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Individual versus system-oriented optimal phase-out of natural gas in decentralized space heating: an Austrian case study by 2040

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Abstract

By 2040, Austria aims to decarbonize its heating sector completely, which means phasing out fossil fuels such as natural gas and transitioning to renewable energy-based heating systems. In urban areas, district heating is a promising option to achieve this green transformation and to supply a large number of consumers with sustainable heat simultaneously. However, convincing consumers to connect to the district heating system remains one of the biggest challenges as there is no obligation to do so. In Vienna, where 50% of the buildings are heated with gas boilers and a well-developed district heating system already exists, this is a significant issue. The objective of this thesis is to contribute to this topic with a techno-economic analysis, focusing on comparing the optimal decision of how to heat buildings from an individual (consumer) and a system-oriented planned (district heating operator) perspective. The study also examines the influence of different political frameworks. For this purpose, the study developed a linear optimization model that minimizes the total costs, including heating and construction costs incurred by 2040. The results show that when the district heating price is lower than the gas price, almost 50% of the thermal demand can be met by district heating under the current government framework. Government intervention, such as prohibiting the use of gas boilers, can further increase the adoption rate of district heating systems. At a threshold of 200€/t_{CO_2} reached in 2040, a significant increase in district heating systems is notable. When fully transitioning to district heating systems, a specific investment cost of 325€/kW will occur compared to 132€/kW when continuing to use gas boilers. Comparing both perspectives, a decline of up to 50% in the DH system can be noted in the system-oriented exit due to the high upfront expansion costs of the existing DH grid. In order to promote district heating in urban areas, a combination of different energy policy instruments, such as subsidies, CO_2 price and eventually government interventions, seem to be promising to achieve the goal of climate neutrality by 2040.

Kurzzusammenfassung

Bis 2040 strebt Österreich an, auf die Nutzung von fossilen Brennstoffen für die Raumwärme Erzeugung zu verzichten und auf Heizsysteme basierend auf erneuerbaren Energieträgern umzusteigen. In urbanen Gebieten stellt die Fernwärmeversorgung eine vielversprechende Option dar, um diese Transformation zu erreichen und gleichzeitig eine große Anzahl von Verbrauchern nachhaltig mit Wärme zu versorgen. Einer der größten Herausforderungen für den Fernwärmebetreiber ist es, die Nutzer von einem Anschluss an das Netz zu überzeugen da hierzu keine Verpflichtung besteht. In Wien, wo 50% der Gebäude mit Gasheizkesseln beheizt werden und bereits ein gut entwickeltes Nahwärmenetz existiert, ist dies ein erhebliches Problem. Das Ziel dieser Arbeit ist es, mit Hilfe einer technisch-wirtschaftlichen Analyse, die optimale wirtschaftliche Entscheidung für eine Heizsystem zu treffen. Dabei wird die Fragestellung aus Sicht eines einzelnen Verbrauchers und aus Sicht eines zentral geplanten Nahwärmebetreibers betrachtet. Die Studie untersucht auch den Einfluss unterschiedlicher politischer Rahmenbedingungen. Zu diesem Zweck wurde ein lineares Optimierungsmodell entwickelt, das die Gesamtkosten minimiert, einschließlich der bis 2040 anfallenden Heiz- und Baukosten. Die Ergebnisse zeigen, dass bei einem Fernwärmepreis, der niedriger ist als der Gaspreis, fast 50% des Wärmebedarfs unter dem aktuellen Regierungsrahmen durch Fernwärme gedeckt werden können. Staatliche Intervention, wie das Verbot von Gasheizkesseln, kann den Umstieg auf Fernwärme weiter steigern. Nach Erreichen eines Schwellenwertes von 200€/t_{CO_2} im Jahr 2040 ist ein signifikanter Anstieg von Fernwärmesystemen feststellbar. Bei einer vollständigen Umstellung aller Heizsysteme im betrachteten Gebiet fallen spezifische Investitionskosten von 325€/kW im Vergleich zu 132€/kW bei fortgesetzter Nutzung von Gasheizkesseln an. Beim Vergleich beider Perspektiven ist ein Rückgang von bis zu 50% im Fernwärmesystem aufgrund der hohen anfänglichen Ausbaukosten des bestehenden Nahwärmenetzes festzustellen. Um den Ausbau der Fernwärme in urbanen Gebieten zu fördern ist eine Kombination verschiedener energiepolitischer Instrumente, wie Subventionen, Steigerung des CO_2-Preises sowie mögliche staatliche Eingriffe nötig, um das Ziel der Klimaneutralität bis 2040 zu erreichen.

Contents

Abbrevations

DH	District heating
DC	Demand curve
noInt	No government intervention
noGB	No gasboiler sold by 2030
noGas	No gas sold by 2030
noSup	No government support
CGS	Current government support
SDH	Subsidization DH price
RGB	Refund gas boiler

1 Introduction

1.1 Backround and motivation

To achieve the goal of limiting global warming to 1.5°C, as outlined in the Paris Agreement (UNFCCC, 2015), it is crucial to reduce carbon dioxide emissions. To achieve this, the European Union has set a target of reducing CO_2 emissions by at least 55% by 2030. In the long term, the EU aims to achieve climate neutrality by 2050 (European Union, 2023a). One of the critical steps towards achieving these goals is the phase-out of fossil fuel boilers, especially natural gas boilers, for decentralized space heating. In fact, buildings today contribute up to 36% of the energy-related greenhouse gas emissions in the European Union (European Union, 2023b).

In Austria, the 2030 Agenda for Sustainable Development ("Aus Verantwortung für Österreich") (Republik Österreich, 2020) has been developed to align with these goals of the European Union. According to the agenda, private heating systems that use coal, oil, and fossil gas will be phased out by 2040. The Austrian government implemented a ban on the use of oil-fired heating systems in new buildings in 2020 and mandated the replacement of oil boilers over 25 years old, according to the "Regierungsprogramm 2020-2024" Republik Österreich, 2020. The ban was extended to include oil boilers in new constructions three years later. At present, approximately 440,000 households in Vienna rely on gas heating (Statista, 2023). To promote the adoption of district heating, the government launched the "Raus aus Öl und Gas" campaign (BMF, 2023).

In urban areas, district heating is a viable and sustainable option to supply a large number of customers with sustainable heat. Expanding the district heating network is essential to achieving a sustainable transformation. However, despite the government's implementation of specific regulations, the pace of transformation remains slow. The high upfront costs of switching to renewable heating systems and the significantly higher operational costs compared to gas boilers are significant deterrents for building owners. As a result, owners hesitate to switch to DH.

1.2 Research questions

The main focus of this thesis is to compare individual and system-oriented planned phase-out of natural gas used for decentralized space heating. A case study in Vienna, where most buildings currently use natural gas boilers and a well-developed district heating system already exists, will be conducted to answer the following two specific research questions:

1. What is the techno-economic difference between an individual and a system-oriented planned perspective on the optimal phase-out of natural gas boilers in an urban area towards a sustainable heating alternative like district heating?
2. If the optimal phase-out of natural gas boilers differs between the individual and the system-oriented planned perspective, what are the most effective policy measures and economic factors to promote the switch to district heating?

1.3 Applied method

In this thesis, a linear optimization model is developed in Python using the Pyomo package[1]. The model is then solved using the Gurobi optimizer [2]. The objective function of the developed model is to minimize the net present value of the entire system, encompassing individual households, government subsidies, as well as grid costs for gas and DH grid costs when satisfying the required heat demand. The model provides a monthly temporal resolution of the DH grid and individual household heating systems between 2011 and 2040. It should be noted that the choice of 2011 as the starting year was made because it allows for a comprehensive consideration of the use of natural gas boilers over the entire lifetime of the appliance, which is crucial when considering the individual perspective. As mentioned above, 2040 is in line with Austria's national climate targets.

The present study incorporates a range of input parameters, including heat demand profiles for multi-residential properties, as well as forecasts for Gas, DH, and CO2 prices. Additionally, Gas and DH pipe parameters are taken into account. The 8^{th} district of Vienna, known as Josefstadt, was selected for this investigation due to its direct connection to the primary DH grid of Vienna, as well as it is the third highest population density in the city (BMF, 2022a).

[1] https://www.pyomo.org/
[2] https://www.gurobi.com/

To construct the DH and gas grid, essential data on current house locations, area, and number of floors were imported from OSM[3] into QGIS (QGIS Association, 2023). The grid connection from the primary network to the individual buildings was modelled in QGIS.

The thermal demand of the surveyed area was obtained from Hotmaps (Hotmaps, 2023). In addition, a supplementary optimization model was utilized to allocate demand profiles to buildings, thus ensuring that the area's demand is met.

1.4 Outline of thesis

The thesis is structured as follows: Chapter 2 provides relevant background information on the heating sector and its options for decarbonization. Thereby, the focus is put on the current role of natural gas in heating multi-residential buildings and the existing governmental support measures for the transition to district heating. In Chapter 3, the developed model and its functionalities are described in detail, along with the input data and the definition of the three use cases and scenarios examined. Then, Chapter 4 presents the results for the Vienna testbed under the scenario and use case settings, and Chapter 5 the sensitivity analysis regarding CO_2 pricing and varying government subsidies. Chapter 6 provides a synthesis and discussion of the results. Finally, Chapter 7 shows the conclusions of the thesis and gives an outlook for future work.

[3] https://www.openstreetmap.org/#map=8/47.714/13.349

2 State of the art and progress beyond

This chapter provides an overview of the heating sector in Europe in the context of the sustainable energy transition. As it is particularly relevant for this thesis, the chapter first describes the current heat supply and its main energy sources, technologies and infrastructures. Subsequently, selected references from the scientific literature dealing with the development of district heating systems from a techno-economic perspective are presented. Afterwards, a rough overview of the regulatory framework for district heating in Austria is given. Finally, the chapter concludes with the own contribution of the thesis and the progress beyond the state of the art.

2.1 Current heating systems in Europe and decarbonisation pathways

At present, the majority of residential and commercial buildings in Europe, approximately 91%, are heated through individual heating systems that are powered mainly by natural gas and heating oil. In contrast, the remaining buildings are connected to a DH network (EUROPEAN COMMISSION, 2021). Despite the availability of renewable heating solutions such as biomass boilers, solar collectors, and ambient heat pumps, the demand for thermal energy is still met predominantly by fossil fuels, accounting for more than 60% of thermal energy demand. This has resulted in 4.2Gt CO2 emissions in 2022 due to space heating (IEA, 2023).

For complete decarbonization of the residential sector by 2040, a transition to renewable heating systems is necessary, along with retrofitting of old buildings with poor energy performance. Extensive renovation can result in significant energy savings, which not only reduces the need for investment in renewable heating energy infrastructure but also lowers operational costs. Improving building efficiency also expands renewable heating system options. However, the current renovation rate in Europe is only 1%, which must be substantially increased (EUROPEAN COMMISSION, 2021).

An essential component of sustainable heating is the utilization of heat pumps that are powered by low-emission electricity. Heat pumps available in the market nowadays are three to five times more energy-efficient than natural gas boilers. Despite this, the high upfront costs of heat pumps discourage customers from switching to renewable heating systems. Nonetheless, in Norway, 60% of buildings are equipped with heat pumps, as well as Sweden and Finland have more than 40% heat pumps. This undermines the argument that heat pumps are not suitable for cold climates (EUROPEAN COMMISSION, 2021).

In urban areas, DH can deliver sustainable solutions for heating, hot water, and cooling to customers. Especially when waste heat from local industries and geothermal energy are available, DH is a more feasible and cost-effective solution than individual-based options. DH has already been widely developed in Northern European countries. A study conducted by Aalborg University in Denmark suggests that up to 50% of Europe's heat demand could be met by DH (Aalborg University, 2018).

In the effort to electrify the heating supply, the potential thermal waste energy from industries is often overlooked, which also limits the coupling of electricity and heat sectors. A balanced distribution of DH and heat pumps can evenly distribute grid costs between the thermal and electricity grids. If DH's shares are lowered, it will increase electricity grid costs and subsequently stall decarbonisation.

It is ultimately the approval of the general public that is vital for accomplishing the objectives of the Paris Agreement. Cost is still the primary deciding factor for customers when considering changing their heating system. Policies must not only increase prices for fossil fuels but also remove switching barriers and support the use of renewable energy.

2.2 Techno-economic modeling of district heating

The literature provides a large number of studies dealing with techno-economic modeling of district heating. Therefore, reference is made to some selected papers, in particular review papers, which provide a comprehensive overview of the topic.

In the context of this thesis, there are two different approaches relevant to modeling a DH system: one can either focus on individual components or simulate the system as a whole. Component models are best suited for design considerations, such as optimizing pipe geometry or generator capacities. On the other hand, holistic models are generally required for system scheduling and management (Brown et al., 2022). In general, three main components can be identified: an energy source, a distribution network, and more than one end-user (Olsthoorn, Haghighat, and Mirzaei, 2016). However, the focus is set explicitly on the last two components, as they are fundamental to this thesis.

Distribution network

The DH network serves to transport thermal energy from the heat generation plant to the consumers. It comprises pipes, valves, heat exchangers, and pumps (Sarbu and Sebarchievici, 2017). However, modelling these networks can be computationally intensive, particularly when simulating large DH systems. Consequently, it is a common practice to develop reduced models that combine multiple individual end-users into a few larger end-users. (del Hoyo Arce et al., 2018).

As DH is a kind of hydronic system, it can be modeled based on the hydraulic equilibrium. Networks with a higher heat density are often designed based on hydraulic equilibrium since heat losses are not that essential (Sarbu, Mirza, and Crasmareanu, 2019). In hydraulic equilibrium, the system is designed based on the mass flow balance and the pressure balance (Ancona et al., 2014). The mass flow balance at each node of the DH grid can be described as follows:

$$\sum_{in} \dot{m}_{in} - \sum_{out} \dot{m}_{out} - \sum_{user} \dot{m}_{user} = 0 \tag{2.1}$$

where $\dot{\mathrm{m}}_{\mathrm{in}}$ is the mass flow entering the node, $\dot{\mathrm{m}}_{\mathrm{out}}$ the mass flow exiting the node and $\dot{\mathrm{m}}_{\mathrm{user}}$ the mass flow required by the end-user. The pressure balance between two nodes can be written as:

$$\Delta p_{ij} - (p_i - p_j) = 0 \tag{2.2}$$

where $\Delta \mathrm{p}_{\mathrm{ij}}$ is the pressure loss between the nodes i and j and p_{i} and p_{j} referees to the pressure at the nodes. The hydraulic equilibrium is also applied in this thesis, with the simplification of no pressure loss between two nodes.

End-user profile

The availability of accurate data on the thermal energy demand of end-users, particularly on an hourly basis, is crucial as it has a significant impact on the efficiency of a DH network and the optimization model. However, the acquisition of annual heat demand and peak heat load data poses challenges due to their dependency on numerous variables that are challenging to detect, such as the thermo-physical properties and usage of the buildings. Furthermore, the insulation of buildings in terms of energy consumption is a vital parameter to consider (Pusat and Erdem, 2014).

One potential approach to designing end-user profiles is to incorporate outdoor ambient temperature as a factor in calculating heat losses (Dotzauer, 2002). However, it should be noted that this method does not account for the influence of social behavior on heating needs. In order to create more effective data, additional factors such as personal preferences and patterns should be considered alongside outdoor temperature.

An alternative approach is to conduct a measurement campaign to obtain reliable input data for the end user demand profile (Talebi et al., 2016). However, achieving a high number of datasets can be very expensive and time-consuming.

A far more complex method is using energy simulation software such as EnergyPlus[1]. This method involves modeling various types of buildings and can achieve highly precise data for small-scale systems with a limited number of buildings. However, it is essential to note that this approach comes with a high computational cost. Providing data for a city's scale using this method can also be highly time-consuming.

2.3 Overview of the current political framework in Austria

In order to overcome these barriers, the following political framework has been established in Austria (BMK, 2023):

- From 2020, the use of oil heating systems is not allowed in new buildings.
- From 2022, replacing an oil heating system will require a climate-friendly alternative.
- By 2035, it is mandatory to shut down all oil-based heating systems.
- By 2040, the entire heat supply should be decarbonized.

At present, a plan is underway to gradually phase out gas heating for space heating, similar to the phased plan for oil.

To encourage property owners to adopt alternative heating systems, the government has launched an initiative called "Raus aus Öl und Gas". This initiative provides private individuals and companies access to a total of 940 million EUR in 2023/2024 to switch to a climate-friendly DH system. In cases where a connection to a district heating system is not possible, subsidies are available for switching to a wood-fired heating system or a heat pump. The respective owner of the heating system will receive payments as specified in tables 2.1 and 2.3.

[1] https://energyplus.net/

Thermal power	Payment
< 50kW	7.500€
50kW - 100kW	12.000€
< 100kW	15.000€

Table 2.1: Subsidies for multi-residential properties to change their heating system to DH (Kommunalkredit Public Consulting GmbH, 2023)

Thermal power	Payment
< 50kW	2.000€
50kW - 100kW	3.200€
< 100kW	4.000€

Table 2.2: Additional payments for exiting gas for space heating (Kommunalkredit Public Consulting GmbH, 2023)

From January 2020 to October 2022, approximately 158.9 million EUR were provided in subsidies to support the transition of 31,800 builders (Bundeskanzleramt Österreich, 2023).

2.4 Novelties and own contribution

Against the background of the existing literature and the state of the art outlined above, the novelties and own contribution of this thesis can be summarized in three different key dimensions: (i) the methodological dimension, (ii) the tailored Vienna case considered, and (iii) the detailed analysis of different policy and regulatory frameworks. In view of that, the novelties are as follows.

- The model is designed to determine the most economically efficient investment decision between DH and gas boiler, including different stakeholder's objectives. Thereby, the model enables the analysis from the individual perspectives of the multi-residual property owner and the tenant, as well as from the heating systems perspective, including the DH grid owner. It takes into account different fuel and political scenarios, along with diverse grid statutes. The results obtained from this model shall assist society in transforming the heating sector towards a more sustainable one.

- To achieve scalable results, Vienna, with a well-established DH grid, is examined from the system-oriented perspective. To effectively address the objectives of a DH grid owner, a potential DH grid is designed for the surveyed area in advance while avoiding a reduction of end-users to a few large entities, as is often the case in literature. This will ensure more accurate results. The initial stage of planning must take into account various building aspects, such as location and thermal demand. However, due to the absence of demand profiles for all buildings, multiple demand profiles are also generated and subsequently assigned to each building. The DH grid is dimensioned based on the thermal demand of each building.

- While the literature primarily focuses on the current political framework in Austria, this work extends the analysis to consider potential political decisions, such as a complete shutdown of gas supply for residual use or discontinuing sales of gas boilers by 2030. Additionally, various support schemes are being considered to complement governmental interventions. These include a refund for citizens based on the age of their gas boiler in the event of a complete gas supply shutdown. Another approach is providing subsidies for DH, which would lower the price for consumers and make it more affordable compared to the current gas prices. These results were compared to the current status quo.

3 Methodology

3.1 Introduction to the optimization model

The flowchart in Figure 3.1 illustrates the chosen approach for optimizing the heating systems and DH grid structure. Preparing the input data in advance is essential before executing the optimization model. The data preparation can be split into three parts marked as A, B and C in the figure.

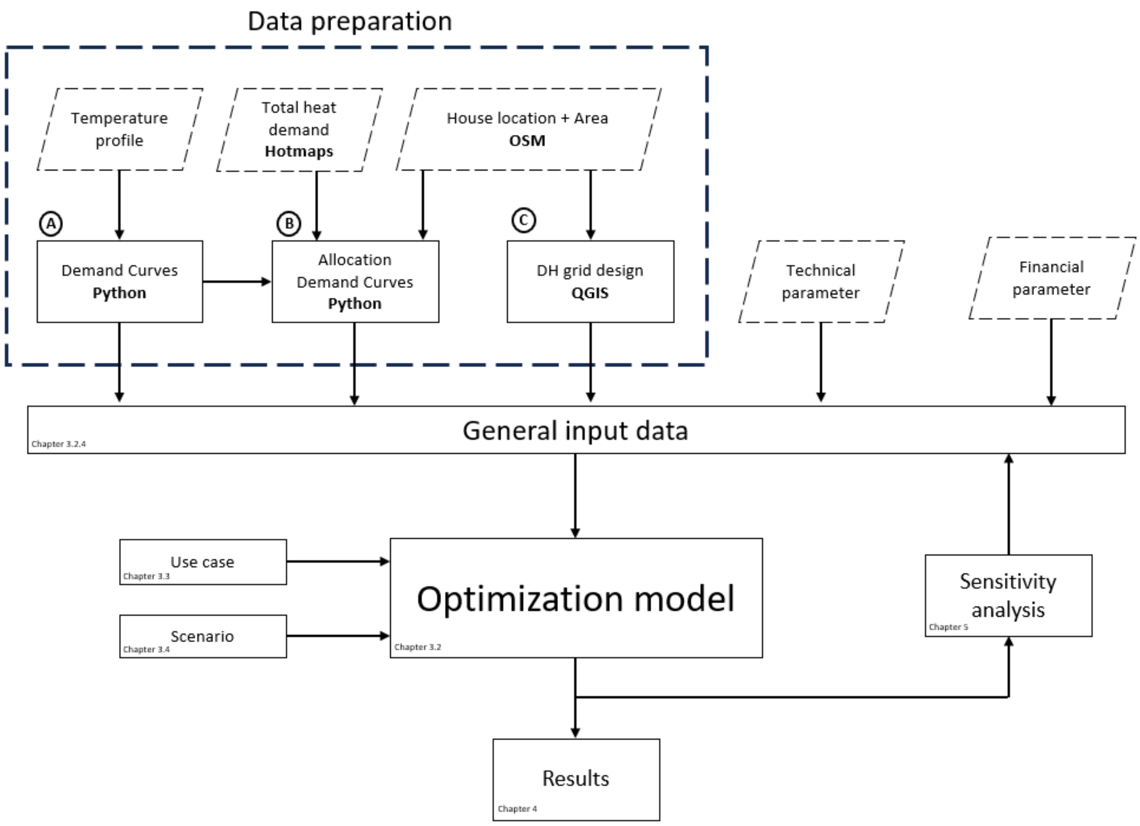

Figure 3.1: Flowchart of the optimisation model

Block A includes the creation of 11 distinct demand curves. With these demand curves, a Python script and temperature data spanning from the years 2000 to 2023, the future thermal demand per square meter for each demand curve is calculated. With these demand curves, it is also possible to determine the output power per square meter of the heating system.

The demand curves created in block A are also allocated to each building in block B. This allocation is done with the help of a self-designed Python optimization model that ensures the necessary thermal demand of the 8th district of Vienna is met. The model takes into consideration the total thermal demand obtained from Hotmaps (Hotmaps, 2023) and the building area of each building obtained from OSM[1] as input data.

In block C, the DH grid is created using QGIS (QGIS Association, 2023), considering the current location of each building, as well as the current DH grid status.

The optimization model is the central component of the flowchart. Technical and financial parameters, along with the generated input data, are fed into the optimization model through an Excel file, thereby allowing quick changes for the sensitivity analysis. The heating system in Josefstadt is analyzed through a range of use cases, scenarios and sensitivity analysis.

[1] https://www.openstreetmap.org/#map=8/47.714/13.349

3.2 Mathematical fundamental

3.2.1 Nomenclature

Set and index	Description	Unit
$y \in \mathcal{Y} = \{2011, \ldots, 2040\}$	Year	
$m \in \mathcal{M} = \{1, \ldots, 12\}$	Month	
$h \in \mathcal{H} = \{1, \ldots, \mathcal{H}\}$	Building	
$dim \in \mathcal{D} = \{0, 25, \ldots, 400\}$	Standard pipe diameter (DN)	
$p \in \mathcal{P} = \{1, \ldots, \mathcal{P}\}$	Pipe in the DH grid	
$n \in \mathcal{N} = \{1, \ldots, \mathcal{N}\}$	Node in the DH grid	

Fuel price	Description	Unit
$C_{y,m}^{Gas}$	Gas price per y and m	€/(kWh)
$C_{y,m}^{DH}$	DH price per y and m	€/(kWh)
$C_{y,m}^{CO_2}$	CO2 price per y and m	€/(kWh)
$F_{y,m}^{DH}$	Share of gas in the energy mix of DH per y and m	%

Pipe	Description	Unit
P_{dim}^{th}	Maximum thermal power of a pipe diameter	W
C_{dim}^{capex}	Capex required to install a pipe	€/m
C_{dim}^{opex}	Opex of installed pipe	€/(m*a)
l_p	Length of pipe p	m

DH grid	Description	Unit
n_p^A	Starting node of pipe p	
n_p^B	Ending node of pipe p	
loss	Losses of the heating system	%

Building	Description	Unit
$D_{h,y,m}$	Heating demand per h, y and m	kWh/m^2
A_h	Building area	m^2
P_h	Power of the heating system	W/m^2
$T_h^{Install}$	Installation year of the present gas boiler	
n_h	Building h is connected via node n to the DH and gas grid	
η^{Gas}	Efficiency of a gas boiler	
l	Lifecycle of a gas boiler	a
C^{ToDH}	Cost to change the heating system from a gas boiler to DH. Cost depends on the installed Power	€/W
C^{ToGas}	Cost to renew the current gas boiler	€/(W*a)
C^{MainDH}	Maintenance cost for a DH system	€/(W*$m^2 * a$)
$C^{MainGas}$	Maintenance cost for a gas boiler	€/(W*$m^2 * a$)
$S_{h,y}^{gov}$	Government support per h and y	€

General Constants	Description	Unit
r_{PP}	Interest rate private person	
r_{DH}	Interest rate of the DH grid operator	

General Decision Variables	Description	Domain
α_y^{PP}	Discount factor for a private person	Float
α_y^{Grid}	Discount factor for the grid operator (Gas & DH),	Float

Decision Variables building	Description	Domain
$\beta^{Gas}_{h,y,m}$	Gas boiler in building h in y and m is installed	Binary
$\beta^{DH}_{h,y,m}$	DH system in building h in y and m is installed	Binary
$\gamma^{ToDH}_{h,y,m}$	Changing gas boiler to DH in building h in y and m	Binary
γ^{ToGas}_{h}	Renewing current gas boiler in building h	Binary
γ^{Renew}_{h}	Heating system has to be renewed in building h because the technical lifespan is reached	Binary
$\epsilon^{Gas}_{h,y}$	Mainting the current gas boiler for building h in y	Binary
$\epsilon^{DH}_{h,y}$	Mainting the current DH system for building h in y	Binary

Decision Variables grid	Description	Domain
$\mathrm{p}^{th}_{n,y}$	Thermal power at node n in y	Float / Unit: W
$\mathrm{d}^{DH}_{p,dim,y}$	Diameter dim of the pipe p in DH grid in y	Binary
$\mathrm{d}^{Gas}_{p,dim}$	Diameter dim of the pipe p in Gas grid	Binary
$\theta^{rep}_{p,dim,y}$	Replacing the current pipe p, with a diameter of dim in DH grid in y	Binary
$\theta^{act}_{n,y}$	Pipe p at starting node n supplies customers with gas	Binary
$\delta^{Gas}_{n,y}$	Customer count at node a in gas grid	Binary

Cost types building	Description	Unit
$c_{h,y}^{fuel}$	Fuel cost per h and y	€
$c_{h,y}^{ex}$	Cost for exchanging the heating system per h	€
$c_{h,y}^{main}$	Maintenance cost for the heating system per h	€
Cost types pipe	**Description**	**Unit**
$c_{p,y}^{capexDH}$	Capex per pipe p in DH grid and y	€
$c_{p,y}^{opexDH}$	Opex per pipe p in DH grid and y	€
$c_{p,y}^{opexGas}$	Opex per pipe p in Gas grid and y	€

3.2.2 Objective function

The objective function maximizes the net present value, including the sum of the installation costs and operational costs of all heating systems, as well as those of the DH grid in the investigated area. It is important to note that in the individual use case mentioned in section 3.3, households are considered on their own, and the costs of the DH grid are not taken into account. Therefore, two different objective functions are defined for the different perspectives.

Individual exit:

$$\max_{\mathrm{x}} - \sum_{\mathrm{y}=2011}^{2040} \left(\mathrm{c}_{\mathrm{h,y}}^{\mathrm{main}} + \mathrm{c}_{\mathrm{h,y}}^{\mathrm{fuel}} + \mathrm{c}_{\mathrm{h,y}}^{\mathrm{ex}} - \mathrm{s}_{\mathrm{h,y}}^{\mathrm{gov}}\right) \tag{3.1}$$

$$\mathrm{x}^{\mathrm{T}} = (\beta_{\mathrm{h,y,m}}^{\mathrm{Gas}}, \beta_{\mathrm{h,y,m}}^{\mathrm{DH}}, \gamma_{\mathrm{h,y,m}}^{\mathrm{GastoDH}}, \gamma_{\mathrm{h,y,m}}^{\mathrm{DHtoGas}}, \gamma_{\mathrm{h}}^{\mathrm{GastoGas}}, \gamma_{\mathrm{h}}^{\mathrm{Renew}}, \epsilon_{\mathrm{h,y}}^{\mathrm{Gas}}, \epsilon_{\mathrm{h,y}}^{\mathrm{DH}}) \tag{3.2}$$

In the individual exit, the objective function maximises the net present value consisting of the sum of maintenance costs $\mathrm{c}_{\mathrm{h,y}}^{\mathrm{main}}$, fuel costs $\mathrm{c}_{\mathrm{h,y}}^{\mathrm{fuel}}$, and the replacement cost of the heating system $\mathrm{c^{ex}_{h,y}}$ over the analyzed time period. Government subsidies $\mathrm{s^{gov}_{h,y}}$ are subtracted by that sum.

System-oriented exit:

$$\max_{x} \quad -\sum_{h=1}^{\mathcal{H}} \sum_{y=2011}^{2040} (\mathrm{c^{main}_{h,y}} + \mathrm{c^{fuel}_{h,y}} + \mathrm{c^{ex}_{h,y}} - \mathrm{s^{gov}_{h,y}}) - \sum_{p=1}^{\mathcal{P}} \sum_{y=2011}^{2040} (\mathrm{c^{capexDH}_{p,y}} + \mathrm{c^{opexDH}_{p,y}} + \mathrm{c^{opexGas}_{p,y}}) \tag{3.3}$$

$$\mathrm{x^T} = (\beta^{\mathrm{Gas}}_{\mathrm{h,y,m}}, \beta^{\mathrm{DH}}_{\mathrm{h,y,m}}, \gamma^{\mathrm{GastoDH}}_{\mathrm{h,y,m}}, \gamma^{\mathrm{DHtoGas}}_{\mathrm{h,y,m}}, \gamma^{\mathrm{GastoGas}}_{\mathrm{h}}, \gamma^{\mathrm{Renew}}_{\mathrm{h}}, \epsilon^{\mathrm{Gas}}_{\mathrm{h,y}}, \epsilon^{\mathrm{DH}}_{\mathrm{h,y}}, \mathrm{p^{th}_{n,y}}, \mathrm{d^{DH}_{p,dim,y}}, \theta^{\mathrm{rep}}_{\mathrm{p,dim,y}}, \theta^{\mathrm{act}}_{\mathrm{n,y}}, \delta^{\mathrm{Gas}}_{\mathrm{n,y}}) \tag{3.4}$$

In the system-oriented exit, the objective function minimizes the cost of all buildings in the observed area and also the grid costs including the investment cost into the DH grid $\mathrm{c^{capexDH}_{p,y}}$ and the operational cost of the DH and gas grid, $\mathrm{c^{opexDH}_{p,y}}$ and $\mathrm{c^{opexGas}_{p,y}}$.

The different cost components are calculated as follows:

$$c^{main}_{h,y} = P_h \cdot A_h \cdot \alpha^{PP}_y \cdot (C^{MainGas} \cdot \epsilon^{Gas}_{h,y} + C^{MainDH} \cdot \epsilon^{DH}_{h,y}) \tag{3.5}$$

The maintenance cost for the current heating system is billed annually. No maintenance costs are charged if the heating system is replaced. In this equation, $\alpha^{\mathrm{PP}}_{\mathrm{y}}$ is the discount factor for private persons, and it is calculated as follows:

$$\alpha^{PP}_y = 1/\left(1 + r_{PP}^{\left(y-2011\right)}\right) \tag{3.6}$$

Equation 3.6 demonstrates the calculation of $\alpha^{\mathrm{PP}}_{\mathrm{y}}$ for grid calculations. For the individual exit, described in chapter 3.3, the year 2011 is substituted with the installation year of the first gas boiler, denoted as $\mathrm{T^{Install}_h}$.

$$c^{fuel}_{h,y} = \sum_{m=1}^{12} \left(A_h \cdot D_{y,m} \cdot \alpha^{PP}_{h,y} \cdot \left(\beta^{Gas}_{h,y,m} \cdot (C^{Gas}_{y,m} + C^{CO_2}_{y,m})/\eta_{Gas} + \beta^{DH}_{h,y,m} \cdot (C^{DH}_{y,m} + C^{CO_2}_{y,m} \cdot F^{DHGas}_{y,m}) \right) \right) \tag{3.7}$$

The cost of fuel varies based on the type of heating system being used. In addition to the fuel price, a CO_2 price is also added. In the case of DH, the CO_2 price is multiplied by a factor called $\mathrm{F}^{\mathrm{DHGas}}_{\mathrm{y,m}}$. This factor is dependent on the amount of gas used to provide heat to customers within the DH system.

$$c^{exchange}_{h,y} = \begin{cases} P_h \cdot A_h \cdot \alpha^{PP}_{h,y} \cdot \left(\gamma^{ToGas}_h \cdot C^{ToGas} + \sum_{m=1}^{12} \left(\gamma^{ToDH}_{h,y,m} \cdot C^{ToDH}\right)\right) & : y = T^{Install}_h + l \\ \sum_{m=1}^{12} \left(P_h \cdot A_h \cdot \alpha^{PP}_y \cdot \gamma^{ToDH}_{h,y,m} \cdot C^{ToDH}\right) & : \forall y \setminus \{T^{Install}_h + l\} \end{cases} \tag{3.8}$$

At the end of a property's lifecycle, the owner must decide whether to switch to DH or stay with a gas boiler. It is also possible to switch to DH before the gas boiler reaches its end of life.

$$c^{capexDH}_{p,y} = \sum_{dim=0}^{\mathcal{D}} \left(\theta^{rep}_{p,dim,y} \cdot C^{capex}_{dim} \cdot l_p \cdot \alpha^{Grid}_y\right) \tag{3.9}$$

$$c^{opexDH}_{p,y} = \sum_{dim=0}^{\mathcal{D}} \left(d^{DH}_{p,dim,y} \cdot C^{opex}_{dim} \cdot l_p \cdot \alpha^{Grid}_y\right) \tag{3.10}$$

$$c^{opexDH}_{p,y} = \sum_{dim=0}^{\mathcal{D}} \left(d^{DH}_{p,dim} \cdot \theta^{act}_{n,y} \cdot C^{opex}_{dim} \cdot l_p \cdot \alpha^{Grid}_y\right) \tag{3.11}$$

The opex and capex of the DH grid are dependent on the length and diameter of the installed pipeline. In the case of a gas grid, if a pipe doesn't supply any customers, it's shut down and no operating expenses are incurred.

3.2.3 Constraints

Constraints building

A gas boiler has been in use from the year it was installed $\mathrm{T}^{\mathrm{Install}}_{\mathrm{h}}$ until the present month $(\mathrm{y}_{\mathrm{current}}, \mathrm{m}_{\mathrm{current}})$. Starting from the current date, property owners have the freedom to choose between using a gas boiler or DH. It is important to note that only one heating system can be used at a time.

$$
\begin{aligned}
\forall y, \forall m \mid y < T_h^{Install}: \quad & \beta_{h,y,m}^{DH} = 0 \qquad \beta_{h,y,m}^{Gas} = 0 \\
\forall y, \forall m \mid y > T_h^{Install} \ \wedge \ y < y_{current}: \quad & \beta_{h,y,m}^{DH} = 0 \qquad \beta_{h,y,m}^{Gas} = 1 \\
\forall y, \forall m \mid y = y_{current} \ \wedge \ m < m_{current}: \quad & \beta_{h,y,m}^{DH} = 0 \qquad \beta_{h,y,m}^{Gas} = 1 \\
\forall y, \forall m \mid y = y_{current} \ \wedge \ m > m_{current}: \quad & \beta_{h,y,m}^{Gas} + \beta_{h,y,m}^{DH} = 1 \\
\forall y, \forall m \mid y > T_h^{Install} \ \wedge \ y > y_{current}: \quad & \beta_{h,y,m}^{Gas} + \beta_{h,y,m}^{DH} = 1
\end{aligned}
\tag{3.12}
$$

The following constraint helps to identify the time when a building switches its heating system. Constraint 3.12 already ensures that no switch to DH occurs before the current date; therefore, it is not considered in constraint 3.13.

$$
\begin{aligned}
\forall y, \forall m \mid y < t_h^{Install}: \quad & \gamma_{h,y,m}^{GastoDH} = 0 \qquad \gamma_{h,y,m}^{DHtoGas} = 0 \\
\forall y, \forall m \mid y \geq t_h^{Install} \ \wedge \ m = 1: \quad & \gamma_{h,y,m}^{GastoDH} = \beta_{h,y-1,12}^{Gas} \cdot \beta_{h,y,m}^{DH} \\
& \gamma_{h,y,m}^{DHtoGas} = \beta_{h,y-1,12}^{DH} \cdot \beta_{h,y,m}^{Gas} \\
\forall y, \forall m \mid y \geq t_h^{Install} \ \wedge \ m \in \mathcal{M} \setminus \{1\}: \quad & \gamma_{h,y,m}^{GastoDH} = \beta_{h,y,m-1}^{Gas} \cdot \beta_{h,y,m}^{DH} \\
& \gamma_{h,y,m}^{DHtoGas} = \beta_{h,y,m-1}^{DH} \cdot \beta_{h,y,m}^{Gas}
\end{aligned}
\tag{3.13}
$$

From an economic point of view, renewing the current gas boiler makes only sense after the lifecycle of the boiler. Therefore, it is only at the end of the lifecycle possible (3.14). The decision variable γ_h^{Renew} is used to track whether the heating system is changed during its lifecycle (3.15). If this is not the case, either a new gas boiler must be installed, or the heating system must be changed to DH(3.16).

$$
\gamma_h^{GastoGas} = \beta_{h,T_h^{Install}+l-1,12}^{Gas} \cdot \beta_{h,T_h^{Install}+l,1}^{Gas} \tag{3.14}
$$

$$
\gamma_h^{Renew} = 1 - \sum_{y=T_h^{Install}}^{T_h^{Install}+l} \sum_{m=1}^{12} \gamma_{h,y,m}^{GastoDH} \tag{3.15}
$$

$$
\gamma_h^{Renew} = \gamma_h^{GastoGas} + \gamma_{h,T_h^{Install}+l,1}^{GastoDH} \tag{3.16}
$$

Due to the restrictions of constraint 3.15, only a single change from a gas boiler to DH and no change from DH to Gas is possible during the lifecycle of the first gas boiler.

$$\sum_{y=t_h^{Install}}^{t_h^{Install}+l} \sum_{m=1}^{12} \gamma_{h,y,m}^{GastoDH} \leq 1 \tag{3.17}$$

$$\sum_{y=t_h^{Install}}^{t_h^{Install}+l} \sum_{m=1}^{12} \gamma_{h,y,m}^{DHtoGas} = 0 \tag{3.18}$$

Maintenance is performed annually, except after changing the heating system.

$$\begin{aligned} \forall y \mid y = T_h^{Install}: \quad & \epsilon_{h,y}^{Gas} = 0 \qquad \epsilon_{h,y}^{DH} = 0 \\ \forall y \mid y = T_h^{Install} + l: \quad & \epsilon_{h,y}^{Gas} = 0 \qquad \epsilon_{h,y}^{DH} = \beta_{h,y,1}^{DH} * \beta_{h,y,12}^{DH} \\ \forall y \mid y = \mathcal{Y} \setminus \{T_h^{Install}, T_h^{Install} + l\}: \quad & \epsilon_{h,y}^{Gas} = \beta_{h,y,1}^{Gas} * \beta_{h,y,12}^{Gas} \\ & \epsilon_{h,y}^{DH} = \beta_{h,y,1}^{DH} * \beta_{h,y,12}^{DH} \end{aligned} \tag{3.19}$$

Constraints DH grid

The power required at each node is the sum of the power needed for all buildings and the power transported from pipe p with starting node $^{A}_{p}$ equal to node n.

$$\forall h \; \forall p \mid n_h = n \; \wedge \; n_p^A = n: \quad P_{n,y}^{th} = \textstyle\sum_{h=1}^{\mathcal{H}} \left(P_h \cdot A_h \cdot \beta_{h,y,m}^{DH}\right) + \sum_{p=1}^{\mathcal{P}} P_{n_p^B,y}^{th} \tag{3.20}$$

With this information, the pipe's dimension is based on the power needed at the end node n_p^B of the pipe. The power at each node is multiplied by a loss factor to account for losses and oversizing for colder winters. It is necessary for the pipe's dimensions to be large enough to accommodate the thermal demand.

$$\sum_{dim=0}^{\mathcal{D}} \left(d_{p,dim,y} \cdot P_{dim}^{th}\right) \geq P_{n_p^B,y,m}^{th} / (1 - loss) \tag{3.21}$$

To determine if the pipe diameter has changed, information on its past diameter is needed. If the current diameter is different, $\theta_{\mathrm{p,dim,y}}$ with the dimension of the new pipe equals 1.

$$\theta_{p,dim,y} = \left(1 - d_{p,dim,y-1,12}\right) \cdot d_{p,dim,y} \tag{3.22}$$

Constraint 3.23 ensures that a pipe has only one diameter. Constraint 3.24 limits pipe dimension changes to 1, since no DH grid operator would change a pipe's dimension within 20 years. In the case of the use case existing grid, listed in chapter 3.3, the dimension changes of the already existing pipes are set to 0.

$$\sum_{dim=0}^{\mathcal{D}} d_{p,dim,y} = 1 \tag{3.23}$$

$$\sum_{dim=0}^{\mathcal{D}} \sum_{y=2011}^{2040} \theta_{p,dim,y} = 1 \tag{3.24}$$

Constraints gas grid

The thermal power at each node for the gas and, subsequently, the pipe diameter are pre-calculated. Therefore, the model only calculates the status of gas transportation. This is performed with a piecewise function. The piecewise function takes the number of customers requiring gas at each node as input.

$$\forall h \mid n_h = n \wedge \forall p \mid n_p^A = n : \quad \delta_{n,y}^{Gas} = \sum_{h=1}^{\mathcal{H}} \left(\beta_{h,y,m}^{Gas}\right) + \sum_{p=1}^{\mathcal{P}} \delta_{n_p^B,y}^{Gas} \tag{3.25}$$

Piecewise function:

$$\theta_{n,y}^{act} = \begin{cases} 0 & \delta_{n,y}^{Gas} = 0 \\ 1 & \delta_{n,y}^{Gas} > 0 \end{cases} \tag{3.26}$$

3.2.4 Key determining input parameters

For the model to produce accurate results, it is crucial to provide precise input data. This section lists the key input parameters and explains how they are pre-processed.

Building isolation & thermal demand

Since there is no concrete data available regarding the actual building insulation and, subsequently, the annual thermal demand and the heating system power of each building, 11 different types of demand curves (DC1 - 11) have been developed. The thermal demand of each building is dependent on the outside temperature (Figure 3.2).

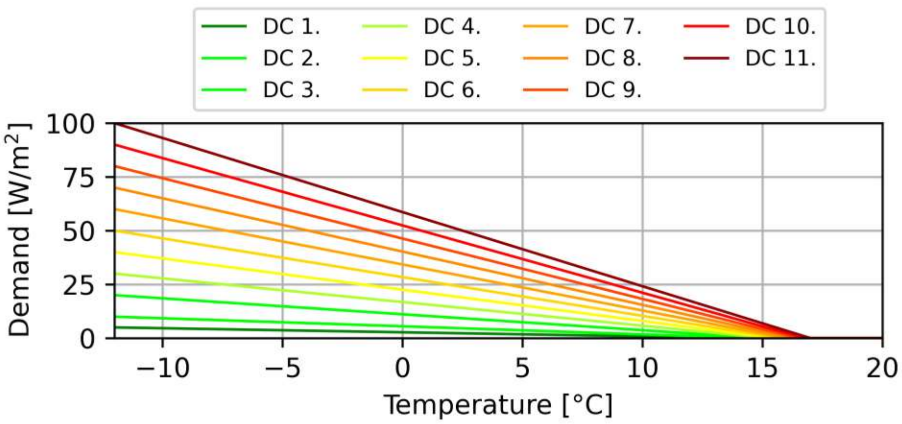

Figure 3.2: Buildings have different DCs, with thermal demand varying based on the external temperature (Source: own work)

Using the DC, the temperature data from the inner city of Vienna in 2022 (GeoSphere Austria, 2022), along with the area of each building and the total thermal heat demand of the 8th district (Hotmaps, 2023), a thermal DC is assigned to each building (Figure 3.3). The allocation is determined by a self-designed optimization model. It's important to note that only buildings with a gas boiler have a DC assigned to them. In the 8th district, 80% of buildings have a gas boiler, so only 80% of the total thermal demand is used for the optimization model.

Figure 3.3: Buildings in the 8^{th} district, with their DCs (Source: own work)

The model distributes the DCs as listed in Figure 3.4. Each DC is assigned to small as well as large buildings, allowing for detailed results based on building size and demand.

To adequately dimension a heating system for a residential property, it is essential to acquire the maximum power output per square meter, utilizing data derived from the period spanning 2000 to 2022. To account for colder winters, a 10% safety factor is applied to each value.

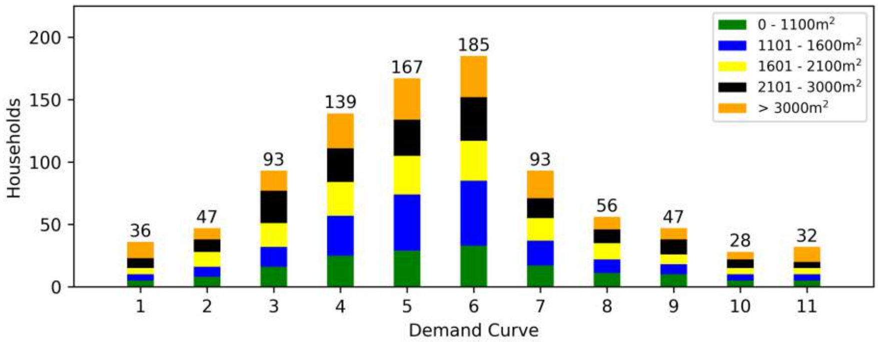

Figure 3.4: Distribution of the DCs (Source: own work)

Fuel and CO_2 price

From 2011 onwards, the gas price was archived by E-Control (E-Control, 2023). Unfortunately, no data exists on DH prices, therefore, just the price from July 2023, 13.41c/kWh is taken into account. Based on the prices provided, five fuel price scenarios are created as shown in Figure 3.5. The first two scenarios indicate a gas price returning to the level of 2021 and be steady until 2040. Meanwhile, the DH price is above the gas price.

In scenarios three and four, the gas price will steadily increase and DH will drop below the gas price in 2030 and 2034.

The last scenario should reflect the situation of the Russian invasion of Ukraine. There would be a steep increase in the gas price but only a slight increase in the DH price due to reduced dependence on gas.

Due to the currently very slowly increasing CO_2 price, an increase to 50€/t in 2040 is assumed. It is noteworthy that, as of 2023, the cost of CO_2 stands at 30€/t. According to the paper "GHG Emission Pathways Until 2300 for the 1.5°C Temperature Rise Target and the Mitigation Costs Achieving the Pathways" (Keigo Akimoto, 2017), it is still possible to achieve a 1.5°C temperature rise by 2100 with the assumed CO_2 price development.

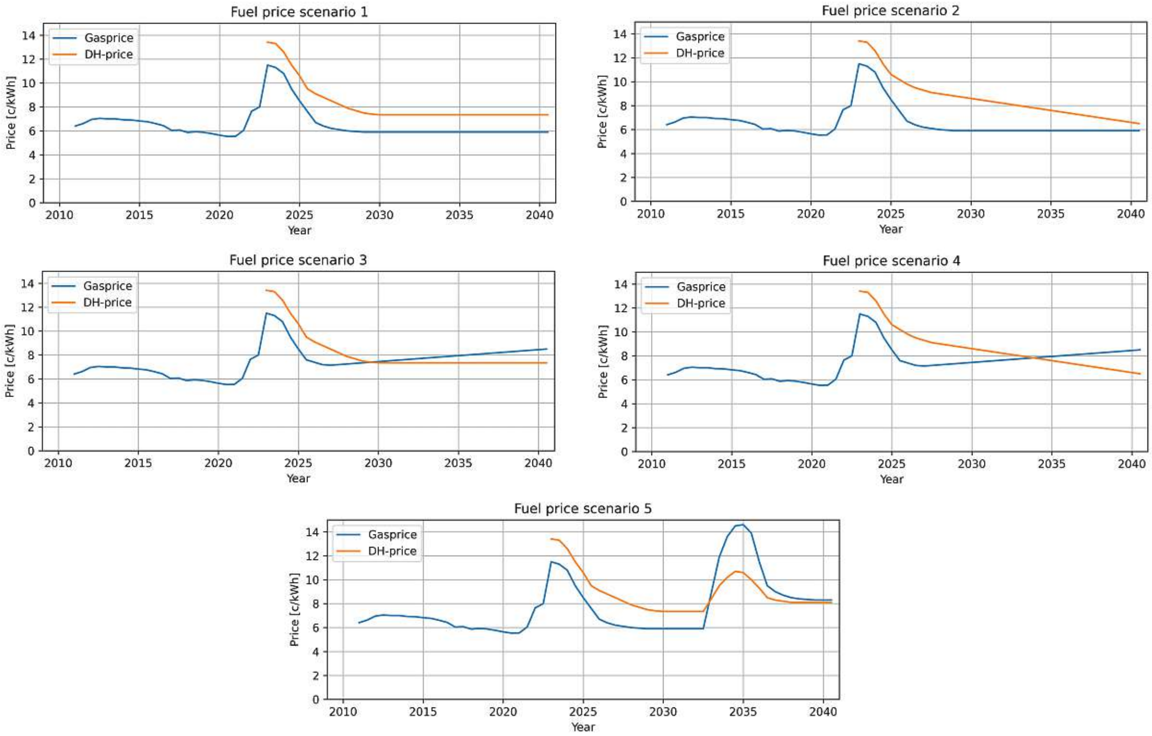

Figure 3.5: Fuel price scenarios (Source: own work)

Heating system costs

The cost of renovating the current heating system is divided into two cost types:

- Heating power dependent cost
- Area dependent cost

In contrast to older, unrenovated buildings, newly constructed and well-insulated buildings require less power for their heating systems. As a result, relying solely on a power-dependent pricing model would significantly underestimate the renovation costs of the heating system for newly built buildings. When switching to DH, it is essential to consider additional costs beyond the DH station, such as installing new distribution lines, individual apartment counters and substations, and the removal of existing gas distribution pipes. Replacing a gas boiler is a much cheaper alternative to converting to DH, as it requires less construction work and utilizes existing infrastructure. Moreover, an economic scale effect is incorporated that further reduces costs. Table 3.1 presents a detailed list of costs based on a retrofitting initiative of a single property in Vienna. The building under consideration has a heating area of 1500 m^2, and each apartment has an average living area of 75 m^2, with a thermal demand of 110 W/m^2.

	Power <200kW		Power >200kW	
	Power	Area	Power	Area
Gas	550 €/kW	4 €/m^2	100 €/kW	1 €/m^2
DH	750 €/kW	17 €/m^2	200 €/kW	4 €/m^2

Table 3.1: Heating system costs

DH and gas pipe properties

In order to determine the appropriate size of the DH pipe for customer supply, it is necessary to calculate the maximum transport capacity of each pipe. This is achieved by first calculating the maximum mass flow $\dot{m}_{max}$ for each dimension using equation 3.27. This equation takes into account the cross-sectional area of the pipe in m^2, denoted by A_{pipe}, the density of water in kg/m^3, represented by ρ_{Water}, and the maximum water velocity in the pipe in m/s, indicated by v_{max} (Thomas Nussbaumer, 2017).

$$\dot{m}_{max} = v_{max} \cdot \rho_{Water} \cdot A_{pipe} \tag{3.27}$$

Equation 3.28 is used to calculate maximum transmitted thermal power P_{th} in kW, based on the maximum mass flow (Tol and Svendsen, 2012). Here, h is the specific enthalpy in kJ/kg of the heat carrier medium at temperature T in °C. The subscriptions S and R indicate the supply and return of the heat medium, respectively.

$$P_{th} = \dot{m}_{max} \cdot (h_S - h_R) \tag{3.28}$$

The supply temperature for dimensions including DN50 and below is 80°C, 100°C for DN65 - DN150, and 160°C for DN200 and above. The returning temperature for all dimensions is 40°C.

Assumptions based on gas transmission lines have been made for the transmission capacities of the gas distribution lines.

Detailed information about the costs of the gas and DH pipes can be found in the appendix 7.

3.3 Definition of use cases and scenarios

The following section describes the three use cases and scenarios studied in this thesis. In this thesis, a use case refers to the development of the DH grid, which ranges from a non-existent state to a fully established DH grid. Scenarios, on the other hand, represent various political frameworks, including interventions and financial support, that are examined in this thesis.

The use cases are tailored to investigate in detail the development of the heating system in Vienna, Austria. More precisely, the model described above is applied to study the subarea of the 8^{th} district of Vienna (*Wien Josefstadt*). This subarea has been selected due to its high population density and thus heat density. In total, more than 24 thousand individuals live in an area of 1.1 km^2 there (BMF, 2022b). The thermal demand of the 8^{th} district sums up to 205.92GWh/a (Hotmaps, 2023). It was assumed that 80% of the buildings are heated by gas boilers, while the remaining 20% use other heating systems such as heat pumps. Since no precise statements can be made about the distribution of the heating systems, each building was randomly assigned a heating system.

Use case 1: Individual exit

The first use case considers the situation in which individuals decide independently whether or not existing gas boilers are replaced with district heating. Thereby, it is assumed that a well-established DH network already exists, which is currently not the case in Wien Josefstadt. Consequently, in this use case, there is no need for the DH operator to build any additional DH distribution pipes for connecting new buildings to the network. In doing so, the most cost-efficient decision of the buildings can be considered individually. DH grid costs are not considered as they do not occur here.

Use case 2: System-oriented exit/Existing grid

For the second use case, the situation differs compared to the first use case in the fact that the main distribution pipes of the DH grid are already built, yet not every building has been connected to the DH grid. Therefore, this use case is analysed from the systems perspective, also considering construction works in the DH distribution grid. The purpose of this use case is to describe the current state of the DH grid in the analysed area. The structure of the main pipes is based on Vienna's current DH grid. The main pipes are connected to the primary grid, which is located underneath the "Ringstraße". Figure 3.6 displays the connection point (CP) between the distribution and the primary grid. In addition, it highlights the main distribution pipelines that are already present in the given use case.

Figure 3.6: Grid status of the use case Existing grid

Use case 3: System-oriented exit/Greenfield

In the third use case, no existing DH pipes are taken into account. To use the heating system, it is essential to establish the entire DH grid first. This approach can aid other cities that lack a DH system to assess from a system's perspective whether it's beneficial to construct a new DH system or to concentrate on alternative technologies.

Scenarios

This section describes various governmental decisions which are examined in this thesis. The government framework can be divided into two parts: government interventions and financial support. In this work, the government framework is addressed with government intervention/financial support. All scenarios are listed in Table 3.2.

Scenario	Intervention	Financial support
noInt/noSup	The government will not intervene in heating system choices until 2040	The government gives no financial support to encourage the transition to DH.
noInt/CGS	The government will not intervene in heating system choices until 2040	Government supports the change to DH like stated in chapter 2.3
noGB/CGS	Starting in 2030, gas boilers will no longer be available for sale	Government supports the change to DH like stated in chapter 2.3
noGB/SDH	Starting in 2030, gas boilers will no longer be available for sale	Starting in 2030, the DH price will be subsidized by 2 cents below the gas price.
noGas/RGB	In 2023 the government announces that stating from 2030, private heating systems will no longer be able to use gas as a fuel. Switching to DH is mandatory.	In the case of noGas, the government purchases existing gas boilers from the property owners at a price depending on the installation year and heating system power. This should compensate the heating system owner for the expenses. A newly installed gas boiler is fully refunded and depreciates by 6% each year of operation.

Table 3.2: Scenarios with different government frameworks

4 Results

In this chapter, the results of the use cases, which are calculated with the optimization model from chapter 3.2, are presented. The study demonstrates the influence of different political frameworks, described in chapter 3.3 on residential complexes, with a comprehensive analysis of investment cost, net public balance and CO_2 emissions.

4.1 Results of Individual exit

Heating system

First, the impact on each heating system is being evaluated. Figure 4.1 displays the decision made for the heating system in each building. All buildings are classified on three key parameters: the installation year (I), the house area (A) and the demand curve (DC). The corresponding categories are marked in red, where less than 30% of households adopt DH. Conversely, categories where more than 70% of households adopt DH are marked in green. This helpful visual aid can help identify areas of success and potential areas for improvement in adopting DH.

Based on the findings, it can be inferred in the case of noInt/noSup that in the event of gas prices returning to the pre-Russian invasion level (Scenario 1 & 2), the most advantageous course of action for property owners and their tenants would be to adhere to the usage of gas boilers. In the context of the other three fuel scenarios, it can be observed that property owners and their tenants in buildings with a DC 8-11 tend to switch heating systems in response to high thermal demand and, consequently, a higher fuel demand. Large buildings with an area $> 3000\text{m}^2$ tend to exhibit this behaviour even more prominently.

In the case of noGB, heating systems installed after 2019 tend to switch to DH after the lifetime of the gas boiler expires. From an economic perspective, it doesn't make sense to replace the heating system before 11 years have passed just to avoid political intervention. It is likely that heating systems built before 2019 are replaced before 2030, particularly if the cost of gas remains lower than the cost of DH. This trend can be mitigated by subsidization of the DH price for buildings with high thermal energy demands.

		Fuel scen. 1			Fuel scen. 2			Fuel scen. 3			Fuel scen. 4			Fuel scen. 5		
		DC 1-4	DC 5-7	DC 8-11	DC 1-4	DC 5-7	DC 8-11	DC 1-4	DC 5-7	DC 8-11	DC 1-4	DC 5-7	DC 8-11	DC 1-4	DC 5-7	DC 8-11
noInt/noSup	I ≤ 2014	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	63,5%	0,0%	0,0%	30,8%	0,0%	4,4%	63,5%
	2015 ≤ I ≤ 2018	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	63,8%	0,0%	2,4%	63,8%	0,6%	12,0%	63,8%
	I ≥ 2019	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	32,1%	0,0%	0,0%	50,0%	0,0%	15,4%	53,6%
	A ≤ 1500m²	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	1500m² < A ≤ 3000m²	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	58,1%	0,0%	0,0%	54,7%	0,0%	0,0%	62,8%
	A ≥ 3000m²	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	84,9%	0,0%	4,1%	77,4%	1,1%	61,2%	100,0%
noInt/CGS	I ≤ 2014	0,6%	0,0%	0,0%	0,6%	0,0%	0,0%	1,3%	19,8%	65,4%	1,3%	9,9%	57,7%	1,3%	18,7%	65,4%
	2015 ≤ I ≤ 2018	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	20,5%	66,7%	0,0%	20,5%	66,7%	2,4%	31,3%	71,0%
	I ≥ 2019	0,0%	0,0%	0,0%	0,0%	0,0%	1,8%	0,0%	13,5%	55,4%	0,7%	17,3%	58,9%	0,7%	19,2%	58,9%
	A ≤ 1500m²	0,6%	0,0%	0,0%	0,6%	0,0%	2,6%	1,2%	17,7%	15,8%	1,8%	15,3%	15,8%	2,4%	25,0%	23,7%
	1500m² < A ≤ 3000m²	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	62,8%	0,0%	0,0%	62,8%	0,0%	0,0%	62,8%
	A ≥ 3000m²	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	55,1%	96,2%	0,0%	51,0%	92,5%	3,4%	65,3%	100,0%
noGB/CGS	I ≤ 2014	0,6%	1,1%	0,0%	0,6%	1,1%	0,0%	1,3%	20,9%	67,3%	1,3%	13,2%	57,7%	1,3%	19,8%	69,2%
	2015 ≤ I ≤ 2018	0,6%	8,4%	2,9%	2,4%	12,0%	2,9%	12,2%	55,4%	97,1%	12,2%	59,0%	95,7%	21,3%	80,7%	100,0%
	I ≥ 2019	19,5%	71,2%	46,4%	21,5%	74,0%	51,8%	28,2%	100,0%	100,0%	30,9%	100,0%	100,0%	28,2%	100,0%	100,0%
	A ≤ 1500m²	11,9%	42,7%	39,5%	14,9%	46,8%	39,5%	27,4%	70,2%	78,9%	28,6%	66,9%	73,7%	33,9%	71,8%	81,6%
	1500m² < A ≤ 3000m²	4,3%	24,8%	15,1%	4,7%	25,7%	18,6%	6,2%	42,9%	87,2%	6,6%	43,8%	87,2%	6,6%	54,3%	89,5%
	A ≥ 3000m²	2,2%	6,1%	0,0%	2,2%	6,1%	0,0%	5,6%	75,5%	100,0%	6,7%	73,5%	92,5%	9,0%	87,8%	100,0%
noGB/SDH	I ≤ 2014	1,9%	6,6%	75,0%	1,3%	6,6%	65,4%	0,0%	4,4%	63,5%	1,3%	6,6%	63,5%	1,9%	6,6%	75,0%
	2015 ≤ I ≤ 2018	1,8%	18,1%	94,2%	1,8%	18,1%	94,2%	0,0%	12,0%	76,8%	0,6%	12,0%	81,2%	1,8%	24,1%	100,0%
	I ≥ 2019	1,3%	100,0%	100,0%	1,3%	100,0%	100,0%	0,0%	85,6%	100,0%	8,1%	100,0%	100,0%	1,3%	74,0%	100,0%
	A ≤ 1500m²	0,0%	40,3%	78,9%	0,0%	40,3%	71,1%	0,0%	33,1%	44,7%	1,8%	37,9%	52,6%	0,0%	29,0%	84,2%
	1500m² < A ≤ 3000m²	0,0%	36,2%	89,5%	0,0%	36,2%	87,2%	0,0%	26,7%	83,7%	2,4%	34,3%	83,7%	0,0%	29,5%	91,9%
	A ≥ 3000m²	9,0%	75,5%	100,0%	7,9%	75,5%	100,0%	0,0%	69,4%	100,0%	7,9%	75,5%	100,0%	9,0%	73,5%	100,0%
noGas/RGB	I ≤ 2014	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
	2015 ≤ I ≤ 2018	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
	I ≥ 2019	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
	I ≤ 1500m²	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
	1500m² < A ≤ 3000m²	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
	I ≥ 3000m²	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Figure 4.1: Percentage of households shifting to DH under various circumstances such as political framework and fuel costs for the individual exit. Here, I denote the year of installation, A denotes the area of the house, and DC denotes the demand curve. When more than 70% of households switch to DH, the house category is marked green; when less than 30% make the change, it is marked red.

Buildings with a low energy demand (DC 1-4) tend to stick with gas boilers for both noInt and noGB. This is because the costs associated with converting the heating system, especially the area-dependent costs, are higher than the savings generated through financial support and the fuel price (fuel scenario 3-5).

In the case of noGas, as expected, all buildings switched their heating system to DH.

To further emphasize the fact that most high-demand buildings switch to DH, Figure 4.2 is displayed. It also reveals a significant difference between the percentage of houses supplied and the percentage of peak heat capacity that is met by DH in the case of noGB/SDH. As shown, DH satisfies up to 70% of the heat demand, while only up to 30% of the houses switch to DH to meet their heating needs.

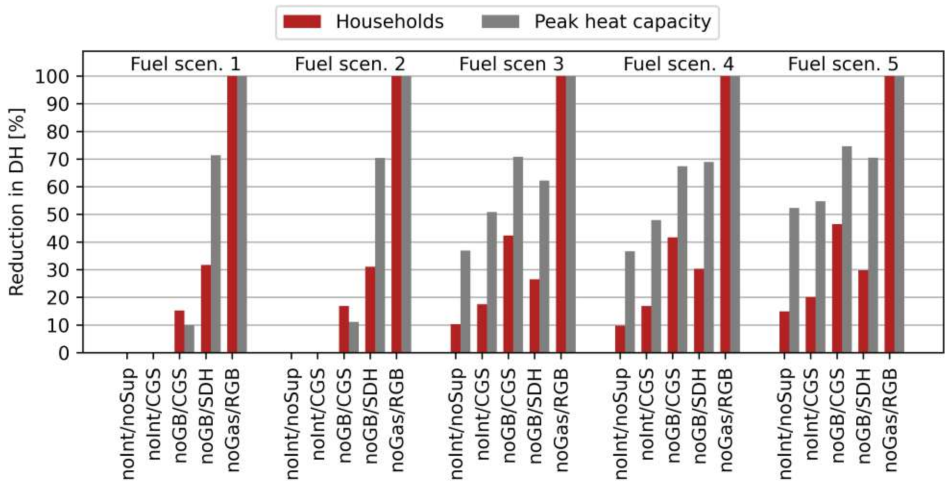

Figure 4.2: Percentage houses and peak heat capacity changed to DH for the individual exit

Specific investment costs & Net public balance

Figure 4.3 represents the current value of future specific investment costs using a discount rate of 6%. In fuel scenario 1; noInt/noSup, it requires an investment of 130€/kW to renew the heating infrastructure. On the other hand, transitioning to an environmentally friendly infrastructure would result in a cost increase of up to 248%.

In the case of noGB/CGS, some houses renew their gas boiler before the end of their lifetime due to government intervention. This is particularly evidenced in fuel scenarios 1 and 2, as the costs associated with installing gas boilers are higher than those in noInt/noSup or noInt/CGS. This higher price is due to the discount rate, which lowers future investments.

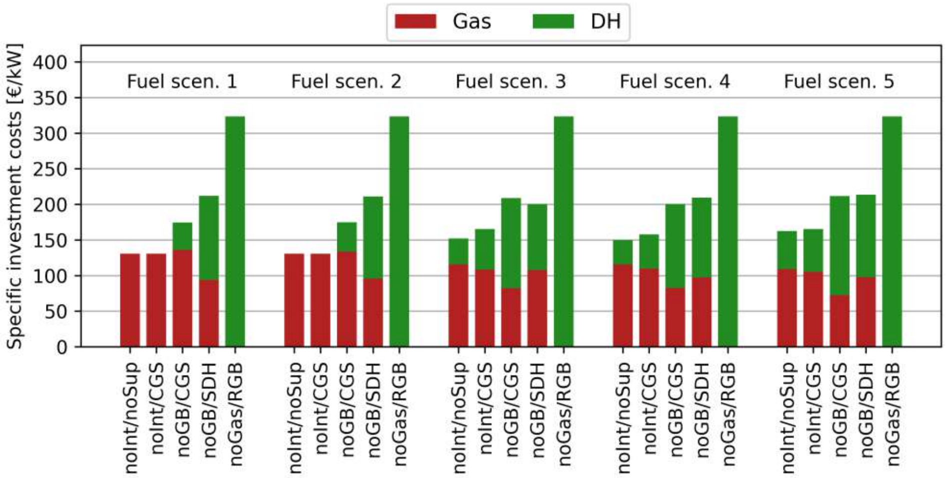

Figure 4.3: Specific cost of investment for heating systems for the individual exit

When comparing financial support schemes, it is also essential to consider the net public balance. This is plotted in Figure 4.4. When gas prices continue to be at an all-time low level, like in fuel scenarios 1 & 2, subsidizing the DH would be up to 390% more expensive than compared to noGas/RGB. For the noGas/RGB case, there is minimal government spending as the intervention in 2030 is already known in 2023. This means that for buildings where the gas boiler needs to be replaced between 2023 and 2030, it is not economically feasible to install a new one and replace it with a DH system a couple of years later, as the governmental subsidies are too low. Since the government provides no subsidies before 2030, most of the renovation costs must be borne by the property owners.

When DH prices fall below gas prices, like in fuel scenarios 3 - 5, and no gas boilers are sold, the current support scheme results in a positive net public balance compared to the other two support schemes. Moreover, it also leads to higher penetration of DH systems in comparison to NoGB/SDH, see Figure 4.2.

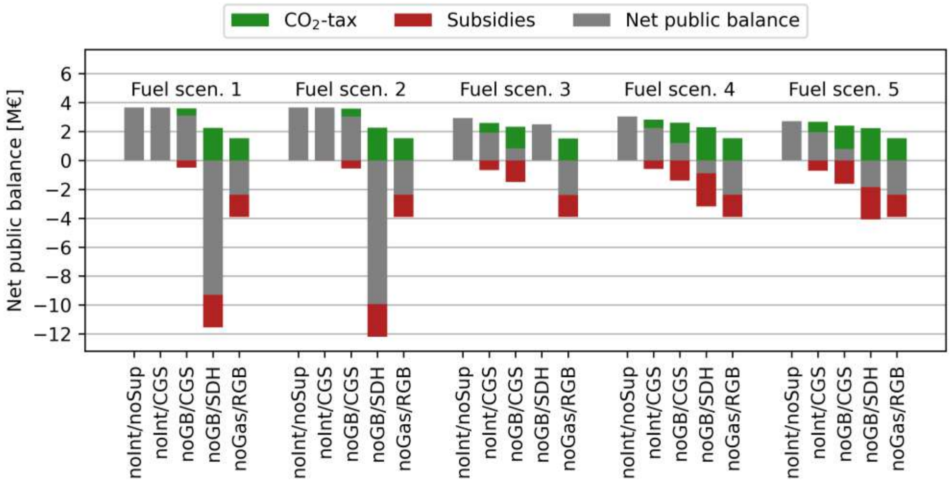

Figure 4.4: Net public balance for the individual exit

CO2 emissions

When it comes to achieving climate neutrality, it is vital to consider CO_2 savings, which are plotted in Figure 4.5. A mandatory switch to DH means potential savings up to 55% of CO_2 can be achieved compared to noInt/noSup.

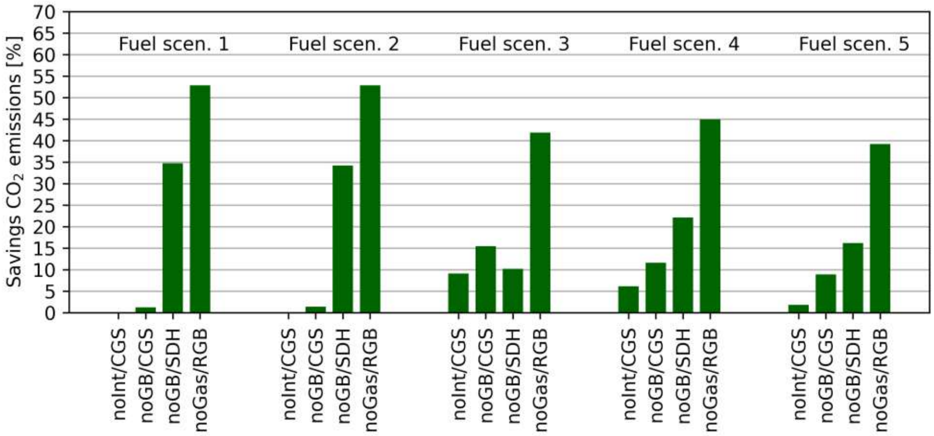

Figure 4.5: From 2023 onwards, CO2 savings are compared to noInt/noSup for the individual exit

The current support scheme and the absence of gas boiler sales result in a higher DH penetration rate compared to SDH, as previously stated. However, despite the higher number of DH heating systems, the CO_2 balance doesn't reflect the same, particularly for fuel scenario 4. Specifically, even though 37.5% more households switch to DH, CO_2 savings decrease by 10.5%. This phenomenon can be explained by the fact that buildings operating under the SDH schema shifted to DH earlier than those under the present support schema. Consequently, with the SDH schema, energy consumption from DH is 50% higher and therefore also the CO_2 saving.

4.2 Results of System-oriented exit/Existing grid

Heating system

This use case takes into account the current grid status and therefore, assumes that all the primary pipes in the grid are already in place. Figure 4.6 illustrates the results of households that have transitioned their heating system to DH. As observed in this use case, a substantial reduction in connections to the DH grid is evident, with a significant decrease of up to 50% in almost all scenarios.

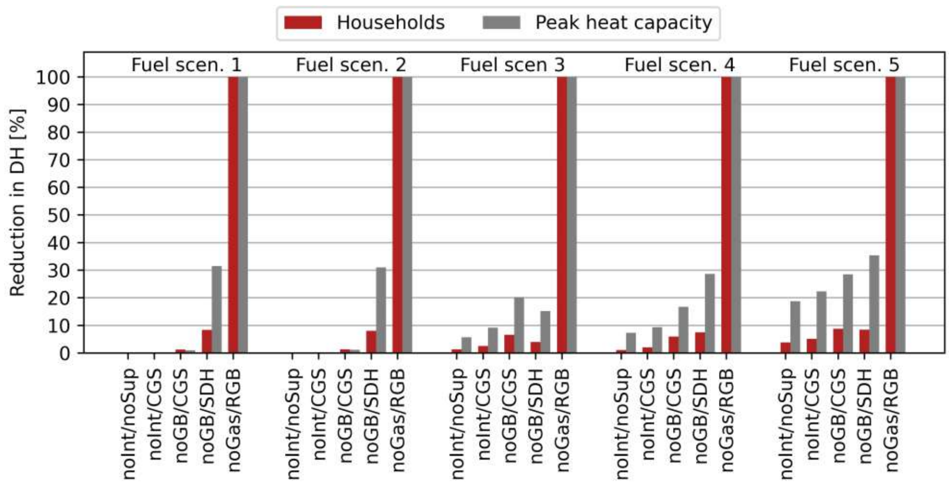

Figure 4.6: Percentage houses and peak heat capacity changed to DH for the existing grid

The existing political framework does not support the adoption of DH systems. This is particularly evident in situations where gas prices are low, as no property owners are willing to undertake the necessary changes to their heating systems. Even in the other fuel price scenarios, where DH may be a viable alternative, as seen in 4.1, only a limited number of property owners are willing to make the switch. Most of these properties that switched to DH are located near existing DH grids to avoid additional costs associated with grid expansion.

Specific investment costs & Net public balance

The investment costs associated with district heating have undergone a significant decline, as seen in Figure 4.7. In most cases, the investment costs were predominantly attributed to gas boilers, with the exception of the noGas/RGB scenario. In this particular case, the investment costs can be divided into two components, with 19% of the investments allocated towards the grid and the remaining 81% directed towards the DH heating system.

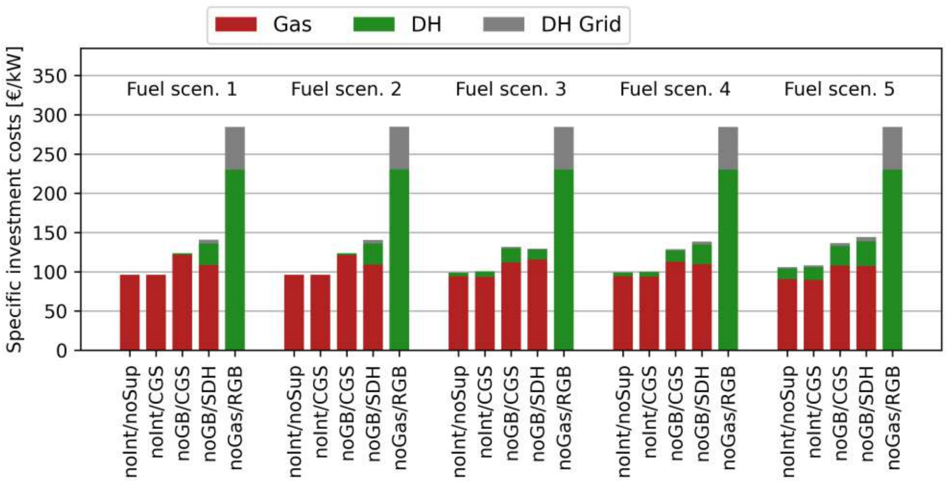

Figure 4.7: Specific cost of investment for heating systems for the existing grid

In those cases when DH is implemented, the corresponding investments required for grid expansion tend to be quite limited. In fact, the grid expansion would cover only 3% of the specific investment costs. Comparing this with the costs of expanding the rest of the network, it only corresponds to 6.1% of the entire grid expansion costs. This highlights the fact that only buildings close to the existing grid infrastructure are more likely to change their heating system.

From a governmental standpoint, NoGas/RGB represents the most profitable framework towards the transition of heating systems due to the already mentioned fact in chapter 4.1. In the event that gas prices should remain low, subsidizing DH would result in an increased expenditure of up to 49% for the government compared to noGas/RGB. This is despite DH only addressing 30% of the total heat demand in 2040.

Across all other fuel scenarios, the government records a positive net balance attributed to the CO_2 taxes, except for NoGas/RGB. This implies that the government's revenue from CO_2 taxes is sufficient to offset any kind of subsidies, thereby resulting in a positive net balance.

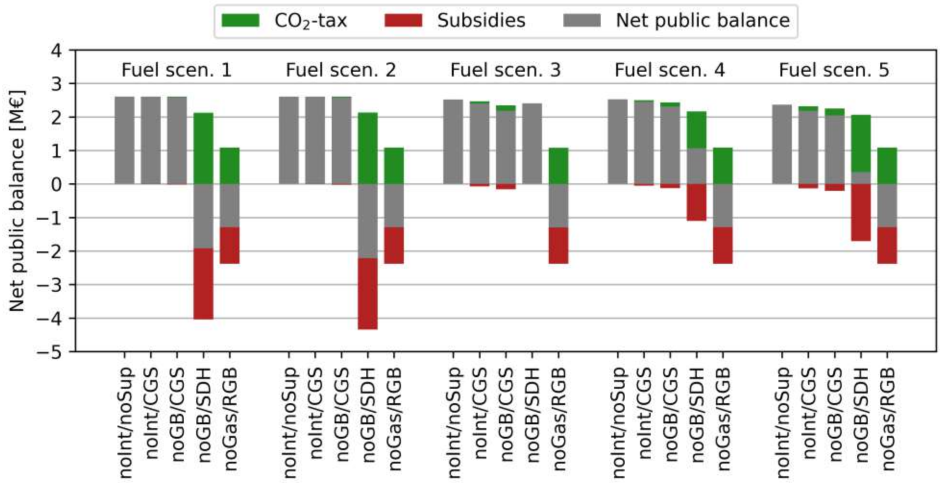

Figure 4.8: Net public balance for the existing grid

CO2 emissions

Compared to the noInt/noSup option, the second-highest reduction of CO_2 emissions can be obtained by implementing the noGB/SDH framework alongside noGas/RGB. However, these savings are dependent on receiving the highest level of government subsidies. In fuel scenarios 1 and 2, the potential to reduce CO_2 emissions add up to 17%. Nevertheless, this stands as a decline of 50% of the total savings in comparison to those achieved in the individual exit.

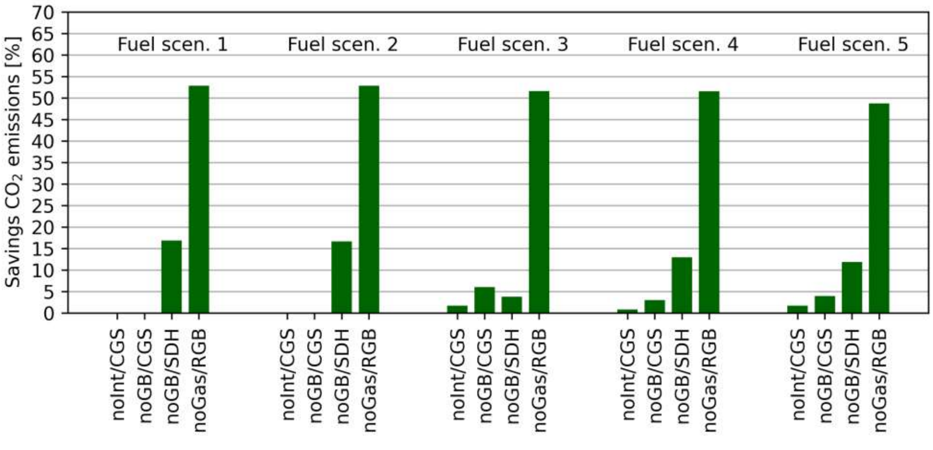

Figure 4.9: From 2023 onwards, CO_2 savings are compared to noInt/noSup for the existing grid

4.3 Comparison individual vs system-oriented exit

The following section compares the individual exit with the system-oriented exit/existing grid. However, no outcomes are presented for the system-oriented exit/greenfield because no buildings are connected to DH in all scenarios besides noGas/RGB. This can be mainly attributed to the high initial grid costs that need to be paid to extend the DH network prior to using DH systems.

Figure 4.10 shows the reduction of DH systems and peak heat capacity of the sys. exit compared to the ind. exit. It is observed that in all fuel scenarios where noGas/RGB is used, there is no reduction of DH systems since switching to DH is mandatory. For fuel scenarios 1 & 2, the decline of DH system in all government frameworks is almost the same. The most significant decline is recorded in noGas/SDH, where a decrease of almost 40% in peak heat capacity corresponds to approximately 22% of the total heating systems can be observed.

When the DH price drops below the gas price, as in fuel scenarios 3 - 5, a reduction of up to 50% in peak heat capacity connected to DH is recorded. The lowest decrease is recorded in fuel scenario 3 with the framework noInt/noSup. This is due to the fact that only a few buildings in the ind. exit switch to DH, and thus the reduction in DH cannot be as high as for the noGB/CGS schema.

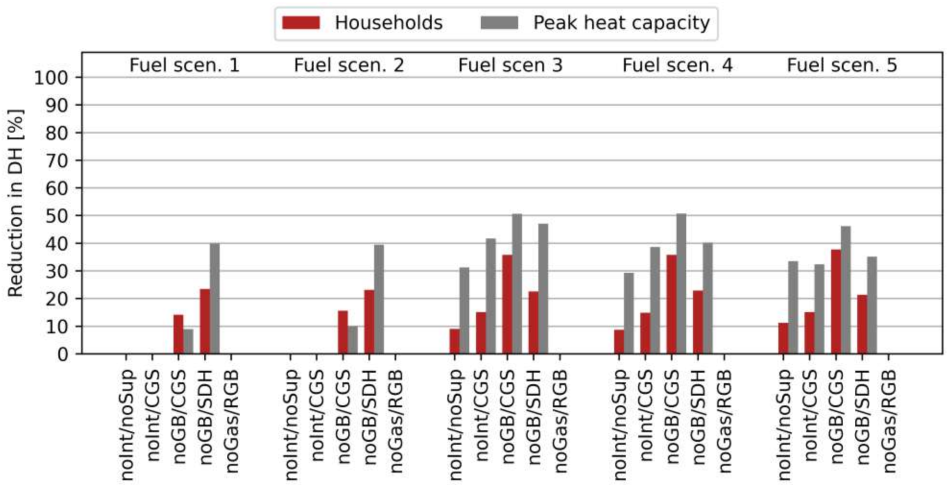

Figure 4.10: Reduction in DH systems in the use case sys. exit compared to the individual exit

The amount of CO_2 saved by the ind. exit compared to the sys. exit is shown in Figure 4.11. It is interesting to note that in fuel scenarios 1 and 2; noGB/CGS, even with a 10% reduction in peak heat capacity supply by DH, only 1% more CO_2 can be saved by the individual exit. With the noGB/SDH framework, almost 22% more CO_2 is saved in the individual exit.

The results of the other three fuel scenarios demonstrate a similar trend as the reduction of the DH system. However, due to the lower penetration of the DH system in the sys. exit, up to 25% more CO_2 can be saved in the ind. exit.

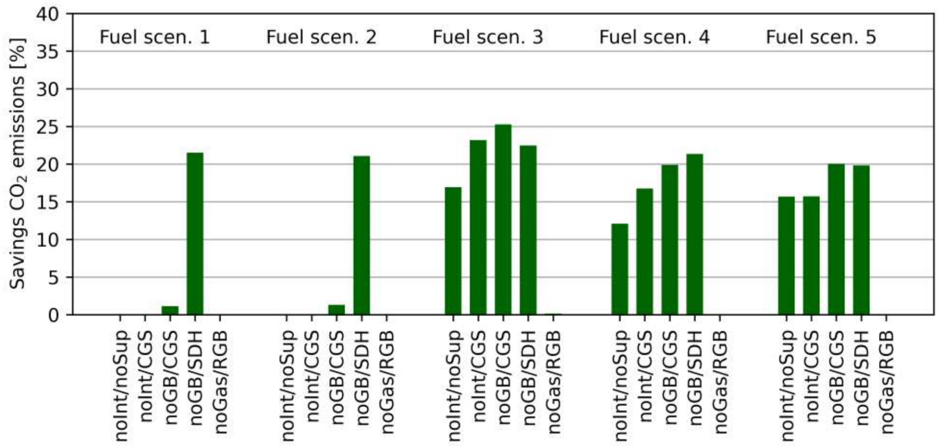

Figure 4.11: CO_2 savings of the ind. exit compared to the sys. exit

5 Sensitivity analysis

The subsequent sensitivity analysis serves to validate the results presented in chapter 4 by examining the effects of adjusting various input parameters on the three use cases. Basically, the following two sensitivities are analyzed:

1. Increasing CO_2 prices or taxes, respectively
2. Increasing government subsidies

5.1 CO2 price variations

As part of the sensitivity analyses, a more significant increase in the CO_2 price is considered. The results obtained are based on a pessimistic outlook of the CO_2 price development, where a price of only 50€/t_{CO_2} by 2040 is assumed. This analysis is particularly relevant because CO_2 price can drastically influence the gas price and, subsequently, the decision-making process regarding the heating system.

The graph presented in Figure 5.1 illustrates the diverse CO_2 price curves that are employed in the sensitivity analysis. For the analysis in chapter 4, CO_2 price 1 was utilized. In this analysis, a CO_2 price of up to 800€/t_{CO_2} is used, which is equivalent to a 25 cent/kWh increase in gas prices.

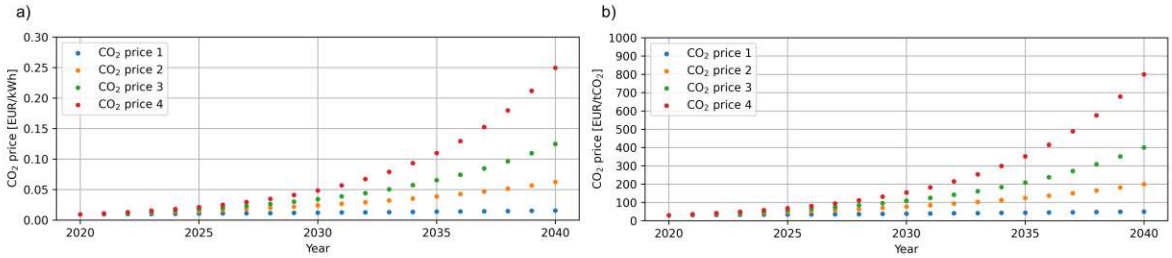

Figure 5.1: CO_2 prices for the sensitivity analyse. a) indicates the CO_2 price in cent/kWh, while b) represents the CO_2 price in €/t_{CO_2}. In Chapter 4, the CO_2 price 1 is utilized.

In the sensitivity analysis of the CO_2 price, only noInt/CGS and noGB/SDH are considered as a political framework. This is because noGB/SDH achieved higher CO_2 savings compared to noGB/CGS. Moreover, the CO_2 price will not have any impact on the outcome of noGas/RGB framework.

5.1.1 Individual exit

Heating system

Figure 5.2 illustrates the proportion of households and peak heat capacity that transition to DH. A noticeable increase in DH heating systems is observed as the cost of CO_2 rises. Specifically, at a CO_2 price of 800€/t_{CO_2}, DH heating systems account for up to 97% of the total thermal demand, corresponding to 73% DH heating systems in all scenarios. Especially the current framework noInt/CGS relies on an increase in the price of CO_2 in order to function effectively. Even if the CO_2 tax increased up to 200€/t_{CO_2}, 55% of the total demand can be fulfilled by DH with the current framework.

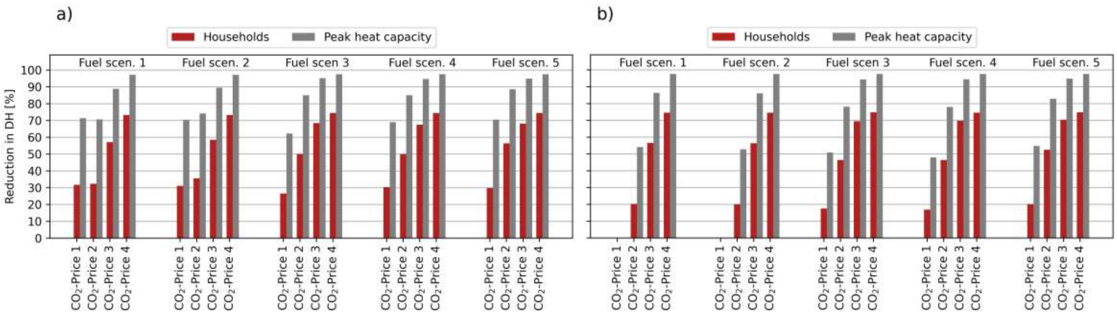

Figure 5.2: a) Houses that change the heating system with the noGB/SDH government framework. b) Houses that change the heating system with the noInt/CGS government framework

Upon comparing the two government frameworks, it is apparent that more households are expected to switch from gas boilers to DH systems with noGB/SDH if the cost of CO_2 is set at or below the threshold of 200€/t_{CO_2} by 2040. That trend is primarily attributed to the subsidization of DH costs, as well as the fact that gas prices, including the CO_2 tax, have not yet reached the level of DH prices. But if this is the case, a significant increase in the DH heating system can be especially noted for the noInt/CGS government framework, and it also outmatches the noGB/SDH in the CO_2 price scenarios 3 & 4.

Specific investment costs & Net public balance

Regarding the net public balance, Figure 5.3 is plotted. As stated before, if CO_2 taxes are low, noGB/SDH supports the transition to DH more. But this perhaps comes with higher government expenses. In the event of a CO_2 price of 50€/t_{CO_2}, the subsidies provided exceed the revenue generated from the CO_2 taxes, resulting in a negative net public balance (Figure 5.3a)). Conversely, with higher CO_2 taxes, the subsidies are covered, resulting in a positive net public balance.

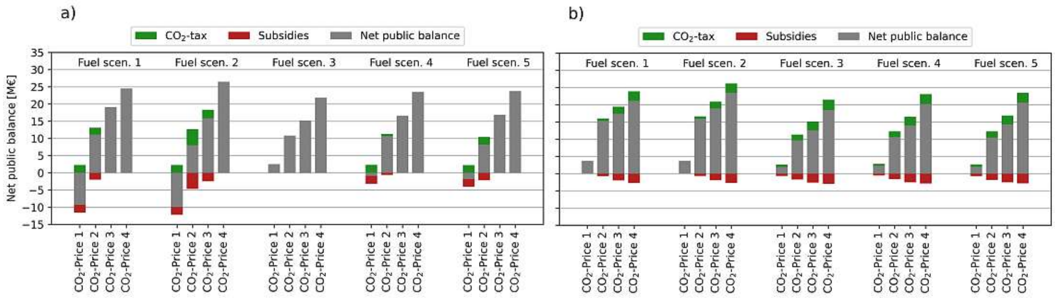

Figure 5.3: a) Government net balance with the noGB/SDH government framework. b) Government net balance with the noInt/CGS government framework

In the event of noInt/CGS, subsidies come into effect for higher CO_2 taxes. Across all CO_2 price scenarios, the net public balance remains positive and reaches up to 23.5M€. As a result, higher CO_2 taxes can be accompanied by increased subsidies to promote the transition to DH further because the income generated by CO_2 taxes is up to 10 times higher than the expenses incurred by subsidies.

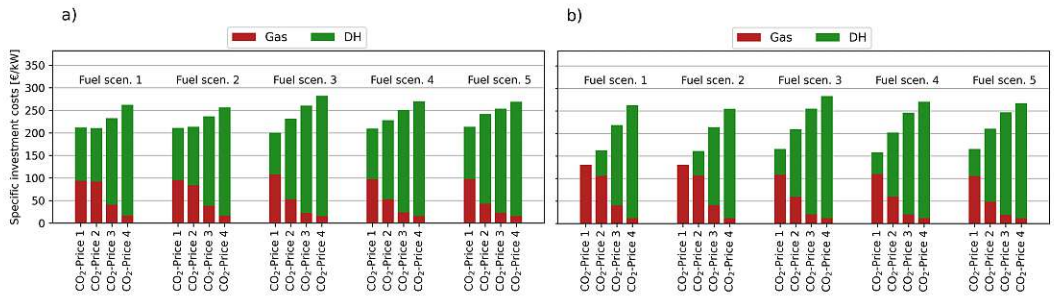

Figure 5.4: a) Specific investment costs with the noGB/SDH government framework. b) Specific investment costs with the noInt/CGS government framework

The graph depicted in Figure 5.4 presents the specific investment cost as the price of

CO_2 increases. Under the noGB/SDH framework, where the penetration of DH heating systems is already high with a low CO_2 price, the specific investment cost increases to a maximum of 35%. In contrast, under the noInt/CGS framework, the specific investment cost increases up to 108%.

CO2 emissions

It is worth noting that the bandwidth of savings when the CO_2 price increases is much narrower with the noGB/SDH framework compared to the noInt/CGS. This especially takes effect when gas prices are lower than those of DH. Having a close look at fuel scenario 1, when increasing the CO_2 price, the savings only increase from 34% to 49.5%. However, with the noInt/CGS, the savings increase from 0% to 50.5% and thus slightly exceed the results of noGB/SDH. This emphasizes the significant impact of the CO_2 price on the effectiveness of the noInt/CGS framework.

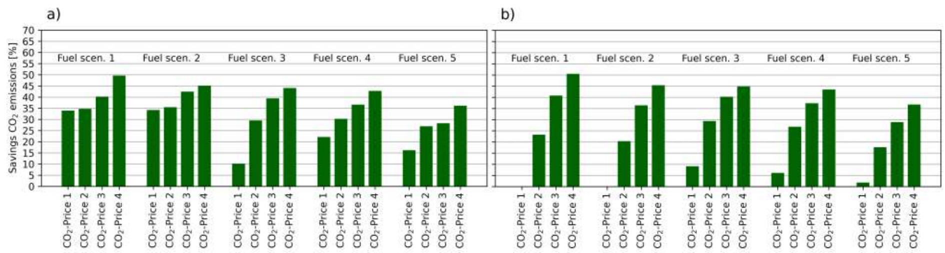

Figure 5.5: Compared to noInt/noSup with a CO_2 price of 50€/t_{CO_2} in 2040, the CO2 savings for each fuel scenario are presented for a) the government framework noGB/SDH and b) the government framework noInt/CGS

5.1.2 System-oriented exit/Existing grid

Heating system

Figure 5.6 displays the results of the sensitivity analysis conducted on the current grid. The analysis indicates that when gas prices are low (fuel scenario 1 & 2), CO_2 prices become relevant only when they exceed 200€/t_{CO_2}. In these scenarios when the CO_2 taxes don't exceed 200€/t_{CO_2}, the covered thermal demand by DH increases only up to 21% with the noInt/CGS government framework. Meanwhile, with the noGas/SDH framework, it remains steady at 30%. Compared to individual exits, only half of the buildings have switched to DH.

As the price of CO_2 increases, the results tend to become more similar to the individual exit. In scenario 4, where the CO_2 price is 800€/t_{CO_2}, the difference between the individual exit and the existing grid is less than 5% of the total demand covered. These results demonstrate that if the CO_2 price reaches 800€/t_{CO_2}, the costs of expanding the DH grid will be negligible. From a system perspective, investing in the DH grid would be profitable.

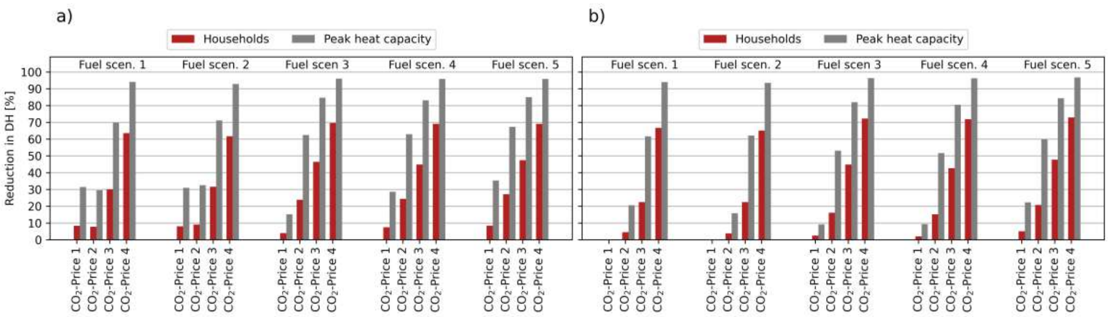

Figure 5.6: a) Houses that change the heating system with the noGB/SDH government framework. b) Houses that change the heating system with the noInt/CGS government framework

Specific investment costs & Net public balance

Figure 5.7 illustrates the specific investment costs for the current sensitivity analysis. In the case of the noGas/SDH framework, shown in Figure 5.7a), the specific investment costs are projected to increase up to 85%, compared to the initial CO_2 price of 50€/t_{CO_2}, when the CO_2 price reaches 800€/t_{CO_2}. This increase is due to the higher investment cost of the DH heating system, with one-third of the increase attributed to additional grid expansion costs.

In the noInt/CGS framework, an increase of up to 142% can be observed. The higher percentage increase is due to the higher penetration of gas boilers in the CO_2 price scenario 1.

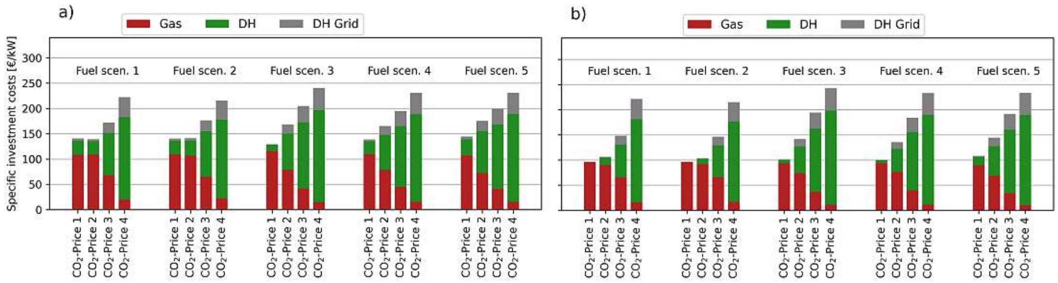

Figure 5.7: a) Specific investment costs with the noGB/SDH government framework. b) Specific investment costs with the noInt/CGS government framework

The public net balance for all scenarios is illustrated in Figure 5.8. As for the individual exit, when the CO_2 price is low, subsidies are provided to support the transformation with the noGB/SDH intervention. However, when the CO_2 price is high, the current government framework further promotes the transition to DH.

It is generally observed that the government maintains a positive net balance in most cases. Based on this observation, it is recommended that subsidies be increased, especially in the context of high CO_2 prices. By doing so, the government can more effectively incentivize the adoption of DH while still maintaining a positive net balance.

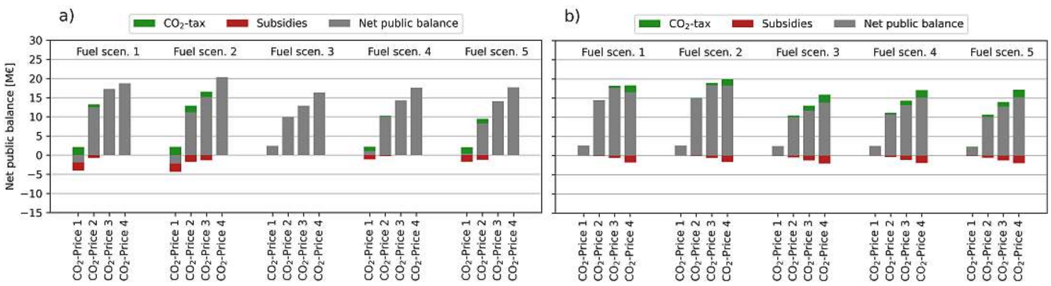

Figure 5.8: a) Government net balance with the noGB/SDH government framework. b) Government net balance with the noInt/CGS government framework

CO2 emissions

The graph presented in Figure 5.9 illustrates the potential CO_2 savings when compared to the noInt/noSup. Notably, the establishment of a DH grid prior to implementation of DH has a significant impact on the level of CO_2 savings. It is important to note that savings are reduced by over 50% in all fuel scenarios when the CO_2 price only reaches a maximum of 200€/t_{CO_2}, as compared to individual exit. However, when the CO_2 price increases up to 400€/t_{CO_2}, no significant changes can be observed. This suggests that extending a DH grid at this CO_2 price is not a significant barrier to overcome.

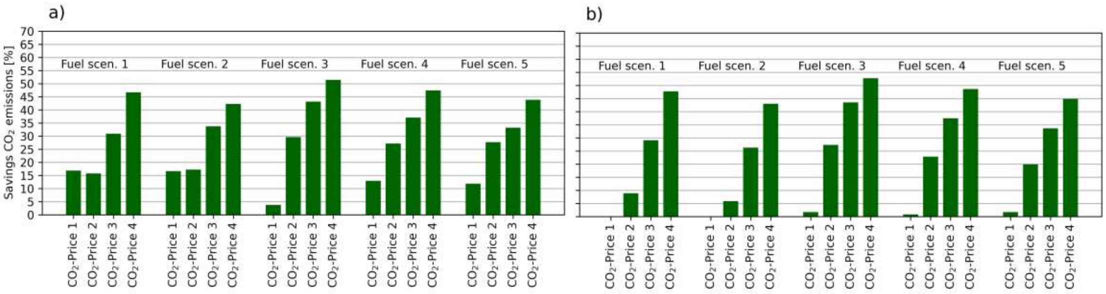

Figure 5.9: CO_2 savings compared to noInt/noSup for each fuel scenario with a) the government framework noGB/SDH b)the government framework noInt/CGS

5.1.3 System-oriented exit/Greenfield

Heating system

Figure 5.10 shows the sensitivity analysis of CO_2 prices on the development of DH systems under the circumstances that no DG grid exists. If the CO_2 price is lower than 200€/t_{CO_2}, there are no changes to DH for fuel scenario 1 & 2. However, for the other three scenarios, when the CO_2 price reaches 200€/t_{CO_2}, 40% to 60% of the thermal demand is covered by DH.

In the case of high CO_2 prices, the results can be compared with those of the existing grid. In the greenfield use case, the aggregate demand fulfilled and the quantity of households that switch to DH is no more than 5% lower than that of the current grid. These results indicate that grid costs no longer pose a significant barrier to implementing DH in urban areas in case of high CO_2 prices.

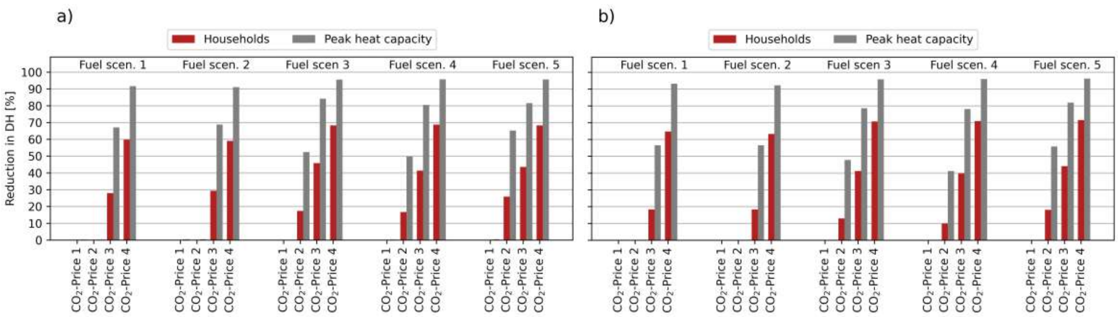

Figure 5.10: a) Houses that change the heating system with the noGB/SDH government framework. b) Houses that change the heating system with the noInt/CGS government framework

Specific investment costs & Net public balance

Figure 5.11 displays the specific investment costs. It can be observed that in CO_2 price 3 & 4, the specific investment cost increases by approximately 6% when compared to the costs associated with the existing grid. This increase can be primarily attributed to the higher investment cost required for the grid expansion.

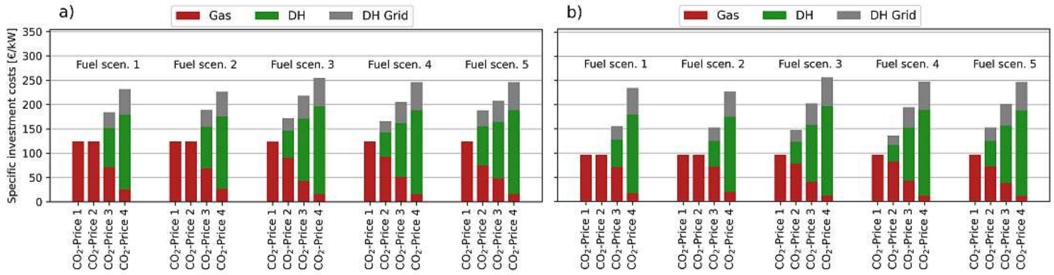

Figure 5.11: a) Specific investment costs with the noGB/SDH government framework. b) Specific investment costs with the noInt/CGS government framework

It is worth noting that the subsidies for noGas/SDH, as illustrated in Figure 5.12a), have decreased to almost negligible levels. This is because when the CO_2 price is low, it is not economically viable to expand the grid, hence no subsidies are paid out. On the other hand, when the CO_2 price is high enough to make expanding the grid worthwhile, the gas price also rises above the DH price, which results in no subsidies being paid out as well. This once again highlights the benefits of the current support system, as it offers more significant subsidies. However, the income from CO_2 taxes still far outweighs the expenses from subsidies, suggesting a need for further subsidy increases.

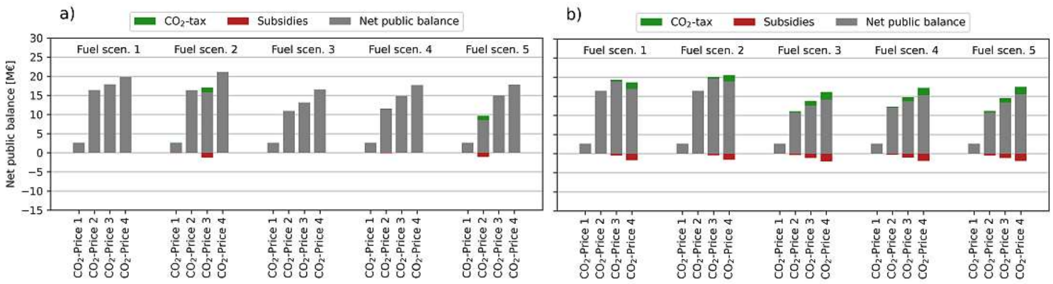

Figure 5.12: a) Government net balance with the noGB/SDH government framework. b) Government net balance with the noInt/CGS government framework

CO2 emissions

Regarding the CO_2 savings Figure 5.12 is plotted. As expected, in the case of CO_2 price 3 & 4, only minor deviations occur compared to the existing grid. In fact, the maximum deviation is 5% in total CO_2 savings. However in CO_2 price scenario 2, especially in the case of fuel scenarios 1 & 2 with the noGB/SDH framework, significant discrepancies are noticeable. In the greenfield use case, there were no CO_2 savings, which means a decrease of 17%.

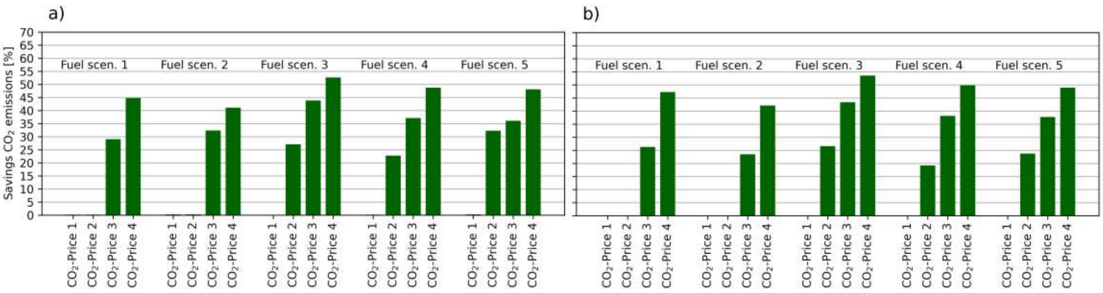

Figure 5.13: CO_2 savings compared to noInt/noSup for each fuel scenario with a) the government framework noGB/SDH b) the government framework noInt/CGS

5.2 Increasing government support

Government subsidies can play a significant role in encouraging building owners to switch to an environmentally friendly DH. This section examines the impact of increasing government support while not taking into account any government intervention as is currently the case. For the analysis, it is assumed that the government provides subsidies for all construction work related to switching from a gas heating system to a DH system, covering both the power-dependent and area-dependent costs of a DH system. In this sensitivity analysis, the subsidies range from 30% to 100% of the construction costs.

5.2.1 Individual exit

Heating system

In Figure 5.14, one can see the percentage of houses and thermal demand that have adopted DH due to government subsidies. The graph illustrates that there are significant differneces depending on whether the price of gas is lower or higher than the price of DH. When the price of DH is lower than the price of gas (Fuel scenario 3-5), only a 30% heating system renovation cost subsidy is enough to cover 80% of the thermal demand with DH. This equals 40% of all buildings in the 8$^{\text{th}}$ district. By increasing the subsidies even more, the peak heat capacity comes closer to 100%. Eventually, after 70% of the subsidies, the peak heat capacity reaches 100%. Higher subsidies are necessary to encourage building owners with a low thermal demand to switch to district heating.

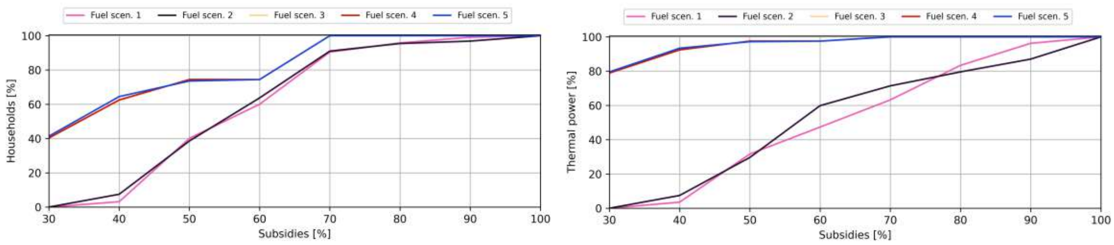

Figure 5.14: Percentage of houses and peak heat capacity that have adopted DH due to government subsidies, for the individual exit

In the case when the gas price is lower than DH (Fuel scenario 1 & 2), subsidies in the amount of 30% would lead to no change of the heating system. However, after the subsidies exceed 30%, there will be a near-linear rise in the thermal demand covered by DH.

When the thermal demand covered by DH reaches 80%, 95% of buildings make this switch when gas prices are high, compared to only 40% when gas prices are low. This is due to the fact that building owners with a high demand find it economically unfeasible to bear the higher fuel costs, even when they receive high subsidies.

Specific investment costs & Net public balance

Regarding the specific investment cost, Figure 5.15 is plotted. Even with a 20% increase in DH users, so to say, an increase of subsidies from 30% to 100% and when the DH price is below the gas price, the specific investment cost can increase up to 46%. In fuel scenario 3, an increase up to 76% is notable. This increase is mainly attributed to the earlier investment decision of the building owners. In the event of high gas prices, the specific investment costs increase due to the higher cost of DH investment.

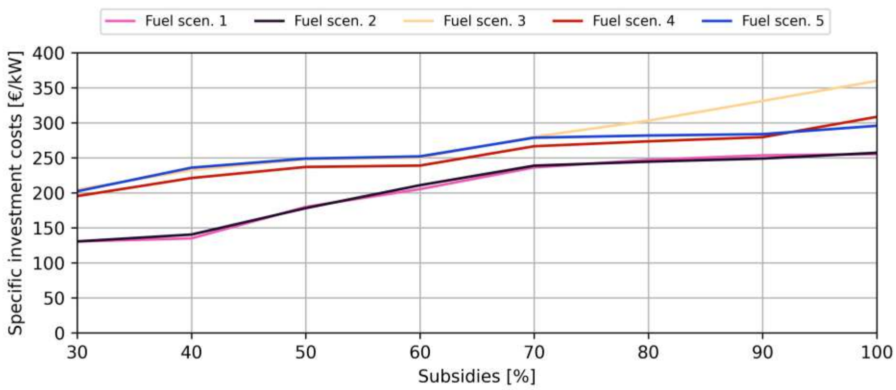

Figure 5.15: Specific investment cost depending on the subsidies provided, for the individual exit

The graph shown in 5.16 displays the net public balance. It can be observed that for fuel scenarios 1 & 2, the public balance is negative when subsidies exceed 40%. Similarly, in fuel scenarios 3 - 5, the public balance becomes negative when subsidies surpass 30%.

When the entirety of buildings are supplied by DH, fuel scenarios 3-5 result in a public net balance of approximately -18.5M€ to 20M€. However, fuel cases 1 & 2 create a net public deficit of 25.8M€ at the 100% mark.

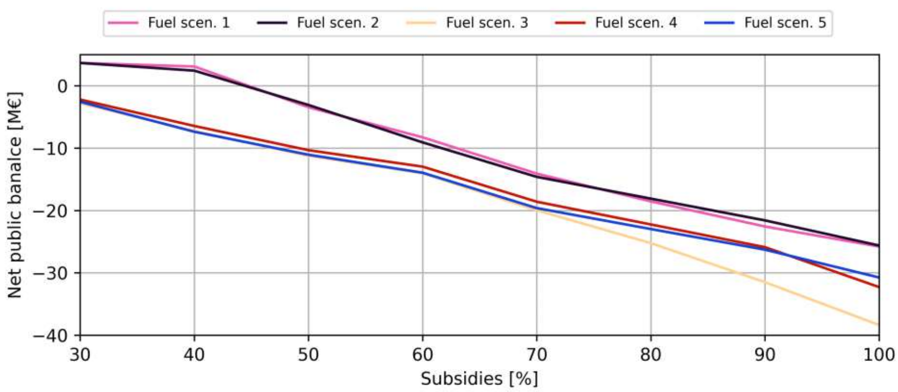

Figure 5.16: Net public balance depending on the subsidies provided, for the individual exit

CO2 emissions

The figure depicted in 5.17 exhibits the CO_2 savings for the five fuel scenarios. Generally, there is a linear increase in savings for fuel scenarios 1 and 2 when subsidies exceed 40%. When subsidies reach 100%, it is possible to achieve up to 33% CO_2 savings.

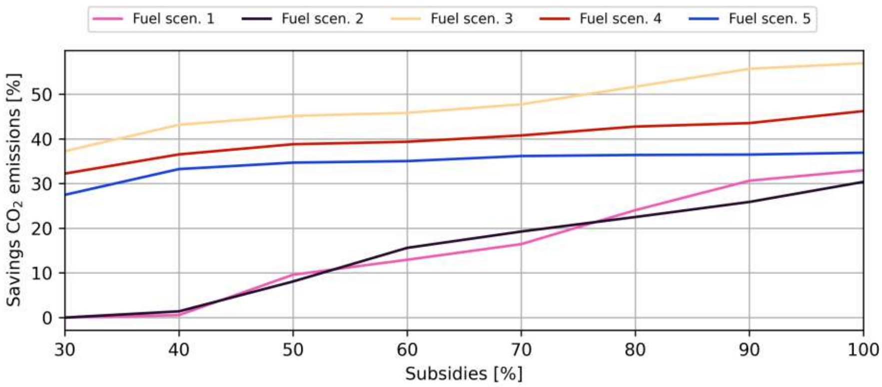

Figure 5.17: CO_2 savings compared to noInt/noSup depending on the government subsidies, for the individual exit

When it comes to fuel scenarios 3 - 5, it is possible to achieve maximum savings in the range of 37% to 57%. It is worth noting that in the case of fuel scenario 5, the savings won't increase once subsidies reach 70%. This means that increasing subsidies won't encourage building owners to change their heating system earlier. However, this is not the case with the other two fuel scenarios. Notably, in fuel scenario 3, a further increase of 10% in savings is notable after exceeding 70% of subsidies.

5.2.2 System-oriented exit/Existing grid

Heating system

The graph 5.18 presents the rate of adoption of DH systems among households and peak heat capacity, based on the government subsidies received. For fuel scenarios 3 - 5, a significant decrease in the use of DH systems is noticeable when the government refunds only 30% of the cost. In fact, only 9% of all houses use DH systems, compared to 40% in the individual use case.

In fuel scenarios 3 - 5, there is a clear trend of a nearly linear increase in the adoption of DH by households and a corresponding increase in the peak heat capacity supplied by the system. It's important to note that a 100% supply by DH is only achieved by fuel scenarios 3 - 5 when subsidies reach 100%. In contrast, even when subsidies reach 100% in fuel scenarios 1 & 2, at best, only 66% of all households are connected to the district heating grid.

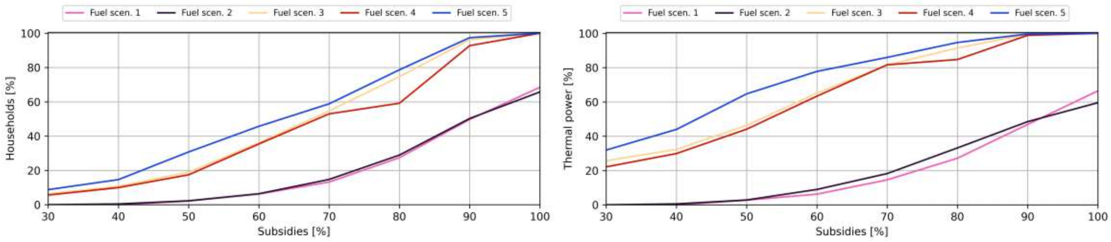

Figure 5.18: Percentage of houses and peak heat capacity that have adopted DH due to government subsidies, for the existing grid

Specific investment costs & Net public balance

The graph shown in 5.19 follows a similar trend to the proportion of buildings transitioning to DH. When the DH grid is entirely constructed, and all buildings are supplied through it, the investment cost related to the grid infrastructure will be approximately 19.5% of the total investment cost. In the case of fuel scenarios 1 & 2, 42% less money is invested in the grid as compared to a full grid expansion.

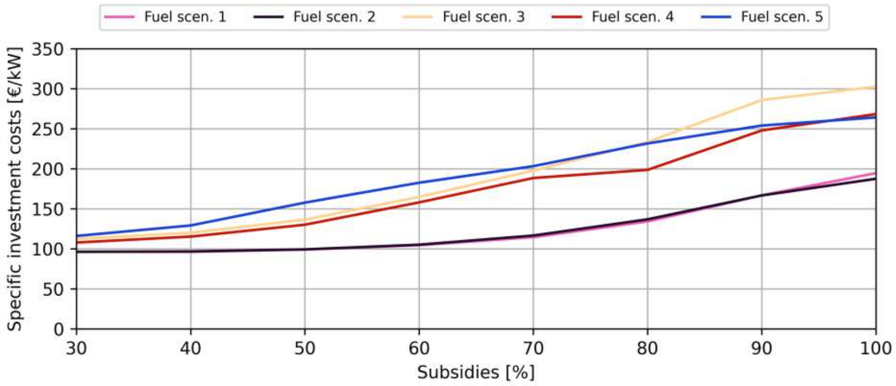

Figure 5.19: Specific investment cost depending on the subsidies provided, for the existing grid

The graph shown in 5.16 displays the net public balance. It can be observed that for fuel scenarios 3-5, the public balance is negative when subsidies exceed 40%. Similarly, in fuel scenarios 1 & 2, the public balance becomes negative when subsidies surpass 70%. It is noteworthy that at this point, only 15% - 18% of the peak heat capacity is being supplied with DH. In contrast, when fuel scenarios 3-5 reach net zero, at least 30% of the thermal demand is being supplied by DH.

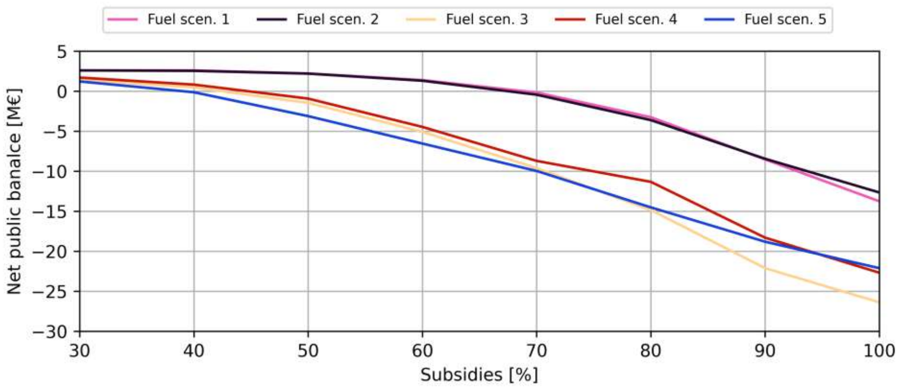

Figure 5.20: Net public balance depending on the subsidies provided, for the existing grid

When the entirety of buildings are supplied by DH, fuel scenarios 3 - 5 result in a public net balance of approximately -22M€ to 26M€. However, fuel cases 1 & 2 create only a net public deficit of 14M€, when subsidies are at 100%. Notably, in these scenarios, only 66% of all households are supplied by DH.

CO2 emissions

The year in which the heating system is installed can have a significant impact on the amount of CO_2 savings that are realized, as illustrated in Figure 5.21. Even if a DH system is installed in all buildings, a considerable range of CO_2 savings can be observed. In fuel scenario 3, for instance, CO_2 savings of up to 56% can be achieved in comparison to noInt/noSup. In contrast, fuel scenario 5 can only facilitate up to 36% of CO_2 savings.

It should be noted that subsidies play a crucial role in fuel scenarios 1 & 2 in terms of CO_2 emissions. Specifically, CO_2 emissions remain negligible as long as subsidies do not exceed 50%. However, a steady increase in emissions is observed once subsidies reach 60%. Notably, when subsidies reach 100%, fuel scenarios 1 & 2 can achieve up to 21% savings in CO_2 emissions.

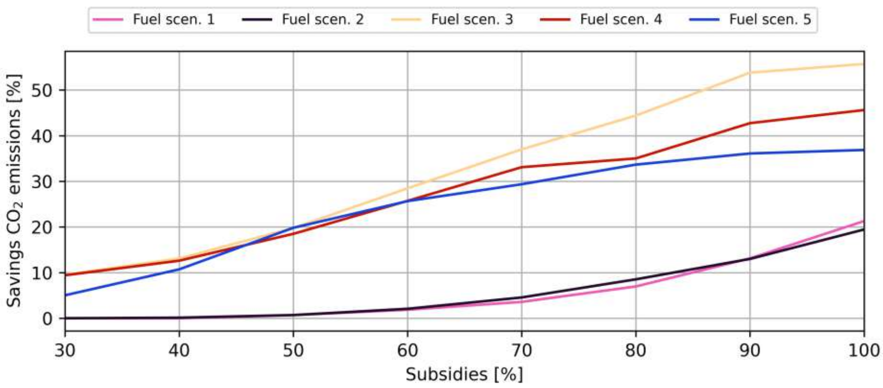

Figure 5.21: CO_2 savings compared to noInt/noSup depending on the government subsidies, for the existing grid

5.2.3 System-oriented exit/Greenfield

Heating system

At the end of this sensitivity analysis, the impact of rising government subsidies is investigated for the greenfield use case. The findings, depicted in Figure 5.22, show the percentage of houses and peak heat capacity that have switched to DH. Notably, it requires significantly higher subsidies to encourage the development of the DH grid to supply customers, when compared to the existing grid. If there is no existing grid, at least 40% subsidies are needed to start expanding the grid. In fuel scenarios 3 - 5, where DH prices are below the gas price, and with 100% subsidies, the DH grid is fully developed.

The absence of an existing grid poses a more significant challenge in the case of fuel scenarios 1 & 2. Due to the high upfront investment cost of the grid necessitates at least 90% of subsidies in the greenfield scenario to establish a DH grid. The results show that when subsidies reach 100%, the outcomes approach those of the existing grid. In this case, the results indicate that DH supplies at least 51% of households, which is approximately 15% less than that of the existing grid.

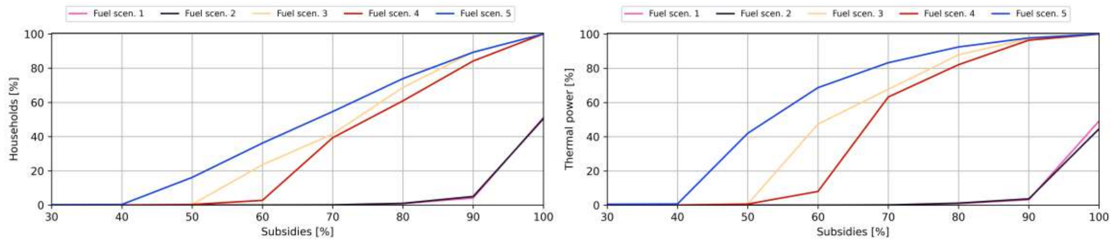

Figure 5.22: Percentage of houses and peak heat capacity that have adopted DH due to government subsidies, for the greenfield use case

Specific investment costs & Net public balance

The diagram in reference 5.23 illustrates the specific investment costs associated with the green field use case, in relation to the subsidies provided by the government. Notably, the specific investment cost in the case of a fully built grid (i.e., 100% subsidies and fuel scenarios 3-5) is distinguished from the existing grid use case by the grid investment cost. The grid investment costs constitute 30% of the total investment costs in the green field use case and result in an additional cost increase of 10% compared to the existing grid.

In fuel scenarios 1 and 2, the specific investment cost remains constant at 96€/kW until subsidies reach 90%, after which it increases to a peak of 182€/kW at 100% subsidies. It is worth noting that 19% of these costs pertain to the expansion of the DH network, which equates to roughly 54% of the entire network expansion costs.

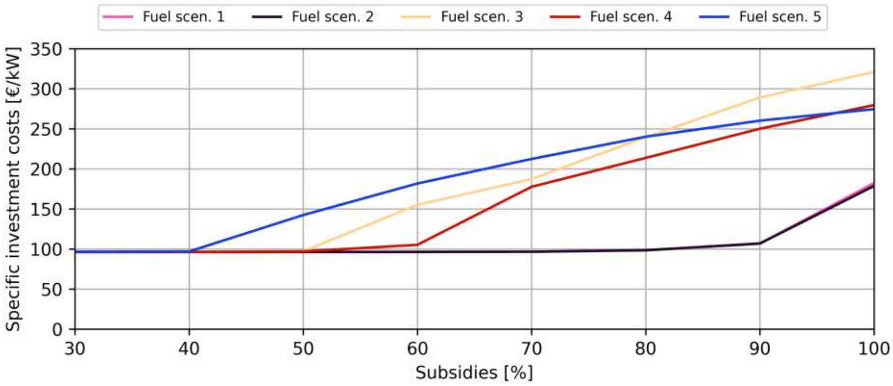

Figure 5.23: Specific investment cost depending on the subsidies provided, for the greenfield use case

The graph shown in Figure 5.24 displays the net public deficit. Scenarios 1 & 2 for fuel show a positive net public balance, except for the 100% subsidies scenario, where the net public deficit amounts to 10M€. This is because only a small number of subsidies were issued for the transition to DH.

For fuel scenarios 3 - 5 at 100% subsidies, the net public deficit is similar to that of the existing grid, as all buildings have been converted to DH. However, the main difference is that net zero is reached at a higher subsidy amount due to the fact that higher subsidies are required to encourage building owners to switch to DH.

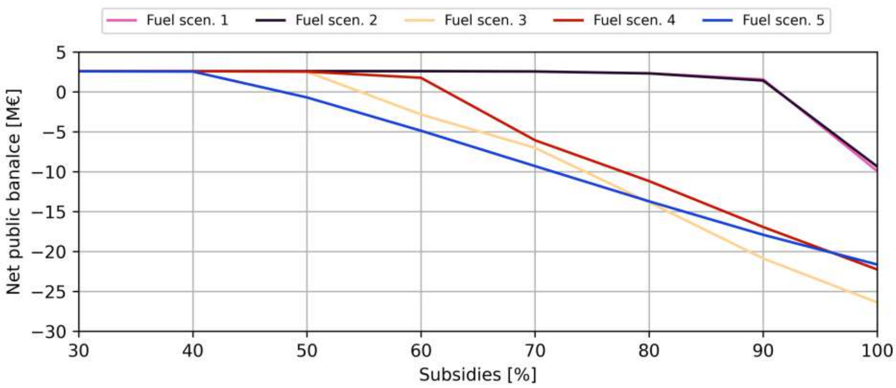

Figure 5.24: Net public balance depending on the subsidies provided, for the greenfield use case

CO2 emissions

According to Figure 5.25, fuel scenarios 1 and 2 achieve limited CO_2 savings, with only a 15.5% reduction with 100% subsidies. This is 5.5% less than the existing grid. However, in fuel scenarios 3-5 the same amount of CO_2 savings as the existing grid are achieved when subsidies are set at 100%.

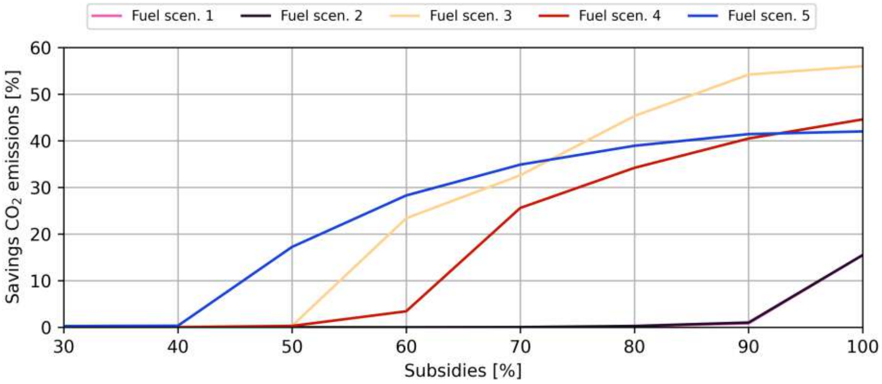

Figure 5.25: CO_2 savings compared to noInt/noSup depending on the government subsidies, for the individual exit

6 Synthesis and discussion

The thesis proposes a linear optimization model to determine the most economically efficient investment decision between two heating systems - DH and gas boiler. Thereby, the model takes into account the needs of the whole heating system, including the heating infrastructure of the multi-residential property owners and tenants as well as the DH grid owner. The results of the optimal heating system choice are examined for three different use cases and under different political frameworks.

The results of each use case demonstrate that the expansion status of the DH network significantly influences the investment decision for the entire system. Upon closer examination of individual buildings, specific scenarios emerge where the transition to DH is financially viable. For instance, if DH prices decrease below gas prices or government subsidies for the DH price, in case of a higher gas price. Notably, properties with low insulation standards and, consequently, high thermal demand tend to profit even more from these mentioned factors. In contrast, buildings with good insulation tend to prefer gas boilers as the conversion costs for DH systems are substantially higher. To achieve decarbonisation in well-insulated buildings, it is vital to implement political measures, such as prohibiting the installation of gas boilers in new buildings when a connection to a DH network exists. When investigating the impact of government policies, it becomes apparent that the current government framework is not as effective as subsidies for the DH price or prohibiting the sale of gas. However, the current framework has the advantage of requiring less financial resources. Against expectations, the highest financial support is needed when subsidising DH, not when gas boilers are refunded, as is the case during a complete shutdown of gas for individual space heating in the year 2030. The minimal government spending is related to the early announcement of the shutdown in 2023. This means that for buildings where the gas boiler needs to be replaced between 2023 and 2030, it is not economically feasible to install a new one and replace it with a DH system a couple of years later, as the governmental subsidies are too low. From a government perspective, these so-called "first movers" shouldn't be left unaccounted for when it comes to subsidizing these DH heating systems. Upon consideration of the grid status, a substantial reduction in changes to DH is apparent. Although a decrease of more than 50% occurred in the current grid use case, there is no expansion advised in the greenfield scenario (i.e., assuming that there is no DH grid available). However, with these results, it is essential to note that revenue from network fees has not been taken into account in order to highlight the actual cost of system-oriented planning. This shows the clear advantage of the gas network over the DH network. The gas network has been in operation for several decades and has already been fully amortized. Apart from political interventions, two key considerations that significantly influence the decision-making process for selecting a heating system are the CO_2 price and government subsidies, which are both subject to sensitivity analysis. From both analyses, it is evident that a significant increase in both government subsidies and CO_2 price is necessary to cause a transition to an environmentally sustainable heating system like DH. It is worth noting that relying on only one of the two factors likely will not suffice to achieve the desired results. Consequently, the taxes collected from CO_2 should also be spent as subsidies for the purpose of switching to DH.

The findings derived from the study not only provide assistance to the Austrian government in developing the DH network but also furnish a platform for further advancement of the DH system of other countries with an already established and highly efficient DH network, such as Denmark. As such, the findings presented in this thesis demonstrate how additional political measures can promote the continued expansion of DH in these countries. It should be noted that the results presented in this thesis are relevant not only to cities with established DH networks but also to cities without DH. Even for those without a DH grid, this thesis offers a political approach to guide the government in establishing one. However, to achieve the desired results, the city's heat density must be comparable or higher to that of Vienna. If this criterion is not met, the result will differ from the outcomes of the thesis, as more investment in the grid infrastructure will be required. A critical decision factor in whether to use DH or gas boilers is the fuel price. In certain northern European Union countries, such as Sweden, the Netherlands, or Denmark, gas prices are notably higher than those in Austria, primarily due to the imposition of additional taxes. A significant increase in the price of gas results in a much faster transition to sustainable and alternative options such as DH, making these technologies compatible with gas. This thesis also provides an appropriate approach to achieving this transition with rising taxes through sensitivity analyses.

In the future, an important aspect to consider is house renovation, which plays a crucial role in the process of reducing carbon emissions. One of the limitations of the model is that these retrofitting mechanisms are not considered. It has been observed that buildings that are well-insulated tend to be hesitant to connect to the DH grid, primarily due to high investment costs and low thermal demand. Therefore, including house renovations in the model, can significantly alter the outcome of the DH evaluation. Also, it is essential to consider alternative technologies when assessing DH systems. One such alternative is heat pumps, which are a viable option in countries with low electricity costs like Norway, Sweden, and Finland. In these countries, heat pumps must be included in the model when assessing the value of DH.

7 Conclusions and outlook

When it comes to addressing climate change and reducing carbon emissions, it is essential to evaluate different sustainable alternatives such as DH. However, the adoption of such technologies is often associated with increased costs. The present research demonstrates that despite both individual and system-oriented planned perspectives, not all buildings have changed their heating systems to DH and instead opted to continue using gas boilers.

Although the actual results differed from expectations when comparing both perspectives, the chosen methodology to address the research question remains appropriate. In particular, the applied approach successfully identifies system boundaries, determining which costs were borne by whom.

In order to achieve a transition towards environmentally sustainable alternatives, policymakers must undertake appropriate measures. One such measure, which has been shown to be highly effective in decarbonizing the space heating sector, is the implementation of a ban on gas for individual space heating. Although this ban is a sensitive subject in society, as it results in high upfront costs for many stakeholders, it is a straightforward intervention that can provide planning security for many end customers, as well as a significant reduction in CO_2 emissions over the long term.

By extending the existing literature with other various types of government frameworks, an in-depth analysis of different political frameworks, such as the before-mentioned ban on gas or also the ban on gas boilers, is now possible. Moreover, different grid scenarios can be analysed with the designed model.

Nonetheless, it is noteworthy that crucial technologies and opportunities, such as heating pumps and building renovations, have been left unaccounted for in this thesis. To further improve this optimization model, these opportunities need to be included, and the timeframe should be extended up to 70 years since building renovations are a long-term investment. Moreover, in the system-oriented planned perspective, revenues for the grid owner can be included to fully include the objectives of this stakeholder.

In the future, the model can be redesigned in order to be utilized in other potential technologies, such as district cooling. District cooling is gaining popularity, mainly because the average temperature during summer months is consistently rising. As a result, district cooling has the potential to be a practical solution for densely populated urban areas to cool their rooms. Although the primary focus of this thesis is on DH, the design for the district cooling network can be replicated in its entirety. It is essential to assume a greenfield scenario when planning a district cooling network since no grid infrastructure exists in most cases. Furthermore, it is crucial to note that only a few end customers are equipped with cooling devices and heat pumps must be considered as they are the most significant competitors. Additionally, it is vital to assess the appropriate cooling demand beforehand in order to enable the assessment of the long-term profitability of such an investment.

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Appendix

Appendix A

Demand Curves

Year	Month	DC 1	DC2	DC 3	DC 4	DC 5	DC 6	DC 7	DC 8	DC 9	DC 10	DC 11
2010	1	2,159566038	4,34829907	8,75385185	13,2150826	17,7304727	22,2985586	26,9179286	31,5872212	36,3051228	41,0703652	45,8817241
2010	2	1,593830189	3,22063551	6,50607407	9,85453211	13,2642909	16,7336937	20,2611429	23,8450973	27,4840702	31,1766261	34,9213793
2010	3	1,070188679	2,18011215	4,4397037	6,77757798	9,19301818	11,6863964	14,2568571	16,9033274	19,626386	22,4253391	25,3034483
2010	4	0,45509434	0,94986916	1,97955556	3,08895413	4,27869091	5,54954955	6,90342857	8,33953982	9,85936842	11,4608348	13,1455172
2010	5	0,133773585	0,29506542	0,64696296	1,06062385	1,53861818	2,08495495	2,70364286	3,39530973	4,16336842	5,01307826	5,94793103
2010	6	0,022169811	0,05237383	0,122	0,21341284	0,33047273	0,47846847	0,66021429	0,87915044	1,13515789	1,4292	1,76
2010	7	0	0	0	0,00038532	0,00261818	0,00801802	0,01778571	0,03431858	0,06231579	0,10252174	0,16344828
2010	8	0,016188679	0,03676636	0,08274074	0,1386055	0,20538182	0,28333333	0,37414286	0,47984071	0,6085614	0,75693913	0,93034483
2010	9	0,103641509	0,23080374	0,51207407	0,84957798	1,24494545	1,70333333	2,23071429	2,83617699	3,51887719	4,2825913	5,12862069
2010	10	0,728207547	1,50975701	3,12511111	4,84447706	6,66589091	8,58756757	10,6073571	12,7232743	14,9319298	17,2311652	19,6186207
2010	11	0,834169811	1,71214953	3,51081481	5,39466055	7,36261818	9,4136036	11,5461429	13,7607611	16,0547368	18,4258957	20,8758621
2010	12	2,213490566	4,45514019	8,96555556	13,5297248	18,1461818	22,8135135	27,5303571	32,2953982	37,1073684	41,9650435	46,8672414
2011	1	1,754301887	3,54534579	7,16281481	10,850422	14,6062545	18,4284685	22,3152857	26,2649912	30,2759298	34,3465043	38,4751724
2011	2	1,628830189	3,28964486	6,64207407	10,0557248	13,5290182	17,0602703	20,6481429	24,2913628	27,9882105	31,7374435	35,5382759
2011	3	0,980113208	2,00317757	4,09111111	6,264	8,52145455	10,8614414	13,2827143	15,7856814	18,3694035	21,0322957	23,7731034
2011	4	0,231245283	0,49357009	1,05096296	1,67438532	2,36625455	3,13	3,96514286	4,87509735	5,86245614	6,93062609	8,0762069
2011	5	0,14454717	0,31162617	0,66948148	1,07537615	1,5296	2,03414414	2,58921429	3,19695575	3,86049123	4,58358261	5,36931034
2011	6	0,003169811	0,00848598	0,02222222	0,04249541	0,07025455	0,10927928	0,16178571	0,22846018	0,31298246	0,41650435	0,54034483
2011	7	0,006433962	0,01742056	0,04622222	0,0906055	0,15229091	0,23432432	0,33942857	0,46906195	0,62961404	0,8229913	1,05586207
2011	8	0,005735849	0,01373832	0,03222222	0,05587156	0,08494545	0,12126126	0,16521429	0,21842478	0,28463158	0,36328696	0,45655172
2011	9	0,030226415	0,06925234	0,15703704	0,26658716	0,39970909	0,55954955	0,74978571	0,97182301	1,22975439	1,52514783	1,86034483
2011	10	0,585924528	1,21448598	2,51303704	3,89444037	5,35694545	6,90108108	8,52621429	10,2322655	12,021614	13,8908348	15,8393103
2011	11	1,36654717	2,77484112	5,63162963	8,56811009	11,5821091	14,6715315	17,8343571	21,0686372	24,3724912	27,7441043	31,1817241
2011	12	1,335603774	2,7157757	5,51903704	8,40737615	11,3784727	14,4300901	17,5600714	20,7663363	24,0468772	27,3997565	30,8231034
2012	1	1,55309434	3,14669159	6,37288889	9,67640367	13,0551273	16,507027	20,0301429	23,6225841	27,2825263	31,0082087	34,797931
2012	2	2,066056604	4,15854206	8,36896296	12,6298349	16,9397818	21,2974775	25,7016429	30,1510442	34,6444912	39,1808348	43,7589655
2012	3	0,713773585	1,47179439	3,03155556	4,67823853	6,4112	8,23054054	10,1348571	12,1248673	14,1992982	16,355113	18,5937931
2012	4	0,507679245	1,05291589	2,18177778	3,38757798	4,66967273	6,02792793	7,46335714	8,9759823	10,5644912	12,229513	13,9724138
2012	5	0,105735849	0,22790654	0,48933333	0,7852844	1,11796364	1,48918919	1,90092857	2,35410619	2,8485614	3,38713043	3,97241379
2012	6	0,010867925	0,02657944	0,06503704	0,11917431	0,19185455	0,28522523	0,40307143	0,54810619	0,72280702	0,9288	1,16586207
2012	7	0,000660377	0,00226168	0,00762963	0,01772477	0,03389091	0,05936937	0,09664286	0,15077876	0,22596491	0,31977391	0,43482759
2012	8	0,001283019	0,00471028	0,01422222	0,02994495	0,05294545	0,08612613	0,12985714	0,18460177	0,25066667	0,32853913	0,42241379
2012	9	0,056943396	0,12833645	0,28807407	0,48390826	0,71752727	0,99081081	1,30928571	1,67764602	2,09880702	2,57947826	3,11586207
2012	10	0,516132075	1,07760748	2,24577778	3,50411009	4,85250909	6,28990991	7,81457143	9,42584071	11,1236491	12,9119478	14,7868966
2012	11	0,87154717	1,79375701	3,68725926	5,67781651	7,76305455	9,94072072	12,2080714	14,5627257	17,002386	19,5248348	22,127931
2012	12	1,759226415	3,5551028	7,18214815	10,879156	14,6442182	18,4754955	22,3712143	26,3296637	30,349193	34,4282087	38,5651724
2013	1	1,797754717	3,63134579	7,33318519	11,103633	14,9408	18,8428829	22,8081429	26,8349027	30,9215439	35,0665043	39,2682759
2013	2	1,557037736	3,1477757	6,3617037	9,6399633	12,9808	16,3825225	19,8435	23,3621593	26,9369825	30,5665043	34,2493103
2013	3	1,49554717	3,03134579	6,14214815	9,33099083	12,5957818	15,934955	19,3465714	22,8284248	26,3792281	29,9978609	33,6824138
2013	4	0,488320755	1,00394393	2,06333333	3,18088073	4,35796364	5,59513514	6,89528571	8,26185841	9,696	11,1953739	12,7603448
2013	5	0,151716981	0,33115888	0,71881481	1,1647156	1,6704	2,24045045	2,87507143	3,57631858	4,34835088	5,19730435	6,12241379
2013	6	0,068207547	0,15226168	0,3377037	0,55893578	0,81890909	1,11882883	1,46057143	1,8520885	2,29277193	2,78092174	3,31758621
2013	7	0,000226415	0,00072897	0,00207407	0,00445872	0,00785455	0,01243243	0,018	0,02490265	0,03368421	0,04570435	0,06310345
2013	8	0	0	0,00014815	0,00159633	0,00610909	0,0163964	0,03664286	0,07037168	0,12491228	0,20848696	0,31689655
2013	9	0,094301887	0,21082243	0,46866667	0,77752294	1,14050909	1,56045045	2,03914286	2,58157522	3,19045614	3,86890435	4,6137931
2013	10	0,362339623	0,76983178	1,63118519	2,58489908	3,63243636	4,77495495	6,01178571	7,34702655	8,78287719	10,3160348	11,9465517
2013	11	0,968396226	1,98416822	4,06140741	6,2293211	8,48610909	10,8296396	13,2572143	15,7667257	18,3564912	21,0250957	23,7710345
2013	12	1,440754717	2,92411215	5,93185185	9,02091743	12,1890909	15,4342342	18,7542857	22,1472566	25,6112281	29,1443478	32,7448276
2014	1	1,577924528	3,19588785	6,47037037	9,8212844	13,2465455	16,7441441	20,3121429	23,9486726	27,6519298	31,4201739	35,2517241
2014	2	1,15754717	2,35626168	4,79333333	7,30899083	9,90109091	12,5675676	15,3064286	18,1157522	20,9936842	23,9384348	26,9482759
2014	3	0,583773585	1,21263551	2,51577778	3,90985321	5,3952	6,97081081	8,63828571	10,3954336	12,2411228	14,1760174	16,1975862
2014	4	0,269226415	0,57276636	1,21614815	1,93249541	2,72363636	3,59441441	4,54607143	5,57844248	6,69305263	7,89229565	9,17448276
2014	5	0,194018868	0,41764486	0,8962963	1,43790826	2,04450909	2,7181982	3,45985714	4,27037168	5,14835088	6,09401739	7,10827586
2014	6	0,003584906	0,0108785	0,032	0,06605505	0,11549091	0,18063063	0,26571429	0,37106195	0,50021053	0,66083478	0,85344828
2014	7	0,000301887	0,00145794	0,00496296	0,01155963	0,02123636	0,03522523	0,05571429	0,08672566	0,12687719	0,17984348	0,24586207
2014	8	0,004886792	0,0126729	0,03214815	0,06231193	0,10516364	0,16216216	0,23764286	0,33785841	0,46175439	0,60730435	0,78103448
2014	9	0,042150943	0,0988785	0,2297037	0,39776147	0,61207273	0,87792793	1,20192857	1,58559292	2,032	2,54786087	3,13103448
2014	10	0,321150943	0,67097196	1,4022963	2,19968807	3,06865455	4,01882883	5,05414286	6,17511504	7,37796491	8,6702087	10,0503448
2014	11	0,788037736	1,62342056	3,34074074	5,15031193	7,05047273	9,04063063	11,1212143	13,2893451	15,5438596	17,8838609	20,3048276
2014	12	1,376018868	2,79499065	5,67459259	8,63686239	11,68	14,8028829	18,0034286	21,2790088	24,6276491	28,0474435	31,5365517
2015	1	1,470433962	2,98142056	6,04259259	9,18137615	12,3957818	15,683964	19,0442143	22,4748319	25,9741754	29,5422261	33,1772414
2015	2	1,420320755	2,8768972	5,82496296	8,84223853	11,9268364	15,0769369	18,2907857	21,5666903	24,9030175	28,2981913	31,7506897
2015	3	0,940943396	1,93125234	3,96	6,08488073	8,304	10,6159459	13,0185	15,5101416	18,0895439	20,7550957	23,5037931
2015	4	0,47390566	0,982	2,03288889	3,1539633	4,34778182	5,61423423	6,954	8,36890265	9,85824561	11,4187304	13,0551724
2015	5	0,097943396	0,22050467	0,49251852	0,81930275	1,20465455	1,6518018	2,16814286	2,75440708	3,40996491	4,13593043	4,93413793
2015	6	0,009716981	0,02461682	0,06125926	0,11146789	0,17687273	0,26099099	0,36514286	0,4919823	0,64561404	0,83191304	1,04931034
2015	7	0,000169811	0,00052336	0,00162963	0,00385321	0,00727273	0,01297297	0,02121429	0,03382301	0,05164912	0,07513043	0,10551724
2015	8	0	1,8692E-05	0,0002963	0,0013211	0,00378182	0,00936937	0,01907143	0,03246018	0,05192982	0,07982609	0,11827586
2015	9	0,062264151	0,1451215	0,33466667	0,57522936	0,86778182	1,2145045	1,62128571	2,09306195	2,63129825	3,24469565	3,93137931
2015	10	0,520773585	1,09151402	2,28385185	3,57616514	4,96785455	6,46135135	8,05264286	9,74102655	11,5250526	13,4020174	15,3748276
2015	11	0,69954717	1,43515888	2,94192593	4,52152294	6,17483636	7,90522523	9,71164286	11,5962124	13,5621053	15,6096	17,7368966
2015	12	1,321320755	2,68738318	5,46259259	8,32337615	11,2674909	14,2926126	17,3965714	20,5772743	23,8327018	27,1609043	30,56
2016	1	1,746566038	3,52899065	7,12851852	10,7968624	14,5323636	18,3334234	22,1993571	26,1294513	30,122386	34,1752696	38,2865517
2016	2	0,946867925	1,93841121	3,9657037	6,08080734	8,28130909	10,5657658	12,9323571	15,3785664	17,9025965	20,5029391	23,1775862
2016	3	0,989811321	2,02693458	4,14733333	6,35922936	8,6608	11,05	13,5248571	16,0842655	18,7284211	21,4549043	24,2627586
2016	4	0,424150943	0,88833645	1,85777778	2,91027523	4,04567273	5,26432432	6,56957143	7,95769912	9,42792982	10,9834435	12,6258621
2016	5	0,130886792	0,2868785	0,62644444	1,02253211	1,4768	1,99162162	2,56842857	3,2119469	3,92224561	4,70081739	5,54724138
2016	6	0,000415094	0,00117757	0,00362963	0,00809174	0,01541818	0,02747748	0,04692857	0,07830088	0,128	0,20457391	0,31241379
2016	7	0,001018868	0,00304673	0,00888889	0,01816514	0,03127273	0,05135135	0,07864286	0,11361062	0,1597193	0,22069565	0,29413793
2016	8	0,004207547	0,01029907	0,02511111	0,04601835	0,07389091	0,10990991	0,15428571	0,20715044	0,2714386	0,35170435	0,45551724
2016	9	0,021566038	0,05046729	0,11674074	0,20097248	0,30458182	0,43072072	0,58028571	0,75674336	0,95859649	1,19332174	1,46551724
2016	10	0,55090566	1,15321495	2,40866667	3,76557798	5,22210909	6,77693694	8,42678571	10,1720531	12,0084211	13,9366957	15,9572414
2016	11	1,141641509	2,32751402	4,7422963	7,24299083	9,82821818	12,4954054	15,2432143	18,069292	20,9712281	23,9478261	26,9965517
2016	12	1,665962264	3,37031776	6,816	10,3349725	13,9252364	17,5848649	21,312	25,1048496	28,9616842	32,8808348	36,8606897
2017	1	2,382981132	4,79095327	9,63096296	14,5186789	19,4528	24,4320721	29,4552857	34,5212743	39,6289123	44,777113	49,9648276
2017	2	1,283962264	2,60530841	5,28466667	8,03653211	10,8590545	13,7510811	16,7104286	19,7356637	22,8252632	25,9771304	29,1910345
2017	3	0,615037736	1,27730841	2,64859259	4,11357798	5,67185455	7,32279279	9,06492857	10,8970796	12,818807	14,8293391	16,9262069
2017	4	0,544415094	1,13257944	2,35288889	3,66187156	5,05890909	6,54513514	8,11757143	9,77670796	11,5216842	13,3522435	15,267931
2017	5	0,111433962	0,23927103	0,51288889	0,82359633	1,17265455	1,56441441	2,00507143	2,49584071	3,0394386	3,64132174	4,30413793
2017	6	0,000716981	0,00205607	0,0057037	0,01117431	0,01963636	0,03540541	0,06	0,09453097	0,13810526	0,19471304	0,2662069
2017	7	0,000150943	0,00057944	0,00222222	0,00605505	0,01250909	0,02288288	0,039	0,06442478	0,09964912	0,14838261	0,21172414
2017	8	0,000226415	0,00099065	0,00325926	0,00737615	0,01396364	0,02405405	0,03814286	0,05761062	0,08589474	0,12443478	0,17103448
2017	9	0,077584906	0,18074766	0,41503704	0,70673394	1,05934545	1,4790991	1,968	2,53015929	3,17052632	3,89222609	4,6937931
2017	10	0,28290566	0,60865421	1,30437037	2,08965138	2,96567273	3,93279279	4,99114286	6,13968142	7,37880702	8,70714783	10,1244828
2017	11	1,007415094	2,06185047	4,21681481	6,46343119	8,79898182	11,221982	13,7299286	16,3211504	18,9939649	21,7458783	24,5744828
2017	12	1,435735849	2,91409346	5,912	8,99141284	12,1501091	15,3859459	18,6968571	22,0808496	25,536	29,0604522	32,6524138
2018	1	1,306245283	2,65725234	5,40266667	8,23392661	11,1489455	14,1457658	17,2219286	20,3753274	23,6039298	26,9057739	30,2789655
2018	2	1,82390566	3,67652336	7,40940741	11,1971009	15,0381091	18,930991	22,8743571	26,8668673	30,9072281	34,9941913	39,1265517

2018	3	1,397490566	2,83738318	5,75822222	8,76077064	11,8442182	15,0058559	18,2442857	21,5569027	24,9423158	28,3983652	31,9231034
2018	4	0,136886792	0,29328972	0,62674074	1,00420183	1,42807273	1,89918919	2,4195	2,99054867	3,61431579	4,29777391	5,03931034
2018	5	0,013981132	0,03381308	0,08022222	0,14223853	0,22283636	0,32828829	0,46028571	0,6220708	0,81515789	1,04853913	1,32137931
2018	6	0,004603774	0,01171963	0,02903704	0,0533945	0,08567273	0,12792793	0,1845	0,25819469	0,34863158	0,45986087	0,59482759
2018	7	0,002150943	0,00519626	0,01222222	0,02163303	0,03418182	0,05009009	0,06985714	0,09428319	0,12350877	0,15714783	0,19551724
2018	8	0,001188679	0,0035514	0,00962963	0,01904587	0,03170909	0,04774775	0,06792857	0,09230088	0,12238596	0,1584	0,2
2018	9	0,078037736	0,16641121	0,35444444	0,56565138	0,79985455	1,0581982	1,34271429	1,6559646	2,0002807	2,38038261	2,80034483
2018	10	0,202433962	0,43798131	0,944	1,52113761	2,1712	2,89711712	3,702	4,58679646	5,55621053	6,61241739	7,75137931
2018	11	0,954339623	1,95429907	3,99888889	6,13233028	8,35243636	10,6578378	13,0476429	15,5194336	18,0727018	20,7046957	23,4148276
2018	12	1,502811321	3,04706542	6,17548148	9,38300917	12,6674909	16,0268468	19,4590714	22,9622301	26,5344561	30,1739478	33,8789655
2019	1	1,784698113	3,60557009	7,28214815	11,0277798	14,8405818	18,7187387	22,6605	26,664177	30,7281404	34,8508174	39,0306897
2019	2	1,050962264	2,14321495	4,36785185	6,67233028	9,05541818	11,5145946	14,0481429	16,6543009	19,3327719	22,0808348	24,897931
2019	3	0,687056604	1,4233271	2,94422222	4,56181651	6,27505455	8,08306306	9,98314286	11,9733451	14,0513684	16,2153391	18,4668966
2019	4	0,372132075	0,78213084	1,64066667	2,57686239	3,59214545	4,68810811	5,86692857	7,12649558	8,46708772	9,88841739	11,3896552
2019	5	0,280622642	0,59719626	1,26777778	2,01385321	2,83825455	3,74306306	4,72692857	5,79129204	6,93810526	8,16824348	9,48275862
2019	6	0	0	0	0	0	0	0	0	0	0,00031304	0,00206897
2019	7	0	0	7,4074E-05	0,00055046	0,00145455	0,00315315	0,00642857	0,01164602	0,02105263	0,04132174	0,07793103
2019	8	0	0	0,00014815	0,0007156	0,00232727	0,00567568	0,01071429	0,01771681	0,02750877	0,04132174	0,06172414
2019	9	0,038339623	0,0862243	0,19318519	0,32510092	0,48712727	0,68531532	0,92228571	1,20387611	1,53319298	1,91253913	2,34724138
2019	10	0,325679245	0,69095327	1,46325926	2,32040367	3,26210909	4,29072072	5,40792857	6,6120885	7,90624561	9,29066087	10,76
2019	11	0,768320755	1,58743925	3,27503704	5,06014679	6,94021818	8,91333333	10,977	13,1290265	15,3670175	17,6896174	20,0958621
2019	12	1,361811321	2,76766355	5,62185185	8,56018349	11,5803636	14,6801802	17,8575	21,1102655	24,4364912	27,8342609	31,3017241
2020	1	1,691113208	3,41958879	6,91251852	10,4773761	14,1122909	17,8155856	21,5862857	25,4220177	29,3209825	33,2815304	37,302069
2020	2	0,913867925	1,87302804	3,8357037	5,88611009	8,02254545	10,2424324	12,5440714	14,9268496	17,3877895	19,9252174	22,5396552
2020	3	0,903396226	1,85190654	3,79266667	5,82027523	7,93425455	10,1364865	12,4232143	14,7923009	17,2440702	19,7777739	22,3893103
2020	4	0,311924528	0,6537757	1,36785185	2,1433211	2,98167273	3,88567568	4,85678571	5,89833628	7,01473684	8,20455652	9,47
2020	5	0,186792453	0,4048785	0,87474074	1,41363303	2,0224	2,70207207	3,456	4,28486726	5,19214035	6,1812	7,25034483
2020	6	0,009113208	0,02295327	0,05562963	0,1006789	0,16392727	0,24936937	0,36278571	0,50561062	0,67677193	0,88466087	1,1362069
2020	7	0,001	0,00383178	0,01296296	0,02955963	0,05469091	0,08981982	0,135	0,19253097	0,26498246	0,35718261	0,46517241
2020	8	0	7,4766E-05	0,00066667	0,00280734	0,00770909	0,01540541	0,02785714	0,04658407	0,07326316	0,10674783	0,14862069
2020	9	0,072018868	0,15764486	0,344	0,56201835	0,81541818	1,10504505	1,43464286	1,80761062	2,22540351	2,69045217	3,20034483
2020	10	0,405679245	0,85648598	1,8037037	2,84174312	3,97105455	5,19315315	6,50614286	7,91371681	9,41136842	11,0003478	12,6796552
2020	11	1,026981132	2,09828037	4,28385185	6,55502752	8,9104	11,3490991	13,8692143	16,4690796	19,1458246	21,8986435	24,7255172
2020	12	1,447867925	2,93820561	5,95977778	9,06242202	12,2439273	15,5021622	18,8350714	22,2406726	25,7170526	29,2623652	32,8748276
2021	1	1,659943396	3,35839252	6,79237037	10,2998532	13,8788364	17,5273874	21,2436429	25,0258053	28,8721404	32,7809739	36,7506897
2021	2	1,382754717	2,80108411	5,67244444	8,61286239	11,6206545	14,6945045	17,8322143	21,0320885	24,2924912	27,612313	30,99
2021	3	1,097849057	2,23742056	4,55733333	6,95851376	9,43941818	11,9988288	14,6357143	17,349469	20,1397895	23,0046261	25,942069
2021	4	0,722113208	1,48579439	3,05444444	4,70625688	6,43956364	8,25522523	10,1515714	12,1275929	14,1830175	16,3202087	18,5365517
2021	5	0,207113208	0,45185047	0,98155556	1,59385321	2,29265455	3,07774775	3,95207143	4,91759292	5,97333333	7,11829565	8,35310345
2021	6	0,004471698	0,01125234	0,02725926	0,04866055	0,07578182	0,1090991	0,14914286	0,19699115	0,25375439	0,32243478	0,40034483
2021	7	0	0	0	0	0	0	0,00064286	0,00223009	0,00533333	0,0108	0,02241379
2021	8	0,002056604	0,00652336	0,02	0,04205505	0,07447273	0,11990991	0,18021429	0,25955752	0,36126316	0,49038261	0,6562069
2021	9	0,026849057	0,06364486	0,14925926	0,26185321	0,40625455	0,5872973	0,80914286	1,07725664	1,39508772	1,76290435	2,18724138
2021	10	0,442207547	0,93211215	1,95948148	3,08245872	4,30123636	5,61540541	7,02535714	8,52897345	10,1254737	11,8131652	13,5903448
2021	11	1,042754717	2,1331215	4,3597037	6,67717431	9,08305455	11,575045	14,1514286	16,8099115	19,5480702	22,3638261	25,2551724
2021	12	1,452830189	2,94702804	5,97540741	9,08300917	12,2685091	15,5303604	18,8659286	22,2747434	25,7555088	29,3052522	32,922069
2022	1	1,445603774	2,93362617	5,95066667	9,04888073	12,2260364	15,48	18,8087143	22,2101947	25,6825263	29,2238609	32,8324138
2022	2	0,947018868	1,93850467	3,96444444	6,07546789	8,26952727	10,5442342	12,8974286	15,327646	17,8338246	20,4137217	23,0648276
2022	3	1,026396226	2,09459813	4,27274074	6,53350459	8,87607273	11,2999099	13,803	16,3869381	19,0498246	21,7898609	24,6041379
2022	4	0,600622642	1,24302804	2,56933333	3,97976147	5,47461818	7,05324324	8,715	10,4629558	12,2944561	14,2113913	16,2124138
2022	5	0,02545283	0,06018692	0,14014815	0,24500917	0,37890909	0,5454955	0,74742857	0,99325664	1,28421053	1,63017391	2,03
2022	6	0	0	0	0,0006055	0,00450909	0,01405405	0,02871429	0,05166372	0,08673684	0,13429565	0,19551724
2022	7	0	0	0	0	0,00043636	0,00189189	0,00514286	0,01176991	0,02301754	0,04116522	0,06896552
2022	8	0	0	0	0	0	0	0,00085714	0,00569912	0,01431579	0,02973913	0,05344828
2022	9	0,119660377	0,26319626	0,57614815	0,9413945	1,35941818	1,8318018	2,36292857	2,95127434	3,5994386	4,3142087	5,09448276
2022	10	0,174943396	0,39011215	0,86251852	1,42007339	2,06618182	2,80333333	3,63364286	4,55730973	5,57473684	6,69177391	7,90448276
2022	11	0,905641509	1,85908411	3,81207407	5,85699083	7,99185455	10,2148649	12,5245714	14,9187965	17,3956491	19,954487	22,5917241
2022	12	1,567075472	3,17439252	6,42777778	9,75798165	13,1629091	16,6405405	20,1889286	23,8061947	27,4905263	31,2401739	35,0534483
2023	1	2,255582278	4,53965654	9,13441101	13,7816018	18,479307	23,2267792	28,0226103	32,8657069	37,7549572	42,6892229	47,6673332
2023	2	0,553352377	1,15582605	2,40870344	3,75664878	5,19752033	6,72902547	8,34885604	10,0552236	11,8462493	13,7197464	15,6744611
2023	3	1,418933488	2,87786806	5,83471044	8,86914405	11,9796819	15,1650737	18,4227854	21,7511637	25,1493991	28,6164351	32,1498973
2023	4	0,286509396	0,60509223	1,27542582	2,01333254	2,8207901	3,6990801	4,65040693	5,64598534	6,7006589	7,82400265	9,01499489
2023	5	0,308004527	0,65562829	1,3919705	2,21094235	3,11569844	4,10729653	5,18525412	6,35117913	7,6060143	8,95201201	10,3895677
2023	6	0,00079386	0,00297983	0,00911228	0,01938815	0,03574555	0,06026393	0,09500021	0,14192564	0,20293648	0,28186642	0,38008353
2023	7	0	0	0	0	0	0	0	0	0	0	0
2023	8	0,012709156	0,02878673	0,0647309	0,10840542	0,16067499	0,2325206	0,34066029	0,48211749	0,65916367	0,8752638	1,13788309
2023	9	0,01142548	0,03194679	0,08434406	0,16196146	0,26802998	0,40687148	0,58337141	0,80138605	1,06436438	1,37686726	1,74055369
2023	10	0,608391641	1,26162565	2,61313226	4,05450235	5,58516976	7,2049545	8,91427486	10,7120518	12,5982148	14,573054	16,6335591
2023	11	0,689071054	1,42661341	2,94908136	4,56604559	6,27602307	8,07827946	9,97133322	11,9535613	14,0235029	16,1799515	18,4206216
2023	12	1,639475759	3,31778455	6,71181263	10,1799683	13,720284	17,3309432	21,0099447	24,7555426	28,5661292	32,439896	36,3751916
2024	1	1,584422601	3,20847035	6,49483451	9,85713275	13,2933053	16,8013707	20,3796234	24,0262088	27,7393508	31,5173842	35,3586006
2024	2	0,746171314	1,53855952	3,16838965	4,88757376	6,69404136	8,58561692	10,5601128	12,6158163	14,7509851	16,9635268	19,2522911
2024	3	0,397819452	0,84480445	1,78734592	2,82680476	3,9633794	5,19689764	6,525997	7,95083603	9,47085293	11,0839549	12,7888992
2024	4	0,518310893	1,07285024	2,21853828	3,43854133	4,73303909	6,10305191	7,54892869	9,08894287	10,7159563	12,4257092	14,2183245
2024	5	0,334046635	0,7101112	1,50570941	2,3885262	3,36184567	4,42645552	5,58141929	6,82820371	8,16770035	9,60195741	11,1313172
2024	6	0	0	0	0	0	0	0	0	0	0	0
2024	7	0	0	0	0	0	0	0	0	0	0	0
2024	8	0	0	0	0	0	0	0	0	0	0	0
2024	9	0,024406179	0,05860681	0,13885732	0,2451908	0,38055264	0,54890512	0,75491568	1,00207103	1,29345243	1,63364203	2,02426936
2024	10	0,587553533	1,2200361	2,53014699	3,93042153	5,42035538	6,99992387	8,66955904	10,4281712	12,2756217	14,2122592	16,2350052
2024	11	1,288896008	2,61981203	5,32201697	8,10432964	10,9645945	13,9010854	16,9121982	19,9962339	23,1516117	26,3769077	29,669855
2024	12	0,914163119	1,88047859	3,86344929	5,94618321	8,12611723	10,4008569	12,7677282	15,2244924	17,7689175	20,3985198	23,1110717
2025	1	2,036339419	4,10485948	8,27233548	12,4999582	16,7857305	21,128515	25,5268094	29,9792738	34,4845815	39,0414305	43,6484677
2025	2	1,033778984	2,10944497	4,30154249	6,57447625	8,92628719	11,3549756	13,8585356	16,4353668	19,0839206	21,802253	24,5893513
2025	3	0,544351815	1,13646411	2,36779151	3,69308083	5,1123345	6,62524819	8,23022574	9,92720576	11,7156348	13,5935825	15,5595909
2025	4	0,302008204	0,63613278	1,33754976	2,10658397	2,94513008	3,85444248	4,83665551	5,86555986	6,95492039	8,11352557	9,34037639
2025	5	0,248661957	0,53192515	1,13459043	1,8103315	2,56208074	3,3912222	4,29883357	5,28696766	6,35631055	7,51020198	8,74892385
2025	6	0,023296351	0,0515412	0,11319123	0,18557805	0,2697145	0,36711913	0,48810372	0,6315423	0,7984365	0,99069707	1,20947824
2025	7	0	0	0	0	0	0	0	0	0	0	0
2025	8	0	0	0	0	0	0	0	0	0	0	0
2025	9	0,15278153	0,32501861	0,68939788	1,09453752	1,54119894	2,03007976	2,56321989	3,14150284	3,76476158	4,43746168	5,16086851
2025	10	0,167832358	0,37925888	0,84684331	1,40523803	2,05603406	2,8025202	3,64484818	4,58311026	5,61639913	6,74610998	7,97000184
2025	11	1,36065547	2,76252148	5,60573842	8,52724472	11,5247997	14,5965747	17,7409779	20,9563172	24,2410163	27,5936499	31,0119188
2025	12	1,627552009	3,29417955	6,66506868	10,110522	13,6285568	17,2173566	20,8748904	24,5993968	28,3892853	32,2427275	36,1580601
2026	1	1,61600921	3,27118306	6,61927522	10,0422378	13,5379807	17,1045966	20,7403975	24,4435673	28,2123638	32,0451568	35,940255
2026	2	1,053647337	2,14887819	4,3798052	6,69097017	9,08041204	11,546141	14,0861597	16,6988777	19,3827773	22,1359111	24,957307
2026	3	1,221032341	2,4836212	5,04940834	7,69608539	10,4226046	13,22798	16,1097437	19,066692	22,098171	25,2029571	28,3787654
2026	4	0,172274662	0,37415073	0,8089589	1,30728293	1,87205376	2,50466417	3,20833055	3,93004569	4,69619257	5,52341438	6,4100281
2026	5	0,237092791	0,5078724	1,0846692	1,73280798	2,45518817	3,25321624	4,12834898	5,08274352	6,11698267	7,23470685	8,43614237

2026	6	0,059208079	0,12926606	0,28033006	0,45342395	0,64819057	0,86537578	1,12753282	1,42906998	1,76960546	2,14805837	2,56528548
2026	7	0	0	0	0	0	0	0	0	0	0	0
2026	8	0,007118416	0,01635873	0,0374397	0,0639909	0,09683983	0,14207472	0,2089377	0,29611657	0,40615353	0,54192059	0,70873329
2026	9	0,175555595	0,37202599	0,78600821	1,24278606	1,74267424	2,28576423	2,87367345	3,50672626	4,18414347	4,91040021	5,68670399
2026	10	0,600871849	1,24704207	2,58481445	4,01330308	5,53184685	7,14029633	8,8391516	10,6271374	12,504075	14,4702943	16,522455
2026	11	1,269612349	2,58136514	5,24535518	7,9896916	10,8122297	13,7113125	16,6854018	19,7328382	22,8520885	26,0417921	29,2996023
2026	12	1,636677735	3,31227544	6,70094783	10,1638697	13,6990628	17,3047232	20,9788184	24,7195898	28,5254686	32,3946303	36,3254178
2027	1	2,003611536	4,04000709	8,14382628	12,3089783	16,5334241	20,8159815	25,155137	29,5495163	33,9977625	38,498558	43,0505154
2027	2	1,317301006	2,67221587	5,41857952	8,23737193	11,1267333	14,0848348	17,1098455	20,2002777	23,3547934	26,5715795	29,8497933
2027	3	1,270519298	2,5820685	5,24522746	7,98817274	10,809817	13,7091426	16,683565	19,7318291	22,8533096	26,0468454	29,3100486
2027	4	0,563335989	1,16336659	2,40037152	3,71241072	5,09936864	6,56220076	8,10097394	9,74227423	11,4752613	13,2931891	15,1963248
2027	5	0,323812573	0,68905563	1,46243841	2,32195251	3,27088889	4,3099122	5,4386812	6,65881584	7,97093178	9,37765076	10,8791499
2027	6	0,042943754	0,09391503	0,20394445	0,33037824	0,47340903	0,63405144	0,82993271	1,05716738	1,31597086	1,60656594	1,92991512
2027	7	0,001971733	0,00474925	0,01111078	0,02184654	0,03745731	0,05903566	0,08757421	0,12399618	0,16897048	0,22660539	0,29928029
2027	8	0	0	0	0	0	0	0	0	0	0	0
2027	9	0	0	0	0	0	0	0	0	0	0	0
2027	10	0,409814793	0,864408	1,81891095	2,86457818	4,00167818	5,23156455	6,55462563	7,9700845	9,47739519	11,0773679	12,7669806
2027	11	1,119441357	2,28258477	4,65104115	7,10330838	9,63740358	12,251941	14,9454511	17,7163166	20,5630612	23,4844134	26,477973
2027	12	1,347191262	2,73862563	5,56413499	8,47413004	11,4663934	14,5388932	17,6893227	20,9157245	24,2162889	27,5889192	31,0317276
2028	1	1,733813427	3,50490481	7,08281113	10,7315084	14,4488915	18,2332867	22,0830622	25,9965382	29,9720917	34,0081963	38,103246
2028	2	1,860687253	3,75081195	7,55949728	11,424528	15,344264	19,317211	23,3418849	27,4170086	31,541593	35,7141185	39,9339729
2028	3	0,870217146	1,78500907	3,6583677	5,61899214	7,66648017	9,80024888	12,018138	14,3196241	16,7042024	19,1703127	21,7159827
2028	4	0,448152164	0,9307524	1,93100829	3,00263347	4,14643459	5,36348943	6,65482866	8,02321278	9,46902712	10,9925075	12,5933105
2028	5	0,045310484	0,10762341	0,25099638	0,43389327	0,65841937	0,92733723	1,24659738	1,61966627	2,04668656	2,53416391	3,08220237
2028	6	0	0	0	0	0	0	0	0	0	0	0
2028	7	0,002442875	0,0058676	0,01361353	0,02655085	0,04530614	0,07108202	0,10503759	0,14790395	0,20014248	0,26655896	0,34960224
2028	8	0	0	0	0	0	0	0	0	0	0	0
2028	9	0,224438971	0,47297029	0,99356553	1,5614262	2,17591871	2,8358383	3,54188778	4,29320864	5,08771408	5,92989441	6,82083173
2028	10	0,088723885	0,22124281	0,53131179	0,933106	1,42848652	2,02133945	2,71184558	3,50011502	4,38500637	5,36813205	6,44708369
2028	11	1,200465709	2,44372502	4,97141779	7,5808825	10,2700408	13,0373889	15,8814672	18,8006636	21,7935046	24,8587131	27,9938577
2028	12	0,908475015	1,86925421	3,84127589	5,91329234	8,08272498	10,3471941	12,7039825	15,1508331	17,685564	20,3056684	23,0089094
2029	1	2,131446855	4,29362511	8,64681467	13,0569066	17,5218488	22,0407113	26,612041	31,2346114	35,907195	40,6285855	45,3974891
2029	2	1,343327598	2,72386826	5,52108725	8,38994395	11,3285688	14,3351442	17,4078476	20,5452055	23,745934	27,0082048	30,331252
2029	3	0,496966086	1,04180696	2,17872131	3,40986478	4,73547668	6,15538066	7,66780838	9,27292092	10,9703284	12,7580993	14,634646
2029	4	0,736918961	1,51349196	3,10600982	4,77834734	6,52906662	8,3589212	10,2666234	12,3136297	14,4728918	16,7273934	19,0782257
2029	5	0,199427327	0,42953765	0,92203436	1,48017431	2,1067454	2,8032443	3,57233065	4,41649383	5,33600272	6,33543956	7,4148636
2029	6	0,01107156	0,02463564	0,05423717	0,08920484	0,13080678	0,18058201	0,24652179	0,32807545	0,42662792	0,5449553	0,68422653
2029	7	0	0	0	0	0	0	0	0	0	0	0
2029	8	0,014115088	0,0317489	0,07091102	0,11786964	0,17340995	0,25002944	0,36697518	0,51986883	0,71123439	0,94494616	1,22935159
2029	9	0	0	0	0	0	0	0	0	0	0	0
2029	10	0,663825343	1,37365621	2,83923537	4,39632235	6,0438018	7,78099688	9,60854139	11,5247533	13,5294691	15,6228842	17,8011682
2029	11	1,316511171	2,67453332	5,43035035	8,26506675	11,1764698	14,1628787	17,2228344	20,3547253	23,5570719	26,8285773	30,1667823
2029	12	0,878472722	1,80981195	3,72349382	5,73823821	7,85143927	10,0606981	12,3632605	14,7568454	17,2392586	19,8079607	22,4606902
2030	1	1,922069985	3,87836583	7,8234372	11,8327556	15,9042135	20,0365012	24,2280743	28,4774695	32,7832531	37,1440578	41,5584192
2030	2	0,628951366	1,30585425	2,70643396	4,19977127	5,78368354	7,45590819	9,21415628	11,0566827	12,9817891	14,9872267	17,0720044
2030	3	1,229338937	2,49984457	5,08106721	7,74238421	10,482895	13,3016838	16,1960435	19,164896	22,2077397	25,3234067	28,5094186
2030	4	0,374503574	0,78185346	1,63023927	2,54736472	3,53465233	4,59325119	5,72484627	6,91656244	8,17623794	9,50867023	10,9130877
2030	5	0,102319697	0,22687304	0,49990462	0,82246592	1,1969425	1,62551853	2,11312747	2,66292131	3,27494716	3,9552362	4,70378649
2030	6	0	0	0	0	0	0	0	0	0	0	0
2030	7	0	0	0	0	0	0	0	0	0	0	0
2030	8	0	0	0	0	0	0	0	0	0	0	0
2030	9	0	0	0	0,02322574	0,06882331	0,14023296	0,24308296	0,38074545	0,55680778	0,77610953	1,04041863
2030	10	0,709828683	1,46598776	3,02441791	4,67459799	6,41513371	8,24497433	10,1648167	12,1727683	14,2687147	16,4527446	18,7208072
2030	11	1,054909138	2,1540814	4,39517564	6,72128627	9,13048636	11,6215538	14,1931271	16,8436537	19,5717376	22,3762166	25,2545671
2030	12	0,899530454	1,85155294	3,80623163	5,86123645	8,01397605	10,2620732	12,6027837	15,0338368	17,5530706	20,1579609	22,8462616
2031	1	1,441658813	2,92552133	5,93407756	9,02370614	12,1921959	15,437356	18,7574295	22,1504088	25,6143847	29,1476147	32,748248
2031	2	1,793476931	3,61738795	7,29463415	11,0301819	14,8223315	18,6695396	22,5702662	26,5232143	30,5274119	34,5812562	38,6842115
2031	3	0,981311177	2,00595554	4,0977266	6,27416576	8,53481216	10,8790269	13,3043441	15,8101521	18,3960386	21,0605932	23,8015772
2031	4	0,140449505	0,30930575	0,67699008	1,10618388	1,60016377	2,16033253	2,7903048	3,42909635	4,10714725	4,84336817	5,63577585
2031	5	0,036023423	0,08854526	0,21184614	0,37374284	0,57635167	0,82230471	1,11812678	1,46743135	1,87008646	2,33315862	2,85658672
2031	6	0	0	0	0	0	0	0	0	0	0	0
2031	7	0	0	0	0	0	0	0	0	0	0	0
2031	8	0,0139909	0,03142613	0,07010931	0,11639504	0,17104224	0,2465216	0,36209992	0,51315437	0,70230675	0,93349267	1,21510963
2031	9	0	0	0	0	0	0	0	0	0	0	0
2031	10	0,26321797	0,57133564	1,23323344	1,98755116	2,83512697	3,77843647	4,8178764	5,95281658	7,18232676	8,50760856	9,9255102
2031	11	0,7214134	1,49061017	3,07556396	4,75336253	6,52244469	8,38216822	10,3312872	12,3683199	14,4919705	16,7012407	18,9935361
2031	12	1,491234896	3,02411757	6,12997913	9,31526738	12,5778718	15,9158955	19,3271259	22,8096878	26,3619533	29,9819413	33,6678734
2032	1	1,564970176	3,17013527	6,41916813	9,74498055	13,1453654	16,6183677	20,1622876	23,7752584	27,4554949	31,201357	35,0110882
2032	2	1,433709964	2,90325968	5,87713767	8,91994814	12,0298286	15,2050102	18,4437162	21,7445138	25,1062316	28,5270479	32,0063302
2032	3	0,931092076	1,90589327	3,89837412	5,97632211	8,13939745	10,387033	12,716766	15,1281072	17,620693	20,1930734	22,8430214
2032	4	0,225636533	0,48112992	1,02327795	1,62928002	2,30176417	3,04203396	3,85303982	4,69090491	5,57811897	6,52855369	7,54062881
2032	5	0,035117566	0,08675844	0,20832479	0,36854574	0,5695507	0,81391125	1,10829512	1,45635051	1,85785694	2,3200385	2,84277914
2032	6	0	0	0	0	0	0	0	0	0	0	0
2032	7	0,003030227	0,00714688	0,01617221	0,03124485	0,05304037	0,08278316	0,12174802	0,17030686	0,22842064	0,30179772	0,393118
2032	8	0,002211092	0,00536861	0,01314418	0,02415583	0,03915409	0,06007512	0,08992252	0,1283549	0,17831196	0,24227485	0,32384261
2032	9	0	0	0	0,0117139	0,05038752	0,11321522	0,20594904	0,3317408	0,49411163	0,69797566	0,94511967
2032	10	0,350974352	0,74732208	1,58592913	2,51716196	3,54136692	4,66031514	5,87449716	7,18294756	8,58485843	10,0812212	11,668569
2032	11	0,844225063	1,73487858	3,56126601	5,47746458	7,4817712	9,5733552	11,7509698	14,0131321	16,3585392	18,78617	21,2934031
2032	12	0,798903581	1,65216915	3,41113808	5,27400393	7,23808772	9,30094103	11,4597086	13,7120446	16,0557261	18,488127	21,006919
2033	1	1,00142211	2,05239221	4,20282979	6,4497804	8,79091834	11,2232537	13,7448371	16,3531629	19,0458883	21,8209318	24,6760845
2033	2	0,610300299	1,26881851	2,63289379	4,09024654	5,63865499	7,27583775	8,99948114	10,8078391	12,6992594	14,671438	16,7234779
2033	3	0,341968686	0,73290057	1,56314665	2,48994258	3,51393791	4,63519578	5,85190522	7,16463701	8,57318691	10,0755118	11,6700183
2033	4	0,105294685	0,23810452	0,53291793	0,88776568	1,30623846	1,78976784	2,34230999	2,89510877	3,48237322	4,12526632	4,82157129
2033	5	0,223001857	0,47918209	1,02629703	1,64386249	2,33483628	3,10026156	3,94276722	4,86480398	5,86632438	6,95217576	8,12219952
2033	6	0	0	0	0	0	0	0	0	0	0	0
2033	7	0	0	0	0	0	0	0	0	0	0	0
2033	8	0,006386432	0,01457195	0,03319845	0,05650803	0,08523635	0,12511089	0,18502989	0,26293722	0,36172422	0,48443973	0,63645212
2033	9	0	0	0	0	0	0	0	0	0	0,05367153	0,21955863
2033	10	0,47179439	0,98955367	2,07127618	3,24580161	4,51281592	5,873124	7,32733456	8,87404811	10,5126371	12,2438009	14,0636825
2033	11	0,895631632	1,8370997	3,76446421	5,78030597	7,88285943	10,0712257	12,3441753	14,7002356	17,1381131	19,6567935	22,2536211
2033	12	0,527752703	1,11485412	2,34633169	3,69129458	5,14683949	6,71030498	8,37857829	10,1491271	12,0195037	13,9868268	16,0485519
2034	1	1,533268384	3,10731809	6,29469456	9,56000078	12,900988	16,3156582	19,8023009	23,359016	26,9839894	30,6755659	34,4319557
2034	2	0,963182023	1,96927045	4,02322571	6,16000998	8,37754056	10,6737523	13,0465556	15,4943415	18,0156914	20,6084865	23,2719912
2034	3	0,832757675	1,70995727	3,50800728	5,39308239	7,36508149	9,4235788	11,5661153	13,7924429	16,102295	18,4941445	20,9657856
2034	4	0,68109882	1,40021432	2,87636444	4,42960817	6,05904138	7,76545415	9,54815206	11,4557126	13,4674411	15,5700281	17,7641414
2034	5	0,06496394	0,14928967	0,33903778	0,57288	0,8531087	1,1819283	1,56559111	2,00760814	2,50762578	3,07275822	3,70278167
2034	6	0	0	0	0	0	0	0	0	0	0	0
2034	7	0	0	0	0	0	0	0	0	0	0	0
2034	8	0,007899791	0,01789232	0,0404027	0,06807321	0,10162576	0,14818899	0,21885892	0,31086511	0,42711162	0,57087764	0,74820507

2034	9	0	0	0	0	0	0	0	0	0	0	0
2034	10	0	0	0	0	0	0,06084227	0,36915981	0,77954097	1,29030636	1,9036013	2,61677304
2034	11	0,533116748	1,11590022	2,33004251	3,64118122	5,04794881	6,55007513	8,14645378	9,83568734	11,6165895	13,4883217	15,4481545
2034	12	1,402773812	2,84885402	5,78270348	8,79912822	11,8959373	15,0711772	18,3225261	21,648038	25,0460488	28,5144819	32,0514855
2035	1	1,081812713	2,21190562	4,51921736	6,92027136	9,41272026	11,9937386	14,6614162	17,4133416	20,247254	23,1611458	26,1528639
2035	2	1,554740887	3,14348731	6,35394308	9,62971956	12,9689743	16,3700062	19,8311041	23,3508878	26,9283169	30,5615935	34,2502299
2035	3	0,728859092	1,50302194	3,09590336	4,77763326	6,54831809	8,40765945	10,3532661	12,3851056	14,5029714	16,7052413	18,9897834
2035	4	0,239306362	0,50835725	1,07747307	1,71022179	2,40918197	3,17562699	4,01248001	4,87777136	5,79328937	6,77230056	7,81321026
2035	5	0,066174425	0,15192196	0,34472539	0,58203748	0,86617286	1,19925897	1,58764417	2,03486036	2,54046837	3,11171153	3,74831129
2035	6	0,010396758	0,02255521	0,04824279	0,07696777	0,1097313	0,14775058	0,2013475	0,26874507	0,35123265	0,45143041	0,57039279
2035	7	0,006666799	0,01597591	0,03645215	0,06956199	0,11713698	0,1814485	0,26521401	0,36752754	0,4871624	0,63515413	0,81447127
2035	8	0,002259692	0,00540355	0,01307545	0,02377809	0,0382225	0,05851553	0,08801657	0,12592924	0,17533453	0,23883534	0,32020244
2035	9	0	0	0	0	0	0	0	0	0	0	0
2035	10	0	0	0,04786505	0,21075359	0,4696174	0,82923757	1,28990901	1,85159516	2,51271907	3,27524393	4,13622771
2035	11	1,173231684	2,38924834	4,86237956	7,41715958	10,0515035	12,7640815	15,5536545	18,4187425	21,3580299	24,3704443	27,4532784
2035	12	0,961479229	1,97437324	4,04971889	6,22324002	8,49238234	10,8548426	13,3078858	15,8492647	18,4769408	21,1884251	23,9815144
2036	1	1,217966625	2,48199221	5,05481787	7,71664376	10,4651288	13,2977074	16,2125318	19,2073465	22,2800269	25,4286784	28,6512522
2036	2	0,772564215	1,59089204	3,27215676	5,04186755	6,89784014	8,83788646	10,8597851	12,9618583	15,1426099	17,3997833	19,7326408
2036	3	1,287073911	2,61431997	5,30799723	8,07971159	10,9287102	13,8541357	16,8528679	19,9239381	23,0670635	26,281207	29,5635468
2036	4	0,587902775	1,21185985	2,49602346	3,85406476	5,28584873	6,79225838	8,37341241	10,0582594	11,8354283	13,6973441	15,6441474
2036	5	0,276228869	0,59063884	1,25916791	2,00772854	2,8395595	3,75508743	4,75613078	5,84487927	7,02109744	8,2893543	9,64933017
2036	6	0,000442618	0,0008796	0,0013091	0,00119659	0,00186088	0,00466194	0,01707194	0,03827368	0,06991416	0,11539779	0,17583596
2036	7	0	0	0	0	0	0	0	0	0	0	0
2036	8	0,015603219	0,03486857	0,07738682	0,12772333	0,18657058	0,26805869	0,39417405	0,55896006	0,76523885	1,01734298	1,32458658
2036	9	0	0	0	0	0	0	0	0	0	0	0
2036	10	0,385503562	0,81714729	1,72692906	2,73043493	3,82765752	5,02005593	6,30826258	7,69091733	9,16714595	10,7378828	12,3991198
2036	11	0,641305257	1,33103576	2,75770579	4,27857648	5,89214941	7,5980089	9,39508189	11,2819905	13,2575662	15,3209815	17,4694393
2036	12	1,158130173	2,364079	4,82203588	7,37122748	10,0092575	12,7339856	15,5428471	18,4337238	21,4047638	24,4536556	27,5783509
2037	1	0,733609722	1,52132152	3,14993962	4,88452132	6,72262117	8,66078498	10,696951	12,8283146	15,0522723	17,3665506	19,7687114
2037	2	1,489145714	3,01327402	6,09546201	9,24488974	12,4596661	15,7380446	19,0782632	22,4789206	25,938975	29,4565615	33,0312356
2037	3	0,336843651	0,72238227	1,54157106	2,45677045	3,4687988	4,57780342	5,78175028	7,08135911	8,47658055	9,96541385	11,546087
2037	4	0,240239097	0,50999692	1,0803028	1,71384879	2,41324463	3,17975258	4,01634412	4,88064985	5,7947734	6,7720686	7,81088979
2037	5	0,347464147	0,73948907	1,56955849	2,49184576	3,50991429	4,62356929	5,83317417	7,14048255	8,54527036	10,0512958	11,6581889
2037	6	0	0	0	0	0	0	0	0	0	0	0
2037	7	0	0	0	0	0	0	0	0	0	0	0
2037	8	0,014467464	0,0323344	0,07180314	0,11860196	0,17341065	0,2493819	0,36702092	0,52065234	0,71317186	0,94880661	1,23645377
2037	9	0,045470649	0,09834743	0,21270304	0,34667838	0,5019356	0,68148029	0,89022986	1,12972485	1,40195315	1,71194988	2,06138997
2037	10	0,496301085	1,03929813	2,17206579	3,3987434	4,71871428	6,13255063	7,64099569	9,24228517	10,9357076	12,7219302	14,5965774
2037	11	0,813910745	1,67435983	3,44040985	5,2964416	7,24075935	9,27267511	11,3911022	13,5946541	15,8821428	18,2526983	20,7035008
2037	12	1,001123085	2,05295733	4,20548817	6,454809	8,79839255	11,233977	13,7588448	16,370768	19,0677706	21,8473913	24,7074561
2038	1	1,371184447	2,78595537	5,65763605	8,61299868	11,6496936	14,7654542	17,9585048	21,2267664	24,5682688	27,9812491	31,4637721
2038	2	1,106456213	2,2536454	4,58765098	7,00020524	9,48924455	12,0527829	14,6888064	17,3957693	20,1724166	23,0166512	25,9279238
2038	3	1,34849576	2,73645037	5,55080289	8,44170193	11,4083759	14,4499433	17,5630952	20,7468262	24,0009179	27,3244199	30,7143474
2038	4	0,106259372	0,23944417	0,53442697	0,88842116	1,30510605	1,78588696	2,33485191	2,88196621	3,46235796	4,09749044	4,78501248
2038	5	0,260527962	0,55806334	1,19168836	1,9031276	2,69558607	3,5694774	4,52721352	5,57114424	6,70083784	7,9213649	9,23229499
2038	6	0,039744303	0,08584817	0,18379593	0,29324238	0,41396291	0,5464213	0,71187198	0,90441334	1,12416007	1,37121062	1,64633275
2038	7	0	0	0	0	0	0	0	0	0	0	0
2038	8	0,009465002	0,0212548	0,04755392	0,07928605	0,11711986	0,16975877	0,25085687	0,35647321	0,48966582	0,65406632	0,85656327
2038	9	0	0	0	0	0,02472828	0,07004213	0,14084613	0,23956797	0,36944861	0,53562202	0,73992199
2038	10	0	0	0	0	0	0	0	0,30884434	0,75746258	1,30985	1,96297211
2038	11	0,661383936	1,370893	2,83677536	4,39616003	6,04751569	7,79042949	9,62388425	11,5465355	13,5572531	15,6552568	17,8376734
2038	12	1,117623931	2,28383343	4,66304448	7,13493677	9,69707552	12,3472974	15,0829818	17,9019759	20,8024197	23,7819554	26,8385
2039	1	0,705594089	1,46581569	3,03996377	4,72109671	6,50672807	8,39336746	10,3789442	12,4606244	14,6357791	16,9021231	19,2571876
2039	2	1,80595484	3,64211854	7,34364989	11,1030289	14,9184778	18,7884418	22,7113549	26,6859417	30,7113909	34,7859875	38,9094692
2039	3	0,955051771	1,95304518	3,99112454	6,11309903	8,31887116	10,607987	12,9775537	15,4272856	17,9570832	20,5656044	23,2502718
2039	4	0,792776877	1,62502326	3,32855521	5,11147834	6,97210922	8,91108931	10,9269565	13,0896268	15,3687292	17,7446125	20,2183699
2039	5	0,037568314	0,09260863	0,22193139	0,39179811	0,60446798	0,86202067	1,17192958	1,53802854	1,95948975	2,44452212	2,9926258
2039	6	0,021824607	0,04690962	0,09968411	0,15779498	0,22162836	0,2919498	0,38454308	0,49540865	0,62532123	0,77581926	0,94778901
2039	7	0	0	0	0	0	0	0	0	0	0	0
2039	8	0	0	0	0	0	0	0	0	0	0	0
2039	9	0,104791835	0,22097803	0,46512759	0,73461625	1,02998615	1,35268387	1,70649427	2,09157297	2,50833971	2,9618323	3,45357
2039	10	0,220089293	0,48621204	1,06513878	1,73877953	2,50783694	3,37505076	4,34101884	5,40465691	6,56470514	7,82252878	9,17414852
2039	11	0,787637453	1,62200835	3,3360946	5,1405676	7,03375029	9,01503557	11,0834045	13,237511	15,4762169	17,7987179	20,2021138
2039	12	1,670558889	3,37957041	6,83453877	10,3626588	13,9619449	17,6306828	21,3667484	25,1683576	29,0341511	32,9622777	36,9510919
2040	1	0,922469652	1,89601031	3,8930438	5,9894965	8,18290267	10,4701811	12,8493595	15,3178516	17,8732451	20,5134312	23,2361099
2040	2	0,97143019	1,98561455	4,05561308	6,20813302	8,4410327	10,7522376	13,1396381	15,6016408	18,1369471	20,7433533	23,4203285
2040	3	1,191460723	2,42364446	4,92778395	7,51114806	10,1732985	12,9135559	15,7286859	18,6180261	21,5814674	24,6179219	27,7244936
2040	4	0,123896398	0,2748006	0,60525497	0,99482895	1,44710206	1,96345005	2,54787352	3,1333505	3,75372576	4,42954775	5,1584988
2040	5	0,335233657	0,71426479	1,51760033	2,41173082	3,40021796	4,4827594	5,660358	6,93493362	8,30598352	9,77786622	11,3500465
2040	6	0	0	0	0	0	0	0	0	0	0	0
2040	7	0,003641713	0,00831867	0,01805394	0,03450089	0,05823576	0,0903449	0,13209553	0,18331889	0,2431183	0,31818776	0,41164893
2040	8	0	0	0,00081781	0,00350509	0,00861055	0,01626683	0,02693286	0,03999929	0,0588404	0,08594311	0,12432898
2040	9	0,179766378	0,37644067	0,78612321	1,22942932	1,70559568	2,21414858	2,7573604	3,3338172	3,94202348	4,58696426	5,26994952
2040	10	0,58904006	1,22558938	2,54598603	3,96105832	5,46958349	7,07137051	8,76731829	10,5551667	12,4342719	14,4050926	16,4626957
2040	11	0,629310345	1,30700289	2,70951208	4,20606665	5,79516043	7,47647123	9,24905102	11,1115969	13,0630296	15,1026373	17,2274655
2040	12	1,200437621	2,44796515	4,98834775	7,61850078	10,3360517	13,1389134	16,0245221	18,9907733	22,0359077	25,157635	28,3539357

Appendix B

Fuel prices

		Fuel scenario 1		Fuel scenario 2		Fuel scenario 3		Fuel scenario 4		Fuel scenario 5						
Year	Month	Gas [EUR/kWH]	DH [EUR/kWh]	Gas [EUR/kWH]	DH [EUR/kWh]	Gas [EUR/kWH]	DH [EUR/kWh]	Gas [EUR/kWH]	DH [EUR/kWh]	Gas [EUR/kWH]	DH [EUR/kWh]	CO_scen 1	CO_scen 2	CO_scen 3	CO_scen 4	DH_Gas_factor
2011	1	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0	0	0	0	0,699212932
2011	2	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0	0	0	0	0,699212932
2011	3	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0	0	0	0	0,699212932
2011	4	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0	0	0	0	0,699212932
2011	5	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0	0	0	0	0,699212932
2011	6	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0,064116026	0	0	0	0	0	0,699212932
2011	7	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0	0	0	0	0,699212932
2011	8	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0	0	0	0	0,699212932
2011	9	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0	0	0	0	0,699212932
2011	10	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0	0	0	0	0,699212932
2011	11	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0	0	0	0	0,699212932
2011	12	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0,066259714	0	0	0	0	0	0,699212932
2012	1	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0	0	0	0	0,681887123
2012	2	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0	0	0	0	0,681887123
2012	3	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0	0	0	0	0,681887123
2012	4	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0	0	0	0	0,681887123
2012	5	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0	0	0	0	0,681887123
2012	6	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0,069559778	0	0	0	0	0	0,681887123
2012	7	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0	0	0	0	0,681887123
2012	8	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0	0	0	0	0,681887123
2012	9	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0	0	0	0	0,681887123
2012	10	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0	0	0	0	0,681887123
2012	11	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0	0	0	0	0,681887123
2012	12	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0,070477589	0	0	0	0	0	0,681887123
2013	1	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0	0	0	0	0,699277106
2013	2	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0	0	0	0	0,699277106
2013	3	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0	0	0	0	0,699277106
2013	4	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0	0	0	0	0,699277106
2013	5	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0	0	0	0	0,699277106
2013	6	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0,070044708	0	0	0	0	0	0,699277106
2013	7	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0	0	0	0	0,699277106
2013	8	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0	0	0	0	0,699277106
2013	9	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0	0	0	0	0,699277106
2013	10	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0	0	0	0	0,699277106
2013	11	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0	0	0	0	0,699277106
2013	12	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0,07004692	0	0	0	0	0	0,699277106
2014	1	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0	0	0	0	0,722046112
2014	2	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0	0	0	0	0,722046112
2014	3	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0	0	0	0	0,722046112
2014	4	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0	0	0	0	0,722046112
2014	5	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0	0	0	0	0,722046112
2014	6	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0,069262737	0	0	0	0	0	0,722046112
2014	7	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0	0	0	0	0,722046112
2014	8	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0	0	0	0	0,722046112
2014	9	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0	0	0	0	0,722046112
2014	10	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0	0	0	0	0,722046112
2014	11	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0	0	0	0	0,722046112
2014	12	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0,069078397	0	0	0	0	0	0,722046112
2015	1	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0	0	0	0	0,691334157
2015	2	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0	0	0	0	0,691334157
2015	3	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0	0	0	0	0,691334157
2015	4	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0	0	0	0	0,691334157
2015	5	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0	0	0	0	0,691334157
2015	6	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0,068285771	0	0	0	0	0	0,691334157
2015	7	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0	0	0	0	0,691334157
2015	8	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0	0	0	0	0,691334157
2015	9	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0	0	0	0	0,691334157
2015	10	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0	0	0	0	0,691334157
2015	11	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0	0	0	0	0,691334157
2015	12	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0,067649227	0	0	0	0	0	0,691334157
2016	1	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0	0	0	0	0,665025655
2016	2	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0	0	0	0	0,665025655
2016	3	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0	0	0	0	0,665025655
2016	4	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0	0	0	0	0,665025655
2016	5	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0	0	0	0	0,665025655
2016	6	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0,066119921	0	0	0	0	0	0,665025655
2016	7	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0	0	0	0	0,665025655
2016	8	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0	0	0	0	0,665025655
2016	9	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0	0	0	0	0,665025655
2016	10	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0	0	0	0	0,665025655
2016	11	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0	0	0	0	0,665025655
2016	12	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0,064317486	0	0	0	0	0	0,665025655
2017	1	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0	0	0	0	0,667553969
2017	2	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0	0	0	0	0,667553969
2017	3	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0	0	0	0	0,667553969
2017	4	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0	0	0	0	0,667553969
2017	5	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0	0	0	0	0,667553969
2017	6	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0,06043	0	0	0	0	0	0,667553969
2017	7	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0	0	0	0	0,667553969
2017	8	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0	0	0	0	0,667553969
2017	9	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0	0	0	0	0,667553969
2017	10	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0	0	0	0	0,667553969
2017	11	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0	0	0	0	0,667553969
2017	12	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0,06078	0	0	0	0	0	0,667553969
2018	1	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0	0	0	0	0,669881203
2018	2	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0	0	0	0	0,669881203
2018	3	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0	0	0	0	0,669881203
2018	4	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0	0	0	0	0,669881203
2018	5	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0	0	0	0	0,669881203
2018	6	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0,05871	0	0	0	0	0	0,669881203
2018	7	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0	0	0	0	0,669881203
2018	8	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0	0	0	0	0,669881203
2018	9	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0	0	0	0	0,669881203
2018	10	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0	0	0	0	0,669881203
2018	11	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0	0	0	0	0,669881203
2018	12	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0,05927	0	0	0	0	0	0,669881203
2019	1	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0	0	0	0	0,662167841
2019	2	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0	0	0	0	0,662167841
2019	3	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0	0	0	0	0,662167841
2019	4	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0	0	0	0	0,662167841
2019	5	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0	0	0	0	0,662167841
2019	6	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0,05883	0	0	0	0	0	0,662167841
2019	7	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0	0	0	0	0,662167841
2019	8	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0	0	0	0	0,662167841
2019	9	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0	0	0	0	0,662167841
2019	10	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0	0	0	0	0,662167841
2019	11	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0	0	0	0	0,662167841
2019	12	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0,05773	0	0	0	0	0	0,662167841
2020	1	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0	0	0	0	0,650326792
2020	2	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0	0	0	0	0,650326792
2020	3	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0	0	0	0	0,650326792
2020	4	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0	0	0	0	0,650326792
2020	5	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0	0	0	0	0,650326792
2020	6	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0,05642	0	0	0	0	0	0,650326792
2020	7	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0	0	0	0	0,650326792
2020	8	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0	0	0	0	0,650326792
2020	9	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0	0	0	0	0,650326792
2020	10	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0	0	0	0	0,650326792
2020	11	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0	0	0	0	0,650326792
2020	12	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0,05536	0	0	0	0	0	0,650326792
2021	1	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	2	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	3	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	4	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	5	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	6	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,05549	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	7	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	8	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	9	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441

2021	10	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	11	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2021	12	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,06054	0	0,00024215	0,00093132	0,00129425	0,00166997	0,647007441
2022	1	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	2	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	3	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	4	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	5	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	6	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,07648	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	7	0,08	0	0,08	0	0,08	0	0,08	0	0,08	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	8	0,08	0	0,08	0	0,08	0	0,08	0	0,08	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	9	0,08	0	0,08	0	0,08	0	0,08	0	0,08	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	10	0,08	0	0,08	0	0,08	0	0,08	0	0,08	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	11	0,08	0	0,08	0	0,08	0	0,08	0	0,08	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2022	12	0,08	0	0,08	0	0,08	0	0,08	0	0,08	0	0,00049056	0,00195532	0,00276746	0,00363789	0,614657069
2023	1	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	2	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	3	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	4	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	5	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	6	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,115	0,1341	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	7	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	8	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	9	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	10	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	11	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2023	12	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,113	0,133	0,00074539	0,0030812	0,00444437	0,00595691	0,582306697
2024	1	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	2	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	3	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	4	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	5	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	6	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,108	0,126	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	7	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	8	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	9	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	10	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	11	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2024	12	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,095	0,115	0,00100682	0,0043191	0,00635316	0,00868968	0,549956325
2025	1	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	2	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	3	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	4	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	5	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	6	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,085	0,106	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	7	0,076	0,095	0,076	0,102	0,076	0,095	0,076	0,102	0,076	0,095	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	8	0,076	0,095	0,076	0,102	0,076	0,095	0,076	0,102	0,076	0,095	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	9	0,076	0,095	0,076	0,102	0,076	0,095	0,076	0,102	0,076	0,095	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	10	0,076	0,095	0,076	0,102	0,076	0,095	0,076	0,102	0,076	0,095	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	11	0,076	0,095	0,076	0,102	0,076	0,095	0,076	0,102	0,076	0,095	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2025	12	0,076	0,095	0,076	0,102	0,076	0,095	0,076	0,102	0,076	0,095	0,00127501	0,00568018	0,00852589	0,01191003	0,517605953
2026	1	0,067	0,091	0,067	0,098	0,074	0,091	0,074	0,098	0,067	0,091	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	2	0,067	0,091	0,067	0,098	0,074	0,091	0,074	0,098	0,067	0,091	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	3	0,067	0,091	0,067	0,098	0,074	0,091	0,074	0,098	0,067	0,091	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	4	0,067	0,091	0,067	0,098	0,074	0,091	0,074	0,098	0,067	0,091	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	5	0,067	0,091	0,067	0,098	0,074	0,091	0,074	0,098	0,067	0,091	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	6	0,067	0,091	0,067	0,098	0,074	0,091	0,074	0,098	0,067	0,091	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	7	0,064	0,088	0,064	0,095	0,072	0,088	0,072	0,095	0,064	0,088	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	8	0,064	0,088	0,064	0,095	0,072	0,088	0,072	0,095	0,064	0,088	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	9	0,064	0,088	0,064	0,095	0,072	0,088	0,072	0,095	0,064	0,088	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	10	0,064	0,088	0,064	0,095	0,072	0,088	0,072	0,095	0,064	0,088	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	11	0,064	0,088	0,064	0,095	0,072	0,088	0,072	0,095	0,064	0,088	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2026	12	0,064	0,088	0,064	0,095	0,072	0,088	0,072	0,095	0,064	0,088	0,00155014	0,00717669	0,01099905	0,01570493	0,48525558
2027	1	0,062	0,085	0,062	0,093	0,0715	0,085	0,0715	0,093	0,062	0,085	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	2	0,062	0,085	0,062	0,093	0,0715	0,085	0,0715	0,093	0,062	0,085	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	3	0,062	0,085	0,062	0,093	0,0715	0,085	0,0715	0,093	0,062	0,085	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	4	0,062	0,085	0,062	0,093	0,0715	0,085	0,0715	0,093	0,062	0,085	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	5	0,062	0,085	0,062	0,093	0,0715	0,085	0,0715	0,093	0,062	0,085	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	6	0,062	0,085	0,062	0,093	0,0715	0,085	0,0715	0,093	0,062	0,085	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	7	0,061	0,082	0,061	0,091	0,072	0,082	0,072	0,091	0,061	0,082	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	8	0,061	0,082	0,061	0,091	0,072	0,082	0,072	0,091	0,061	0,082	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	9	0,061	0,082	0,061	0,091	0,072	0,082	0,072	0,091	0,061	0,082	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	10	0,061	0,082	0,061	0,091	0,072	0,082	0,072	0,091	0,061	0,082	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	11	0,061	0,082	0,061	0,091	0,072	0,082	0,072	0,091	0,061	0,082	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2027	12	0,061	0,082	0,061	0,091	0,072	0,082	0,072	0,091	0,061	0,082	0,00183239	0,00882209	0,01381418	0,0201769	0,452905208
2028	1	0,06	0,079	0,06	0,09	0,0725	0,079	0,0725	0,09	0,06	0,079	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	2	0,06	0,079	0,06	0,09	0,0725	0,079	0,0725	0,09	0,06	0,079	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	3	0,06	0,079	0,06	0,09	0,0725	0,079	0,0725	0,09	0,06	0,079	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	4	0,06	0,079	0,06	0,09	0,0725	0,079	0,0725	0,09	0,06	0,079	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	5	0,06	0,079	0,06	0,09	0,0725	0,079	0,0725	0,09	0,06	0,079	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	6	0,06	0,079	0,06	0,09	0,0725	0,079	0,0725	0,09	0,06	0,079	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	7	0,0595	0,077	0,0595	0,089	0,073	0,077	0,073	0,089	0,0595	0,077	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	8	0,0595	0,077	0,0595	0,089	0,073	0,077	0,073	0,089	0,0595	0,077	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	9	0,0595	0,077	0,0595	0,089	0,073	0,077	0,073	0,089	0,0595	0,077	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	10	0,0595	0,077	0,0595	0,089	0,073	0,077	0,073	0,089	0,0595	0,077	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	11	0,0595	0,077	0,0595	0,089	0,073	0,077	0,073	0,089	0,0595	0,077	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2028	12	0,0595	0,077	0,0595	0,089	0,073	0,077	0,073	0,089	0,0595	0,077	0,00212194	0,01063122	0,01701858	0,02544674	0,420554836
2029	1	0,059	0,075	0,059	0,088	0,0735	0,075	0,0735	0,088	0,059	0,075	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	2	0,059	0,075	0,059	0,088	0,0735	0,075	0,0735	0,088	0,059	0,075	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	3	0,059	0,075	0,059	0,088	0,0735	0,075	0,0735	0,088	0,059	0,075	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	4	0,059	0,075	0,059	0,088	0,0735	0,075	0,0735	0,088	0,059	0,075	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	5	0,059	0,075	0,059	0,088	0,0735	0,075	0,0735	0,088	0,059	0,075	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	6	0,059	0,075	0,059	0,088	0,0735	0,075	0,0735	0,088	0,059	0,075	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	7	0,059	0,074	0,059	0,087	0,074	0,074	0,074	0,087	0,059	0,074	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	8	0,059	0,074	0,059	0,087	0,074	0,074	0,074	0,087	0,059	0,074	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	9	0,059	0,074	0,059	0,087	0,074	0,074	0,074	0,087	0,059	0,074	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	10	0,059	0,074	0,059	0,087	0,074	0,074	0,074	0,087	0,059	0,074	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	11	0,059	0,074	0,059	0,087	0,074	0,074	0,074	0,087	0,059	0,074	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2029	12	0,059	0,074	0,059	0,087	0,074	0,074	0,074	0,087	0,059	0,074	0,00241898	0,01262036	0,02066606	0,0316568	0,388204464
2030	1	0,059	0,0735	0,059	0,086	0,0745	0,0735	0,0745	0,086	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	2	0,059	0,0735	0,059	0,086	0,0745	0,0735	0,0745	0,086	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	3	0,059	0,0735	0,059	0,086	0,0745	0,0735	0,0745	0,086	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	4	0,059	0,0735	0,059	0,086	0,0745	0,0735	0,0745	0,086	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	5	0,059	0,0735	0,059	0,086	0,0745	0,0735	0,0745	0,086	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	6	0,059	0,0735	0,059	0,086	0,0745	0,0735	0,0745	0,086	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	7	0,059	0,0735	0,059	0,085	0,075	0,0735	0,075	0,085	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	8	0,059	0,0735	0,059	0,085	0,075	0,0735	0,075	0,085	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	9	0,059	0,0735	0,059	0,085	0,075	0,0735	0,075	0,085	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	10	0,059	0,0735	0,059	0,085	0,075	0,0735	0,075	0,085	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	11	0,059	0,0735	0,059	0,085	0,075	0,0735	0,075	0,085	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2030	12	0,059	0,0735	0,059	0,085	0,075	0,0735	0,075	0,085	0,059	0,0735	0,00272371	0,01480742	0,02481789	0,03897483	0,355854092
2031	1	0,059	0,0735	0,059	0,084	0,0755	0,0735	0,0755	0,084	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	2	0,059	0,0735	0,059	0,084	0,0755	0,0735	0,0755	0,084	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	3	0,059	0,0735	0,059	0,084	0,0755	0,0735	0,0755	0,084	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	4	0,059	0,0735	0,059	0,084	0,0755	0,0735	0,0755	0,084	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	5	0,059	0,0735	0,059	0,084	0,0755	0,0735	0,0755	0,084	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	6	0,059	0,0735	0,059	0,084	0,0755	0,0735	0,0755	0,084	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	7	0,059	0,0735	0,059	0,083	0,076	0,0735	0,076	0,083	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	8	0,059	0,0735	0,059	0,083	0,076	0,0735	0,076	0,083	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	9	0,059	0,0735	0,059	0,083	0,076	0,0735	0,076	0,083	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	10	0,059	0,0735	0,059	0,083	0,076	0,0735	0,076	0,083	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	11	0,059	0,0735	0,059	0,083	0,076	0,0735	0,076	0,083	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2031	12	0,059	0,0735	0,059	0,083	0,076	0,0735	0,076	0,083	0,059	0,0735	0,00303632	0,01721209	0,02954381	0,04759851	0,32350372
2032	1	0,059	0,0735	0,059	0,082	0,0765	0,0735	0,0765	0,082	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	2	0,059	0,0735	0,059	0,082	0,0765	0,0735	0,0765	0,082	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	3	0,059	0,0735	0,059	0,082	0,0765	0,0735	0,0765	0,082	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	4	0,059	0,0735	0,059	0,082	0,0765	0,0735	0,0765	0,082	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	5	0,059	0,0735	0,059	0,082	0,0765	0,0735	0,0765	0,082	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	6	0,059	0,0735	0,059	0,082	0,0765	0,0735	0,0765	0,082	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	7	0,059	0,0735	0,059	0,081	0,077	0,0735	0,077	0,081	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	8	0,059	0,0735	0,059	0,081	0,077	0,0735	0,077	0,081	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348

2032	9	0,059	0,0735	0,059	0,081	0,077	0,0735	0,077	0,081	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	10	0,059	0,0735	0,059	0,081	0,077	0,0735	0,077	0,081	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	11	0,059	0,0735	0,059	0,081	0,077	0,0735	0,077	0,081	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2032	12	0,059	0,0735	0,059	0,081	0,077	0,0735	0,077	0,081	0,059	0,0735	0,00335701	0,01985602	0,03492321	0,05776079	0,291153348
2033	1	0,059	0,0735	0,059	0,08	0,0775	0,0735	0,0775	0,08	0,089	0,084	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	2	0,059	0,0735	0,059	0,08	0,0775	0,0735	0,0775	0,08	0,089	0,084	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	3	0,059	0,0735	0,059	0,08	0,0775	0,0735	0,0775	0,08	0,089	0,084	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	4	0,059	0,0735	0,059	0,08	0,0775	0,0735	0,0775	0,08	0,089	0,084	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	5	0,059	0,0735	0,059	0,08	0,0775	0,0735	0,0775	0,08	0,089	0,084	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	6	0,059	0,0735	0,059	0,08	0,0775	0,0735	0,0775	0,08	0,089	0,084	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	7	0,059	0,0735	0,059	0,079	0,078	0,0735	0,078	0,079	0,119	0,095	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	8	0,059	0,0735	0,059	0,079	0,078	0,0735	0,078	0,079	0,119	0,095	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	9	0,059	0,0735	0,059	0,079	0,078	0,0735	0,078	0,079	0,119	0,095	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	10	0,059	0,0735	0,059	0,079	0,078	0,0735	0,078	0,079	0,119	0,095	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	11	0,059	0,0735	0,059	0,079	0,078	0,0735	0,078	0,079	0,119	0,095	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2033	12	0,059	0,0735	0,059	0,079	0,078	0,0735	0,078	0,079	0,119	0,095	0,003686	0,02276303	0,04104644	0,06973618	0,258802976
2034	1	0,059	0,0735	0,059	0,078	0,0785	0,0735	0,0785	0,078	0,136	0,102	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	2	0,059	0,0735	0,059	0,078	0,0785	0,0735	0,0785	0,078	0,136	0,102	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	3	0,059	0,0735	0,059	0,078	0,0785	0,0735	0,0785	0,078	0,136	0,102	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	4	0,059	0,0735	0,059	0,078	0,0785	0,0735	0,0785	0,078	0,136	0,102	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	5	0,059	0,0735	0,059	0,078	0,0785	0,0735	0,0785	0,078	0,136	0,102	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	6	0,059	0,0735	0,059	0,078	0,0785	0,0735	0,0785	0,078	0,136	0,102	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	7	0,059	0,0735	0,059	0,077	0,079	0,0735	0,079	0,077	0,145	0,107	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	8	0,059	0,0735	0,059	0,077	0,079	0,0735	0,079	0,077	0,145	0,107	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	9	0,059	0,0735	0,059	0,077	0,079	0,0735	0,079	0,077	0,145	0,107	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	10	0,059	0,0735	0,059	0,077	0,079	0,0735	0,079	0,077	0,145	0,107	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	11	0,059	0,0735	0,059	0,077	0,079	0,0735	0,079	0,077	0,145	0,107	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2034	12	0,059	0,0735	0,059	0,077	0,079	0,0735	0,079	0,077	0,145	0,107	0,00402351	0,02595929	0,04801636	0,08384817	0,226452604
2035	1	0,059	0,0735	0,059	0,076	0,0795	0,0735	0,0795	0,076	0,146	0,106	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	2	0,059	0,0735	0,059	0,076	0,0795	0,0735	0,0795	0,076	0,146	0,106	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	3	0,059	0,0735	0,059	0,076	0,0795	0,0735	0,0795	0,076	0,146	0,106	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	4	0,059	0,0735	0,059	0,076	0,0795	0,0735	0,0795	0,076	0,146	0,106	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	5	0,059	0,0735	0,059	0,076	0,0795	0,0735	0,0795	0,076	0,146	0,106	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	6	0,059	0,0735	0,059	0,076	0,0795	0,0735	0,0795	0,076	0,146	0,106	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	7	0,059	0,0735	0,059	0,075	0,08	0,0735	0,08	0,075	0,139	0,1	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	8	0,059	0,0735	0,059	0,075	0,08	0,0735	0,08	0,075	0,139	0,1	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	9	0,059	0,0735	0,059	0,075	0,08	0,0735	0,08	0,075	0,139	0,1	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	10	0,059	0,0735	0,059	0,075	0,08	0,0735	0,08	0,075	0,139	0,1	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	11	0,059	0,0735	0,059	0,075	0,08	0,0735	0,08	0,075	0,139	0,1	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2035	12	0,059	0,0735	0,059	0,075	0,08	0,0735	0,08	0,075	0,139	0,1	0,00436974	0,02947358	0,05595003	0,10047794	0,194102232
2036	1	0,059	0,0735	0,059	0,074	0,0805	0,0735	0,0805	0,074	0,115	0,093	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	2	0,059	0,0735	0,059	0,074	0,0805	0,0735	0,0805	0,074	0,115	0,093	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	3	0,059	0,0735	0,059	0,074	0,0805	0,0735	0,0805	0,074	0,115	0,093	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	4	0,059	0,0735	0,059	0,074	0,0805	0,0735	0,0805	0,074	0,115	0,093	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	5	0,059	0,0735	0,059	0,074	0,0805	0,0735	0,0805	0,074	0,115	0,093	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	6	0,059	0,0735	0,059	0,074	0,0805	0,0735	0,0805	0,074	0,115	0,093	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	7	0,059	0,0735	0,059	0,073	0,081	0,0735	0,081	0,073	0,095	0,085	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	8	0,059	0,0735	0,059	0,073	0,081	0,0735	0,081	0,073	0,095	0,085	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	9	0,059	0,0735	0,059	0,073	0,081	0,0735	0,081	0,073	0,095	0,085	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	10	0,059	0,0735	0,059	0,073	0,081	0,0735	0,081	0,073	0,095	0,085	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	11	0,059	0,0735	0,059	0,073	0,081	0,0735	0,081	0,073	0,095	0,085	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2036	12	0,059	0,0735	0,059	0,073	0,081	0,0735	0,081	0,073	0,095	0,085	0,00472494	0,03333754	0,06498073	0,12007473	0,16175186
2037	1	0,059	0,0735	0,059	0,072	0,0815	0,0735	0,0815	0,072	0,09	0,083	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	2	0,059	0,0735	0,059	0,072	0,0815	0,0735	0,0815	0,072	0,09	0,083	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	3	0,059	0,0735	0,059	0,072	0,0815	0,0735	0,0815	0,072	0,09	0,083	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	4	0,059	0,0735	0,059	0,072	0,0815	0,0735	0,0815	0,072	0,09	0,083	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	5	0,059	0,0735	0,059	0,072	0,0815	0,0735	0,0815	0,072	0,09	0,083	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	6	0,059	0,0735	0,059	0,072	0,0815	0,0735	0,0815	0,072	0,09	0,083	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	7	0,059	0,0735	0,059	0,071	0,082	0,0735	0,082	0,071	0,087	0,082	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	8	0,059	0,0735	0,059	0,071	0,082	0,0735	0,082	0,071	0,087	0,082	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	9	0,059	0,0735	0,059	0,071	0,082	0,0735	0,082	0,071	0,087	0,082	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	10	0,059	0,0735	0,059	0,071	0,082	0,0735	0,082	0,071	0,087	0,082	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	11	0,059	0,0735	0,059	0,071	0,082	0,0735	0,082	0,071	0,087	0,082	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2037	12	0,059	0,0735	0,059	0,071	0,082	0,0735	0,082	0,071	0,087	0,082	0,00508932	0,03758597	0,07526015	0,14316789	0,129401488
2038	1	0,059	0,0735	0,059	0,07	0,0825	0,0735	0,0825	0,07	0,085	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	2	0,059	0,0735	0,059	0,07	0,0825	0,0735	0,0825	0,07	0,085	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	3	0,059	0,0735	0,059	0,07	0,0825	0,0735	0,0825	0,07	0,085	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	4	0,059	0,0735	0,059	0,07	0,0825	0,0735	0,0825	0,07	0,085	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	5	0,059	0,0735	0,059	0,07	0,0825	0,0735	0,0825	0,07	0,085	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	6	0,059	0,0735	0,059	0,07	0,0825	0,0735	0,0825	0,07	0,085	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	7	0,059	0,0735	0,059	0,069	0,083	0,0735	0,083	0,069	0,084	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	8	0,059	0,0735	0,059	0,069	0,083	0,0735	0,083	0,069	0,084	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	9	0,059	0,0735	0,059	0,069	0,083	0,0735	0,083	0,069	0,084	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	10	0,059	0,0735	0,059	0,069	0,083	0,0735	0,083	0,069	0,084	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	11	0,059	0,0735	0,059	0,069	0,083	0,0735	0,083	0,069	0,084	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2038	12	0,059	0,0735	0,059	0,069	0,083	0,0735	0,083	0,069	0,084	0,081	0,00546312	0,04225711	0,08696094	0,17038123	0,097051116
2039	1	0,059	0,0735	0,059	0,068	0,0835	0,0735	0,0835	0,068	0,0835	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	2	0,059	0,0735	0,059	0,068	0,0835	0,0735	0,0835	0,068	0,0835	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	3	0,059	0,0735	0,059	0,068	0,0835	0,0735	0,0835	0,068	0,0835	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	4	0,059	0,0735	0,059	0,068	0,0835	0,0735	0,0835	0,068	0,0835	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	5	0,059	0,0735	0,059	0,068	0,0835	0,0735	0,0835	0,068	0,0835	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	6	0,059	0,0735	0,059	0,068	0,0835	0,0735	0,0835	0,068	0,0835	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	7	0,059	0,0735	0,059	0,067	0,084	0,0735	0,084	0,067	0,083	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	8	0,059	0,0735	0,059	0,067	0,084	0,0735	0,084	0,067	0,083	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	9	0,059	0,0735	0,059	0,067	0,084	0,0735	0,084	0,067	0,083	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	10	0,059	0,0735	0,059	0,067	0,084	0,0735	0,084	0,067	0,083	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	11	0,059	0,0735	0,059	0,067	0,084	0,0735	0,084	0,067	0,083	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2039	12	0,059	0,0735	0,059	0,067	0,084	0,0735	0,084	0,067	0,083	0,081	0,0058466	0,04739304	0,10027965	0,20244985	0,064700744
2040	1	0,059	0,0735	0,059	0,066	0,0845	0,0735	0,0845	0,066	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	2	0,059	0,0735	0,059	0,066	0,0845	0,0735	0,0845	0,066	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	3	0,059	0,0735	0,059	0,066	0,0845	0,0735	0,0845	0,066	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	4	0,059	0,0735	0,059	0,066	0,0845	0,0735	0,0845	0,066	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	5	0,059	0,0735	0,059	0,066	0,0845	0,0735	0,0845	0,066	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	6	0,059	0,0735	0,059	0,066	0,0845	0,0735	0,0845	0,066	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	7	0,059	0,0735	0,059	0,065	0,085	0,0735	0,085	0,065	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	8	0,059	0,0735	0,059	0,065	0,085	0,0735	0,085	0,065	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	9	0,059	0,0735	0,059	0,065	0,085	0,0735	0,085	0,065	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	10	0,059	0,0735	0,059	0,065	0,085	0,0735	0,085	0,065	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	11	0,059	0,0735	0,059	0,065	0,085	0,0735	0,085	0,065	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372
2040	12	0,059	0,0735	0,059	0,065	0,085	0,0735	0,085	0,065	0,083	0,081	0,00624	0,05304	0,11544	0,24024	0,032350372

Appendix C

House parameter

House	m2	DC	Installation Year	Node
1	109338	4	2013	45
5	9405	3	2016	803
8	2960	4	2014	142
10	6018	11	2015	229
13	13375	11	2011	1083
16	5210	11	2018	513
18	4785	9	2019	260
22	2995	6	2015	1207
23	3215	7	2020	1232
25	2020	1	2011	1195
27	7743	6	2017	790
34	1668	6	2022	761
35	2555	1	2019	760
36	3715	1	2013	228
38	7770	1	2013	203
40	3195	6	2019	170
42	4035	3	2013	187
49	4796	9	2012	224
54	3112	1	2022	254
56	4470	9	2017	774
58	14165	11	2013	257
60	2525	3	2013	175
61	3940	1	2017	173
63	3155	1	2022	329
64	6620	3	2013	387
70	4112	1	2022	909
71	5700	6	2022	922
75	2728	1	2020	665
76	2040	1	2020	693
77	2270	11	2018	1164
80	2595	9	2020	994
82	1530	6	2019	1127
83	2005	1	2014	1086
84	2132	9	2016	1010
86	3865	11	2017	1011
87	3665	3	2021	108
94	3630	1	2022	116
96	6470	11	2018	1037
97	11588	11	2019	1218
98	5165	1	2015	1244
103	1885	4	2021	420
109	10456	6	2015	497
112	3505	6	2015	10
113	2765	7	2019	162
114	3375	11	2012	3
115	1248	1	2022	584
128	520	7	2016	1247
131	2700	11	2012	1092
132	1580	1	2018	1191
136	4475	4	2016	1192
138	3696	4	2022	1141
141	815	3	2016	1097
143	2455	1	2018	1203
144	1165	1	2015	1134
147	655	6	2019	1135
152	1770	6	2022	1089
153	1135	6	2022	1204
154	1600	7	2021	1259
157	1395	1	2020	1124
159	850	3	2014	1210
163	2919	11	2016	1177
164	2005	1	2018	1278
165	1990	6	2014	1436
174	670	4	2016	1344
178	1350	1	2013	1291
179	3065	1	2011	1289
180	565	6	2020	1337
181	1210	1	2011	1333
182	1005	3	2014	1338
188	2295	3	2014	1294
198	1422	3	2016	1239
200	1392	4	2016	1298
204	1242	4	2016	1297
207	1510	4	2017	1236
209	1085	3	2012	1233
212	1220	7	2011	1238
214	1030	4	2021	1226
219	4890	1	2013	1095
227	1255	4	2016	826
229	9000	1	2015	1437
230	1485	6	2013	574
233	1210	1	2019	523
234	1080	7	2016	517
242	1632	6	2022	577
247	1735	1	2017	541
248	960	4	2016	535
249	3240	6	2018	505
251	1975	1	2011	543
262	1070	6	2013	533
264	710	6	2012	339
265	1430	11	2018	333
266	3410	11	2016	345
268	2886	3	2021	331
269	1665	9	2013	461
270	2130	4	2015	458
277	1992	1	2011	450
278	2094	4	2017	453
279	930	11	2012	443
285	2155	3	2017	317
286	595	3	2022	323
292	770	6	2016	609
293	670	3	2011	611
295	815	3	2011	606
298	870	11	2015	343
299	2225	1	2012	447
300	1035	6	2022	446
304	400	7	2019	448
305	2595	6	2015	460
306	905	4	2016	459
309	1370	6	2017	554
310	1655	11	2013	547
311	905	11	2019	550
312	3423	4	2022	784
314	1650	6	2019	806
320	1547	11	2015	811
321	3192	4	2016	796
322	10265	11	2016	1169
323	2785	7	2022	1165
324	1685	6	2021	478
327	2535	6	2014	601
328	1130	1	2012	598
330	4905	11	2012	442
331	1620	1	2014	452
334	1050	4	2019	414
336	1040	3	2012	451
777	2000	4	2018	1273
784	1640	1	2013	1265
785	640	7	2018	1049
795	2220	4	2018	631
798	1550	1	2015	676
804	1045	6	2021	624
812	2765	6	2011	1050
813	5090	3	2016	1442
818	1470	6	2018	1350
822	2370	6	2019	1358
827	1910	1	2019	801
828	1640	1	2016	800
830	5768	11	2014	634
834	1768	6	2016	689
842	1124	1	2018	691
843	2964	3	2019	852
846	2090	1	2014	740
850	1415	1	2016	630
851	1085	1	2013	585
852	2875	3	2017	588
853	7525	6	2012	569
854	465	6	2018	1155
855	1800	1	2014	1053
859	1025	11	2022	578
866	2580	1	2012	715
867	1405	1	2012	1043
871	595	7	2020	416
875	1600	3	2021	492
876	3245	7	2022	720
879	2352	7	2022	723
880	3087	7	2016	729
882	3882	9	2019	862
883	1925	4	2018	1430
884	940	4	2015	1379
886	10565	3	2019	856
888	2737	11	2013	853
892	1400	1	2020	1354
893	1305	1	2011	735
899	4340	3	2011	1396
901	685	7	2019	1395
903	4205	7	2022	1392
904	2365	3	2020	908
908	2355	6	2021	906
909	2730	4	2017	117
911	1310	6	2021	120
912	2445	6	2021	900
915	2080	9	2015	133
916	1375	3	2019	1410
917	4613	4	2014	1418
920	1045	6	2012	1411
921	2250	11	2017	1415
922	684	6	2020	1404
924	3159	3	2018	1403
927	2030	1	2013	17
933	3738	4	2015	860
935	2325	11	2021	755
938	1992	1	2014	753
941	1230	1	2011	1435
945	4625	4	2015	1431
946	2880	11	2014	1391
949	2615	7	2013	1423
950	3576	6	2021	1394
954	7734	6	2015	41
955	1052	3	2015	37
956	2682	11	2018	93
959	1512	1	2020	106
962	2560	4	2012	31
963	2680	1	2014	43
965	1395	11	2013	102
968	880	4	2018	1443
969	885	3	2011	49
972	1300	6	2011	309
976	810	4	2016	942
981	1452	11	2021	1146
986	1740	1	2016	1142
990	2792	3	2019	1288
994	2155	9	2022	1215
996	1405	1	2014	1229
997	2820	7	2012	1202
1001	1430	9	2021	216
1004	2056	11	2018	7
1007	1570	1	2013	6
1009	880	6	2021	161
1015	1465	1	2020	465
1016	690	6	2017	463
1019	330	9	2019	518
1022	1565	1	2012	164
1023	1475	6	2022	207
1024	325	9	2022	898
1029	4852	1	2019	299
1030	1015	3	2022	243
1032	1795	6	2021	404
1035	1392	4	2022	50
1037	3780	9	2012	40
1039	1140	4	2015	1453
1042	768	6	2011	34
1043	940	4	2019	97
1049	1890	1	2016	938
1058	1840	3	2018	622
1060	735	6	2013	572
1062	3072	7	2016	615
1063	2765	11	2016	582
1065	1390	9	2017	599
1070	635	3	2013	668
1075	1030	3	2019	625
1093	1430	6	2011	710
1095	1250	3	2022	670
1097	2145	1	2018	730
1100	6924	9	2022	711
1102	2985	11	2019	708
1108	6426	3	2015	712
1111	865	4	2018	707
1113	930	4	2016	752
1114	965	4	2015	709
1118	940	4	2022	1107
1119	3530	1	2019	1452
1123	1380	1	2015	1451
1124	1385	1	2011	1054
1149	895	4	2016	1114
1150	2495	1	2014	1080
1151	1850	1	2019	1242
1158	8825	11	2016	111
1163	1005	4	2018	467
1166	405	6	2014	507
1174	1620	9	2018	1371
1430	1095	4	2022	413
1431	1520	11	2016	777
1434	1550	11	2020	493
1435	2212	6	2019	240
1436	1410	7	2013	267
1437	2928	4	2012	223
1438	1988	1	2018	875
1439	2590	4	2011	1045
1441	2565	11	2021	890
1442	1670	7	2017	1046
1443	3735	4	2018	772
1444	4770	11	2015	967
1445	1770	1	2017	969
1446	3048	1	2018	172
1447	4074	6	2022	177
1448	1815	11	2018	178
1449	1405	3	2020	218
1450	2095	11	2015	215
1451	1835	3	2015	189
1453	1345	4	2011	190
1455	4675	3	2020	13
1456	1410	4	2017	176
1457	1780	3	2022	214
1459	1405	1	2012	867
1460	3130	7	2019	181
1461	4460	11	2013	183
1463	1644	3	2014	212
1465	2690	11	2014	188
1467	1375	1	2017	951
1469	2575	4	2018	184
1470	2034	1	2019	953
1472	2320	6	2020	954
1473	1115	6	2021	783
1474	1890	11	2022	1066
1475	1590	1	2014	896
1476	1076	4	2015	958
1477	835	7	2016	952
1479	5075	6	2014	1448
1480	2079	1	2022	90
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1484	3012	1	2018	989
1485	3085	11	2017	991
1486	1800	3	2017	986
1487	2385	6	2011	995
1488	1220	7	2022	1006
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356	1720	6	2020	388
358	1160	1	2020	369
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363	2364	6	2011	247
364	4175	9	2016	227
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374	8217	4	2016	311
377	1460	1	2014	284
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382	715	6	2018	368
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395	1750	1	2021	377
396	1320	6	2013	374
399	1735	11	2011	306
401	1775	3	2014	304
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412	1825	6	2015	278
413	1200	3	2020	294
415	1800	1	2015	287
416	3415	6	2014	290
418	1732	11	2021	423
419	2200	7	2016	428
420	3075	4	2019	765
421	2110	7	2015	432
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426	1745	6	2013	482
427	2750	11	2019	776
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431	3445	11	2022	485
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437	2480	1	2012	412
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453	2256	11	2019	236
454	10260	3	2018	234
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458	2658	11	2015	888
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486	2205	1	2022	169
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495	2820	7	2021	217
496	2300	4	2018	222
497	3225	1	2014	219
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591	2745	6	2012	998
593	2080	11	2017	992
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608	3355	4	2020	1068
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616	3756	6	2020	804
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637	1915	11	2015	1154
638	1985	1	2020	1162
641	1480	6	2011	686
646	2460	1	2015	839
649	940	6	2015	695
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1239	4122	3	2019	873
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1780	3846	1	2022	1241
1781	2835	1	2012	1078
1782	535	7	2012	319
1783	585	6	2016	644
1784	990	4	2016	445
1785	375	7	2011	530
1786	1290	1	2011	529
1788	2675	1	2013	1327
1789	1725	7	2013	1326
1790	2000	7	2021	1374
1791	4190	6	2020	1380
1795	435	6	2013	809
1796	1450	6	2015	815
1797	1490	1	2016	810
1798	570	6	2022	552
1799	1880	1	2015	553
1800	680	6	2021	561
1801	124	4	2011	1444
1802	2975	9	2018	912

Appendix D

Pipe parameter

DH Pipes

dim	ID[mm]	ID[m]	max_velocity[m/s]	Density_water[kg/m3]	Area[m^2]	specific_enthalpy_100°C[kJ/kg]	specific_enthalpy_40°C[kJ/kg]	P[kW]	Price/m	Opex/m
0	0	0	0	0	0	0	0	1	0	0
20	21,6	0,0216	0,6	977	0,00036644	335,01	167,54	35,9732949	391	19,55
25	27,2	0,0272	1	977	0,00058107	335,01	167,54	95,0734543	396	19,8
32	36,1	0,0361	1,1	977	0,00102354	335,01	167,54	184,216512	422	21,1
40	42	0,042	1,2	977	0,00138544	335,01	167,54	272,020286	437	21,85
50	53,1	0,0531	1,4	977	0,00221452	335,01	167,54	507,269258	495	24,75
65	68,8	0,0688	1,6	977	0,00371764	419,17	167,54	1462,32438	537	26,85
80	80,8	0,0808	1,8	977	0,00512758	419,17	167,54	2269,03967	616	30,8
100	105,1	0,1051	1,9	977	0,00867552	419,17	167,54	4052,34018	760	38
125	129,7	0,1297	2	977	0,01321204	419,17	167,54	6496,16146	913	45,65
150	155,2	0,1552	2,5	977	0,01891792	419,17	167,54	11627,0705	1101	55,05
200	211,9	0,2119	3,3	977	0,03526564	675,47	167,54	57751,6189	1311	65,55
250	265,8	0,2658	3,9	977	0,0554881	675,47	167,54	107389,759	1755	87,75
300	315,9	0,3159	4,3	977	0,07837709	675,47	167,54	167246,107	2100	105

Gas Pipes

dim	ID[mm]	ID[m]	Area[m^2]	P[kW]	Opex/m
0	0	0	0	1	0
20	21,6	0,0216	0,000366435	1870,114691	19,55
25	27,2	0,0272	0,000581069	2965,504228	19,8
32	36,1	0,0361	0,001023539	5223,662907	21,1
40	42	0,042	0,001385442	7070,649679	21,85
50	53,1	0,0531	0,002214517	11301,85632	24,75
65	68,8	0,0688	0,003717635	18973,0703	26,85
80	80,8	0,0808	0,005127582	26168,77909	30,8
100	105,1	0,1051	0,008675516	44275,77498	38
125	129,7	0,1297	0,013212039	67428,06421	45,65
150	155,2	0,1552	0,018917917	96548,19821	55,05
200	211,9	0,2119	0,035265642	179979,3392	65,55
250	265,8	0,2658	0,055488098	283185,2916	87,75
300	315,9	0,3159	0,07837709	400000	105

Appendix E

Grid layout

Pipe	Length	NodeA	NodeB	Init DH current	Init_DH_greenfield	Init_Gas
1	6,139	27	1	300	0	DN200
2	18,16	1	2	300	0	DN200
3	26,568	2	5	300	0	DN200
4	20,816	5	9	300	0	DN200
5	34,628	9	19	300	0	DN200
6	18,395	19	21	300	0	DN200
7	22,995	21	23	300	0	DN200
8	32,955	23	54	250	0	DN200
9	23,044	54	55	250	0	DN200
10	9,904	55	56	250	0	DN200
11	26,738	57	58	250	0	DN200
12	12,463	58	59	250	0	DN200
13	22,619	59	60	250	0	DN200
14	18,794	60	61	250	0	DN200
15	53,626	61	62	250	0	DN200
16	12,177	62	63	250	0	DN125
17	44,058	63	64	250	0	DN125
18	17,188	64	65	250	0	DN125
19	17,578	65	66	250	0	DN125
20	19,898	66	67	250	0	DN125
21	19,917	67	68	250	0	DN125
22	12,729	68	69	250	0	DN125
23	10,497	69	70	200	0	DN125
24	11,003	70	71	200	0	DN125
25	9,29	71	72	200	0	DN125
26	19,289	72	73	200	0	DN125
27	22,122	73	74	200	0	DN125
28	14,146	74	75	200	0	DN125
29	22,167	75	76	200	0	DN125
30	30,677	76	77	200	0	DN125
31	19,42	77	78	200	0	DN100
32	22,778	78	79	200	0	DN100
33	19,944	79	80	200	0	DN100
34	13,935	80	81	200	0	DN100
35	20,131	81	82	200	0	DN100
36	27,61	82	83	200	0	DN100
37	16,921	56	57	250	0	DN200
38	14,567	83	352	200	0	DN100
39	32,967	352	354	200	0	DN100
40	8,49	354	356	200	0	DN100
41	21,762	356	358	200	0	DN100
42	44,636	358	359	200	0	DN100
43	48,442	359	360	200	0	DN100
44	17,962	360	361	200	0	DN100
45	21,287	361	362	200	0	DN100
46	20,478	362	363	200	0	DN100
47	31,816	363	364	200	0	DN100
48	51,316	364	496	200	0	DN80
49	66,09	496	499	200	0	DN80
50	20,452	499	502	200	0	DN80
51	18,364	502	504	200	0	DN80
52	15,736	504	509	200	0	DN80
53	61,539	509	511	200	0	DN65
54	27,212	511	514	200	0	DN65
55	64,102	514	565	200	0	DN65
56	33,109	565	614	200	0	DN65
57	29,302	614	617	200	0	DN65
58	16,31	617	619	200	0	DN65
59	33,281	619	649	150	0	DN50
60	16,994	649	650	150	0	DN50
61	16,051	650	651	150	0	DN50
62	40,245	651	652	150	0	DN50
63	40,044	652	653	150	0	DN50
64	19,965	62	899	200	0	DN100
65	21,934	899	901	200	0	DN100
66	50,856	901	903	200	0	DN100
67	23,157	903	905	200	0	DN100
68	29,897	905	907	200	0	DN100
69	22,854	907	910	200	0	DN100
70	59,352	910	924	200	0	DN100
71	23,505	924	925	200	0	DN100
72	20,527	925	926	200	0	DN100
73	14,657	926	927	200	0	DN100
74	45,555	927	971	200	0	DN100
75	18,839	971	972	200	0	DN100
76	12,743	972	973	200	0	DN100
77	21,989	973	974	100	0	DN32
78	22,493	974	975	100	0	DN32
79	19,476	975	976	100	0	DN25
80	29,673	976	977	80	0	DN25
81	38,472	977	978	80	0	DN20
82	22,465	978	979	65	0	DN20
83	31,793	979	932	65	0	DN20
84	14,018	932	980	65	0	DN20
85	14,334	980	981	65	0	DN20
86	16,005	981	982	65	0	DN20
87	16,436	982	983	65	0	DN20
88	14,384	983	984	65	0	DN20
89	16,246	984	985	32	0	DN20
90	67,242	973	1082	200	0	DN80
91	27,898	1085	1088	200	0	DN80
92	23,365	1088	1093	200	0	DN80
93	22,394	1093	1096	200	0	DN80
94	21,729	1082	1098	200	0	DN80
95	23,232	1098	1085	200	0	DN80
96	15,693	1096	1120	150	0	DN40
97	12,397	1120	1122	150	0	DN40
98	13,404	1122	1125	150	0	DN40
99	17,924	1125	1128	150	0	DN40
100	20,936	1128	1130	150	0	DN40
101	37,428	1096	1197	200	0	DN65
102	16,174	1197	1198	200	0	DN65
103	36,314	1198	1201	200	0	DN65
104	28,531	1201	1205	150	0	DN65
105	15,388	1205	1209	150	0	DN50
106	20,16	1209	1211	150	0	DN50
107	39,467	1211	1306	150	0	DN50
108	18,704	1306	1309	150	0	DN50
109	19,502	1309	1314	150	0	DN50
110	18,709	1314	1318	150	0	DN50
111	9,674	1318	1331	150	0	DN50
112	16,168	1331	1319	125	0	DN32
113	14,479	1319	1322	125	0	DN32
114	23,478	1322	1325	125	0	DN32
115	27,318	1325	1328	125	0	DN32
116	17,28	1328	1330	100	0	DN32
1001	11,644252	2	3	0	0	DN20

Pipe	Length	NodeA	NodeB	Init DH current	Init_DH_greenfield	Init_Gas
1611	37,514047	660	666	0	0	DN20
1612	16,990131	666	669	0	0	DN20
1613	20,985707	669	671	0	0	DN20
1614	18,818983	669	670	0	0	DN20
1615	23,320607	653	680	0	0	DN20
1616	12,724864	680	686	0	0	DN20
1617	20,476204	680	681	0	0	DN20
1618	10,73643	681	687	0	0	DN20
1619	25,357958	681	682	0	0	DN20
1620	13,886581	682	688	0	0	DN20
1621	32,326824	682	692	0	0	DN20
1622	8,916676	682	689	0	0	DN20
1623	22,560189	682	683	0	0	DN20
1624	11,770561	683	690	0	0	DN20
1625	17,376782	683	691	0	0	DN20
1626	30,636557	683	684	0	0	DN20
1627	9,123345	684	694	0	0	DN20
1628	9,758532	684	693	0	0	DN20
1629	21,250186	684	685	0	0	DN20
1630	9,535082	685	695	0	0	DN20
1631	11,435612	685	696	0	0	DN20
1632	39,524566	653	697	0	0	DN40
1633	15,140853	697	698	0	0	DN20
1634	15,731248	697	699	0	0	DN20
1635	42,611138	697	700	0	0	DN32
1636	18,131963	700	701	0	0	DN20
1637	14,012569	700	702	0	0	DN20
1638	68,688722	700	703	0	0	DN20
1639	23,481328	703	705	0	0	DN20
1640	30,055183	703	706	0	0	DN20
1641	13,177614	703	704	0	0	DN20
1642	38,588237	703	707	0	0	DN20
1643	33,268212	703	708	0	0	DN20
1644	26,556752	703	709	0	0	DN20
1645	40,847796	703	710	0	0	DN20
1646	12,710592	703	711	0	0	DN20
1647	19,766055	703	712	0	0	DN20
1648	39,256465	703	713	0	0	DN20
1649	39,953292	700	714	0	0	DN25
1650	12,37383	714	715	0	0	DN20
1651	16,325683	714	716	0	0	DN20
1652	33,534458	714	717	0	0	DN25
1653	17,694097	717	718	0	0	DN20
1654	14,848655	718	719	0	0	DN20
1655	13,704214	718	720	0	0	DN20
1656	21,198902	718	721	0	0	DN20
1657	11,435913	721	722	0	0	DN20
1658	21,063683	721	724	0	0	DN20
1659	15,58651	721	723	0	0	DN20
1660	11,810348	724	725	0	0	DN20
1661	16,163671	724	726	0	0	DN20
1662	22,314502	724	727	0	0	DN20
1663	34,095765	727	732	0	0	DN20
1664	42,169553	727	733	0	0	DN20
1665	30,015334	727	731	0	0	DN20
1666	21,786322	727	730	0	0	DN20
1667	14,644499	727	729	0	0	DN20
1668	11,596702	727	728	0	0	DN20
1669	37,355153	717	734	0	0	DN20
1670	11,798664	734	735	0	0	DN20
1671	23,311268	734	736	0	0	DN20
1672	36,665609	717	737	0	0	DN20
1673	11,244688	737	738	0	0	DN20
1674	37,300222	737	741	0	0	DN20
1675	48,192261	737	744	0	0	DN20
1676	15,457072	737	740	0	0	DN20
1677	12,410361	737	739	0	0	DN20
1678	23,514629	737	742	0	0	DN20
1679	13,272083	742	743	0	0	DN20
1680	57,807456	742	747	0	0	DN20
1681	26,262725	747	745	0	0	DN20
1682	13,231493	747	746	0	0	DN20
1683	28,422597	747	748	0	0	DN20
1684	29,305934	742	749	0	0	DN20
1685	9,265857	749	750	0	0	DN20
1686	19,52634	749	751	0	0	DN20
1687	14,813121	751	752	0	0	DN20
1688	9,491871	751	753	0	0	DN20
1689	26,082261	751	754	0	0	DN20
1690	14,026726	754	755	0	0	DN20
1691	37,879287	754	756	0	0	DN20
1692	29,33393	626	758	0	0	DN20
1693	53,276693	504	506	0	0	DN20
1694	55,429664	700	757	0	0	DN20
1695	14,229279	77	759	0	0	DN50
1696	11,311872	759	761	0	0	DN20
1697	15,931589	759	760	0	0	DN20
1698	36,396846	759	762	0	0	DN50
1699	11,301065	762	764	0	0	DN20
1700	10,116894	762	763	0	0	DN20
1701	19,982873	762	767	0	0	DN50
1702	10,430844	767	766	0	0	DN20
1703	9,597237	767	765	0	0	DN20
1704	24,552977	767	768	0	0	DN50
1705	10,95961	768	769	0	0	DN20
1706	45,838217	768	770	0	0	DN50
1707	14,225297	770	772	0	0	DN20
1708	11,461636	770	771	0	0	DN20
1709	20,341969	770	773	0	0	DN50
1710	9,960164	773	774	0	0	DN20
1711	22,961038	773	775	0	0	DN50
1712	9,93996	775	776	0	0	DN20
1713	26,032671	775	778	0	0	DN50
1714	9,939954	778	777	0	0	DN20
1715	22,758771	778	779	0	0	DN50
1716	13,064728	779	781	0	0	DN20
1717	11,329089	779	780	0	0	DN20
1718	34,482099	779	782	0	0	DN50
1719	10,569924	782	783	0	0	DN20
1720	11,127323	782	784	0	0	DN20
1721	27,523277	782	785	0	0	DN40
1722	12,645022	785	786	0	0	DN20
1723	10,220865	785	787	0	0	DN20
1724	20,322405	785	788	0	0	DN40
1725	13,071521	788	789	0	0	DN20
1726	14,090844	788	790	0	0	DN20
1727	23,810013	788	791	0	0	DN40

1002	10,72835	2	4	0	0	DN20
1003	11,266881	5	6	0	0	DN20
1004	30,762108	5	8	0	0	DN20
1005	10,091241	5	7	0	0	DN20
1006	39,919041	1	26	0	0	DN20
1007	10,933168	26	28	0	0	DN20
1008	12,678612	9	10	0	0	DN20
1009	30,364197	9	11	0	0	DN32
1010	28,469035	11	12	0	0	DN20
1011	11,790211	12	13	0	0	DN20
1012	14,425091	12	16	0	0	DN20
1013	8,688681	16	17	0	0	DN20
1014	21,709906	16	18	0	0	DN20
1015	10,107308	12	14	0	0	DN20
1016	21,788401	12	15	0	0	DN20
1017	11,285016	19	20	0	0	DN20
1018	12,482588	21	22	0	0	DN20
1019	54,688023	23	24	0	0	DN20
1020	12,597365	24	25	0	0	DN20
1021	13,732079	11	29	0	0	DN20
1022	26,215361	11	30	0	0	DN20
1023	23,932339	23	33	0	0	DN32
1024	11,955857	33	32	0	0	DN20
1025	13,264598	33	31	0	0	DN20
1026	24,592643	33	36	0	0	DN32
1027	12,6039	36	35	0	0	DN20
1028	11,202166	36	34	0	0	DN20
1029	14,237276	36	53	0	0	DN32
1030	10,146843	53	37	0	0	DN20
1031	30,982831	53	38	0	0	DN32
1032	12,288749	38	40	0	0	DN20
1033	8,186252	38	39	0	0	DN20
1034	42,386839	38	42	0	0	DN32
1035	10,448354	42	41	0	0	DN20
1036	36,822296	42	44	0	0	DN32
1037	12,228787	44	43	0	0	DN20
1038	25,497847	44	46	0	0	DN20
1039	11,954047	46	47	0	0	DN20
1040	26,164598	46	48	0	0	DN20
1041	9,267106	48	50	0	0	DN20
1042	8,856882	48	49	0	0	DN20
1043	31,897021	48	51	0	0	DN20
1044	10,89811	51	52	0	0	DN20
1045	43,164324	44	45	0	0	DN32
1046	21,514176	56	84	0	0	DN32
1047	9,420689	84	88	0	0	DN20
1048	8,625267	84	89	0	0	DN20
1049	25,605675	84	91	0	0	DN32
1050	15,90199	91	90	0	0	DN20
1051	11,568613	91	92	0	0	DN32
1052	11,883738	92	93	0	0	DN20
1053	15,401689	92	95	0	0	DN25
1054	12,315798	95	94	0	0	DN20
1055	22,31152	95	96	0	0	DN25
1056	10,889399	96	97	0	0	DN20
1057	13,615343	96	98	0	0	DN20
1058	28,59234	96	99	0	0	DN20
1059	11,272122	99	100	0	0	DN20
1060	15,42477	99	101	0	0	DN20
1061	11,425078	101	102	0	0	DN20
1062	17,024136	101	103	0	0	DN20
1063	14,699652	103	104	0	0	DN20
1064	16,207532	103	105	0	0	DN20
1065	11,955572	105	106	0	0	DN20
1066	29,082762	105	107	0	0	DN20
1067	11,201888	107	108	0	0	DN20
1068	70,916248	107	109	0	0	DN20
1069	12,749812	109	110	0	0	DN20
1070	15,869252	109	111	0	0	DN20
1071	10,62759	57	87	0	0	DN20
1072	11,20168	55	86	0	0	DN20
1073	8,34767	54	85	0	0	DN20
1074	10,696933	61	113	0	0	DN20
1075	9,761536	60	112	0	0	DN20
1076	13,93311	59	114	0	0	DN20
1077	8,956708	115	116	0	0	DN20
1078	10,152433	115	117	0	0	DN20
1079	21,930679	61	115	0	0	DN25
1080	25,383544	115	118	0	0	DN25
1081	12,078744	118	119	0	0	DN20
1082	10,817822	118	120	0	0	DN20
1083	17,806226	118	121	0	0	DN25
1084	9,764594	121	122	0	0	DN20
1085	11,485058	121	123	0	0	DN20
1086	9,566735	123	124	0	0	DN20
1087	24,582228	123	127	0	0	DN20
1088	16,44522	123	125	0	0	DN20
1089	44,188733	121	128	0	0	DN20
1090	10,154266	125	126	0	0	DN20
1091	11,466966	125	129	0	0	DN20
1092	28,642808	129	130	0	0	DN20
1093	43,381315	129	131	0	0	DN20
1094	32,261078	129	132	0	0	DN20
1095	9,720249	132	134	0	0	DN20
1096	13,632634	132	133	0	0	DN20
1097	23,580815	132	135	0	0	DN20
1098	13,554512	135	136	0	0	DN20
1099	20,093582	135	138	0	0	DN20
1100	12,367005	138	137	0	0	DN20
1101	9,661106	138	139	0	0	DN20
1102	17,967403	139	140	0	0	DN20
1103	13,965187	139	141	0	0	DN20
1104	14,498783	141	142	0	0	DN20
1105	19,789976	141	143	0	0	DN20
1106	15,447425	143	144	0	0	DN20
1107	28,094531	143	145	0	0	DN20
1108	40,250275	11	146	0	0	DN25
1109	11,426493	146	160	0	0	DN20
1110	30,790377	146	161	0	0	DN20
1111	22,941059	146	147	0	0	DN25
1112	11,574943	147	159	0	0	DN20
1113	15,493578	147	148	0	0	DN25
1114	9,911764	148	162	0	0	DN20
1115	15,624202	148	149	0	0	DN25
1116	39,963507	149	150	0	0	DN20
1117	10,419214	150	163	0	0	DN20
1118	35,046673	150	164	0	0	DN20
1119	24,619166	150	151	0	0	DN20

1728	11,247158	791	792	0	0	DN20
1729	22,725764	791	793	0	0	DN32
1730	12,800182	793	794	0	0	DN20
1731	15,093249	793	796	0	0	DN20
1732	29,602078	793	798	0	0	DN20
1733	28,880897	793	799	0	0	DN32
1734	14,074274	799	802	0	0	DN20
1735	14,335452	799	800	0	0	DN20
1736	30,00833	799	801	0	0	DN20
1737	21,797826	799	805	0	0	DN32
1738	13,806847	805	804	0	0	DN20
1739	10,959488	805	803	0	0	DN20
1740	21,775734	805	808	0	0	DN32
1741	11,349889	808	807	0	0	DN20
1742	14,067192	808	806	0	0	DN20
1743	43,32162	808	809	0	0	DN20
1744	38,380697	808	810	0	0	DN20
1745	16,730777	808	811	0	0	DN20
1746	25,369208	808	812	0	0	DN32
1747	12,752451	812	813	0	0	DN20
1748	12,496639	812	814	0	0	DN20
1749	27,850992	812	815	0	0	DN20
1750	25,05555	812	817	0	0	DN32
1751	11,804699	817	816	0	0	DN20
1752	10,225653	817	819	0	0	DN32
1753	12,626194	819	818	0	0	DN20
1754	26,688187	819	821	0	0	DN32
1755	13,903501	819	820	0	0	DN20
1756	12,755622	821	822	0	0	DN20
1757	13,055751	821	824	0	0	DN20
1758	11,418477	821	823	0	0	DN20
1759	29,100194	821	825	0	0	DN25
1760	11,298272	825	827	0	0	DN20
1761	12,110657	825	826	0	0	DN20
1762	24,397585	825	830	0	0	DN25
1763	11,362852	830	832	0	0	DN20
1764	11,917304	830	831	0	0	DN20
1765	11,671857	830	835	0	0	DN25
1766	10,582697	835	834	0	0	DN20
1767	14,345178	835	833	0	0	DN20
1768	53,057119	835	836	0	0	DN25
1769	13,200823	836	837	0	0	DN20
1770	34,779416	836	838	0	0	DN25
1771	12,869362	838	840	0	0	DN20
1772	11,910685	838	839	0	0	DN20
1773	21,610736	838	841	0	0	DN25
1774	12,576991	841	842	0	0	DN20
1775	14,611017	841	845	0	0	DN25
1776	13,308361	845	844	0	0	DN20
1777	22,744246	845	847	0	0	DN25
1778	12,144477	847	846	0	0	DN20
1779	14,611002	847	848	0	0	DN20
1780	11,987107	848	849	0	0	DN20
1781	31,082965	848	850	0	0	DN20
1782	13,487502	850	862	0	0	DN20
1783	29,294269	850	851	0	0	DN20
1784	15,174293	851	853	0	0	DN20
1785	12,267169	851	852	0	0	DN20
1786	44,5581	851	855	0	0	DN20
1787	10,748591	855	856	0	0	DN20
1788	12,732244	855	854	0	0	DN20
1789	56,895897	855	858	0	0	DN20
1790	13,860004	858	859	0	0	DN20
1791	11,63535	858	857	0	0	DN20
1792	27,456759	858	861	0	0	DN20
1793	12,71737	861	860	0	0	DN20
1794	42,941019	69	863	0	0	DN20
1795	9,273977	863	864	0	0	DN20
1796	10,222	863	865	0	0	DN20
1797	18,292552	863	866	0	0	DN20
1798	9,239621	866	868	0	0	DN20
1799	8,261362	866	867	0	0	DN20
1800	48,821904	866	869	0	0	DN20
1801	15,851969	869	877	0	0	DN20
1802	9,905234	877	878	0	0	DN20
1803	14,932261	877	880	0	0	DN20
1804	10,78694	880	879	0	0	DN20
1805	53,352901	880	881	0	0	DN20
1806	11,937674	881	882	0	0	DN20
1807	12,473529	881	883	0	0	DN20
1808	11,191861	881	884	0	0	DN20
1809	32,156384	869	870	0	0	DN20
1810	10,083782	870	872	0	0	DN20
1811	19,969308	870	871	0	0	DN20
1812	11,319499	871	873	0	0	DN20
1813	34,070765	871	874	0	0	DN20
1814	9,742697	874	875	0	0	DN20
1815	25,637378	874	876	0	0	DN20
1816	31,727199	782	885	0	0	DN20
1817	10,14704	885	888	0	0	DN20
1818	19,669769	885	886	0	0	DN20
1819	11,444	886	889	0	0	DN20
1820	23,857191	886	887	0	0	DN20
1821	12,054289	887	890	0	0	DN20
1822	13,844707	887	891	0	0	DN20
1823	23,182875	887	892	0	0	DN20
1824	12,560566	892	894	0	0	DN20
1825	7,025251	892	893	0	0	DN20
1826	18,994003	892	895	0	0	DN20
1827	12,011266	895	897	0	0	DN20
1828	26,910134	895	898	0	0	DN20
1829	11,852354	895	896	0	0	DN20
1830	11,90004	899	900	0	0	DN20
1831	10,790043	901	902	0	0	DN20
1832	11,293277	903	904	0	0	DN20
1833	13,377669	905	906	0	0	DN20
1834	15,918807	907	909	0	0	DN20
1835	13,93111	907	908	0	0	DN20
1836	19,523842	910	911	0	0	DN25
1837	12,821184	911	912	0	0	DN20
1838	17,561135	911	913	0	0	DN20
1839	32,061308	911	914	0	0	DN20
1840	15,22195	914	915	0	0	DN20
1841	14,794947	914	916	0	0	DN20
1842	43,413177	914	917	0	0	DN20
1843	14,794835	917	918	0	0	DN20
1844	25,986089	917	920	0	0	DN20
1845	12,681694	920	919	0	0	DN20

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1121	8,429873	151	166	0	0	DN20
1122	10,115414	150	165	0	0	DN20
1123	20,009039	149	152	0	0	DN20
1124	11,770454	152	168	0	0	DN20
1125	25,910366	152	153	0	0	DN20
1126	10,512697	153	170	0	0	DN20
1127	11,893008	153	169	0	0	DN20
1128	24,096563	153	154	0	0	DN20
1129	11,384411	154	171	0	0	DN20
1130	30,177238	154	155	0	0	DN20
1131	11,426791	155	172	0	0	DN20
1132	10,985423	155	173	0	0	DN20
1133	20,03185	155	156	0	0	DN20
1134	8,740398	156	174	0	0	DN20
1135	6,880426	156	175	0	0	DN20
1136	13,223474	156	157	0	0	DN20
1137	7,488069	157	176	0	0	DN20
1138	19,674941	157	158	0	0	DN20
1139	9,397924	158	177	0	0	DN20
1140	10,62725	158	178	0	0	DN20
1141	18,756504	71	191	0	0	DN20
1142	7,947163	191	189	0	0	DN20
1143	28,320197	191	192	0	0	DN20
1144	8,407158	192	190	0	0	DN20
1145	9,185238	70	188	0	0	DN20
1146	11,1782	68	187	0	0	DN20
1147	11,735722	67	186	0	0	DN20
1148	10,503535	67	185	0	0	DN20
1149	12,7196	65	183	0	0	DN20
1150	9,440398	66	184	0	0	DN20
1151	8,240887	65	182	0	0	DN20
1152	9,708813	64	181	0	0	DN20
1153	10,27201	64	180	0	0	DN20
1154	11,198779	63	179	0	0	DN20
1155	15,797763	58	193	0	0	DN20
1156	32,92553	193	194	0	0	DN20
1157	10,665753	193	204	0	0	DN20
1158	8,54773	193	203	0	0	DN20
1159	9,617932	194	206	0	0	DN20
1160	17,692356	194	195	0	0	DN20
1161	8,986945	195	205	0	0	DN20
1162	9,627024	195	207	0	0	DN20
1163	27,44427	195	196	0	0	DN20
1164	8,575834	196	209	0	0	DN20
1165	21,932302	196	197	0	0	DN20
1166	7,046283	197	210	0	0	DN20
1167	10,915569	197	211	0	0	DN20
1168	24,204852	197	198	0	0	DN20
1169	8,894357	198	212	0	0	DN20
1170	39,735027	198	199	0	0	DN20
1171	7,759262	199	213	0	0	DN20
1172	35,726129	199	200	0	0	DN20
1173	9,042462	200	214	0	0	DN20
1174	8,419967	200	215	0	0	DN20
1175	29,453523	200	201	0	0	DN20
1176	11,377487	201	217	0	0	DN20
1177	6,993385	201	216	0	0	DN20
1178	24,437622	201	202	0	0	DN20
1179	9,087179	202	218	0	0	DN20
1180	10,987948	72	219	0	0	DN20
1181	10,290264	73	220	0	0	DN20
1182	13,675489	73	221	0	0	DN20
1183	8,095399	74	222	0	0	DN20
1184	13,144464	75	224	0	0	DN20
1185	10,228382	75	223	0	0	DN20
1186	11,674547	76	225	0	0	DN20
1187	32,711749	77	226	0	0	DN25
1188	13,839113	226	228	0	0	DN20
1189	15,353967	226	227	0	0	DN20
1190	21,689925	226	231	0	0	DN25
1191	15,084972	231	230	0	0	DN20
1192	13,802488	231	229	0	0	DN20
1193	30,933109	231	232	0	0	DN20
1194	12,671592	232	234	0	0	DN20
1195	15,87698	232	233	0	0	DN20
1196	45,376921	232	235	0	0	DN20
1197	14,627124	235	236	0	0	DN20
1198	18,336706	235	239	0	0	DN20
1199	10,333287	239	238	0	0	DN20
1200	14,245222	235	237	0	0	DN20
1201	15,821669	239	240	0	0	DN20
1202	24,291742	239	241	0	0	DN20
1203	16,437033	241	242	0	0	DN20
1204	31,561983	235	243	0	0	DN20
1205	18,539064	196	208	0	0	DN20
1206	9,3622	79	244	0	0	DN20
1207	8,419669	80	245	0	0	DN20
1208	8,271537	81	246	0	0	DN20
1209	9,442075	81	247	0	0	DN20
1210	10,210737	82	249	0	0	DN20
1211	10,677056	82	248	0	0	DN20
1212	41,649679	83	250	0	0	DN32
1213	12,87772	250	252	0	0	DN20
1214	16,246803	250	251	0	0	DN32
1215	13,373622	251	253	0	0	DN20
1216	17,953542	251	255	0	0	DN25
1217	10,857508	255	254	0	0	DN20
1218	22,051266	255	256	0	0	DN25
1219	16,918532	256	258	0	0	DN20
1220	12,290204	256	257	0	0	DN20
1221	19,838722	256	259	0	0	DN20
1222	18,352965	259	260	0	0	DN20
1223	16,005453	259	261	0	0	DN20
1224	9,289056	261	265	0	0	DN20
1225	17,616152	261	263	0	0	DN20
1226	16,699547	263	264	0	0	DN20
1227	41,181438	263	266	0	0	DN20
1228	25,36099	261	262	0	0	DN20
1229	25,261629	263	267	0	0	DN20
1230	37,076992	263	268	0	0	DN20
1231	50,040722	261	269	0	0	DN20
1232	19,653587	83	270	0	0	DN40
1233	10,626796	270	271	0	0	DN20
1234	15,407632	270	272	0	0	DN40
1235	11,14575	272	273	0	0	DN20
1236	17,970593	272	274	0	0	DN40
1237	10,998781	274	276	0	0	DN20
1846	27,641493	920	921	0	0	DN20
1847	15,057692	921	922	0	0	DN20
1848	15,149656	921	923	0	0	DN20
1849	33,393986	845	843	0	0	DN20
1850	28,734154	825	829	0	0	DN20
1851	29,311721	821	828	0	0	DN20
1852	65,83649	791	797	0	0	DN20
1853	30,265349	793	795	0	0	DN20
1854	20,526822	927	928	0	0	DN20
1855	22,581118	928	929	0	0	DN20
1856	17,144605	928	935	0	0	DN20
1857	14,01197	925	934	0	0	DN20
1858	14,140471	924	933	0	0	DN20
1859	14,228993	926	936	0	0	DN20
1860	11,873345	929	937	0	0	DN20
1861	8,506435	929	938	0	0	DN20
1862	17,068395	929	930	0	0	DN20
1863	13,740779	930	940	0	0	DN20
1864	33,906245	930	942	0	0	DN20
1865	9,299337	930	939	0	0	DN20
1866	13,906478	930	931	0	0	DN20
1867	8,485487	931	941	0	0	DN20
1868	35,10965	927	943	0	0	DN25
1869	9,515484	943	964	0	0	DN20
1870	9,336353	943	963	0	0	DN20
1871	20,337746	943	944	0	0	DN25
1872	11,272105	944	962	0	0	DN20
1873	17,286215	944	945	0	0	DN20
1874	10,916229	944	961	0	0	DN20
1875	9,433497	945	960	0	0	DN20
1876	36,468142	945	946	0	0	DN20
1877	12,848496	946	958	0	0	DN20
1878	41,21168	946	959	0	0	DN20
1879	12,986265	946	947	0	0	DN20
1880	9,193969	947	956	0	0	DN20
1881	25,56261	947	957	0	0	DN20
1882	8,951689	947	954	0	0	DN20
1883	20,590008	947	955	0	0	DN20
1884	22,65371	947	948	0	0	DN20
1885	10,461457	948	953	0	0	DN20
1886	11,740286	948	952	0	0	DN20
1887	14,311126	948	949	0	0	DN20
1888	33,224589	949	950	0	0	DN20
1889	18,801814	950	951	0	0	DN20
1890	16,782012	949	965	0	0	DN20
1891	18,524188	965	969	0	0	DN20
1892	27,344135	965	968	0	0	DN20
1893	13,775989	965	967	0	0	DN20
1894	13,486029	949	966	0	0	DN20
1895	23,837839	965	970	0	0	DN20
1896	14,011899	971	987	0	0	DN20
1897	16,274432	972	988	0	0	DN20
1898	15,000843	971	986	0	0	DN20
1899	13,025689	972	989	0	0	DN20
1900	11,151924	974	990	0	0	DN20
1901	11,429627	975	991	0	0	DN20
1902	12,833106	975	992	0	0	DN20
1903	32,854484	975	993	0	0	DN20
1904	13,121655	976	994	0	0	DN20
1905	9,998277	976	995	0	0	DN20
1906	15,799843	977	996	0	0	DN20
1907	16,364772	977	997	0	0	DN20
1908	15,288238	977	998	0	0	DN20
1909	12,026808	978	999	0	0	DN20
1910	9,70158	978	1000	0	0	DN20
1911	8,859638	979	1001	0	0	DN20
1912	14,799588	980	1002	0	0	DN20
1913	9,580373	932	1003	0	0	DN20
1914	11,881467	980	1004	0	0	DN20
1915	27,992113	980	1005	0	0	DN20
1916	7,864603	981	1006	0	0	DN20
1917	10,491571	982	1008	0	0	DN20
1918	9,932614	982	1007	0	0	DN20
1919	8,827133	983	1009	0	0	DN20
1920	8,667136	984	1010	0	0	DN20
1921	33,49138	984	1011	0	0	DN20
1922	8,885878	985	1012	0	0	DN20
1923	28,462509	950	1013	0	0	DN20
1924	14,367246	1013	1014	0	0	DN20
1925	14,393589	1013	1015	0	0	DN20
1926	24,020031	973	1016	0	0	DN32
1927	11,836821	1016	1037	0	0	DN20
1928	32,742425	1016	1017	0	0	DN25
1929	8,401587	1017	1038	0	0	DN20
1930	11,956159	1017	1039	0	0	DN20
1931	14,677471	1017	1019	0	0	DN25
1932	32,029684	1019	1020	0	0	DN20
1933	10,013235	1020	1040	0	0	DN20
1934	14,997664	1019	1018	0	0	DN25
1935	11,311982	1018	1041	0	0	DN20
1936	21,786361	1018	1021	0	0	DN25
1937	9,222883	1021	1042	0	0	DN20
1938	19,956403	1021	1043	0	0	DN20
1939	34,621241	1021	1022	0	0	DN25
1940	19,414323	1022	1023	0	0	DN25
1941	10,462028	1023	1045	0	0	DN20
1942	9,942075	1023	1044	0	0	DN20
1943	34,8088	1023	1024	0	0	DN20
1944	10,525557	1024	1046	0	0	DN20
1945	11,377405	1024	1047	0	0	DN20
1946	22,547439	1024	1025	0	0	DN20
1947	9,778816	1025	1048	0	0	DN20
1948	29,13488	1022	1026	0	0	DN20
1949	23,137956	1026	1027	0	0	DN20
1950	12,835963	1027	1050	0	0	DN20
1951	25,717432	1027	1067	0	0	DN20
1952	12,476826	1067	1068	0	0	DN20
1953	35,313137	1027	1028	0	0	DN20
1954	8,984575	1028	1051	0	0	DN20
1955	14,712543	1028	1052	0	0	DN20
1956	26,129326	1028	1029	0	0	DN20
1957	6,897727	1029	1054	0	0	DN20
1958	12,730449	1029	1053	0	0	DN20
1959	19,614658	1029	1030	0	0	DN20
1960	10,74756	1030	1056	0	0	DN20
1961	13,251031	1030	1055	0	0	DN20
1962	22,456461	1030	1031	0	0	DN20
1963	8,624117	1031	1057	0	0	DN20

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1239	16,946805	274	277	0	0	DN40
1240	9,478314	277	279	0	0	DN20
1241	13,712546	277	278	0	0	DN20
1242	19,729939	277	280	0	0	DN32
1243	12,829493	280	281	0	0	DN20
1244	11,859629	280	282	0	0	DN32
1245	11,824593	282	283	0	0	DN20
1246	10,888094	282	284	0	0	DN20
1247	18,47256	282	285	0	0	DN32
1248	11,398008	285	286	0	0	DN20
1249	12,405395	285	287	0	0	DN20
1250	33,013498	285	288	0	0	DN32
1251	10,18262	288	289	0	0	DN20
1252	13,091637	288	290	0	0	DN20
1253	18,462222	288	291	0	0	DN32
1254	10,940592	291	293	0	0	DN20
1255	12,346487	291	292	0	0	DN20
1256	12,817222	291	295	0	0	DN32
1257	19,867744	295	296	0	0	DN20
1258	11,976485	295	294	0	0	DN20
1259	14,661387	295	297	0	0	DN32
1260	47,719629	297	298	0	0	DN20
1261	11,25308	298	299	0	0	DN20
1262	51,230218	298	300	0	0	DN20
1263	15,439823	300	301	0	0	DN20
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1265	12,584913	302	304	0	0	DN20
1266	12,895844	302	303	0	0	DN20
1267	19,546458	302	305	0	0	DN20
1268	10,430314	305	306	0	0	DN20
1269	28,683819	305	308	0	0	DN20
1270	7,492874	308	309	0	0	DN20
1271	52,305311	308	310	0	0	DN20
1272	16,373081	310	311	0	0	DN20
1273	41,130981	305	307	0	0	DN20
1274	40,151031	297	312	0	0	DN32
1275	17,722922	312	313	0	0	DN20
1276	62,230696	312	314	0	0	DN25
1277	16,566508	314	315	0	0	DN20
1278	46,958732	314	316	0	0	DN25
1279	15,737382	316	317	0	0	DN20
1280	19,404678	316	318	0	0	DN25
1281	24,164221	318	319	0	0	DN20
1282	22,55268	318	320	0	0	DN25
1283	15,378077	320	321	0	0	DN20
1284	16,52479	320	322	0	0	DN25
1285	13,750073	322	323	0	0	DN20
1286	18,844014	322	324	0	0	DN25
1287	14,470437	324	325	0	0	DN20
1288	12,823616	324	326	0	0	DN25
1289	15,822508	326	327	0	0	DN20
1290	18,395764	326	328	0	0	DN25
1291	19,114896	328	329	0	0	DN20
1292	60,137735	328	330	0	0	DN25
1293	15,579236	330	331	0	0	DN20
1294	21,289979	330	332	0	0	DN25
1295	13,096697	332	333	0	0	DN20
1296	19,295635	332	334	0	0	DN20
1297	11,155745	334	335	0	0	DN20
1298	16,8277	334	336	0	0	DN20
1299	11,602436	336	337	0	0	DN20
1300	30,00221	336	338	0	0	DN20
1301	12,502043	338	339	0	0	DN20
1302	15,591176	338	340	0	0	DN20
1303	12,450307	340	341	0	0	DN20
1304	9,092569	340	342	0	0	DN20
1305	14,524046	342	343	0	0	DN20
1306	14,213074	342	344	0	0	DN20
1307	12,800949	344	345	0	0	DN20
1308	26,839875	344	346	0	0	DN20
1309	14,725176	346	348	0	0	DN20
1310	22,059178	346	347	0	0	DN20
1311	12,554165	347	349	0	0	DN20
1312	13,916079	350	351	0	0	DN20
1313	16,779788	347	350	0	0	DN20
1314	10,081516	352	353	0	0	DN20
1315	18,085317	354	355	0	0	DN20
1316	9,969208	356	357	0	0	DN20
1317	40,285164	358	365	0	0	DN20
1318	11,597612	365	369	0	0	DN20
1319	15,33556	365	366	0	0	DN20
1320	7,019248	366	367	0	0	DN20
1321	8,330024	366	368	0	0	DN20
1322	27,940641	366	370	0	0	DN20
1323	7,127291	370	371	0	0	DN20
1324	12,171644	370	372	0	0	DN20
1325	17,664024	370	373	0	0	DN20
1326	8,451615	373	374	0	0	DN20
1327	12,546228	373	375	0	0	DN20
1328	15,570308	373	376	0	0	DN20
1329	8,637199	376	377	0	0	DN20
1330	12,262241	376	378	0	0	DN20
1331	9,825516	376	379	0	0	DN20
1332	7,664278	379	380	0	0	DN20
1333	12,451848	379	381	0	0	DN20
1334	28,526625	359	382	0	0	DN25
1335	11,666318	382	387	0	0	DN20
1336	18,524404	382	383	0	0	DN25
1337	8,551899	383	385	0	0	DN20
1338	10,776062	383	386	0	0	DN20
1339	18,959709	383	384	0	0	DN25
1340	8,877155	384	388	0	0	DN20
1341	39,793073	384	389	0	0	DN25
1342	14,441738	389	392	0	0	DN20
1343	22,636026	389	390	0	0	DN20
1344	13,866822	390	391	0	0	DN20
1345	18,29775	390	393	0	0	DN20
1346	10,067483	393	394	0	0	DN20
1347	12,338935	393	396	0	0	DN20
1348	10,472741	396	395	0	0	DN20
1349	52,1682	396	397	0	0	DN20
1350	8,354491	397	398	0	0	DN20
1351	13,539003	397	399	0	0	DN20
1352	7,164945	399	400	0	0	DN20
1353	19,223056	399	405	0	0	DN20
1354	9,47851	399	401	0	0	DN20
1355	7,310869	401	402	0	0	DN20

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1965	11,201575	1032	1058	0	0	DN20
1966	10,892517	1032	1059	0	0	DN20
1967	16,862618	1032	1033	0	0	DN20
1968	9,13908	1033	1060	0	0	DN20
1969	17,530315	1033	1034	0	0	DN20
1970	8,372149	1034	1061	0	0	DN20
1971	14,342049	1034	1062	0	0	DN20
1972	18,410251	1034	1035	0	0	DN20
1973	9,522213	1035	1063	0	0	DN20
1974	12,007948	1035	1064	0	0	DN20
1975	31,397795	1035	1036	0	0	DN20
1976	13,690576	1036	1066	0	0	DN20
1977	9,193722	1036	1065	0	0	DN20
1978	13,634214	1026	1049	0	0	DN20
1979	34,641109	977	1069	0	0	DN20
1980	8,785749	1069	1070	0	0	DN20
1981	12,905841	1069	1071	0	0	DN20
1982	8,953189	1071	1072	0	0	DN20
1983	13,563306	1071	1073	0	0	DN20
1984	11,670198	1073	1075	0	0	DN20
1985	10,064615	1075	1076	0	0	DN20
1986	22,696438	1075	1077	0	0	DN20
1987	13,856371	1077	1078	0	0	DN20
1988	22,036807	1077	1079	0	0	DN20
1989	18,308561	1079	1080	0	0	DN20
1990	35,92698	1075	1081	0	0	DN20
1991	11,175087	1082	1084	0	0	DN20
1992	14,546577	1082	1083	0	0	DN20
1993	13,641384	1085	1087	0	0	DN20
1994	12,574474	1085	1086	0	0	DN20
1995	13,44101	1088	1089	0	0	DN20
1996	10,914471	1093	1094	0	0	DN20
1997	9,660674	1093	1095	0	0	DN20
1998	12,946208	1096	1097	0	0	DN20
1999	39,263429	1098	1099	0	0	DN20
2000	9,872767	1099	1100	0	0	DN20
2001	17,486935	1099	1101	0	0	DN20
2002	14,883118	1101	1103	0	0	DN20
2003	10,620786	1101	1102	0	0	DN20
2004	19,14508	1101	1104	0	0	DN20
2005	10,72866	1104	1106	0	0	DN20
2006	13,607218	1104	1105	0	0	DN20
2007	25,801363	1104	1107	0	0	DN20
2008	49,504183	1096	1112	0	0	DN20
2009	11,416529	1112	1113	0	0	DN20
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2012	9,440332	1115	1116	0	0	DN20
2013	11,479171	1115	1117	0	0	DN20
2014	15,248766	1115	1119	0	0	DN20
2015	9,213899	1119	1118	0	0	DN20
2016	33,8136	1088	1092	0	0	DN20
2017	37,013102	1085	1090	0	0	DN20
2018	48,493877	1085	1091	0	0	DN20
2019	10,149762	1120	1121	0	0	DN20
2020	9,918628	1122	1123	0	0	DN20
2021	10,882274	1122	1124	0	0	DN20
2022	11,089327	1125	1127	0	0	DN20
2023	9,170088	1125	1126	0	0	DN20
2024	11,231603	1128	1129	0	0	DN20
2025	16,157644	1130	1131	0	0	DN32
2026	8,973262	1131	1135	0	0	DN20
2027	15,438337	1131	1132	0	0	DN32
2028	11,634841	1132	1133	0	0	DN20
2029	10,411338	1132	1134	0	0	DN20
2030	21,223954	1132	1136	0	0	DN32
2031	12,757689	1136	1137	0	0	DN20
2032	9,703277	1136	1138	0	0	DN20
2033	14,783825	1136	1139	0	0	DN25
2034	22,617965	1139	1140	0	0	DN20
2035	12,088604	1139	1141	0	0	DN20
2036	52,669246	1139	1144	0	0	DN25
2037	15,209765	1144	1145	0	0	DN20
2038	33,354802	1144	1146	0	0	DN20
2039	16,227459	1144	1148	0	0	DN20
2040	13,2241	1148	1147	0	0	DN20
2041	13,508399	1148	1150	0	0	DN20
2042	18,485444	1144	1149	0	0	DN25
2043	28,059953	1149	1151	0	0	DN25
2044	10,677471	1151	1152	0	0	DN20
2045	26,828063	1151	1153	0	0	DN25
2046	12,223725	1153	1154	0	0	DN20
2047	30,448372	1153	1155	0	0	DN20
2048	11,128365	1153	1156	0	0	DN20
2049	20,250613	1153	1157	0	0	DN20
2050	11,881975	1157	1158	0	0	DN20
2051	18,490916	1157	1159	0	0	DN20
2052	13,506629	1159	1160	0	0	DN20
2053	26,372142	1159	1161	0	0	DN20
2054	13,78582	1161	1162	0	0	DN20
2055	21,672013	1161	1166	0	0	DN20
2056	14,510794	1166	1167	0	0	DN20
2057	37,772483	1166	1168	0	0	DN20
2058	15,738618	1168	1170	0	0	DN20
2059	12,807396	1168	1169	0	0	DN20
2060	48,056434	1161	1163	0	0	DN20
2061	11,252842	1163	1164	0	0	DN20
2062	12,698198	1163	1165	0	0	DN20
2063	42,308763	1130	1171	0	0	DN32
2064	9,859109	1171	1173	0	0	DN20
2065	14,297194	1171	1174	0	0	DN32
2066	12,147878	1174	1175	0	0	DN20
2067	27,406063	1174	1172	0	0	DN20
2068	27,438598	1174	1176	0	0	DN25
2069	13,329689	1176	1178	0	0	DN25
2070	12,532181	1176	1177	0	0	DN20
2071	29,984292	1176	1179	0	0	DN20
2072	15,17722	1179	1180	0	0	DN20
2073	22,507807	1179	1181	0	0	DN20
2074	11,454455	1181	1182	0	0	DN20
2075	25,224482	1181	1183	0	0	DN20
2076	13,379404	1183	1184	0	0	DN20
2077	27,685494	1183	1185	0	0	DN20
2078	25,170436	1128	1191	0	0	DN20
2079	15,224868	1130	1190	0	0	DN20
2080	19,237016	1130	1186	0	0	DN20
2081	10,886579	1186	1189	0	0	DN20

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1357	26,185351	401	404	0	0	DN20
1358	36,918669	401	406	0	0	DN20
1359	7,887337	360	408	0	0	DN20
1360	9,921063	360	407	0	0	DN20
1361	16,694259	361	410	0	0	DN20
1362	7,554573	361	409	0	0	DN20
1363	14,428951	362	411	0	0	DN20
1364	13,053809	362	412	0	0	DN20
1365	13,773358	363	413	0	0	DN20
1366	12,322438	363	414	0	0	DN20
1367	23,019758	359	415	0	0	DN20
1368	24,571729	415	416	0	0	DN20
1369	12,265141	415	417	0	0	DN20
1370	9,726487	417	420	0	0	DN20
1371	8,894768	417	418	0	0	DN20
1372	21,480182	417	419	0	0	DN20
1373	9,099371	417	421	0	0	DN20
1374	12,047525	421	422	0	0	DN20
1375	7,177141	421	425	0	0	DN20
1376	8,623819	425	423	0	0	DN20
1377	9,440592	425	424	0	0	DN20
1378	21,064793	425	426	0	0	DN20
1379	9,575141	426	427	0	0	DN20
1380	11,400762	426	429	0	0	DN20
1381	10,524743	426	428	0	0	DN20
1382	31,758541	426	431	0	0	DN20
1383	14,12458	431	432	0	0	DN20
1384	13,289762	431	433	0	0	DN20
1385	11,455535	364	434	0	0	DN20
1386	9,185811	434	456	0	0	DN20
1387	14,206572	434	435	0	0	DN20
1388	12,310296	435	454	0	0	DN20
1389	9,912375	435	455	0	0	DN20
1390	21,203899	435	436	0	0	DN20
1391	11,74434	436	453	0	0	DN20
1392	18,041909	436	452	0	0	DN20
1393	19,646942	436	437	0	0	DN20
1394	11,329417	437	451	0	0	DN20
1395	13,568884	437	450	0	0	DN20
1396	41,983758	437	438	0	0	DN20
1397	12,714321	438	442	0	0	DN20
1398	17,808618	438	439	0	0	DN20
1399	10,638094	439	441	0	0	DN20
1400	10,991815	439	440	0	0	DN20
1401	27,634417	438	444	0	0	DN20
1402	28,957553	332	445	0	0	DN20
1403	12,655201	438	443	0	0	DN20
1404	31,635959	334	446	0	0	DN20
1405	43,0776	437	449	0	0	DN20
1406	59,292039	437	448	0	0	DN20
1407	62,56327	334	458	0	0	DN20
1408	58,724865	336	457	0	0	DN20
1409	56,541168	338	459	0	0	DN20
1410	56,203601	338	460	0	0	DN20
1411	40,353339	338	461	0	0	DN20
1412	64,57325	342	462	0	0	DN20
1413	63,934246	344	463	0	0	DN20
1414	75,426975	346	465	0	0	DN20
1415	58,119497	346	464	0	0	DN20
1416	62,689222	347	466	0	0	DN20
1417	58,574186	350	467	0	0	DN20
1418	22,947661	364	468	0	0	DN20
1419	11,997552	468	470	0	0	DN20
1420	11,063122	468	469	0	0	DN20
1421	15,797272	468	471	0	0	DN20
1422	8,848357	471	472	0	0	DN20
1423	14,505686	471	473	0	0	DN20
1424	8,30342	473	474	0	0	DN20
1425	15,29999	473	476	0	0	DN20
1426	8,570193	476	475	0	0	DN20
1427	21,29934	476	477	0	0	DN20
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1429	13,474778	477	478	0	0	DN20
1430	13,629901	477	480	0	0	DN20
1431	9,635446	480	482	0	0	DN20
1432	9,398027	480	481	0	0	DN20
1433	10,080376	480	483	0	0	DN20
1434	24,20411	480	484	0	0	DN20
1435	9,501363	484	485	0	0	DN20
1436	7,183849	484	486	0	0	DN20
1437	19,908041	484	487	0	0	DN20
1438	16,888132	484	488	0	0	DN20
1439	9,245527	488	489	0	0	DN20
1440	15,683197	488	490	0	0	DN20
1441	7,3323	490	491	0	0	DN20
1442	49,335296	473	492	0	0	DN20
1443	64,012834	473	493	0	0	DN20
1444	63,762224	477	494	0	0	DN20
1445	64,715948	480	495	0	0	DN20
1446	39,313176	426	430	0	0	DN20
1447	39,162444	332	447	0	0	DN20
1448	34,13203	496	498	0	0	DN20
1449	12,406322	496	497	0	0	DN20
1450	12,939191	499	500	0	0	DN20
1451	16,438082	499	501	0	0	DN32
1452	16,016644	502	503	0	0	DN20
1453	14,335647	504	505	0	0	DN20
1454	27,110767	509	507	0	0	DN20
1455	17,303311	509	508	0	0	DN20
1456	14,504372	509	510	0	0	DN20
1457	7,724297	511	513	0	0	DN20
1458	7,969047	511	512	0	0	DN20
1459	8,42867	515	517	0	0	DN20
1460	31,370225	514	515	0	0	DN20
1461	8,882625	515	516	0	0	DN20
1462	28,522196	515	518	0	0	DN20
1463	18,357878	515	519	0	0	DN20
1464	10,889514	519	520	0	0	DN20
1465	7,487765	519	521	0	0	DN20
1466	18,271979	519	522	0	0	DN20
1467	10,201026	522	523	0	0	DN20
1468	10,487443	522	524	0	0	DN20
1469	9,086567	522	525	0	0	DN20
1470	18,755988	522	526	0	0	DN20
1471	11,223684	526	527	0	0	DN20
1472	20,044184	526	528	0	0	DN20
1473	11,793409	528	529	0	0	DN20

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2083	11,259587	1187	1192	0	0	DN20
2084	22,992072	1187	1188	0	0	DN20
2085	13,475631	1188	1193	0	0	DN20
2086	22,515685	1188	1194	0	0	DN20
2087	12,50579	1194	1195	0	0	DN20
2088	10,756379	1194	1196	0	0	DN20
2089	10,607016	1198	1199	0	0	DN20
2090	11,379286	1198	1200	0	0	DN20
2091	11,869216	1201	1202	0	0	DN20
2092	9,829895	1201	1203	0	0	DN20
2093	13,071327	1201	1204	0	0	DN20
2094	34,617639	1205	1208	0	0	DN20
2095	9,769306	1205	1206	0	0	DN20
2096	13,334967	1205	1207	0	0	DN20
2097	8,872394	1209	1210	0	0	DN20
2098	32,879798	1197	1212	0	0	DN25
2099	9,511837	1212	1213	0	0	DN20
2100	21,877625	1212	1214	0	0	DN25
2101	14,900015	1214	1215	0	0	DN20
2102	17,078876	1214	1216	0	0	DN25
2103	11,729104	1216	1218	0	0	DN20
2104	16,058482	1216	1217	0	0	DN20
2105	23,29548	1216	1219	0	0	DN20
2106	9,574164	1219	1220	0	0	DN20
2107	25,91845	1219	1224	0	0	DN20
2108	29,17942	1224	1225	0	0	DN20
2109	13,297904	1225	1226	0	0	DN20
2110	13,956061	1225	1227	0	0	DN20
2111	13,793045	1227	1228	0	0	DN20
2112	14,541976	1227	1229	0	0	DN20
2113	34,576142	1227	1230	0	0	DN20
2114	14,215958	1230	1231	0	0	DN20
2115	12,446869	1230	1232	0	0	DN20
2116	12,498074	1230	1233	0	0	DN20
2117	37,299611	1224	1221	0	0	DN20
2118	11,574743	1221	1223	0	0	DN20
2119	11,43925	1221	1222	0	0	DN20
2120	34,869904	1221	1234	0	0	DN20
2121	12,378997	1234	1235	0	0	DN20
2122	9,71476	1234	1236	0	0	DN20
2123	18,96895	1234	1237	0	0	DN20
2124	9,858559	1237	1238	0	0	DN20
2125	30,863111	1234	1239	0	0	DN20
2126	70,838441	1237	1240	0	0	DN20
2127	8,376834	1240	1242	0	0	DN20
2128	9,219964	1240	1243	0	0	DN20
2129	9,008816	1240	1241	0	0	DN20
2130	24,713946	1240	1244	0	0	DN20
2131	13,944806	1211	1245	0	0	DN25
2132	10,893492	1245	1247	0	0	DN20
2133	11,123362	1245	1246	0	0	DN20
2134	17,756873	1245	1248	0	0	DN25
2135	12,033045	1248	1250	0	0	DN20
2136	14,651583	1248	1249	0	0	DN20
2137	16,910116	1248	1251	0	0	DN20
2138	17,75534	1251	1253	0	0	DN20
2139	11,639707	1251	1252	0	0	DN20
2140	28,374101	1251	1254	0	0	DN20
2141	24,843422	1251	1255	0	0	DN20
2142	7,926844	1255	1256	0	0	DN20
2143	18,647859	1255	1257	0	0	DN20
2144	15,08695	1257	1259	0	0	DN20
2145	12,121978	1257	1258	0	0	DN20
2146	18,816637	1257	1260	0	0	DN20
2147	9,056953	1260	1261	0	0	DN20
2148	17,9147	1260	1262	0	0	DN20
2149	40,226602	1262	1263	0	0	DN20
2150	12,520834	1263	1264	0	0	DN20
2151	13,194174	1263	1265	0	0	DN20
2152	18,545299	1263	1266	0	0	DN20
2153	12,982976	1266	1267	0	0	DN20
2154	11,488324	1266	1268	0	0	DN20
2155	17,328264	1266	1269	0	0	DN20
2156	12,036676	1269	1270	0	0	DN20
2157	31,623005	1269	1272	0	0	DN20
2158	13,732546	1269	1271	0	0	DN20
2159	36,290072	1262	1274	0	0	DN20
2160	13,70568	1274	1275	0	0	DN20
2161	29,548371	1274	1276	0	0	DN20
2162	29,563239	1274	1277	0	0	DN20
2163	13,427737	1277	1278	0	0	DN20
2164	17,59518	1277	1279	0	0	DN20
2165	40,589312	1277	1280	0	0	DN20
2166	17,869322	1277	1281	0	0	DN20
2167	13,948813	1281	1282	0	0	DN20
2168	17,721871	1281	1283	0	0	DN20
2169	22,833208	1281	1284	0	0	DN20
2170	19,129696	1211	1285	0	0	DN20
2171	11,469111	1285	1286	0	0	DN20
2172	19,280267	1285	1287	0	0	DN20
2173	12,546585	1287	1288	0	0	DN20
2174	13,189813	1287	1289	0	0	DN20
2175	18,859492	1287	1290	0	0	DN20
2176	10,847625	1290	1292	0	0	DN20
2177	37,328535	1290	1295	0	0	DN20
2178	12,213839	1290	1291	0	0	DN20
2179	16,024513	1290	1293	0	0	DN20
2180	10,42308	1293	1294	0	0	DN20
2181	86,939391	1293	1296	0	0	DN20
2182	26,516443	1296	1297	0	0	DN20
2183	12,386957	1296	1298	0	0	DN20
2184	14,7535	1296	1299	0	0	DN20
2185	40,682074	1296	1300	0	0	DN20
2186	12,531425	1300	1301	0	0	DN20
2187	35,689068	1300	1305	0	0	DN20
2188	41,941802	1300	1302	0	0	DN20
2189	7,727922	1302	1303	0	0	DN20
2190	16,405282	1302	1304	0	0	DN20
2191	11,905255	1073	1074	0	0	DN20
2192	30,541605	1139	1142	0	0	DN20
2193	32,841156	1139	1143	0	0	DN20
2194	48,078402	1269	1273	0	0	DN20
2195	13,253701	1306	1308	0	0	DN20
2196	10,430018	1306	1307	0	0	DN20
2197	11,73287	1309	1311	0	0	DN20
2198	27,413271	1309	1312	0	0	DN20
2199	15,223801	1309	1310	0	0	DN20

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1475	43,424528	528	532	0	0	DN20
1476	58,21168	528	533	0	0	DN20
1477	18,046039	528	530	0	0	DN20
1478	19,575094	528	534	0	0	DN20
1479	8,862126	534	535	0	0	DN20
1480	11,160097	534	536	0	0	DN20
1481	17,762084	534	537	0	0	DN20
1482	24,57132	534	538	0	0	DN20
1483	41,960351	534	539	0	0	DN20
1484	23,084241	534	540	0	0	DN20
1485	8,099321	540	541	0	0	DN20
1486	22,825012	540	543	0	0	DN20
1487	8,691807	540	542	0	0	DN20
1488	15,645556	540	544	0	0	DN20
1489	43,273772	514	545	0	0	DN20
1490	8,583163	545	547	0	0	DN20
1491	31,596792	545	551	0	0	DN20
1492	42,114299	545	552	0	0	DN20
1493	53,691046	545	554	0	0	DN20
1494	52,354566	545	553	0	0	DN20
1495	9,917257	545	548	0	0	DN20
1496	20,97931	545	546	0	0	DN20
1497	8,601221	546	550	0	0	DN20
1498	11,051328	546	549	0	0	DN20
1499	31,117453	546	555	0	0	DN20
1500	9,435127	555	556	0	0	DN20
1501	24,729135	555	557	0	0	DN20
1502	21,421195	555	558	0	0	DN20
1503	9,734499	558	559	0	0	DN20
1504	9,43281	558	560	0	0	DN20
1505	27,768658	558	561	0	0	DN20
1506	15,195426	558	562	0	0	DN20
1507	7,653473	562	563	0	0	DN20
1508	10,840412	562	564	0	0	DN20
1509	14,553844	565	566	0	0	DN20
1510	8,45424	566	567	0	0	DN20
1511	31,853981	566	568	0	0	DN20
1512	10,490378	568	570	0	0	DN20
1513	9,948174	568	569	0	0	DN20
1514	30,160632	568	571	0	0	DN20
1515	12,049265	571	572	0	0	DN20
1516	14,368407	571	573	0	0	DN20
1517	9,779432	573	574	0	0	DN20
1518	8,477956	573	575	0	0	DN20
1519	15,172441	573	576	0	0	DN20
1520	9,224233	576	577	0	0	DN20
1521	9,309358	576	578	0	0	DN20
1522	17,754465	576	579	0	0	DN20
1523	10,357178	579	581	0	0	DN20
1524	23,320247	579	582	0	0	DN20
1525	9,309387	579	580	0	0	DN20
1526	26,710888	579	583	0	0	DN20
1527	7,891018	583	584	0	0	DN20
1528	9,043877	583	585	0	0	DN20
1529	23,083041	583	586	0	0	DN20
1530	30,885931	586	587	0	0	DN20
1531	14,160922	587	588	0	0	DN20
1532	23,686285	587	589	0	0	DN20
1533	13,870095	589	590	0	0	DN20
1534	9,323664	589	591	0	0	DN20
1535	12,552058	591	592	0	0	DN20
1536	10,406782	591	593	0	0	DN20
1537	13,032338	593	594	0	0	DN20
1538	22,764359	565	595	0	0	DN20
1539	9,731443	595	597	0	0	DN20
1540	22,372659	595	596	0	0	DN20
1541	8,688533	596	598	0	0	DN20
1542	8,245491	596	599	0	0	DN20
1543	25,318492	596	600	0	0	DN20
1544	9,432861	600	601	0	0	DN20
1545	12,935503	600	602	0	0	DN20
1546	28,773013	600	603	0	0	DN20
1547	8,380909	603	604	0	0	DN20
1548	14,970506	603	605	0	0	DN20
1549	8,413314	605	606	0	0	DN20
1550	9,728948	605	607	0	0	DN20
1551	15,839311	605	608	0	0	DN20
1552	8,243349	608	609	0	0	DN20
1553	9,196168	608	610	0	0	DN20
1554	11,176144	608	612	0	0	DN20
1555	9,841391	612	611	0	0	DN20
1556	7,943122	612	613	0	0	DN20
1557	17,495263	614	616	0	0	DN20
1558	13,35781	614	615	0	0	DN20
1559	14,308682	617	618	0	0	DN20
1560	31,370416	619	620	0	0	DN20
1561	11,737378	620	624	0	0	DN20
1562	28,962665	620	625	0	0	DN20
1563	33,121552	620	621	0	0	DN20
1564	13,212139	621	622	0	0	DN20
1565	12,976895	621	623	0	0	DN20
1566	41,455804	621	626	0	0	DN20
1567	11,927652	626	627	0	0	DN20
1568	12,258803	626	628	0	0	DN20
1569	23,906241	626	629	0	0	DN20
1570	12,69732	629	630	0	0	DN20
1571	12,089081	629	632	0	0	DN20
1572	11,866112	629	631	0	0	DN20
1573	45,7582	619	633	0	0	DN20
1574	17,644531	633	634	0	0	DN20
1575	11,209641	633	635	0	0	DN20
1576	56,562251	633	636	0	0	DN20
1577	16,909397	636	637	0	0	DN20
1578	52,538584	636	642	0	0	DN20
1579	13,969796	642	643	0	0	DN20
1580	33,757719	642	644	0	0	DN20
1581	24,338223	642	647	0	0	DN20
1582	12,386111	642	645	0	0	DN20
1583	27,111717	642	646	0	0	DN20
1584	30,865402	642	648	0	0	DN20
1585	20,899785	636	638	0	0	DN20
1586	12,287259	638	639	0	0	DN20
1587	26,31838	638	640	0	0	DN20
1588	24,165844	638	641	0	0	DN20
1589	11,952878	649	658	0	0	DN20
1590	12,739189	650	654	0	0	DN20
1591	14,722851	651	655	0	0	DN20

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2201	8,115474	1314	1313	0	0	DN20
2202	17,386213	1318	1316	0	0	DN20
2203	9,389588	1318	1317	0	0	DN20
2204	10,135987	1319	1321	0	0	DN20
2205	13,914788	1319	1320	0	0	DN20
2206	9,277048	1322	1324	0	0	DN20
2207	16,296397	1322	1323	0	0	DN20
2208	11,238071	1325	1326	0	0	DN20
2209	32,763722	1325	1327	0	0	DN20
2210	14,371205	1328	1329	0	0	DN20
2211	35,305726	1331	1332	0	0	DN20
2212	9,542911	1332	1333	0	0	DN20
2213	17,784646	1332	1334	0	0	DN20
2214	38,364052	1334	1335	0	0	DN20
2215	12,061486	1335	1336	0	0	DN20
2216	15,932432	1335	1339	0	0	DN20
2217	9,307101	1335	1338	0	0	DN20
2218	8,786097	1335	1337	0	0	DN20
2219	18,355985	1334	1340	0	0	DN20
2220	11,730167	1340	1341	0	0	DN20
2221	11,926962	1334	1368	0	0	DN20
2222	11,500382	1340	1342	0	0	DN20
2223	18,81525	1340	1343	0	0	DN20
2224	9,999731	1343	1344	0	0	DN20
2225	11,818109	1343	1345	0	0	DN20
2226	12,222524	1343	1346	0	0	DN20
2227	25,176335	1343	1347	0	0	DN20
2228	35,821387	1347	1348	0	0	DN20
2229	13,146873	1348	1349	0	0	DN20
2230	12,705599	1348	1350	0	0	DN20
2231	16,654519	1347	1351	0	0	DN20
2232	12,862848	1351	1352	0	0	DN20
2233	25,994512	1351	1355	0	0	DN20
2234	10,77503	1355	1353	0	0	DN20
2235	13,097938	1355	1354	0	0	DN20
2236	38,149038	1347	1356	0	0	DN20
2237	11,451258	1356	1358	0	0	DN20
2238	9,772491	1356	1357	0	0	DN20
2239	18,81872	1356	1360	0	0	DN20
2240	9,476009	1360	1359	0	0	DN20
2241	11,732504	1360	1361	0	0	DN20
2242	15,961362	1360	1362	0	0	DN20
2243	10,629953	1362	1363	0	0	DN20
2244	11,156358	1362	1364	0	0	DN20
2245	22,528755	1362	1367	0	0	DN20
2246	10,194474	1367	1366	0	0	DN20
2247	11,856927	1367	1365	0	0	DN20
2248	39,254046	1331	1369	0	0	DN20
2249	13,216477	1369	1370	0	0	DN20
2250	10,714617	1369	1371	0	0	DN20
2251	25,169468	1369	1372	0	0	DN20
2252	12,979307	1372	1373	0	0	DN20
2253	11,788553	1372	1374	0	0	DN20
2254	10,873636	1372	1375	0	0	DN20
2255	55,974697	1372	1376	0	0	DN20
2256	48,216678	1376	1377	0	0	DN20
2257	11,314963	1377	1380	0	0	DN20
2258	14,858561	1377	1378	0	0	DN20
2259	16,4937	1377	1379	0	0	DN20
2260	31,385891	1377	1381	0	0	DN20
2261	10,630887	1381	1382	0	0	DN20
2262	59,700354	1376	1383	0	0	DN20
2263	36,555816	1383	1386	0	0	DN20
2264	9,533085	1383	1384	0	0	DN20
2265	33,768192	1383	1385	0	0	DN20
2266	27,698958	1383	1387	0	0	DN20
2267	12,71613	1387	1388	0	0	DN20
2268	25,5739	1387	1389	0	0	DN20
2269	29,965562	1330	1390	0	0	DN20
2270	13,825188	1390	1392	0	0	DN20
2271	11,746776	1390	1391	0	0	DN20
2272	23,146335	1390	1393	0	0	DN20
2273	11,405764	1393	1394	0	0	DN20
2274	14,600277	1393	1395	0	0	DN20
2275	36,435887	1393	1396	0	0	DN20
2276	55,376985	1330	1397	0	0	DN20
2277	13,367505	1397	1398	0	0	DN20
2278	41,756472	1397	1399	0	0	DN20
2279	11,276489	1399	1400	0	0	DN20
2280	17,927559	1399	1401	0	0	DN20
2281	37,897705	1401	1402	0	0	DN20
2282	15,333889	1402	1403	0	0	DN20
2283	27,975312	1402	1404	0	0	DN20
2284	38,869993	1402	1405	0	0	DN20
2285	19,748559	1401	1406	0	0	DN20
2286	13,833772	1406	1408	0	0	DN20
2287	12,241251	1406	1407	0	0	DN20
2288	25,478128	1406	1409	0	0	DN20
2289	14,63293	1409	1410	0	0	DN20
2290	11,127633	1409	1411	0	0	DN20
2291	15,019103	1409	1412	0	0	DN20
2292	20,170394	1409	1414	0	0	DN20
2293	10,731003	1414	1413	0	0	DN20
2294	8,975289	1414	1415	0	0	DN20
2295	27,685392	1414	1416	0	0	DN20
2296	15,490786	1416	1417	0	0	DN20
2297	27,007771	1416	1419	0	0	DN20
2298	12,399127	1416	1418	0	0	DN20
2299	87,710487	1330	1420	0	0	DN20
2300	12,083691	1420	1421	0	0	DN20
2301	28,374274	1420	1422	0	0	DN20
2302	14,692915	1422	1423	0	0	DN20
2303	25,220228	1422	1425	0	0	DN20
2304	17,404427	1425	1426	0	0	DN20
2305	20,115522	1422	1424	0	0	DN20
2306	45,099938	1420	1427	0	0	DN20
2307	17,34938	1427	1428	0	0	DN20
2308	24,113153	1427	1429	0	0	DN20
2309	11,885292	1429	1430	0	0	DN20
2310	18,42529	1429	1431	0	0	DN20
2311	39,0252	1429	1432	0	0	DN20
2312	39,538579	1432	1433	0	0	DN20
2313	10,125457	1433	1434	0	0	DN20
2314	19,068958	1433	1435	0	0	DN20
2315	38,475636	109	1437	0	0	DN20
2316	25,232776	1262	1436	0	0	DN20
2317	8,840376	390	1438	0	0	DN20

1592	14,546053	651	656	0	0	DN20
1593	16,526331	652	657	0	0	DN20
1594	41,377674	653	659	0	0	DN20
1595	12,046619	659	663	0	0	DN20
1596	9,724624	659	662	0	0	DN20
1597	28,967863	659	664	0	0	DN20
1598	20,236364	659	660	0	0	DN20
1599	10,2904	660	665	0	0	DN20
1600	62,155118	660	661	0	0	DN20
1601	15,521767	661	679	0	0	DN20
1602	34,807288	661	672	0	0	DN20
1603	25,465425	661	675	0	0	DN20
1604	18,803883	661	676	0	0	DN20
1605	32,412653	661	678	0	0	DN20
1606	42,679492	661	677	0	0	DN20
1607	59,38982	661	673	0	0	DN20
1608	71,776083	661	674	0	0	DN20
1609	9,027065	666	667	0	0	DN20
1610	24,039981	666	668	0	0	DN20

2318	9,881771	886	1439	0	0	DN20
2319	26,473268	845	1440	0	0	DN20
2320	24,054569	845	1441	0	0	DN20
2321	25,33762	1017	1442	0	0	DN20
2322	38,029014	107	1452	0	0	DN20
2323	25,378821	48	1443	0	0	DN20
2324	44,183671	42	1453	0	0	DN20
2325	19,029097	58	1451	0	0	DN20
2326	8,570583	1300	1450	0	0	DN20
2327	15,308342	1300	1449	0	0	DN20
2328	46,24381	921	1448	0	0	DN20
2329	47,41833	845	1447	0	0	DN20
2330	43,18076	74	1446	0	0	DN20
2331	24,098282	1362	1445	0	0	DN20
2332	44,494984	109	1444	0	0	DN20
2333	32,766995	1104	1108	0	0	DN20
2334	12,128403	1108	1109	0	0	DN20
2335	18,870608	1108	1110	0	0	DN20
2336	11,84646	1110	1111	0	0	DN20