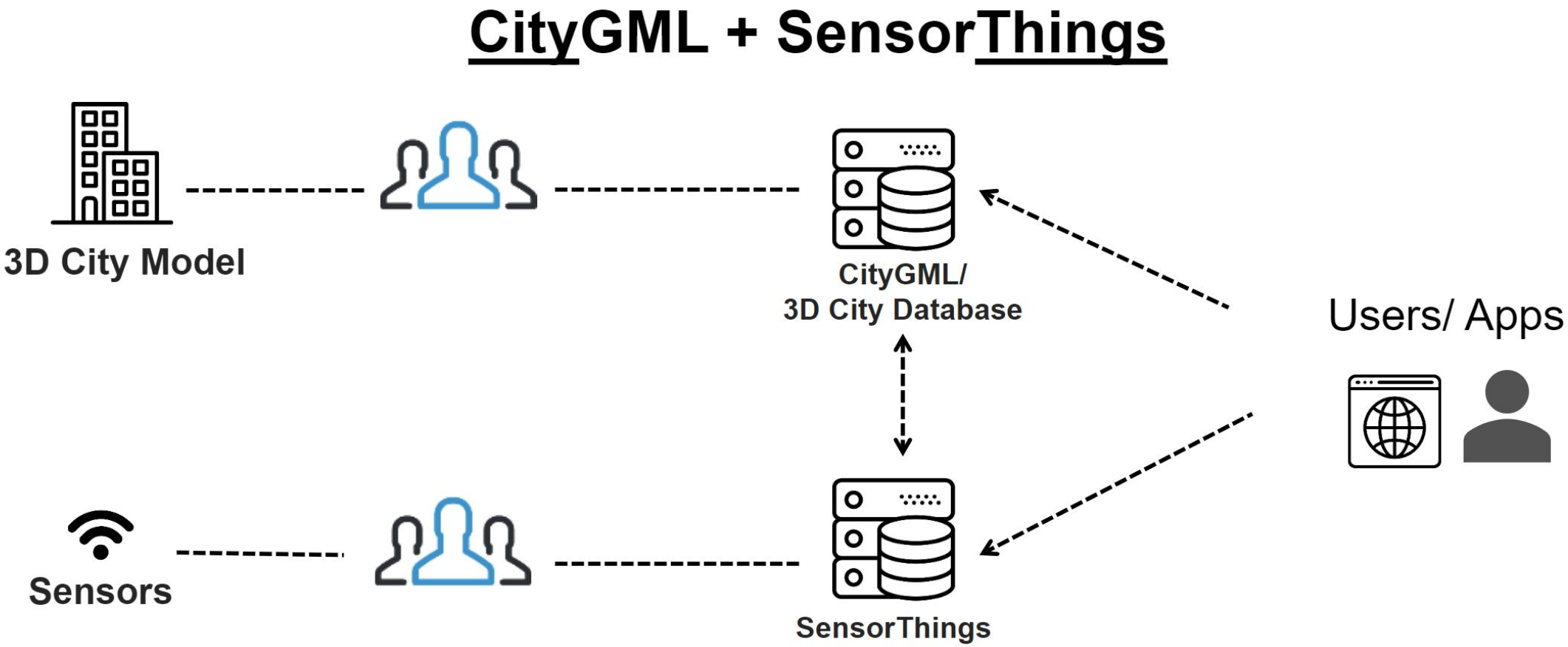

SimStadt


Irradionce & shadow
Simulation Model
Simulation
Energiebedarf
Endenergiebedarf
CO2 -Emissionen 1)
183,3 kWh/(m²·a)
0 50 100 150 200 250 300 350 400 >400
Primärenergiebedarf ("Gesamteffizienz")
210,6 kWh/(m²·a)

https://kartta.hel.fi/3d/heating/Apps/Helsinki/view.html

Rossknecht, M.; Airaksinen, E. Concept and Evaluation of Heating Demand Prediction Based on 3D City Models and the CityGML Energy ADE—Case Study Helsinki. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 602.

City Things



Santhanavanich, T.; Coors, V. CityThings: An integration of the dynamic sensor data to the3D city model. Environment and Planning B: Urban Analytics and City Science2021, 16 pp , https://doi.org/10.1177/2399808320983000

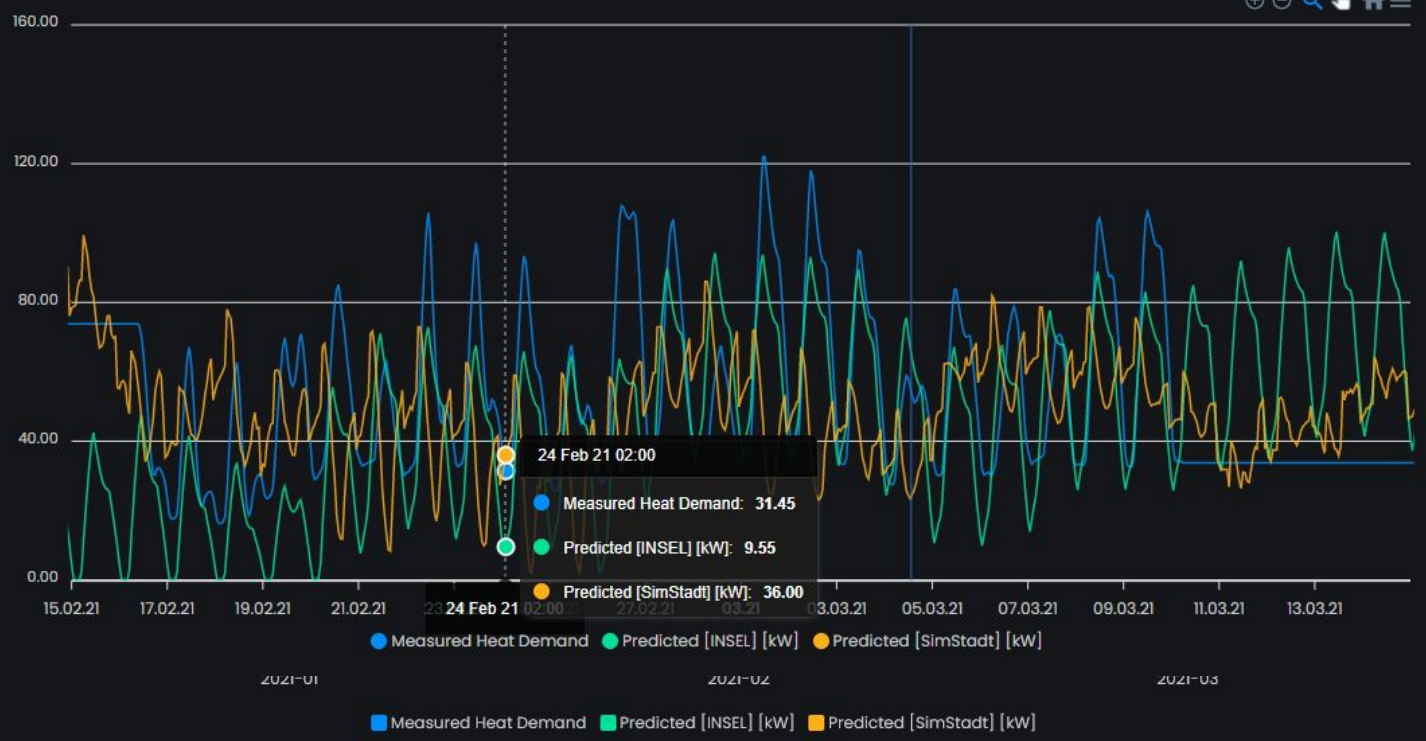
Project NeqModPlus

In the project NeqModPlus we developed models and tools to simulate energy demand and different energy generation systems of buildings and city quarters that can help reach the goal of zero carbon emissions. One of the case studies is a new building of the inner-city campus of the University of Applied Sciences in Stuttgart, Germany. Here we have measured data and can compare this with our models. In this visualization, we compare the measured heating demand with the results of two different simulation models that vary in their complexity. The complex model is a dynamic calibrated white box model that is described in [1]; the other is a steady-state simulation [2] according to German norms DIN V 18599 and VDI 4710. Both simulations include detailed building physics data as well as locally measured weather data; the steady-state simulation also uses the calibration results of the dynamic model for temperature setpoints and schedules.

[1] P. Monsalvete Alvarez de Uribari, and V. Coors: A dynamic model for district-scale building demand simulation, Proceedings Dynastee Symposium The Building as the Cornerstone of our Future Energy Infrastructure, 10-11.4.2019 Bilbao, Spain.
[2] https://simstadt.hft-stuttgart.de/

Measured/Simulated Heat Demand

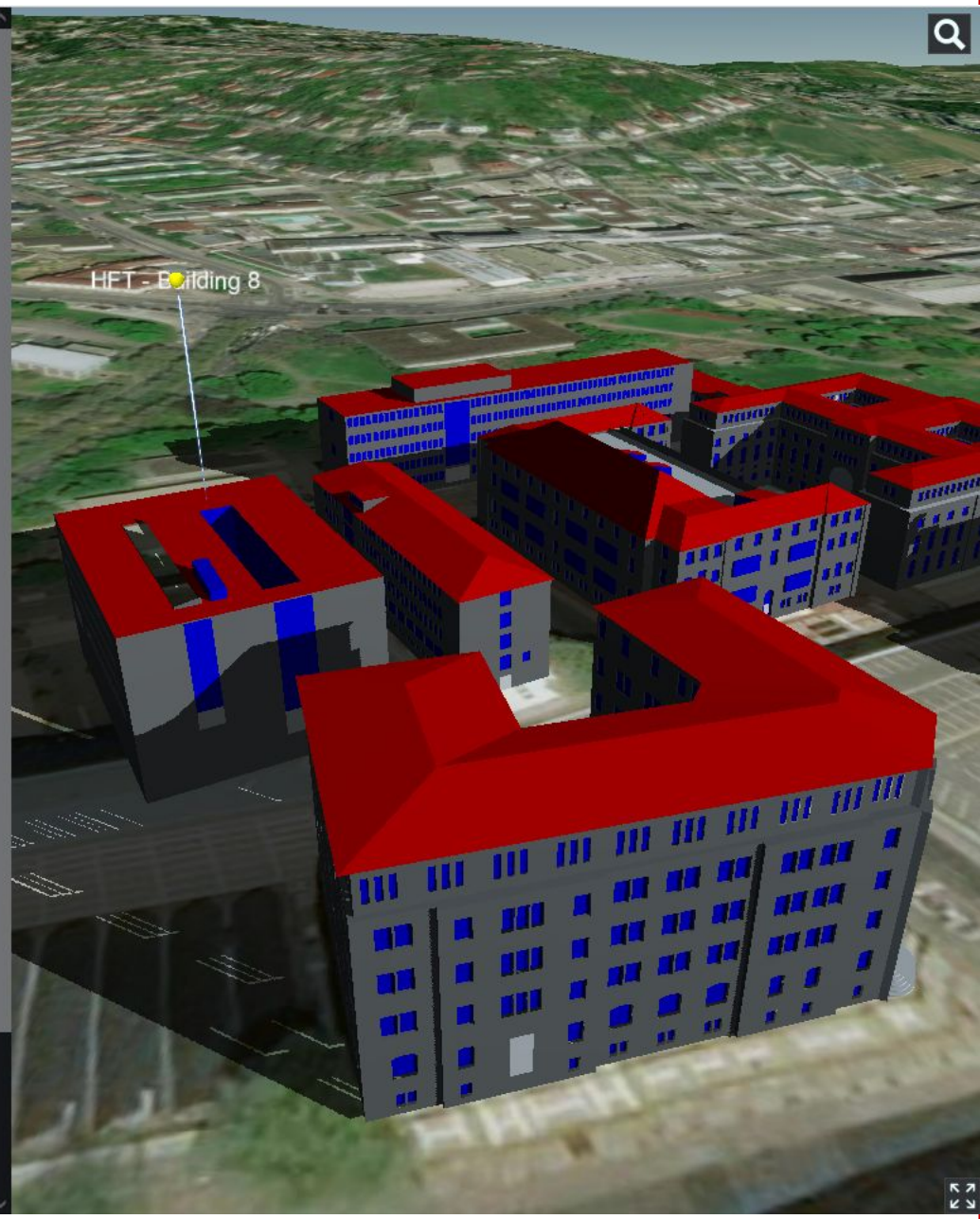
Select Sampling Rate: Hourly



Dataset Explanation

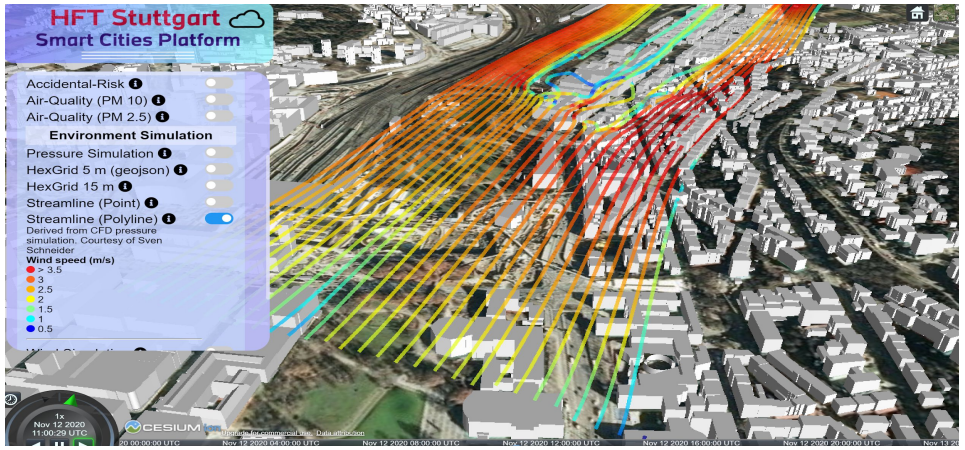
- Measured Heat Demand [kW]: Heating power demand from four heat meters in HFT building 8.
- Predicted (Dynamic White Box Model) [kW]: Simulated heating power demand based on a complex simulation model.
- Predicted (Simplified Steady State Model) [kW]: Simulated heating power demand based on a simulation model with reduced complexity.

Result Interpretation

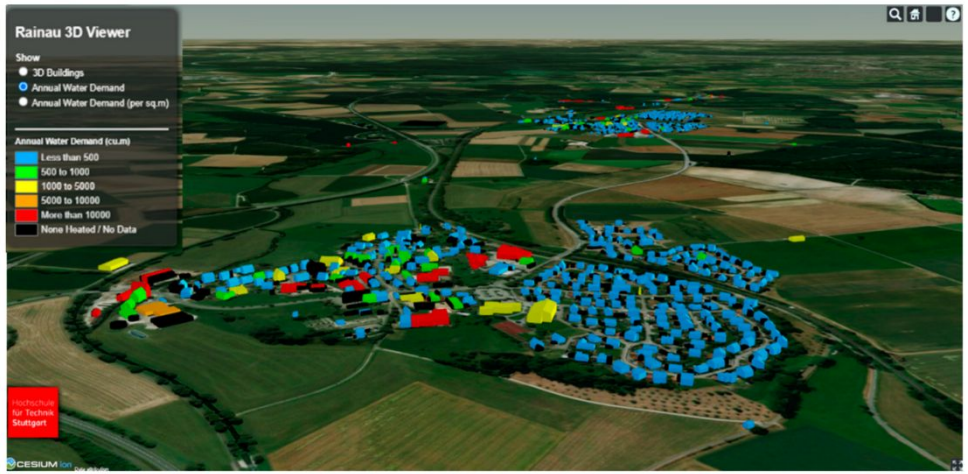


Cross-Sector Data Integration

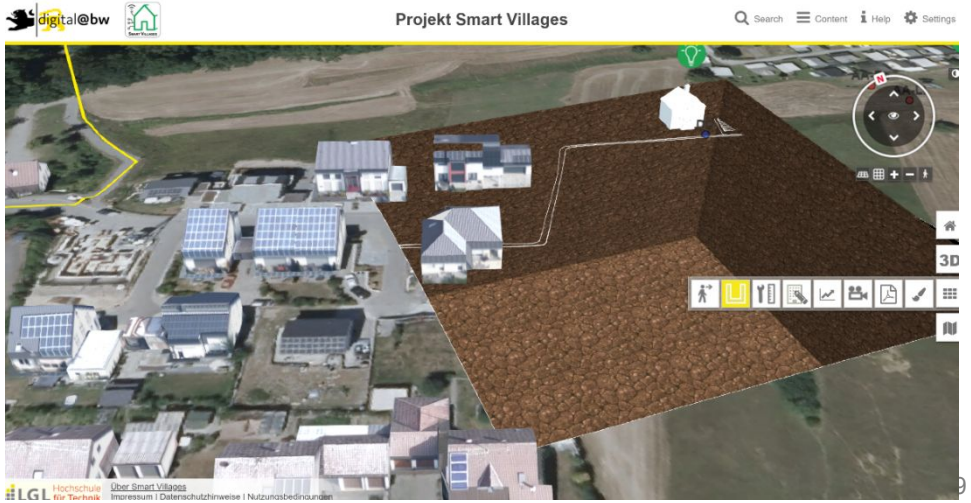
CO2 Emissions Traffic and Building Sector
H. Ebrahim: Concept and Evaluation of an Urban Platform for Interactive Visual Analytics, Master HFT Stuttgart



Deininger et al.: A Continuous, Semi-Automated Workflow: From 3D City Models with Geometric Optimization and CFD Simulations to Visualization of Wind in an Urban Environment. ISPRS Int. J. Geo-Inf. 2020, 9, 657. doi:10.3390/ijgi9110657



Bao et al.: Urban Water Demand Simulation in Residential and Non-Residential Buildings Based on CityGML Data Model, ISPRS Int. J. Geo-Inf. 2020, 9, 642. doi:10.3390/ijgi9110642



Underground Structures (http://3dweb.lgl-bw.de/3D/SmartVillages/#/)

Innovative Hochschule
Eine gemeinsame Initiative von Bund und Ländern

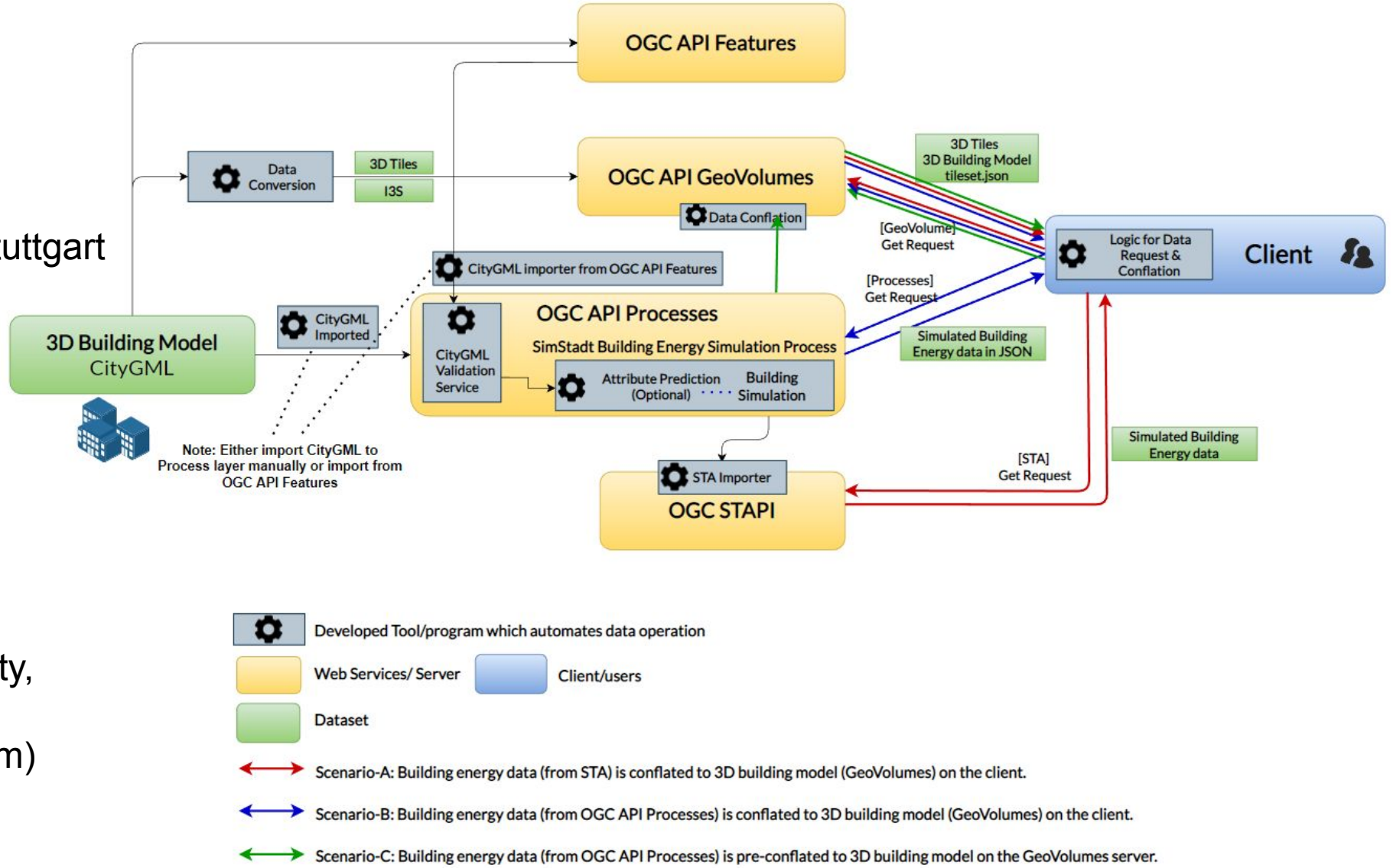
OGC Testbed 18 Building Energy Spatial Data Interoperability

Our contribution

Steinbeis@HFT Stuttgart

Fraunhofer IGD

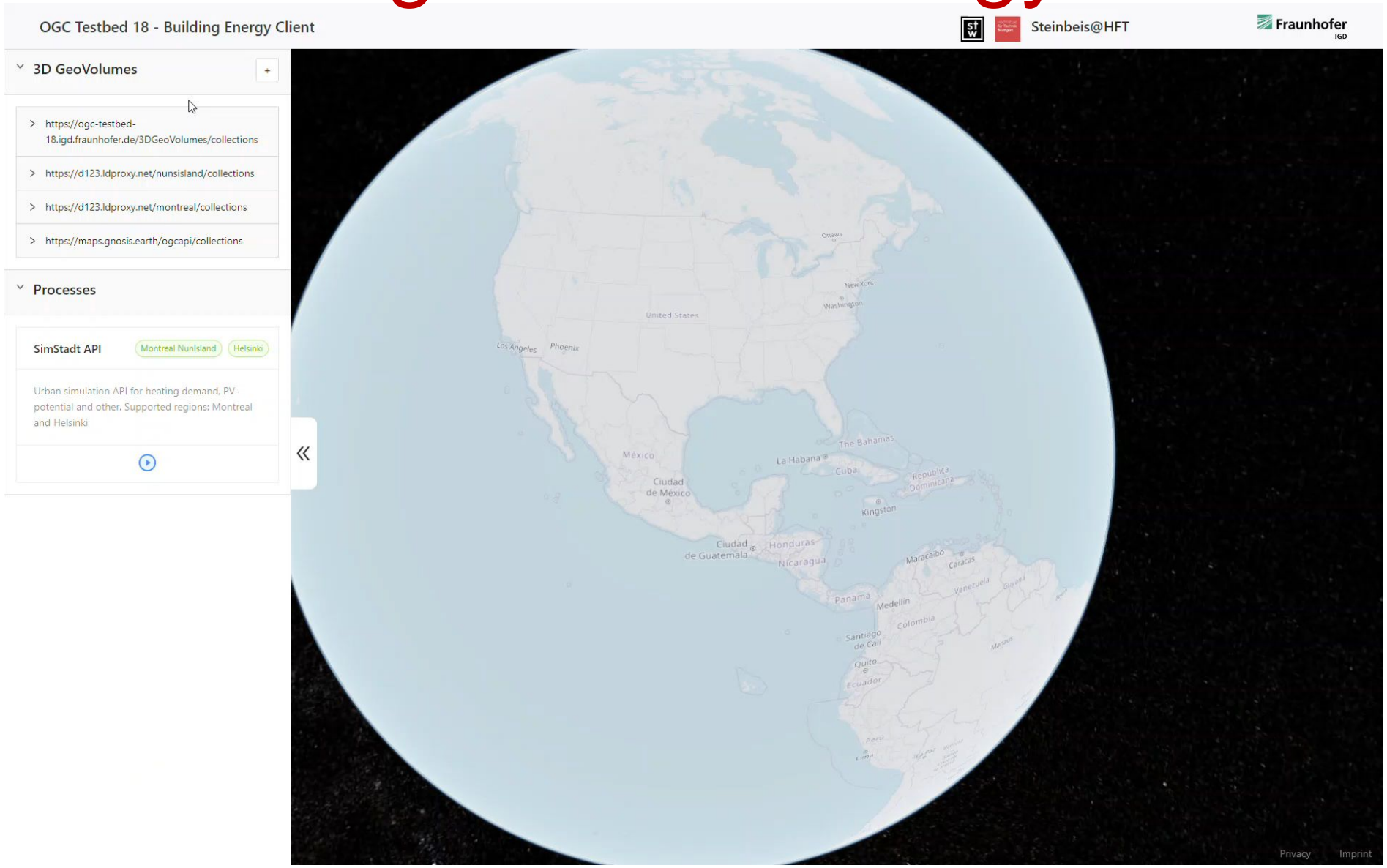
Concordia University,
Next Gen Cities
(Prof. Eicker & Team)



3D Building Model + Energy Simulation

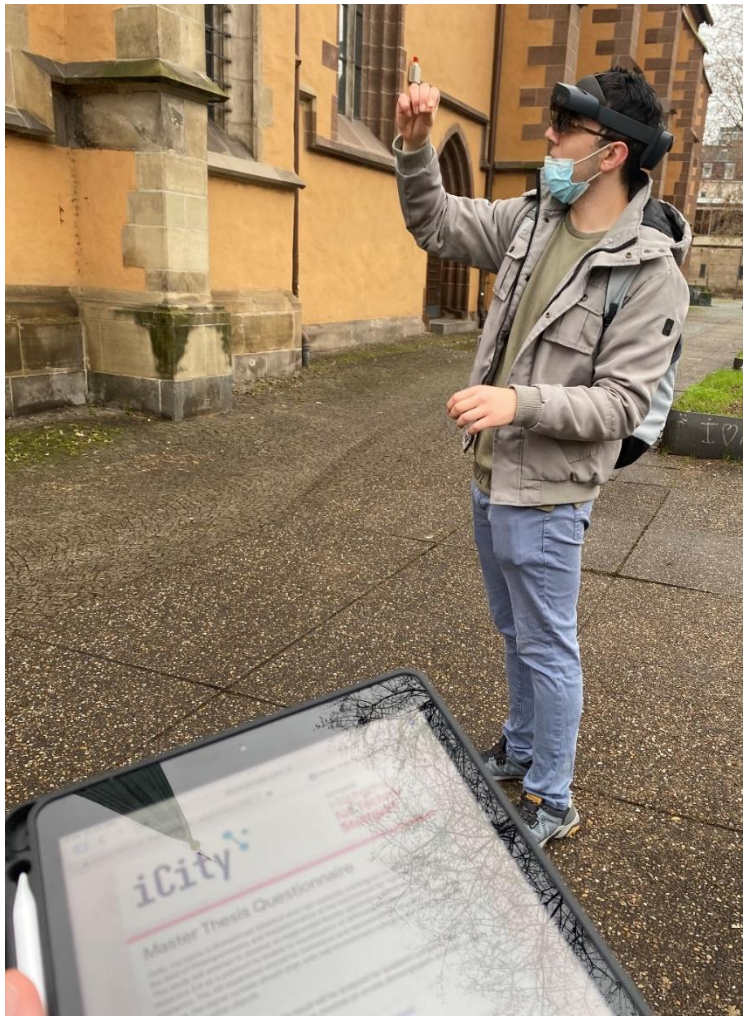
Open Geospatial Consortium

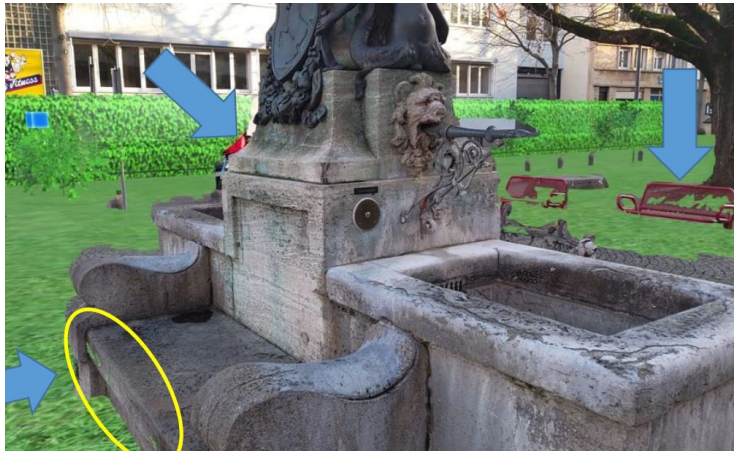
3D Building Model + Energy Simulation



Open Geospatial Consortium

How do I tell it my Citizens?





Urban GeoInformatics Lab @ HFT Stuttgart

https://ugl.hft-stuttgart.de

UDigiT4
iCity

Kontakt

Prof. Dr. Volker Coors
volker.coors@hft-stuttgart.de
http://www.coors-online.de

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aufgrund eines Beschlusses des Deutschen Bundestages

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FORSCHUNG AN FACHHOCHSCHULEN