MODELING OF INNOVATIVE LOAD AND GENERATION TIME SERIES FOR CROSS-SECTOR ENERGY NETWORK PLANNING

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Introduction

The classical, separate consideration of the sectors electricity, gas and heat is no longer sufficient for planning the optimal energy infrastructure due to substantial sector coupling potentials. Particularly in the development of new quarters (“greenfield planning”), complexity increases significantly due to the degrees of freedom in planning. To enable software-supported planning for new quarters, a detailed database is needed, especially with building- and energy-specific indicators besides forecasted consumption profiles and generation potentials [1]. However, such load and generation time series are currently developed using separate methods without dependencies among them and applied for different sectors or the relevant energy carriers, as shown in the meta-study according to [2]. In addition, non-residential buildings (NRB) are sometimes not considered at all or only planned as individual cases. Therefore, this contribution presents a methodology, which allows the determination of individual characteristics as well as coherent energy consumption profiles and generation potentials, based on the planned building typology and structure for a new quarter.

Methodology

The fundamental structure of this methodology follows a bottom-up approach, enabling the construction of a high-resolution, individualized database. This database further allows for the systematic and integrated examination of innovative solutions for the energy supply of a new quarter (e. g. collectively used charging hubs). To validate the resulting time series, the methodology is applied to an exemplary new quarter using freely available Geographic Information System (GIS) data.

Geographic analysis

For this purpose, the considered newly developed quarter is analyzed in GIS with all relevant information (area, location, orientation, building type, etc.). Additionally, various metrics and probability distributions for input data beyond these geometric details (roof shape, electromobility, residents, etc.) can be provided through an input mask. This way different scenarios for the same new quarter can specifically be analyzed and compared. Following this GIS-based analysis, specific metrics for energy characterization are derived for each identified connection area (buildings, parking areas (PA), etc.) individually. This includes spatially conditioned constraints for different types of heat pumps, the available potentials for installing photovoltaic systems, as well as the number and rated power of charging points for electromobility.

Generation of coherent time series

The methodology for deriving specific and individualized time series coherently integrates several methods [3-4]. These methods are schematically illustrated in Figure 1 with their interconnections. Fundamentally, in determining the times series this approach distinguishes between the topological categorization of a connection area into residential buildings (RB), NRB and PA. Additionally, mixed buildings can be represented as a combination of RB and NRB. Each of these methods creates a time series for a substantial energy-related characteristic of the respective connection area over a considered time horizon of one year with a 15-minute resolution.

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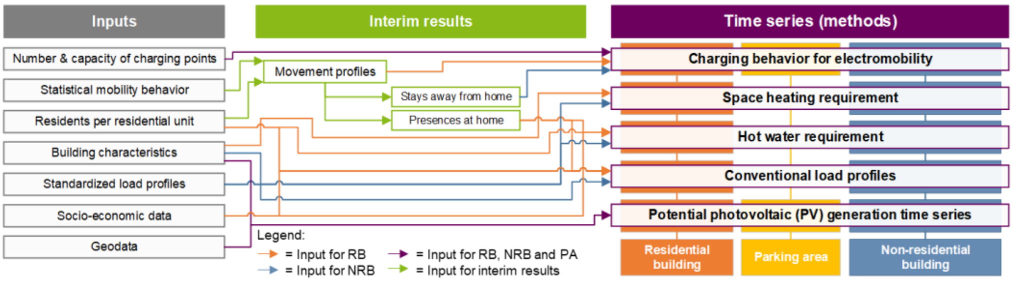

Figure 1: Overview of the dependencies between the methods for calculating coherent time series

Results

In Figure 2, a one-week excerpt of the determined time series for a multi-family house with 8 residential units is exemplarily shown. The results clearly depict, alongside the daily cyclical pattern of each time series, the influence of the external temperature trend as a negative correlation with the space heating profile (yellow line). Furthermore, the impact of minor aggregated presences (blue line), for instance on the dips in the hot water demand time series (blue line), is also evident (see red arrows).

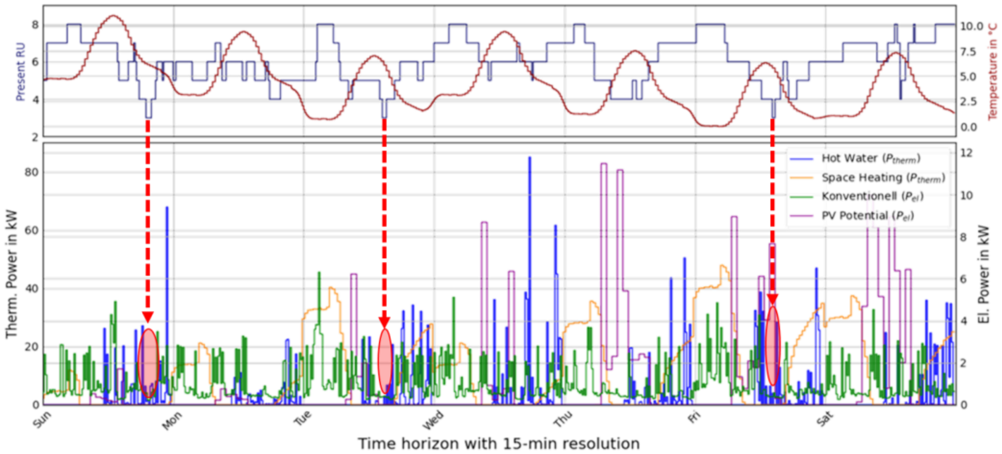

Figure 2: Excerpt of the resulting load and generation time series for an exemplary building in a new quarter

Using the developed methodology, load and generation time series can be determined based on the individual quarter structure. This allows for targeted, high-resolution analyses of the predicted energetic interconnections and synergy potentials for supply concepts of buildings in spatial proximity within a new quarter. This level of detail enables a deeper understanding of the requirements for the energy infrastructure of a newly developed quarter and provides the foundation for its energetical optimization.

Acknowledgment

The presented work in this publication is based on research activities, supported by the State of North Rhine-Westphalia. The Funds are based on the directive for granting funds from the "Programm für rationelle Energieverwendung, Regenerative Energien und Energiesparen (progres.nrw) - Programmbereich Klimaschutztechnik". The described topics are included in the research project “NeuPlan”. Only the authors are responsible for the content of this paper.

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