Master Thesis

for the achievement of the academic degree

Diplom-Ingenieur

in the field of study Electrical Engineering
at TU Wien

Open Source Energy Technology Portfolio Optimization of an Urban Energy Community considering High Shares of Renewable Energy

submitted at
Institute of Energy Systems and Electrical Drives

Supervisor: Privatdoz. Dipl.-Ing. Dr.techn. Johann Auer
Assistent: Univ.Ass. Dipl.-Ing. Theresia Perger, BSc

by

Sebastian Zwickl-Bernhard, BSc
01525191

Wien, April 2020

Abstract

The energy demand in cities will further rise due to the increased proportion of humans living in dense areas. An Energy Community (EC) embedded in Multiple Energy Carrier Systems (MECS) is one approach to take advantage of densely populated areas. Thus, synergies can be determined and used in terms of local renewable generation, energy efficiency, a high share of self-consumption, and energy sector integration. The core objective of this work is to find an optimized energy technology portfolio with a high share of local renewable energy in an EC at minimal costs. Thereby, the partly existing redundancy and thus competitive infrastructure in energy supply (for example gas and district heating network) as well as the increasing importance of the cooling demand are taken into account. To better understand the possible further development of sustainable local energy systems, the Open Source Model (OSM) *urbs* is used. The existing model with a high temporal resolution is further improved and extended to a mixed-integer linear program to include capacity-independent costs for energy supply from outside the EC. The data clustering algorithm *kmeans++* is used to obtain characteristic weeks for the yearly time-series. The extended OSM is applied to a case study in Vienna, Austria. An EC with high-diversity in prosumers is analyzed by three scenarios. The base scenario takes the current state of supply into account and validates the model. In the greenfield scenario, the EC is supplied from scratch and needs to invest in energy technologies and infrastructure. The results show a significant usage of geothermal sources for heating and cooling in combination with the maximum expansion of photovoltaics. However, covering demand for heating and cooling services of the EC by the district heating and cooling network delivering from outside the community become more competitive in terms of CO_2 pricing. The usage and extension of geothermal sources significantly depend on the local Coefficient of Performance (COP). A high COP results in a large proportion of geothermal sources to the heat demand. Otherwise, the EC is connected to the district heating network. Hence, the energy portfolio is more robust against CO_2 pricing in case of district heating due to the limited impact of the CO_2 price. It may be concluded that the approach of multiple energy carriers in an EC can achieve several goals in terms of economic local generation and a high share of self-consumption. OSMs demonstrate sophisticated, high-quality modeling is possible and open access builds the foundation for continuous improvements. Further research may address an elaboration on the impact of the clustering algorithm on the usage of storage. Furthermore, the interaction of the model urbs with further OSMs may enable a higher spatial resolution.

Kurzfasssung

Der Energiebedarf in Städten wird aufgrund des zunehmenden Anteils der Menschen, die in dicht besiedelten Gebieten leben, weiter steigen. Die Bildung von Energiegemeinschaften im Rahmen einer ganzheitlichen Betrachtung potenzieller Energieträger, bietet die Möglichkeit zur Entwicklung und Nutzung von Synergien. Diese können sowohl die lokale Erzeugung erneuerbarer Energien, die Energieeffizienz, als auch den Anteil des Eigenverbrauchs in der Energiegemeinschaft erhöhen. Das Ziel dieser Arbeit ist ein optimiertes Energietechnologieportfolio in einer Energiegemeinschaft mit minimalen Kosten unter Berücksichtigung eines hohen Anteils an lokalen erneuerbaren Energien. Dabei wird insbesondere die konkurrierende Energieversorgung verschiedener Technologien (z.B. Gas- und Fernwärmenetz) und der zunehmende Kältebedarf berücksichtigt. Die Basis dieser Arbeit bildet das Open Source Modell *urbs*. Ausgehend von diesem bestehenden Modell, welches eine hohe zeitliche Auflösung ermöglicht, wird das Modell zu einem gemischt-ganzzahligen linearen Modell erweitert. Dadurch werden leistungsunabhängige Anschlusskosten für die Energieversorgung von außerhalb der Energiegemeinschaft berücksichtigt. Die jährlichen Zeitreihen werden mittels Cluster-Algorithmus *kmeans++* mit vier charakteristischen Wochen dargestellt. Das erweiterte Open-Source Modell wird auf eine Fallstudie in Wien, Österreich angewendet. Die betrachtete Energiegemeinschaft mit einer hohen Diversifikation der Prosumer, wird anhand von drei Szenarien untersucht, die sowohl die derzeitige Versorgung, als auch eine potenzielle Neuversorgung des Gebiets betrachten. Die Ergebnisse zeigen einen erheblichen Ausbau von Geothermie, um den Wärme- und Kältebedarf zu decken. Der Einsatz von Geothermie hängt wesentlich von der lokalen Effizienz und dem Leistungsfaktor ab. Eine geringe Effizienz von Geothermie führt zu einem Anschluss der Energiegemeinschaft an das Fernwärme- und Fernkältenetz, wobei das Portfolio in diesem Fall robuster gegenüber steigenden CO_2 Preisen ist. Diese Arbeit kann durch den gewählten Open-Source Modell Ansatz zeigen, dass durch eine ganzheitliche Betrachtung der Energieträger in einer Energiegemeinschaft die Wirtschaftlichkeit lokaler Erzeugung und der lokale Eigenverbrauchsanteil erhöht werden kann. Open-Source Modellierung beweist dabei hohe Qualität und ermöglicht gleichzeitig Erweiterungen und stetige Verbesserungen der Modelle. Weitere Untersuchungen können den Einfluss der Cluster-Algorithmen auf den Einsatz von Speichertechnologien in der Energiegemeinschaft betreffen. Außerdem kann das Modell urbs mit weiteren Open-Source Modellen gekoppelt werden und dadurch eine höhere geographische Auflösung der Modellierung erreicht werden.

Contents

Abbreviations

BDV	Binary Decision Variables
COP	Coefficient of Performance
EC	Energy Community
ED	Electricity Demand
DSM	Demand Side Management
LP	Linear Program
MECS	Multiple Energy Carrier Systems
Micro-CHP	Micro Combined Heat and Power Unit
MIMO	Multiple Input Multiple Output
MILP	Mixed Integer Linear Program
OSM	Open Source Model
SLP	Standard Load Profile
WU	Vienna University of Economics and Business
w	Weight of Characteristic Week
x_{MILP}	Decision Variable Vector of Mixed Interger Linear Program
Γ^{con}	Capacity-independent Connection Costs
Δ	New Installed Capacity
λ	Peak Load of Customer
ξ	Total Costs
τ	Characteristic Week
$\hat{\chi}$	Upper Bound for Installed Capacity

1. Introduction

1.1. Motivation

By 2050, the proportion of humans living in cities will have already risen to two-thirds of the global population (Ritchie and Roser, 2018). This development increases the complexity of a sustainable supply of energy services in densely populated cities. One possible approach, which takes advantage of densely populated areas regarding their energy supply, is an EC (Fleischhacker et al., 2019). An EC is defined as follows:

> "Legal entity which is effectively controlled by local shareholders or members, generally value rather than profit-driven, involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at a local level, including across borders."
>
> — European Union, 2016

An EC or small urban district[1] offers the opportunity to increase the economic use of renewable energy sources, the local self-production and the integration of end customers as well as prosumers[2]. Small urban districts provide the opportunity of multiple energy carriers and consequently with optimized use, provide further synergies in terms of energy generation, consumption and storage (Lund et al., 2017). To meet the demand for electricity, heating and the increasingly important demand of cooling there are multiple energy carriers which, however, are competing with each other due to increasing sector coupling, decarbonization of the energy system and economical aspects. As stated in (Lazzarin and Noro, 2006), local and central heating systems (e.g. district heating) compete with each other. In principle, oversupply in covering the demand for energy services in an EC is possible, as gas, electricity, district heating, and cooling can usually be available at the same time. When taking a holistic approach, these multi-carrier energy distribution networks offer potential from both, a technical and an economic perspective (Widl et al., 2018).

[1] The notion "Mikroquartier" is common in the German language and could be translated as micro quarter. However, the term Energy Community and small urban districts are used instead of a micro quarter and thus to highlight the basic physical independence and voluntary access. See chapter 2 for more details.

[2] "Prosumers are agents that both consume and produce energy." (Parag and Sovacool, 2016)

1.2. Research question

The first main objective of this thesis is to find an optimized energy technology portfolio for an urban district. Thus, the aspects that arise from the possible supply of a small urban district with multiple energy carriers should be examined. This main objective will be extended to take a high share of self-consumption into account. In this context, as many renewable technologies as possible should be considered to supply energy services in the Energy Community. Thereby, another crucial research question is how the increasingly important demand for cooling can be taken into account. The question therefore arises whether and to what extent the portfolio changes in the context of different scenarios. Thus, the robustness of the portfolio can be analyzed. A distinction can be made in modeling between those models with limited access and Open Source Models. As a consequence, the question arises, whether Open Source Models offer the possibility to carry out a neighborhood analysis in the field of energy systems regarding a high share of self-consumption and local supply of energy services respectively. The work aims to evaluate, whether a wider understanding of the energy supply of small urban districts can be achieved by the application and extension of Open Source Models.

1.3. Applied methods

This work uses the Open Source Model "urbs" by Dorfner (Dorfner and Hamacher, 2015), which enables optimization for distribution networks with a high temporal resolution. It is a Linear Program (LP) for capacity expansion planning concerning multiple energy carriers. The optimization model is implemented in Python, using the Pyomo package[3]. Finally, the model is solved with the glpk optimizer[4]. As objective function, both costs and emissions could be minimized, with costs being minimized in this case. Especially, the proper documentation allows a particularly easy application, whereby the strengths of the model lie in the high temporal resolution. As a further step, the spatial resolution can be analyzed with the OSM "rivus"[5], to calculate the expansion capacity in terms of the geographical area, but this is out of the scope of this work.

In this work, a framework for setting up an Energy Community and the use case of an Open Source Model in a small urban district in Vienna, Austria is proposed. The urban neighborhood in the vicinity of the Vienna University of Economics and Business (WU) so-called *Viertel2* and the surrounding area is investigated. The boundaries of the area

[3]http://www.pyomo.org/
[4]http://www.gnu.org/software/glpk/
[5]The OSM "rivus" is a mixed integer linear optimization model for energy infrastructure networks with a high spatial resolution (Dorfner, 2017).

were chosen to achieve a high diversity in terms of generation units, load profiles, and building structures. The small urban district contains, besides passive and active end consumers, so-called prosumers, one potential new building site, a football stadium as a special customer and supply by different energy carriers like district heating and a Micro Combined Heat and Power Unit (Micro-CHP). As input, the model requires geographical and technical data in addition to time series for time-dependent efficiency, solar radiation, generation, and demand. The yearly time series are clustered with the method *kmeans++* into characteristic weeks, as shown in (Fleischhacker et al., 2019), to limit calculation time. The existing infrastructure is also taken into account and, based on this, an optimized energy technology portfolio is created.

1.4. Outline of thesis

The work is organized as follows. In chapter 2, the state of the art, the approach of Open Source Models and own contribution. Chapter 3 presents the methodology and the model, as well as the mathematical framework, empirical processing and the validation of the model. Chapter 4 presents the results for different scenarios. The "lock-in effect" of the existing infrastructure is investigated in the scenario named *greenfield* in section 4.3. In this scenario, the EC in the urban district has to invest in technologies, such as the distribution grid and storage. Chapter 5 shows the sensitivity analysis. Sensitivities regarding CO_2 pricing and thus the electricity price, the building structure and the efficiency, especially of the heating system are fields of this research. Sensitivities regarding the cooling system and the district cooling network respectively in terms of connection costs and energy prices are of particular importance for this thesis. Chapter 6 discusses and concludes the results of the work.

2. State of the art and progress beyond

This section gives essential aspects of the current state-of-the-art of energy communities from the literature. These aspects can be roughly classified into two parts and concern energy economically aspects and technical, sustainable aspects, which arise based on multi-energy systems. The difference between an Energy Community (EC) and a microgrid is firstly described. Thus, the possible advantages of an EC in the overall context can be shown. Furthermore, relevant aspects of open source modeling in energy systems are presented. This chapter is concluded by own contribution.

2.1. Economic dispatch in an urban district

2.1.1. Distinction between an energy community and a microgrid

An Energy Community (EC) and a microgrid have to be distinguished based on conditions of participation and in terms of the need for physical dependence. However, the term microgrid is not defined concretely. Nevertheless, it can be seen as a separated part of the low voltage distribution grid, whereby the functionality and not the size is decisive. Thereby, a microgrid can be connected to the public network or not. Basically, the demand is supplied by local sources in the microgrid. Thus, microgrids take a physical and financial perspective into account (Soshinskaya et al., 2014). Historically, the approach of isolated systems in the electricity system can be found in the historical progress of the industry in the United States (Marnay and Venkataramanan, 2006). Microgrids had different developments in regions due to this historical aspect, whereby an overview of different approaches is shown in “Overview of current microgrid policies, incentives and barriers in the European Union, United States and China” by Ali et al. (2017). In contrast, an Energy Community (EC) results on a voluntarily. The physical dependency is not present. Essentially, an EC can be seen as a social structure. Thus, energy supply should be achieved in a cleaner way. Furthermore, only economic conditions for agents in der EC exist and extensions in terms of peer-to-peer trading can be implemented (Gui and MacGill, 2018). Although, the distinction above, the term Energy Community or small urban district is used in this thesis. Effectively, the considered EC in this thesis can be seen as a microgrid with a connection to the public network.

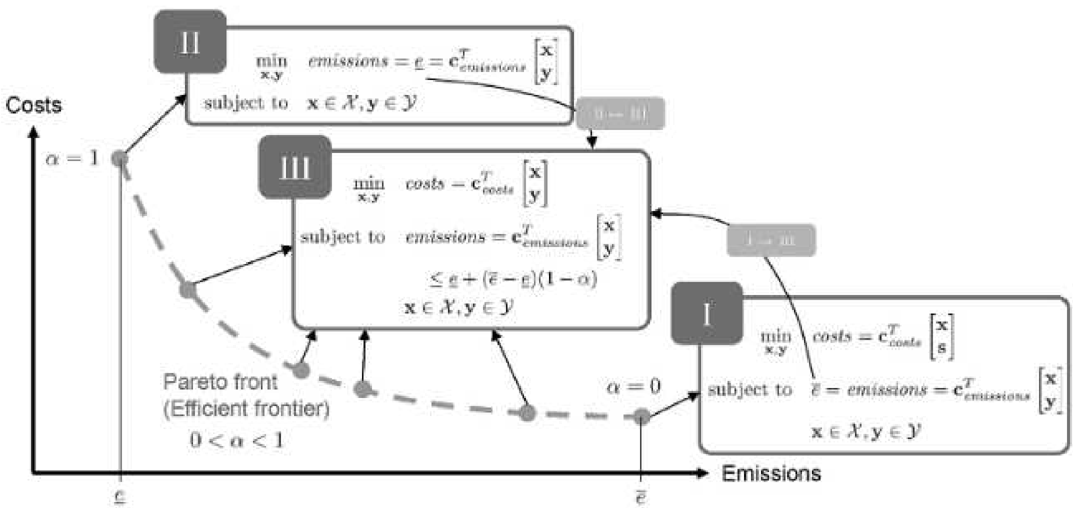
2.1.2. Synergies of multiple energy carrier systems

The integrating of multi-energy carriers is stated in “The optimal structure planning and energy management strategies of smart multi energy systems” by Ma et al. (2018) and improves energy efficiency and can also reduce supply costs. The essential task is to determine which types of processes, capacities, and units are needed and how they can be managed. A Mixed Integer Linear Program (MILP) to minimize costs is proposed. Based on this model, an optimal structure configuration and energy management strategy are created with better economic and environmental performance than the conventional centralized energy system. In this energy system, only transformer, electric heat pump, and electric chiller are selected to cover electricity, heating and cooling demand. The conventional centralized energy system supplies demand exclusively with electricity. As a consequence, the supply is relatively simple but the efficiency of the system can be improved. A system with better performance in cost and environmental can be achieved if further commodities (for example gas) are taken into account. Hence, the complexity of the energy supply depends on the number of commodities but simultaneously synergies arise. Especially, sector coupling increases both, performance and complexity. This also reduces the dependency on one specific commodity.

As stated in (Widl et al., 2018), the integration of multiple energy carriers in operating distribution grids can provide previously unused synergies. On the one hand, these synergies improve the efficiency of generation, storage, and consumption. On the other hand, multiple energy carriers increase the complexity of the system. A central challenge is that conventional systems were designed without capturing all relevant economic and technical aspects of hybrid grids. So-called *hybrid networks* can be obtained if existing network infrastructures are coupled. As a result, higher flexibility can be achieved and the integration of renewable energy sources is supported. Only through a holistic scope of multi-energy carrier systems, the advantages dominate, whereby these can be taken into account for short-term (operational) and long-term (strategical) aspects. The simulations provide operational or strategic recommendations. The two approaches and their results can interact for further investigations. A high temporal resolution is optimized by an economic model.

Multiple energy carrier systems also offer the possibility to reduce both, costs and emissions, whereby these systems can be seen as necessary to increase the efficiency, flexibility, and sustainability of traditional energy systems (Skarvelis-Kazakos et al., 2016). As a consequence, multiple energy carrier systems have increased requirements at the stage of planning and optimized application due to coupling of various energy systems (Huang et al., 2017). While it is a potential of redundancy in multiple energy carrier systems, the supply reliability increases due to flexibilities in the case of disruption of the supply of one energy system (Shariatkhah et al., 2016). However, flexibilities also arise due to the usage of seasonal storage in multiple energy carrier systems, whereby the complexity of the optimization model has to be taken into account and often complicate the modeling of storage (Gabrielli et al., 2018).

Not only since the *European Green Deal*[1] have cities to reduce their emissions[2]. This can be achieved at the district level. One possibility is modeling of hybrid energy systems at micro-district level (Fleischhacker et al., 2019). Both existing and future buildings must be taken into account. The dense building structure in cities enables neighborhood solutions that identify synergies in the system. Local ECs become necessary. These are characterized by their generation capacity, energy demand, and storage capacity as well as their connection to the grid infrastructure. The proposed OSM for optimization of a local energy neighborhood in an urban district shows two objectives: costs and emissions, whereby the solutions of the two objectives are far apart from each other. The so presented multi-objective optimization results in the Pareto Front[3]. The proposed approach is shown in figure 2.1.



Source: Fleischhacker et al., 2019

Figure 2.1.: Multi-objective optimization regarding costs and emissions with Pareto Front

A key challenge to calculate the required capacities is to understand the restrictions of the local energy system, which occur despite oversupply. The multi-energy carrier system

[1] `https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf`
[2] Cities consume more than 60 % of global energy and are responsible for 60-80 % of global greenhouse gas emissions (Regional Policy, 2011)
[3] The Pareto Front shows the optimal solution in terms of both, cost and emissions.

enables sector coupling and requires a distribution grid, which also allows the integration of so-called prosumers. In addition, time-dependent efficiencies that specifically influence the use of the heat pumps were taken into account. As a result, the solution for minimized emissions can be achieved by the electrification of the energy system.

2.2. Models - Open Source Modeling

Basically, modeling offers the chance to improve the understanding of high-complex systems. However, the possibilities for improvements in the models were often limited. Since the past proposed approaches of models were unique and without open access. Most of the modeling frameworks were intransparent black or grey boxes (Kriechbaum, Scheiber, and Kienberger, 2018). In addition to proprietary modeling, open source modeling has also developed and increased importance in recent years. A major reason for this is that further developments of models can easily be shared in terms of OSMs. In contrast to proprietary modeling, new approaches can easily be contributed to the community (Groissböck, 2019). This results in a steady improvement in the models. The quality is being improved and adaption costs are decreased. A possible point of criticism of free access to OSM can be of low quality in modeling. The literature shows that high-quality modeling can be achieved without significant differences in proprietary software (Ajila and Wu, 2007). Based on that, high quality in modeling OSM is used for the analysis of energy systems (Bazilian et al., 2012). Dorfner also demonstrates high-quality modeling with its OSM approach urbs with a scale of urban entities, stated in (Johannes Dorfner, 2016). In further consequence, urbs is applied for portfolio optimization of urban districts (Fleischhacker et al., 2019). In addition, urbs enables possibilities for interoperability and the development of platforms for energy systems. Thereby, soft coupling with further open source integrated platforms is shown in terms of the application of a case study (Alhamwi et al., 2018). Comparison and assessment of urbs and two additional open source frameworks are shown in "Grid-based multi-energy systems—modelling, assessment, open source modelling frameworks and challenges" by Kriechbaum, Scheiber, and Kienberger (2018). Necessary aspects are considered, which arise by modeling multi-energy systems in detail. The comparison relates general (for example modeling scope and formulation respectively) and specific aspects (for example level of detail, spatial and temporal resolution respectively). Thereby, the advanced economic analysis and the consideration of the multi-scenario of urbs for distributed energy systems are highlighted. Furthermore, urbs enables optimizing storage size and use, which models aspects that arise when energy is supplied and it is not totally required. The present work is associated with the two OSMs "urbs"[4] and "rivus"[5] (Dorfner and Hamacher, 2015)(Dorfner, 2017). These models

[4]Latin for city
[5]Latin for stream or canal

are well documented and allow a description of an EC in two-dimensions - temporal and spatial.

urbs[6] (Dorfner and Hamacher, 2015)

Urbs is an Open Source Model for energy systems. It is a Linear Program (LP) model for the planning of capacity expansion for distribution energy systems. The optimization model is scripted in Python and uses Pandas for complex data analysis. The optimization relies on the Pyomo package. The optimization model finds an optimized solution of the LP in terms of minimal energy costs or greenhouse gas emissions respectively. In addition, CO_2 pricing and taxes respectively can be considered due to the distribution of the total costs in the energy system. One part of total costs also concerns investment costs. Thus, transmission or distribution capacities respectively can be considered economically. As a result of the optimization, optimal process capacities can be achieved. Thus, the time-series of energy balance are obtained. One special strength is that multi-energy carriers, as well as a difference in energy demand (for example electricity, heating and cooling), can be taken into account. Multi-commodity energy systems are possible with a high temporal resolution. Basically, it operates on hourly-spaced time steps, which makes the model applicable. The application of the model is especially for urban districts but it is scaleable from small EC like energy neighborhoods up to the size of countries and continents. Furthermore, space limitation can be considered, which concerns, for example, the expansion of photovoltaics. Thus, in the case of modeling cities, the limited space of rooftops in an urban district can be taken into account. Besides transmission or distribution capacities, also storages enable flexibility concerning energy supply. The share of self-consumption and a high degree of self-sufficiency can be achieved. There are also flexibilities on the demand side and Demand Side Management (DSM) is possible. For example, in the case of an urban district with a high share of electric vehicles, DSM can take an optimized charging of electric vehicles into account.

rivus[7] (Dorfner, 2017)

As already mentioned, there are different specific aspects in modeling, whereby these can exclude each other due to simplification and limitation of computing time. With rivus, an open source framework is proposed by Dorfner (2017), which covers a high spatial resolution. Especially, the coupling of the two described models urbs and rivus is possible based on the open source approach and interoperability of the models (Fleischhacker et al., 2019).

[6] https://github.com/tum-ens/urbs
[7] https://github.com/tum-ens/rivus

Basically, rivus is a Mixed Integer Linear Program for the planning of capacities of energy infrastructure networks. It can be seen as a companion model for urbs. The focus is on a high spatial resolution. The objective function is to minimize the costs of energy infrastructure networks for multiple commodities. The model is also written in Python and includes reporting and plotting of results. As a result, the model optimizes the required network capacities (for example gas, electricity) in terms of minimal costs.

2.3. Own contribution

Based on the above-mentioned research question, the own deliverable of the thesis is presented. Basically, the own contribution can be described through representation in three dimensions. These three dimensions are the methodical extension of the Open Source Model, an empirical improvement considering the data clustering algorithm and aspects of energy economic expansion. The three dimensions are shown in figure 2.2 below and stake out the field within which results and sensitivity analysis can be positioned.

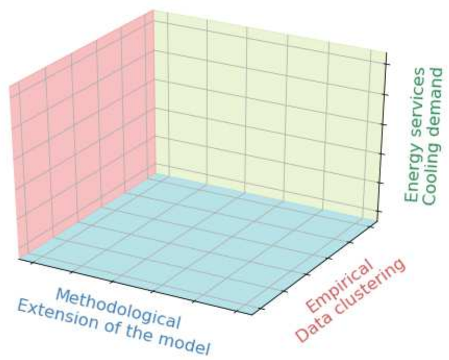


Figure 2.2.: Own contribution presented in three dimensions: methodical extension of the model, empirical data clustering and energy economic expansion.

The extension of the model enables taking further technologies into account. Thus, the model is able to consider investment decisions in terms of a connection to the district heating and cooling network. Therefore, the Linear Program (LP) is expanded to a Mixed Integer Linear Program (MILP).

The empirical part deals with the reduction of data. The application of the *kmeans++* clustering algorithm enables computing yearly time-series of demand, solar radiation and efficiency in a reasonable time without qualitative losses in terms of total energy and peak values respectively.

The third dimension is the expansion of aspects of the energy technology portfolio and energy services. This thesis takes the status quo of the distribution grid into account. Thereby, also further renewable energy sources, for example, geothermal heating and cooling, are considered. Moreover, and of particular significance, the existing district cooling network is analyzed in terms of energy price, CO_2 pricing, the range of the pipeline system and connection costs respectively. This thesis shows a real application of the approach of open source modeling for energy systems. Thereby, a case study for a small city district in Vienna, Austria is carried out. Thus, doors can be opened for energy planners to decarbonize urban districts in terms of minimized costs.

3. Methodology and model

3.1. Flowchart

The main objective of the thesis is to find an optimized energy technology portfolio for the selected small urban district *Viertel2* in Vienna while choosing an OSM approach. This is implemented through the application of the OSM "urbs" by Dorfner (Dorfner and Hamacher, 2015).

The selected approach is shown in the flowchart in figure 3.1 below. The main part of the flowchart is "urbs". Nevertheless, further improvements of the model regarding constraints for process capacities in the EC are made. The EC is analyzed in terms of different scenarios and a sensitivity analysis.

The application of the use case in the selected area *Viertel2* of "urbs" requires economic and technical parameters. The values enable a reflection of the real-life situation as accurately as possible. For better performance and calculation time, time-series data is pre-calculated first and then clustered into characteristic weeks using the *kmeans++* algorithm.

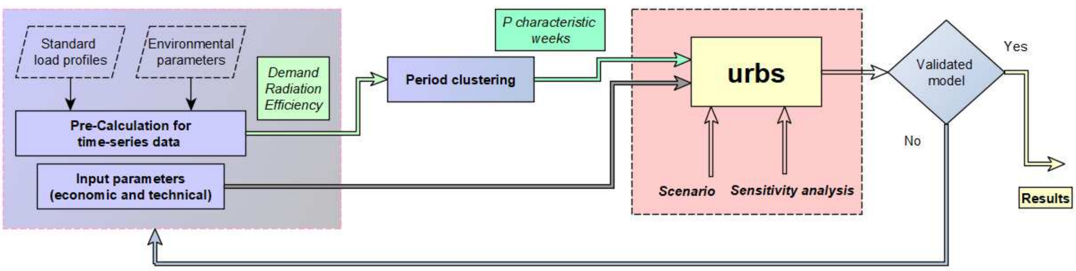


Figure 3.1.: Flowchart of the selected approach

The mathematical model of "urbs" and further improvements are shown in chapter 3.2 below. The determination of the economic and technical input parameters, as well as the time-series data, is shown in chapter 3.3. The definition of the investigated scenarios is shown in chapter 3.4.

3.2. Mathematical framework

3.2.1. Existing Open Source Model (OSM)

The methods of this work are built on the Open Source Model (OSM) "urbs" by Dorfner (Dorfner and Hamacher, 2015). It is a Linear Program (LP), whereby each can be written in the following standard form[1]:

$$\begin{aligned} &\min\ c^{\mathrm{T}} x \\ &\underset{\sim}{A} x = b \\ &\underset{\sim}{B} x \leq d \end{aligned} \tag{3.1}$$

In the standard form x is the variable vector and c the coefficient vector for the objective function. The matrices $\underset{\sim}{A}$ and $\underset{\sim}{B}$, as well as the vectors b and d consider the equality respectively inequality constraints of the mathematical model.

Due to the well documentation of "urbs" it can be reffered to the available documentation (Johannes Dorfner, 2020). The document shows the entire mathematical framework. However, the model is built up with the entities below:

- Commodities: Represent material and energy flows.
- Processes: Converts commodities represented in the model as fixed Multiple Input Multiple Output (MIMO).
- Transmission lines[2]: Transport commodities between sites.
- Storages: Store one type of commodity.
- DSM.

Hence and to make the work more readable, only some aspects of the mathematical model are presented below.

[1] For distinction matrices are marked with a tilde below capital letters. Vectors are represented with lower case letters.

[2] As already mentioned, in this thesis the term distribution lines instead of transmission lines is used.

Objective Function

In this work total costs are minimized. However, total costs ξ can be split up in the following way:

$$\xi = C_{\text{inv}} + C_{\text{fix}} + C_{\text{var}} + C_{\text{fuel}} + C_{\text{env}}, \tag{3.2}$$

where C_{inv} are the annualized investment costs, C_{fix} the annual fixed costs, C_{var} summed variable costs over one year, C_{fuel} summed fuel costs and C_{env}[3].

Decision variable vector

The variable vector in the optimization model "urbs" takes the follwing form:

$$x^T = (\xi, \rho_{ct}, \kappa_p, \hat{\kappa}_p, \mu_{pt}, \epsilon^{in}_{cpt}, \epsilon^{out}_{cpt}), \tag{3.3}$$

where ξ are total annualized system costs, ρ_{ct} the amount of commodity c at the timestep t, κ_p the total installed capacitiy per process p, $\hat{\kappa}_p$ the newly installed capacity per process p, μ_{pt} the operational state of process p at timestep t and ϵ^{in}_{cpt} respectively ϵ^{out}_{cpt} the total inputs and outputs of commodities per process p at timestep t.

Consequently, the coefficient vector c is given as:

$$c = (1, 0, 0, 0, 0, 0, 0). \tag{3.4}$$

3.2.2. Further improvements of the model

Capacity-independent connection costs for the district heating and cooling network

Investment costs are one major reason for the usage of technology and, consequently, they influence whether technology is selected in the energy technology portfolio or not. Based on the annuity method, investment costs are annualized and therefore given as:

[3]The total costs for environmental pollution can be seen as a representation of CO_2 taxes. The total costs for environmental pollution. The impact of C_{env} on the objective function and therefore on the energy technology portfolio is analyzed in the sensitivity analysis in chapter 5.1

$$C_{\text{inv}} = \sum_{p \in P_{\text{exp}}} a_{\text{p}} \cdot \{sicc_p^{inv} \cdot \Delta_p + \Gamma_p^{con}\}, \tag{3.5}$$

where a is the annuity factor, $sicc$ the specific investment costs per capacity, Δ the new installed capacity[4] and Γ^{con} capacity-independent connection costs per process p in the subset P_{exp}. This subset collects all processes that are actually expanded. The connection costs are only considered for district heating and cooling in the case of a connection to the network.

Extension from a Linear Program (LP) to a Mixed Integer Linear Program (MILP)

Vector x contains the decision variables of the model. This vector is extended with additional Binary Decision Variables (BDV) in the following form:

$$x_{MILP}^T = [x, \text{BDV}], \tag{3.6}$$

where x_{MILP} contains the decision variables of the MILP[5]. BDV are used for the investment decision and to consider these costs in the objective function. BDV are taken into account for every process $p \in Process$ in the EC. The following constraint applies:

$$\Delta_p \leq \text{BDV}_p \cdot \hat{\chi}_p, \tag{3.7}$$

where $\hat{\chi}_{\text{p}}$ represents the upper bound for the installed capacity per process p.

Exclusive use of gas and district heating network in one site

In addition, the following constraint considers the exclusive use of district heating or a gas-fired Micro-CHP unit in a site $s \in Sites$.

[4] The variable name Δ_p is used instead of $\hat{\kappa}_p$ to highlight the own contribution to the investment costs. However, the equation $\Delta_p = \hat{\kappa}_p$ is valid.

[5] BDV consider the special case of a MILP optimization in which for some variables only binary states are possible.

$$\text{BDV}^s_{DH} + \text{BDV}^s_{Micro-CHP} \leq 1, \quad (3.8)$$

where BDV^s_{DH} represents the decision of whether district heating is connected or not in site s. Analogously, this applies to existing capacities of a Micro-CHP in site s. Equation 3.8 forces that only district heating or a gas-fired Micro-CHP is installed in a site, which is especially important in the greenfield scenario[6].

3.3. Empirical processing

3.3.1. Economic and technical input parameters

Table 3.1 below shows selected technical input parameters of the processes. A complete list of these parameters and the values for storages and transmission can be found in the Appendix A.

Process	inv-costs [EUR/kW]	area [m^2/kW]	con-cost [EUR/m]
Photovoltaics	850	6.50	-
Solarthermal	1 200	1.25	-
Micro-CHP	875	-	-
Geothermal	1 600	-	-
Heat pump (air water)	510	-	-
District heating	-	-	1 000
District cooling	-	-	1 000
Compression machine	200	-	-
Absorption machine	800	-	-

Table 3.1.: Investment costs and connection costs of technologies respectively. In addition, required area for photovoltaics and solarthermal.

[6]Basically the clustering algorithm supports in some cases a combination of district heating and a Micro-CHP if the constraint in equation 3.8 is deactivated. See also chapter 4.

The input parameters base on the data of:

- "Portfolio optimization of energy communities to meet reductions in costs and emissions" by Fleischhacker et al. (2019), whereby in addition learning effects of technologies (for example phtovoltaics and solarthermal) are assumed.
- Investment costs for geothermal are taken from "Investment cost for geothermal power plants" by Stefansson (2002).
- Specific connection costs per metre for district heating are taken from Johannes Dorfner, 2016, p. 126 respectively DECC, 2015, p. 42.

Table 3.2 below shows the economic input parameters.

Commodity	Price [EUR/MWh]	Source
Gas	18	(Rademakers et al., 2018, p. 76)
CO_2	20	(Fina, Auer, and Friedl, 2019)
Electricity buy	200	-
Electricity sell	30	-
Heat buy	50	(Ahlgren, Simbolotti, and Tosato, 2013)
Cold buy	50	-

Table 3.2.: Economic input parameters in terms of commodity prices

3.3.2. Pre-Calculation of time-series

Electricity Demand

The calculated time-series are based on a bottom-up approach. Standard Load Profile (SLP)s for different types of end-customers (for example flat, office or trade) were used[7]. The Electricity Demand (ED) for each site is therefore given as:

$$\mathrm{ED} = \sum_i \mathrm{SLP_i} \cdot \lambda_\mathrm{i}, \tag{3.9}$$

where λ_i is the peak load of customer i.

[7] https://www.apcs.at/de/clearing/technisches-clearing/lastprofile

Heating and cooling Demand

The heating demand is based on the real loadprofil of a district heating network. The temporal course of the heating demand in the sites is calculated based on the composition of customers and their assumed heating demand per year. The approach is described in the following equations 3.10 and 3.11 below:

$$Total\ Heating\ Demand_{\text{ year}} = \sum_i C_{\text{i}} \cdot \hat{E}_i, \tag{3.10}$$

$$Total\ Heating\ Demand_{\text{ year}} = \sum_t heating\ demand\ (t), \tag{3.11}$$

where C is the number of end-consumer per type (for example C_1 flats), $\hat{E}_i$ the total heating demand per end-consumer and type and *heating demand*(t) the temporal course of heating demand per timestep t.

Cooling demand is generated by considering outdoor temperatures (ϑ). The following equation 3.12 is used as an assumption and gives a relation between the outdoor temperature and a standardized cooling demand profile.

$$Cooling\ Demand\ (\vartheta) = \frac{1}{1 + \exp \frac{-\vartheta + \vartheta_0}{1.5}} \tag{3.12}$$

In this context, ϑ_0 means a specific outdoor temperature where the cooling demand is set to a half. By the choice of ϑ_0, the cooling demand can be adjusted. While assuming thermal time constants, the cooling demand is just a section of the results of equation 3.12. It can be argued that this approach takes the outdoor temperature of the previous days into account. This can be observed at the beginning of an outdoor heat period when cooling demand is delayed some days. Results of standardized heating and cooling demand can be seen in figure 3.2 below.

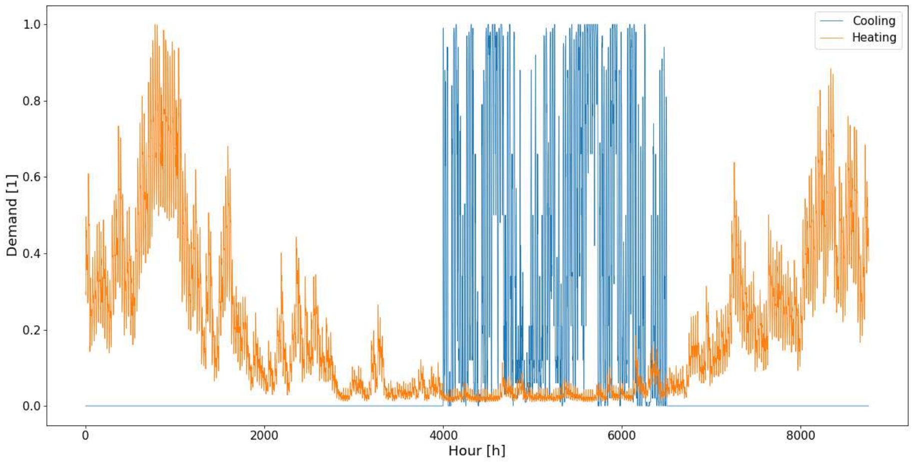


Figure 3.2.: Standardized heating and cooling demand considering a real district heating load profile and the outdoor temperature for the cooling demand profile.

Heat pump efficiency

The heat pump efficiency significantly depends on the outdoor temperature and the flow temperature. A higher flow temperature needs more energy and decreases energy efficiency. The maximum and the value of COP at an outdoor temperature of 0° are assumed. In addition, a typical course of the COP is interpolated. A bundle of curves is received while considering different flow temperatures. In the following, different flow temperatures represent different building classes. Those buildings with lower energy demand, as an example because of better insulation, have also a lower flow temperature. As a consequence, the efficiency and economic aspects of heat pumps increase. This is also analyzed in the sensitivity analysis in chapter 5.3.

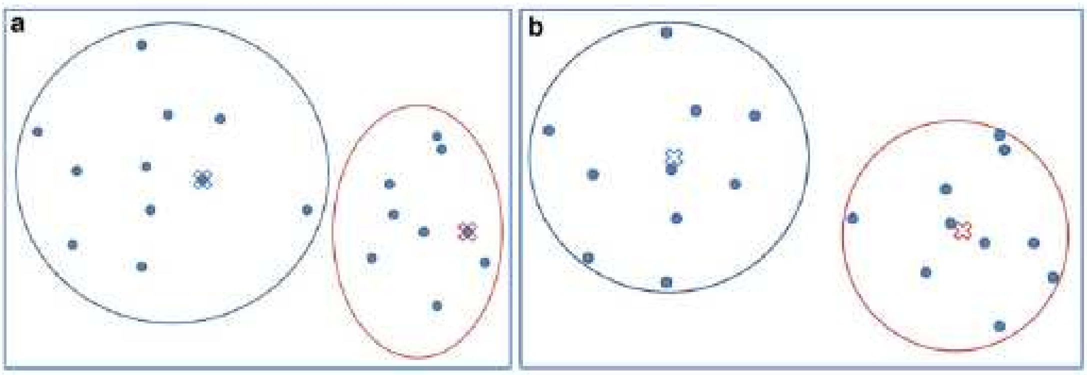
3.3.3. Period clustering algorithm

As a result of chapter 3.3.2, the annual time-series have to be clustered into characteristic weeks. This approach limits the calculation time of the simulation. Therefore, the period clustering algorithm *kmeans++* is used (Jin and Han, 2017). *Kmeans++* can be used for data points and time-series, as also shown in "Portfolio optimization of energy communities to meet reductions in costs and emissions" by Fleischhacker.

The algorithm requires a matrix $\underset{\sim}{M}$ as input. The algorithm specifies a set of clusters (P) with m_k as the centroid of a cluster P. This is shown in figure 3.3 below. The two centroids in the picture (a) are represented by crosses. The centroids are identical to data points as a result of the initialization of the algorithm. Subsequently, each data point is assigned to a cluster. A data point is assigned to a cluster if the distance to the corresponding centroid is minimal. The clustered data points are represented by the shapes and the area enclosed by the lines. Afterward, the centroids of the cluster are recalculated, as shown in picture (b). The location of the new centroids is the center of the previous clustered data points. All data points are assigned again to the corresponding cluster in terms of minimum distance to the centroids. This iteration continues as long as the centroids stay at the same location after one iteration step. The algorithm optimizes the centroids m_k of the clusters while considering the following objective function, where x is a data point:

$$min \sum_{P} \sum_{x \in P_i} dist(x, m_k), \tag{3.13}$$

In this context, the distance between two points is the euclidean distance.



Source: (Jin and Han, 2017, p. 696)

Figure 3.3.: Visualization of the *kmeans++* algorithm with two clusters. Each data point is allocated to the corresponding cluster, whereby distance to the centroid is minimal.

Input matrix of the clustering algorithm

To obtain the input matrix, time vectors of demand (D), radiation (R) and efficiency (E) are reshaped as below:

$$D_s^{Elec}, D_s^{Heat}, D_s^{Cool}, R_s^{PV}, E_s^{HP} \in \mathbb{R}^{T_w \times W}, \tag{3.14}$$

with $s \in Sites$ and T_w timesteps within a week w. The input matrix $\underset{\sim}{M}$ is given by:

$$\underset{\sim}{M} = \begin{pmatrix} D_{Viertel2}^{Elec} & \cdots & D_{Neubau}^{Elec} \\ \vdots & \ddots & \vdots \\ E_{Viertel2}^{HP} & \cdots & E_{Neubau}^{HP} \end{pmatrix} \tag{3.15}$$

For visualization of the algorithm and the optimization, the following example is given: Figure 3.4 shows the result of period clustering for the annual solar radiation time-series with four characteristic days. In this case, the input matrix $\underset{\sim}{M}$ is given as:

$$\underset{\sim}{M} = \begin{pmatrix} R_{Viertel2}^{PV} & R_{WU}^{PV} & R_{Stadion}^{PV} & R_{Neubau}^{PV} \end{pmatrix} \tag{3.16}$$

Each dashed color line represents a characteristic day of solar radiation. Thereby, one cluster or characteristic day respectively consists of 24 single centroids. The figure shows an additional result of the clustering. The maximum value of the annual time-series of solar radiation is higher than the maximum of the characteristic days. This finding is also described in greater detail below.

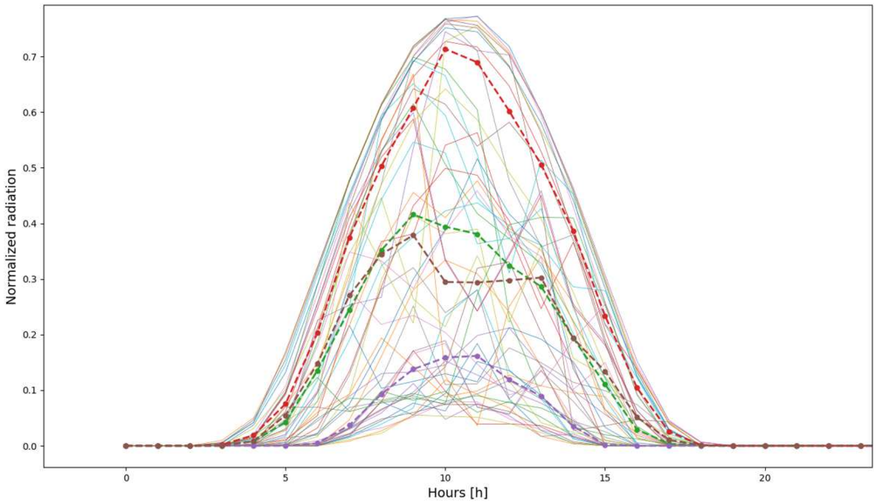


Figure 3.4.: Example for the results of the *kmeans++* algorithm. Four characteristic days of the annual solar radiation, represented by the dashed colored lines.

The difference in peak values of the annual time-series and the clustered time-series depends on the input matrix $\underset{\sim}{M}$. Figure 3.5 shows the the results of *kmeans++* with three characteristic weeks $\tau_{1,2,3}$ for the heat demand. ΔPeak is the difference between the peak load of the annual time-series and the peak load of the clustered time-series. As a result, three characteristic weeks are calculated by *kmeans++*. In addition, the week of the annual time-series with the highest heat demand is added to the time-series of heating demand. This is only necessary for the time-series of heating demand[8]. The difference in peak values of electricity and cooling demand is significantly lower than the ones in the heat demand. Basically, results of the algorithm can be adjusted by the input matrix $\underset{\sim}{M}$.

[8]However, all time-series are expanded with the corresponding week.

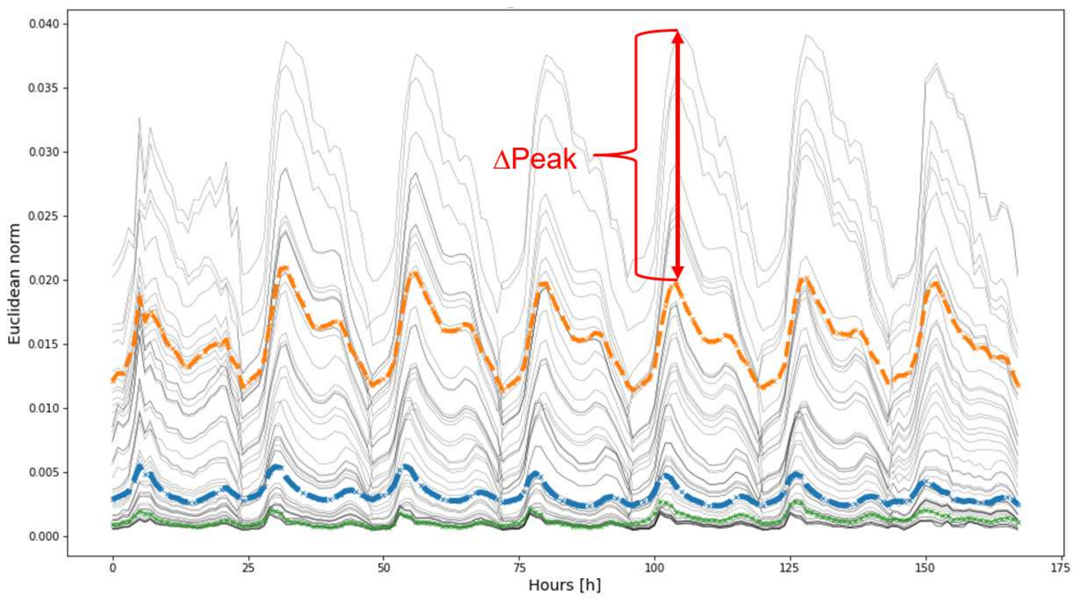


Figure 3.5.: Annual heat demand time-series clustered into three characteristic weeks. ΔPeak depends on the input matrix $\underset{\sim}{M}$ and is significantly for heat demand.

Weighting of the characteristic weeks

As a result of the period clustering algorithm, the weight w_{j} of each characteristic week τ_{j} can be defined as below:

$$w_{\mathrm{j}} = \sum_{i} \alpha_i \text{ with } \begin{cases} 1 & \min(dist(w_i, \tau)) = dist(w_i.\tau_j) \\ 0 & \text{otherwise} \end{cases} \tag{3.17}$$

where τ represent the time-series of each characteristic week. In sum, the weight w_j gives the number of weeks in a year which has the minimal distance to the corresponding characteristic week τ_j. The summation of all weights w of the characteristic weeks τ has to be W weeks again (Compare the dimension of $\mathbb{R}$ in equation 3.14). Weights w_j are used in the objective function to calculate the total costs for the supply of year. Therefore weights multiply the corresponding parts of total costs. This concerns the variable, fuel and environmental costs.

Required number of clusters

Figure 3.6 below shows a comparison between period clustering with 2 and 4 clusters respectively during characteristic weeks. The colored dashed curves show a section of the characteristic weeks τ. The thickness of the lines represents the corresponding weights w. The thicker the lines the higher the weight of the characteristic weeks (See equation 3.13. This means again that the distance from the corresponding characteristic week to a week w is minimal.). Basically, the number of clusters can be adjusted. The trade-off is shown in figure 3.6. If the number of clusters is small, basically each cluster has a relatively high weight. In some cases, the peak value of time-series is lost due to the small number of clusters. If the number of clusters increases, some characteristic weeks have small weights because they just represent a small number of weeks but the peak load is covered well. This is shown in figure 3.6 if the thickness from the colored dashed lines is compared.

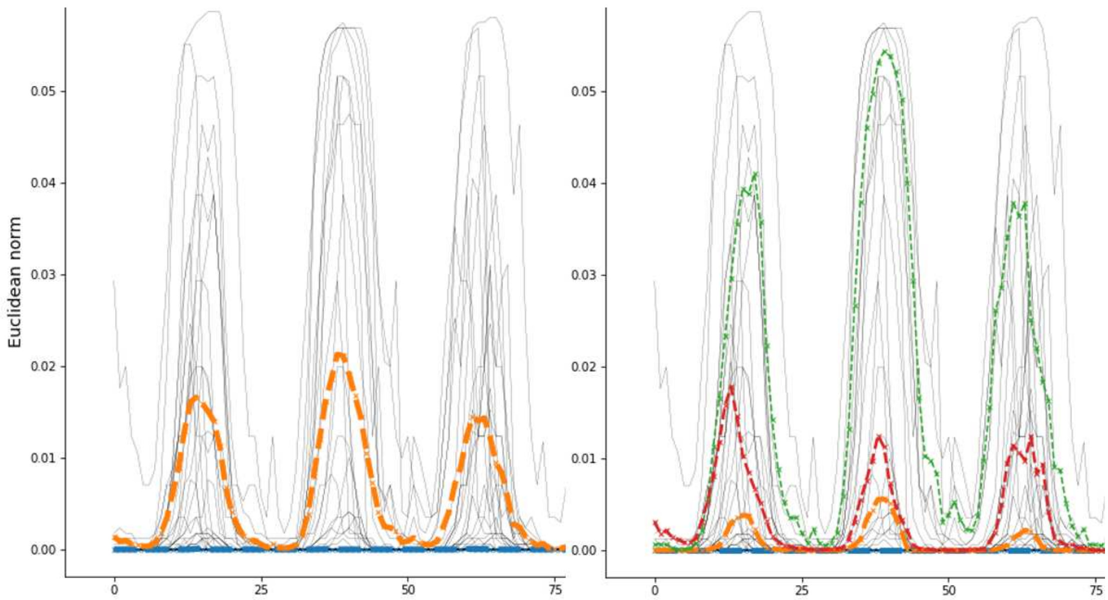
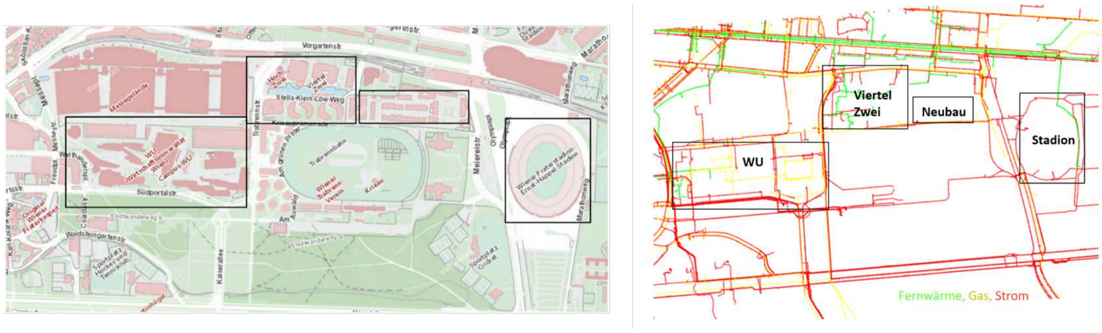


Figure 3.6.: Comparison of different numbers of clusters. Thickness of the colored dashed lines represent the weight of the corresponding characteristic week τ

3.4. Definition of scenarios

An EC in the city of Vienna, Austria is proposed. The method described in chapter 3 is applied to the area called *Viertel2* and its surrounding areas. A geographical overview of the area is shown in figure 3.7 below. The left picture localizes the sites. The right picture shows the distribution grid infrastructure for electricity (red), gas (yellow) and district heating (green). The area is chosen because of the dense supply of multi-energy carriers.



Source: Left: Stadt Wien. Right: Magistratsabteilung 28

Figure 3.7.: Geograpgical overview and distribution grid for available commodities of the EC

Four different sites are selected in the EC as follows:

- *Viertel2*: Modern residental and office buildings with trade and shops. Head office of companies with restaurants.
- *WU*: Campus of the University with several buildings and restaurants.
- *Neubau*: Potential area for residental buildings.
- *Stadion*: Special end-customer with much space for photovoltaics and some days of peak load (for example concerts or football games).

Basically, the following scenarios are investigated in terms of the structural supply of the EC:

1. Base scenario: Takes the current state of supply into account. Reflection of the current state of energy supply. The results of the scenario are used for the validation of the model in chapter 3.5.
2. District Heating extension: Favors the extension of the district heating network in the EC. Therefore, a lower efficiency for geothermal units at the location is considered.

The lower efficiency of the geothermal units can be argued by the geographical location. The potential of geothermal units and therefore the achievable efficiency significantly depends on the location.

3. Greenfield: No existing capacities are taken into account. The EC is investing in infrastructure and technologies. It helps to understand the "lock-in effect" of technologies in the portfolio. Implementing from scratch is necessary for the energy technology portfolio of the EC.

3.5. Validiation of the model

This section validates the model and its parameters and assumptions. The link between the results of the model and the available data is verified. If necessary, possible causes for differences in behavior should be shown. Basically, structural differences or parameter values can be possible causes. Structural differences can be split up into intended abstraction, unintended inaccuracies, so-called bugs, and errors. In general, validation can be described by three different types: Function-related, results-based and theoretical validation. The following can be categorized into results-based validation. The compared results, which are in turn compared with real data, are from the scenario in chapter 4.1. The so-called *Base* scenario calculates the current state of supply while taking existing infrastructure into account. Further assumptions in terms of efficiency of the processes are shown in table 3.3 below. CO_2 emissions for electricity can be seen as a reference value for the Austrian electricity mix[9]. The CO_2 emissions of district heating are also a reference value[10]. Time-series can be found in the Appendix B.

[9] https://www.e-control.at/documents/1785851/1811582/e-control-Stromkennzeichnungsbericht-2018.pdf/ddefad7a-219f-9360-0806-b26458b0ff6b?t=1539001268730

[10] https://www.ots.at/presseaussendung/OTS_20071204_OTS0186/mit-fernwaerme-co2-einsparen

As a result, photovoltaics is especially at *Stadion* significantly expanded and produces about 3000 MWh per year. The installed capacity is 3 MW and therefore the full load hours are about 1000 h, which is a typical value for Austria (Haas et al., 2013). The produced energy can also be compared with other photovoltaic systems on rooftops of stadiums in Austria. A much smaller stadium in lower Austria got a 400 kWp photovoltaic systems and produces about 300 MWh[11], which makes the results also plausible if values are scaled up by a factor of ten.

The existing heating supply of *WU* is based on a combination of geothermal and district heating, whereby geothermal supplies baseload and district heating peak load. Data of the energy demand at *WU* is well documented as shown in the annually published environmental statement[12]. In the following, the heat demand is considered in particular because, in the current state, no photovoltaic system is installed. Therefore the entire electricity is purchased. Nevertheless, the bottom-up calculated electricity demand of 13 557 MWh can be compared with the factual electricity demand of about 13 056 MWh. This is the documented electricity demand of *WU* without electricity for heating and cooling. The model calculates produced total energy of district heating of 2085 MWh, whereby in the year 2018, the factual use of district heating was 1808 MWh. The real electricity demand for heating and cooling is about 3005 MWh. The simulation calculates a demand of 2346 MWh and can be split into 364 MWh for the compression machine, 1030 MWh for geothermal heating and 952 MWh for geothermal cooling. The difference between the simulation and the real value can be explained with the uncertainty of the assumed geothermal capacity and efficiency. A small variation of geothermal capacity affects the energy produced of geothermal sources because of its use for the supply of baseload. The available data of *WU* show a higher demand for cooling than for heating, which is also evident in the higher electricity demand for cooling.

[11] `http://nvarena.skn-stpoelten.at/de/4419`

[12] The current environmental statement of Vienna University of Economics and Business (WU) can be found at `https://www.wu.ac.at/fileadmin/wu/h/structure/servicecenters/procurement/Umwelt/Umwelterklaerung19_web_final.pdf`.

Process	Commodity	Direction	ratio
Photovoltaics	Solar	In	var
	Elec	Out	1
Micro-CHP	Gas	In	1
	Heat	Out	0.9
	CO_2	Out	0.46
Solarthermal	Solar	In	1
	Heat	Out	0.8
Heat pump (air water)	Elec	In	1
	Heat	Out	var
	CO_2	Out	0.1
Geothermal heating	Elec	In	1
	Heat	Out	4
	CO_2	Out	0.1
District heating	Heat buy	In	1
	Heat	Out	1
	CO_2	Out	0.13
District cooling	Cold buy	In	1
	Cold	Out	1
	CO_2	Out	0.13
Absorption machine	Heat	In	1
	Cold	Out	1
	CO_2	Out	0.13
Compression machine	Elec	In	1
	Cold	Out	1
	CO_2	Out	0.1
Geothermal cooling	Elec	In	1
	Cold	Out	4
	CO_2	Out	0.1

Table 3.3.: Relationship between the input value and the output value of in terms of commodities in the EC. The ratio of inputs and outputs of heat pumps is not constant and therefore marked as a variable (var).

An existing Micro-CHP at *Viertel2* is also taken into account. The simulation calculates an amount of produced energy of 1431 MWh. This energy is produced by the gas-fired unit especially in the characteristic week, which can be seen as a representation of a week in winter. Available data show that the demand of gas is in the range of 200-450 MWh in one winter month[13]. Based on an estimation that this demand is valid for three to five months, the result of the simulation for the usage of the gas-fired Micro-CHP is plausible.

Presented data in footnote 13 show an electricity demand for heating between 50-140 MWh in one winter month. Analogous to the assumptions before, the electricity demand for heating can be estimated in the range of 300-600 MWh per year. The simulation shows an electricity demand for heating of 541 MWh. Basically, a high total of produced energy by gas-fired Micro-CHP decreases the electricity demand in terms of heating and vice versa. After the *kmeans++* algorithm, the calculated cooling demand at *Viertel2* is 2029 MWh. Based on the literature, cooling demand can be assumed with 30 kWh/m^2 for comparable buildings (Berger et al., 2014). As an estimation, cooling demand is therefore about 2400 MWh, whereby an area of 80 000 m^2 is assumed[14].

Some findings of the validation are summarized in table 3.4 below. The calculated values are those after the clustering to characteristic weeks with *kmeans++*. The analysis of the table enables an overview of the plausibility of the results in chapter 4 and subsequently the sensitivity analysis in chapter 5. The estimated value for the produced energy of the gas-fired Micro-CHP at *Viertel2* is the average value of the described range above.

Description	Type	*WU*.Electricity	*Viertel2*.Heat	*WU*.Heat	*WU*.Cold
Demand	Reality	13 056	3 385	5 602	6 954
	Calculated	13 557	3 601	6 254	4 889
Micro-CHP	Estimated	-	1 425	-	-
	Calculated	-	1 431	-	-
District heating	Reality	-	-	1 808	
	Calculated	-	-	2 085	
Electricity for heat and cold	Reality	2 786	-	-	-
	Calculated	2 346	-	-	-

Table 3.4.: Validation of the model. Comparison between real data and calculated values for demand and production in the sites *WU* and *Viertel2* of the EC.

[13] https://nachhaltigwirtschaften.at/resources/sdz_pdf/events/20190131-tws-sdz/03_Vogl_KWK_Viertel_Zwei.pdf?m=1549984836&

[14] The clustering algorithm reduces cooling demand. The annual time-series, which was input data for *kmeans++* had an demand of 2542 MWh for cooling.

4. Results

This chapter describes a series of three scenarios, using the presented Open Source Model (OSM) approach described in the previous chapters. Each scenario places the focus on a different aspect of modeling energy systems and the effect on the energy technology portfolio. The analysis of the scenarios is split into two parts. Firstly, the input data and development of the scenario. The motivation of the scenario should again be briefly described. Also, the modified values are highlighted and its modification argued. Secondly, the results of the model, which are described by the total costs of supply and total produced energy per technology. The results of each scenario are described as qualitative and quantitative.

4.1. Basic structural supply in the current state (base)

4.1.1. Input data and development of scenario

This section shows the results of basic structural supply at all sites in the Energy Community. Thereby, the current technology portfolio in the considered sites is taken into account. Especially, the installed processes to meet demand at *Neubau* can be seen as an investment recommendation because supply has to be done without any existing capacity.

At *Viertel2*, the existing energy technology portfolio is given as a photovoltaic system, a gas-fired and heat-driven Micro-CHP unit, a geothermal heating and cooling unit and compression machines[1]. At *WU*, the technologies are a geothermal heating and cooling unit, a connection to the district heating network and compression machines. The connection to the district heating network is also valid for *Stadium*. As already mentioned, there are no existing capacities at *Neubau* considered. The results of the *base* scenario are also used for the validation of the model in chapter 3.5.

[1]The assumed installed capacities can be seen in the Appendix A

4.1.2. Results

Total costs and electricity

The calculated total annual costs are 4.48 million euro per year, whereby these costs are dominated by the costs of electricity purchase, especially because of electricity demand at WU. Revenues are low due to high self-consumption of the EC and the low commodity selling prices. The current CO_2 price is reflected in low environmental costs. Annuity of investment costs can be split as follow: Compression machines to cover cooling demand at base of electricity, maximum expansion of photovoltaics and geothermal heating, as well as cooling. As a consequence, no solar thermal, heat pump, absorption machine or new district heating connection is in the energy technology portfolio in the base scenario.

The usage of technologies in the EC is shown in figure 4.1 below and gives a quantitative overview of the technology portfolio in the current state scenario (base).

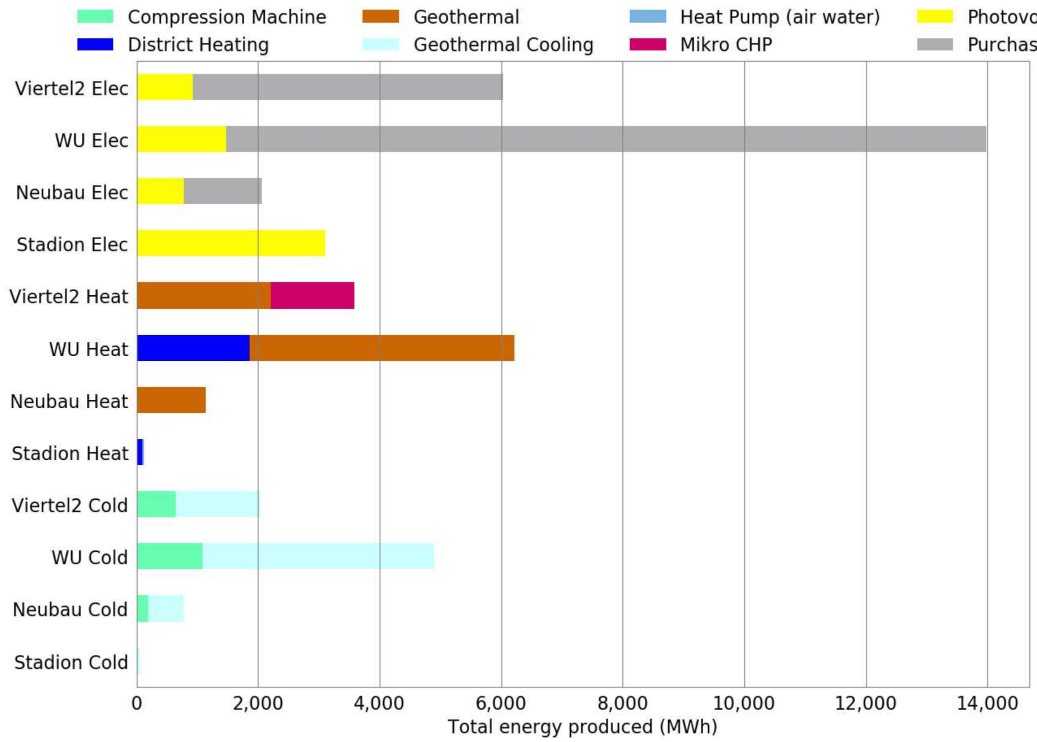


Figure 4.1.: Base scenario: basic structural supply for electricity, heating and cooling in the Energy Community. Quantitative overview of total energy produced per technology.

At all sites, electricity demand is supplied by photovoltaics and purchase. Photovoltaics is maximum expanded considering the limited available area. Volatile generation from photovoltaic systems forces distribution capacities[2], which are only between *Stadion* and *WU* as well as *Stadion* and *Viertel2*. There are hydrogen storages at *Stadion* and *Neubau*. At *Stadion*, these storage capacities are used to catch the peaks of photovoltaics generation and to transfer the energy. Otherwise, the distribution capacities have to be expanded and this would mean an increase in costs. The electricity supply and demand for *WU* with a high temporal resolution is shown in figure 4.2. The green-colored areas are the electricity of the photovoltaic system at *Stadion*.

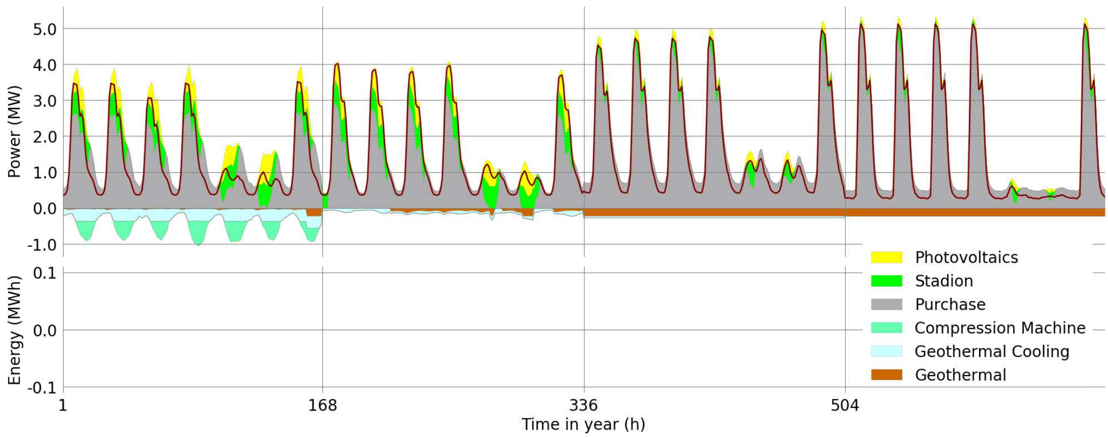


Figure 4.2.: Base scenario: temporal course of the electricity demand and supply respectively at *WU*. Electricity from photovoltaics and *Stadion* supply the cooling demand.

Heating

The already existing geothermal heating unit and the Micro-CHP at *Viertel2* supply demand there. Due to the low commodity and CO_2 price, the gas-fired Micro-CHP is in use. Geothermal and district heating supply the heating demand at *WU*, whereas district heating covers the peak load. In those areas where capacities for heating supply have been assumed, no technologies are being developed or expanded. At *Neubau*, the heat demand is covered by a new geothermal unit in combination with heat storages, which cover especially the peak loads. The transmission capacities for electricity primarily direct electricity of photovoltaics from *Stadion* to the other sites. There, this electricity is used for geothermal heating and cooling. This can be seen in figure 4.2, where the green

[2]As already mentioned, the term distribution capacity is used instead of transmission capacity due to the considered distribution network.

areas represent transmitted electricity from photovoltaics capacities at *Stadion* and the brown and light blue areas are electricity demand for geothermal heating and cooling. The heating supply and demand of *WU* with a high temporal resolution is shown in figure 4.3 below.

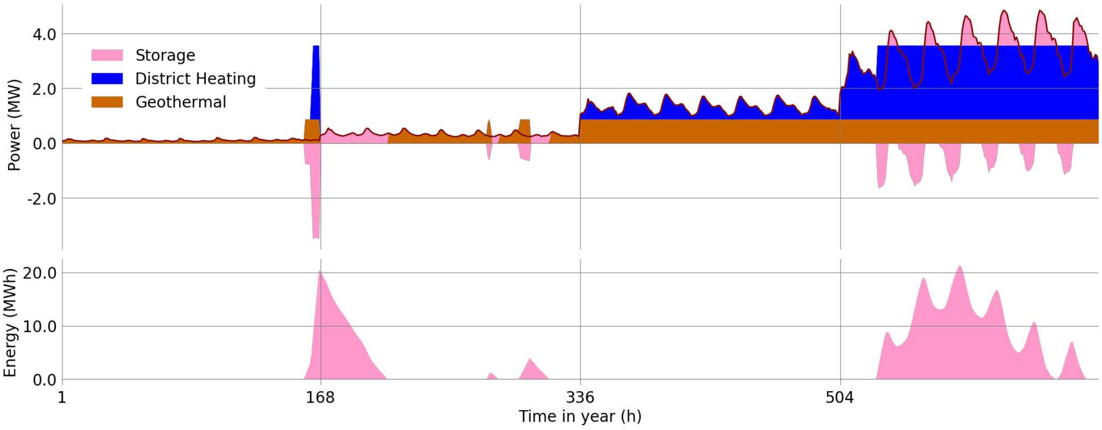


Figure 4.3.: Base scenario: temporal course of the heating demand and supply respectively at *WU*. Geothermal sources supply the base load and district heating covers the peak load of the heat demand.

Cooling

The cooling demand is covered by geothermal cooling units and compression machines. Geothermal cooling covers the baseload and compression machines at the peak load. This is valid for all sites in the EC. The structure of supply is independent of total cooling demand and peak values of cooling demand respectively. Therefore, covering cooling demand with the minimum of costs strongly depends on electricity. The temporal resolution of cooling demand and supply respectively at *Neubau* is shown in figure 4.4 below. The results in the figure correspond to the findings in the validation of the model in chapter 3.5. The first characteristic week, which is a representation of a typical summer week is covered by geothermal sources and compression machines. The cooling demand in the other two characteristic weeks is exclusively covered by geothermal sources. The third characteristic weeks shows a constant cooling demand. This is a result of the period clustering. The third week is a representation of the constant cooling demand for peripheral technology. The cooling supply significantly depends on electricity due to excessively abundant production of geothermal sources and compression machines.

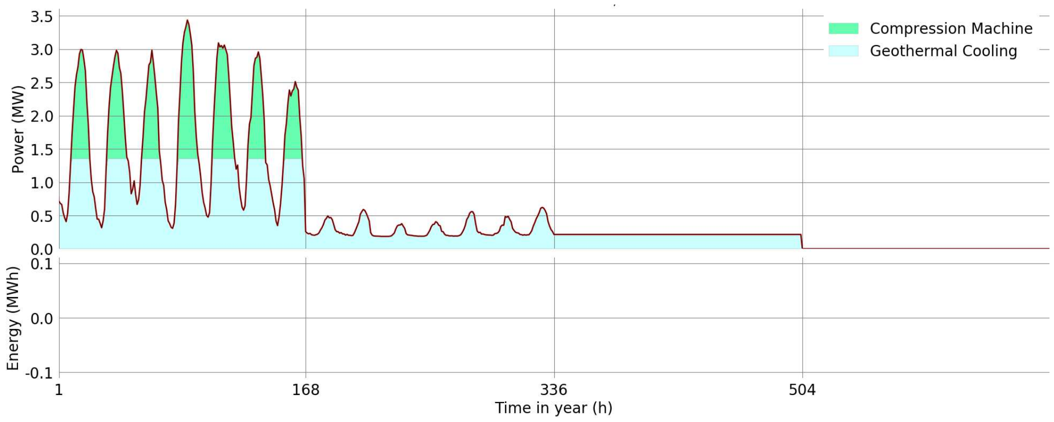


Figure 4.4.: Base scenario: temporal course of the cooling demand and supply respectively at *WU*. The peak loads of the cooling demand are covered by compression machines. Geothermal cooling sources cover the base load.

The following figure 4.5 shows the Sankey diagram of electricity in the EC. The electricity of photovoltaics from *Stadion* is exported to the sites *Viertel2* and WU to be used as input for geothermal cooling and the compression machines.

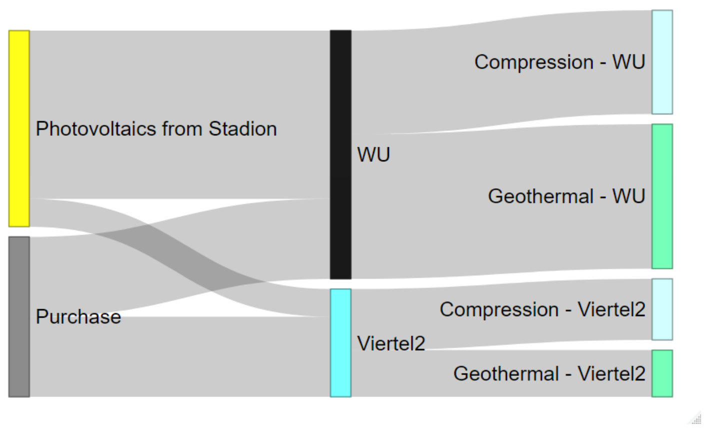


Figure 4.5.: Energy balance in the sankey diagram. Electricity from photovoltaics at *Stadion* is exported to *Viertel2* and WU to supply geothermal sources and compression machines. Quantitative overview for a characteristic week in summer.

Qualitative overview

In summary, the following table 4.1 gives a qualitative overview, whether a process is part of the energy technology portfolio or not. Especially, the number of pluses indicates the extent of the process in the Energy Community (EC).

	Current state scenario (base)		
Demand / Technology	Electricity	Heating	Cooling
Absorption machine			-
Compression machine			++
District cooling			-
District heating		+	
Geothermal sources		++	++
Heat pumps		-	
Micro-CHP		+	
Photovoltaics	++		
Solarthermal		-	

Table 4.1.: Current state scenario (base). Qualitative overview of the processes in the Energy Community. The number of pluses indicates the extent of the process. Otherwise, the fields are marked with a stroke (-), which represents that the technology is able to cover the corresponding energy demand but is not installed.

4.2. District heating network extension

4.2.1. Input data and scenario development

This scenario favors the connection to the district heating network in the EC. As a result of the base scenario in chapter 4.1, geothermal sources supply significant shares of the heating demand. Consequently, the total produced energy of district heating is relatively low, as shown in figure 4.1. However, the connection to the district heating network leads to capacity independent investment costs (Compare table 3.1). The scenario has high relevance for city planners due to oversupply and competitive energy carriers and technologies especially in the heating system[3]. Furthermore, the impact of the distribution of the energy technology portfolio in terms of covering the heating demand on the electricity demand is analyzed.

Basically, there can be two different options for a district heating network extension considered.

1. Forced connection to the district heating network in the EC.
2. Supported extension of the district heating distribution grid due to economic and technical aspects respectively.

Firstly, the connection to the district heating is forced. This approach shows essentially the same results as in the base scenario. The total produced energy of district heating is low despite the forced connection to the district heating network. The main reason is the more economic production of geothermal heating units. Geothermal sources cover the baseload and are, therefore, more economic for the EC than district heating, as shown in figure 4.3. The reason for this is the assumed high value of the Coefficient of Performance (COP) for geothermal plants.

Secondly, economic and technical input parameters can be adjusted. The change of parameters can favorite total produced energy of district heating. The following results take a 15 % lower value of COP of the geothermal units than in the base scenario into account. However, the real value of the COP of a geothermal unit significantly depends on the properties of the location.

[3] Competitve energy carriers and their distribution grid is shown in figure 3.7.

4.2.2. Results

Total costs and electricity

As mentioned, this scenario reflects the supply of the demand in the case of the lower efficiency of geothermal units at the location of the EC. The results of the total produced energy, as well as the distribution, is shown in figure 4.6 below. In the scenario, total costs per year are comparable with those in the base scenario. Total costs just increase by 2 %.

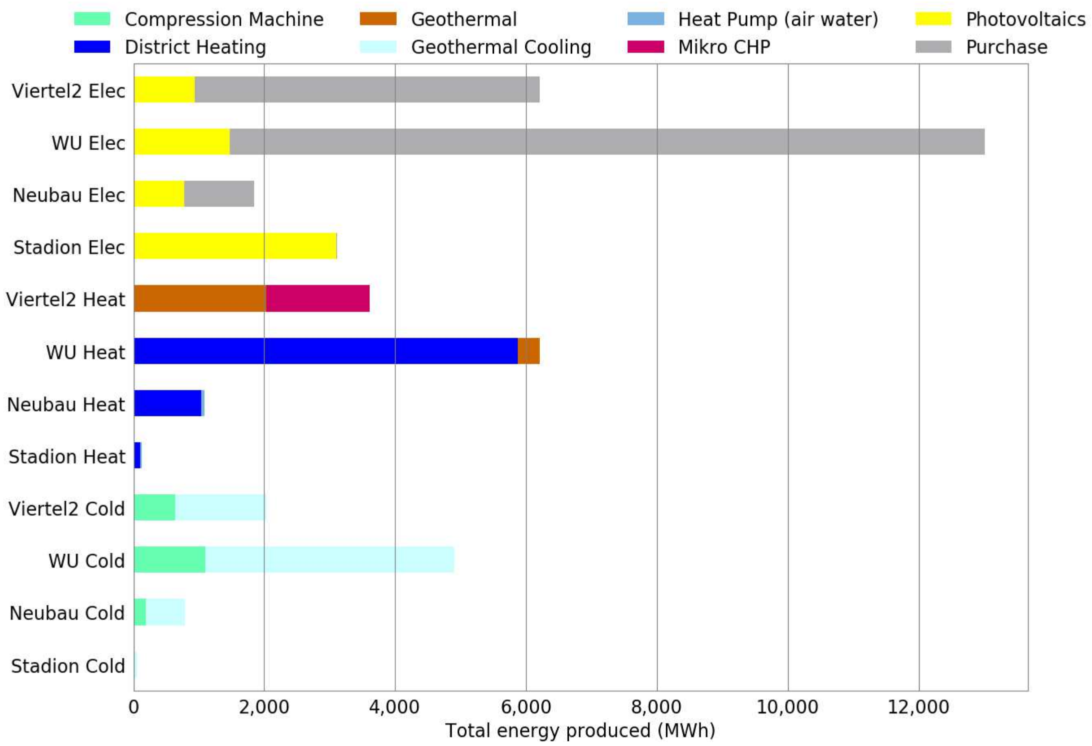


Figure 4.6.: District heating network extension: structural supply for electricity, heating and cooling in the EC.Quantitative overview of total energy produced per technology.

In most instances, there is no oversupply for electricity, especially for urban districts. However, the maximum expansion of photovoltaics takes place at each site in the EC. The total produced energy of photovoltaics is therefore independent of the selected heating system. Due to the high share of self-consumption in the EC, there is no selling of electricity. There are no revenues in the EC. Total electricity demand at WU decreases by about 10 % in comparison to the base scenario. The electricity supply and demand for

Neubau are shown in figure 4.7 below. The energy production of photovoltaics is used for geothermal cooling and compression machines. In the case of low cooling demand electricity from photovoltaics is stored in hydrogen storage. This enables transporting produced electricity of photovoltaics from days with low electricity demand to those with high demand. The stored electricity replaces electricity, which has to be purchased and therefore the total costs of supply decrease. The hydrogen storages are mainly used in the first characteristic week, which can be seen as a representation of a typical summer week in terms of demand and production.

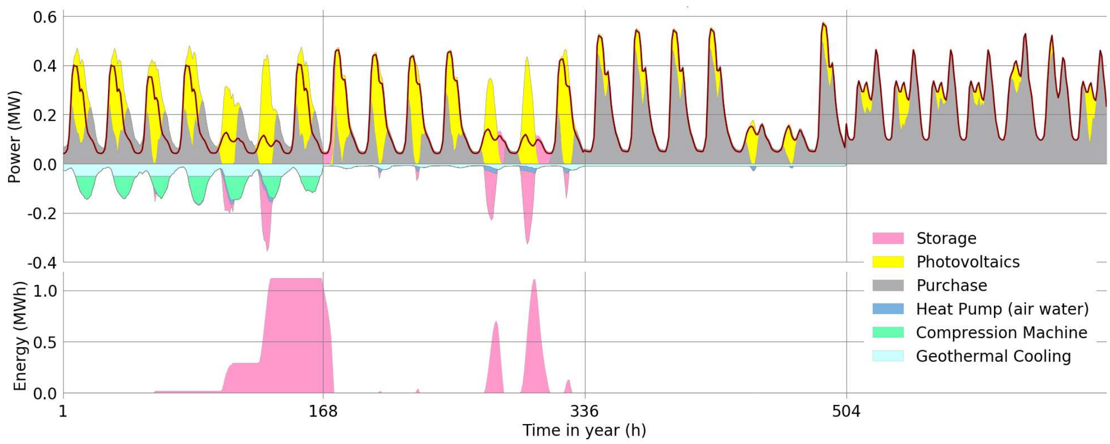


Figure 4.7.: District heating network extension: temporal course of the electricity demand at *Neubau*. Producing surplus of electricty from photovoltaic is stored in hydrogen storages.

Heating

The heating demand at *Viertel2* is supplied by the heat-driven gas-fired Micro-CHP unit and a geothermal heating unit. The capacity of the Micro-CHP is expanded. In comparison to the base scenario total produced energy of the Micro-CHP increases significantly and a large proportion of the demand is covered. As a result of the lower geothermal efficiency environmental costs increase by almost 50 % in comparison to the results of the base scenario. Figure 4.8 below shows the supply of the heat demand at WU. In contrast to the base scenario district heating supplies most of the heat demand. Based on the limited capacity of district heating geothermal, heat pumps and heat storages are installed. It is assumed that the capacity of the district heating network at WU can not be expanded in comparison to the existing capacity. As a consequence, heat storages cover the peak load. Therefore the capacities of geothermal can be limited. Besides, low capacities of heat pumps are installed due to the optimization. Total produced energy of district heating increases by almost 260 % in comparison to the base scenario. Heating demand at the potential new building area *Neubau* is supplied by district heating. In principle, heat storage is not needed. Nevertheless, day heat storages and low capacities of heat pumps are installed also. Heat pumps cover the demand in those weeks with low total heat demand. The structure of supply at *Stadion* is mostly similar such as at *Neubau*.

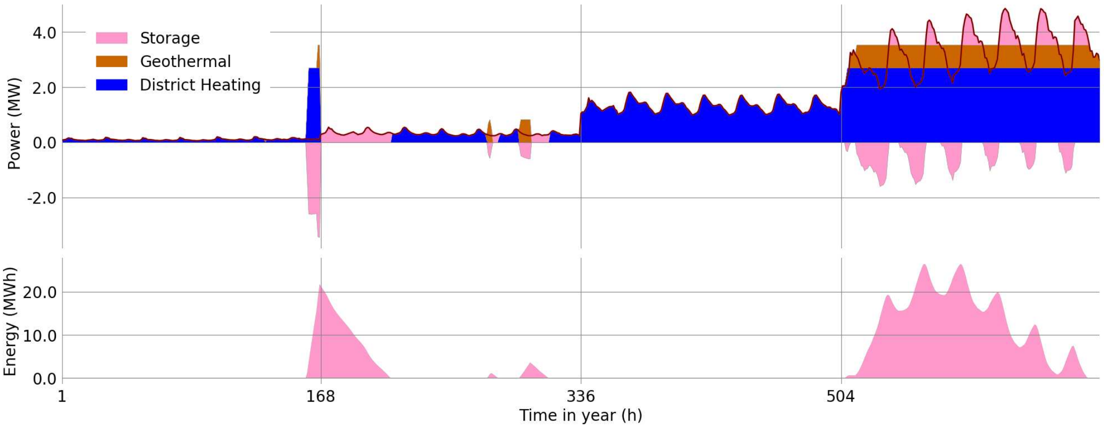


Figure 4.8.: District heating network extension: temporal course of the heating demand at *WU*. District heating covers a major proportion of the demand and storages cover the peak loads.

Cooling

The cooling demand is supplied by geothermal cooling sources and compression machines as in the base scenario. The share of electricity for the supply of cooling demand is 10 % of the total electricity demand in the EC. Basically, absorption machines could be favored based on the conversion of heat to cold in the district heating-favored scenario. However, the costs for cooling by absorption machines are much higher than of compression machines. Therefore, electricity is the major input commodity as in the base scenario before. The results at *Neubau* are shown in figure 4.9 below.

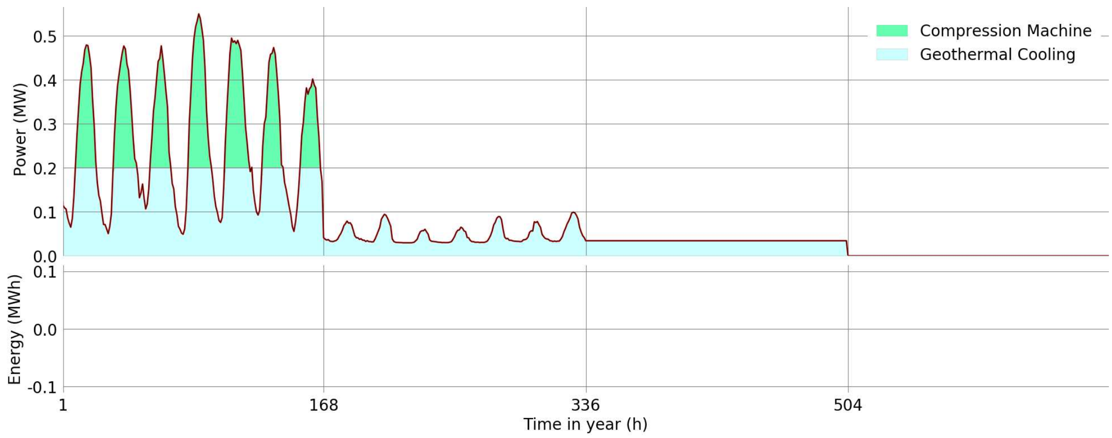


Figure 4.9.: District heating network extension: temporal course of cooling demand at *Neubau*. Despite connecting to the district heating network, no absorption machines are installed.

Qualitative overview of capacities

In summary, the following table 4.2 gives a qualitative overview, whether a process is part of the energy technology portfolio or not. As mentioned, the number of pluses indicates the extent of the process. The gray-colored cells changed in comparison to the current state scenario (base).

	District heating extension		
Demand / Technology	Electricity	Heating	Cooling
Absorption machine			-
Compression machine			++
District cooling			-
District heating		++	
Geothermal sources		+	++
Heat pumps		-	
Micro-CHP		+	
Photovoltaics	++		
Solarthermal		-	

Table 4.2.: District heating network extension scenario. Qualitative overview of the processes in the Energy Community (EC). The number of pluses indicats the extent of the process. Otherwise, the fields are marked with a stroke (-), which represents that the technology is able to cover the corresponding energy demand but is not installed.

4.3. Energy technology portfolio in the greenfield

4.3.1. Input data and development of scenario

This scenario puts the investment decision in the foreground. Thus, the supply and the future development of the energy system can be analyzed.

In this scenario, no existing capacities in the sites are considered. As a consequence, there is no generation and distribution system available. The EC has to invest in the grid infrastructure. The energy technology portfolio is built without any "lock-in effect".

Each technology would be possible at the sites except district cooling. The connection is only possible for WU. This restriction takes the possible extension of the real district cooling network into account. The central cooling supply by the district cooling network is only an option for large consumers. However, the following results also show that small consumers in terms of cooling demand are supplied mainly by geothermal sources and compression machines.

The greenfield scenario is analyzed at the current CO_2 price, which is relatively low. It is the same price as in the findings before. CO_2 pricing and higher CO_2 price levels respectively are considered in the following sensitivity analysis in chapter 5.1.

4.3.2. Results

Total costs and electricity

Structural supply and total costs are shown in figure 4.10 below. The maximum expansion of photovoltaics takes place at all sites in the EC. At *WU*, electricity purchasing decreases in comparison to the base scenario. Mainly, the transition in the cooling supply from compression machines and geothermal cooling to district cooling enables decreasing in electricity demand. The dependency of electricity for cooling in the EC is lower than in the base scenario. Du to the required investments, total costs of supply are higher than in the base scenario.

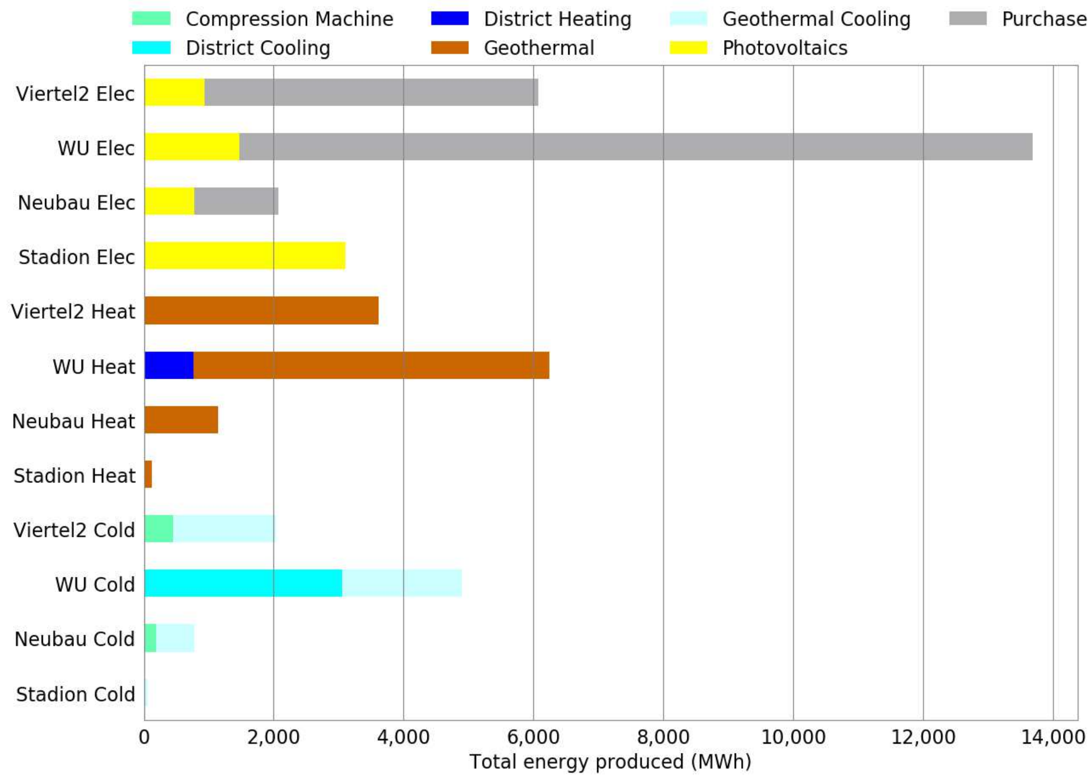


Figure 4.10.: Greenfield scenario: structural supply and costs for electricity, heating and cooling in the EC. left: distribution of costs, right: total energy produced

Heating

Heating supply is dominated by geothermal sources. The total heating demand is supplied by geothermal units. In addition, *WU* is connected to the district heating network. District heating covers again the peak loads, as shown also in the base scenario in chapter 4.1. Nevertheless, the total produced energy of district heating is lower than in the base scenario but the structure of supply is similar. The gas-fired Micro-CHP unit at *Viertel2* is replaced and therefore environmental costs and greenhouse gas emissions respectively are lower than in the base scenario. Figure 4.11 below shows the temporal resolution of heating demand at *Neubau* and the usage of heat storages. Heat day storages are implemented in each site to cover peak load. The storage is loaded by geothermal sources. Due to the storages, the required capacities of geothermal units can be minimized. This reduces total costs because of lower investment costs for heat storage than for geothermal capacities.

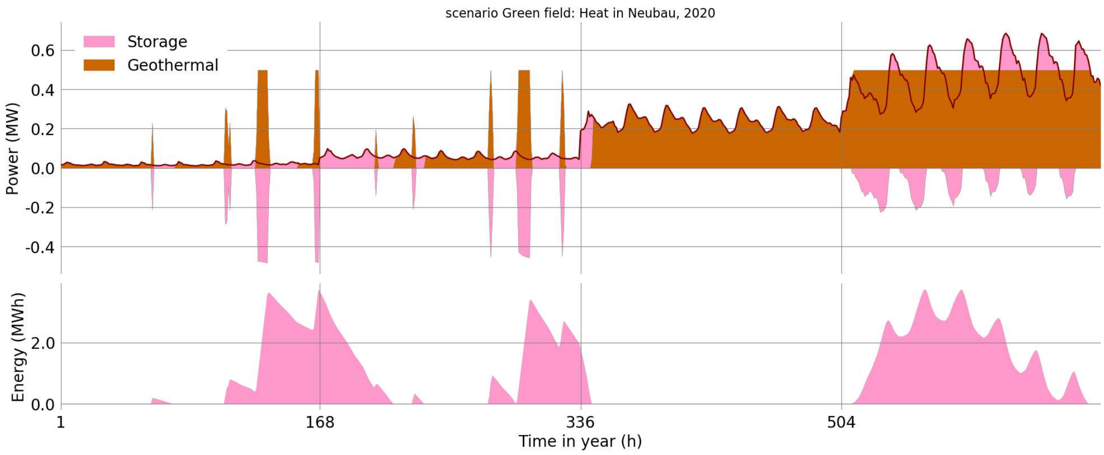


Figure 4.11.: Greenfield scenario: temporal course of the heating demand at *Viertel2*. Geothermal sources cover the heat demand. In addition, day heat storages cover the peak loads.

Cooling

From today's point of view, district cooling is only for major consumers in terms of their cooling demand an option. As mentioned, this is taken into, by the exclusive option for connecting to the district cooling network at *WU*. However, due to minimized costs WU is connected to the district cooling distribution network and the majority of the cooling demand is thereby supplied. This is shown in figure 4.12 below. Besides, geothermal cooling supplies parts of the baseload. In the other sites, cooling demand is supplied by geothermal sources and compression machines. As before, geothermal cooling covers baseload. Instead of district cooling, compression machines cover the peak load. As a consequence, electricity demand increases.

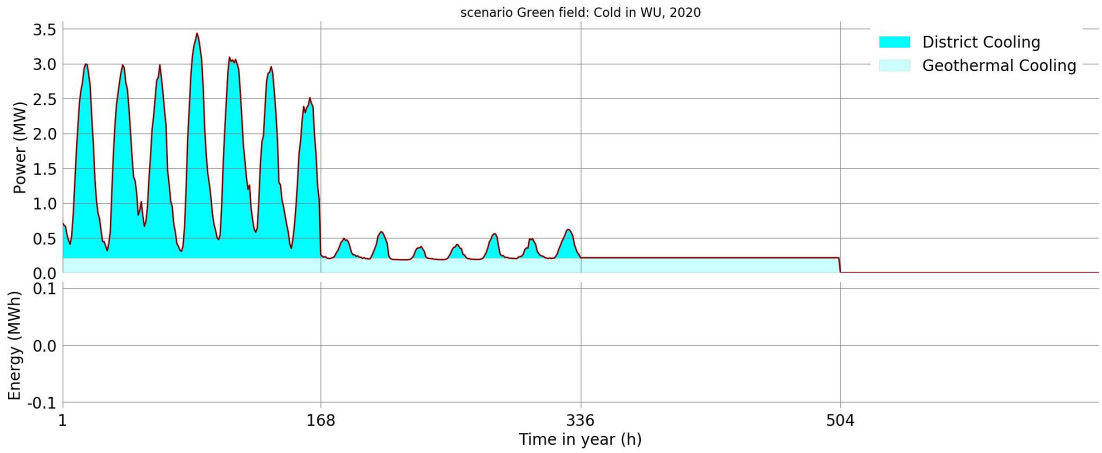


Figure 4.12.: Greenfield scenario: temporal course of the cooling demand at WU. District cooling covers a major proportion of the cooling demand. Base load is covered by geothermal cooling.

Qualitative overview of capacities

As with the results made earlier, the following table 4.3 shows a qualitative overview of the results in the greenfield scenario. Again, the number of pluses indicates the extent of each technology. The gray-colored cells changed in comparison to the current state scenario (base).

	Greenfield scenario		
Technology \ Demand	Electricity	Heating	Cooling
Absorption machine			-
Compression machine			+
District cooling			++
District heating		+	
Geothermal sources		++	++
Heat pumps		-	
Micro-CHP		-	
Photovoltaics	++		
Solarthermal		-	

Table 4.3.: Greenfield scenario. Qualitative overview of the processes in the Energy Community (EC). The number of pluses indicats the extent of the process. Otherwise, the fields are marked with a stroke (-), which represents that the technology is able to cover the corresponding energy demand but is not installed.

4.4. Overview of installed capacities and total costs

As a result of the different scenarios, the installed capacity for each technology varies significantly. Therefore, the following figure 4.13 makes it easier to obtain a rapid overview without going into details. At this point, it is pointed out that in the district heating network extension scenario, the efficiency of geothermal sources was assumed 15 % lower than in the current state. As a consequence, the Micro-CHP is slightly expanded and produces more energy in comparison to the base and greenfield scenario respectively.

The installed capacities in the figure below are the electrical installed capacities. For reasons of clarity, the capacities of geothermal heating and cooling respectively are presented together. As a result of the optimization, photovoltaics is developed to its maximum capacity in each considered scenario. The difference in the installed capacity of district heating is relatively low due to the already existing connection at the largest customer WU in the base scenario. However, total produced energy varies markedly as shown in the findings above. Geothermal sources (heat and cold) are relatively constant, whereby the capacities of compression machines are very different. In the greenfield scenario, the gas-fired heat-driven Micro-CHP is excluded.

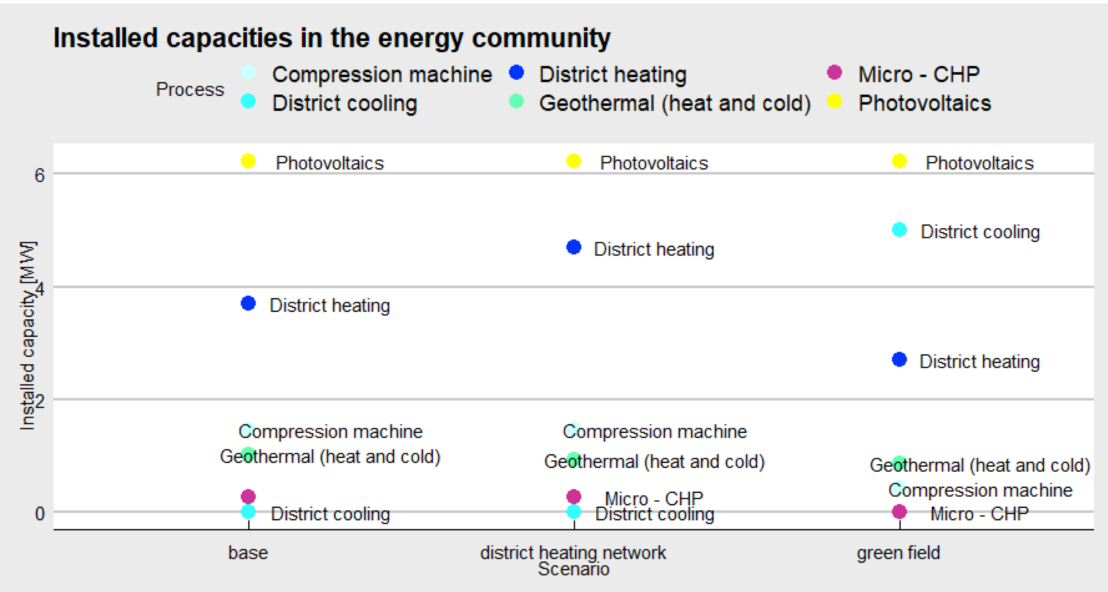


Figure 4.13.: Overview of the overall installed capacities in the EC. Comparison between the base, district heating network extension and greenfield scenario.

As already mentioned, the objective function of the optimization is to minimize total cost. As a consequence, the costs of technologies decide whether technology is part of the energy technology portfolio in the EC or not. The following figure 4.14 shows the total costs in the EC per year. It becomes apparent that the computed total costs per year are very similar in each compared scenario. The total costs per year are around 4.5 millions euro per year. Essential for the total costs are the costs of purchasing electricity.

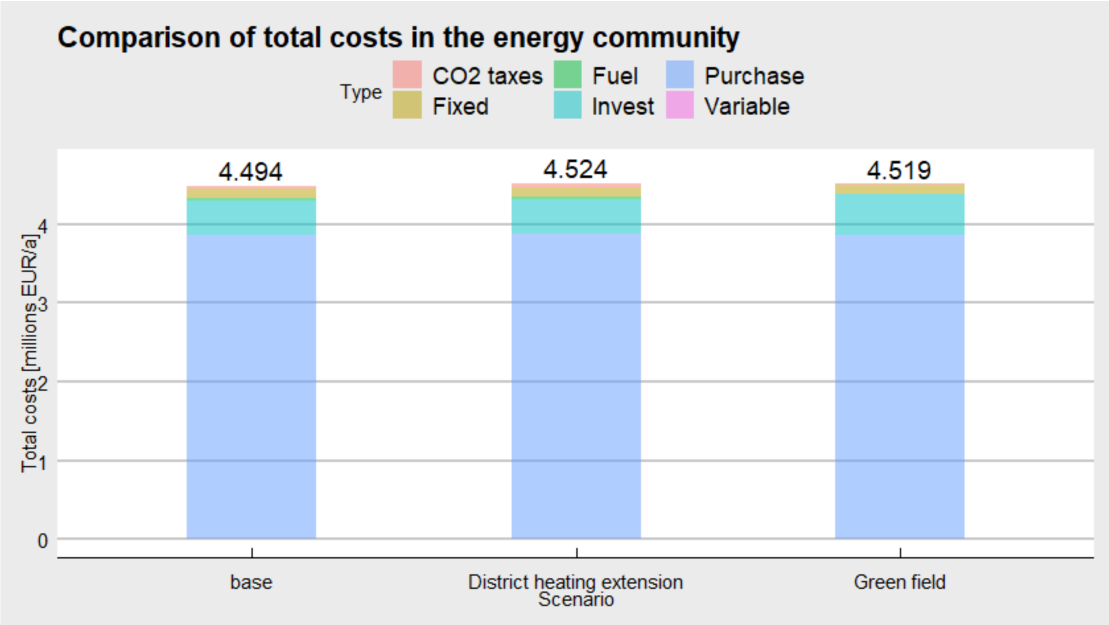


Figure 4.14.: Overview of the total costs in the EC per year. Comparison between the current state, district heating network extension scenario and the greenfield scenario. Purchasing of electricity has a large share of total costs.

5. Sensitivity analysis

The following sensitivity analysis is used to verify the results of chapter 4 regarding selected parameters and assumptions. In this term, the sensitivity analysis inspects the energy technology portfolio on its robustness. Basically, the following three different sensitivities are analyzed:

1. CO_2 price or taxes respectively
2. Connection costs and energy price of the district cooling network
3. Geothermal and heat pumps efficiency respectively

As to the first point, externalities of energy production are taken into account. As previously stated, it is considered that the price for pollution of greenhouse gas emissions will increase. This analysis is particularly relevant, as an increase in CO_2 prices can be expected in the future. The robustness of the energy technology portfolio is primarily determined by the difference in terms of CO_2 prices. Especially, the total produced energy of the Micro-CHP at *Viertel2* is analyzed. Furthermore, this sensitivity analysis provides information about the so-called "lock-in effect".

As to the second point, it shall be assumed that in the next years, cooling demand will exceed the heating demand. Due to the higher outdoor temperature, the cooling demand will increase[1]. The question for the future is how to supply this demand. Basically, a central approach while using the district cooling network and a decentral approach with local geothermal sources, compression, and absorptions machines are possible. The investment decision for the district cooling network significantly depends on the distance to the next interconnection point, as the connection costs rise linearly with the increase in distance.

In respect of the third point, the investment decision of geothermal plants significantly depends on the efficiency or COP respectively. Basically, this sensitivity analysis takes different undergrounds into account, which are the major reasons for a higher or lower performance of geothermal sources. This applies primarily to cities, where space is usually limited. This analysis is particularly relevant because of the high number of total produced

[1]Compare the approach for the cooling demand profile in equation 3.12.

energy of geothermal sources in the current state (base) scenario and for the investment decision in the potential new building site *Neubau*. As regards the third aspect, heat pumps have the potential to reduce greenhouse gas emissions in the heating sector. Similar to geothermal energy, the efficiency of heat pumps shows dependencies, which are in terms of the location and the supplied building. The higher the energy class of the building the higher the efficiency or COP respectively of heat pumps. As already mentioned, the main reason is the lower flow temperature.

In summary, it can, therefore, be said concerning the question of the robustness of the results that only due to the sensitivity analysis the energy technology portfolio provides information about the investment decision for city planners.

5.1. CO2 price or taxes

The results of the sensitivity analysis are shown in figure 5.1 below. The left picture shows again total costs, the right picture total produced energy for each technology at dependency of the CO_2 price. As already mentioned before, geothermal sources have a large proportion in terms of supplying the heat demand. In addition, this proportion increases with a higher CO_2 price.

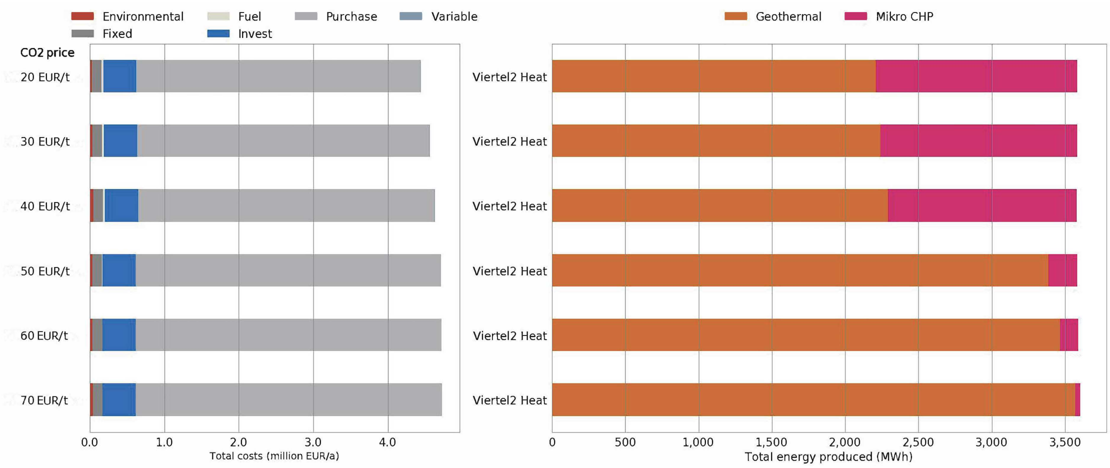


Figure 5.1.: Heating supply of *Viertel2* in terms of an increasing CO_2 price. The proportion of geotheral sources increases and displaces the gas-fired heatdriven Micro-CHP unit at *Viertel2*.

Concerning the heating supply, therefore the focus is put on the energy technology portfolio at *Viertel2*. In the current state, the gas-fired heat-driven Micro-CHP covers almost 40 % of the heat demand. The higher the CO_2 price or taxes respectively the lower total produced energy by the Micro-CHP. The externalities drive the technology from a baseload to a peak load supplying technology. The usage of the Micro-CHP at a CO_2 price of 60 EUR/t is shown in figure 5.2 below.

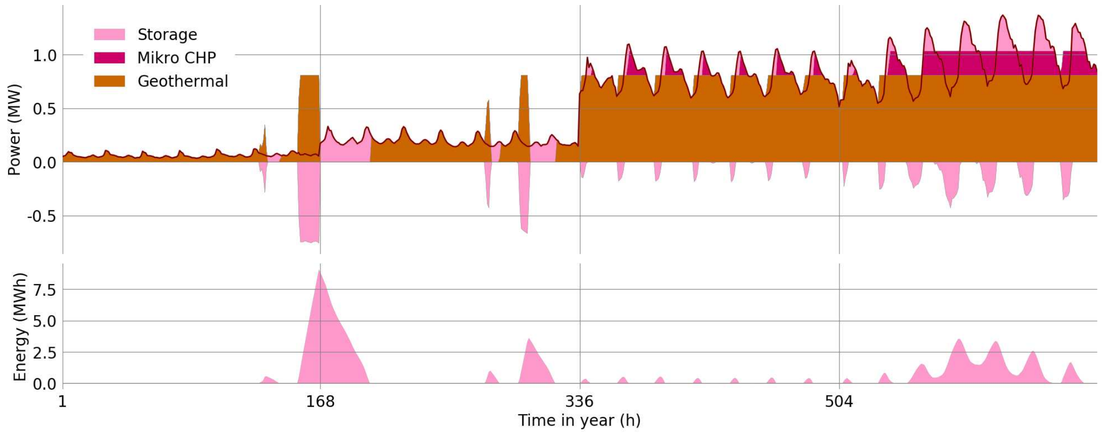


Figure 5.2.: Geothermal sources cover major parts of the heat demand. Peak loads are covered by the Micro-CHP unit and storages at a CO_2 price of 60 EUR/t.

Total produced energy of district heating at *WU* is the same as in the current state and greenfield scenario respectively. As a consequence, the useage of district heating shows great robustness in terms of an increasing CO_2 price. Nevertheless, the higher CO_2 price declines the economic performance of district heating. However, geothermal sources are not expanded due to high investment costs. The usage of district heating for heat demand at a CO_2 price of 70 EUR/t is the same as shown in figure 4.12 in the greenfield scenario and current state (base) scenario respectively. Summarized, the increased CO_2 has a higher impact on the total produced energy of the gas-fired Micro-CHP than on district heating. Figure 5.3 below displays the results of the sensitivity analysis. The current CO_2 price favors the usage of the existing Micro-CHP unit. The calculation for the current state (base) scenario shows a high number of full load hours for the gas-fired heat-driven Micro-CHP. It is used to cover baseload. Total produced energy is relatively stable until a CO_2 price of 40 EUR/t. With a further increase of the CO_2 price the heat production costs of the geothermal source become cheaper. Then the base load is covered by the geothermal unit. Total produced energy of the Micro-CHP decreases to almost zero at a price of 70 EUR/t CO_2. In this respect, the total costs increase until the CO_2 price gets 50 EUR/t. Subsequently, the total costs remain constant.

The increasing CO_2 price changes the competitiveness of energy carriers. It was shown that in the case of 50 EUR/t, geothermal sources with a high efficiency replace gas-fired

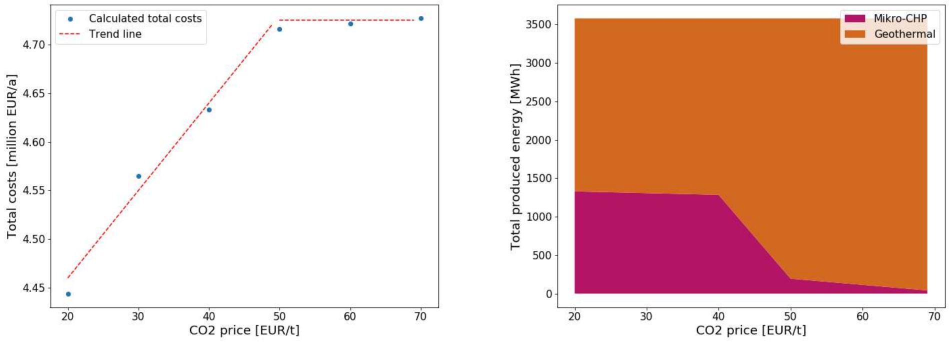


Figure 5.3.: Overview of the sensitivity analysis regarding CO_2 pricing. Total costs and proportion of geothermal sources respectively increase up to the value of 50 EUR/t CO_2. Subsequently, total costs remain constant.

Micro-CHP - independent of whether or not they are installed ("Lock-in effect"). The results in figure 5.4 below show the total produced energy in terms of lower geothermal efficiency. The efficiency of geothermal sources is 85 %. As a consequence, the total produced energy of the gas-fired heat-driven Micro-CHP increases. However, district heating is connected instead if the CO_2 price reaches the value of 30 EUR/t.

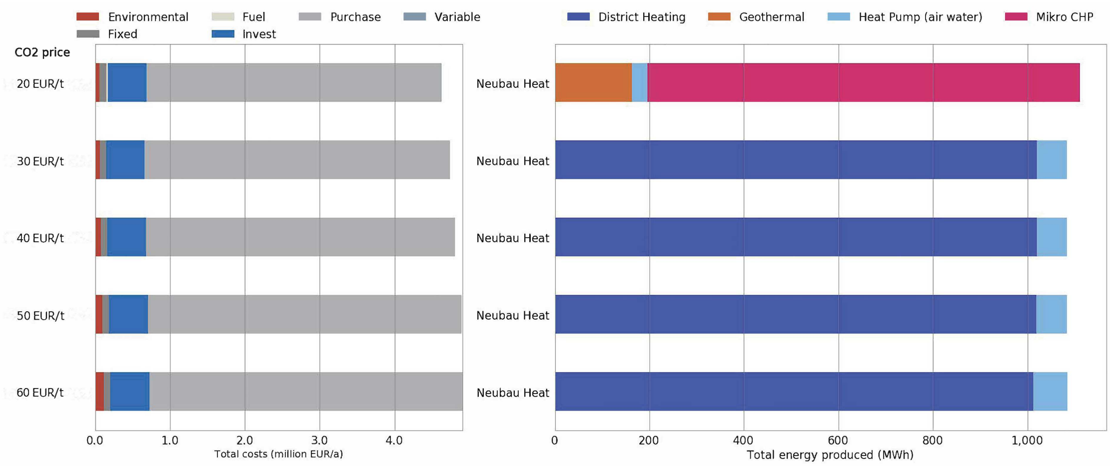


Figure 5.4.: Total produced energy for the heat demand at *Neubau*. The Micro-CHP unit covers a major proportion of the heat demand taking a lower efficiency of the geothermal source into account. District heating covers almost the whole heat demand starting at a CO_2 price of 30 EUR/t.

5.2. District cooling network connection point

In the future, energy system planners will also have to take the cooling demand into account. The connection to the district cooling network enables possibilities regarding large consumers. In the following, a sensitivity analysis in terms of the usage for the cooling demand of WU is concluded. The results in the greenfield scenario in chapter 4.3 show that the cooling demand at WU is supplied by the combination of geothermal cooling sources and district cooling. This takes the connection to the next district cooling connection point into account. It is assumed that the next connection point is 1050 m away. This is shown in figure 5.5 below. The red point marks the possible connection point of WU, the green one the nearest connection point to the district cooling network[2]. The blue line represents a possible course for the district cooling pipelines.

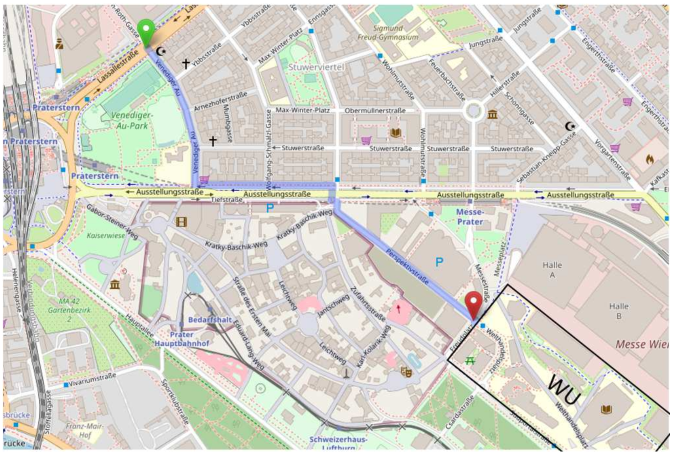


Figure 5.5.: Assumed course of the district cooling piplines to connect WU to the network. The green point represents the next district cooling centre. District cooling supplies major parts of the cooling demand in the greenfield scenario there beacuse of the rather short distance and relatively low connection costs.

In the following, the distance to the next district cooling connection point is increased. The results of the sensitivity analysis are shown in figure 5.6 below. The cooling demand at WU is supplied by district cooling in the greenfield scenario. Basically, the next connection point to the district cooling network is close enough. The connection costs are relatively low. This changes as soon as the distance to the next connection point increases. District cooling is not used anymore in case of a distance of 1250 m to the next connection point. Therefore, the use of district cooling is very sensitive in terms of connection costs and distance to the next connection point respectively. A combination

[2]There is the district cooling center *Austria Campus* located.

of geothermal cooling sources and compression machines is installed instead. Geothermal cooling covers the base load of cooling demand and compression machines the peak load respectively.

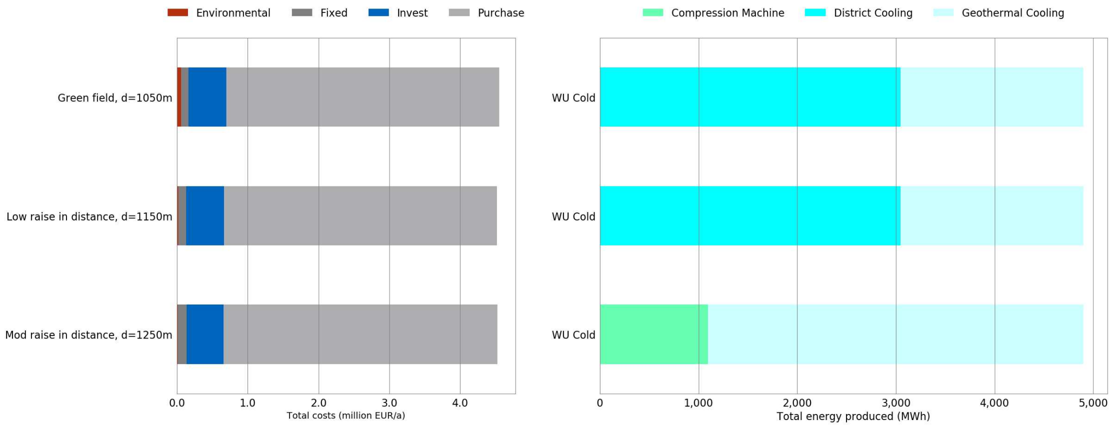


Figure 5.6.: Supply of the cooling demand in the greenfield scenario considering different distances. Geothermal cooling sources and compression machines cover the demand due to the high connection costs in case of a further distance in the third case.

In addition, the connection between connection costs and energy prices for cooling is analyzed. It is assumed that the next connection point to the district cooling network is about 3500 m away. One possible course of the pipeline system is shown in figure 5.7 below by the blue line, which connects the WU and the assumed next connection point[3]. As a result of figure 5.6 district cooling is not installed in case of a distance more than 1150 m.

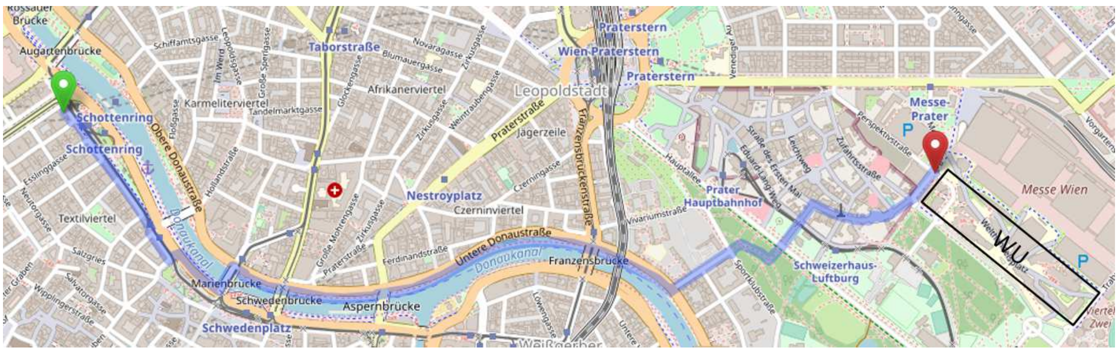


Figure 5.7.: Possible connection of WU to the district cooling network. The connection costs increase in terms of a further distance than in the greenfield scenario.

[3] There is the district cooling center *Ringturm*.

In the following sensitivity analysis, the energy price is decreased to understand the causal link between connection costs and energy price. As a consequence of the necessary pipelines, represented by the blue line in figure 5.7, investment costs are more than three times higher than in the greenfield scenario. Accordingly, district cooling is not connected taking the same energy price as before into account. However, district cooling is installed if the energy price is reduced by 20 %. In terms of a district cooling network connection, a three times greater distance requires a 20 % lower energy price. The following figure 5.8 gives a detailed overview of the relation between the required energy price depending on the distance to the next district cooling center. The CO_2 price of the current state scenario (base) is taken into account. As already mentioned, connection costs increase linearly with the distance. In the following figure, the computed points in the corresponding color represent the structure of the cooling supply in the greenfield scenario at WU. The gray dashed line gives the linear trend. The cooling demand at WU is mainly supplied by district cooling in the blue area.

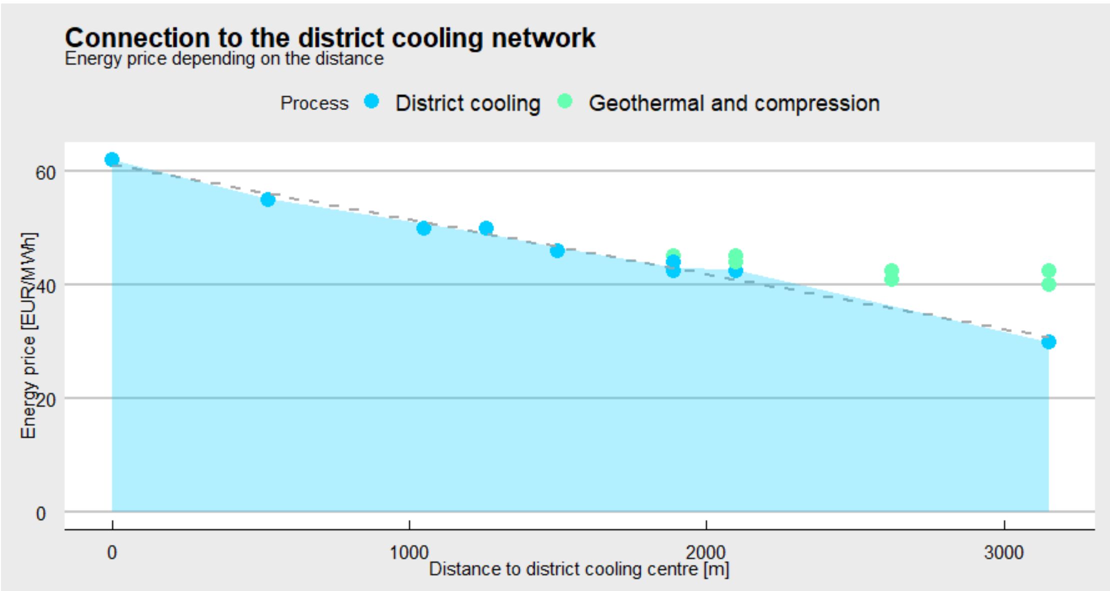


Figure 5.8.: District cooling network: the relation between connection costs and energy price. An increase in the connection costs results in a decrease in the energy price so that district cooling covers cooling demand at WU.

To conclude this sensitivity analysis of the cooling demand the impact of the CO_2 price on the cooling supply is analyzed. Geothermal sources and compression machines require electricity to cover the cooling demand. In the following the cooling supply at WU in the greenfield is investigated. As already mentioned, the increasing CO_2 price also raises the electricity price[4] As a consequence, the maximum distance between WU and the next district cooling connection point and center respectively extends. The results for three different CO_2 prices are shown in figure 5.9 below.

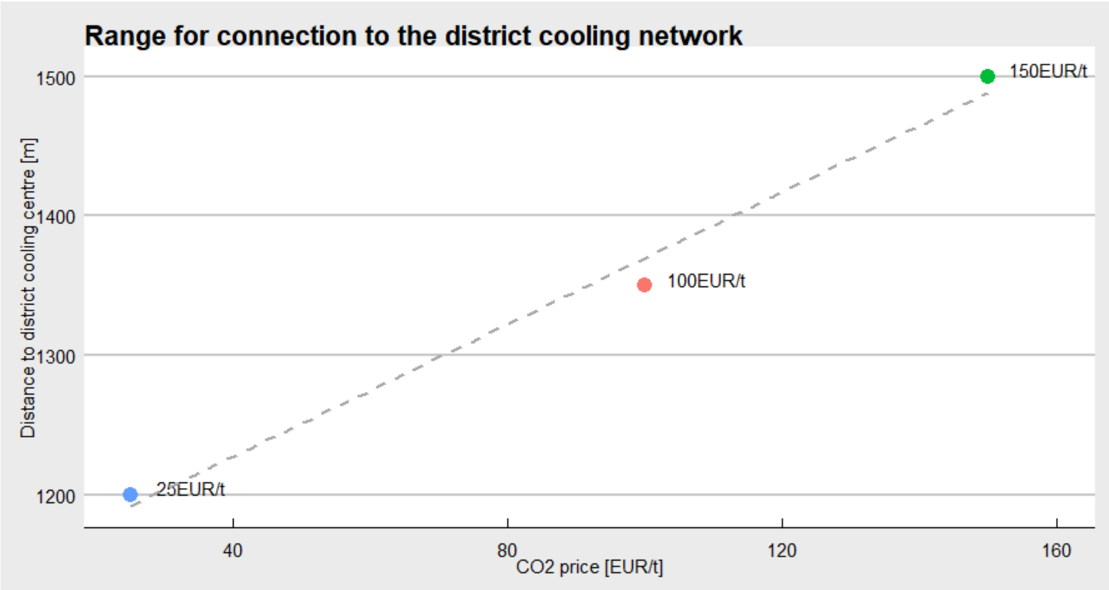


Figure 5.9.: Impact of the CO_2 price on the maximum distance to connect WU to the district cooling network in the greenfield scenario. The higher the CO_2 the greater the distance due to the increase of electricity.

[4]This approach is also shown in "Profitability of PV sharing in energy communities: Use cases for different settlement patterns."

5.3. Geothermal and heat pumps efficiency

Geothermal Efficiency η_1

This section shows the sensitivity of the results in terms of a lower geothermal efficiency η_1 or COP[5] respectively. As already mentioned, geothermal sources cover a high proportion of the heat demand in the EC. However, this proportion depends on the COP, whereby this value depends on the location and underground of the space. Assumptions regarding the COP of geothermal sources have already been shown in table 3.3.

The results in section 4.1 of the total energy produced in the current state show a significant amount of geothermal sources at *Neubau*. The whole demand is covered by geothermal sources in the potential new building area. Especially, this high share leads to the sensitivity analysis in this section, considering a district heating connection is possible there. The results of the variation of the Coefficient of Performance (COP) of geothermal sources are shown in figure 5.10 below. The whole heat demand at *Neubau* is covered by geothermal sources until the COP is higher than 4. The connection to the district heating network is more economic in the case of a COP lower than 4. As a consequence, no geothermal capacities are installed due to the binary investment decision of district heating.

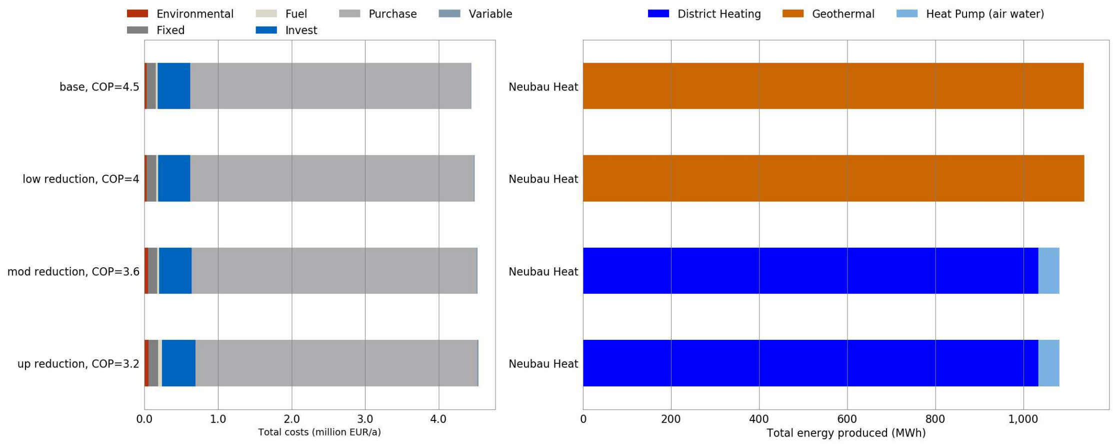


Figure 5.10.: Total produced energy at *Viertel2*. The Usage of geothermal sources significantly depends on the Coefficient of Performance (COP). District heating covers almost the whole heat demand taking a COP of 3.6 into account.

As already shown in the results of the district heating favored scenario in chapter 4.2, which also takes a lower geothermal efficiency into account, the total produced energy

[5]For geothermal and heat pumps, the term COP is more commonly used.

of the gas-fired heat-driven Micro-CHP unit increases. The capacities are expanded considering the current state of the CO_2 price.

Heat pumps efficiency η_2

In the fututre, it will be necessary to reduce greenhouse gas emissions in the energy system. For this, it is essential to reduce and display fossil fuels in the heating sector. Basically, heat pumps can substitute fossil fuels in the heating supply, if electricity is from renewable energy sources. As a consequence, heat pumps have to be economic so that they are invested. The relatively low investment costs per capacity are one major advantage of heat pumps. However, the efficiency of heat pumps depends on the outdoor temperature. The lower the outdoor temperature the lower the COP. As already mentioned, the economic performance also depends on the flow temperature and building classes respectively. In the following, the heat supply at the potential new building site *Neubau* is analyzed. The results of the sensitivity analysis in terms of the heat pumps efficiency are shown in figure 5.11 below.

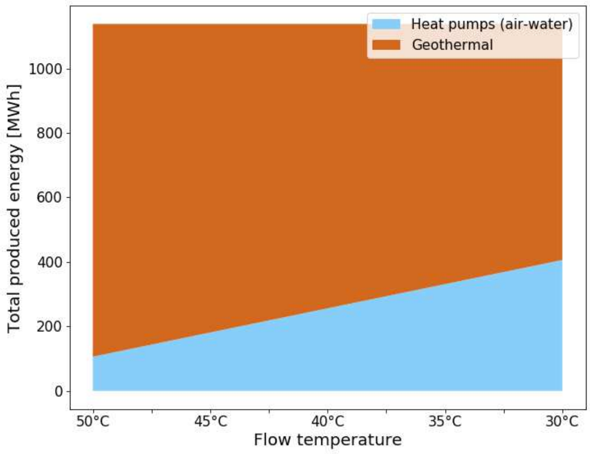


Figure 5.11.: Proportion of heat pumps in terms of different flow temperatures. Heat pumps show possibilities in the heat sector in case of high energy classes of buildings and low flow temperatures.

As a comparison the greenfield scenario is taken. In the greenfield scenario, there are not heat pumps installed in the entire Energy Community (EC) due to the relatively poor Coefficient of Performance (COP). The whole heat demand is covered by geothermal sources in the greenfield scenario at *Neubau*. No heat pumps are installed. The higher the efficiency of the heat pumps the higher the proportion of total produced energy. Analogously, the higher the efficiency the lower the flow temperature of the heat pumps. In summary, the assumed efficiencies can be assigned to corresponding flow temperatures. Heat pumps only become relevant in terms of the heat supply with the approach of low flow temperatures in high-efficiency buildings in this case.

6. Synthesis of results and conclusions

In this thesis, the application of the open source energy system model urbs is proposed. This includes further improvements to the existing model. Thus, an energy technology portfolio for a small urban district in Vienna, Austria, is built in terms of minimal total costs. This approach quantifies the value of energy communities in the context of sustainable supply in multiple energy carrier systems. Also, temporal data clustering has been applied to increase modeling efficiency. The selected approach demonstrates high-quality open source modeling in terms of the supply in multiple energy carrier systems that increases the understanding of high-complex energy systems. This thesis shows that open source models can be easily used, improved and extended due to the open access and the previous contributions of the research and modeling community.

The high-quality open source modeling may also be shown by the validation of the model. Deviations between the ”true values” and the calculated values in the current state (base scenario) are small and can be argued by assumed parameters. The computed values of the heating and cooling demand show proper accuracy in comparison to the available data. Thus, also the application of the data clustering algorithm *kmeans++* can be seen as approved. Therefore, the yearly time-series for demand, solar radiation and efficiency can be displayed by the representation of four characteristic weeks in total without qualitative losses. The accuracy of modeling can be increased while considering the week with the peak load in heating demand. As a result, capacities in the portfolio consider the peak loads in the demand accordingly. The application of the clustering algorithm requires verification, whether further weeks with a peak load have to be considered, for example, the week with the highest demand for electricity or cooling. This depends essentially on the input matrix of the clustering algorithm and can be adjusted by it.

The results of each scenario in the energy community show that a high share of renewable energy can be achieved. Especially, often less considered technologies (e.g. geothermal heating and cooling) are part of the energy technology portfolio. Besides, the maximum expansion of photovoltaics takes place and supports the high production of geothermal sources for heating and cooling. This can be shown by the energy flow (Sankey diagram) in the energy community. Nevertheless, geothermal sources depend significantly on the location-dependent coefficient of performance, which must, therefore, be given particular attention. As a consequence, the economic efficiency of district heating significantly depends on the usage of geothermal sources in the heating sector. In the case of a connection to the district heating network almost the entire heat demand is covered by district heating. Furthermore, the impact of CO_2 pricing in terms of total costs is reduced. To understand the robustness of the energy technology portfolio, especially in the case of CO_2 pricing, the sensitivity analysis helps to understand the development of total produced energy to supply the energy community and the so-called "lock-in effect", which may quantify the vulnerability of the portfolio in the case of a higher CO_2 price. As a consequence, geothermal sources and district heating displace the existing gas-fired and heat-driven micro combined heat power unit in the case of a higher CO_2 price.

The sensitivity analysis shows that in the cooling sector central and decentral supply compete with each other. Thereby, the decentral supply based on compression machines and geothermal sources increases the demand and dependency of electricity. However, this increase in demand correlates temporally with the production of photovoltaics. The district cooling network offers possibilities to supply cooling demand without a significant increase in electricity demand. The further development of the district cooling network significantly depends on the relation between capacity-independent connection costs and cooling energy prices. Once an expansion of the district cooling network has taken place, the central cooling supply becomes more economic. However, CO_2 pricing expands the range for the district cooling network system and the connection to the network.

Further work based on this thesis may include an even more precise examination of the geothermal heating and cooling sources. In particular, those units that can supply both, heating and cooling demand. Furthermore, the clustering algorithm may also be applied to the outdoor temperature to increase the detail of modeling the heat pump efficiency. Moreover, the effect in general of the clustering algorithm approach on the use of different energy storage technologies may be analyzed and improved. The curtailment of the data and the observation of characteristic weeks may suppress the utilization of storage. As already mentioned in the introduction of the thesis, a further step may include the open source model rivus, which enables considering energy systems with a high spatial resolution. Thus, understanding of different configurations and set-ups of energy communities may be further improved. The combination of both, urbs and rivus, may be applied to densely populated but also more rural areas.

Bibliography

Ahlgren, E, G Simbolotti, and G Tosato (2013). “District heating.” In: *Energy technology systems analysis programme, Technology Brief E* 16 (cit. on p. 20).

Ajila, Samuel A and Di Wu (2007). “Empirical study of the effects of open source adoption on software development economics.” In: *Journal of Systems and Software* 80.9, pp. 1517–1529 (cit. on p. 10).

Alhamwi, Alaa et al. (2018). “FlexiGIS: an open source GIS-based platform for the optimisation of flexibility options in urban energy systems.” In: *Energy Procedia* 152, pp. 941–946 (cit. on p. 10).

Ali, Amjad et al. (2017). “Overview of current microgrid policies, incentives and barriers in the European Union, United States and China.” In: *Sustainability* 9.7, p. 1146 (cit. on p. 7).

Bazilian, Morgan et al. (2012). “Open source software and crowdsourcing for energy analysis.” In: *Energy Policy* 49, pp. 149–153 (cit. on p. 10).

Berger, Tania et al. (2014). “Impacts of climate change upon cooling and heating energy demand of office buildings in Vienna, Austria.” In: *Energy and buildings* 80, pp. 517–530 (cit. on p. 32).

DECC, AECOM (2015). “Assessment of the Costs, Performance, and Characteristics of UK Heat Networks.” In: *London, UK: nd* (cit. on p. 20).

Dorfner, J (2017). “Urbs: A mixed integer linear Optimisation Model for Energy infrastructure networks.” In: 1 (cit. on pp. 4, 10, 11).

Dorfner, J and T Hamacher (2015). “Urbs: A Linear Optimisation Model for Distributed Energy System.” In: *Urbs 0.7* 1 (cit. on pp. 4, 10, 11, 15, 16).

Dorfner, Johannes (2016). “Open source modelling and optimisation of energy infrastructure at urban scale.” PhD thesis. Technische Universität München (cit. on pp. 10, 20).

Dorfner, Johannes (2020). “urbs: a linear optimisation model for distributed energy systems—urbs 1.0.0 documentation.” In: *Chair of Renewable and Sustainable Energy Systems, Technical University of Munich https://urbs. readthedocs. io* (cit. on p. 16).

Fina, Bernadette, Hans Auer, and Werner Friedl (2019). “Profitability of PV sharing in energy communities: Use cases for different settlement patterns.” In: *Energy* 189, p. 116148 (cit. on pp. 20, 58).

Fleischhacker, Andreas et al. (2019). "Portfolio optimization of energy communities to meet reductions in costs and emissions." In: *Energy* 173, pp. 1092–1105 (cit. on pp. 3, 5, 9–11, 20, 22).

Gabrielli, Paolo et al. (2018). "Optimal design of multi-energy systems with seasonal storage." In: *Applied Energy* 219, pp. 408–424 (cit. on p. 9).

Groissböck, Markus (2019). "Are open source energy system optimization tools mature enough for serious use?" In: *Renewable and Sustainable Energy Reviews* 102, pp. 234–248 (cit. on p. 10).

Gui, Emi Minghui and Iain MacGill (2018). "Typology of future clean energy communities: An exploratory structure, opportunities, and challenges." In: *Energy research & social science* 35, pp. 94–107 (cit. on p. 7).

Haas, Reinhard et al. (2013). "The looming revolution: How photovoltaics will change electricity markets in Europe fundamentally." In: *Energy* 57, pp. 38–43 (cit. on p. 30).

Huang, Wujing et al. (2017). "Optimal configuration planning of multi-energy systems considering distributed renewable energy." In: *IEEE Transactions on Smart Grid* 10.2, pp. 1452–1464 (cit. on p. 8).

Jin, Xin and Jiawei Han (2017). "K-Means Clustering." In: *Encyclopedia of Machine Learning and Data Mining*. Ed. by Claude Sammut and Geoffrey I. Webb. Boston, MA: Springer US, pp. 695–697. ISBN: 978-1-4899-7687-1. DOI: 10.1007/978-1-4899-7687-1_431. URL: https://doi.org/10.1007/978-1-4899-7687-1_431 (cit. on pp. 22, 23).

Kriechbaum, Lukas, Gerhild Scheiber, and Thomas Kienberger (2018). "Grid-based multi-energy systems—modelling, assessment, open source modelling frameworks and challenges." In: *Energy, Sustainability and Society* 8.1, p. 35 (cit. on p. 10).

Lazzarin, R and M Noro (2006). "Local or district heating by natural gas: Which is better from energetic, environmental and economic point of views?" In: *Applied Thermal Engineering* 26.2-3, pp. 244–250 (cit. on p. 3).

Lund, Henrik et al. (2017). "Smart energy and smart energy systems." In: *Energy* 137, pp. 556–565 (cit. on p. 3).

Ma, Tengfei et al. (2018). "The optimal structure planning and energy management strategies of smart multi energy systems." In: *Energy* 160, pp. 122–141 (cit. on p. 8).

Marnay, Chris and Giri Venkataramanan (2006). "Microgrids in the evolving electricity generation and delivery infrastructure." In: *2006 IEEE power engineering society general meeting*. IEEE, 5–pp (cit. on p. 7).

Parag, Yael and Benjamin K Sovacool (2016). "Electricity market design for the prosumer era." In: *Nature energy* 1.4, pp. 1–6 (cit. on p. 3).

Rademakers, Koen et al. (Nov. 2018). "Study on Energy Prices, Costs and Subsidies and their Impact on Industry and Households." In: DOI: 10.2833/825966 (cit. on p. 20).

Regional Policy, European Union. European Commission. Directorate-General for (2011). *Cities of tomorrow: Challenges, visions, ways forward*. Publications Office of the European Union (cit. on p. 9).

Ritchie, Hannah and Max Roser (2018). "Urbanization." In: *Our World in Data* (cit. on p. 3).

Shariatkhah, Mohammad-Hossein et al. (2016). "Adequacy modeling and evaluation of multi-carrier energy systems to supply energy services from different infrastructures." In: *Energy* 109, pp. 1095–1106 (cit. on p. 8).

Skarvelis-Kazakos, Spyros et al. (2016). "Multiple energy carrier optimisation with intelligent agents." In: *Applied energy* 167, pp. 323–335 (cit. on p. 8).

Soshinskaya, Mariya et al. (2014). "Microgrids: Experiences, barriers and success factors." In: *Renewable and Sustainable Energy Reviews* 40, pp. 659–672 (cit. on p. 7).

Stefansson, Valgardur (2002). "Investment cost for geothermal power plants." In: *Geothermics* 31.2, pp. 263–272 (cit. on p. 20).

Union, Europäische (2016). "Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity." In: *Interinstitutional File* 380 (cit. on p. 3).

Widl, Edmund et al. (2018). "Studying the potential of multi-carrier energy distribution grids: A holistic approach." In: *Energy* 153, pp. 519–529 (cit. on pp. 3, 8).

Appendix

Appendix A.

Economic and technical input values

	Site	Storage	Commodity	inst.cap.c	cap.lo.c	cap.up.c	cap.up.p	eff.in	eff.out	inv.cost.p	inv.cost.c	fix.cost.p	wacc	depreciation	discharge
1	WU	Hydrogen	Elec	0	0	inf	Inf	0.65	0.65	100	25000	0	0.02	25	3.5e−06
2	WU	Battery	Elec	0	0	inf	Inf	0.96	0.96	10 000	500000	0	0.02	15	3.5e−06
3	WU	Day Storage	Heat	0	0	2 000	100	0.95	0.95	0	5000	100	0.02	30	1.0e−02
4	WU	Seasonal Storage	Heat	0	0	100 000	200	0.95	0.95	0	1500	2	0.02	40	1.0e−02
5	Viertel2	Hydrogen	Elec	0	0	inf	Inf	0.65	0.65	100	25000	0	0.02	25	3.5e−06
6	Viertel2	Battery	Elec	0	0	inf	Inf	0.96	0.96	10 000	500000	0	0.02	15	3.5e−06
7	Viertel2	Day Storage	Heat	0	0	2 000	100	0.95	0.95	0	5000	100	0.02	30	1.0e−02
8	Viertel2	Seasonal Storage	Heat	0	0	100 000	200	0.95	0.95	0	1500	2	0.02	40	1.0e−02
9	Neubau	Hydrogen	Elec	0	0	inf	Inf	0.65	0.65	100	25000	0	0.02	25	3.5e−06
10	Neubau	Battery	Elec	0	0	inf	Inf	0.96	0.96	10 000	500000	0	0.02	15	3.5e−06
11	Neubau	Day Storage	Heat	0	0	2 000	100	0.95	0.95	0	5000	100	0.02	30	1.0e−02
12	Neubau	Seasonal Storage	Heat	0	0	100 000	200	0.95	0.95	0	1500	2	0.02	40	1.0e−02
13	Stadion	Hydrogen	Elec	0	0	inf	Inf	0.65	0.65	100	25000	0	0.02	25	3.5e−06
14	Stadion	Battery	Elec	0	0	inf	Inf	0.96	0.96	10 000	500000	0	0.02	15	3.5e−06
15	Stadion	Day Storage	Heat	0	0	2 000	100	0.95	0.95	0	5000	100	0.02	30	1.0e−02
16	Stadion	Seasonal Storage	Heat	0	0	100 000	200	0.95	0.95	0	1500	2	0.02	40	1.0e−02
17				NA	NA		NA	NA	NA		NA	NA	NA	NA	NA

	Site.In	Site.Out	Transmission	Commodity	eff	inv.cost	fix.cost	var.cost	inst.cap	cap.lo	cap.up	wacc	depreciation
1	WU	Neubau	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
2	WU	Stadion	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
3	WU	Viertel2	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
4	Viertel2	Stadion	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
5	Viertel2	Neubau	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
6	Stadion	Neubau	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
7	Neubau	WU	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
8	Stadion	WU	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
9	Viertel2	WU	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
10	Stadion	Viertel2	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
11	Neubau	Viertel2	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40
12	Neubau	Stadion	hvac	Elec	0.9	1 650 000	16 500	0	0	0	Inf	0.02	40

	Site	Process	inst.cap	cap.up	inv.cost	fix.cost	var.cost	wacc	depreciation	area.per.cap	con.cost
1	Viertel2	Photovoltaics	0.28	999	850 000	8 500	0.0	0.02	20	6500	0
2	WU	Photovoltaics	0.00	999	850 000	8 500	0.0	0.02	20	6500	0
3	Stadion	Photovoltaics	0.00	999	850 000	8 500	0.0	0.02	20	6500	0
4	Neubau	Photovoltaics	0.00	999	850 000	8 500	0.0	0.02	20	6500	0
5	Viertel2	Solarthermal	0.00	999	1 200 000	12 000	0.0	0.02	20	1250	0
6	WU	Solarthermal	0.00	999	1 200 000	12 000	0.0	0.02	20	1250	0
7	Stadion	Solarthermal	0.00	999	1 200 000	12 000	0.0	0.02	20	1250	0
8	Neubau	Solarthermal	0.00	999	1 200 000	12 000	0.0	0.02	20	1250	0
9	Viertel2	Feed−in	0.00	999	0	0	0.0	0.02	1	0	0
10	WU	Feed−in	0.00	999	0	0	0.0	0.02	1	0	0
11	Stadion	Feed−in	0.00	999	0	0	0.0	0.02	1	0	0
12	Neubau	Feed−in	0.00	999	0	0	0.0	0.02	1	0	0
13	Viertel2	Purchase	0.00	999	0	80	0.0	0.02	1	0	0
14	WU	Purchase	0.00	999	0	80	0.0	0.02	1	0	0
15	Stadion	Purchase	0.00	999	0	80	0.0	0.02	1	0	0
16	Neubau	Purchase	0.00	999	0	80	0.0	0.02	1	0	0
17	Viertel2	Mikro CHP	0.25	999	875 000	26 250	6.4	0.02	20	0	0
18	WU	Mikro CHP	0.00	999	875 000	26 250	6.4	0.02	20	0	0
19	Stadion	Mikro CHP	0.00	999	875 000	26 250	6.4	0.02	20	0	0
20	Neubau	Mikro CHP	0.00	999	875 000	26 250	6.4	0.02	20	0	0
21	Viertel2	Geothermal	0.18	999	1 600 000	32 000	0.0	0.02	40	0	0
22	WU	Geothermal	0.20	999	1 600 000	32 000	0.0	0.02	40	0	0
23	Stadion	Geothermal	0.00	999	1 600 000	32 000	0.0	0.02	40	0	0
24	Neubau	Geothermal	0.00	999	1 600 000	32 000	0.0	0.02	40	0	0
25	Viertel2	Heat Pump (air water)	0.00	999	510 000	10 200	0.5	0.02	20	0	0
26	WU	Heat Pump (air water)	0.00	999	510 000	10 200	0.5	0.02	20	0	0
27	Stadion	Heat Pump (air water)	0.00	999	510 000	10 200	0.5	0.02	20	0	0
28	Neubau	Heat Pump (air water)	0.00	999	510 000	10 200	0.5	0.02	20	0	0
29	Viertel2	District Heating	0.00	2	0	0	0.0	0.02	40	0	300 000
30	WU	District Heating	2.70	5	0	0	0.0	0.02	40	0	300 000
31	Stadion	District Heating	1.00	1	0	0	0.0	0.02	40	0	300 000
32	Neubau	District Heating	0.00	1	0	0	0.0	0.02	40	0	300 000
33	Viertel2	District Cooling	0.00	0	0	0	0.0	0.02	40	0	1 050 000
34	WU	District Cooling	0.00	6	0	0	0.0	0.02	40	0	1 050 000
35	Stadion	District Cooling	0.00	0	0	0	0.0	0.02	40	0	1 050 000
36	Neubau	District Cooling	0.00	0	0	0	0.0	0.02	40	0	1 050 000
37	Viertel2	Compression Machine	0.65	999	200 000	4 000	0.0	0.02	20	0	0
38	WU	Compression Machine	0.50	999	200 000	4 000	0.0	0.02	20	0	0
39	Stadion	Compression Machine	0.00	999	200 000	4 000	0.0	0.02	20	0	0
40	Neubau	Compression Machine	0.00	999	200 000	4 000	0.0	0.02	20	0	0
41	Viertel2	Absorption Machine	0.00	999	800 000	16 000	0.0	0.02	20	0	0
42	WU	Absorption Machine	0.00	999	800 000	16 000	0.0	0.02	20	0	0
43	Stadion	Absorption Machine	0.00	999	800 000	16 000	0.0	0.02	20	0	0
44	Neubau	Absorption Machine	0.00	999	800 000	16 000	0.0	0.02	20	0	0
45	Viertel2	Geothermal Cooling	0.10	999	1 600 000	32 000	0.0	0.02	40	0	0
46	WU	Geothermal Cooling	0.25	999	1 600 000	32 000	0.0	0.02	40	0	0
47	Stadion	Geothermal Cooling	0.00	999	1 600 000	32 000	0.0	0.02	40	0	0
48	Neubau	Geothermal Cooling	0.00	999	1 600 000	32 000	0.0	0.02	40	0	0

Appendix B.

Time-series input values

t	Weight	Solar	Efficiency	Viertel2.Elec	WU.Elec	Stadion.Elec	Neubau.Elec	Viertel2.Heat	WU.Heat	Stadion.Heat	Neubau.Heat	Viertel2.Cold	WU.Cold	Stadion.Cold	Neubau.Cold
0	11.00	0.00	3.34	0.15	0.37	0.00	0.04	0.05	0.08	0.00	0.01	0.41	0.98	0.01	0.16
1	11.00	0.00	3.26	0.14	0.36	0.00	0.04	0.05	0.08	0.00	0.01	0.30	0.72	0.01	0.11
2	11.00	0.00	3.23	0.14	0.36	0.00	0.04	0.05	0.09	0.00	0.02	0.28	0.68	0.01	0.11
3	11.00	0.00	3.21	0.16	0.40	0.01	0.05	0.06	0.10	0.00	0.02	0.28	0.66	0.01	0.11
4	11.00	0.00	3.15	0.20	0.52	0.01	0.06	0.08	0.13	0.00	0.02	0.22	0.54	0.01	0.09
5	11.00	0.01	3.11	0.38	0.95	0.01	0.11	0.09	0.16	0.00	0.03	0.19	0.46	0.01	0.07
6	11.00	0.07	3.10	0.76	1.94	0.03	0.22	0.09	0.14	0.00	0.03	0.17	0.41	0.00	0.07
7	11.00	0.18	3.17	1.23	3.11	0.04	0.36	0.09	0.14	0.00	0.03	0.22	0.53	0.01	0.08
8	11.00	0.32	3.30	1.37	3.47	0.05	0.40	0.07	0.11	0.00	0.02	0.35	0.84	0.01	0.13
9	11.00	0.38	3.42	1.36	3.44	0.05	0.40	0.06	0.10	0.00	0.02	0.53	1.28	0.01	0.21
10	11.00	0.44	3.54	1.35	3.43	0.05	0.40	0.05	0.09	0.00	0.02	0.71	1.72	0.02	0.28
11	11.00	0.43	3.63	1.22	3.09	0.04	0.36	0.05	0.08	0.00	0.01	0.87	2.09	0.02	0.33
12	11.00	0.42	3.72	1.00	2.55	0.03	0.29	0.05	0.08	0.00	0.01	1.01	2.43	0.03	0.39
13	11.00	0.44	3.76	1.04	2.63	0.04	0.30	0.04	0.07	0.00	0.01	1.09	2.62	0.03	0.42
14	11.00	0.41	3.80	0.98	2.48	0.03	0.29	0.04	0.07	0.00	0.01	1.13	2.73	0.03	0.44
15	11.00	0.27	3.84	0.76	1.93	0.03	0.22	0.04	0.07	0.00	0.01	1.21	2.93	0.03	0.47
16	11.00	0.19	3.84	0.55	1.39	0.02	0.16	0.04	0.06	0.00	0.01	1.24	2.99	0.03	0.48
17	11.00	0.08	3.84	0.43	1.09	0.01	0.13	0.04	0.07	0.00	0.01	1.24	2.99	0.03	0.48
18	11.00	0.02	3.80	0.39	0.98	0.01	0.11	0.05	0.08	0.00	0.01	1.18	2.85	0.03	0.46
19	11.00	0.00	3.78	0.35	0.88	0.01	0.10	0.05	0.08	0.00	0.01	1.11	2.67	0.03	0.43
20	11.00	0.00	3.64	0.32	0.81	0.01	0.09	0.06	0.10	0.00	0.02	0.92	2.21	0.03	0.35
21	11.00	0.00	3.54	0.27	0.69	0.01	0.08	0.06	0.11	0.00	0.02	0.77	1.86	0.02	0.30
22	11.00	0.00	3.41	0.21	0.54	0.01	0.06	0.06	0.09	0.00	0.02	0.56	1.35	0.02	0.22
23	11.00	0.00	3.32	0.16	0.41	0.01	0.05	0.05	0.08	0.00	0.01	0.43	1.04	0.01	0.17
24	11.00	0.00	3.25	0.15	0.37	0.00	0.04	0.04	0.07	0.00	0.01	0.36	0.86	0.01	0.14
25	11.00	0.00	3.21	0.14	0.36	0.00	0.04	0.04	0.07	0.00	0.01	0.32	0.78	0.01	0.12
26	11.00	0.00	3.15	0.14	0.36	0.00	0.04	0.05	0.08	0.00	0.01	0.25	0.60	0.01	0.10
27	11.00	0.00	3.11	0.16	0.40	0.01	0.05	0.05	0.09	0.00	0.02	0.18	0.45	0.01	0.07
28	11.00	0.00	3.07	0.20	0.52	0.01	0.06	0.07	0.11	0.00	0.02	0.18	0.44	0.01	0.07
29	11.00	0.01	3.05	0.38	0.96	0.01	0.11	0.11	0.18	0.00	0.03	0.16	0.38	0.00	0.06
30	11.00	0.07	3.03	0.76	1.94	0.03	0.22	0.10	0.17	0.00	0.03	0.13	0.32	0.00	0.05
31	11.00	0.17	3.08	1.23	3.11	0.04	0.36	0.09	0.15	0.00	0.03	0.17	0.42	0.00	0.07
32	11.00	0.31	3.18	1.37	3.47	0.05	0.40	0.07	0.11	0.00	0.02	0.25	0.60	0.01	0.10
33	11.00	0.40	3.35	1.36	3.44	0.05	0.40	0.06	0.11	0.00	0.02	0.49	1.18	0.01	0.19
34	11.00	0.45	3.49	1.35	3.43	0.05	0.40	0.06	0.10	0.00	0.02	0.71	1.72	0.02	0.27
35	11.00	0.46	3.59	1.22	3.09	0.04	0.36	0.06	0.10	0.00	0.02	0.88	2.12	0.02	0.34
36	11.00	0.47	3.66	1.00	2.55	0.03	0.29	0.05	0.09	0.00	0.02	1.00	2.42	0.03	0.39
37	11.00	0.41	3.69	1.04	2.63	0.04	0.30	0.05	0.08	0.00	0.01	1.07	2.58	0.03	0.41
38	11.00	0.36	3.72	0.98	2.48	0.03	0.29	0.05	0.08	0.00	0.01	1.14	2.74	0.03	0.44
39	11.00	0.30	3.74	0.76	1.93	0.03	0.22	0.04	0.07	0.00	0.01	1.20	2.88	0.03	0.46
40	11.00	0.18	3.76	0.55	1.39	0.02	0.16	0.04	0.07	0.00	0.01	1.24	2.98	0.03	0.48
41	11.00	0.08	3.75	0.43	1.09	0.01	0.13	0.04	0.07	0.00	0.01	1.22	2.94	0.03	0.47
42	11.00	0.02	3.70	0.39	0.98	0.01	0.11	0.05	0.08	0.00	0.01	1.13	2.72	0.03	0.44
43	11.00	0.00	3.70	0.35	0.88	0.01	0.10	0.06	0.09	0.00	0.02	1.09	2.63	0.03	0.42
44	11.00	0.00	3.68	0.32	0.81	0.01	0.09	0.06	0.10	0.00	0.02	0.98	2.36	0.03	0.38
45	11.00	0.00	3.60	0.27	0.69	0.01	0.08	0.05	0.09	0.00	0.02	0.84	2.03	0.02	0.33
46	11.00	0.00	3.51	0.21	0.54	0.01	0.06	0.05	0.08	0.00	0.02	0.69	1.67	0.02	0.27
47	11.00	0.00	3.41	0.17	0.42	0.01	0.05	0.04	0.07	0.00	0.01	0.57	1.38	0.02	0.22
48	11.00	0.00	3.38	0.15	0.38	0.01	0.04	0.03	0.06	0.00	0.01	0.55	1.32	0.02	0.21
49	11.00	0.00	3.34	0.14	0.37	0.00	0.04	0.04	0.06	0.00	0.01	0.48	1.15	0.01	0.18
50	11.00	0.00	3.23	0.14	0.36	0.00	0.04	0.04	0.07	0.00	0.01	0.34	0.83	0.01	0.13
51	11.00	0.00	3.25	0.16	0.40	0.01	0.05	0.04	0.07	0.00	0.01	0.37	0.90	0.01	0.14
52	11.00	0.00	3.26	0.20	0.50	0.01	0.06	0.06	0.09	0.00	0.02	0.42	1.02	0.01	0.16
53	11.00	0.02	3.20	0.34	0.87	0.01	0.10	0.10	0.16	0.00	0.03	0.34	0.82	0.01	0.13
54	11.00	0.08	3.16	0.68	1.72	0.02	0.20	0.09	0.15	0.00	0.03	0.28	0.67	0.01	0.11
55	11.00	0.17	3.19	1.08	2.74	0.04	0.32	0.08	0.14	0.00	0.02	0.31	0.74	0.01	0.12
56	11.00	0.27	3.27	1.21	3.07	0.04	0.35	0.06	0.10	0.00	0.02	0.39	0.95	0.01	0.15
57	11.00	0.37	3.43	1.20	3.06	0.04	0.35	0.06	0.09	0.00	0.02	0.56	1.36	0.02	0.22
58	11.00	0.50	3.54	1.20	3.06	0.04	0.35	0.06	0.09	0.00	0.02	0.70	1.68	0.02	0.27
59	11.00	0.52	3.64	1.08	2.75	0.04	0.32	0.05	0.09	0.00	0.02	0.85	2.06	0.02	0.33
60	11.00	0.54	3.68	0.90	2.27	0.03	0.26	0.05	0.08	0.00	0.01	0.93	2.25	0.03	0.36
61	11.00	0.46	3.73	0.92	2.33	0.03	0.27	0.04	0.07	0.00	0.01	1.04	2.51	0.03	0.40
62	11.00	0.37	3.78	0.86	2.19	0.03	0.25	0.04	0.07	0.00	0.01	1.15	2.76	0.03	0.44
63	11.00	0.30	3.78	0.68	1.72	0.02	0.20	0.04	0.06	0.00	0.01	1.16	2.80	0.03	0.45
64	11.00	0.21	3.84	0.50	1.28	0.02	0.15	0.04	0.06	0.00	0.01	1.24	2.98	0.03	0.48
65	11.00	0.08	3.81	0.41	1.04	0.01	0.12	0.04	0.06	0.00	0.01	1.16	2.80	0.03	0.45
66	11.00	0.02	3.75	0.38	0.95	0.01	0.11	0.04	0.07	0.00	0.01	1.07	2.58	0.03	0.41
67	11.00	0.00	3.71	0.34	0.87	0.01	0.10	0.05	0.09	0.00	0.02	0.97	2.34	0.03	0.37
68	11.00	0.00	3.64	0.32	0.80	0.01	0.09	0.06	0.09	0.00	0.02	0.88	2.11	0.02	0.34
69	11.00	0.00	3.49	0.27	0.69	0.01	0.08	0.05	0.09	0.00	0.02	0.61	1.47	0.02	0.24
70	11.00	0.00	3.43	0.21	0.53	0.01	0.06	0.05	0.08	0.00	0.01	0.53	1.28	0.01	0.20
71	11.00	0.00	3.38	0.16	0.41	0.01	0.05	0.04	0.07	0.00	0.01	0.43	1.03	0.01	0.16
72	11.00	0.00	3.36	0.15	0.37	0.00	0.04	0.04	0.06	0.00	0.01	0.39	0.95	0.01	0.15
73	11.00	0.00	3.27	0.14	0.36	0.00	0.04	0.04	0.06	0.00	0.01	0.29	0.70	0.01	0.11
74	11.00	0.00	3.24	0.14	0.36	0.00	0.04	0.04	0.07	0.00	0.01	0.24	0.59	0.01	0.09
75	11.00	0.00	3.17	0.16	0.40	0.01	0.05	0.05	0.08	0.00	0.01	0.17	0.42	0.00	0.07
76	11.00	0.00	3.14	0.21	0.52	0.01	0.06	0.06	0.10	0.00	0.02	0.16	0.38	0.00	0.06
77	11.00	0.01	3.10	0.38	0.96	0.01	0.11	0.10	0.17	0.00	0.03	0.13	0.32	0.00	0.05
78	11.00	0.07	3.05	0.77	1.94	0.03	0.22	0.09	0.15	0.00	0.03	0.13	0.31	0.00	0.05
79	11.00	0.19	3.13	1.23	3.11	0.04	0.36	0.08	0.13	0.00	0.02	0.16	0.38	0.00	0.06
80	11.00	0.28	3.28	1.37	3.47	0.05	0.40	0.06	0.09	0.00	0.02	0.28	0.66	0.01	0.11
81	11.00	0.37	3.44	1.36	3.45	0.05	0.40	0.05	0.09	0.00	0.02	0.50	1.21	0.01	0.19
82	11.00	0.45	3.59	1.35	3.43	0.05	0.40	0.05	0.09	0.00	0.02	0.80	1.92	0.02	0.31
83	11.00	0.47	3.68	1.22	3.09	0.04	0.36	0.05	0.08	0.00	0.01	0.97	2.35	0.03	0.38
84	11.00	0.47	3.78	1.00	2.55	0.03	0.29	0.05	0.07	0.00	0.01	1.16	2.80	0.03	0.45
85	11.00	0.40	3.87	1.04	2.63	0.04	0.30	0.04	0.06	0.00	0.01	1.28	3.09	0.04	0.50
86	11.00	0.34	3.91	0.98	2.48	0.03	0.29	0.04	0.06	0.00	0.01	1.35	3.25	0.04	0.52

87	11.00	0.29	3.94	0.76	1.93	0.03	0.22	0.04	0.06	0.00	0.01	1.38	3.33	0.04	0.53
88	11.00	0.18	3.95	0.55	1.39	0.02	0.16	0.03	0.05	0.00	0.01	1.43	3.44	0.04	0.55
89	11.00	0.08	3.95	0.43	1.09	0.01	0.13	0.04	0.06	0.00	0.01	1.40	3.37	0.04	0.54
90	11.00	0.02	3.91	0.39	0.98	0.01	0.11	0.04	0.06	0.00	0.01	1.34	3.23	0.04	0.52
91	11.00	0.00	3.88	0.35	0.88	0.01	0.10	0.05	0.08	0.00	0.01	1.27	3.06	0.04	0.49
92	11.00	0.00	3.79	0.32	0.81	0.01	0.09	0.05	0.09	0.00	0.02	1.11	2.67	0.03	0.43
93	11.00	0.00	3.62	0.27	0.70	0.01	0.08	0.05	0.08	0.00	0.01	0.86	2.07	0.02	0.33
94	11.00	0.00	3.53	0.22	0.56	0.01	0.06	0.05	0.08	0.00	0.01	0.70	1.69	0.02	0.27
95	11.00	0.00	3.46	0.18	0.46	0.01	0.05	0.04	0.07	0.00	0.01	0.59	1.42	0.02	0.23
96	11.00	0.00	3.41	0.15	0.39	0.01	0.04	0.04	0.07	0.00	0.01	0.53	1.27	0.01	0.20
97	11.00	0.00	3.36	0.15	0.37	0.00	0.04	0.04	0.07	0.00	0.01	0.45	1.08	0.01	0.17
98	11.00	0.00	3.29	0.15	0.37	0.00	0.04	0.05	0.08	0.00	0.01	0.35	0.85	0.01	0.14
99	11.00	0.00	3.21	0.15	0.38	0.01	0.04	0.05	0.09	0.00	0.02	0.29	0.70	0.01	0.11
100	11.00	0.00	3.17	0.16	0.42	0.01	0.05	0.07	0.12	0.00	0.02	0.25	0.61	0.01	0.10
101	11.00	0.03	3.10	0.21	0.53	0.01	0.06	0.12	0.20	0.00	0.03	0.21	0.50	0.01	0.08
102	11.00	0.10	3.10	0.27	0.68	0.01	0.08	0.11	0.18	0.00	0.03	0.20	0.48	0.01	0.08
103	11.00	0.20	3.17	0.33	0.84	0.01	0.10	0.10	0.17	0.00	0.03	0.23	0.54	0.01	0.09
104	11.00	0.33	3.32	0.39	0.99	0.01	0.11	0.08	0.12	0.00	0.02	0.40	0.97	0.01	0.15
105	11.00	0.41	3.50	0.42	1.07	0.01	0.12	0.07	0.12	0.00	0.02	0.66	1.59	0.02	0.25
106	11.00	0.41	3.62	0.43	1.10	0.01	0.13	0.07	0.11	0.00	0.02	0.85	2.06	0.02	0.33
107	11.00	0.40	3.72	0.40	1.02	0.01	0.12	0.06	0.10	0.00	0.02	1.03	2.47	0.03	0.40
108	11.00	0.39	3.83	0.35	0.88	0.01	0.10	0.06	0.10	0.00	0.02	1.19	2.88	0.03	0.46
109	11.00	0.34	3.88	0.32	0.81	0.01	0.09	0.05	0.09	0.00	0.02	1.28	3.09	0.04	0.49
110	11.00	0.37	3.85	0.31	0.78	0.01	0.09	0.05	0.08	0.00	0.02	1.26	3.03	0.04	0.49
111	11.00	0.30	3.85	0.31	0.78	0.01	0.09	0.05	0.08	0.00	0.02	1.27	3.05	0.04	0.49
112	11.00	0.18	3.83	0.32	0.82	0.01	0.09	0.05	0.08	0.00	0.01	1.25	3.01	0.03	0.48
113	11.00	0.08	3.82	0.35	0.89	0.01	0.10	0.05	0.08	0.00	0.01	1.27	3.06	0.04	0.49
114	11.00	0.02	3.81	0.35	0.88	0.01	0.10	0.06	0.09	0.00	0.02	1.24	2.99	0.03	0.48
115	11.00	0.00	3.79	0.32	0.80	0.01	0.09	0.07	0.11	0.00	0.02	1.21	2.92	0.03	0.47
116	11.00	0.00	3.72	0.31	0.78	0.01	0.09	0.07	0.11	0.00	0.02	1.08	2.60	0.03	0.42
117	11.00	0.00	3.63	0.28	0.72	0.01	0.08	0.06	0.11	0.00	0.02	0.92	2.23	0.03	0.36
118	11.00	0.00	3.54	0.22	0.57	0.01	0.07	0.06	0.10	0.00	0.02	0.76	1.83	0.02	0.29
119	11.00	0.00	3.47	0.18	0.46	0.01	0.05	0.05	0.08	0.00	0.01	0.67	1.61	0.02	0.26
120	11.00	0.00	3.39	0.16	0.39	0.01	0.05	0.04	0.07	0.00	0.01	0.56	1.36	0.02	0.22
121	11.00	0.00	3.36	0.15	0.38	0.01	0.04	0.05	0.07	0.00	0.01	0.50	1.20	0.01	0.19
122	11.00	0.00	3.37	0.15	0.37	0.00	0.04	0.05	0.08	0.00	0.01	0.52	1.26	0.01	0.20
123	11.00	0.00	3.27	0.14	0.37	0.00	0.04	0.05	0.09	0.00	0.02	0.38	0.93	0.01	0.15
124	11.00	0.00	3.20	0.15	0.38	0.01	0.04	0.07	0.12	0.00	0.02	0.31	0.76	0.01	0.12
125	11.00	0.02	3.16	0.17	0.44	0.01	0.05	0.12	0.20	0.00	0.04	0.26	0.62	0.01	0.10
126	11.00	0.07	3.14	0.22	0.56	0.01	0.06	0.12	0.20	0.00	0.04	0.24	0.58	0.01	0.09
127	11.00	0.19	3.15	0.29	0.74	0.01	0.08	0.11	0.19	0.00	0.03	0.27	0.64	0.01	0.10
128	11.00	0.35	3.29	0.34	0.87	0.01	0.10	0.08	0.14	0.00	0.02	0.43	1.03	0.01	0.17
129	11.00	0.49	3.48	0.37	0.95	0.01	0.11	0.08	0.13	0.00	0.02	0.64	1.55	0.02	0.25
130	11.00	0.55	3.57	0.39	1.00	0.01	0.12	0.08	0.12	0.00	0.02	0.78	1.88	0.02	0.30
131	11.00	0.55	3.59	0.36	0.92	0.01	0.11	0.07	0.11	0.00	0.02	0.82	1.97	0.02	0.32
132	11.00	0.58	3.67	0.30	0.77	0.01	0.09	0.06	0.11	0.00	0.02	0.98	2.36	0.03	0.38
133	11.00	0.54	3.75	0.27	0.69	0.01	0.08	0.06	0.09	0.00	0.02	1.14	2.75	0.03	0.44
134	11.00	0.44	3.78	0.24	0.62	0.01	0.07	0.05	0.09	0.00	0.02	1.19	2.86	0.03	0.46
135	11.00	0.31	3.80	0.24	0.61	0.01	0.07	0.05	0.09	0.00	0.02	1.19	2.88	0.03	0.46
136	11.00	0.21	3.82	0.27	0.67	0.01	0.08	0.05	0.08	0.00	0.01	1.23	2.96	0.03	0.47
137	11.00	0.08	3.79	0.30	0.77	0.01	0.09	0.05	0.09	0.00	0.02	1.19	2.86	0.03	0.46
138	11.00	0.02	3.71	0.32	0.82	0.01	0.09	0.06	0.10	0.00	0.02	1.08	2.60	0.03	0.42
139	11.00	0.00	3.64	0.31	0.79	0.01	0.09	0.07	0.12	0.00	0.02	0.96	2.31	0.03	0.37
140	11.00	0.00	3.56	0.30	0.75	0.01	0.09	0.08	0.13	0.00	0.02	0.80	1.93	0.02	0.31
141	11.00	0.00	3.44	0.26	0.65	0.01	0.08	0.07	0.12	0.00	0.02	0.54	1.29	0.01	0.21
142	11.00	0.00	3.43	0.20	0.50	0.01	0.06	0.06	0.11	0.00	0.02	0.52	1.26	0.01	0.20
143	11.00	0.00	3.36	0.16	0.41	0.01	0.05	0.06	0.09	0.00	0.02	0.43	1.04	0.01	0.17
144	11.00	0.00	3.31	0.15	0.37	0.00	0.04	0.06	0.11	0.00	0.02	0.39	0.94	0.01	0.15
145	11.00	0.00	3.26	0.14	0.36	0.00	0.04	0.06	0.10	0.00	0.02	0.34	0.82	0.01	0.13
146	11.00	0.00	3.21	0.14	0.36	0.00	0.04	0.06	0.09	0.00	0.02	0.29	0.69	0.01	0.11
147	11.00	0.00	3.17	0.16	0.40	0.01	0.05	0.06	0.10	0.00	0.02	0.24	0.58	0.01	0.09
148	11.00	0.00	3.13	0.21	0.52	0.01	0.06	0.08	0.13	0.00	0.02	0.17	0.41	0.00	0.07
149	11.00	0.01	3.10	0.37	0.94	0.01	0.11	0.10	0.16	0.00	0.03	0.14	0.35	0.00	0.06
150	11.00	0.06	3.13	0.77	1.94	0.03	0.22	0.10	0.17	0.00	0.03	0.20	0.48	0.01	0.08
151	11.00	0.19	3.19	1.24	3.16	0.04	0.36	0.10	0.16	0.00	0.03	0.28	0.67	0.01	0.11
152	11.00	0.33	3.29	1.38	3.52	0.05	0.41	0.09	0.15	0.00	0.03	0.39	0.95	0.01	0.15
153	11.00	0.45	3.41	1.37	3.49	0.05	0.40	0.08	0.13	0.00	0.02	0.54	1.29	0.01	0.21
154	11.00	0.46	3.52	1.37	3.48	0.05	0.40	0.09	0.14	0.00	0.03	0.71	1.71	0.02	0.27
155	11.00	0.43	3.57	1.24	3.14	0.04	0.36	0.07	0.11	0.00	0.02	0.78	1.89	0.02	0.30
156	11.00	0.44	3.66	1.02	2.58	0.03	0.30	0.07	0.11	0.00	0.02	0.91	2.19	0.03	0.35
157	11.00	0.46	3.70	1.05	2.66	0.04	0.31	0.07	0.11	0.00	0.02	0.99	2.39	0.03	0.38
158	11.00	0.40	3.67	1.00	2.53	0.03	0.29	0.08	0.13	0.00	0.02	0.95	2.30	0.03	0.37
159	11.00	0.31	3.69	0.78	1.98	0.03	0.23	0.07	0.12	0.00	0.02	0.98	2.37	0.03	0.38
160	11.00	0.20	3.71	0.56	1.42	0.02	0.16	0.07	0.11	0.00	0.02	1.00	2.40	0.03	0.38
161	11.00	0.08	3.76	0.44	1.11	0.01	0.13	0.06	0.10	0.00	0.02	1.04	2.51	0.03	0.40
162	11.00	0.01	3.73	0.39	0.99	0.01	0.11	0.06	0.09	0.00	0.02	1.01	2.43	0.03	0.39
163	11.00	0.00	3.71	0.35	0.89	0.01	0.10	0.07	0.11	0.00	0.02	0.99	2.38	0.03	0.38
164	11.00	0.00	3.60	0.32	0.81	0.01	0.09	0.07	0.12	0.00	0.02	0.82	1.98	0.02	0.32
165	11.00	0.00	3.50	0.27	0.69	0.01	0.08	0.07	0.12	0.00	0.02	0.70	1.69	0.02	0.27
166	11.00	0.00	3.38	0.21	0.53	0.01	0.06	0.07	0.11	0.00	0.02	0.52	1.24	0.01	0.20
167	11.00	0.00	3.33	0.16	0.41	0.01	0.05	0.05	0.09	0.00	0.02	0.44	1.06	0.01	0.17
168	21.50	0.00	2.77	0.15	0.37	0.00	0.04	0.17	0.29	0.01	0.05	0.11	0.26	0.00	0.04
169	21.50	0.00	2.70	0.14	0.36	0.00	0.04	0.18	0.31	0.01	0.05	0.10	0.24	0.00	0.04
170	21.50	0.00	2.66	0.14	0.36	0.00	0.04	0.19	0.32	0.01	0.06	0.09	0.22	0.00	0.04
171	21.50	0.00	2.64	0.15	0.38	0.01	0.04	0.21	0.35	0.01	0.06	0.10	0.23	0.00	0.04
172	21.50	0.00	2.60	0.21	0.53	0.01	0.06	0.26	0.44	0.01	0.08	0.09	0.21	0.00	0.03
173	21.50	0.01	2.58	0.32	0.80	0.01	0.09	0.33	0.55	0.01	0.10	0.09	0.21	0.00	0.03
174	21.50	0.06	2.55	0.73	1.86	0.02	0.21	0.29	0.49	0.01	0.09	0.08	0.20	0.00	0.03

175	21.50	0.16	2.60	1.33	3.37	0.04	0.39	0.29	0.48	0.01	0.09	0.09	0.21	0.00	0.03
176	21.50	0.30	2.69	1.56	3.95	0.05	0.46	0.25	0.41	0.01	0.07	0.09	0.22	0.00	0.03
177	21.50	0.42	2.82	1.58	4.01	0.05	0.46	0.22	0.36	0.01	0.06	0.10	0.24	0.00	0.04
178	21.50	0.49	2.92	1.58	4.01	0.05	0.46	0.20	0.33	0.01	0.06	0.12	0.28	0.00	0.04
179	21.50	0.49	3.04	1.47	3.73	0.05	0.43	0.18	0.30	0.01	0.05	0.13	0.32	0.00	0.05
180	21.50	0.48	3.14	1.20	3.05	0.04	0.35	0.18	0.29	0.01	0.05	0.15	0.36	0.00	0.06
181	21.50	0.40	3.23	1.16	2.96	0.04	0.34	0.16	0.27	0.01	0.05	0.18	0.43	0.00	0.07
182	21.50	0.36	3.29	1.17	2.97	0.04	0.34	0.16	0.26	0.01	0.05	0.19	0.46	0.01	0.07
183	21.50	0.26	3.31	0.99	2.51	0.03	0.29	0.16	0.26	0.01	0.05	0.20	0.49	0.01	0.08
184	21.50	0.15	3.28	0.72	1.82	0.02	0.21	0.17	0.28	0.01	0.05	0.19	0.47	0.01	0.07
185	21.50	0.06	3.21	0.52	1.33	0.02	0.15	0.18	0.30	0.01	0.05	0.20	0.47	0.01	0.08
186	21.50	0.01	3.15	0.44	1.12	0.01	0.13	0.19	0.32	0.01	0.06	0.18	0.44	0.01	0.07
187	21.50	0.00	3.09	0.38	0.97	0.01	0.11	0.20	0.34	0.01	0.06	0.15	0.36	0.00	0.06
188	21.50	0.00	2.98	0.33	0.84	0.01	0.10	0.22	0.36	0.01	0.06	0.12	0.29	0.00	0.05
189	21.50	0.00	2.90	0.27	0.69	0.01	0.08	0.23	0.38	0.01	0.07	0.11	0.26	0.00	0.04
190	21.50	0.00	2.82	0.21	0.54	0.01	0.06	0.21	0.34	0.01	0.06	0.11	0.26	0.00	0.04
191	21.50	0.00	2.76	0.17	0.42	0.01	0.05	0.19	0.31	0.01	0.06	0.10	0.23	0.00	0.04
192	21.50	0.00	2.73	0.15	0.37	0.00	0.04	0.17	0.28	0.01	0.05	0.10	0.24	0.00	0.04
193	21.50	0.00	2.67	0.14	0.36	0.00	0.04	0.18	0.30	0.01	0.05	0.09	0.22	0.00	0.04
194	21.50	0.00	2.63	0.14	0.36	0.00	0.04	0.19	0.31	0.01	0.05	0.09	0.22	0.00	0.04
195	21.50	0.00	2.61	0.15	0.38	0.01	0.04	0.20	0.33	0.01	0.06	0.09	0.20	0.00	0.03
196	21.50	0.00	2.58	0.20	0.51	0.01	0.06	0.23	0.39	0.01	0.07	0.09	0.22	0.00	0.03
197	21.50	0.01	2.54	0.31	0.80	0.01	0.09	0.30	0.49	0.01	0.09	0.08	0.20	0.00	0.03
198	21.50	0.05	2.54	0.70	1.79	0.02	0.21	0.32	0.54	0.01	0.10	0.08	0.20	0.00	0.03
199	21.50	0.16	2.57	1.26	3.21	0.04	0.37	0.32	0.53	0.01	0.09	0.08	0.20	0.00	0.03
200	21.50	0.30	2.63	1.49	3.79	0.05	0.44	0.28	0.46	0.01	0.08	0.08	0.20	0.00	0.03
201	21.50	0.41	2.77	1.51	3.84	0.05	0.44	0.25	0.41	0.01	0.07	0.10	0.24	0.00	0.04
202	21.50	0.47	2.91	1.51	3.85	0.05	0.44	0.22	0.37	0.01	0.07	0.12	0.29	0.00	0.05
203	21.50	0.50	3.01	1.40	3.57	0.05	0.41	0.20	0.34	0.01	0.06	0.14	0.35	0.00	0.06
204	21.50	0.52	3.11	1.15	2.93	0.04	0.34	0.19	0.32	0.01	0.06	0.17	0.41	0.00	0.06
205	21.50	0.47	3.18	1.12	2.84	0.04	0.33	0.18	0.30	0.01	0.05	0.22	0.52	0.01	0.08
206	21.50	0.41	3.19	1.11	2.83	0.04	0.33	0.17	0.29	0.01	0.05	0.23	0.56	0.01	0.09
207	21.50	0.30	3.23	0.94	2.39	0.03	0.28	0.17	0.28	0.01	0.05	0.24	0.59	0.01	0.09
208	21.50	0.15	3.25	0.69	1.75	0.02	0.20	0.17	0.29	0.01	0.05	0.24	0.58	0.01	0.09
209	21.50	0.05	3.21	0.51	1.30	0.02	0.15	0.18	0.30	0.01	0.05	0.22	0.53	0.01	0.09
210	21.50	0.01	3.16	0.44	1.11	0.01	0.13	0.20	0.32	0.01	0.06	0.20	0.48	0.01	0.08
211	21.50	0.00	3.07	0.38	0.96	0.01	0.11	0.21	0.35	0.01	0.06	0.17	0.42	0.00	0.07
212	21.50	0.00	2.94	0.33	0.84	0.01	0.10	0.22	0.36	0.01	0.06	0.10	0.24	0.00	0.04
213	21.50	0.00	2.84	0.27	0.70	0.01	0.08	0.21	0.35	0.01	0.06	0.08	0.20	0.00	0.03
214	21.50	0.00	2.79	0.21	0.54	0.01	0.06	0.19	0.32	0.01	0.06	0.08	0.19	0.00	0.03
215	21.50	0.00	2.74	0.17	0.42	0.01	0.05	0.18	0.30	0.01	0.05	0.08	0.19	0.00	0.03
216	21.50	0.00	2.68	0.15	0.37	0.00	0.04	0.17	0.29	0.01	0.05	0.08	0.19	0.00	0.03
217	21.50	0.00	2.64	0.14	0.36	0.00	0.04	0.19	0.31	0.01	0.06	0.08	0.19	0.00	0.03
218	21.50	0.00	2.59	0.14	0.36	0.00	0.04	0.20	0.33	0.01	0.06	0.08	0.19	0.00	0.03
219	21.50	0.00	2.54	0.15	0.38	0.01	0.04	0.21	0.35	0.01	0.06	0.08	0.19	0.00	0.03
220	21.50	0.00	2.52	0.20	0.52	0.01	0.06	0.24	0.40	0.01	0.07	0.08	0.19	0.00	0.03
221	21.50	0.01	2.49	0.31	0.78	0.01	0.09	0.31	0.50	0.01	0.09	0.08	0.19	0.00	0.03
222	21.50	0.05	2.49	0.70	1.77	0.02	0.20	0.33	0.54	0.01	0.10	0.08	0.19	0.00	0.03
223	21.50	0.14	2.54	1.25	3.18	0.04	0.37	0.32	0.52	0.01	0.09	0.08	0.19	0.00	0.03
224	21.50	0.28	2.64	1.47	3.73	0.05	0.43	0.27	0.45	0.01	0.08	0.08	0.19	0.00	0.03
225	21.50	0.42	2.77	1.49	3.78	0.05	0.44	0.24	0.40	0.01	0.07	0.08	0.19	0.00	0.03
226	21.50	0.53	2.89	1.49	3.80	0.05	0.44	0.22	0.36	0.01	0.06	0.08	0.19	0.00	0.03
227	21.50	0.53	3.01	1.39	3.53	0.05	0.41	0.20	0.33	0.01	0.06	0.09	0.21	0.00	0.03
228	21.50	0.52	3.12	1.14	2.90	0.04	0.33	0.19	0.31	0.01	0.05	0.10	0.24	0.00	0.04
229	21.50	0.49	3.21	1.10	2.80	0.04	0.32	0.17	0.29	0.01	0.05	0.12	0.30	0.00	0.05
230	21.50	0.37	3.26	1.11	2.81	0.04	0.32	0.17	0.28	0.01	0.05	0.14	0.34	0.00	0.05
231	21.50	0.21	3.25	0.94	2.38	0.03	0.27	0.17	0.28	0.01	0.05	0.15	0.36	0.00	0.06
232	21.50	0.12	3.22	0.68	1.74	0.02	0.20	0.17	0.28	0.01	0.05	0.15	0.36	0.00	0.06
233	21.50	0.05	3.23	0.51	1.28	0.02	0.15	0.18	0.29	0.01	0.05	0.16	0.38	0.00	0.06
234	21.50	0.01	3.15	0.43	1.09	0.01	0.13	0.19	0.32	0.01	0.06	0.14	0.34	0.00	0.05
235	21.50	0.00	3.09	0.38	0.95	0.01	0.11	0.20	0.34	0.01	0.06	0.13	0.31	0.00	0.05
236	21.50	0.00	3.00	0.33	0.84	0.01	0.10	0.21	0.34	0.01	0.06	0.09	0.23	0.00	0.04
237	21.50	0.00	2.90	0.27	0.70	0.01	0.08	0.20	0.33	0.01	0.06	0.09	0.21	0.00	0.03
238	21.50	0.00	2.85	0.21	0.54	0.01	0.06	0.19	0.31	0.01	0.06	0.09	0.21	0.00	0.03
239	21.50	0.00	2.76	0.16	0.42	0.01	0.05	0.17	0.29	0.01	0.05	0.08	0.20	0.00	0.03
240	21.50	0.00	2.72	0.15	0.37	0.00	0.04	0.16	0.27	0.01	0.05	0.08	0.20	0.00	0.03
241	21.50	0.00	2.62	0.14	0.36	0.00	0.04	0.16	0.27	0.01	0.05	0.08	0.20	0.00	0.03
242	21.50	0.00	2.62	0.14	0.36	0.00	0.04	0.17	0.28	0.01	0.05	0.08	0.19	0.00	0.03
243	21.50	0.00	2.61	0.15	0.38	0.01	0.04	0.18	0.30	0.01	0.05	0.08	0.19	0.00	0.03
244	21.50	0.00	2.60	0.21	0.52	0.01	0.06	0.21	0.35	0.01	0.06	0.08	0.19	0.00	0.03
245	21.50	0.01	2.58	0.32	0.81	0.01	0.09	0.27	0.45	0.01	0.08	0.08	0.19	0.00	0.03
246	21.50	0.05	2.58	0.73	1.85	0.02	0.21	0.30	0.49	0.01	0.09	0.08	0.19	0.00	0.03
247	21.50	0.13	2.61	1.31	3.33	0.04	0.38	0.28	0.46	0.01	0.08	0.08	0.19	0.00	0.03
248	21.50	0.24	2.73	1.53	3.90	0.05	0.45	0.24	0.39	0.01	0.07	0.08	0.19	0.00	0.03
249	21.50	0.34	2.87	1.55	3.95	0.05	0.45	0.21	0.34	0.01	0.06	0.08	0.19	0.00	0.03
250	21.50	0.44	3.00	1.56	3.96	0.05	0.46	0.18	0.30	0.01	0.05	0.08	0.20	0.00	0.03
251	21.50	0.42	3.13	1.45	3.67	0.05	0.42	0.17	0.28	0.01	0.05	0.10	0.24	0.00	0.04
252	21.50	0.40	3.20	1.19	3.01	0.04	0.35	0.16	0.27	0.01	0.05	0.12	0.28	0.00	0.04
253	21.50	0.37	3.26	1.15	2.93	0.04	0.34	0.15	0.25	0.01	0.04	0.14	0.33	0.00	0.05
254	21.50	0.32	3.30	1.15	2.93	0.04	0.34	0.14	0.24	0.00	0.04	0.15	0.36	0.00	0.06
255	21.50	0.23	3.34	0.97	2.47	0.03	0.28	0.14	0.23	0.00	0.04	0.15	0.37	0.00	0.06
256	21.50	0.14	3.34	0.70	1.78	0.02	0.21	0.14	0.23	0.00	0.04	0.17	0.41	0.00	0.07
257	21.50	0.06	3.33	0.51	1.30	0.02	0.15	0.15	0.24	0.01	0.04	0.16	0.39	0.00	0.06
258	21.50	0.01	3.29	0.43	1.10	0.01	0.13	0.16	0.27	0.01	0.05	0.15	0.35	0.00	0.06
259	21.50	0.00	3.24	0.38	0.96	0.01	0.11	0.18	0.30	0.01	0.05	0.14	0.34	0.00	0.06
260	21.50	0.00	3.12	0.33	0.84	0.01	0.10	0.18	0.31	0.01	0.05	0.11	0.26	0.00	0.04
261	21.50	0.00	3.00	0.27	0.70	0.01	0.08	0.18	0.30	0.01	0.05	0.11	0.26	0.00	0.04
262	21.50	0.00	2.94	0.22	0.56	0.01	0.06	0.17	0.28	0.01	0.05	0.09	0.22	0.00	0.03

263	21.50	0.00	2.85	0.18	0.46	0.01	0.05	0.15	0.25	0.01	0.04	0.08	0.20	0.00	0.03
264	21.50	0.00	2.82	0.15	0.39	0.01	0.05	0.15	0.24	0.01	0.04	0.08	0.20	0.00	0.03
265	21.50	0.00	2.75	0.14	0.37	0.00	0.04	0.16	0.26	0.01	0.05	0.08	0.19	0.00	0.03
266	21.50	0.00	2.70	0.14	0.37	0.00	0.04	0.17	0.28	0.01	0.05	0.08	0.19	0.00	0.03
267	21.50	0.00	2.68	0.14	0.36	0.00	0.04	0.18	0.29	0.01	0.05	0.08	0.19	0.00	0.03
268	21.50	0.00	2.64	0.16	0.40	0.01	0.05	0.21	0.34	0.01	0.06	0.08	0.19	0.00	0.03
269	21.50	0.01	2.61	0.20	0.52	0.01	0.06	0.27	0.45	0.01	0.08	0.08	0.19	0.00	0.03
270	21.50	0.05	2.60	0.27	0.70	0.01	0.08	0.29	0.47	0.01	0.08	0.08	0.19	0.00	0.03
271	21.50	0.14	2.68	0.37	0.93	0.01	0.11	0.27	0.45	0.01	0.08	0.08	0.19	0.00	0.03
272	21.50	0.27	2.79	0.44	1.11	0.01	0.13	0.24	0.39	0.01	0.07	0.08	0.20	0.00	0.03
273	21.50	0.38	2.91	0.47	1.18	0.02	0.14	0.21	0.35	0.01	0.06	0.09	0.21	0.00	0.03
274	21.50	0.44	3.00	0.48	1.22	0.02	0.14	0.19	0.31	0.01	0.06	0.10	0.25	0.00	0.04
275	21.50	0.45	3.11	0.45	1.15	0.02	0.13	0.17	0.28	0.01	0.05	0.12	0.29	0.00	0.05
276	21.50	0.45	3.20	0.39	1.00	0.01	0.11	0.16	0.27	0.01	0.05	0.15	0.35	0.00	0.06
277	21.50	0.42	3.26	0.35	0.88	0.01	0.10	0.15	0.25	0.01	0.05	0.18	0.44	0.01	0.07
278	21.50	0.32	3.32	0.33	0.83	0.01	0.10	0.14	0.24	0.00	0.04	0.20	0.48	0.01	0.08
279	21.50	0.24	3.37	0.33	0.84	0.01	0.10	0.14	0.24	0.00	0.04	0.22	0.54	0.01	0.09
280	21.50	0.13	3.37	0.35	0.90	0.01	0.10	0.14	0.24	0.00	0.04	0.23	0.56	0.01	0.09
281	21.50	0.05	3.35	0.39	0.98	0.01	0.11	0.15	0.25	0.01	0.04	0.23	0.56	0.01	0.09
282	21.50	0.01	3.32	0.38	0.97	0.01	0.11	0.17	0.27	0.01	0.05	0.21	0.51	0.01	0.08
283	21.50	0.00	3.22	0.34	0.86	0.01	0.10	0.18	0.30	0.01	0.05	0.16	0.38	0.00	0.06
284	21.50	0.00	3.10	0.32	0.81	0.01	0.09	0.19	0.31	0.01	0.06	0.11	0.27	0.00	0.04
285	21.50	0.00	2.98	0.29	0.74	0.01	0.09	0.18	0.30	0.01	0.05	0.10	0.24	0.00	0.04
286	21.50	0.00	2.91	0.24	0.60	0.01	0.07	0.16	0.27	0.01	0.05	0.10	0.25	0.00	0.04
287	21.50	0.00	2.88	0.19	0.49	0.01	0.06	0.15	0.25	0.01	0.05	0.09	0.22	0.00	0.04
288	21.50	0.00	2.81	0.16	0.40	0.01	0.05	0.15	0.24	0.01	0.04	0.09	0.22	0.00	0.04
289	21.50	0.00	2.79	0.15	0.38	0.01	0.04	0.16	0.26	0.01	0.05	0.09	0.21	0.00	0.03
290	21.50	0.00	2.73	0.15	0.37	0.00	0.04	0.17	0.27	0.01	0.05	0.09	0.21	0.00	0.03
291	21.50	0.00	2.71	0.14	0.36	0.00	0.04	0.18	0.29	0.01	0.05	0.09	0.21	0.00	0.03
292	21.50	0.00	2.67	0.15	0.37	0.00	0.04	0.21	0.35	0.01	0.06	0.09	0.21	0.00	0.03
293	21.50	0.02	2.65	0.17	0.43	0.01	0.05	0.27	0.44	0.01	0.08	0.09	0.21	0.00	0.03
294	21.50	0.07	2.65	0.22	0.55	0.01	0.06	0.29	0.48	0.01	0.09	0.08	0.20	0.00	0.03
295	21.50	0.18	2.70	0.29	0.73	0.01	0.08	0.28	0.46	0.01	0.08	0.09	0.21	0.00	0.03
296	21.50	0.31	2.81	0.35	0.88	0.01	0.10	0.24	0.40	0.01	0.07	0.09	0.23	0.00	0.04
297	21.50	0.43	2.94	0.38	0.97	0.01	0.11	0.21	0.35	0.01	0.06	0.10	0.23	0.00	0.04
298	21.50	0.54	3.05	0.41	1.03	0.01	0.12	0.19	0.32	0.01	0.06	0.10	0.24	0.00	0.04
299	21.50	0.57	3.16	0.38	0.95	0.01	0.11	0.18	0.29	0.01	0.05	0.11	0.27	0.00	0.04
300	21.50	0.52	3.27	0.31	0.80	0.01	0.09	0.16	0.27	0.01	0.05	0.14	0.33	0.00	0.05
301	21.50	0.45	3.36	0.28	0.71	0.01	0.08	0.15	0.26	0.01	0.05	0.15	0.36	0.00	0.06
302	21.50	0.39	3.42	0.26	0.65	0.01	0.07	0.15	0.24	0.01	0.04	0.15	0.35	0.00	0.06
303	21.50	0.28	3.46	0.25	0.63	0.01	0.07	0.14	0.24	0.00	0.04	0.20	0.48	0.01	0.08
304	21.50	0.16	3.47	0.27	0.69	0.01	0.08	0.15	0.24	0.01	0.04	0.20	0.47	0.01	0.08
305	21.50	0.06	3.43	0.32	0.81	0.01	0.09	0.15	0.25	0.01	0.05	0.20	0.49	0.01	0.08
306	21.50	0.01	3.39	0.34	0.85	0.01	0.10	0.17	0.28	0.01	0.05	0.18	0.44	0.01	0.07
307	21.50	0.00	3.27	0.32	0.81	0.01	0.09	0.18	0.30	0.01	0.05	0.17	0.40	0.00	0.06
308	21.50	0.00	3.16	0.30	0.76	0.01	0.09	0.18	0.30	0.01	0.05	0.13	0.31	0.00	0.05
309	21.50	0.00	3.08	0.25	0.65	0.01	0.07	0.18	0.30	0.01	0.05	0.11	0.27	0.00	0.04
310	21.50	0.00	2.98	0.20	0.52	0.01	0.06	0.16	0.27	0.01	0.05	0.10	0.25	0.00	0.04
311	21.50	0.00	2.93	0.17	0.42	0.01	0.05	0.15	0.24	0.01	0.04	0.10	0.24	0.00	0.04
312	21.50	0.00	2.86	0.15	0.37	0.00	0.04	0.16	0.26	0.01	0.05	0.10	0.24	0.00	0.04
313	21.50	0.00	2.78	0.14	0.36	0.00	0.04	0.16	0.27	0.01	0.05	0.09	0.22	0.00	0.03
314	21.50	0.00	2.74	0.14	0.36	0.00	0.04	0.16	0.27	0.01	0.05	0.09	0.21	0.00	0.03
315	21.50	0.00	2.70	0.15	0.38	0.01	0.04	0.17	0.28	0.01	0.05	0.08	0.20	0.00	0.03
316	21.50	0.00	2.69	0.20	0.51	0.01	0.06	0.20	0.33	0.01	0.06	0.09	0.21	0.00	0.03
317	21.50	0.02	2.66	0.30	0.77	0.01	0.09	0.24	0.39	0.01	0.07	0.08	0.20	0.00	0.03
318	21.50	0.08	2.65	0.68	1.74	0.02	0.20	0.25	0.42	0.01	0.07	0.09	0.21	0.00	0.03
319	21.50	0.20	2.68	1.22	3.10	0.04	0.36	0.24	0.40	0.01	0.07	0.09	0.21	0.00	0.03
320	21.50	0.34	2.78	1.43	3.63	0.05	0.42	0.22	0.37	0.01	0.07	0.10	0.24	0.00	0.04
321	21.50	0.48	2.92	1.45	3.68	0.05	0.42	0.21	0.34	0.01	0.06	0.11	0.27	0.00	0.04
322	21.50	0.56	3.02	1.45	3.69	0.05	0.43	0.20	0.33	0.01	0.06	0.14	0.34	0.00	0.05
323	21.50	0.60	3.13	1.35	3.43	0.05	0.39	0.17	0.28	0.01	0.05	0.16	0.39	0.00	0.06
324	21.50	0.60	3.21	1.11	2.81	0.04	0.32	0.17	0.27	0.01	0.05	0.19	0.45	0.01	0.07
325	21.50	0.54	3.25	1.07	2.73	0.04	0.31	0.16	0.26	0.01	0.05	0.20	0.49	0.01	0.08
326	21.50	0.44	3.30	1.07	2.73	0.04	0.31	0.16	0.26	0.01	0.05	0.23	0.54	0.01	0.09
327	21.50	0.31	3.35	0.91	2.30	0.03	0.27	0.16	0.26	0.01	0.05	0.25	0.61	0.01	0.10
328	21.50	0.18	3.34	0.66	1.68	0.02	0.19	0.16	0.26	0.01	0.05	0.26	0.62	0.01	0.10
329	21.50	0.07	3.33	0.49	1.26	0.02	0.14	0.15	0.25	0.01	0.05	0.25	0.61	0.01	0.10
330	21.50	0.01	3.26	0.42	1.08	0.01	0.12	0.15	0.26	0.01	0.05	0.24	0.58	0.01	0.09
331	21.50	0.00	3.19	0.37	0.94	0.01	0.11	0.17	0.28	0.01	0.05	0.22	0.53	0.01	0.08
332	21.50	0.00	3.06	0.33	0.83	0.01	0.10	0.17	0.29	0.01	0.05	0.17	0.41	0.00	0.07
333	21.50	0.00	3.00	0.27	0.69	0.01	0.08	0.18	0.30	0.01	0.05	0.14	0.34	0.00	0.05
334	21.50	0.00	2.87	0.21	0.53	0.01	0.06	0.17	0.28	0.01	0.05	0.12	0.29	0.00	0.05
335	21.50	0.00	2.83	0.16	0.41	0.01	0.05	0.15	0.24	0.01	0.04	0.11	0.26	0.00	0.04
336	19.50	0.00	2.11	0.18	0.47	0.01	0.05	0.63	1.05	0.02	0.19	0.09	0.21	0.00	0.03
337	19.50	0.00	2.09	0.17	0.44	0.01	0.05	0.66	1.10	0.02	0.20	0.09	0.21	0.00	0.03
338	19.50	0.00	2.10	0.17	0.43	0.01	0.05	0.66	1.10	0.02	0.20	0.09	0.21	0.00	0.03
339	19.50	0.00	2.08	0.17	0.42	0.01	0.05	0.72	1.19	0.02	0.21	0.09	0.21	0.00	0.03
340	19.50	0.00	2.04	0.17	0.43	0.01	0.05	0.79	1.31	0.03	0.23	0.09	0.21	0.00	0.03
341	19.50	0.00	2.02	0.24	0.61	0.01	0.07	0.97	1.61	0.03	0.29	0.09	0.21	0.00	0.03
342	19.50	0.00	2.03	0.36	0.92	0.01	0.11	0.88	1.46	0.03	0.26	0.09	0.21	0.00	0.03
343	19.50	0.01	2.02	0.94	2.37	0.03	0.27	0.92	1.52	0.03	0.27	0.09	0.21	0.00	0.03
344	19.50	0.05	2.03	1.64	4.18	0.06	0.48	0.88	1.46	0.03	0.26	0.09	0.21	0.00	0.03
345	19.50	0.12	2.07	1.78	4.52	0.06	0.52	0.84	1.40	0.03	0.25	0.09	0.21	0.00	0.03
346	19.50	0.17	2.12	1.76	4.48	0.06	0.52	0.79	1.31	0.03	0.23	0.09	0.21	0.00	0.03
347	19.50	0.19	2.17	1.74	4.43	0.06	0.51	0.77	1.27	0.03	0.23	0.09	0.21	0.00	0.03
348	19.50	0.19	2.22	1.57	3.98	0.05	0.46	0.74	1.23	0.03	0.22	0.09	0.21	0.00	0.03
349	19.50	0.14	2.25	1.24	3.16	0.04	0.36	0.70	1.16	0.02	0.21	0.09	0.21	0.00	0.03
350	19.50	0.10	2.28	1.24	3.14	0.04	0.36	0.69	1.14	0.02	0.20	0.09	0.21	0.00	0.03

351	19.50	0.05	2.27	1.28	3.25	0.04	0.37	0.71	1.18	0.02	0.21	0.09	0.21	0.00	0.03
352	19.50	0.01	2.23	1.09	2.76	0.04	0.32	0.74	1.22	0.03	0.22	0.09	0.21	0.00	0.03
353	19.50	0.00	2.19	0.83	2.10	0.03	0.24	0.75	1.25	0.03	0.22	0.09	0.21	0.00	0.03
354	19.50	0.00	2.18	0.66	1.67	0.02	0.19	0.77	1.28	0.03	0.23	0.09	0.21	0.00	0.03
355	19.50	0.00	2.16	0.53	1.35	0.02	0.16	0.78	1.30	0.03	0.23	0.09	0.21	0.00	0.03
356	19.50	0.00	2.14	0.42	1.08	0.01	0.12	0.78	1.30	0.03	0.23	0.09	0.21	0.00	0.03
357	19.50	0.00	2.11	0.36	0.92	0.01	0.11	0.80	1.33	0.03	0.24	0.09	0.21	0.00	0.03
358	19.50	0.00	2.11	0.29	0.74	0.01	0.09	0.72	1.19	0.02	0.21	0.09	0.21	0.00	0.03
359	19.50	0.00	2.11	0.22	0.57	0.01	0.07	0.70	1.15	0.02	0.21	0.09	0.21	0.00	0.03
360	19.50	0.00	2.09	0.18	0.47	0.01	0.05	0.61	1.01	0.02	0.18	0.09	0.21	0.00	0.03
361	19.50	0.00	2.07	0.17	0.44	0.01	0.05	0.63	1.04	0.02	0.19	0.09	0.21	0.00	0.03
362	19.50	0.00	2.04	0.17	0.43	0.01	0.05	0.65	1.07	0.02	0.19	0.09	0.21	0.00	0.03
363	19.50	0.00	2.03	0.17	0.42	0.01	0.05	0.67	1.10	0.02	0.20	0.09	0.21	0.00	0.03
364	19.50	0.00	2.01	0.17	0.44	0.01	0.05	0.72	1.19	0.02	0.21	0.09	0.21	0.00	0.03
365	19.50	0.00	2.00	0.24	0.62	0.01	0.07	0.87	1.43	0.03	0.26	0.09	0.21	0.00	0.03
366	19.50	0.00	1.99	0.37	0.94	0.01	0.11	1.00	1.65	0.03	0.29	0.09	0.21	0.00	0.03
367	19.50	0.01	1.97	0.97	2.46	0.03	0.28	1.09	1.81	0.04	0.32	0.09	0.21	0.00	0.03
368	19.50	0.05	1.98	1.72	4.36	0.06	0.50	1.10	1.82	0.04	0.32	0.09	0.21	0.00	0.03
369	19.50	0.13	2.03	1.86	4.72	0.06	0.54	1.05	1.73	0.04	0.31	0.09	0.21	0.00	0.03
370	19.50	0.19	2.07	1.84	4.67	0.06	0.54	0.99	1.64	0.03	0.29	0.09	0.21	0.00	0.03
371	19.50	0.23	2.13	1.81	4.61	0.06	0.53	0.95	1.57	0.03	0.28	0.09	0.21	0.00	0.03
372	19.50	0.23	2.17	1.63	4.13	0.06	0.48	0.90	1.49	0.03	0.27	0.09	0.21	0.00	0.03
373	19.50	0.19	2.22	1.29	3.27	0.04	0.38	0.86	1.42	0.03	0.25	0.09	0.21	0.00	0.03
374	19.50	0.12	2.24	1.28	3.26	0.04	0.38	0.85	1.41	0.03	0.25	0.09	0.21	0.00	0.03
375	19.50	0.05	2.23	1.33	3.38	0.05	0.39	0.86	1.42	0.03	0.25	0.09	0.21	0.00	0.03
376	19.50	0.01	2.18	1.13	2.86	0.04	0.33	0.86	1.43	0.03	0.26	0.09	0.21	0.00	0.03
377	19.50	0.00	2.14	0.84	2.14	0.03	0.25	0.88	1.45	0.03	0.26	0.09	0.21	0.00	0.03
378	19.50	0.00	2.12	0.66	1.69	0.02	0.19	0.87	1.44	0.03	0.26	0.09	0.21	0.00	0.03
379	19.50	0.00	2.08	0.53	1.36	0.02	0.16	0.83	1.37	0.03	0.24	0.09	0.21	0.00	0.03
380	19.50	0.00	2.06	0.43	1.08	0.01	0.12	0.76	1.26	0.03	0.23	0.09	0.21	0.00	0.03
381	19.50	0.00	2.05	0.36	0.93	0.01	0.11	0.73	1.20	0.03	0.22	0.09	0.21	0.00	0.03
382	19.50	0.00	2.03	0.29	0.74	0.01	0.08	0.69	1.15	0.02	0.21	0.09	0.21	0.00	0.03
383	19.50	0.00	2.00	0.22	0.57	0.01	0.07	0.65	1.07	0.02	0.19	0.09	0.21	0.00	0.03
384	19.50	0.00	1.98	0.18	0.47	0.01	0.05	0.62	1.02	0.02	0.18	0.09	0.21	0.00	0.03
385	19.50	0.00	1.96	0.17	0.44	0.01	0.05	0.63	1.04	0.02	0.19	0.09	0.21	0.00	0.03
386	19.50	0.00	1.96	0.17	0.43	0.01	0.05	0.64	1.06	0.02	0.19	0.09	0.21	0.00	0.03
387	19.50	0.00	1.97	0.17	0.42	0.01	0.05	0.66	1.09	0.02	0.19	0.09	0.21	0.00	0.03
388	19.50	0.00	1.97	0.17	0.44	0.01	0.05	0.72	1.18	0.02	0.21	0.09	0.21	0.00	0.03
389	19.50	0.00	1.95	0.25	0.62	0.01	0.07	0.85	1.41	0.03	0.25	0.09	0.21	0.00	0.03
390	19.50	0.00	1.95	0.37	0.94	0.01	0.11	0.98	1.62	0.03	0.29	0.09	0.21	0.00	0.03
391	19.50	0.01	1.95	0.97	2.46	0.03	0.28	1.07	1.77	0.04	0.32	0.09	0.21	0.00	0.03
392	19.50	0.06	1.98	1.72	4.36	0.06	0.50	1.07	1.78	0.04	0.32	0.09	0.21	0.00	0.03
393	19.50	0.12	2.03	1.86	4.72	0.06	0.54	1.03	1.70	0.04	0.30	0.09	0.21	0.00	0.03
394	19.50	0.18	2.07	1.84	4.67	0.06	0.54	0.97	1.61	0.03	0.29	0.09	0.21	0.00	0.03
395	19.50	0.21	2.11	1.81	4.61	0.06	0.53	0.93	1.54	0.03	0.27	0.09	0.21	0.00	0.03
396	19.50	0.20	2.16	1.63	4.13	0.06	0.48	0.89	1.46	0.03	0.26	0.09	0.21	0.00	0.03
397	19.50	0.17	2.19	1.29	3.27	0.04	0.38	0.84	1.39	0.03	0.25	0.09	0.21	0.00	0.03
398	19.50	0.11	2.21	1.28	3.26	0.04	0.38	0.84	1.39	0.03	0.25	0.09	0.21	0.00	0.03
399	19.50	0.04	2.19	1.33	3.38	0.05	0.39	0.84	1.39	0.03	0.25	0.09	0.21	0.00	0.03
400	19.50	0.01	2.17	1.13	2.86	0.04	0.33	0.85	1.40	0.03	0.25	0.09	0.21	0.00	0.03
401	19.50	0.00	2.13	0.84	2.14	0.03	0.25	0.87	1.43	0.03	0.26	0.09	0.21	0.00	0.03
402	19.50	0.00	2.08	0.66	1.69	0.02	0.19	0.86	1.43	0.03	0.25	0.09	0.21	0.00	0.03
403	19.50	0.00	2.05	0.53	1.36	0.02	0.16	0.82	1.35	0.03	0.24	0.09	0.21	0.00	0.03
404	19.50	0.00	2.02	0.43	1.08	0.01	0.12	0.76	1.26	0.03	0.22	0.09	0.21	0.00	0.03
405	19.50	0.00	2.01	0.36	0.93	0.01	0.11	0.73	1.20	0.03	0.21	0.09	0.21	0.00	0.03
406	19.50	0.00	1.98	0.29	0.74	0.01	0.08	0.69	1.14	0.02	0.20	0.09	0.21	0.00	0.03
407	19.50	0.00	1.96	0.22	0.57	0.01	0.07	0.64	1.06	0.02	0.19	0.09	0.21	0.00	0.03
408	19.50	0.00	1.95	0.18	0.47	0.01	0.05	0.60	0.98	0.02	0.18	0.09	0.21	0.00	0.03
409	19.50	0.00	1.94	0.17	0.44	0.01	0.05	0.61	1.01	0.02	0.18	0.09	0.21	0.00	0.03
410	19.50	0.00	1.94	0.17	0.43	0.01	0.05	0.63	1.04	0.02	0.19	0.09	0.21	0.00	0.03
411	19.50	0.00	1.91	0.17	0.42	0.01	0.05	0.65	1.07	0.02	0.19	0.09	0.21	0.00	0.03
412	19.50	0.00	1.89	0.17	0.44	0.01	0.05	0.70	1.15	0.02	0.21	0.09	0.21	0.00	0.03
413	19.50	0.00	1.90	0.25	0.62	0.01	0.07	0.83	1.38	0.03	0.25	0.09	0.21	0.00	0.03
414	19.50	0.00	1.89	0.37	0.95	0.01	0.11	0.95	1.56	0.03	0.28	0.09	0.21	0.00	0.03
415	19.50	0.01	1.88	0.98	2.49	0.03	0.29	1.03	1.70	0.04	0.30	0.09	0.21	0.00	0.03
416	19.50	0.06	1.89	1.73	4.40	0.06	0.51	1.03	1.71	0.04	0.30	0.09	0.21	0.00	0.03
417	19.50	0.12	1.95	1.87	4.75	0.06	0.55	0.98	1.63	0.03	0.29	0.09	0.21	0.00	0.03
418	19.50	0.17	1.99	1.85	4.70	0.06	0.54	0.93	1.54	0.03	0.27	0.09	0.21	0.00	0.03
419	19.50	0.20	2.06	1.83	4.64	0.06	0.53	0.89	1.48	0.03	0.26	0.09	0.21	0.00	0.03
420	19.50	0.20	2.10	1.63	4.15	0.06	0.48	0.85	1.41	0.03	0.25	0.09	0.21	0.00	0.03
421	19.50	0.16	2.14	1.30	3.29	0.04	0.38	0.81	1.34	0.03	0.24	0.09	0.21	0.00	0.03
422	19.50	0.11	2.15	1.29	3.28	0.04	0.38	0.80	1.32	0.03	0.24	0.09	0.21	0.00	0.03
423	19.50	0.04	2.15	1.34	3.40	0.05	0.39	0.80	1.33	0.03	0.24	0.09	0.21	0.00	0.03
424	19.50	0.01	2.13	1.13	2.88	0.04	0.33	0.81	1.34	0.03	0.24	0.09	0.21	0.00	0.03
425	19.50	0.00	2.07	0.85	2.16	0.03	0.25	0.83	1.37	0.03	0.25	0.09	0.21	0.00	0.03
426	19.50	0.00	2.03	0.67	1.71	0.02	0.20	0.83	1.37	0.03	0.24	0.09	0.21	0.00	0.03
427	19.50	0.00	2.00	0.54	1.37	0.02	0.16	0.79	1.31	0.03	0.23	0.09	0.21	0.00	0.03
428	19.50	0.00	1.99	0.43	1.08	0.01	0.12	0.74	1.22	0.03	0.22	0.09	0.21	0.00	0.03
429	19.50	0.00	1.97	0.36	0.93	0.01	0.11	0.71	1.17	0.02	0.21	0.09	0.21	0.00	0.03
430	19.50	0.00	1.96	0.29	0.74	0.01	0.08	0.67	1.11	0.02	0.20	0.09	0.21	0.00	0.03
431	19.50	0.00	1.94	0.23	0.59	0.01	0.07	0.62	1.02	0.02	0.18	0.09	0.21	0.00	0.03
432	19.50	0.00	1.94	0.20	0.51	0.01	0.06	0.60	0.99	0.02	0.18	0.09	0.21	0.00	0.03
433	19.50	0.00	1.94	0.18	0.45	0.01	0.05	0.61	1.01	0.02	0.18	0.09	0.21	0.00	0.03
434	19.50	0.00	1.94	0.17	0.43	0.01	0.05	0.63	1.03	0.02	0.18	0.09	0.21	0.00	0.03
435	19.50	0.00	1.92	0.16	0.41	0.01	0.05	0.64	1.06	0.02	0.19	0.09	0.21	0.00	0.03
436	19.50	0.00	1.92	0.16	0.42	0.01	0.05	0.69	1.15	0.02	0.20	0.09	0.21	0.00	0.03
437	19.50	0.00	1.93	0.19	0.48	0.01	0.06	0.83	1.37	0.03	0.24	0.09	0.21	0.00	0.03
438	19.50	0.00	1.91	0.25	0.63	0.01	0.07	0.94	1.56	0.03	0.28	0.09	0.21	0.00	0.03

439	19.50	0.01	1.91	0.33	0.83	0.01	0.10	1.02	1.69	0.04	0.30	0.09	0.21	0.00	0.03
440	19.50	0.06	1.93	0.42	1.06	0.01	0.12	1.03	1.71	0.04	0.30	0.09	0.21	0.00	0.03
441	19.50	0.12	1.96	0.47	1.20	0.02	0.14	0.98	1.62	0.03	0.29	0.09	0.21	0.00	0.03
442	19.50	0.17	2.01	0.51	1.29	0.02	0.15	0.92	1.53	0.03	0.27	0.09	0.21	0.00	0.03
443	19.50	0.22	2.07	0.52	1.32	0.02	0.15	0.89	1.47	0.03	0.26	0.09	0.21	0.00	0.03
444	19.50	0.23	2.11	0.51	1.29	0.02	0.15	0.84	1.40	0.03	0.25	0.09	0.21	0.00	0.03
445	19.50	0.20	2.13	0.45	1.15	0.02	0.13	0.81	1.33	0.03	0.24	0.09	0.21	0.00	0.03
446	19.50	0.12	2.14	0.41	1.04	0.01	0.12	0.79	1.32	0.03	0.23	0.09	0.21	0.00	0.03
447	19.50	0.05	2.14	0.40	1.02	0.01	0.12	0.80	1.32	0.03	0.23	0.09	0.21	0.00	0.03
448	19.50	0.01	2.12	0.45	1.14	0.02	0.13	0.80	1.33	0.03	0.24	0.09	0.21	0.00	0.03
449	19.50	0.00	2.08	0.52	1.33	0.02	0.15	0.82	1.36	0.03	0.24	0.09	0.21	0.00	0.03
450	19.50	0.00	2.06	0.54	1.37	0.02	0.16	0.81	1.35	0.03	0.24	0.09	0.21	0.00	0.03
451	19.50	0.00	2.05	0.49	1.24	0.02	0.14	0.78	1.29	0.03	0.23	0.09	0.21	0.00	0.03
452	19.50	0.00	2.03	0.39	0.99	0.01	0.11	0.73	1.21	0.03	0.22	0.09	0.21	0.00	0.03
453	19.50	0.00	2.01	0.35	0.88	0.01	0.10	0.70	1.16	0.02	0.21	0.09	0.21	0.00	0.03
454	19.50	0.00	1.98	0.32	0.80	0.01	0.09	0.66	1.09	0.02	0.19	0.09	0.21	0.00	0.03
455	19.50	0.00	1.98	0.26	0.67	0.01	0.08	0.62	1.02	0.02	0.18	0.09	0.21	0.00	0.03
456	19.50	0.00	1.94	0.21	0.53	0.01	0.06	0.61	1.00	0.02	0.18	0.09	0.21	0.00	0.03
457	19.50	0.00	1.95	0.18	0.47	0.01	0.05	0.62	1.03	0.02	0.18	0.09	0.21	0.00	0.03
458	19.50	0.00	1.96	0.17	0.44	0.01	0.05	0.63	1.05	0.02	0.19	0.09	0.21	0.00	0.03
459	19.50	0.00	1.95	0.16	0.42	0.01	0.05	0.65	1.08	0.02	0.19	0.09	0.21	0.00	0.03
460	19.50	0.00	1.95	0.16	0.41	0.01	0.05	0.70	1.16	0.02	0.21	0.09	0.21	0.00	0.03
461	19.50	0.00	1.94	0.17	0.44	0.01	0.05	0.84	1.39	0.03	0.25	0.09	0.21	0.00	0.03
462	19.50	0.00	1.94	0.19	0.49	0.01	0.06	0.96	1.59	0.03	0.28	0.09	0.21	0.00	0.03
463	19.50	0.01	1.92	0.25	0.63	0.01	0.07	1.05	1.73	0.04	0.31	0.09	0.21	0.00	0.03
464	19.50	0.06	1.93	0.36	0.90	0.01	0.10	1.05	1.74	0.04	0.31	0.09	0.21	0.00	0.03
465	19.50	0.12	1.96	0.44	1.11	0.01	0.13	1.01	1.67	0.03	0.30	0.09	0.21	0.00	0.03
466	19.50	0.16	1.99	0.50	1.26	0.02	0.14	0.96	1.59	0.03	0.28	0.09	0.21	0.00	0.03
467	19.50	0.19	2.03	0.53	1.34	0.02	0.15	0.92	1.53	0.03	0.27	0.09	0.21	0.00	0.03
468	19.50	0.20	2.09	0.47	1.20	0.02	0.14	0.88	1.46	0.03	0.26	0.09	0.21	0.00	0.03
469	19.50	0.17	2.11	0.39	0.98	0.01	0.11	0.83	1.38	0.03	0.25	0.09	0.21	0.00	0.03
470	19.50	0.11	2.14	0.34	0.87	0.01	0.10	0.83	1.37	0.03	0.25	0.09	0.21	0.00	0.03
471	19.50	0.04	2.13	0.32	0.82	0.01	0.09	0.82	1.36	0.03	0.24	0.09	0.21	0.00	0.03
472	19.50	0.01	2.12	0.35	0.88	0.01	0.10	0.82	1.36	0.03	0.24	0.09	0.21	0.00	0.03
473	19.50	0.00	2.10	0.41	1.04	0.01	0.12	0.84	1.39	0.03	0.25	0.09	0.21	0.00	0.03
474	19.50	0.00	2.06	0.47	1.18	0.02	0.14	0.83	1.38	0.03	0.25	0.09	0.21	0.00	0.03
475	19.50	0.00	2.05	0.45	1.15	0.02	0.13	0.80	1.32	0.03	0.24	0.09	0.21	0.00	0.03
476	19.50	0.00	2.02	0.39	0.99	0.01	0.11	0.74	1.23	0.03	0.22	0.09	0.21	0.00	0.03
477	19.50	0.00	2.03	0.35	0.88	0.01	0.10	0.71	1.18	0.02	0.21	0.09	0.21	0.00	0.03
478	19.50	0.00	2.01	0.28	0.72	0.01	0.08	0.68	1.12	0.02	0.20	0.09	0.21	0.00	0.03
479	19.50	0.00	1.99	0.22	0.57	0.01	0.07	0.63	1.04	0.02	0.19	0.09	0.21	0.00	0.03
480	19.50	0.00	1.98	0.18	0.46	0.01	0.05	0.64	1.05	0.02	0.19	0.09	0.21	0.00	0.03
481	19.50	0.00	1.99	0.17	0.44	0.01	0.05	0.66	1.08	0.02	0.19	0.09	0.21	0.00	0.03
482	19.50	0.00	2.00	0.17	0.43	0.01	0.05	0.66	1.09	0.02	0.19	0.09	0.21	0.00	0.03
483	19.50	0.00	1.99	0.17	0.42	0.01	0.05	0.67	1.11	0.02	0.20	0.09	0.21	0.00	0.03
484	19.50	0.00	1.96	0.17	0.44	0.01	0.05	0.72	1.20	0.02	0.21	0.09	0.21	0.00	0.03
485	19.50	0.00	1.97	0.25	0.63	0.01	0.07	0.82	1.36	0.03	0.24	0.09	0.21	0.00	0.03
486	19.50	0.00	1.98	0.37	0.95	0.01	0.11	0.97	1.61	0.03	0.29	0.09	0.21	0.00	0.03
487	19.50	0.01	1.98	1.01	2.55	0.03	0.29	1.03	1.70	0.04	0.30	0.09	0.21	0.00	0.03
488	19.50	0.05	1.99	1.80	4.58	0.06	0.53	1.03	1.71	0.04	0.30	0.09	0.21	0.00	0.03
489	19.50	0.11	2.01	1.95	4.95	0.07	0.57	0.98	1.63	0.03	0.29	0.09	0.21	0.00	0.03
490	19.50	0.17	2.06	1.92	4.89	0.07	0.56	0.94	1.55	0.03	0.28	0.09	0.21	0.00	0.03
491	19.50	0.21	2.12	1.90	4.82	0.06	0.56	0.88	1.46	0.03	0.26	0.09	0.21	0.00	0.03
492	19.50	0.19	2.17	1.70	4.33	0.06	0.50	0.84	1.40	0.03	0.25	0.09	0.21	0.00	0.03
493	19.50	0.12	2.23	1.34	3.41	0.05	0.39	0.82	1.35	0.03	0.24	0.09	0.21	0.00	0.03
494	19.50	0.07	2.26	1.34	3.40	0.05	0.39	0.80	1.32	0.03	0.24	0.09	0.21	0.00	0.03
495	19.50	0.03	2.25	1.40	3.55	0.05	0.41	0.77	1.27	0.03	0.23	0.09	0.21	0.00	0.03
496	19.50	0.01	2.22	1.18	3.00	0.04	0.35	0.77	1.28	0.03	0.23	0.09	0.21	0.00	0.03
497	19.50	0.00	2.19	0.88	2.24	0.03	0.26	0.77	1.27	0.03	0.23	0.09	0.21	0.00	0.03
498	19.50	0.00	2.15	0.68	1.74	0.02	0.20	0.73	1.21	0.03	0.22	0.09	0.21	0.00	0.03
499	19.50	0.00	2.15	0.54	1.38	0.02	0.16	0.73	1.21	0.03	0.22	0.09	0.21	0.00	0.03
500	19.50	0.00	2.13	0.43	1.09	0.01	0.13	0.73	1.21	0.03	0.22	0.09	0.21	0.00	0.03
501	19.50	0.00	2.13	0.37	0.93	0.01	0.11	0.72	1.19	0.02	0.21	0.09	0.21	0.00	0.03
502	19.50	0.00	2.11	0.29	0.74	0.01	0.09	0.67	1.10	0.02	0.20	0.09	0.21	0.00	0.03
503	19.50	0.00	2.09	0.22	0.57	0.01	0.07	0.61	1.02	0.02	0.18	0.09	0.21	0.00	0.03
504	1.00	0.00	1.56	0.13	0.28	0.00	0.16	0.51	1.82	0.04	0.26	0.00	0.00	0.00	0.00
505	1.00	0.00	1.56	0.12	0.28	0.00	0.11	0.58	2.04	0.04	0.29	0.00	0.00	0.00	0.00
506	1.00	0.00	1.54	0.12	0.28	0.00	0.10	0.58	2.05	0.04	0.29	0.00	0.00	0.00	0.00
507	1.00	0.00	1.56	0.12	0.28	0.00	0.10	0.58	2.06	0.04	0.29	0.00	0.00	0.00	0.00
508	1.00	0.00	1.51	0.12	0.27	0.00	0.10	0.67	2.36	0.04	0.33	0.00	0.00	0.00	0.00
509	1.00	0.00	1.51	0.12	0.26	0.00	0.11	0.73	2.57	0.04	0.36	0.00	0.00	0.00	0.00
510	1.00	0.00	1.47	0.13	0.29	0.00	0.19	0.92	3.26	0.04	0.46	0.00	0.00	0.00	0.00
511	1.00	0.00	1.42	0.16	0.36	0.00	0.31	0.89	3.16	0.04	0.45	0.00	0.00	0.00	0.00
512	1.00	0.00	1.43	0.97	2.17	0.02	0.34	0.94	3.35	0.04	0.47	0.00	0.00	0.00	0.00
513	1.00	0.03	1.42	2.06	4.62	0.03	0.32	0.90	3.20	0.04	0.45	0.00	0.00	0.00	0.00
514	1.00	0.06	1.42	2.29	5.12	0.04	0.29	0.88	3.12	0.04	0.44	0.00	0.00	0.00	0.00
515	1.00	0.10	1.46	2.25	5.04	0.04	0.29	0.85	3.02	0.04	0.43	0.00	0.00	0.00	0.00
516	1.00	0.15	1.51	2.19	4.91	0.04	0.32	0.80	2.85	0.04	0.40	0.00	0.00	0.00	0.00
517	1.00	0.13	1.56	1.92	4.30	0.03	0.33	0.76	2.68	0.04	0.38	0.00	0.00	0.00	0.00
518	1.00	0.10	1.59	1.47	3.30	0.02	0.30	0.75	2.66	0.04	0.38	0.00	0.00	0.00	0.00
519	1.00	0.08	1.56	1.50	3.35	0.03	0.27	0.71	2.50	0.04	0.35	0.00	0.00	0.00	0.00
520	1.00	0.05	1.61	1.59	3.56	0.03	0.26	0.72	2.57	0.04	0.36	0.00	0.00	0.00	0.00
521	1.00	0.00	1.61	1.26	2.82	0.02	0.30	0.73	2.59	0.04	0.37	0.00	0.00	0.00	0.00
522	1.00	0.00	1.61	0.76	1.71	0.01	0.39	0.76	2.70	0.04	0.38	0.00	0.00	0.00	0.00
523	1.00	0.00	1.61	0.43	0.95	0.01	0.46	0.76	2.68	0.04	0.38	0.00	0.00	0.00	0.00
524	1.00	0.00	1.62	0.26	0.58	0.00	0.44	0.73	2.58	0.04	0.36	0.00	0.00	0.00	0.00
525	1.00	0.00	1.61	0.19	0.42	0.00	0.37	0.69	2.45	0.04	0.35	0.00	0.00	0.00	0.00
526	1.00	0.00	1.61	0.16	0.36	0.00	0.31	0.70	2.50	0.04	0.35	0.00	0.00	0.00	0.00

527	1.00	0.00	1.61	0.14	0.31	0.00	0.24	0.67	2.39	0.04	0.34	0.00	0.00	0.00	0.00
528	1.00	0.00	1.61	0.13	0.28	0.00	0.16	0.62	2.19	0.04	0.31	0.00	0.00	0.00	0.00
529	1.00	0.00	1.61	0.12	0.28	0.00	0.11	0.55	1.93	0.04	0.27	0.00	0.00	0.00	0.00
530	1.00	0.00	1.56	0.12	0.28	0.00	0.10	0.56	1.97	0.04	0.28	0.00	0.00	0.00	0.00
531	1.00	0.00	1.51	0.12	0.28	0.00	0.10	0.56	1.99	0.04	0.28	0.00	0.00	0.00	0.00
532	1.00	0.00	1.56	0.12	0.27	0.00	0.10	0.59	2.08	0.04	0.29	0.00	0.00	0.00	0.00
533	1.00	0.00	1.58	0.12	0.26	0.00	0.11	0.63	2.25	0.04	0.32	0.00	0.00	0.00	0.00
534	1.00	0.00	1.56	0.13	0.29	0.00	0.19	0.83	2.93	0.04	0.41	0.00	0.00	0.00	0.00
535	1.00	0.00	1.56	0.16	0.36	0.00	0.31	1.01	3.59	0.04	0.51	0.00	0.00	0.00	0.00
536	1.00	0.00	1.53	0.97	2.17	0.02	0.34	1.14	4.06	0.04	0.57	0.00	0.00	0.00	0.00
537	1.00	0.07	1.47	2.06	4.62	0.03	0.32	1.16	4.12	0.04	0.58	0.00	0.00	0.00	0.00
538	1.00	0.16	1.51	2.29	5.12	0.04	0.29	1.14	4.05	0.04	0.57	0.00	0.00	0.00	0.00
539	1.00	0.20	1.55	2.25	5.04	0.04	0.29	1.09	3.88	0.04	0.55	0.00	0.00	0.00	0.00
540	1.00	0.20	1.61	2.19	4.91	0.04	0.32	1.07	3.80	0.04	0.54	0.00	0.00	0.00	0.00
541	1.00	0.23	1.61	1.92	4.30	0.03	0.33	1.01	3.60	0.04	0.51	0.00	0.00	0.00	0.00
542	1.00	0.15	1.67	1.47	3.30	0.02	0.30	0.94	3.34	0.04	0.47	0.00	0.00	0.00	0.00
543	1.00	0.09	1.71	1.50	3.35	0.03	0.27	0.95	3.38	0.04	0.48	0.00	0.00	0.00	0.00
544	1.00	0.05	1.71	1.59	3.56	0.03	0.26	0.92	3.28	0.04	0.46	0.00	0.00	0.00	0.00
545	1.00	0.00	1.72	1.26	2.82	0.02	0.30	0.89	3.17	0.04	0.45	0.00	0.00	0.00	0.00
546	1.00	0.00	1.71	0.76	1.71	0.01	0.39	0.89	3.17	0.04	0.45	0.00	0.00	0.00	0.00
547	1.00	0.00	1.71	0.43	0.95	0.01	0.46	0.86	3.04	0.04	0.43	0.00	0.00	0.00	0.00
548	1.00	0.00	1.70	0.26	0.58	0.00	0.44	0.78	2.75	0.04	0.39	0.00	0.00	0.00	0.00
549	1.00	0.00	1.71	0.19	0.42	0.00	0.37	0.69	2.43	0.04	0.34	0.00	0.00	0.00	0.00
550	1.00	0.00	1.71	0.16	0.36	0.00	0.31	0.64	2.29	0.04	0.32	0.00	0.00	0.00	0.00
551	1.00	0.00	1.70	0.14	0.31	0.00	0.24	0.62	2.19	0.04	0.31	0.00	0.00	0.00	0.00
552	1.00	0.00	1.71	0.13	0.28	0.00	0.16	0.56	2.00	0.04	0.28	0.00	0.00	0.00	0.00
553	1.00	0.00	1.71	0.12	0.28	0.00	0.11	0.59	2.08	0.04	0.29	0.00	0.00	0.00	0.00
554	1.00	0.00	1.69	0.12	0.28	0.00	0.10	0.60	2.12	0.04	0.30	0.00	0.00	0.00	0.00
555	1.00	0.00	1.71	0.12	0.28	0.00	0.10	0.60	2.14	0.04	0.30	0.00	0.00	0.00	0.00
556	1.00	0.00	1.71	0.12	0.27	0.00	0.10	0.63	2.23	0.04	0.32	0.00	0.00	0.00	0.00
557	1.00	0.00	1.69	0.12	0.26	0.00	0.11	0.68	2.42	0.04	0.34	0.00	0.00	0.00	0.00
558	1.00	0.00	1.71	0.13	0.29	0.00	0.19	0.89	3.14	0.04	0.44	0.00	0.00	0.00	0.00
559	1.00	0.00	1.66	0.16	0.36	0.00	0.31	1.09	3.86	0.04	0.54	0.00	0.00	0.00	0.00
560	1.00	0.00	1.67	0.97	2.17	0.02	0.34	1.23	4.37	0.04	0.62	0.00	0.00	0.00	0.00
561	1.00	0.03	1.71	2.06	4.62	0.03	0.32	1.25	4.43	0.04	0.62	0.00	0.00	0.00	0.00
562	1.00	0.06	1.71	2.29	5.12	0.04	0.29	1.23	4.36	0.04	0.61	0.00	0.00	0.00	0.00
563	1.00	0.10	1.71	2.25	5.04	0.04	0.29	1.18	4.18	0.04	0.59	0.00	0.00	0.00	0.00
564	1.00	0.07	1.71	2.19	4.91	0.04	0.32	1.15	4.09	0.04	0.58	0.00	0.00	0.00	0.00
565	1.00	0.08	1.71	1.92	4.30	0.03	0.33	1.09	3.87	0.04	0.55	0.00	0.00	0.00	0.00
566	1.00	0.07	1.72	1.47	3.30	0.02	0.30	1.01	3.59	0.04	0.51	0.00	0.00	0.00	0.00
567	1.00	0.03	1.71	1.50	3.35	0.03	0.27	1.02	3.63	0.04	0.51	0.00	0.00	0.00	0.00
568	1.00	0.00	1.71	1.59	3.56	0.03	0.26	0.99	3.52	0.04	0.50	0.00	0.00	0.00	0.00
569	1.00	0.00	1.70	1.26	2.82	0.02	0.30	0.96	3.40	0.04	0.48	0.00	0.00	0.00	0.00
570	1.00	0.00	1.71	0.76	1.71	0.01	0.39	0.96	3.41	0.04	0.48	0.00	0.00	0.00	0.00
571	1.00	0.00	1.71	0.43	0.95	0.01	0.46	0.92	3.26	0.04	0.46	0.00	0.00	0.00	0.00
572	1.00	0.00	1.68	0.26	0.58	0.00	0.44	0.83	2.95	0.04	0.42	0.00	0.00	0.00	0.00
573	1.00	0.00	1.66	0.19	0.42	0.00	0.37	0.73	2.60	0.04	0.37	0.00	0.00	0.00	0.00
574	1.00	0.00	1.66	0.16	0.36	0.00	0.31	0.69	2.45	0.04	0.35	0.00	0.00	0.00	0.00
575	1.00	0.00	1.65	0.14	0.31	0.00	0.23	0.66	2.35	0.04	0.33	0.00	0.00	0.00	0.00
576	1.00	0.00	1.66	0.13	0.28	0.00	0.16	0.61	2.15	0.04	0.30	0.00	0.00	0.00	0.00
577	1.00	0.00	1.61	0.12	0.28	0.00	0.11	0.69	2.46	0.04	0.35	0.00	0.00	0.00	0.00
578	1.00	0.00	1.63	0.12	0.28	0.00	0.10	0.70	2.47	0.04	0.35	0.00	0.00	0.00	0.00
579	1.00	0.00	1.61	0.12	0.28	0.00	0.10	0.72	2.54	0.04	0.36	0.00	0.00	0.00	0.00
580	1.00	0.00	1.61	0.12	0.27	0.00	0.10	0.74	2.63	0.04	0.37	0.00	0.00	0.00	0.00
581	1.00	0.00	1.60	0.12	0.26	0.00	0.11	0.79	2.80	0.04	0.40	0.00	0.00	0.00	0.00
582	1.00	0.00	1.61	0.13	0.29	0.00	0.19	1.00	3.56	0.04	0.50	0.00	0.00	0.00	0.00
583	1.00	0.00	1.61	0.16	0.36	0.00	0.31	1.17	4.14	0.04	0.58	0.00	0.00	0.00	0.00
584	1.00	0.00	1.60	0.97	2.17	0.02	0.34	1.26	4.45	0.04	0.63	0.00	0.00	0.00	0.00
585	1.00	0.03	1.61	2.06	4.62	0.03	0.31	1.31	4.65	0.04	0.66	0.00	0.00	0.00	0.00
586	1.00	0.06	1.66	2.29	5.12	0.04	0.29	1.30	4.62	0.04	0.65	0.00	0.00	0.00	0.00
587	1.00	0.06	1.64	2.25	5.04	0.04	0.29	1.28	4.54	0.04	0.64	0.00	0.00	0.00	0.00
588	1.00	0.11	1.66	2.19	4.91	0.04	0.32	1.27	4.50	0.04	0.63	0.00	0.00	0.00	0.00
589	1.00	0.07	1.71	1.92	4.30	0.03	0.33	1.20	4.27	0.04	0.60	0.00	0.00	0.00	0.00
590	1.00	0.08	1.70	1.47	3.30	0.02	0.30	1.10	3.91	0.04	0.55	0.00	0.00	0.00	0.00
591	1.00	0.02	1.71	1.50	3.35	0.03	0.27	1.09	3.86	0.04	0.54	0.00	0.00	0.00	0.00
592	1.00	0.03	1.71	1.59	3.56	0.03	0.26	1.08	3.84	0.04	0.54	0.00	0.00	0.00	0.00
593	1.00	0.00	1.72	1.26	2.82	0.02	0.30	1.02	3.61	0.04	0.51	0.00	0.00	0.00	0.00
594	1.00	0.00	1.71	0.76	1.71	0.01	0.39	1.04	3.67	0.04	0.52	0.00	0.00	0.00	0.00
595	1.00	0.00	1.71	0.43	0.95	0.01	0.46	1.03	3.64	0.04	0.51	0.00	0.00	0.00	0.00
596	1.00	0.00	1.68	0.26	0.58	0.00	0.44	0.96	3.42	0.04	0.48	0.00	0.00	0.00	0.00
597	1.00	0.00	1.71	0.19	0.42	0.00	0.37	0.86	3.06	0.04	0.43	0.00	0.00	0.00	0.00
598	1.00	0.00	1.66	0.16	0.36	0.00	0.31	0.86	3.05	0.04	0.43	0.00	0.00	0.00	0.00
599	1.00	0.00	1.68	0.14	0.31	0.00	0.23	0.80	2.85	0.04	0.40	0.00	0.00	0.00	0.00
600	1.00	0.00	1.66	0.13	0.28	0.00	0.17	0.71	2.50	0.04	0.35	0.00	0.00	0.00	0.00
601	1.00	0.00	1.66	0.12	0.26	0.00	0.14	0.75	2.67	0.04	0.38	0.00	0.00	0.00	0.00
602	1.00	0.00	1.69	0.12	0.27	0.00	0.11	0.76	2.68	0.04	0.38	0.00	0.00	0.00	0.00
603	1.00	0.00	1.71	0.12	0.27	0.00	0.10	0.76	2.69	0.04	0.38	0.00	0.00	0.00	0.00
604	1.00	0.00	1.71	0.12	0.26	0.00	0.10	0.80	2.83	0.04	0.40	0.00	0.00	0.00	0.00
605	1.00	0.00	1.71	0.11	0.26	0.00	0.10	0.85	3.02	0.04	0.43	0.00	0.00	0.00	0.00
606	1.00	0.00	1.71	0.13	0.28	0.00	0.12	1.04	3.67	0.04	0.52	0.00	0.00	0.00	0.00
607	1.00	0.00	1.66	0.13	0.30	0.00	0.18	1.20	4.27	0.04	0.60	0.00	0.00	0.00	0.00
608	1.00	0.00	1.66	0.14	0.32	0.00	0.28	1.31	4.64	0.04	0.65	0.00	0.00	0.00	0.00
609	1.00	0.00	1.71	0.19	0.42	0.00	0.35	1.35	4.79	0.04	0.68	0.00	0.00	0.00	0.00
610	1.00	0.02	1.71	0.24	0.54	0.00	0.37	1.37	4.85	0.03	0.68	0.00	0.00	0.00	0.00
611	1.00	0.05	1.76	0.27	0.61	0.00	0.38	1.35	4.78	0.03	0.67	0.00	0.00	0.00	0.00
612	1.00	0.13	1.81	0.26	0.58	0.00	0.41	1.32	4.70	0.03	0.66	0.00	0.00	0.00	0.00
613	1.00	0.17	1.81	0.23	0.52	0.00	0.42	1.25	4.42	0.03	0.62	0.00	0.00	0.00	0.00
614	1.00	0.12	1.83	0.19	0.42	0.00	0.39	1.20	4.24	0.03	0.60	0.00	0.00	0.00	0.00

615	1.00	0.04	1.81	0.16	0.36	0.00	0.36	1.15	4.07	0.03	0.57	0.00	0.00	0.00	0.00
616	1.00	0.02	1.87	0.16	0.36	0.00	0.35	1.14	4.04	0.03	0.57	0.00	0.00	0.00	0.00
617	1.00	0.00	1.84	0.15	0.34	0.00	0.42	1.06	3.76	0.03	0.53	0.00	0.00	0.00	0.00
618	1.00	0.00	1.87	0.16	0.35	0.00	0.51	1.09	3.86	0.03	0.55	0.00	0.00	0.00	0.00
619	1.00	0.00	1.81	0.16	0.36	0.00	0.53	1.05	3.71	0.03	0.52	0.00	0.00	0.00	0.00
620	1.00	0.00	1.82	0.16	0.36	0.00	0.46	0.96	3.42	0.03	0.48	0.00	0.00	0.00	0.00
621	1.00	0.00	1.81	0.15	0.34	0.00	0.35	0.89	3.15	0.03	0.44	0.00	0.00	0.00	0.00
622	1.00	0.00	1.81	0.13	0.29	0.00	0.31	0.91	3.22	0.03	0.45	0.00	0.00	0.00	0.00
623	1.00	0.00	1.79	0.13	0.29	0.00	0.27	0.83	2.93	0.04	0.41	0.00	0.00	0.00	0.00
624	1.00	0.00	1.71	0.13	0.29	0.00	0.21	0.74	2.63	0.04	0.37	0.00	0.00	0.00	0.00
625	1.00	0.00	1.66	0.12	0.26	0.00	0.15	0.72	2.56	0.04	0.36	0.00	0.00	0.00	0.00
626	1.00	0.00	1.65	0.12	0.27	0.00	0.12	0.73	2.57	0.04	0.36	0.00	0.00	0.00	0.00
627	1.00	0.00	1.66	0.12	0.27	0.00	0.10	0.75	2.65	0.04	0.37	0.00	0.00	0.00	0.00
628	1.00	0.00	1.61	0.12	0.26	0.00	0.10	0.77	2.74	0.04	0.39	0.00	0.00	0.00	0.00
629	1.00	0.00	1.61	0.11	0.26	0.00	0.10	0.82	2.92	0.04	0.41	0.00	0.00	0.00	0.00
630	1.00	0.00	1.56	0.13	0.28	0.00	0.10	1.04	3.70	0.04	0.52	0.00	0.00	0.00	0.00
631	1.00	0.00	1.56	0.13	0.30	0.00	0.11	1.22	4.31	0.04	0.61	0.00	0.00	0.00	0.00
632	1.00	0.00	1.48	0.13	0.30	0.00	0.19	1.31	4.64	0.04	0.65	0.00	0.00	0.00	0.00
633	1.00	0.02	1.51	0.14	0.31	0.00	0.32	1.37	4.84	0.04	0.68	0.00	0.00	0.00	0.00
634	1.00	0.05	1.61	0.14	0.32	0.00	0.41	1.36	4.81	0.04	0.68	0.00	0.00	0.00	0.00
635	1.00	0.07	1.71	0.14	0.32	0.00	0.49	1.33	4.73	0.03	0.67	0.00	0.00	0.00	0.00
636	1.00	0.09	1.81	0.15	0.33	0.00	0.52	1.32	4.68	0.03	0.66	0.00	0.00	0.00	0.00
637	1.00	0.04	1.87	0.15	0.33	0.00	0.46	1.25	4.45	0.03	0.63	0.00	0.00	0.00	0.00
638	1.00	0.05	1.93	0.14	0.30	0.00	0.36	1.15	4.07	0.03	0.57	0.00	0.00	0.00	0.00
639	1.00	0.02	1.98	0.14	0.31	0.00	0.30	1.14	4.02	0.03	0.57	0.00	0.00	0.00	0.00
640	1.00	0.01	1.98	0.15	0.33	0.00	0.27	1.13	3.99	0.03	0.56	0.00	0.00	0.00	0.00
641	1.00	0.00	1.95	0.15	0.34	0.00	0.29	1.06	3.76	0.03	0.53	0.00	0.00	0.00	0.00
642	1.00	0.00	1.87	0.15	0.34	0.00	0.37	1.08	3.83	0.03	0.54	0.00	0.00	0.00	0.00
643	1.00	0.00	1.81	0.16	0.37	0.00	0.43	1.07	3.79	0.03	0.53	0.00	0.00	0.00	0.00
644	1.00	0.00	1.85	0.16	0.36	0.00	0.42	1.00	3.55	0.03	0.50	0.00	0.00	0.00	0.00
645	1.00	0.00	1.87	0.15	0.34	0.00	0.35	0.90	3.19	0.03	0.45	0.00	0.00	0.00	0.00
646	1.00	0.00	2.04	0.14	0.31	0.00	0.30	0.90	3.17	0.03	0.45	0.00	0.00	0.00	0.00
647	1.00	0.00	2.00	0.13	0.30	0.00	0.23	0.84	2.96	0.03	0.42	0.00	0.00	0.00	0.00
648	1.00	0.00	1.98	0.13	0.29	0.00	0.16	0.73	2.60	0.03	0.37	0.00	0.00	0.00	0.00
649	1.00	0.00	1.98	0.12	0.28	0.00	0.11	0.68	2.42	0.03	0.34	0.00	0.00	0.00	0.00
650	1.00	0.00	2.02	0.12	0.28	0.00	0.10	0.71	2.52	0.03	0.36	0.00	0.00	0.00	0.00
651	1.00	0.00	2.04	0.12	0.28	0.00	0.10	0.71	2.52	0.03	0.36	0.00	0.00	0.00	0.00
652	1.00	0.00	1.98	0.12	0.27	0.00	0.10	0.72	2.55	0.03	0.36	0.00	0.00	0.00	0.00
653	1.00	0.00	2.02	0.12	0.26	0.00	0.11	0.75	2.67	0.03	0.38	0.00	0.00	0.00	0.00
654	1.00	0.00	1.98	0.13	0.29	0.00	0.19	0.94	3.32	0.03	0.47	0.00	0.00	0.00	0.00
655	1.00	0.00	1.92	0.16	0.36	0.00	0.31	1.24	4.41	0.03	0.62	0.00	0.00	0.00	0.00
656	1.00	0.00	1.92	0.97	2.17	0.02	0.33	1.27	4.49	0.03	0.63	0.00	0.00	0.00	0.00
657	1.00	0.04	1.92	2.06	4.62	0.03	0.31	1.29	4.57	0.03	0.65	0.00	0.00	0.00	0.00
658	1.00	0.10	1.92	2.29	5.12	0.04	0.29	1.25	4.43	0.03	0.62	0.00	0.00	0.00	0.00
659	1.00	0.20	2.01	2.25	5.04	0.04	0.29	1.21	4.28	0.03	0.60	0.00	0.00	0.00	0.00
660	1.00	0.30	2.10	2.19	4.91	0.04	0.32	1.21	4.28	0.03	0.60	0.00	0.00	0.00	0.00
661	1.00	0.27	2.10	1.92	4.30	0.03	0.33	1.16	4.10	0.03	0.58	0.00	0.00	0.00	0.00
662	1.00	0.14	2.13	1.47	3.30	0.02	0.29	1.15	4.07	0.03	0.57	0.00	0.00	0.00	0.00
663	1.00	0.11	2.17	1.50	3.35	0.03	0.27	1.10	3.89	0.02	0.55	0.00	0.00	0.00	0.00
664	1.00	0.02	2.30	1.59	3.56	0.03	0.26	1.02	3.63	0.03	0.51	0.00	0.00	0.00	0.00
665	1.00	0.00	2.18	1.26	2.82	0.02	0.30	0.93	3.31	0.03	0.47	0.00	0.00	0.00	0.00
666	1.00	0.00	2.17	0.76	1.71	0.01	0.39	0.93	3.31	0.03	0.47	0.00	0.00	0.00	0.00
667	1.00	0.00	2.10	0.43	0.95	0.01	0.46	0.87	3.08	0.02	0.43	0.00	0.00	0.00	0.00
668	1.00	0.00	2.36	0.26	0.58	0.00	0.44	0.87	3.10	0.02	0.44	0.00	0.00	0.00	0.00
669	1.00	0.00	2.37	0.19	0.42	0.00	0.36	0.91	3.23	0.02	0.46	0.00	0.00	0.00	0.00
670	1.00	0.00	2.37	0.16	0.36	0.00	0.31	0.90	3.19	0.02	0.45	0.00	0.00	0.00	0.00
671	1.00	0.00	2.29	0.14	0.31	0.00	0.23	0.84	2.99	0.03	0.42	0.00	0.00	0.00	0.00

Statutory Declaration

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

Vienna, Austria on ______________________ ______________________

Date Signature