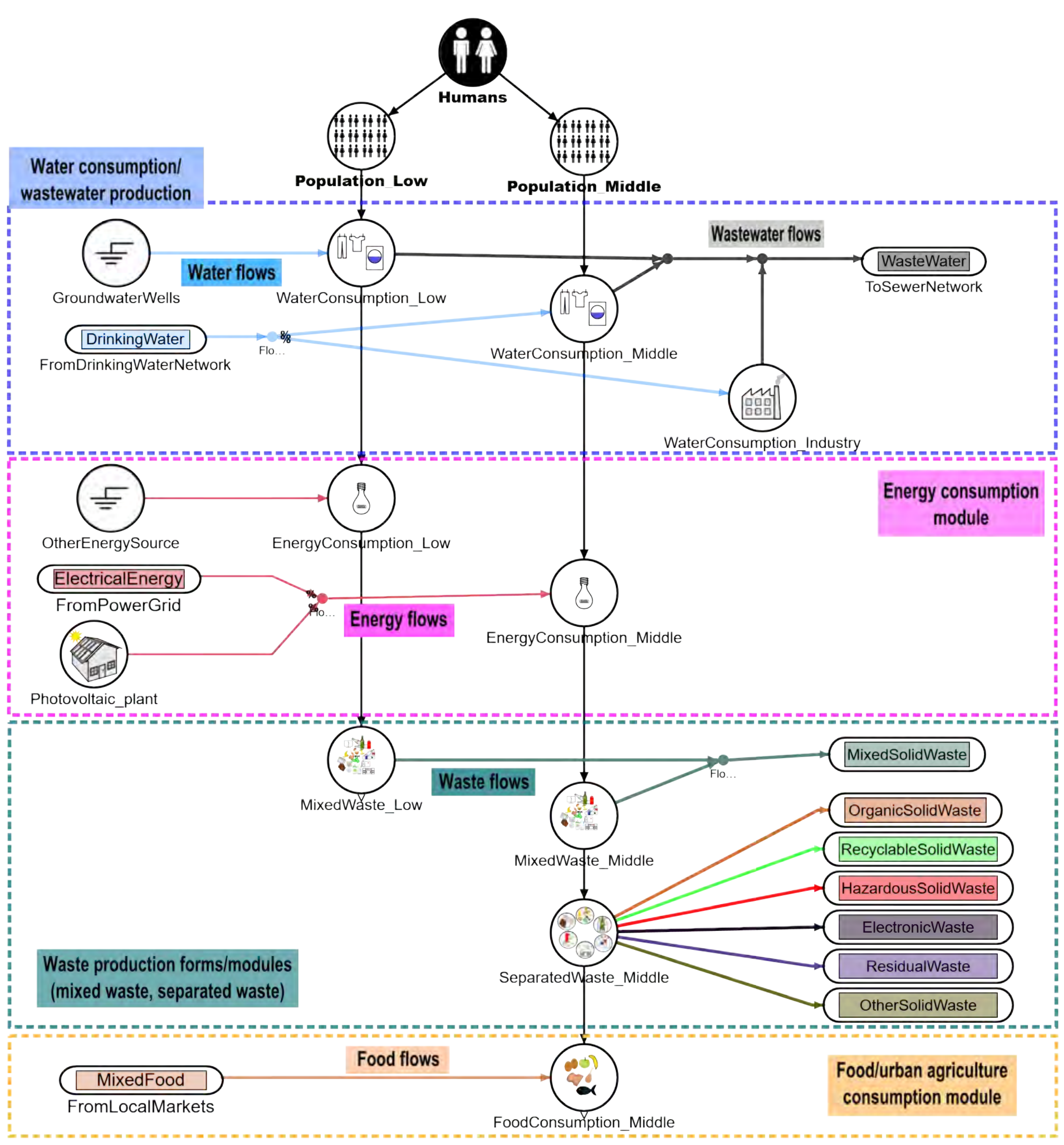
RAPID PLANNING SIMULATOR (RP SIMULATOR): A SUPPORT TOOL FOR THE INTEGRATED MODELLING AND PLANNING OF SUPPLY AND DISPOSAL INFRASTRUCTURES IN FAST GROWING CITIES

1. Introduction

Urban supply and disposal infrastructure systems of the sectors water/wastewater, energy, food/urban agriculture and waste consist of many components and processes which exacerbates the challenges of planning and management tasks. The sectoral and trans-sectoral interactions and synergies between these infrastructures are frequently not known or incomplete or not fully understood by the decision makers. This is particularly true in fast growing cities such as Da Nang (Vietnam), Kigali (Rwanda) and Assuit (Egypt), where the population and their needs for basic supply and disposal services are growing rapidly and at a faster rate than the development of supply and collection infrastructures. In order to overcome the challenges related to the planning and management of natural and technical resources, one of the objectives of the "Rapid Planning" project is to develop a novel trans-sectoral simulator (RP Simulator) in close cooperation with the sector experts of the project partners.

Figure 1: Structure of the "Spatial unit" module



2. Rapid Planning Simulator (RP Simulator)

The general objective of the RP Simulator is to support the management and pre-planning processes of supply and disposal infrastructures of the sectors water/wastewater, energy, food/urban agriculture and waste in fast growing cities from a sustainable and trans-sectoral perspective, taking into account variable boundary conditions.

The RP Simulator is a special further development of the LiWatool developed within the Future Megacities Programme funded by the German Federal Ministry of Education and Research and is based on the SIMBA# modelling and simulation framework. The modelling approach of the RP Simulator combines the principles of Material Flow Analysis (MFA) and dynamic process modelling (e.g. for networks, hydraulics, energy, water treatment). The MFA allows the accounting of material and energy flows at different spatial scales with little effort. Dynamic process models allow the detailed description and the accounting of material and/ or energy flows in unit processes (see Figure 2) under variable and dynamically changing conditions (e.g. technical, demographical, natural, operational conditions).

2.1. Features

- **Trans-sectoral point of view:** Integrated modelling and analysis (in one single model) of supply and collection infrastructures in a fast and easy manner
- **Accounting of resource fluxes** at macroscopic (overall sectoral/trans-sectoral infrastructures) and microscopic (individual unit processes, "Spatial Units") level
- **Time series/scenario analysis:** Analysis of sectoral supply and disposal infrastructures under variable conditions (e.g. population development, resources availability) at different spatial scales (e.g. month, years, decades)
- **Predictability:** State of the system under dynamically changing conditions, provision of sufficient and accurate information of the system considered
- **Interlinkages and potential synergies:** Accounting of interlinkages and potential synergies between the sectors water/wastewater, energy, waste, and food/urban agriculture
- **Flexibility and user-friendliness:** Sectoral components and processes can be described and modelled by the implementation of well-established or user-defined mathematical models with different levels of complexity
- **Evaluation of measures:** Potential technical and non-technical measures from a sectoral and trans-sectoral point of view
- **Data generation:** Provision of (additional) data and information of sectoral infrastructures (e.g. material/ energy flows, interlinkages and synergies) from a trans-sectoral point of view
- **Transferability:** Sectoral supply and collection infrastructures of other cities can be integrated, modelled and analysed with little effort
- **Resource allocation:** Automatic allocation of resources (equality/prioritized)

2.2. Sectoral modules

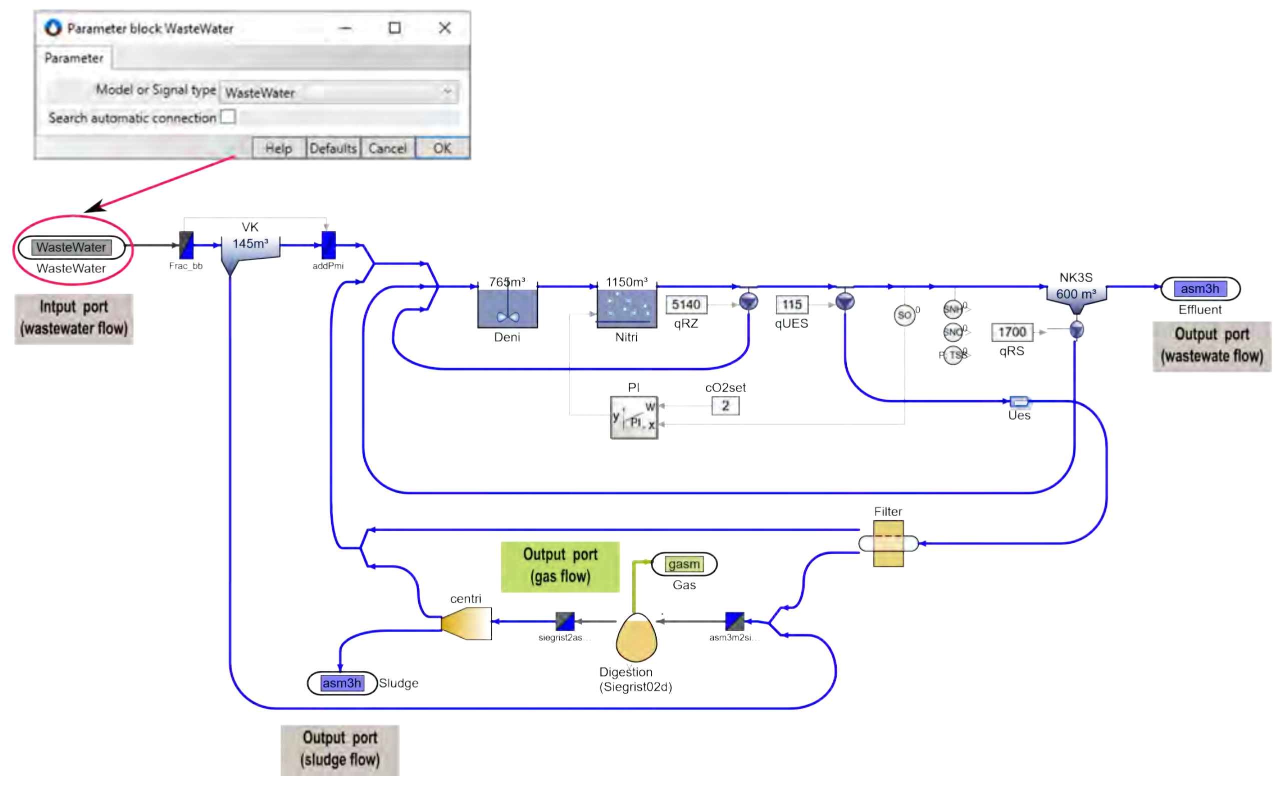
"Spatial Unit" Module (Endusers)

The "Spatial Unit" concept is a generic concept developed for the modelling of end users and their resources consumption and disposal patterns at different spatial scales. In this context, a "Spatial Unit" can represent a single house, block, sector, city district or the entire city. Resources between different users within the "Spatial Unit" can be by priority or equality allocated. In contrast, resources at macroscopic level can be allocated taking into account the distance between supply/disposal infrastructures and the endusers ("Service distance") (see Figure 3).

Individual unit processes

Figure 2 illustrates - as an example - a wastewater treatment plant modelled by the implementation of well-established dynamic process models (Activated Sluge Model Nr. 3). This model will be coupled with the macroscopic model presented in Figure 3. The coupling between both models is technically carried out through the exchange of information (wastewater flows) transferred by the input and output ports "WasteWater" and "Effluent" and "Sludge" and "Gas", respectively.

Figure 2: Example of the modelling of a wastewater treatment plant

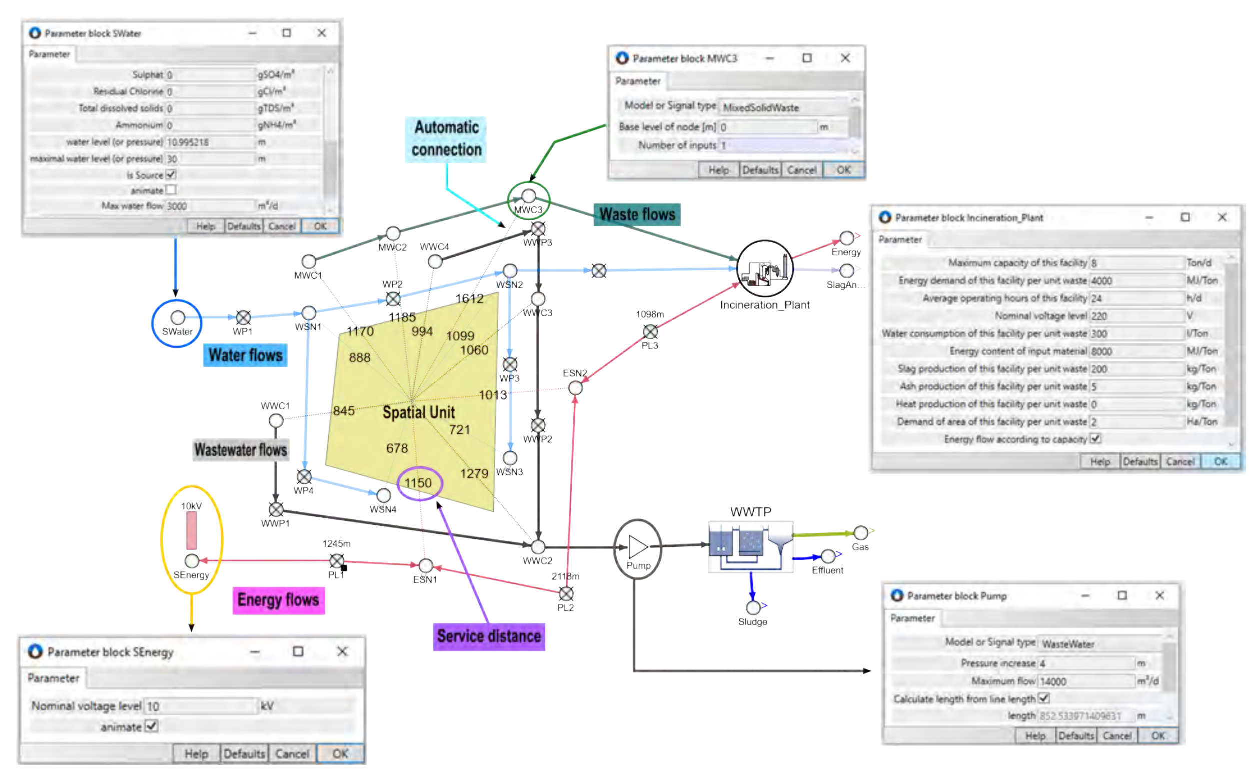


3. Implementation: A trans-sectoral academic example

3.1. Trans-sectoral example model

Figure 3 shows the principles of the approach implemented for the trans-sectoral modelling of infrastructures. The trans-sectoral model is composed of one "Spatial Unit" (presented in Figure 1) and networks for drinking water supply (light blue lines), energy supply (red lines), wastewater collection (dark grey lines) and waste collection (dark green lines). The drinking water supply system is composed of one water source with infinite capacity (SWater), four supply nodes (WSN1,.., WSN4) and four pipelines (WP1,.., WP4). The wastewater collection system is composed of four collection nodes (WWC1,..,WWC4), three pipelines (WWP1,...,WWP3), one pumping station and the wastewater treatment plant (WWTP, illustrated in Figure 2). The energy system is composed of one energy source (SEnergy), three power transmission lines (PL1,..., PL3) and two supply nodes (ESN1, ES2). The solid waste collection system is composed of three collection nodes (MWC1,..., MWC3) and an incineration plant. Furthermore, the automatic connection and the distance between the supply and collection nodes and the "Spatial Unit" are also illustrated (see the slim blue, grey, red and dark green lines).

Figure 3: Example of a trans-sectoral model of the sectors water/wastewater, energy and waste



4. Conclusion and outlook

Due to the combination and implementation of different approaches with different levels of complexity (MFA, dynamic process models), the RP Simulator allows to model and to analyse supply and disposal infrastructures of the sectors water/wastewater, waste, food/urban agriculture and energy in a fast and easy manner and from a trans-sectoral perspective. Within a simple example of a trans-sectoral system, some sectoral modules implemented so far in the RP and the principles of integrated modelling of supply and disposal infrastructures of the sectors considered in the Rapid Planning Project have been presented.

Future work includes further development of the sectoral and trans-sectoral models in close cooperation with the sector and city experts of the Rapid Planning project.

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