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Towards a DESTEST: a District Energy Simulation Test Developed in IBPSA Project 1

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Abstract

This paper presents the first steps towards a District Energy Simulation Test (DESTEST), which is part of IBPSA Project 1. The goal is to develop a test sequel for district energy simulations, inspired by principles of the BESTEST. It aims at providing a means to validate District Energy System models. The description of the DESTEST cases and the simulation results of extensively verified models will be available as a reference for verification. By presenting the research plan, goal and first results, the district energy simulation community is informed about the project's intentions, offering a chance for feedback and collaboration.

Introduction

Recent developments to reduce the energy use of buildings focus on the integration of renewables and further increase of energy efficiency. European legislation enforces that new buildings are nearly Zero-Energy Buildings and requires the deployment of a European Smart Grid. These requirements represent important technological challenges as the interaction of buildings becomes increasingly important. To quantify these interactions as well as the restrictions caused by the existing neighbourhood topologies and grid configurations, a modelling environment, here referred to as District Energy Simulations (DES), is needed.

Compared against more traditional building simulations that focus on the performance of individual buildings, the analysis of District Energy Systems requires even more sophisticated tools and presents additional modelling challenges, which are presented below.

First, the scale is larger. Even if buildings are represented by only one volume, District Energy Systems requires simulations of hundreds to thousands of buildings.

Secondly, District Energy Systems are characterized by a complex interaction of energy and power flows of different energy carriers (electricity, thermal, gas), energy flexibility and storage, and generation from different energy sources. Describing such systems requires a multi-disciplinary and multi-domain approach. In these systems, the knowledge of building, electrical and mechanical engineering should be combined and advanced control techniques (such as model predictive control (MPC) and hierarchical controllers) should be employed. Although analysis of individual buildings may be considered as multi-domain and multi-disciplinary, the analysis in District Energy Systems is more complex.

Thirdly, collection of all data required to set up the simulations is very tedious and often not possible. Amongst other data, DES require geometrical data, material properties, installation properties, occupancy and usage patterns of all buildings. Sometimes these data are available from Geographic Information Systems (GIS). Furthermore, national datasets or surveys, standards, scientific literature, detailed on site measurements (such as smart meter data), Energy Performance Certificates which can provide both real and statistical data. However, in many cases existing situations are evaluated for which often data are unknown or the quality cannot be guaranteed. For instance, in districts not all renovations are completely accounted for or the energy performance of old buildings is uncertain. Moreover, uncertainty arises from user behaviour: occupancy and temperature set points are unknown, and there is hardly knowledge on the use of sanitary hot water or the appliances and lighting.

Solutions for these simulation challenges start emerging. For instance Allegrini et al. (2015), Reinhart et al. (2016) and Frayssinet et al. (2018) present reviews on the state-of-the-art of Urban Energy Modelling but they focus mainly on the simulation of building energy demand. Huang et al. (2015) emphasise the analysis of energy planning simulation.

To ensure the quality of District Energy System models, validation is essential. Although some validation data sets exist (Allegrini et al, 2015), there is currently a lack, especially for the energy demand in large scale District

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Energy Systems. Apart from the high cost of obtaining detailed measurements, problems often arise with the use of these data sets because of privacy concerns, the uncertainty on the accuracy of the obtained measurements and the uncertainty on individual energy use due to aggregation of data. Even if data are available, as described above, the necessary simulation input is often lacking or uncertain.

Recently, new ways to build and operate district heating systems have emerged, for example to allow the use of low-temperature residual heat or renewable energy sources (Bunning et al., 2018). In order to design such networks and their control, detailed simulation models of the distribution network have been developed and tested. Usually models for district heating systems are validated against other models or case-study data. Larsen et al. (2002) applied topological model reduction for a real district heating system in Hvalso, Denmark, compared the reduced model to the detailed model and validated the model with real system data. Raab et al. (2005) validated a TRNSYS XST-model of the thermal behaviour of a solar-assisted district heating system with ground-buried hot water storage with measurement data from a real system in Hannover, Germany. Gabrielaitiene et al. (2007, 2008 and 2010) modelled district heating systems using the pseudo-transient approach and the node approach, and validated with experimental data. Stevanovic et al. (2009) developed a model to simulate the thermal transients in district heating systems and validated against a real district heating system in Zemum, Serbia. Giraud et al. (2015) developed a Modelica model for fast, precise and robust district heating components, validated with the data used by Gabrielaitiene et al. (2007, 2008 and 2010). van der Heijde et al. (2017) developed a plug-flow pipe model in Modelica and validated against a discretized pipe model as well as data from an experimental set-up and a real district heating system.

Although the individual validation of models with the help of experimental data ensures validity of models, it does not allow direct comparison of different models. We therefore propose a DESTEST framework, which constitutes a standard for testing and benchmarking District Energy System models, similar to the BESTEST (Neymark and Judko, 2004) for building energy models. The DESTEST aims at providing a similar framework on a larger scale, including district heating and cooling networks and smart grid evaluation.

This paper discusses the rationale towards a DESTEST that is being set up within WP3 of IBPSA Project 1 (https://ibpsa.github.io/project1/). Furthermore, the paper elaborates on the results of the first steps, which include the selection, description and simulation of a district heating network topology that will be used as a simple first case. Subsequently, the future research plan is outlined and conclusions are presented.

DESTEST

District Energy Systems are used in different contexts with different energy carriers, different scopes and aims. Well-known are thermal networks that provide heat or cold in different climatic conditions but also electrical and gas networks can be considered as District Energy Systems. The extensiveness of District Energy Systems makes the definition of a comprehensive framework to test simulation tools a more complex task than the BESTEST which aims at the energy demand, power and temperature profiles prediction in a single building.

Since the scope of District Energy Systems is broader than the scope of single buildings, we first define the three subsystems found in typical District Energy Systems:

1. The *energy demand* system defining the need for energy.
2. The *distribution* system coupling generation and demand.
3. The *generation* system producing heat, cold and electricity.

The control systems that manage the operation can be implemented as an additional subsystem or may be integrated in one of the previously defined subsystems.

The aim of the DESTEST is twofold:

1. Firstly, the DESTEST aims at providing a framework to compare the results from different tools on representative districts or neighbourhoods. As such the DESTEST cases and results will serve as a basis for intermodel comparison.
2. Secondly, the DESTEST aims at developing typical or representative DES configurations that can be used for testing different DES models or different DES solutions (e.g. central vs decentral storage).

The first aim focuses on the precise description of cases that can be simulated by different DES tools. Given the complexity and variety of District Energy Systems, many cases will have to be defined. In order to be comprehensive these cases have to reflect the 4th generation district heating and cooling networks, optimization, energy flexibility, … Additionally, the test framework should allow for testing specific models that are embedded in the DES tools, such as substations, pipes and central supplies, …

Also important is the definition of Key Performance Indicators (KPIs). Apart from the typical quantities such as the energy use, peak power and evaluation of thermal comfort, also indicators that reflect upon and describe the time dependency of the results have to be properly defined, such as self-consumption of electricity generated by photovoltaics and thermal load duration curve. This is particularly important for assessing the integration of renewable energy as studies report on the issues that arise from the mismatch between supply and demand of energy (Protopapadaki and Saelens, 2018).

The following sections outline the first steps that have been taken into the DESTEST development. It was decided to work with common exercises in which different participants solve a well described case, discuss the difficulties during execution and compare the results. This methodology has already been proven successful in other projects such as IEA EBC Annexes 58, 60 and 71 and stimulate knowledge development and sharing among participants. The idea of the DESTEST common exercises is to detangle the main problem into smaller subprojects. While progressing, the complexity of the subprojects is increased to move to a more detailed analysis. This also allows to self-reflect and to quickly respond to problems that are encountered during the execution of the subprojects. The method facilitates communication of issues regarding the use of different software tools and modelling techniques to the researchers and manufacturers that develop code.

It was decided to start the common exercises with a simple case in which only the energy demand and the distribution subsystem of a district heating system are modelled. The work has been divided over two groups that work interactively: the *building modelling* group focusses on the selection and modelling of the buildings in the district (demand side), the *network modelling* group looks into the sizing and modelling of the energy network (distribution side). The building modelling group defined the buildings of the district heating system and five research groups used different approaches to model the energy demand. The differences between the five modelling approaches are discussed. The network modelling group developed an automated toolchain to size the district heating network. Again, the results of different approaches to simulate the energy use of the district heating system are compared.

In its final form, the DESTEST will contain multiple district definitions (e.g. old residential neighbourhood, new mixed-use neighbourhood). However, to be able to easily pinpoint the differences between multiple modelling environments, it is decided to start from a simple district. The simplicity of the case allows to detect errors and discrepancies straightforwardly. Furthermore different partners participate in the exercise using tools with different sophistication or scope. The main results of the building modelling and network modelling subgroups are explained in the following sections.

Part 1: Focus on buildings

In this Section, the focus of the building modelling group over the first phase of the project is presented. Firstly, the initial district definition is described. Then, the five different modelling environments are introduced. Finally, some preliminary results are presented.

Case description

The simple district contains 16 identical single-family dwellings (Figure 1). In this first stage, it was chosen to simulate buildings with a high heat demand. Hence, the single-family dwelling is supposed to be constructed in the 1980s and has a rather bad thermal quality.

To create a building energy model, information is required about the building location and climate, building geometry, building envelope, heating, ventilation and air conditioning (HVAC) systems as well as the building occupants. The building definition is made available to all participants via the IBPSA Project 1 GitHub repository.

Firstly, the building is assumed to be located in the heating dominated climate of Belgium. Hence, a Belgian climate file is used. Secondly, the building geometry is modelled as a simple building block, consisting of two floors, each 8.0 m x 8.0 m x 3.5 m. Thirdly, the building envelope is selected based on the Belgian TABULA residential building typologies (TABULA Project Team 2012), which define the U-values of outer walls, roof, ground floor and windows as a function of the building type and construction year. The infiltration rate is assumed to be 0.4 air changes per hour (ACH). Fourthly, regarding the HVAC systems, the building is modelled without a ventilation system due to its age. Nor is a cooling system included. The building is implemented with an ideal radiator system, since the purpose is to model the energy demand to be used as an input for the network model. Fifthly, the building occupants are modelled following the ISO13790 standard. This includes a schedule of temperature set-points for day zone and night zone as well as of internal heat gains. Window opening is not included. The building is modelled as a two-zone model, with the ground floor representing the day zone and the upper floor belonging to the night zone. This level of detail enables an in-depth comparison between the different modelling environments.

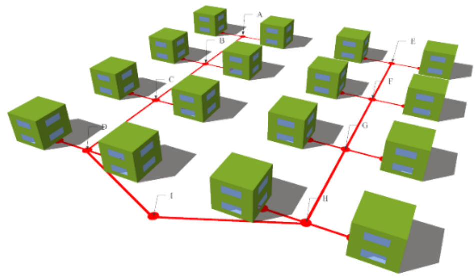

Figure 1: Visual representation of the first simplified district definition.

Methodology

The focus of the building modelling group is on quantifying the district energy demand as a function of time and space. Initially, only the selected residential building is considered and modelled in five modelling environments: the Modelica Libraries Aixlib, Buildings and IDEAS, as well as the non-Modelica environments DIMOSIM and IDA ICE. The modelling environments are briefly introduced below.

All used Modelica libraries are available open-source and are based on the Modelica-ibpsa core library (https://github.com/ibpsa/modelica-ibpsa), enabling the use of base models, developed during the Annex60 and further improved by the IBPSA Project 1. The *AixLib Modelica library* is developed by RWTH Aachen University, providing components and system models for building performance simulation of high and low order building models as well as common HVAC systems (Muller et al., 2016). The used thermal zone models for the investigated example is a low order model automated generated with TEASER (Remmen et al, 2018). The *Buildings Modelica library* contains component and system models for building energy and control systems. Thermal zone models assume completely mixed air, and they can have any number of constructions and surfaces that participate in the heat exchange through convection,

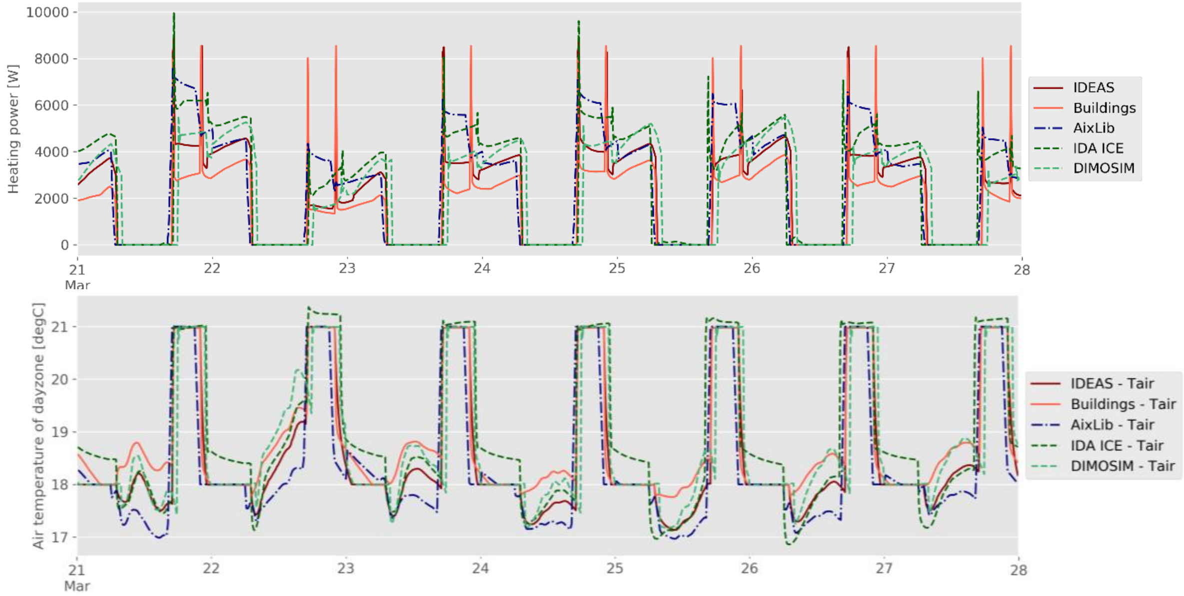

Figure 2: Heating power (top) and temperature of the day zone (bottom) for a week in March as obtained by the five modelling environments. The x-axes start at March 21, midnight.

conduction, infrared radiation and solar radiation (Wetter et al., 2014). The *IDEAS Modelica library*, developed by KU Leuven and 3E (Jorissen et al. 2018), supports detailed building energy simulations modelling transient thermal phenomena using a zonal modelling approach, assuming perfect mixture of the air inside the zone. The building model in IDEAS is a high-order model, in which all layers of all building components are modelled separately. The simulations are performed in Dymola, using the Dassl solver with an output interval of 10 min.

DIMOSIM (District Modeller Simulator) is an integrated simulation tool developed by CSTB (Centre Scientifique et Technique du Batiment), implemented in Python, for the optimisation and analysis of feasibility, conception and operation of district multi-energy systems (Riederer et al., 2015). *IDA-ICE* is a detailed and dynamic multi-zone simulation environment to study the thermal indoor climate and the energy use of buildings (EQUA, 2019).

All modelling environments enable dynamic energy simulations, allowing to assess time-dependent KPIs. In this work, the annual energy demand, the peak energy demand, the load duration curve and the thermal comfort are selected as KPIs. The annual energy demand gives a general indication, however the time-dependent behaviour is more important within the DESTEST framework. Therefore, the peak energy demand is studied as well, along with the load duration curves. A load duration curve shows the duration for which a certain heating power level is exceeded over the whole year. Dynamic energy simulations also allow to assess the overheating risk, calculated as the temperature exceedance above 25°C multiplied by its duration.

Results

As the process of pinpointing the differences between the different models is ongoing, this paper reports the current status of results. The simulation results for the single family dwelling are compared for the five simulation environments.

Multiple simulation "rounds" were required to align the simulation models, illustrating the difficulty of modelling the building in the same way in different environments. A first example is the definition of the temperature. Buildings and IDEAS used the operative temperature to control the heating system, whereas the other models employed the air temperature. All models are now based on the air temperature. A second example is the peak power definition. Apparently, all models use a different definition of the maximal heating power for the ideal heater. To eliminate this deviation, the maximal power of all ideal heaters is set to the required power as calculated by a steady-state heat loss calculation. However, some models (Modelica AixLib and DIMOSIM) do not need this maximal heating power.

Within the context of designing and operating district energy systems, the temporal behaviour of the district energy demand is of high importance. Figure 2 shows the heating power and the air temperature of the day zone for the five building models during a week in March. In general, all models respond very quickly and cool down rather fast. This is partially caused by the ideal heater that operates based on the air temperature. Additionally, there is a one-hour delay for some models, probably due to a different implementation of the temperature set point schedules. Also, in IDA ICE, daylight saving time is included automatically and is difficult to turn off.

The deviations of the different models in terms of load duration curves are illustrated in Figure 3. For designing or operating District Energy Systems, the high heating powers are most important. The peak heating power varies between 14.2 and 16.6 kW, but decreases quickly.

Both the AixLib and the IDA ICE model show a slightly higher power demand compared to the other models during the first 1000 hours of the load duration curve. Both the Buildings and IDEAS model show a steeper behaviour than the other models. At the lower end of the curve, all models show a different behaviour.

Table 1: General overview of the annual heat demand, the peak power and the overheating of the day zone for the five modelling environments.

	Annual heat demand [kWh]	Peak power [kW]	Overheating of the day zone [Kh]
IDEAS	18224	16.6	3019.9
Buildings	16029	16.6	4584.5
AixLib	20822	14.2	220.2
IDA ICE	22538	16.5	1272.5
DIMOSIM	20333	15.9	1829.5

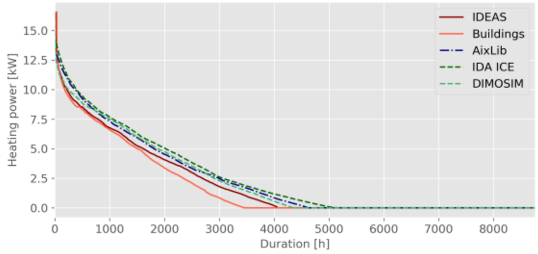

Figure 3: Load duration curves of the single family house in the five modelling environments.

Finally, to get a general overview of the different models, the annual heat demand is shown in Table 1, along with the peak power and the day zone overheating. Despite the effort to align the simulation assumptions, the annual heat demand still varies between 16029 kWh and 22538 kWh. It is not the purpose to fine-tune all models such that they produce identical results, but rather to pinpoint where the differences come from. Here models with different degrees of complexity are used, some assumptions still differ, so deviations are still to be expected.

It proved not straightforward to align the results of building energy models from different modelling environments, considering the significant amount of input data that is required to create these models. Starting simple, however, helped the modellers to pinpoint some obvious differences in modelling. Still, several issues are to be analysed, before formulating a final assessment and proceeding to more complex district definitions.

Part 2: Focus on networks

This Section focuses on the first phase of the network modelling group. Firstly, the considered thermal network is described. Then, the pipe sizing approach and different network models are introduced. Finally, preliminary results are presented.

Case description

The case is based on the sixteen buildings described in Part 1. The buildings are thermally connected through a conventional pipe network with radial structure that resembles two streets in a neighbourhood (Figure 1). Each building has a substation with a pump and an ideal controller that adjusts the mass flow rate to guarantee a fixed temperature difference of 20°C between supply and return on the network-side of the heat exchanger. If there is no heating load in the buildings, the pumps guarantee a fixed bypass mass flow rate of 0.2 g/s in the substation. At the connecting node of the two streets the network has a central ideal heat source with a supply temperature of 50°C. The ground temperature is constant and equals 12°C. The pipe network is sized with a semi-automated procedure as described below.

Methodology

<u>Pipe network sizing</u>

For the first and the following case studies, it is important that all simulations are based on the same boundary conditions. In the case of a district heating system this also includes the sizing of pipes. In order to be able to quickly adjust the test case to changing heating or cooling loads in the sixteen buildings, a tool to automatically size the pipe network according to these loads was developed. The tool is Python based, inspired by Fuchs et al. (2016), and uses the graph package networkX.

The pipe sizing is based on the load data and locations of the buildings of Part 1. The calculation of the pipe diameters is done with the Darcy-Weisbach equation with an explicit friction factor approximation (by Moody) in a way that a predefined pressure drop per pipe length is not exceeded. The pipe diameters are chosen according to the corresponding DIN EN ISO 6708 standard and insulation thickness is selected after industry standards.

The output of the tool is a scheme of the network structure as depicted in Figure 1 and tables that include all relevant information about each pipe segment.

This results in an overall workflow, which is easily adjustable and adoptable to different future test cases in terms of network layout and pipe sizing. In the current state of the DESTEST development, network layout and sizing with the described tool is seen as a first reference draft to identify important network descriptions and boundary conditions defining the test case.

<u>Comparison of different network models</u>

The first test exercise was conducted with the following network simulation models:

- Dynamic pipe model (Wetter et al., 2014)
- IBPSA Plug flow pipe model (van der Heijde et al., 2017)
- Supply models from the Buildings Modelica library with plug flow pipe model (Wetter et al., 2014)
- Supply and Demand models from the AixLib Modelica library with automated model generation and plug flow pipe model (Muller et al., 2016)
- Supply and Demand models from DIMOSIM with dynamic pipe model (Riederer et al., 2015)

Based on the described network layout and pipe sizing, the test with the AixLib Modelica Library uses the python graph framework uesgraphs (Fuchs et al., 2016) to create the district heating network structure. It directly connects to an automated model generation for Modelica simulation models. The automated model generation is handled with python and mako templates in a python package called uesmodels. The boundary conditions as well as the plug flow pipe model and its attributes were set as described before. The used models for the district heating demand and supply are available in the AixLib Library (Muller et al., 2016).

Results

The comparison of the five described network simulation models is shown in Figure 4, which depicts the total heat loss of the network system as an indicator for dynamic simulation behaviour. In comparison to the plug flow pipe model, the dynamic pipe model shows a significantly smoother behaviour. Whereas all Modelica simulation models show the same heat loss during continuous flow situations, the overall heat loss differs when nearly zero flow occurs in the system. In these cases, the plug flow model spikes to near zero heat loss and increases again to a specific heat loss plateau. One can identify differences to the simulation with DIMOSIM as the variations between peaks and the time constant are smaller. The reasons for this are multiple: the coupling implemented in DIMOSIM between the buildings and the network leads to interacting effects with smaller peak demands, the different implementation of the insulation quality of the tubes in the models introduce differences for the steady state results while the different by-pass flowrate and the solver change the dynamic calculation results. Further assessement will be undertaken to clarify this.

Supplementary to this comparison, a simulation study focusing on the impact of solvers was performed using the AixLib model. All Modelica models above were simulated in Dymola with the Euler solver and a fixed 1s time step. The following simulation compares this Euler solver with two other solvers: the variable time step solvers Dassl and Cvode were chosen. Figure 5 shows the total network heat loss for a different week. Again, differences between the solvers are noticeable in times where small bypass mass flow rates dominate the system behaviour. Starting with similar deviations using Dassl and Cvode in comparison to the Euler solver, the deviations become different from each other later in the week. This result shows that in dynamic thermal network simulations using Modelica and Dymola, the solver can have a significant impact on the simulation results. Thus, the comparative study concludes that fixed boundary conditions regarding the solvers of the simulations need to be defined in the frame of the DESTEST.

Research plan and outlook

The DESTEST has to provide a meaningful environment to test simulation issues that can occur while modelling District Energy Systems. which consist of many subsystems that are heavily interlinked. So, in order to provide a comprehensive test environment, the DESTEST has to allow testing demand and network separately with different degrees of complexity but should also be capable of testing the different subsystems simultaneously. Another point of attention is the scale of the problem. Urban Energy Systems can be very large and are determined by complex interactions between a large diversity of users. Hence, large enough systems with a highly diverse energy demand should be incorporated in the DESTEST as well. Moreover, also fully coupled systems have to be assessed. Therefore, the future steps will be split up into three main aspects as sketched below. The steps that will be taken in IBPSA project 1 will be inspired by this description. However, because of time limitations an exhaustive all-inclusive DESTEST will not be achieved. Nevertheless, the outcome of this research may serve as a basis for initiatives and collaborations beyond IBPSA Project 1.

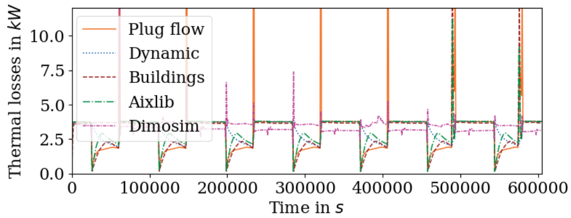

Figure 4: Thermal losses in the test case obtained by different network models for one week.

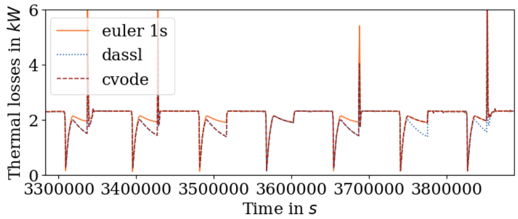

Figure 5: Comparison of one week thermal losses with different solvers in Dymola using the AixLib model.

Future steps in the demand calculations

Currently very simple building and district definitions are used. In real districts, however, there is much more diversity. So, the next step in the common exercise is to improve the diversity by following a stepwise approach. The increase in diversity will be achieved by changing different aspects, among them: building typology, building characteristics, boundary conditions and scale.

Influence of building typology and characteristics

As a first step, the impact of different types of dwellings (detached, semi-detached and terraced buildings) and energy levels will be analysed. The latter will be achieved by changing the insulation and infiltration levels and defining different heating systems (leading to e.g. old, new and mixed neighbourhoods).

The first common exercise focuses on residential buildings. A logical extension is to add different building types. In a consecutive common exercise, office buildings with a variation of energy levels and appropriate occupancy patterns will also be added to the district. This ensures an increase in diversity of the energy demand and also cooling will become an important energy service.

Influence of boundary conditions

Next, the impact of boundary conditions will be analysed by changing the climate and generating different scenarios for occupant behaviour. Regarding the climate, one exercise will focus on the impact of solar radiation on the energy demand and generation of renewable energy. By changing the distance between buildings and analysing the impact of shadowing, a case will be defined to assess the appropriateness of and the impact of different solar simulators. Regarding occupant behaviour, the dwellings will use different occupancies, generated by StROBe (Baetens and Saelens, 2016). This allows to define cases in which the distribution of the energy demand over the dwellings can be carefully checked. By adding the occupancy and implementing different heating systems including heat pumps, the electricity demand can also be assessed properly. This is, amongst others, an important input parameter to assess the interaction between dwellings that are part of a connected energy grid such as a thermal network or a smart electricity grid.

Increase of scale

For each of the above described steps, cases with different number of buildings will be defined. It is envisaged to define small, medium and large scale scenarios district. The small scale is the current scale with 16 buildings. While not representative, it does allow rapid testing and implementation and requires the lowest computational power. A more realistic scale would be a medium scale (e.g. a neighbourhood) with 50 up to some 200 buildings, which should be representative for a typical low voltage feeder. The largest scale should be representative for larger districts and even whole cities. The number of buildings should be 1000 or more.

Apart from testing the accuracy of traditional quantities such as energy demand, load duration curves and the distribution of the energy use over time and space these cases can be used to test computational efficacy and robustness of codes related to these large problems, as well as the need for clustering or aggregation.

As an extension and outreach to other IBSPA Project 1 WPs, it will be investigated whether the original case can be extended by using GIS and BIM from WP 2.

Future steps in the distribution network modelling

Besides the already mentioned planned improvements, such as standardising insulation properties and defining boundary conditions for the solvers, future work will contain further development of different network testing cases. These will include the addition of district cooling, which will become more relevant with changing climate, and new concepts such as low temperature networks and bidirectional networks. Furthermore, different network topologies will be included and more advanced substations added, which will allow to address novel concepts such as thermal energy storage in the face of renewable integration in district energy concepts.

Furthermore, electrical networks will also be included in the series of test cases. Possible points of attention here could be, amongst others, the accurate modelling of heat sources using electricity as an energy source (e.g. heat pumps), electricity storage and local electricity sources.

Combination and system approach

Currently heat demand and thermal network calculations are executed separately, where the results of the heat demand calculation serve as an input for the network simulation. A logical next step in the development of a comprehensive DESTEST is the coupling of both simulations. This is for instance a necessary step to assess the performance of control actions such as active demand response but also to check interoperability of tools that model separate subsystems.

As mentioned in the introduction, for the analysis of active demand response, smart steering of the energy demand and generation are key in future energy systems. Nevertheless, the envisaged DESTEST will not present/include sophisticated control strategies. However, the definition of the representative district and neighbourhoods resulting from this second aim will facilitate the analysis of different control approaches. In IBPSA Project 1 it is envisaged to collaborate with WP1.2 to explore the potential of setting up test cases for controller assessment. The focus of WP1.2 is now on building level (BOPTEST) but may extend to district level, in interaction with WP3.

Conclusions

In this paper, the aims and first steps towards a framework for testing District Energy System simulations (DESTEST) are presented. Firstly, the DESTEST should serve as a validation tool that can be used by other software developers. Secondly, the DESTEST provides a test framework that can be used as a reference environment for testing new technologies and innovative solutions in the context of District Energy Systems.

The results of the first common exercise, a simple case in which the energy demand and the distribution subsystem of a district heating system are modelled, demonstrated how such a DESTEST could be used. The energy demand was modelled with five simulation environments, illustrating the difficulty of modelling the exact same building in different environments. The network modelling was also used to compare the output of 5 network simulation models and proved useful to assess the impact of different numerical solvers.

The outlook showed how the work will continue to develop a comprehensive framework. The DESTEST should be representative by defining cases that differ in scale and diversity. To achieve this different building typology and characteristics, climate and occupancy patterns as well as districts with different scales will be used in future work. With respect to networks also cooling networks and electrical grids will be analysed. Finally, demand and distribution subsystems should be combined to assess the performance of control actions and to check interoperability of tools that model separate subsystems.

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