

## MASTER

### Encouraging the energy transition

### Understanding low-income homeowner motives and best practices for Phasing Out Natural Gas

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**Master thesis**

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February 12, 2025

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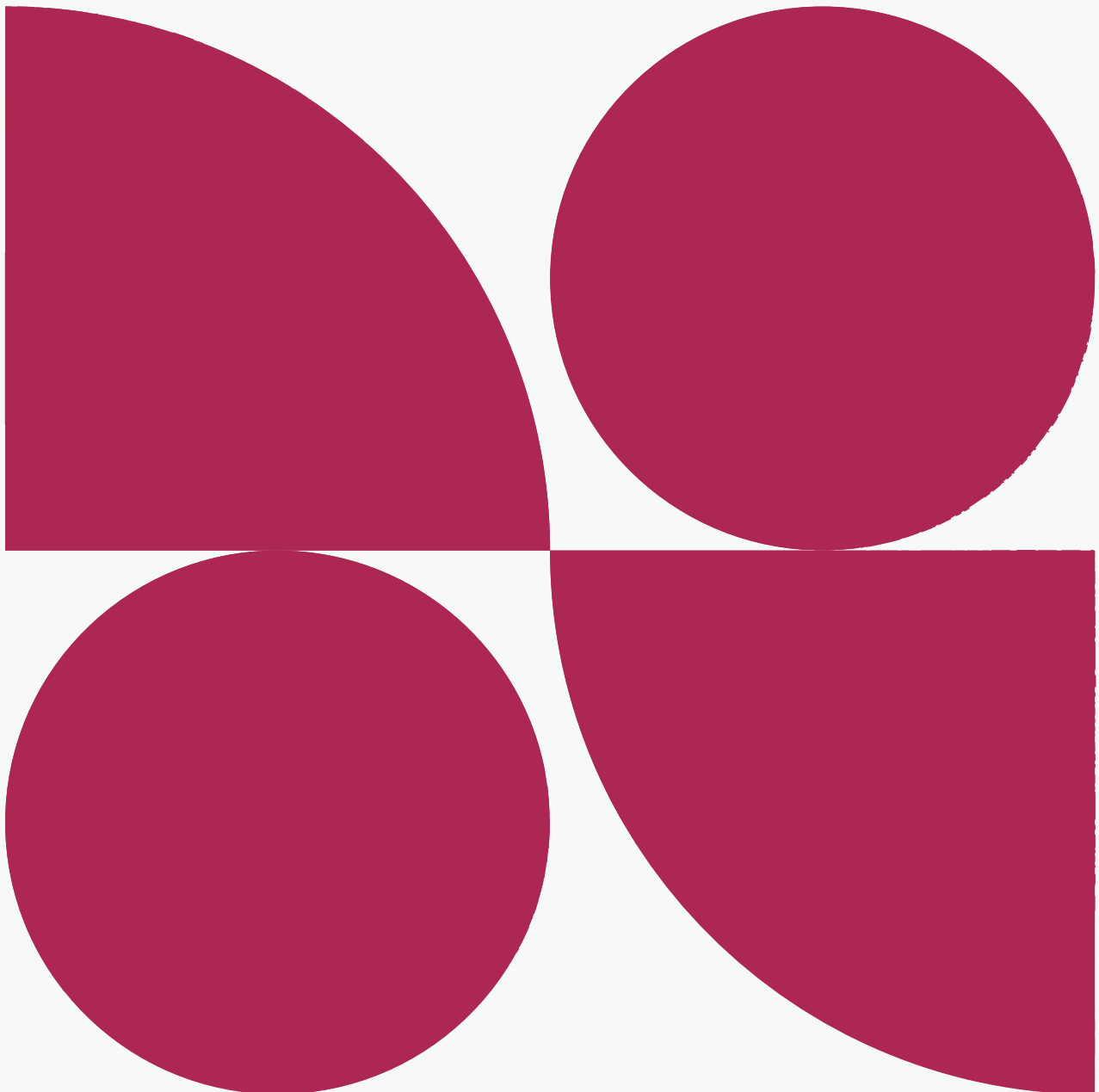
Architecture, Building and Planning

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# **Encouraging the energy transition:** Understanding low-income homeowner motives and best practices for Phasing Out Natural Gas



## COLOFON

Project Title	Master thesis Motivating low-income homeowners to phase out natural gas: motives and best practices
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## Preface

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The completion of this master's thesis marks the end of my studies at Eindhoven University of Technology. This research was written to complete the master's degree in Architecture, Building, and Planning, specializing in Urban Systems & Real Estate.

I am grateful for the opportunity to conduct research on a current and socially relevant topic. It was especially interesting to see how strong this topic is in the Netherlands. I hope this thesis can make a valuable contribution to future developments around this topic and that municipalities, as well as homeowners, can take my insights into account in the offer to homeowners in natural gas phase-out projects.

I would like to thank my supervisor, Dr. Ioulia Ossokina, for her guidance, valuable feedback, and critical insights throughout the process. Her support played an important role in the successful completion of this research. Furthermore, I would also like to thank Ir. Aloys Borgers for his help, insights, and feedback. Finally, I would also like to thank Prof. Dr. Theo Arentze as chairman of my thesis committee for his feedback.

In addition, I would like to thank Marijke Wobben and Alex Mellema of RVO for their guidance and support during this process. Their expertise and commitment played an essential role in the realization of this research. In addition, I am very grateful to RVO and NPLW for the opportunity to participate in the interactive Impulse Day and the PONG workshop, which provided me with valuable information and inspiration. Furthermore, I would like to thank all interviewees for sharing their valuable experiences and insights. It was inspiring to see how relevant insights emerged that were also recognized by the interview candidates themselves. Their input greatly enriched the research and provided important perspectives that complemented the knowledge.

Lastly, I would also like to thank my parents, brother, and friend for their unconditional support, patience, and encouragement during the writing of this thesis. Without them, this journey would have been much more challenging. My thanks also go to the rest of my family and my friends, who were always there for me during the process.

This thesis is dedicated to my dear grandfather, whose kindness and endless support have been a guiding light in my life. I will carry his wisdom and love with me in everything I do.

After a year of intense focus on this master's thesis, I am ready for my next chapter with the knowledge and experiences I have gained.

I hope this research can inspire others and be a step forward in phasing out natural gas projects.

Annick Pans  
Maastricht, February 2025

## Summary

To meet the Dutch government's climate goals, homeowners must also make their homes more sustainable, as stipulated in the Energy Agreement. This includes insulating 2.5 million homes by 2030 and making all homes completely gas-free by 2050. For many homeowners, this represents a major challenge. There are both incentives that make sustainability attractive and barriers that make the transition to a gas-free home difficult. In addition, there is a special group of homeowners in the Netherlands: low-income homeowners. This group can often just barely pay their mortgage and other fixed expenses and has no room left over for other investments. They also often live in homes with overdue maintenance, and this target group has little knowledge of sustainability and phasing out natural gas.

This research focuses on this special group: low-income homeowners. The purpose of this research is to find out what barriers and interventions low-income homeowners experience and encourage, and what interventions municipalities can best include in their offerings to encourage homeowners to make their homes more sustainable or switch to a home with an alternative heat source to natural gas. In collaboration with RVO and NPLW, this led to the following main question: **“What policies can municipalities best use to encourage low-income homeowners to switch to natural gas-free alternatives based on motives and best practices?”**

The study was structured using two frameworks: Hamilton et al.'s (2000) social customer journey and Steg et al.'s (2014) motives for sustainable decision-making. The social customer journey is a marketing model that depicts the steps a consumer takes from learning about a product or service to making a final purchase, as well as the subsequent stages of customer care and loyalty; see Figure 1. This study focused on the customer's journey to a natural gas-free home.

The study by Steg et al. (2014) outlines three psychological motives for environmentally friendly behavior and provides a comprehensive approach to understanding and supporting such behavior. The motives are financial, environmental, and comfort-related. This research adds a fourth motive: trust; see Figure 2. The financial motive has to do with reducing energy costs, using financial incentives from the municipality or government (e.g., energy independence and increasing property values). The comfort motive is twofold: first, it has to do with increasing thermal comfort after implementing energy efficiency measures; second, it relates to unburdening and reducing the hassle, mess, and inconvenience of phasing out natural gas in the home. The environmental motive links the environment to personal responsibility for addressing environmental issues through phasing out natural gas in the home. The trust motive is also twofold; it involves trust in individuals, organizations such as the municipality and government, and technology, as well as receiving correct and consistent information to participate in the energy transition.

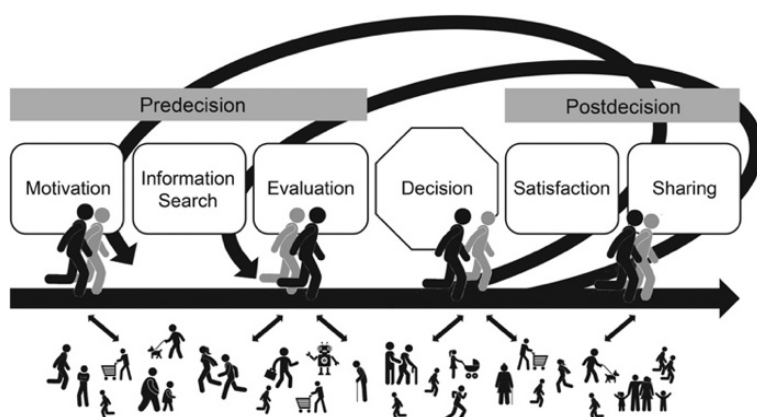


Figure 1 Social customer journey (Hamilton et al., 2020)

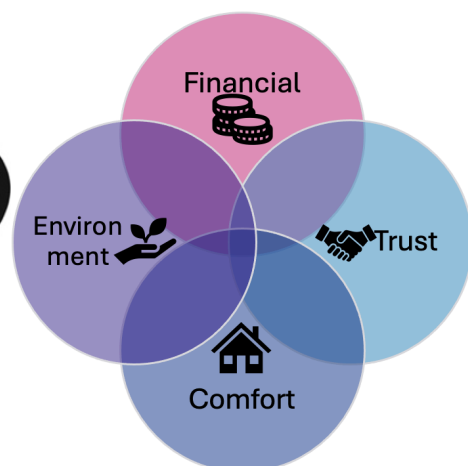


Figure 2 Motives for making sustainable choices

The report is structured as follows: first, an extensive literature review was conducted on several topics, including the barriers to adopting energy-efficient measures. The main barriers in the literature are that low-income homeowners often do not have the financial resources to implement energy-efficient measures in their homes; they cannot afford the high initial costs and are afraid that the investment will not yield a return. Furthermore, barriers include a lack of information, a lack of motivation, a failure to recognize the need for energy efficiency measures, and ignorance of incentives, technology, and suppliers. Homeowners also report experiencing hassles and inconveniences before, during, and after the sustainability work. Finally, a lack of trust in the government, municipalities, and suppliers was also found to be a barrier.

Next, existing interventions that municipalities can use to encourage homeowners to participate in the energy transition were researched. The interventions were also structured using the frameworks. The main interventions from the literature are financial interventions such as grants, low-interest loans, tax incentives, and simplified assistance programs to help low-income homeowners take energy-saving measures. Trust-related interventions include open and consistent communication, neighborhood events, and neighbor success stories. Comfort-related interventions include the use of energy coaches and counseling, knowledge desks for tailored help, and workshops on energy-saving strategies. It also appears that a multifaceted strategy is needed to ensure that all homeowners, especially those with lower incomes, can participate in the natural gas phase-out.

Long lists were developed for both barriers and interventions based on these studies, with both barriers and interventions structured according to the frameworks used. The research also looked at linking opportunities, showing that neighborhood renewal, improving public spaces, bringing social benefits, and improving social cohesion and cooperation with housing associations can act as incentives for homeowners to participate in the energy transition.

Following the literature review on barriers and possible interventions, research was conducted on current policies and initiatives in the Netherlands aimed at making homes and neighborhoods more sustainable and natural gas-free. The Netherlands has already put in place a number of policies and subsidies, including SVOH, ISDE, SAH, and WGIW, and is now working on developing them (WCW). However, problems like high initial costs, complicated technology, and differing stakeholder views remain. This shows how important it is to communicate and work together effectively in order to reach long-term energy transition goals. The policies of countries such as Denmark, Germany, and England can show the Netherlands that the transition to renewable energy requires strong government support, cooperation, and strategic planning. These countries also show that a successful energy transition has clear policy goals, significant investment in infrastructure and technology, and the ability to overcome challenges such as financing and innovation.

Expert interviews were then conducted with individuals who are working on natural gas-free projects in practice, such as employees of municipalities and energy cooperatives. A total of seven useful interviews were conducted. The interviews were designed to compare the results of the literature review with practice, which showed that the literature and practice generally have a great deal in common regarding barriers and interventions. The interviews revealed that finances are an important motive, as well as trust and comfort. Thus, interviewees indicated that a lot of money and time should be put into projects involving natural gas-free neighborhoods to gain the trust of residents and get them to participate in the energy transition. They also reported that homeowners who have already taken sustainable measures in their homes can serve well as ambassadors for other residents in the neighborhood. It was striking that in all interviews it was clear that the environment is not a motive for sustainability among low-income homeowners, whereas the literature states that it is. Also, using the results from the interviews, a long list of interventions was developed.

The study conducted ten interviews. Seven interviews involved natural gas-free neighborhoods that could serve as case studies. In three interviews, no specific cases were discussed. Although this is a small sample and the neighborhoods differ greatly from each other in terms of residents, neighborhood layout, approach, budget, time, and participation, the seven cases provided interesting insights, and some clear similarities can be identified. Best-practice case studies are characterized by clear policy visions, elaborate technical and legal preconditions, zero costs all the way to the front door, far-reaching relief, and the use of a carbon-neutral and sustainable heat source. It is essential to consider the diversity of homeowners and ensure customization within the policy vision, with residents retaining as much freedom of choice as possible. On the other hand, worst-practice cases are characterized by a lack of clarity about policy plans, an accumulation of too many challenges and wanting to achieve too many goals at once, and uncertainty about the cost of the alternative to gas.

Then, further analysis and synthesis compared the literature review and interviews, compared the best and worst practice interventions, and discussed current policies. The findings from the literature and the interviews are generally consistent, with financial and trust interventions again being key. While the literature primarily discussed broad, overarching interventions, the interviewees provided insight into more local, practical, and context-specific solutions based on their unique experiences. The interviews also revealed that existing subsidies are not always known to homeowners, especially those with low incomes. When comparing the best and worst practice interventions, the need for communication with stakeholders, proper planning and participation, and personalized approaches emerges again. The discussion of current policies shows that the Netherlands is already strongly committed to sustainable policies. However, interventions and guidance need to be more tailored to the specific financial and emotional needs of homeowners, as many of them do not know where to find subsidies and miss out on them, even though these programs are meant to help them. It is also necessary to deploy additional interventions to effectively encourage homeowners to participate in the energy transition, where a complete and clear offer is essential, understandable, and thus personalized for all residents.

In conclusion, municipalities can best facilitate the transition to natural gas-free living through a combination of financial, comfort-enhancing, and confidence-building interventions. The analysis shows that the barriers and interventions for low-income homeowners in the Netherlands are well documented; extensive research has already been done on these topics. The interviews confirm this. It appears that there is no standard procedure for municipalities, but they can learn well from other municipalities that are already further along in the process. Since NPLW and RVO already map these successful projects and disseminate information, it could be made clearer where this information can be found, also for homeowners. It is also important for the municipality to know what stage of the customer journey the municipality and homeowners are in, as there are specific interventions associated with that. It also appears that the supply and associated interventions are highly dependent on the alternative heat source chosen by the municipality. This should be considered in the offer.

The research has some limitations. A first limitation is the lack of the resident perspective, as no interviews were conducted with residents living in natural gas-free neighborhoods. However, their experiences and opinions could be considered valuable and useful. Additionally, variations in project approaches can also be seen as a shortcoming, as the small sample size limited the ability to fully capture the effects of different approaches, thereby reducing the generalizability of the findings. This concerns, for example, budget, planning, and especially resident participation. On the other hand, variations allow for an understanding of what works well and what does not in these types of projects. The final limitation is the influence of changing external factors, over which both municipalities and homeowners have no direct control. Energy laws, subsidies, and technologies are constantly changing, so interventions that are effective today may become less relevant or even obsolete in the future due to new regulations or incentives.

Finally, recommendations for future research and practice are described. An example for future research is to conduct a more in-depth study to find out what the preferred interventions are for homeowners, such as a survey and specific techniques to measure preferences. Recommendations for practice are addressed to municipalities. First, this includes involving homeowners from the beginning of the project. At the same time, it is recommended to create complete policies and proper offerings before communicating them to homeowners while also providing accurate and consistent information. Finally, collaboration with different parties in natural gas-free projects is recommended to make the energy transition smoother and achieve the government's climate goals.

Looking back, this research has provided valuable and practically applicable insights that can support municipalities in the Netherlands and abroad. These insights focus on helping and motivating homeowners to phase out natural gas and switch to renewable energy sources. In doing so, they contribute to the energy transition and support the set climate goals.

## Samenvatting

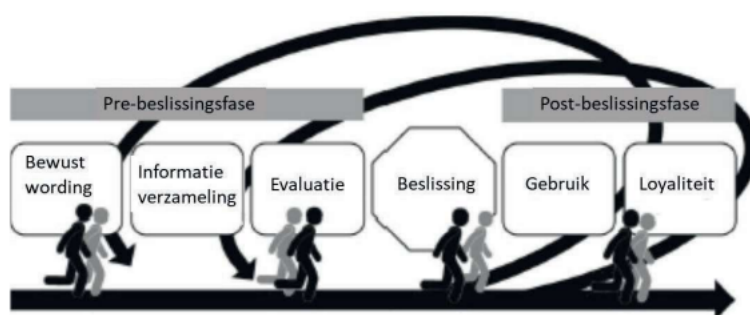
Om de klimaatdoelen van de Nederlandse overheid te behalen, moeten ook huiseigenaren hun woningen verduurzamen, zoals vastgelegd in het Energieakkoord. Dit omvat het isoleren van 2,5 miljoen woningen vóór 2030 en het volledig gasvrij maken van alle woningen vóór 2050. Voor veel huiseigenaren vormt dit een grote uitdaging. Er zijn zowel stimulansen die de verduurzaming aantrekkelijk maken als barrières die de overstap naar een gasvrije woning moeilijk maken. Daarbij is er nog een speciale groep huiseigenaren in Nederland: huiseigenaren met een laag inkomen. Deze groep kan vaak net hun hypotheek en andere vaste lasten betalen en heeft geen ruimte over voor andere investeringen. Ook wonen ze vaak in een woning met achterstallig onderhoud en heeft deze doelgroep weinig kennis van verduurzaming en overstappen op een aardgasvrije bron.

Dit onderzoek richt zich op deze speciale groep: huiseigenaren met een laag inkomen. Het doel van dit onderzoek is om te achterhalen welke barrières en interventies huiseigenaren met een laag inkomen ervaren en stimuleren en welke interventies gemeenten het beste in hun aanbod kunnen opnemen om huiseigenaren te stimuleren hun woningen te verduurzamen of over te stappen op een woning met een alternatieve warmtebron voor aardgas. In samenwerking met RVO en NPLW leidde dit tot de volgende hoofdvraag: **"Welk beleid kunnen gemeenten het best formuleren om huiseigenaren met een laag inkomen te stimuleren hun woning te verduurzamen en over te stappen op aardgasvrije alternatieven, rekening houdend met motieven en best practices?"**

Het onderzoek is gestructureerd met behulp van twee raamwerken: Hamilton et al.'s (2000) sociale klantreis en Steg et al.'s (2014) motieven voor duurzame keuzevorming. De sociale klantreis is een marketingmodel dat de stappen weergeeft die een consument neemt van het kennismaken met een product of dienst tot het doen van een uiteindelijke aankoop, evenals de daaropvolgende fasen van klantenzorg en loyaliteit, zie figuur 3. Dit onderzoek richtte zich op de klantreis naar een aardgasvrij huis.

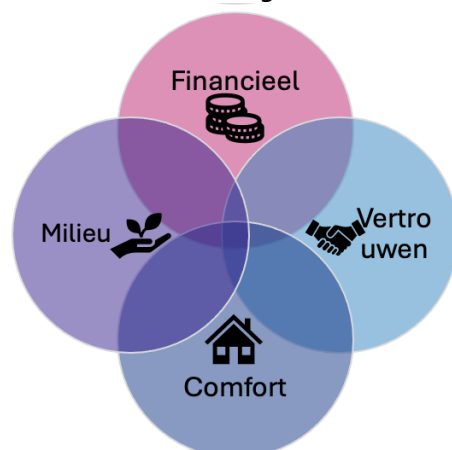
De studie van Steg et al. (2014) schetst drie psychologische motieven voor milieuvriendelijk gedrag en biedt een uitgebreide benadering om dergelijk gedrag te begrijpen en te ondersteunen. De motieven zijn financieel, milieu- en comfortgerelateerd. Dit onderzoek voegt een vierde motief toe: vertrouwen, zie figuur 4. Het financiële motief heeft te maken met het verlagen van energiekosten, het gebruik van financiële stimulans door bijvoorbeeld de gemeente of overheid, energieonafhankelijkheid en het verhogen van de waarde van onroerend goed. Het comfortmotief is tweeledig; ten eerste heeft het te maken met het verhogen van het thermisch comfort na het toepassen van energiezuinige maatregelen en ten tweede ook met ontzorging, en het gedoe, rommel en overlast bij het uitfaseren van aardgas in de woning te beperken. Het milieumotief relateert het milieu aan de persoonlijke verantwoordelijkheid om milieukwesties aan te pakken door middel van het uitfaseren van aardgas in de woning. Het vertrouwenmotief is ook tweeledig; het heeft te maken met vertrouwen in personen, organisaties zoals de gemeente en overheid en technologie, evenals het verschaffen van correcte en consistente informatie om zo mee te doen met de energietransitie.

FIGUUR 1 ► KLANTREIS NAAR WONINGVERDUURZAMING



Bron: naar Hamilton et al. (2020).

Figuur 3 Sociale klantreis (Hamilton et al., 2020)



Figuur 4 Motieven voor het maken van duurzame keuzes

De opzet van dit onderzoek is als volgt. Op de eerste plaats is er uitgebreid literatuuronderzoek gedaan naar verschillende onderwerpen, waaronder de barrières voor het nemen van energie-efficiënte maatregelen. De belangrijkste barrières in de literatuur zijn dat huiseigenaren met een laag inkomen vaak niet de financiële middelen hebben om energie-efficiënte maatregelen in hun huis te implementeren, dat huiseigenaren met een laag inkomen de hoge initiële kosten niet kunnen opbrengen en dat ze bang zijn dat de investering geen rendement oplevert. Verder zijn gebrek aan informatie, geen motivatie en het niet zien van de noodzaak van energie-efficiënte maatregelen, onwetendheid over stimulansen, technologie en leveranciers ook barrières. Gedoe en ongemak voor, tijdens en na de verduurzamingswerkzaamheden blijken ook een belemmering te zijn voor huiseigenaren. Tot slot blijkt ook het gebrek aan vertrouwen in de overheid, gemeenten en aannemers een barrière te zijn.

Daarna is onderzoek gedaan naar bestaande interventies die gemeentes kunnen inzetten om huiseigenaren te stimuleren mee te doen met de energietransitie. De interventies zijn ook gestructureerd aan de hand van de raamwerken. Voornaamste interventies uit de literatuur zijn financiële interventies zoals eerdergenoemde subsidies, leningen met lage rente, belastingvoordelen en vereenvoudigde hulpprogramma's om huiseigenaren met een laag inkomen te helpen energiebesparende maatregelen te nemen. Vertrouwen gerelateerde interventies zijn onder andere open en consistente communicatie, buurt evenementen en succesverhalen van burens. Comfortgerelateerde interventies zijn onder andere het inzetten van energiecoaches en het geven van advies, kennisdesks voor hulp op maat en workshops over energiebesparende strategieën. Ook blijkt dat een veelzijdige strategie nodig is om ervoor te zorgen dat alle huiseigenaren, vooral die met lagere inkomens, kunnen deelnemen aan de uitfasering van aardgas.

Zowel voor de barrières als de interventies zijn op basis van deze onderzoeken long lists ontwikkeld, waarbij zowel de barrières als de interventies zijn gestructureerd volgens de gebruikte raamwerken. In het onderzoek is ook gekeken naar koppelkansen, waaruit blijkt dat buurtvernieuwing, het verbeteren van de openbare ruimte, het brengen van sociale voordelen en het verbeteren van de sociale cohesie en samenwerking met woningcorporaties kunnen fungeren als stimulans voor huiseigenaren om deel te nemen aan de energietransitie.

Na het literatuuronderzoek naar de barrières en mogelijke interventies is onderzoek gedaan naar het huidige beleid en initiatieven in Nederland, gericht op verduurzaming en het aardgasvrij maken van woningen en wijken. Hoewel Nederland al een aantal beleidsmaatregelen en subsidies heeft geïmplementeerd (zoals SVOH, ISDE, SAH en WGIW) en aan het ontwikkelen is (WCW), vormen hoge initiële kosten, technologische complexiteit en conflicterende perspectieven van belanghebbenden nog steeds grote problemen, wat het belang benadrukt van effectieve communicatie en samenwerking bij het bereiken van langetermijnenergietransitiedoelen. Het beleid van landen zoals Denemarken, Duitsland en Engeland kan Nederland laten zien dat de overgang naar hernieuwbare energie sterke overheidssteun, samenwerking en strategische planning vereist. Ook laten deze landen zien dat een succesvolle energietransitie duidelijke beleidsdoelstellingen, aanzienlijke investeringen in infrastructuur en technologie heeft, evenals het vermogen om uitdagingen zoals financiering en innovatie te overwinnen.

Vervolgens zijn expertinterviews gehouden met personen die in de praktijk bezig zijn met aardgasvrije projecten zoals werknemers van gemeentes en energie coöperaties. In totaal zijn zeven bruikbare gesprekken gevoerd. De interviews zijn bedoeld om de resultaten van het literatuuronderzoek te vergelijken met de praktijk, waaruit is gebleken dat de literatuur en de praktijk over het algemeen een grote overeenkomst hebben met betrekking tot de barrières en interventies. Uit de gesprekken bleek dat de financiën een belangrijk motief vormen, evenals vertrouwen en comfort. De geïnterviewden gaven dan ook aan dat er veel geld en tijd in projecten van aardgasvrije wijken gestoken moet worden, om zo het vertrouwen van bewoners te verkrijgen en te laten

participeren in de energietransitie. Ook meldden ze dat huiseigenaren die al duurzame maatregelen hebben getroffen aan de woning goed kunnen fungeren als ambassadeurs voor de andere bewoners in de wijk. Opvallend was dat in alle interviews duidelijk bleek dat milieu geen motief is voor verduurzaming van huiseigenaren met een laag inkomen, terwijl de literatuur dat wel stelt. Ook met de resultaten uit de interviews is een long list ontwikkeld met interventies.

Voor het onderzoek zijn tien interviews afgenomen. In zeven interviews was sprake van aardgasvrije wijken, die als casus kunnen dienen. In drie interviews werden geen specifieke casussen werden besproken. Hoewel dit een kleine steekproef is en de wijken sterk van elkaar verschillen, in termen van bewoners, wijkindeling, aanpak, budget, tijd en participatie, hebben de zeven casussen interessante inzichten opgeleverd en zijn er een aantal duidelijke overeenkomsten te herkennen. 'Best practice'-casussen worden gekenmerkt door duidelijke beleidsvisies, door uitgewerkte technische en juridische randvoorwaarden, door nul kosten tot aan de voordeur, door verregaande ontzorging en het gebruik van een CO<sub>2</sub>-neutrale en duurzame warmtebron. Het is essentieel om rekening te houden met de diversiteit van huiseigenaren en te zorgen voor maatwerk binnen de beleidsvisie, waarbij bewoners zoveel mogelijk keuzevrijheid behouden. Aan de andere kant kenmerken 'worst practice'-casussen zich door onduidelijkheid over beleidsplannen, een opeenstapeling van te veel uitdagingen en het willen bereiken van te veel doelen tegelijkertijd, en de onzekerheid over de kosten van het alternatief voor gas.

Vervolgens zijn in de verdere analyse en synthese het literatuuronderzoek en de interviews met elkaar vergeleken, de beste en slechtste praktijkinterventies naast elkaar gelegd en het huidige beleid besproken. De bevindingen uit de literatuur en de interviews komen over het algemeen overeen, waarbij financiële en vertrouwensinterventies opnieuw van groot belang zijn. Terwijl de literatuur voornamelijk brede, overkoepelende interventies bespreekt, gaven de interviews inzicht in meer lokale, praktische en context specifieke oplossingen op basis van hun unieke ervaringen. Uit de interviews kwam ook naar voren dat bestaande subsidies niet altijd bekend zijn bij huiseigenaren, vooral niet bij die met een laag inkomen. Bij het vergelijken van de beste en slechtste praktijkinterventies komt de noodzaak van communicatie met belanghebbenden, goede planning en participatie, en persoonlijke benaderingen opnieuw naar voren. Uit de bespreking van het huidige beleid blijkt dat Nederland zich al redelijk heeft gecommitteerd aan duurzaam beleid, maar dat personaliseren van interventies en begeleiding nodig is om beter aan te sluiten bij de individuele financiële en emotionele behoeften van huiseigenaren, omdat huiseigenaren de subsidies vaak niet weten te vinden en daardoor mislopen, ook al zijn deze regelingen voor hen bedoeld. Ook is het nodig aanvullende interventies in te zetten om huiseigenaren effectief te stimuleren deel te nemen aan de energietransitie, waarbij een compleet en duidelijk aanbod essentieel is, dat begrijpelijk en dus gepersonaliseerd is voor alle bewoners.

Concluderend kunnen gemeenten de overgang naar aardgasvrij wonen het beste faciliteren door een combinatie van financiële, comfortverhogende en vertrouwenwekkende interventies. Uit de analyse van de deelvragen blijkt dat de barrières en interventies voor woningeigenaren met een laag inkomen in Nederland goed gedocumenteerd zijn; er is al uitgebreid onderzoek gedaan naar deze onderwerpen. De interviews bevestigen dit. Het blijkt dat er geen standaardprocedure is voor gemeenten, maar dat gemeenten goed kunnen leren van andere gemeenten die al verder zijn in het proces. Omdat NPLW en RVO deze succesvolle projecten al in kaart brengen en informatie verspreiden, zou duidelijker gemaakt kunnen worden waar deze informatie te vinden is, ook voor huiseigenaren. Het is ook belangrijk voor de gemeente om te weten in welke fase van de klantreis de gemeente en de huiseigenaren zich bevinden, omdat daar specifieke interventies aan verbonden zijn. Ook blijkt dat het aanbod en de bijbehorende interventies sterk afhankelijk zijn van de alternatieve warmtebron die de gemeente kiest. Hier moet rekening mee gehouden worden in het aanbod.

Het onderzoek kent enkele tekortkomingen. Een eerste tekortkoming is het ontbreken van het bewonersperspectief, omdat er geen interviews werden afgenomen met bewoners die in aardgasvrije buurten wonen. Hun ervaring en mening zouden echter als waardevol en nuttig kunnen worden beschouwd. Ook kunnen variaties in projectbenaderingen ook worden gezien als een tekortkoming, omdat vanwege de kleine steekproefomvang de effecten van de verschillende benaderingen niet volledig konden worden vastgelegd, waardoor de generaliseerbaarheid van de bevindingen werd beperkt. Dit betreft bijvoorbeeld budget, planning en vooral bewonersparticipatie. Maar aan de andere kant kunnen door variaties ook gezien worden wat wel en niet goed werkt in dit soort projecten. De laatste tekortkoming is de invloed van veranderende externe factoren, waarop zowel gemeenten als huiseigenaren geen directe controle hebben. Energiewetten, subsidies en technologieën veranderen voortdurend, waardoor interventies die nu effectief zijn in de toekomst minder relevant of zelfs achterhaald kunnen raken door nieuwe regelgeving of stimuleringsmaatregelen.

Tot slot zijn er aanbevelingen voor toekomstig onderzoek en voor de praktijk beschreven. Een voorbeeld voor toekomstig onderzoek is het uitvoeren van een verdiepingsonderzoek om te achterhalen wat de voorkeursinterventies zijn voor huiseigenaren, zoals een enquête en specifieke technieken om voorkeuren te meten. Aanbevelingen voor de praktijk zijn gericht aan de gemeente. Ten eerste omvat dit het betrekken van huiseigenaren vanaf het begin van het project. Tegelijkertijd is de aanbeveling het maken van compleet beleid en een goed aanbod alvorens dit naar huiseigenaren wordt gecommuniceerd, maar ook het verschaffen van correcte en consistente informatie. Ook is het advies om het samenwerken met verschillende partijen in aardgasvrije projecten te bevorderen om de energietransitie soepeler te laten verlopen en de klimaatdoelstellingen van de overheid te behalen.

Terugkijkend heeft dit onderzoek waardevolle en praktisch toepasbare inzichten opgeleverd die gemeenten in Nederland en daarbuiten kunnen ondersteunen. Deze inzichten richten zich op het helpen en motiveren van huiseigenaren om aardgas af te bouwen en over te stappen op duurzame energiebronnen. Daarmee dragen ze bij aan de energietransitie en ondersteunen ze de gestelde klimaatdoelstellingen.

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## Terminology and abbreviations

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ACM	Authority Consumer and Market (Autoriteit Consument & Markt)
CBS	Central Bureau of Statistics (Centraal Bureau voor de Statistiek)
EP	Energy poverty
EPA	Energy performance advice (Energie Prestatie Advies)
EU	European Union
HA	Housing association
ISDE	Renewable energy and energy conservation investment subsidy (Investeringssubsidie duurzame energie en energiebesparing)
NPLW	National Local Heat Transition Program (Nationaal Programma Lokale Warmtetransitie)
PAW	Natural gas-free neighborhoods program (Proeftuin Aardgasvrije wijk)
PONG	Phase-Out of Natural Gas
RVO	Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland)
SVOH	Sustainability and Maintenance Grant Scheme for Rental Housing (Subsidieregeling Verduurzaming en Onderhoud Huurwoningen)
WCW	Collective Heat Supply Act (Wet Collectieve Warmte)
WGIW	Heat Transition Act (Wet Gemeentelijke Instrumenten Warmtetransitie)
WOAB	Home subscription service (Woningabonnement)
WOZ	Property valuation (Waardering Onroerende Zaken)

## Chapter 1 Introduction

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The introductory chapter of this research consists of an introduction to energy transition and phasing out natural gas, the description of energy poverty, the role of energy transition in combating energy poverty, the actors in energy transition, as well as a brief introduction on the barriers to adopting energy efficiency measures. Next, the main question of the research and the sub-questions will be discussed with explanations. Finally, the scope, as well as the academic and practical relevance of the research will be discussed.

### 1.1 Energy transition and phasing out natural gas

By 2050, seven million Dutch dwellings need to switch from natural gas-based heating and cooking to other non-fossil sources to meet the climate policy goals. By law, the Phase-Out of Natural Gas in the residential sector (further referred to here as PONG) will be governed by local authorities and will take place sequentially, by urban neighborhood. For most neighborhoods, the preferred (supported) alternative sources of heating have recently been specified in the heating visions of the 400 Dutch municipalities. Municipalities will also have the right to determine when exactly the natural gas supply to a specific neighborhood will cease. The policy aim is however to incentivize most households to switch to other heating and cooking sources voluntarily before the decision about ceasing gas supply is made.

Phasing out gas in households can be achieved in several ways, including implementing energy efficiency measures or connecting to a heat grid. In the Netherlands, numerous municipalities are preparing neighborhoods to be "natural gas-free ready," which means that homes will be upgraded to link smoothly to future heat networks. This proactive strategy is consistent with continuing efforts in the Dutch electricity sector, where environmental concerns are progressively being integrated amidst deregulation and Europeanization (Verbong & Geels, 2007). Energy-efficient solutions, such as home insulation and solar panel installations, not only reduce energy usage but also promote environmentally friendly energy practices. Alternatively, heat network grids, which use waste or renewable heat sources, provide collective heating solutions without relying on natural gas. Local considerations such as infrastructural availability, financial sustainability, and community engagement frequently influence which initiatives are chosen (Safari et al., 2019).

A few European countries started transition to gas-free real estate earlier than Netherlands. Denmark is a European leader in energy transition and natural gas-free operations. Other countries, including Sweden, Germany, and the United Kingdom, have already begun to phase out gas. Denmark's energy transition resulted from a complex combination of actors, context, and stories, emphasizing the significance of stories in shaping future policy and practice (Veenman et al. 2019). As part of its broader energy transition agenda, the government has vowed to phase out natural gas fully by 2030. This policy intends to significantly reduce reliance on fossil fuels while promoting renewable energy sources. The Danish government has implemented several initiatives, including financial assistance and subsidies for the construction of alternative heating systems such as heat pumps and district heating (Lund and Persson, 2016). In addition, municipalities are actively involved to accelerate local plans and adapt infrastructure. Community-based renewable energy in Denmark has grown because of shared identification and goals, reliance on state and top-down policies, and local approaches (Mey & Diesendorf, 2018). These combined initiatives highlight Denmark's dedication to sustainability and environmental protection, while also serving as an example for other countries seeking similar environmental goals. According to Krog and Sperling (2019), the execution of strategic energy planning in Denmark can be improved by including key components from the international literature and applying a theoretical framework, but the same is true in the Netherlands. In Sweden, district heating is widely used thanks to strong national policies, such as high taxes on fossil fuels and transparent rules for district heating (Werner, 2017).

## 1.2 Energy poverty

Energy poverty (EP) is a growing problem worldwide. There are various definitions of energy poverty, and almost all refer to insufficient energy use to meet basic essential needs. In this study, a definition of Mulder et al. (2023), will be used: energy poverty is a combination of bad affordability of energy, low energetic quality of houses, and insufficient households' ability to engage in the energy transition. Energy poverty is a multidimensional issue; hence it cannot be measured by a single indicator. According to the European Parliament, the indicators to measure energy poverty include overdue utility bills, a low absolute energy consumption, a high share of energy expenditure in income, and the difficulty to keep home appropriately warm (Energy Poverty Advisory Hub, 2023). From 2015 to 2021, the portion of the worldwide population with access to electricity rose from 87% to 91% (Martin, 2023). Also in Europe, more than 41 million people (9.3% of the EU's population) were not able to keep their homes appropriately warm in 2022, compared to 6.9% in 2021 (eurostat, 2024). In the Netherlands, the number of households suffering from energy poverty in has increased from 512 000 (6.4%) in 2020 to 602 000 (7.4%) by 2022 (Mulder, Batenburg, & Dalla Longa, 2023). These numbers most likely increased due to the impact of the COVID-19 pandemic and the rising energy prices due to the war in Ukraine (Schislyaeva & Saychenko, 2022; Widuto, 2023).

The consequences of living in energy poverty include a variety of factors as EP happens when a household's energy use is reduced to such an extent that it has a negative influence on the residents' health and well-being (Thomson et al., 2017). The core reasons for this issue are excessive household energy expenditure, low income, and poor building and appliance energy performance. The research of Sovacool's (2012) states that energy poverty has an impact on public health, gender roles, education, and the environment. The impacts of EP are the greatest on vulnerable groups, such as women, children and the elderly (Xiao et al., 2021; Zhang et al., 2021). The research of Lewandowski et al. (2023) indicates that EP increases the risk of poor health outcomes, which accounts for 16% of the variance in the development of respiratory disease, whilst the study of Liddell and Morris (2010) states practically the same, as EP can have a severe physical health impact on children's respiratory health, as well as significant mental health consequences for adults and adolescents.

Other than the impacts of energy poverty on health, EP causes poor living circumstances and social isolation. High energy prices compared to income can worsen poverty and unemployment, locking families in a vicious circle of financial misery. Eventually, energy poverty can reduce GDP and social welfare if long-term consistency is not paid attention to. Addressing energy poverty necessitates a multifaceted approach that addresses not only infrastructure development but also the underlying political, institutional, and social impediments (Liddell et al., 2012). Long-term effects can lead to limited educational and economic opportunities, deteriorated housing and social isolation. Tackling energy poverty requires a comprehensive approach to provide sustainable solutions and promote well-being. To address energy poverty, actions must be taken to enhance energy efficiency, lower energy prices, and promote access to clean and inexpensive energy sources, all of which improve vulnerable populations' living standards and well-being. The Netherlands' transition to gas-free homes is an important part of national efforts to combat climate change. It eliminates the use of natural gas because of its high CO<sub>2</sub> emissions and negative environmental impact and instead switches to clean, renewable energy that does not emit greenhouse gases. Concerns about Groningen and the desire to be less dependent on foreign sources are driving the move away from natural gas.

### 1.3 Role of energy transition in combatting energy poverty

Energy efficiency measures are technologies that optimize financial or environmental benefits in existing buildings and offering them as a service can benefit all parties involved (Tan et al., 2016). Energy-efficient solutions could be implemented in the home to improve it and thereby reduce energy poverty. Based on Dutch policies, three groups of energy efficiency measures can be distinguished:

- I. Small improvements that increase comfort and lead to energy savings
- II. Upgrades in insulation, electricity and heating that allow to phase out natural gas
- III. Phasing out natural gas for heating and cooking

The small improvements include draft strips, place tow strips and radiator/heat foil, seal gaps and cracks, switch to energy-efficient lighting, and provide energy-efficient appliances (Aranda et al., 2017). One of the initiatives offering small improvements to households is the Dutch Klusbus. The Klusbus helps designated households that have a low income and/or high energy costs and live in a home with poor energy quality with measures that directly help with energy savings (Klusbus, 2024). In Eindhoven, the housing associations and their contracting partners are jointly helping families who are in trouble due to rising energy prices. Homes in various selected neighborhoods are made more energy efficient with minor adjustments free of charge. In Eindhoven these concerns at least 14,000 households. The handymen look at the measures that will yield the most savings in the tenants' situation. These are all measures that immediately help with energy savings (De Eindhovense klusbus, 2022). Small adjustments can often save energy and money.

More impactful measures include improving building insulation, using solar energy and smarter thermostats, conducting energy audits, and monitoring and using green building materials. Insulation, better glazing, installation measures and renewable energy systems are the most cost-effective energy-saving solutions for remodeled homes (Verbeeck & Hens, 2005). Insulation is especially necessary when considering switching to natural gas heating.

Phasing out natural gas for heating and cooking in homes is a critical component of the national efforts to combat climate change. Besides insulating the house, other measures to make a home natural gas-free include an alternative heating system such as heat pumps, electric cooking, ventilation with heat recovery, and long-lasting energy sources such as solar panels, and finally removing the gas meter (Milieu Centraal, 2024). Guidelines and infrastructure must be followed, and installations must be certified. This results in a gas-free home with lower costs and environmental benefits. These measures not only help to reduce energy costs, but they also reduce environmental effects by reducing energy use and the use of renewable energy sources. Some of these steps are required to transition to a gas-free home, the most important of which is switching to another energy source.

Many countries are also attempting to achieve sustainability. Germany, Denmark and the United Kingdom have announced ambitious plans to reduce greenhouse gas emissions by speeding up the transition to renewable energy sources. In Germany, the Energiewende, or energy transition, is being pursued with the goal of speeding up the transition to renewable energy sources while lowering carbon emissions. This includes phasing out coal and nuclear energy while encouraging solar and wind energy (Von Hirschhausen, 2014). Denmark is also noted for its efforts in sustainable energy, with a significant emphasis on wind energy and a goal of achieving climate neutrality by 2050. The United Kingdom has similar aims, promoting electric heating and renewable energy sources as alternatives to natural gas (Chilvers et al., 2017). These international projects indicate a growing awareness of the urgency of climate change and the drive toward a more sustainable future with less reliance on fossil fuels (Veenman et al., 2019).

## 1.4 Actors in energy transition and phasing out natural gas

The energy transition is a crucial process in the fight against climate change and reducing dependence on fossil fuels. This section looks at the various actors involved in phasing out natural gas. Analyzing the roles, challenges, and collaborations of these actors provides a better understanding of the complexity and urgency of the natural gas transition and the steps needed to achieve a sustainable energy system. Figure 5 introduces the key actors involved in the local heat transition. Research by CE Delft et al. (2022) identifies a wide range of potential stakeholders in the energy transition. However, not all of these stakeholders are relevant to this specific study. Only the actors essential to this research's scope and goals are described below. These selected actors are integral to understanding the dynamics of the local heat transition and its implementation. For this study, but not shown in the figure, RVO, NPLW and ACM are also important actors. Morskieft (2021) also mentions knowledge institutions and social organizations as relevant actors in phasing out natural gas.

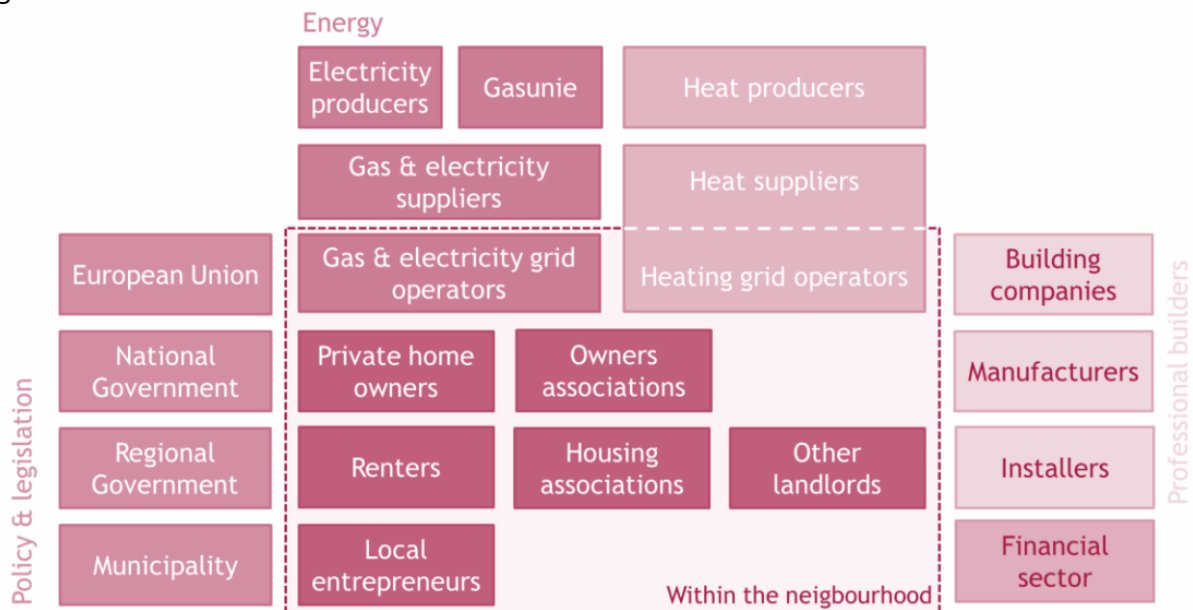


Figure 5 Overview of actors in energy transition (CE Delft et al., 2022)

### 1.4.1 Policy and legislation

#### 1.4.1.1 European Union

The European Union (EU) plays a central role in the energy transition by providing policy, regulation, and financing to support member states' transition to a sustainable and carbon-neutral energy supply. The European Green Deal facilitates this transition through three principles: providing a safe and inexpensive energy supply, developing an integrated and digitalized energy market, and emphasizing energy efficiency alongside renewable energy development (European Commission, 2022).

#### 1.4.1.2 National and regional government

The Dutch government plays a central role in the energy transition and aims for a climate neutral sustainable energy supply in 2050. This goal is in line with the European reduction target of 55% less CO<sub>2</sub> emissions by 2030. The transition to renewable energy is crucial to combat climate change, reduce dependence on fossil fuels and reduce dependence on foreign energy sources (Ministerie van Algemene Zaken, 2023). The government is committed to energy conservation, a shift from coal to renewable sources of electricity (such as solar and wind), and replacing natural gas with renewable heat sources, such as geothermal, waste heat and green hydrogen. To increase acceptance and involvement, the government encourages local participation and co-ownership in energy projects and ensures their careful incorporation into the landscape (Ministerie van Algemene Zaken, 2023).

#### 1.4.1.3 Municipality

Municipalities have an important role in encouraging sustainable practices and facilitating energy transition. Local governments are well-positioned to have a direct impact on reducing CO<sub>2</sub> emissions and promoting renewable energy sources (Papp, 2023). Municipalities can support sustainable initiatives such as installing solar panels on public buildings, promoting energy efficiency in homes and businesses, and encouraging sustainability through policies, regulations, and investments (Caputo & Pasetti, 2015). Furthermore, municipalities can encourage local collaboration and citizen participation in order to increase community involvement in energy transition and the acceptance of long-term policies (Van Staden, 2017). Municipalities can play a crucial role in achieving national and international climate goals and creating a sustainable future for their residents by playing a leading role in the energy transition (Vringer et al., 2021). But municipalities cannot do this alone; citizens must contribute to this. In the field of sustainability, municipalities can focus on coaching, sustainability initiatives from residents, citizen consultation, creating energy counters, fighting energy poverty and providing financial arrangements (Binnenlands Bestuur, 2023).

#### 1.4.1.4 RVO

The Netherlands Enterprise Agency (RVO, Rijksdienst voor Ondernemend Nederland) supports the energy transition by offering subsidies, financing and advice to companies, municipalities and individuals. Through schemes such as the ISDE and SDE++, the RVO stimulates investments in sustainable energy and energy conservation. In this way, the RVO plays a crucial role in translating policy objectives into concrete actions (RVO.nl, 2022).

#### 1.4.1.5 NPLW

The National Local Heat Transition Program (NPLW, Nationaal Programma Lokale Warmtetransitie) supports municipalities in their management role to make homes and buildings natural gas-free (NPLW, 2024). NPLW offers tools, expertise and financing, so that municipalities can develop and implement effective heat plans. In addition, it facilitates cooperation with local partners, resident participation and the implementation of sustainable alternatives such as heat networks. In this way, the NPLW plays a central role in the realization of the national climate goals for 2050.

#### 1.4.1.6 Energy market regulators

The Consumer & Market Authority (ACM) sets rules to ensure fair competition in the energy market and promotes the transition to alternative energy sources, such as renewable heat networks (ACM, 2024).

### 1.4.2 Within the neighborhood

#### 1.4.2.1 Private (low-income) homeowner

As direct energy consumers, homeowners can make adjustments to their energy consumption and lessen their environmental impact (Schot et al., 2016). This means that homeowners play an important part in the energy transition by implementing sustainable practices in their own houses as investing in energy-efficient technology such as installing heat pumps and solar panels can help homeowners minimize their energy consumption and reliance on fossil fuels (Haas et al., 1998). They can also enhance energy efficiency by insulating their homes, replacing windows with energy-efficient choices, and deploying smarter technologies to conserve energy. Implementing these long-term steps not only decreases energy usage but also helps to reduce CO<sub>2</sub> emissions and promotes a more ecologically conscious lifestyle (Rausser et al., 2023).

Abbas et al. (2020) shows that house size, household wealth, gender, education, occupation (clerical, sales, or agricultural), and the head of the household's marital status are significant negative socioeconomic determinants of household multidimensional energy poverty, whereas place of residence, house ownership status, family size, and age of the primary breadwinner play a significant positive role, but it is unclear whether there is a difference for tenants or owners. Pelenur and Cruickshank (2012) also state that marital status, education level, dwelling type and location

significantly impact the adoption of domestic energy efficiency measures in UK cities. Additionally, Aristondo and Onaindia (2018) show that semidetached and rented dwellings had the highest energy poverty rates.

Owner associations and other landlords, local entrepreneurs and renters also have a role in energy transition, of course, but because the focus of this study is on homeowners, these groups are not explained in more detail.

#### **1.4.2.2 Housing association**

Housing associations (HA) play a dual role in energy transition: they make social housing more sustainable and support tenants. HA invests in measures such as insulation, heat pumps and solar panels to both lower energy costs and reduce their carbon footprint. At the same time, legal regulations protect tenants from rent increases, placing the financial burden on the corporations. In addition to sustainability, housing corporations inform and involve tenants in the measures. In this way, corporations contribute to an inclusive energy transition without additional financial pressure on tenants.

Tenants are more likely to experience energy poverty because they have less influence over energy-saving measures in their houses (Thomson and Snell, 2013). Social housing corporations utilize the energy-saving means. This may be accompanied by a rent increase or, in some cases, be completely free of charge (Ministry of General Affairs, 2024). Importantly, only improvements that increase home comfort, such as insulation or new heating systems, can result in a rent increase. Maintenance work does not affect the rent. Homeowners, on the other hand, must pay for energy transition measures themselves, which can be a serious barrier to participation in the energy transition.

#### **1.4.3 Energy**

##### **1.4.3.1 Gas & electricity producers, suppliers and operators**

Gas and electricity producers are responsible for generating energy, with their choices of fossil or renewable sources having a direct impact on carbon emissions. By investing in technologies such as green hydrogen production and large-scale solar and wind farms, they contribute to making energy supply more sustainable (CREG, 2024). Energy suppliers buy energy from producers and sell it to end users such as households and businesses. They increase demand for renewable energy, while dynamic prices and smart meters encourage energy efficiency (VREG, 2024).

Grid operators are in charge of operating and maintaining the infrastructure needed to supply energy. Gas grid operators transport gas through pipelines, while electricity grid operators maintain the grid and invest in smart grids and storage systems to support the integration of renewables. Their investments in grid reinforcement and innovative technologies are crucial to meet peak renewable energy demand (VREG, 2024).

##### **1.4.3.2 Heating grid producers, heat suppliers and operators**

In addition to gas and electricity, heat networks are an important part of the energy transition. Heat producers generate heat for district heating, increasingly using renewable sources such as waste heat, geothermal and biomass. Heat suppliers ensure that this heat reaches end users through distribution networks and play an important role in increasing the acceptance of district heating by offering transparency and affordable prices. Heat network operators manage the physical network and invest in expansions and optimizations to minimize heat loss and connect more households (VREG, 2024).

##### **1.4.3.3 Energy cooperation**

Local energy communities in neighborhoods are often initiated by front-runners. Energy cooperatives also play an important role in achieving climate goals while promoting fairer distribution within the

energy system by giving communities equal access to renewable energy, providing control, reducing costs and reinvesting revenues locally. By generating renewable energy locally, these cooperatives not only accelerate the energy transition but also strengthen social cohesion and improve livability in villages and neighborhoods (TNO, 2023).

#### **1.4.4 Professional builders**

##### **1.4.4.1 Building companies, manufacturers and installers**

Construction companies, manufacturers and installers play a crucial role in the energy transition by shaping the future of sustainable construction and renovation. Construction companies are key players in the design and construction of energy-efficient homes and commercial buildings. They are responsible for integrating sustainable solutions, such as advanced insulation materials, energy-efficient windows and construction techniques, that help to significantly reduce energy consumption and improve overall building performance (Ministerie van Algemene Zaken, 2024).

Manufacturers contribute by producing the materials and technologies needed for the energy transition, including highly efficient heating systems, solar panels and insulation products. These innovations are essential for reducing the environmental impact of a building (Rassineux, 2024).

Installers bring these materials and systems to life by ensuring that sustainable technologies, such as heat pumps, solar panels and smart energy systems, are installed and functioning correctly. Their efforts are critical to improving energy efficiency in both new and existing buildings, lowering gas consumption and CO<sub>2</sub> emissions (Energietransitie door Installateurs, 2024).

#### **1.4.5 Other actors in the energy transition**

In addition to the above-mentioned important actors, several other actors play a role in the Dutch energy transition. Although their role is less prominent, they are essential to realizing a sustainable energy future.

##### **1.4.5.1 Research institutions**

Universities and research centers develop knowledge and innovative solutions for the energy transition. They play a key role in improving technologies such as energy storage, heat pumps and smart grids, as well as advising policymakers (EU, 2024).

##### **1.4.5.2 Welfare organizations**

Welfare organizations play a crucial role in the energy transition, especially in neighborhoods with low socioeconomic status and areas where people experience energy poverty. Welfare organizations concentrate on the social aspects of the transition, including the prevention and reduction of energy poverty and the engagement of vulnerable groups that may otherwise face exclusion. Through their efforts, they increase support for sustainable solutions and ensure that these communities can also benefit from renewable energy (Farent, 2024).

Other social services also play an important role, such as elderly associations, general practitioners and neighborhood teams. They are in contact with vulnerable groups, such as the elderly and low-income people, and can inform them about and support energy-saving measures (Dominelli, 2022).

Schools contribute by making younger generations aware of the importance of sustainability and involving them in local initiatives (De Caluwé et al., 2020). Besides these, there are many more social organizations that can contribute to the energy transition and stand by homeowners.

## 1.5 Target group

Clearly, there are many actors in the energy transition. In this research, the target group is low-income homeowners. According to CBS data, approximately 1% of homeowners, or 41,000 households, were classified as low-income in 2023 (CBS, 2024). Furthermore, TNO (2024) estimates that around 12% of low-energy dwellings are owner-occupied. In addition to this group, there is a growing number of near-poor homeowners in the Netherlands who barely make ends meet monthly and face chronic financial insecurity. These homeowners often experience stress due to mortgage payments and are not sure if they will be able to continue to meet their existing expenses in the future (Klerks, 2024). They lack the funds to invest in sustainable solutions, making it hard for them to become energy transition participants.

Therefore, this research focuses in particular on low-income homeowners who already own a home, not people who are going to buy one. This group is important for the energy transition and often faces specific problems as mentioned above. Many of these homeowners also face poorly insulated homes, overdue maintenance and high energy costs, while their limited financial resources prevent them from investing in sustainable solutions such as insulation, heat pumps or solar panels. Moreover, while these homes are often not yet disconnected from the natural gas grid or connected to a renewable heat source, they are located in municipalities that have made explicit plans to switch to renewable energy. This not only increases the risk of energy poverty but also exposes them to rising energy costs and reduced home comfort (Brown et al., 2020). While many low-income residents in the Netherlands live in social housing, where housing corporations are responsible for implementing energy-saving measures, low-income homeowners must make repairs themselves (TNO et al., 2024). This makes help from the municipality necessary to include these homeowners in the energy transition, because they too are needed to achieve the goals of a natural gas-free Netherlands.

## 1.6 Problem statement and research question

By 2050, the Netherlands aims to be gas-free (Ministerie van Algemene Zaken, 2024). Millions of homeowners will face costs, inconvenience, and uncertainty as a result of the project for phasing out natural gas. The high cost and scarcity of available stimulants can make it difficult for homeowners to participate, resulting in an unsatisfactory scenario. Due to budgetary constraints, low-income households are frequently unable to renovate their homes or invest in sustainable alternatives. Municipalities and heating companies are working together to create an appealing switch offer for citizens. Elements of this offer include interventions that reduce financial constraints and other barriers residents experience. Examples include subsidies for home renovation and/or connection to a heat network; de-care concepts that take the hassle out of the hands of homeowners; investments in local public spaces that take place at the same time as the switch, and more.

This situation creates a pressing problem: how can homeowners with low incomes, with the support of municipalities and other actors, contribute to the longevity of their homes while also improving thermal comfort and contributing to sustainability goals? Local governments can play a vital role by providing financial assistance, implementing regulations, and implementing educational programs that encourage homeowners to participate in renovation projects. Other actors can use their knowledge and resources to guide homeowners through the process, provide technical assistance, and explore financial options that make renovations more affordable.

In collaboration with RVO and NPLW, this research seeks to identify which interventions are most effective in motivating residents to switch to renewable energy. Therefore, the main research question of this research is:

***"What policies can municipalities best use to encourage low-income homeowners to switch to natural gas-free alternatives: based on motives and best practices?"***

The aim of this research is to identify and understand the main barriers and motivators that influence the adoption of energy-efficient measures in low-income homeowners. By investigating the major barriers and best practice interventions, the study intends to provide findings that can be used to improve policy development and contribute to initiatives aimed at increasing the adoption of energy-efficient practices in low-income housing. The objective is to alleviate energy poverty and improve living conditions for vulnerable groups while contributing to the energy transition. By understanding how they can work together to encourage people to make their homes more sustainable and natural gas-free (ready), municipalities and housing associations can help homeowners extend the life of their homes, improving not only energy efficiency but also the thermal comfort and quality of life for all residents. This will not only help municipalities achieve their goals but also create sustainable and resilient communities in the future.

Answering the research question is done based on the following sub-questions:

1. *What barriers do low-income homeowners face when participating in the energy transition and phasing out natural gas in Dutch municipalities?*
2. *What are the interventions by Dutch municipalities to help low-income homeowners participate in the energy transition and phase out gas?*
3. *How are barriers and interventions for participation in the energy transition currently being addressed in policy implementation?*
4. *Which interventions are likely to be most successful for Dutch low-income homeowners?*

The sub-questions above are formulated to create a systematic approach to answering the main question. The research involves multiple steps and aims to explain what role municipalities can play in stimulating low-income homeowners (facing energy poverty) for phasing out natural gas as well as aims to promote the energy transition for low-income Dutch householders by investigating various issues and solutions. First, a literature review will be conducted to determine what defines energy poverty and the main barriers and incentives to combat energy poverty. Hereby, sub-question 1 will help to understand the main barriers for adopting energy-efficient measures. It determines which actions there are in convincing these homeowners to implement energy-efficient solutions. Sub-question 2 will investigate which interventions currently exist in Dutch municipalities to encourage homeowners based on literature research and expert interviews. Sub-question 3 will investigate how the barriers and interventions are currently used in Dutch municipalities to encourage homeowners, based on desk research. Next, sub-question 4 investigates which specific measures and policy interventions exist in encouraging low-income homeowners in the Netherlands to make energy-efficient renovations to their homes. This is investigated based on literature, desk research and field research.

### **1.7 Scope**

The scope of this study was carefully defined to meet the specific issues of stimulating low-income homeowners in the Netherlands to phase out natural gas to more environmentally friendly energy sources. This research, undertaken in conjunction with RVO (Rijksdienst voor Ondernemend Nederland) and NPLW (Nationaal Programma Lokale Warmtetransitie), aims to identify the most effective interventions that municipalities may implement to encourage homeowners to engage in this transition. This includes homeowners who live in all parts of the Netherlands, so it is applicable to all municipalities.

## **1.8 Academic relevance**

The energy transition is one of the greatest societal challenges of this time, and understanding barriers and effective interventions is essential to making this transition smooth and successful. Through a combination of literature review, data from interviews and analysis, this research makes a valuable contribution to scientific knowledge about barriers and interventions in energy transition. By using structured frameworks, this research provides an overview of the best and worst practices of interventions that municipalities can use to support homeowners. This research contributes to scientific knowledge in two ways. First, the research links theory to practice by converting theoretical models into practical recommendations, drawing on expert insights and experiences. This creates a connection between academic understanding and the current practice. Second, the research brings new insights into policy development as it adds valuable knowledge by creating tools for designing interventions specific to the needs and challenges of low-income homeowners. This contributes to more effective strategies for actively engaging this group in the energy transition. By combining theoretical foundations with practical applicability, this research represents an important step in the development of inclusive and effective interventions and offerings to homeowners that not only accelerate the energy transition but also contribute to an equitable and sustainable future.

## **1.9 Practical relevance**

Different communities, including different segments of the population, experience different degrees of energy poverty because of their specific characteristics (Papada & Kaliampakos, 2019). The research findings will help municipalities in their efforts to transition to natural gas-free neighborhoods and increase homeowner satisfaction. Understanding how low-income homeowners can successfully implement energy-saving measures, as well as effective communication methods, and what the municipality's governing role is in this regard, is crucial to achieving climate goals. Moreover, the findings of this study contribute to the formulation of the offer that municipalities make to (low-income) homeowners, aimed at improving the sustainability of homes nationwide and making them gas-free. By examining key challenges and policy interventions for transitioning to natural gas-free measures, this research can provide new perspectives and move policymakers to implement successful policies that motivate homeowners to phase out natural gas and transition to a sustainable energy future. Finally, the comprehensive list of measures presented in this thesis not only enhances academic understanding but also empowers municipalities to overcome barriers in natural gas-free projects.

## 1.10 Reading guide

The reading guide for this research is as follows; see Figure 6. The research is divided into 7 chapters. In the visualization below is an overview of the structure of the research with a brief description of the chapters. Each chapter ends with a conclusion relating to the sub-questions.

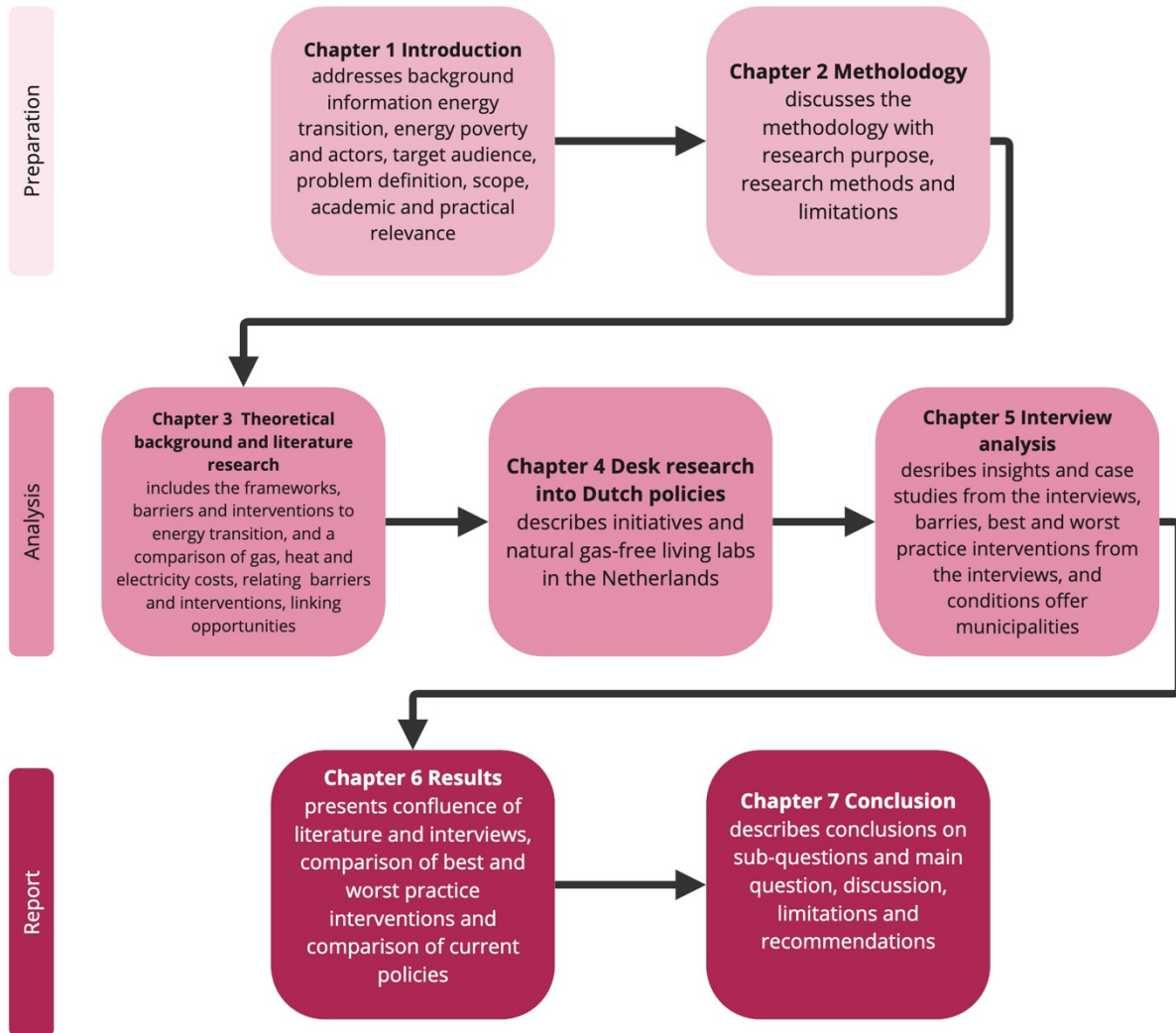


Figure 6 Reading guide

## Chapter 2 Methodology

This chapter describes the methodology of the research, which starts with the explanation and visualization of the used research methods for this research. This chapter ends with a chapter conclusion.

### 2.1 Research methods

The methodology of this research consists of four main components, each of which plays a crucial role in answering the research question. See Figure 7. First, the literature study establishes a theoretical framework by investigating existing information about barriers and interventions to transition to natural gas-free solutions. This provides a more comprehensive understanding of important elements and current policy responses. Then, expert interviews were undertaken to collect useful practical suggestions. Interviews with experts provide important perspectives by sharing their experiences and decisions on promoting natural gas-free initiatives. The insights gained from these interviews supplement the findings of the literature and provide a realistic picture of the barriers and treatments. Next, the intermediate result is the long list of measures compiled from the findings of the literature review and expert interviews. This list summarizes the main interventions that can encourage homeowners to switch to natural gas-free alternatives.



Figure 7 Research methods

#### 2.2.1 Desk research and literature review

Firstly, a literature review is done to gather knowledge on the topic. This focuses on the theory of energy poverty and phasing out natural gas, policies on this topic in the Netherlands, barriers and interventions and how they are related. Furthermore, international sources with examples from countries such as Denmark, England and Germany have also been used for this purpose as they have experience in advanced energy transition policies and may provide significant insights into renewable energy adoption. It also discusses other factors associated with energy poverty such as energy efficiency measures. The academic databases used in this study were Scopus and Google Scholar. Keywords used to find relevant articles were energy transition, natural gas-free, barriers to going natural gas-free, policy interventions natural gas-free, energy-saving technologies for homes, and renewable energy homes. The language of the articles used was Dutch and English.

#### 2.2.2 Expert interviews

The aim of the interviews is to find out how the municipality is working to create natural gas-free neighborhoods and how they experience this process. The ideal respondents are employees of municipalities and heating companies who have been involved in the creation of natural gas-free neighborhoods for residents and who have guided the participation process with residents. During April and May 2024, 10 interviews were conducted with different employees of municipalities and

heat companies. Participants for the interviews were approached by first doing online research on natural gas-free projects in the Netherlands. For this purpose, websites, news items and social media posts were viewed. Then the participants were approached by e-mail with a small introduction to the study and the question of whether they wanted to participate in the interview. In almost all cases, the interview took place online. Barriers and interventions will be further explored from the interviews and from the interviewees' experiences based on the social customer journey. The interviews are intended to enrich and expand the extensive list of best practice interventions identified through desk research.

### **2.2.3 Long list of best practice interventions**

The results of the literature review, supplemented by insights and experiences from the expert interviews, led to a comprehensive list of best practice measures that can be used to encourage the transition to a natural gas-free home. This long list of best practice measures contains a wide range of factors that can influence the transition to natural gas-free measures. By combining the theoretical findings with practical experiences from experts, a detailed overview of relevant measures and possible interventions that can be deployed to support homeowners in the transition to sustainable energy solutions emerged.

### **2.2.4 Analysis and synthesis**

Based on the long list of best practices, a process of analysis and synthesis takes place. The final output of this research includes a thorough analysis and synthesis of possible interventions based on the findings from desk research, literature studies and interviews. In doing so, it compares the findings from the various methods and current policies, including a comparison of best and worst practices. These interventions are developed into concrete and applicable best practices. These results serve as input for the presentation to RVO and NPLW and form an important basis for making the findings applicable in practice.

## **2.2 Conclusion**

This chapter describes the methodology of the research, focused on supporting low-income homeowners in the transition to natural gas-free homes. Through literature research and desk research, barriers and incentives of the transition to natural gas-free homes will be defined. Through interviews with experts, the literature and desk research findings will be evaluated and supplemented. The outcomes of these steps in the research result in a long list of interventions that municipalities can use in the transition to natural gas-free homes. Then the analysis and synthesis compare the findings, making them concrete and usable for practice.

## Chapter 3 Theoretical background and literature research

The chapter begins with a description of the frameworks used in this study. It then describes the barriers to taking energy efficiency measures, using existing literature. It then reviews gas, electricity and heat prices in the Netherlands. Then the interventions are named. The following section provides an overview of barriers and interventions based on the theoretical frameworks that emerged from the literature review. Specific considerations for low-income homeowners within these frameworks are discussed, as well as their effects on motives for making choices and Hamilton's social customer experience. Barriers are then linked to the interventions and, finally, linking opportunities (koppelkansen) in the Dutch energy transition are discussed.

### 3.1 Frameworks

This research was structured using the following frameworks: the social customer journey and the motives for making choices. The frameworks are described below.

#### 3.1.1 Social customer journey

The first framework used in this research is the customer journey (e.g. Hamilton et al. (2020)). The customer journey is a detailed marketing model that illustrates the process that a consumer goes through from their first introduction to a product or service to the final purchase, as well as the subsequent phase of customer care and loyalty, see Figure 8. The journey contains all touchpoints and interactions between the customer and the company, both online and offline. This specific model has been chosen because a thorough analysis of the customer journey can provide companies with insight into their customers' behavior and needs, allowing them to enhance the customer experience. In this thesis, the customer journey model of Hamilton et al. was chosen because of its broad applicability and scientific foundation. This model provides a systematic way of mapping customer interactions and has previously been successfully applied in similar studies. In this research, this concerns a customer journey of a low-income homeowner to a sustainable natural gas-free home. The six phases are:

- *Motivation*: There is always a reason or need that prompts the beginning of the customer journey.
- *Information search*: During this phase, the consumer looks for relevant information about a product in the surrounding environment.
- *Evaluation*: This entails interpreting and assessing the collected data.
- *Decision*: This phase is broken into two parts: making the decision to purchase or not and carrying out the purchase.
- *Satisfaction*: Using and evaluating the product after purchase.
- *Sharing*: Sharing experiences after purchase.

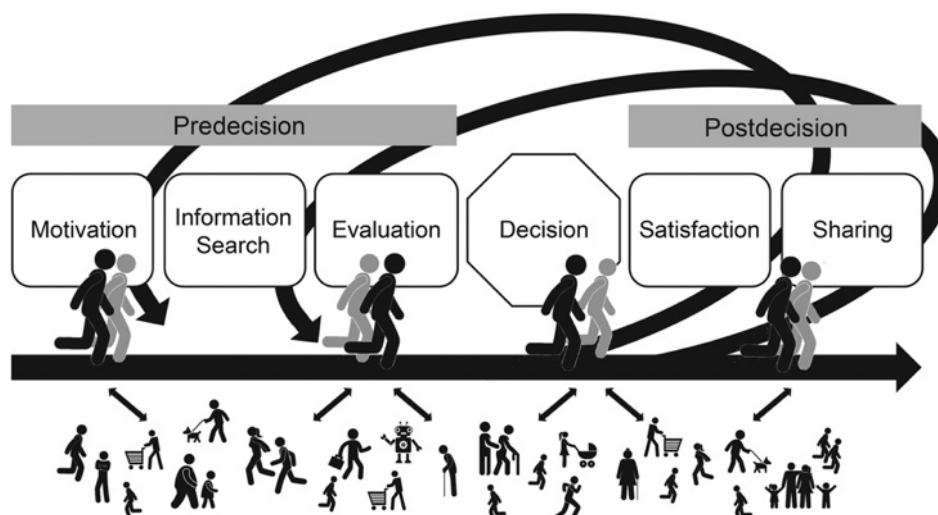


Figure 8 Social customer journey (Hamilton et al., 2020)

The customer journey is an iterative process where individuals can stop at any step, return later, or start again at a later stage. In the context of the energy transition, the customer journey can be outlined as follows:

1. The energy transition journey begins with awareness of the need for energy transition (phasing out natural gas). Growing awareness of the environmental impact of natural gas or high prices of natural gas makes people consider switching to more sustainable energy sources.
2. With the help of specialists and consultants, homeowners are looking for measures that are within their financial means and also suitable for their homes, such as sustainable heating and energy solutions that not only contribute to environmental goals but also lead to long-term cost savings.
3. Available options are compared based on various criteria.
4. The decision is made, and energy-saving measure(s) are implemented.
5. Residents live in their improved home and gain insight into the energy savings, comfort improvements, etc. Regular tracking of energy consumption and maintenance of the new systems keeps residents involved in optimizing the efficiency of their home.
6. Once residents have lived with the modifications for a while, they will share their experiences (positive or negative) with others as a final step in the customer journey.

Much research has been done on the customer journey when purchasing products. Customer journey is also an important topic within service management and design (Følstad & Kvale, 2018), as well as in the context of energy transition. Pantouvakis & Gerou (2022) additionally argue that monitoring the customer journey contributes to sustainability by stimulating service innovation and improving and optimizing resource allocation and service design. The customer journey is frequently applied in research on energy investments (Nieboer, & Straub, 2018), sustainability (Hassink, 2024) and solar panels such as the research of Sinitskaya et al. (2019), but not yet frequently in switching to a natural gas-free home.

However, TNO has developed its own customer journey model for the transition to a natural gas-free home, consisting of nine steps (Kooger et al., 2023). Although this model is similar to Hamilton's customer journey mentioned earlier and details the steps consumers go through, this research is not based on TNO's model. Understanding the customer journey helps identify barriers and facilitators at different stages, from motivation to sharing. This understanding supports the design of targeted interventions to promote the use of renewable energy. By mapping the customer journey, companies can better address consumer concerns and provide relevant information and support at each stage. This ultimately leads to higher adoption of renewable energy solutions.

Low-income homeowners may not even get beyond the first step. For many, financial constraints are the biggest obstacle, preventing them from considering such investments. Moreover, some low-income people are busy with their daily living, which prevents them from participating in the energy transition. In some cases, a lack of mental space prevents these people from thinking about climate change, let alone freeing up resources to make their homes more energy efficient. Yet it is essential to remember that people can be motivated by more than just the desire to reduce their carbon footprint. There are other reasons why people may choose energy-efficient practices; these other possible motivations are discussed below.

### 3.1.2 Motives for making choices

During the first four stages of the customer journey, people's behavior may be guided by different motives. Additional to the customer journey of Hamilton, in this research the typology of Steg et al. (2014) is used. This research distinguishes three psychological motives for environment-friendly behavior and provides a comprehensive approach to understanding and promoting pro-environmental behavior. These motives are gain (monetary savings can be realized), hedonic (higher level of comfort can be achieved) and normative (it is appropriate to contribute to better environment). Firstly, the gain motive focuses on the financial benefits, such as monetary savings from reduced energy bills or financial incentives. Second, the hedonic motive emphasizes personal comfort and satisfaction, like improved living conditions and more consistent indoor temperatures through energy-efficient measures. Lastly, the normative motive is driven by a sense of moral obligation and social responsibility, where individuals feel it is appropriate to contribute to a better environment for the greater good.

To make the motives of Steg et al. (2014) useful for this research, they were translated into the following motives. The gain motive is translated into a financial motive, the hedonic motive into a comfort motive, and the normative motive into an environmental motive, see figure 9. According to research, most homeowners combine their stated motives for interventions with their motivation to switch to energy-efficient practices (van Middelkoop, 2014).

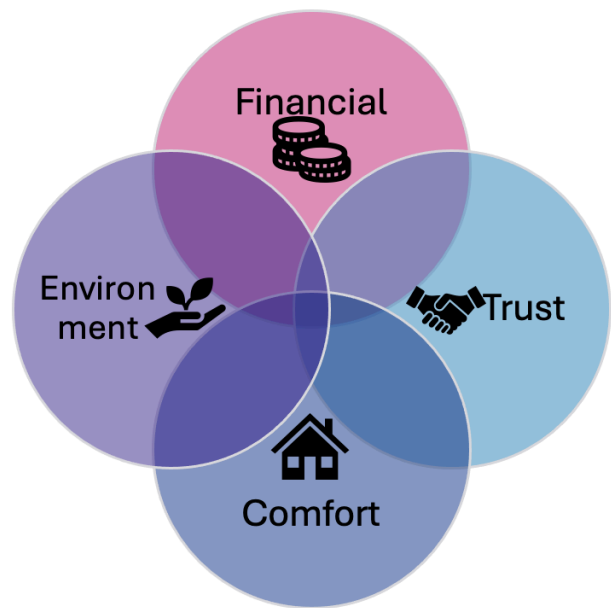


Figure 9 Motives for making sustainable choices

First, the financial motive is described. For many homeowners, especially those with low incomes, financial considerations play an important role in deciding whether to invest in energy-efficient improvements because money is often an important factor in making choices. Financial motives consist of:

- **Reducing energy costs**  
A primary financial motive of homeowners to participate in the energy transition is by investing in the energy efficient measures is to ultimately save monthly costs on energy bills (Cole et al., 2018).
- **Using financial interventions**  
Another financial motive may be that the homeowner can now make use of an intervention such as a subsidy, from for example the municipality or the government, which makes it more beneficial at a certain point to invest in energy-efficient measures in the home (Zhao et al., 2012).
- **Energy independence**  
Another financial motive for phasing out natural gas also has to do with becoming independent of gas supplies and being self-sufficient and thus protecting themselves from future price increases of natural gas by switching to renewable energy sources that have fewer fluctuating costs (Beauchampet & Walsh, 2021).
- **Increasing property value**  
Furthermore, energy-efficient upgrades and the phasing out of natural gas can significantly increase the value of the home. Studies show that homes with energy-efficient features have a greater market value, making them more appealing to potential purchasers (Zundel & Stieβ, 2011; Popescu et al., 2011).

The second motive is comfort. Comfort motives are twofold and consist of:

- **Increasing thermal comfort after renovation**  
Improving the indoor environment, particularly thermal comfort, is an important reason why many homeowners consider improvements. Thermal comfort refers to the sense of well-being that occurs when a home's temperature remains steady and pleasant (Chow, 2022). The extent to which this comfort improves following renovations can have a significant impact on how homeowners view the project's effectiveness. Performing chores to improve comfort is included, as components of indoor environmental quality, such as air quality, lighting and noise levels, are also important, although their importance varies depending on the building, occupants and even visitors. Thermal comfort is usually considered the most important component (Lai & Yik, 2009).
- **Too much hassle for phasing out natural gas**  
The second aspect of comfort motive has to do with hassle and inconvenience during renovation work, such as being out in the cold, chaos and clutter, dust nuisance, being out of work. But what also contributes to comfort motive is help filling out grant forms and help making decisions about alternative energy efficiency measures and choosing vendors. All of this has to do with hassle, upheaval and inconvenience of switching to a natural gas-free home and can count as a comfort motive for homeowners.

Third, the environment motive: homeowners are aware of the ecological footprint of their homes and want to contribute to reducing it.

- **Personal responsibility to act on environmental issues**  
For instance, environmental protection, reduced reliance on fossil fuels, and increased awareness of renewable heating technologies all inspire German homeowners to transition from fossil fuel to renewable energy (Michelsen & Madlener, 2015). Homeowners may be motivated to carry out energy-efficient renovations to reduce their impact on the environment and contribute to sustainability.

This research adds a fourth motive – trust. Interpersonal, impersonal, and professional trust play a crucial role in persuading homeowners to adopt low-carbon renovation measures and promote sustainable housing (De Wilde, 2019). Trust motives are twofold and consist of:

- **Trust in persons, organizations and technology**  
Trust is an important determinant of citizens' willingness to participate in community energy projects (Kalkbrenner & Roosen, 2015). In order to participate in the energy transition, it is crucial that homeowners have confidence in the government, municipalities, heating companies, residents, suppliers, the techniques used and those performing the renovations, as uncertainty does not promote the energy transition. Additionally, homeowners must have trust that energy-saving measures will deliver the promised savings and that contractors and energy suppliers are reliable in their work. In general, homeowners should also have trust in the technology of phasing out natural gas and see its advantage over gas (Żywiołek et al., 2022).
- **Obtaining correct information**  
A second trust factor for homeowners is receiving inconsistent/confusing information that leaves homeowners unaware of what is expected of them. In addition, some homeowners do not know if they are entitled to certain initiatives or subsidies and do not know what opportunities are available to make their home more sustainable and participate in the energy transition. With correct and consistent information from municipalities and other relevant companies and organizations, homeowners will be more likely to participate in the energy transition (Risholt & Berker, 2013).

### 3.2 Barriers to adopting to energy-efficient measures

For homeowners, especially those with low incomes, the transition to more sustainable energy systems is affected by a range of barriers and necessary interventions. Barriers are obstacles or impediments that make it difficult for people to engage in certain behaviors or achieve goals. They can be physical, social, economic, psychological, or organizational in nature. Barriers prevent homeowners from adopting renewable energy solutions. Interventions are targeted actions or measures to change or correct behavior. Interventions are necessary to support and accelerate this transition by lowering technical and financial barriers, increasing trust and awareness among residents, and contributing to the realization of sustainability and climate policy goals, see Figure 10.

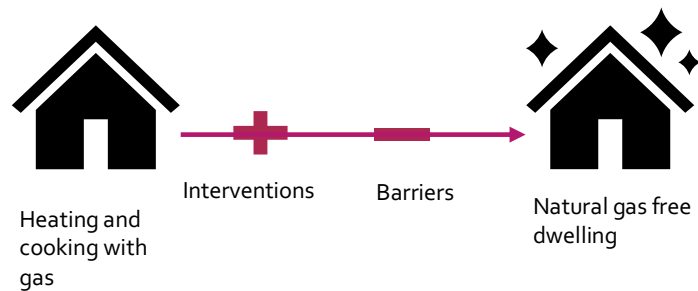


Figure 10 Barriers and incentives for transitioning to natural gas-free homes

There are various barriers to improving energy efficiency in houses. In this section these barriers to implementing energy-efficient measures for homeowners are described. Some barriers can be challenging to distinguish clearly due to overlaps with other barriers. Nevertheless, efforts have been made to categorize and differentiate them where possible. Below they are structured by motive they refer to. See table 1 for an overview.

#### 3.2.1 Financial barriers

Financing barriers, particularly for low-income homeowners, are a notable obstacle to energy efficiency adoption (Ameli & Kammen, 2012; Reames, 2016). The literature identifies several financial barriers to improving energy efficiency in residential buildings.

- According to Schleich et al. (2021), homeowners in EU countries with limited access to funds are less likely to undertake renovations. The initial investment required for energy-efficient upgrades can be challenging and intimidating, especially when access to financing is limited (Dolores et al., 2022). Financial barriers include a lack of understanding of costs and returns, high upfront costs, and limited funding schemes (Hesselink & Chappin, 2019).
- Additionally, homeowners often lack insight into financial attractiveness and affordability, and are unsure about maintenance, undermining trust in financial feasibility (Hills, 2011; Aung et al., 2022).
- Bader and Oostra (2022) argue that unmet basic needs, particularly among low-income homeowners, are a substantial impediment to improving energy efficiency in homes. This implies that addressing basic needs is critical to overcome difficulties in implementing energy-efficient solutions. Unstable energy prices and economic uncertainty also discourage the adoption of energy-efficient measures.
- In China, financial barriers to energy efficiency encompass capital costs, uneven financial strategies, unclear procedures, and rising energy expenses (Ma et al., 2022).

#### 3.2.2 Trust barriers

Mistrust in new technologies and a lack of knowledge and understanding of various energy-saving options add to the reluctance to embrace sustainable practices. Many people struggle to obtain appropriate and relevant information because they do not have the necessary resources or because they face information barriers. When there is no trust in the municipality, heat supplier and other actors, homeowners will not participate in the energy transition.

- Homeowners and tenants, as well as governments and housing associations, lack sufficient knowledge about how to utilize energy-efficient solutions (Prete et al., 2017). This underlines the importance of bridging information gaps and tailoring available information to the specific needs of those striving to change their behavior.
- Dutch local government stakeholders saw mixed public interest and financial willingness for gas-free options, with costs and citizen participation being the main barriers to the transition (Beauchampet & Walsh, 2021). This finding affects trust, because trust in government, technology and financial feasibility is crucial for the acceptance of gas-free options.
- Conflicting or unclear governance guidelines and a lack of policy coordination are major trust barriers to energy efficiency, limiting its impact on climate change, economic development, and energy security (Langlois-Bertrand et al., 2015).

### 3.2.3 Comfort barriers

A major comfort barrier is inconvenience during the work and after energy efficiency measures are implemented. Since comfort barriers are related to limited technical skills and insufficient knowledge about energy efficiency, including a lack of technological understanding to implement effective solutions, this represents another comfort barrier. Moreover, comfort and unburdening also highlight other barriers, such as the inconvenience of the process and the scarcity of time, which often prevent individuals from fully embracing sustainable solutions. Comfort barriers prevent homeowners from making informed decisions and adopting more efficient practices.

- Limited awareness and understanding of existing technologies hinder the successful implementation of energy projects. The fear of adjustments in the home and discomfort during work are also comfort barriers, as the lack of insight into physical changes in homes deters people (X. Liu et al., 2023).
- Furthermore, the absence of electronic infrastructure and deferred maintenance in the home makes necessary updates more difficult. Low-income homeowners face significant challenges in energy efficiency and justice, with lower participation in programs, fewer energy efficiency appliances, and inflexible schedules (Xu & Chen, 2019). This concerns comfort because homeowners may face a longer and more intensive renovation period, which may affect the comfort of the residents.
- In Sweden, homeowners hesitate to adopt energy efficiency measures due to satisfaction with the existing components and economic factors (Nair et al., 2010).
- Lastly, the rebound effect is a barrier, in which predicted energy savings are offset by increased use, is a common problem that diminishes the benefits of efficiency increases (Coynes et al., 2018).

### 3.2.4 Environment barriers

According to the literature, many people do not experience the environment as a barrier in energy transition because people are not concerned with this motive. Of all the motives listed, the environment will be the least important motive for barriers to adopting energy efficiency measures. This is mainly because low-income people are often unaware of the need for energy transition.

However, the alternative heat source plays a crucial role in determining its environmental impact and sustainability. For example, natural gas is neither environmentally friendly nor sustainable due to its contribution to carbon emissions and limited availability. Industrial residual heat (waste heat) can be considered environmentally friendly because it involves reusing existing heat, thereby reducing waste. However, it is not sustainable in the long term, as industries may choose to terminate contracts or relocate, leaving residents without a reliable source of heat. Aquatherm, on the other hand, is both environmentally friendly and sustainable. It harnesses heat from water sources in a way that is non-exhaustive and renewable, ensuring long-term reliability without depleting natural resources.

Table 1 Barriers to adopting energy-efficient measures

Barriers	Financial	Trust	Comfort	Environment
<i>Motivation</i>	<ul style="list-style-type: none"> <li>- Little insight into energy costs</li> <li>- Lack of awareness of energy consumption and savings</li> <li>- Lacking understanding of costs and returns</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of engagement and motivation</li> <li>- Lack of trust in new technologies</li> <li>- Insufficient knowledge about energy-efficient solutions</li> </ul>	<ul style="list-style-type: none"> <li>- Insufficient knowledge about energy efficiency</li> <li>- Limited technological knowledge</li> <li>- Limited technical skills</li> <li>- No need to modify home, mess and hassle</li> </ul>	
<i>Information search</i>	<ul style="list-style-type: none"> <li>- High complexity</li> <li>- Uncertainty about cost savings</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of information and resources about available energy-saving measures</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of information about sustainable energy sources</li> <li>- Overdue maintenance and lack of electronic infrastructure at home</li> </ul>	
<i>Evaluation</i>	<ul style="list-style-type: none"> <li>- Unbalanced financial plans</li> <li>- Limited access to financing for energy-saving measures</li> </ul>	<ul style="list-style-type: none"> <li>- Regulatory barriers such as bureaucratic procedures</li> <li>- Inadequate information about measures</li> </ul>	<ul style="list-style-type: none"> <li>- Uncertainty about supplier reliability</li> </ul>	<p>No specific barriers identified. Environment is the least prioritized motive, especially among low-income homeowners. Also does not appear in the customer journey.</p>
<i>Decision</i>	<ul style="list-style-type: none"> <li>- Political uncertainty</li> <li>- Unstable energy prices and economic uncertainty</li> <li>- High initial costs of energy-efficient technologies</li> </ul>	<ul style="list-style-type: none"> <li>- Inadequate support from governments and policymakers</li> <li>- Distrust in new technologies</li> </ul>		
<i>Satisfaction</i>			<ul style="list-style-type: none"> <li>- Rebound effect that reduces energy efficiency benefits</li> <li>- Sometimes little to no insight into physical changes in homes</li> </ul>	
<i>Sharing</i>			<ul style="list-style-type: none"> <li>- Insufficient knowledge on how to apply the new energy efficiency measures</li> <li>- Unwanted side effects of the measures</li> </ul>	
<i>Specific for low-income homeowners</i>	<ul style="list-style-type: none"> <li>- Financial restrictions</li> <li>- Political instability</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of knowledge</li> <li>- No trust in government</li> </ul>	<ul style="list-style-type: none"> <li>- Difficulty fulfilling basic needs</li> </ul>	

### 3.2.5 Barriers specific for low-income homeowners

Low-income residents face challenges in improving their homes' energy performance due to their struggle to satisfy basic demands. Financial constraints are the major barrier to these homeowners adopting energy-efficient lifestyles and engaging in efficiency programs (Azimi et al., 2023). Furthermore, inadequate institutional capacity and policy fragmentation hinder successful efforts to combat energy poverty (Murshed & Öztürk, 2023). The lack of understanding worsens the situation (Hasheminasab et al., 2023). These characteristics, combined, make it more difficult for low-income homeowners to benefit from energy-saving improvements.

### 3.2.6 Barriers related to the customer journey from the literature

For low-income homeowners, several barriers may develop during Hamilton's customer journey that prevent progress in energy transition projects. During the motivation phase, lack of awareness, high initial costs of energy-saving technologies, limited access to financing, and economic uncertainty (Schleich et al., 2021; Hills, 2011) can discourage homeowners from considering renewable energy solutions. During the information phase, lack of information and resources on available energy-saving measures and regulatory obstacles (Prete et al., 2017; Gonzalez-Arcos et al., 2021) are major barriers. In the evaluation phase, no desire for hassle and mess during the work, uncertainty about the reliability of the supplier and limited technical skills (Coyne et al., 2018; Ma et al., 2022) can deter homeowners from making informed decisions. During the decision phase, financial constraints are important factors that complicate the final decision and purchase (Bader & Oostra, 2022; Azimi et al., 2023). Decision-making is additionally shaped by factors such as gender, age, education level, and building type (Ma et al., 2022). These obstacles differ across demographic groups, with younger individuals expressing interest but frequently facing cost impediments (Balcombe et al., 2013). In the satisfaction phase, a lack of understanding of the physical changes and rebound effects may reduce the benefits of energy conservation, leading to less satisfaction (Nair et al., 2010). Finally, during the sharing phase, experiences with unwanted side effects and insufficient knowledge may limit the spread of positive experiences.

## 3.3 Gas, heat and electricity prices in the Netherlands

In the Netherlands, gas, heat and electricity prices are structured differently. Gas prices are heavily influenced by variable usage costs and taxes, whereas city heating costs are more centralized around broad costs, with less additional taxes. Understanding this distinction is critical for homeowners, especially when it comes to energy efficiency, costs, and the transition to natural gas-free. Price comparisons between gas, heat and electricity influence choices for renewable systems and encourage the transition to energy efficiency and natural gas-free solutions. Table 2 below compares the cost structure for gas, heat and electricity in the Netherlands.

### 3.3.1 Price structures

#### 3.3.1.1 Gas

The gas rates differ. Gas prices have increased dramatically since October 2021. This is partially related to the ongoing war between Russia and Ukraine. Price caps exist in 2023, prices started rising about halfway through the year, but there are none beyond 2024. For gas, prices vary depending on the supplier (ANWB, 2024). The price of gas in the Netherlands includes delivery expenses, network costs, taxes and charges, and meter fees. Gas delivery expenses include both fixed and variable prices. The fixed delivery rates are applied monthly, regardless of gas consumption. These cover administrative and service expenses. Variable delivery prices are calculated per cubic meter (m<sup>3</sup>) of gas consumed. The price per m<sup>3</sup> varies based on gas source and market prices. Next, the network costs include transit and connection fees. Transportation expenses are the costs of moving gas across the national and regional gas networks, whereas connection charges are the price of connecting a residence to the gas network. Furthermore, taxes and levies include the energy tax, and VAT. The energy tax is a government-imposed charge on gas usage that promotes sustainability. Finally, meter costs include the costs of operating and maintaining the gas meter. There is also a region surcharge, profit and risk margin (ANWB, 2024).

Table 2 Cost structure for gas, heat and electricity in the Netherlands

<b>Costs</b>	<b>Gas</b>	<b>Heat</b>	<b>Electricity</b>
<b>Delivery costs</b>			
<i>Fixed costs</i>	Monthly fixed costs	Monthly fixed costs	Monthly fixed costs
<i>Variable costs</i>	Costs per cubic meter (m <sup>3</sup> ) used gas	Costs per gigajoule (GJ) used heat	Cost per kilowatt hour (kWh) used electricity
<b>Network costs</b>			
<i>Transport costs</i>	Monthly transportation costs	Included in fixed costs	Monthly transportation costs
<i>Connection costs</i>	Monthly connections costs	Included in fixed costs	One-off connection costs
<b>Taxes and charges</b>			
<i>Energy tax</i>	Charges per cubic meter (m <sup>3</sup> ) used gas	Does not apply	Charges per kilowatt hour (kWh) used electricity
VAT	21% tax on the overall cost of gas supply	21% tax on the overall cost of heat supply	21% tax on the overall cost of electricity supply
<b>Meter- and service costs</b>			
<i>Meter costs</i>	Monthly costs for meter maintenance	Included in fixed costs	Monthly costs for meter maintenance
<i>Service costs</i>	Not mentioned	Included in fixed costs	Not mentioned
<b>Additional</b>	Region surcharge, profit, and risk	Does not apply	Gas correction factor

### 3.3.1.2 Heat

Heat prices in the Netherlands are structured differently, with the following components: fixed costs, variable costs, and taxes and levies. The Authority Consumer and Market (ACM) sets both the consumption tariff and the fixed tariffs (HVC Groep, 2023). Fixed costs for heat include the charges for meter rental, delivery set rental, the standing charge regardless of consumption and the connection costs. The variable expenses include consumption charges, depending on the amount of heat purchased, which are the cost per gigajoule (GJ) of heat utilized. These expenses vary according to the heat source and contract terms. The taxes and charges include VAT, which is a 21% tax on the overall cost of heat supply. There is no energy tax imposed on district heating, but they are capped by ACM. Maintenance and service charges are the costs of maintaining and servicing the heating system, which are frequently included in the fixed costs (WarmteStad, 2023).

### 3.3.1.3 Electricity

Energy costs are structured as follows and similar to the structure of gas prices. The price of electricity in the Netherlands includes delivery costs, network costs, taxes and levies, and meter costs. As with gas, delivery costs for electricity include both fixed and variable prices and work the same as gas: fixed delivery charges are applied monthly and variable delivery charges are calculated per kilowatt hour (kWh) of electricity consumed. Furthermore, the costs include network charges, energy tax and VAT, and service charges. Additionally, the gas correction factor adjusts the energy bill for differences in calorific value and temperature (Milieu Centraal, 2024). An important item in electricity costs is the energy tax reduction. This fixed amount is set annually and automatically reduces energy bills (Belastingdienst, 2024).

### 3.3.1.4 Price disparities

The price disparities between gas, heat and electricity are difficult to compare due to variables such as market prices, (energy) taxes, network expenses, and seasonal variations. These factors heavily influence gas and electricity prices, whereas fixed and variable supply costs and VAT mostly influence heat prices. The price differences between gas and electric are also related to regulation and government intervention, the national energy production mix, market speculation, environmental costs, currency, disruptions and weather conditions (Koenraadt, 2024). There are different types of energy contracts in the Netherlands: fixed, variable, or dynamic (Milieu Centraal, 2024), which also

affects the price people pay. Prices in January 2024 were calculated based on an average annual use of 1112 m<sup>3</sup> of gas and 1880 kWh of electricity (as projected by the Netherlands Environmental Assessment Agency). The average annual gas consumption was €1,867, while the average annual electricity consumption was €1,128 (CBS, 2024). There are no concrete sources for the costs of heat.

The current Heat Act states that heat tariffs are linked to gas prices. Each year, the ACM sets a maximum heat tariff based on the gas tariff for the following year. Because people typically do not have a choice of heat provider, which can lead to unreasonable prices. ACM protects consumers in this way. Suppliers may not charge more than these amounts (Acm, 2024). At a heat rate, consumers would never pay more than gas users. This is also known as the "no more than usual" principle (De Jong, 2024). The ACM has established laws to govern heating networks and protect consumers' interests. These laws include establishing maximum heat supply rates, assuring rate and contract transparency, barring customer discrimination, establishing complaint processing criteria, and monitoring the market, with enforcement as needed. All of this is designed to ensure fair competition and reasonable prices for consumers (Acm, 2024). The new Heat Act rates may be based on the supplier's own costs and limit the increase in fixed costs (Acm-Consuwijzer, 2023), as recent reports from Amsterdam, Rotterdam and Utrecht show that the principle is not always the case in practice. In these cities, tenants are connected to the heat grid and have to pay high costs afterwards, much higher than gas, which were not indicated beforehand, because the standing charge for heat is much higher than for gas and that it is still tied to gas. So, they pay much more than gas users. Amsterdam corporations will no longer connect homes to district heating for the time being after the price for heat became too high for tenants following an increase from the energy company (NOS, 2024), which is not motivating for other corporations, municipalities and homeowners. Because of the excessive costs, the city of Utrecht therefore wants to build its own heat networks (NOS, 2024).

#### 3.3.1.5 Further costs

This paragraph provides a brief outline of other costs. Most households in the Netherlands are connected to the gas network. In most cases, homeowners pay an energy bill for electricity and gas. The connection costs to a house for a new connection to the heating network are one-off and a maximum of €5.250 (Acm-Consuwijzer, 2024). From February 1, 2024, homeowners can have their gas connections disconnected for free. This project was implemented to help with the transition to natural gas-free homeowners and to remove unused gas pipes, which constitute a safety risk and was created in partnership with ACM and energy suppliers. If the removal must take place on a date other than the one stated by the grid operator, the consumer will incur additional fees. Furthermore, in the case of all-electric, costs also must be incurred for purchasing the heat pump. The costs for a hybrid heat pump with boiler are between € 15.000 and € 18.000. The costs for a heat pump are between €5.000 and €6.000, while the costs for a central heating boiler are between € 1.500 and € 2.500 (Stichting Duurzaam Berkum et al., 2023). Finally, costs must also be charged for insulating the house and switching to induction cooking, which for example sometimes also requires the purchase of new pans and cooking appliance (Gemeente Groningen et al., 2022). Switching to natural gas-free systems requires large upfront investments, which can be especially difficult for low-income homes. The lack of immediate rewards on investment can be discouraging for them, making the transition even more challenging.

As stated above, the heat price expenses vary according to the heat source and contract terms and on top of that the monthly costs are partly dependent on usage and energy suppliers. Energy suppliers must adhere to the maximum rate set by the ACM, but many of the energy suppliers remain below the previously established price ceiling. Yet there are differences in the costs of energy suppliers. Most heat suppliers charge prices in a specific range, as imposed by the ACM. Other energy suppliers provide variable rates and discounts based on heat source and contract terms. For example, Eneco offers a variety of contracts for district heating and geothermal energy, with rates ranging based on

the options chosen (Eneco, 2023b). Vattenfall, another major player, provides a range of heating prices depending on location and type of connection (Vattenfall, 2024).

### **3.4 Interventions to adopting energy efficient measures from literature**

In this section interventions for adopting to energy-efficient measures for homeowners are described. Improving energy efficiency in houses requires a variety of interventions that meet a variety of issues such as financial, trust, comfort, and environmental concerns. Some interventions can be challenging to distinguish clearly due to overlaps with other interventions. Nevertheless, efforts have been made to categorize and differentiate them where possible. An overview of these interventions is provided in table 3 for clarity and reference.

#### **3.4.1 Financial interventions**

According to the study by De Koning et al. (2020), financial interventions are the most important for homeowners. These interventions can address the biggest concerns about cost, savings, reliability and the environment, and help ensure that homeowners participate in the transition to natural gas-free by choosing energy-efficient measures. Financial interventions can reduce the high initial cost of energy-saving measures, making these homeowners more likely to participate in the energy transition.

- Financial assistance, including grants, tax breaks, and low-interest loans, is crucial for enabling low-income homeowners to transition to gas-free living (Neuhoff et al., 2011; García-Quevedo & Jové-Llopis, 2021; Liberalesso et al., 2020; Jacobsen, 2024). Grants and subsidies provide direct support for vulnerable groups, while tax rebates and utility benefits help reduce financial constraints (Schleich et al., 2021).
- In addition to financing renovations, subsidies should also support non-energy measures to simplify the process for homeowners, such as assistance with permits, group purchases, and cost management (Brown et al., 2019; Onencan et al., 2024). For social housing tenants, interventions like on-bill financing and subsidized energy-saving measures, including free light bulbs and insulation, can enhance energy efficiency and address energy poverty (Bird & Hernández, 2012; Miniaci et al., 2014).
- Municipalities play a vital role by facilitating group purchases, offering financial incentives, and expediting procedures (EHPA, 2023). Highlighting the financial and environmental benefits of energy retrofits, such as cost savings and reduced carbon emissions, further motivates participation.

#### **3.4.2 Trust interventions**

When it comes to implementing sustainable measures, trust interventions are very important. Increasing trust in parties such as the municipality and the heat supply companies will encourage more people to switch to energy-efficient measures.

- Building trust is very important for successful energy transition initiatives. Interventions such as neighborhood transition plans, knowledge desks, and public awareness campaigns are essential for informing and engaging residents (Berman et al., 2015). Furthermore, trust in municipalities, suppliers, and technology significantly impacts attitudes toward natural gas-free living, with perceived behavioral control, subjective norms, and environmental concern playing key roles (Prete et al., 2017). Also, transparency, clear objectives, and consistent communication further strengthen public confidence (Jansma et al., 2020; Abrahamse et al., 2007).
- Regulatory measures such as building codes and energy efficiency laws also enhance trust by promoting compliance and fostering trust in technology and suppliers (Liu et al., 2020). Financial incentives paired with targeted marketing campaigns have been shown to drive adoption of energy-efficient technologies, as evidenced by Sweden's success with district heating systems (Mahapatra & Gustavsson, 2009).

- Social interventions, including peer success stories and community-driven projects, foster collaboration, a sense of ownership, and collective accountability for environmental care (TNO, 2022). Strong political commitment and alignment between centralized and decentralized policies are critical for low-carbon governance, as demonstrated in Croatia and other European countries (Bukarica & Robić, 2013; Sarrica et al., 2018).
- Pilot programs such as the Dutch PAW neighborhoods show how government-funded projects can take the lead in the transition to natural gas-free communities (Ministerie van Algemene Zaken, 2024). In both the Netherlands and the United Kingdom, municipal regulations with clear deadlines encourage homeowners to choose alternative solutions by providing information, financial support and inspiration of successful retrofits (Yale360, 2020; Bobrova et al., 2021).

### 3.4.3 Comfort interventions

Improving home comfort is a key focus of energy transition interventions. Combining retrofit and behavior change interventions is more effective than either method alone in reducing the energy consumption of low-income homeowners (James & Ambrose, 2017). The literature highlights the role of energy coaches, fixers and advisors in supporting sustainability efforts and the transition to gas-free living. A systematic approach to selecting and identifying the best retrofit options for existing buildings is crucial for promoting energy conservation and sustainability (Ma et al., 2012).

- Governments and housing organizations can encourage energy-efficient practices through a variety of efforts, such as offering energy coaches, energy fixers, and other resident assistance. Making homeowners aware of the risks connected with poor housing conditions empowers them to advocate for their rights and seek assistance, fostering accountability among homeowners, landlords, and legislators.
- Municipal assistance is crucial for coordinating local initiatives and maintaining sustainable energy systems, including financial and procedural interventions (Inenergie, 2023). Municipalities should promote local efforts to close the distance between government agencies and homeowners, resulting in a smoother transition to sustainable living (Project GRETA, 2023). Professionals can help homeowners hire installers and manage renovation projects. Energy coaches give technical assistance that is critical for transitioning to gas-free households.
- Additionally, even if energy-efficient solutions do not produce the predicted economic gains, homeowners can benefit from enhanced comfort (Aranda et al., 2017). As a result, it is critical to make energy efficiency relevant and accessible by emphasizing personal responsibility and offering clear, tangible solutions.
- Free consultations on energy savings and home renovations can help homeowners determine the best plans to increase their homes' efficiency.

### 3.4.4 Environment interventions

In contrast to being a barrier, the environment is actually an intervention for homeowners.

- Previous research has shown that homeowners' environmental concerns positively influence their willingness to adopt energy-efficient measures (Broers et al., 2019). According to Asadi et al. (2012), retrofitting dwellings are driven by sustainability concerns but also by the desire to increase energy efficiency and indoor environmental quality.
- People get more interested in improving their energy behaviors as they learn knowledge and are given solutions, but their level of awareness remains low (Gaspari et al., 2021). To make the need clear, interventions aimed at raising awareness of switching to sustainable energy include setting up a public awareness campaign and a knowledge desk in the neighborhood where residents can obtain information for free and easily, thereby reducing the step in making a choice, even though this also has to do with trust (Milieu Centraal, 2023).

- Through environmental certifications and ratings, the environmental performance of products, services and organizations can be more easily assessed, helping consumers make environmentally friendly decisions (RVO, 2022).
- Finally, local needs and greater support can be gained through civic engagement programs involving local people, for example, in environmental policies and projects (RVO, 2022).

#### 3.4.5 Interventions specific for low-income homeowners

Low-income homeowners benefit most from well-planned and high-impact interventions (Stern et al., 1986). Deep energy renovation for vulnerable homeowners is driven by health, quality of life, financial considerations, legal mandates, stakeholder trust and communication (Tozer et al., 2023). For these homeowners, environmental benefits are often less important compared to financial, trust and comfort interventions. The main motivators for low-income homeowners to embrace natural gas-free alternatives are thermal comfort and monthly income (Vilches et al., 2017). Low-income homeowners in the EU are less likely to adopt expensive energy-efficient technologies, making targeted policies more effective (Schleich, 2019). McAndrew et al. (2021) found that using a variety of strategies and activities enhances the likelihood of effective interventions. Furthermore, tailored feedback and interactive awareness programs have been showed to boost energy efficiency in low-income households (Podgornik et al., 2016). Bird and Hernández (2012) demonstrated the effectiveness of well-designed incentive programs and utility-administered on-bill financing in increasing energy efficiency and reducing energy poverty among low-income homeowners in the United States.

#### 3.4.6 Interventions related to the customer journey from the literature

Hamilton's customer journey model can be well related to the various interventions mentioned in the literature. At each phase of the customer journey, different interventions can be implemented for low-income homeowners. During the motivation phase, financial interventions such as subsidies, low-interest loans, and group purchases (Schleich et al., 2021) can be effective in attracting and stimulating customers' interest, as well as encouraging customers to consider renewable energy solutions (Bird & Hernández, 2012; Jacobsen, 2024). During the information search phase, trust and comfort are important. Interventions such as energy coaches, energy advisors, and energy conservation advice (Ma et al., 2021; Bobrova et al., 2021) can assist customers in making informed decisions while also making them feel supported. Additionally, trust interventions, while creating trust in people and organizations and providing information such as awareness campaigns and education about renewable energy (Gonzalez-Arcos et al., 2021; Prete et al., 2017) help inform the homeowner and build trust. In the evaluation phase, energy coaches and building codes (Aranda et al., 2017; Coyne et al., 2018) help customers assess options. Interventions such as permit application assistance and municipal financial support (Ebrahimigharehbaghi, 2022) during the decision phase enable easy implementation and post-purchase satisfaction, resulting in a pleasant customer experience and long-term customer relationships. Additionally, financial assistance and measures for low-income homeowners (Vilches et al., 2017; Tozer et al., 2023) can convince the homeowner to make the purchase. There are not any real interventions aimed at the satisfaction phase. Finally, interventions such as technical assistance and regular communication (Abrahamse et al., 2007; Jansma et al., 2020) in the sharing phase ensure a positive user experience and customer satisfaction. Interventions for the sharing phase include sharing the experiences of homeowners who have already implemented the measures, such as ambassadors.

Table 3 Interventions for energy renovation from the literature

<i>Interventions</i>	<i>Financial</i>	<i>Trust</i>	<i>Comfort</i>	<i>Environment</i>
<i>Motivation</i>	<b>Subsidies</b> <ul style="list-style-type: none"> <li>- Subsidies</li> <li>- Free/subsidized measures</li> </ul> <b>Loans</b> <ul style="list-style-type: none"> <li>- Sustainability/ low-interest loans</li> </ul> <b>Discounts</b> <ul style="list-style-type: none"> <li>- Vouchers</li> <li>- Group purchases</li> <li>- Tax incentives</li> <li>- Free energy-saving resources</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Public awareness campaign</li> </ul> <b>Information and advice</b> <ul style="list-style-type: none"> <li>- Knowledge desk</li> <li>- Information campaigns</li> <li>- Pilot programs</li> <li>- Energy-efficiency programs</li> </ul> <b>Communication</b> <ul style="list-style-type: none"> <li>- Clear gas end date in neighborhood</li> <li>- Regulatory and legislative actions to encourage energy transition</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Free advice on energy savings and renovation</li> </ul> <b>Information and advice</b> <ul style="list-style-type: none"> <li>- Energy coaches</li> <li>- Energy fixers</li> <li>- Energy advisors</li> </ul> <b>Support</b> <ul style="list-style-type: none"> <li>- Support for local initiatives</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Information on environmental benefits</li> <li>- Public awareness campaigns</li> </ul> <b>Participation</b> <ul style="list-style-type: none"> <li>- Neighborhood activities to increase awareness</li> <li>- Emphasizing individual responsibility</li> <li>- Social norms</li> </ul>
<i>Information search</i>	<b>Financial assistance</b> <ul style="list-style-type: none"> <li>- Municipal financial support</li> <li>- Tax breaks and benefits</li> </ul> <b>Information</b> <ul style="list-style-type: none"> <li>- Financial knowledge desk</li> <li>- Financial advisory services</li> <li>- Insight in end-user expenses</li> </ul>	<b>Information and advice</b> <ul style="list-style-type: none"> <li>- Energy coaches and guidance</li> <li>- Community meetings</li> </ul> <b>Education</b> <ul style="list-style-type: none"> <li>- Education on sustainable energy</li> <li>- Incentive programs</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Awareness of risks</li> </ul> <b>Information and advice</b> <ul style="list-style-type: none"> <li>- Free advice on energy savings</li> <li>- Free advice on renovation</li> <li>- Technical assistance programs</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Information on environmental benefits</li> </ul>
<i>Evaluation</i>	<b>Financial assistance and information</b> <ul style="list-style-type: none"> <li>- Help with permit acquisition</li> <li>- Insight in end-user expenses</li> <li>- Group purchasing</li> <li>- Provide practical information regarding costs and feasibility</li> </ul> <b>Communication</b> <ul style="list-style-type: none"> <li>- Be clear of who will pay the costs of transition and feasibility</li> </ul>	<b>Participation</b> <ul style="list-style-type: none"> <li>- Community involvement</li> <li>- Housing association as a booster</li> </ul> <b>Communication</b> <ul style="list-style-type: none"> <li>- Consistent communication</li> <li>- Concrete plans and good communication are needed for everyone involved</li> </ul>	<b>Norms</b> <ul style="list-style-type: none"> <li>- Energy efficiency standards</li> <li>- Building codes</li> <li>- Sustainable energy policies</li> <li>- Combining interventions</li> <li>- Customized consumption feedback</li> </ul>	<b>Norms</b> <ul style="list-style-type: none"> <li>- Environmental certifications</li> </ul>
<i>Decision</i>	<b>Financial assistance</b> <ul style="list-style-type: none"> <li>- Affordable financing options</li> </ul>	<b>Communication</b> <ul style="list-style-type: none"> <li>- Clear deadlines from the government/municipality to switch away from gas</li> <li>- Housing association as a booster</li> <li>- Transparency and accessibility</li> <li>- Continuous support and maintenance services</li> </ul>	<b>Comfort assistance</b> <ul style="list-style-type: none"> <li>- Targeted policies</li> </ul>	
<i>Satisfaction</i>				
<i>Sharing</i>	<b>Financial assistance</b> <ul style="list-style-type: none"> <li>- Financial incentives for referrals</li> </ul>	<b>Communication</b> <ul style="list-style-type: none"> <li>- Peer success stories</li> <li>- Feedback mechanisms</li> </ul>	<b>Norms</b> <ul style="list-style-type: none"> <li>- Comfort and usability assessments</li> </ul>	<b>Participation</b> <ul style="list-style-type: none"> <li>- Community engagement programs</li> </ul>
<i>Specific for low-income homeowners</i>	<ul style="list-style-type: none"> <li>- Combining multiple interventions</li> <li>- Customized incentive programs</li> <li>- Financial assistance</li> </ul>	<ul style="list-style-type: none"> <li>- Health considerations</li> <li>- Government support</li> </ul>	<ul style="list-style-type: none"> <li>- Increasing thermal comfort</li> <li>- Customized consumption feedback</li> <li>- Support for retrofitting measures</li> </ul>	<ul style="list-style-type: none"> <li>- Interactive awareness campaigns</li> </ul>

### 3.5 Relating barriers to interventions in energy transition

Several barriers and interventions in energy transition have been identified from the literature. This section relates the barriers and interventions to each other, with the goal of providing insight into how municipalities can effectively address low-income homeowners' challenges.

Table 4 below provides an overview linking some of the most common and significant barriers for homeowners to specific interventions. For the financial motive, barriers such as limited access to financing and uncertainty about cost savings can be reduced through grants, loans, rebates and clear communication about costs and feasibility. Comfort-related motives as barriers, such as overdue maintenance or lack of knowledge, can be addressed with tailored support, such as maintenance services, model homes, energy coaches and technical assistance programs. The trust motive has barriers, such as uncertainty about municipal and supplier reliability, engagement and motivation, and lack of trust. Interventions to increase trust in the project include public awareness campaigns, peer success stories and community activities that promote trust, cohesion and active participation by residents.

These interventions can be used by municipalities to alleviate barriers and increase the likelihood of participation in the energy transition. Examples include financial support measures for high investment costs, information campaigns to reduce technical unfamiliarity, and neighborhood-oriented support to promote trust and social cohesion. In addition, it is important to note that many interventions do not exclusively target one specific barrier. They can simultaneously help solve multiple problems, creating a more integrated approach. This makes interventions such as grant programs, transparent communication and collaborative neighborhood initiatives valuable in creating support and achieving a successful energy transition.

Table 4 Relating barriers to interventions

	Barriers	Interventions
Financial	Limited access to financing for energy-saving measures	- Subsidies - Loans
	Uncertainty about cost savings	- Discounts - Clear insight into end-user expenses - Practical information on costs and feasibility through workshops, brochures, or online tools
Trust	Uncertainty about the municipalities or government's reliability	- Transparent and consistent communication about goals, timelines, and responsibilities - Clear and binding deadlines for phasing out natural gas
	Distrust/ uncertainty about supplier reliability	- Rate guarantee
	Lack of engagement and motivation among residents	- Public awareness campaigns - Neighborhood activities - Peer success stories, ambassadors - Community engagement programs
Comfort	Social resistance or lack of trust between community and stakeholders	- Neighborhood activities to build social cohesion - Regular town hall meetings to address concerns and share updates
	Lack of electronic infrastructure at home and no insight into physical changes in homes	- Continuous support and maintenance services - Model homes
	Lack of knowledge/information of energy consumption and savings and resources about available energy-saving measures	- Energy coaches and guidance - Knowledge desks for personalized advice - Free workshops on energy-saving strategies - Technical assistance programs

### 3.6 Linking opportunities in Dutch energy transition

A successful energy transition requires tackling multiple tasks. This not only saves money, but also decreases inconvenience and suffering for residents, resulting in better outcomes (Vervloesem et al., 2022). By connecting one solution to multiple issues, governments and energy cooperatives can respond more effectively to the various concerns inside communities, increasing residents' willingness to engage in the energy transition.

An important aspect of this approach is the use of linking opportunities. For example, in some neighborhoods, the replacement of the sewage can serve as a reason for the construction of a heating network. Because the streets must be opened for the sewer replacement, the construction of the heating network is carried out more efficiently, which reduces inconvenience for residents. In addition, neighborhood renewal can go hand in hand with energy measures, such as the redesign of streets to make room for sustainable infrastructure.

Improving public space plays a crucial role in promoting the energy transition. The construction of cycle paths and footpaths, more greenery and climate-adaptive infrastructure, and natural water storage are examples of measures that not only improve the living environment but also contribute to sustainable energy solutions. This has no effect on energy bills, but an improved neighborhood does contribute to higher home values and a more pleasant feeling in the neighborhood. In addition, accessibility by public transport can be improved, which reduces dependence on fossil fuels and optimizes mobility within the neighborhood. This way, the energy transition can be integrated with alternative energy sources, sustainable home renovation and the creation of new forms of employment. Sustainable mobility goes beyond just the construction of other traffic infrastructures; it also includes the redevelopment of public space, the creation of a better and healthier living environment, and the construction of safe, accessible and child-friendly streets (Vervloesem et al., 2022).

Baart's (2019) research shows that the energy transition can offer not only sustainable, but also social benefits. By exploiting linking opportunities, such as neighborhood involvement, community building and life-course-proof living, projects can contribute to social cohesion and health. In addition, the energy transition offers opportunities to tackle poverty, unemployment and 'behind-the-front-door problems', such as loneliness. Training and employment programs linked to these projects strengthen this impact and make the energy transition a driver for social progress.

Another important strategy is cooperation with other municipalities and housing associations. Large industries with a lot of residual heat can serve multiple municipalities, as can aquathermal solutions that provide sustainable heat. These collaborations increase the efficiency and scalability of sustainable energy projects, reducing costs and increasing impact.

Finally, creating employment within the energy transition offers a double win. Participants are trained by experienced instructors in sectors such as construction, healthcare and services, technology, transport and logistics, which not only supports the energy transition but also strengthens the local economy (TNO, 2023; Van Der Kolk, 2023). This means that residents are actively involved in the drastic changes in their neighborhood while paying attention to social issues. By linking the energy transition to social improvements, the transition is not seen as an external threat but as part of an integrated neighborhood approach aimed at improving the quality of housing and the living environment (Kranenborg, 2023). By placing diversity and freedom of choice at the center of the policy vision, projects can respond flexibly to the diverse needs of residents. This not only increases participation but also ensures that the energy transition is broadly supported and sustainably anchored in the community.

The advantage of the above linkage opportunities for low-income homeowners is that these opportunities offer significant benefits through bringing financial support for sustainability measures, providing access to expertise and creating a more comfortable living environment. Collaborations with municipalities, energy cooperatives and other organizations make sustainability more affordable and help homeowners. In addition, such projects strengthen social cohesion in neighborhoods and contribute to the sustainable valuation of homes, which also benefits low-income residents in the long run.

### **3.7 Conclusion**

This chapter starts with explaining the two frameworks used, which are Hamilton's social journey and motives for making choices by Steg et al. This chapter further examined the barriers and interventions for low-income homeowners to implement energy efficiency measures and move to natural gas-free living.

This chapter seeks answers to sub-questions 1 and 2. Answering sub-question 1, which was posed to gain insight into the barriers that homeowners experience when phasing out natural gas. The literature review states that homeowners with low income face problems such as high initial costs, lack of understanding and complex information about the energy transition. Structural problems such as aging homes with overdue maintenance and prioritizing immediate needs are barriers, as are high repair prices and start-up costs, lack of knowledge of interventions and cumbersome procedures.

Sub-question 2 asks what interventions are being used by Dutch municipalities to encourage low-income homeowners to move away from natural gas. The literature review revealed that governments and organizations offer financial interventions such as subsidies, low-interest loans, tax breaks and simplified support programs to help low-income homeowners implement energy-saving measures. Other interventions related to trust include transparent and consistent communication, neighborhood activities and peer success stories. Interventions related to comfort are energy coaches and guidance, knowledge desks for personalized advice and workshops on energy-saving strategies. A multifaceted strategy is essential to ensure that all homeowners, especially those with lower incomes, can participate in and benefit from the transition to a more sustainable and equitable energy future.

An analysis of gas, electricity and heat prices shows that heat is significantly more expensive compared to gas and electricity. This represents a significant barrier, especially for low-income homeowners, as the higher costs make switching to renewable alternatives less attractive. In addition, this chapter explored the relationship between barriers and interventions.

The main barriers were linked to possible interventions that municipalities can deploy to facilitate the energy transition. This provides tools to develop targeted solutions to specific challenges. The final section looked at linking opportunities within the Dutch energy transition. These opportunities, which include sustainable, disempowering and social interventions, can be added to policy offerings. By deploying such strategies, homeowners can be additionally motivated to actively participate in the energy transition. With these barriers, interventions and linking opportunities in mind, the next chapter examines the policies and initiatives currently implemented in the Netherlands.

## Chapter 4 Desk research into Dutch policies

This chapter describes sustainability initiatives in the Netherlands, followed by describing living labs that are natural gas-free in the Netherlands.

### 4.1 Initiatives in the Netherlands

Initiatives in the Netherlands are mainly financial measures aimed at making housing more sustainable. Table 5 provides an overview of sustainability initiatives in the Netherlands, and these initiatives are explained below.

Table 5 Sustainability initiatives in the Netherlands

<i>Initiative</i>	<i>Authority</i>	<i>Year</i>
<i>National Heat Act</i>	National level	2014
<i>ISDE</i>	National level	2017-2030
<i>SVOH</i>	National level	2022-2029
<i>SAH</i>	National level	2020-2024
<i>WCW</i>	National level	?
<i>WGIW</i>	National level	?
<i>VET</i>	National level	2018
<i>PAW</i>	National level	2018-2022
<i>Insulation vouchers</i>	Provincial level: Province of Utrecht	2022
<i>Composite Project 3 (SP3)</i>	Provincial level: Province of Noord Brabant	2023
<i>Standardized process approach</i>	Municipal level: Municipality of Tilburg	2021
<i>Collective sustainability</i>	Municipal level: Municipality, housing associations and associations of owners, Amsterdam	2022
<i>Sustainable Living Plan</i>	Municipal level: Municipality, housing association and private owners, Rosmalen	2022
<i>Subsidy scheme for energy-saving measures for mixed property</i>	Municipal level: Municipality of Den Bosch	2024
<i>Renovation shop where people buy sustainability in packages</i>	Municipal level: Municipality and housing associations, Enschede	2018
<i>Repurchasing previously sold homes and making them more sustainable</i>	Housing association, Kerkrade	2020

The government has devised a wide range of incentives and financial mechanisms for inhabitants and building owners, with the goal of enabling everyone to make their buildings more sustainable. National initiatives already in use are the National Heat Fund, ISDE, SVOH and SAH. The National Heat Act (Warmtewet, 2014) came into effect on 1 January 2014 and provides rules for district heating and heating networks. Because the consumer cannot switch suppliers, the consumer is protected by the Heat Act (RVO, 2017). The ISDE (Investment subsidy for sustainable energy and energy saving, Investeringssubsidie duurzame energie en energiebesparing) is to make a home more sustainable. This allows people to claim back money for installing a (hybrid) heat pump, solar boiler or electric cooking facility, or insulating the home or connecting it to a heating network (RVO, 2017). The SVOH (Subsidy scheme for sustainability and maintenance of rental properties, Subsidieregeling Verduurzaming en Onderhoud Huurwoningen) is the subsidy scheme for sustainability and maintenance of rental properties (RVO, 2021). A mixed homeowners' association or a landlord of one or more rental properties can apply for the SAH (Incentive Scheme for Natural Gas-Free Rental Homes, Stimuleringsregeling aardgasvrije huurwoningen) for subsidy for existing homes that will be disconnected from natural gas within 6 years. These homes are, or will be, connected to a heating network (RVO, 2020).

Moreover, the Dutch government is actively developing new laws to promote the energy transition, including the WCW (Collective Heat Act, Wet Collectieve Warmte) and the WGIW (Integrated Collective Heat Supply Act, Wet Gemeentelijke Instrumenten Warmtetransitie). The laws were

scheduled for 2025, but the government recently indicated that it would not be able to meet this deadline, and the laws have been postponed.

The WCW replaces the current Heat Act and aims to facilitate the development of new heat networks. This law is an important step toward accelerating the energy transition by promoting collective heat supply, such as heat networks, which increasingly use renewable sources such as waste heat, geothermal, or biomass. The purpose of the WCW is not only to promote energy transition but also to ensure the affordability, reliability, and sustainability of collective heat supply so that consumers maintain a stable and affordable heat supply (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2023).

The WGIW aims to give municipalities more powers to direct heat transition at the district or area level. This law enables municipalities to develop area-specific plans and coordinate the transition to sustainable heat solutions, for example by building heat networks or promoting other sustainable heating systems. This allows the energy transition to be locally driven and tailored to the specific needs and circumstances of different neighborhoods, increasing the effectiveness and speed of the energy transition (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2023).

Since 2018, the Netherlands has had the Energy Transition Progress Act in force for new-build homes. This law stipulates that the gas connection obligation for new construction is no longer required. This means that from 1 July 2018, project developers, contractors and municipalities must take into account the fact that new buildings may no longer be connected to the gas network (RVO, 2023).

From 2018 to 2022, 64 Dutch municipalities took part in the PAW program (living labs natural gas free Proeftuinen Aardgasvrij), which intended to transfer certain neighborhoods to sustainable heating options. Through 66 pilot projects, PAW aimed to unplug nearly 50,000 households, offices, and shops from natural gas while creating scalable solutions for the national heat shift (Ministerie van Algemene Zaken, 2024b). The national government provided funding to participating municipalities for building renovations, insulation installation, and sustainable heating systems. Each municipality tailored its approach to meet the unique needs of its communities, using cost-effective and practical solutions. The program's findings will assist establishing national policy for making all neighborhoods natural gas-free by 2050, delivering valuable lessons in strategy and implementation (NPLW, 2024). The PAW initiative's results and measures will be discussed in greater detail in the next section.

In addition, the government has also introduced several sustainability initiatives for buildings involving energy cooperatives, homeowners' associations, and housing associations; however, these are not included in this research.

The provinces and municipalities in the Netherlands have also set up initiatives for phasing out natural gas. For example, the province of Utrecht provides a subsidy through the Energy Transition Program for making homes more sustainable, and they also work with insulation vouchers (Utrecht, 2024). The province of North Brabant is working with municipalities in the Composite Project 3 (SP3), by making existing real estate more sustainable. In addition to a financial contribution, municipalities in North Brabant can also rely on knowledge of the province, which is necessary for the further development of their project ideas (Energiewerkplaats Brabant, 2023).

Collaboration between housing associations and municipalities is necessary to ensure the long-term viability of mixed-ownership areas. Areas with mixed property can be made more sustainable through the following methods: co-creation and collaboration aimed at a renovation for tenants and owners; co-creation and collaboration on different jobs and different timeframes; a large-scale approach by housing associations; and a demand-driven approach (Van Berkel & Rutten, 2021). In Tilburg, the housing associations and the municipality are working together on a standardized process approach,

to increase the chance that private homeowners in a former association home can and want to participate in a housing association's renovation or maintenance approach (Agterbosch & Koomen, 2021). In den Bosch, the municipality issue subsidy schemes to owner-occupiers in former corporation homes to take energy-saving measures in their existing home (Gemeente 'S-Hertogenbosch, 2023). The municipality in Enschede, together with corporations, have established a store concept where customers buy sustainability products similar to those found in supermarkets (Renda, 2018). The Sustainable Housing Plan, in collaboration with municipalities, corporations, and homeowners in Rosmalen, can help accomplish the aims of the performance agreements by incorporating measures for rental properties into a tool. Each measure's energy savings is indicated, as well as their monthly expenses, with a special emphasis on communication and information for tenants and buyers (Inge, 2022). An alternative to these methods is for housing associations to try to sell back the sold real estate to make it more sustainable, as in Kerkrade (Baggerman, 2020). Overall, quite a few initiatives have been launched in recent years, and there are even more than these described, but what emerges from each initiative is the importance of good communication between stakeholders.

Although several initiatives and subsidies exist in the Netherlands, many low-income homeowners do not take advantage of them. This is often due to a lack of awareness or an inability to navigate through the complex and time-consuming application processes (Ebrahimigharehbaghi et al., 2019). According to Association Eigen Huis, there are several additional barriers to accessing subsidies. These include difficulty in finding the right website, complicated and time-consuming application systems, difficulty in creating user profiles and confusion about required documentation, such as guidelines for photos. In addition, many homeowners are uncertain about accessing grants. In addition, many homeowners are unclear about product codes or have difficulty applying for specific subsidies, such as those for glass insulation. In addition, grant amounts often fall short of expectations, making them less attractive (Vereniging Eigen Huis, 2023). These obstacles discourage many homeowners, especially those with low incomes, from taking advantage of the financial assistance available to them. For low-income homeowners, this is altogether out of the question.

In addition, there is fear of uncertainty for sustainability initiatives from the government, the example being the abolition of schemes such as the energy-saving scheme. While it makes sense for policies to have an end date, this sometimes leads to uncertainty and frustration. For example, the abolition of the subsidy on solar panels in the Netherlands caused homeowners to receive less financial benefit from their investment. With the removal of the net-metering scheme, people can no longer offset generated energy in full against their annual consumption, making the payback period for solar panels longer. This has particularly negative consequences for low-income homeowners, for whom financial benefits are essential to participating in the energy transition (Ministerie van Algemene Zaken, 2024). This can be solved by setting a clear end-term in advance and not changing it or changing it as little as possible.

## **4.2 Natural gas-free living labs in the Netherlands**

Natural gas-free living labs in the Netherlands are experimental environments in which innovative solutions are tested to transform cities into natural gas-free communities. In a compact approach, sustainable technologies, rules and participatory processes are implemented and evaluated on a small scale, with the aim of generating practical insights for greater adoption in the energy transition (NPLW, 2023). In order to gain a better understanding of how municipalities proceed with projects, the following overview (table 6) has been prepared. This will structure living labs for natural gas-free neighborhoods in the natural gas-free neighborhoods program (PAW) in the Netherlands, with regard to the stakeholders, the measures taken and what the supply consists of, and how this process was organized in terms of communication and participation, and what barriers they encountered during the project (Ministry of General Affairs, 2023). All named municipalities strive to be natural gas-free.

In a few neighborhoods in Amsterdam and Rotterdam, the transition from gas to a heat network is proving unsuccessful. This is not due to the process but to the energy bills that turn out to be much higher than agreed upon after renovation. This is mainly due to energy companies with a monopoly position, who own the pipes to the homes. This is a problem that may occur more often in the coming years and does not contribute to creating support for the energy transition. Especially people with low incomes cannot afford this. The result could be that residents of neighborhoods that need to get rid of gas will resist connection to a heat network.

Table 6 Living labs natural gas-free in the Netherlands

	<b>Place and municipality</b>	<b>Stakeholders</b>	<b>Measures</b>	<b>To what extent successful</b>	<b>Communitation and barriers</b>
1	Groenoord, Schiedam 2020-2024 (Eneco, 2023)	Municipality of Schiedam, housing association, Eneco	Natural gas free Heat network and heating station	Successful	High level of communication and participation
2	Paddepoel-Zuid, Groningen 2018-2029 (Proeftuin de Wijert, Paddenpoel and Selwerd in Beeld - Programma Aardgasvrije Wijken, 2022)	Municipality of Groningen, housing associations, residents' organizations, energy suppliers	Natural gas free Installation of heat pumps, insulation of homes, use of solar energy, infrastructure for heating networks	Successful, because project is constructed	High costs for homeowners, technical complexity of natural gas-free solutions, resistance to change
3	Buiksloterham, Amsterdam 2018-2025 (Zonnewarmte Geeft Nieuwe Impuls Aan Circulaire Wijk Buiksloterham, 2023)	Municipality of Amsterdam, project developers, housing associations, residents' associations	Natural gas free Zero-on-the-meter homes, heat pumps, solar energy, green roofs, electric mobility	N/A	High initial costs for new construction, limited availability of green financing, resistance to technological changes
4	Overvecht-Noord, Utrecht 2018-2030 (Uitgelicht: Overvecht-Noord - Programma Aardgasvrije Wijken, 2021)	Municipality of Utrecht, housing associations, neighborhood organizations, energy suppliers.	Natural gas free Heat pumps, insulation, green roofs, solar energy, collective energy storage	N/A	Financial constraints for households, lack of awareness of sustainable options, technical challenges in older homes
5	Panoramabuurt, Vlissingen 2022-2030 (Vlissingen, 2023)	Municipality of Vlissingen, housing associations, residents' groups, energy cooperatives	Natural gas free Heat pumps, insulation, energy-efficient renovations, collective solar energy projects, energy-efficient systems, subsidies	Successful	Financial constraints, technical challenges in adapting older homes to modern sustainability standards
6	Pendrecht, Rotterdam 2018-2030 (Duurzaam010, 2024)	Municipality of Rotterdam, housing associations, neighborhood organizations, energy companies	Natural gas free District heating, heat pumps, insulation, green roofs, solar energy, hydrogen as an alternative energy source	Successful	Lack of available space for sustainable infrastructure, lack of financial support for households, cultural resistance to change
7	Hengstdal, Nijmegen 2020-2030 (PAW in de Praktijk:	Municipality of Nijmegen, housing associations, neighborhood	Natural gas-free Heat pumps, insulation, solar energy, collective	Successful	High costs for homeowners, lack of available financing options, technical

	<i>Hengstdal Programma Aardgasvrije Wijken, 2022)</i>	-	associations, sustainability organizations	energy storage, electric shared mobility		complexity of natural gas-free solutions
8	Strijp Eindhoven 2018-2040 ( <i>Stichting Warmtenetwerk, 2023)</i>	S,	Municipality of Eindhoven, developers, energy cooperatives, residents' platforms	Natural gas-free Heat net, heat pumps, insulation, solar energy, energy-efficient renovations, smart energy management systems	Successful	Lack of technical expertise among residents, high costs for technological implementation, limited availability of sustainable financing
9	Spijkerkwartier, Arnhem 2018-2050 ( <i>Energietransitie Spijkerkwartier  Spijkerenergie  MijnSpijkerkwartier.nl, 2021)</i>		Municipality of Arnhem, housing associations, neighborhood committees, energy cooperatives	Natural gas-free Heat pumps, insulation, green roofs, collective solar energy projects, electric charging infrastructure	Successful	Meetings and activities, but limited knowledge about sustainable options, resistance to change due to historical characteristics of the neighborhood, financial challenges for low-income households

The above table highlights some significant findings from the natural gas-free living labs. First, it emphasizes the importance of multiple stakeholders. Many efforts involve additional actors besides governments and homeowners, such as housing associations, energy providers, energy cooperatives, residents' and neighborhood organizations, developers, contractors, and even sustainability organizations. This indicates that the transition to natural gas-free living is a multidisciplinary effort that requires collaboration from a wide variety of stakeholders to be successful.

The table also describes the various measures used in the projects, which range from the installation of heat pumps, home insulation, and solar energy to more comprehensive solutions such as green roofs, collective energy storage, electric charging infrastructure, and hydrogen as an alternative energy source. Although all these projects share the same overarching goal – natural gas-free living – the approaches and solutions offered to residents vary considerably. This variability reflects the need to tailor strategies to local circumstances and residents' preferences.

Furthermore, the table reveals differences in communication strategies and barriers encountered in the projects. Common barriers in these initiatives include a lack of available area for sustainable infrastructure, insufficient financial support for homeowners, cultural reluctance to change, high prices for homeowners, and limited access to funding choices. Technical problems include the complexity of natural gas-free technologies, homeowners' lack of technical skills, and difficulties in installing natural gas-free systems. Furthermore, some areas have unique challenges, such as opposition to change due to historical or cultural traits, or limited resources for low-income homeowners.

Despite these issues, numerous projects have been successful by proactively addressing them and including residents' wants and preferences into the design and construction processes. This underlines the need for targeted communication, financial support systems, and collaborative ways to promote resident participation and project success. The diversity of stakeholders, measures, and challenges points out the complexity of the transition to a natural gas-free future, as well as the adaptation required to ensure project success.

### 4.3 Current policies in other countries

Although the first chapter already briefly described the energy transition in other countries, such as Denmark, England and Germany, this section returns to it briefly. Denmark is one of the forerunners in the energy transition and has implemented effective policies to involve homeowners in the energy transition. Denmark's success factors are ambitious goals, long-term planning, a stable political climate, and an integrated approach with an emphasis on energy security and regional cooperation. Advice from Denmark is institutionalizing scientific input, promoting system-wide change, engaging stakeholders and society, and taking a comprehensive approach. Despite these interventions, barriers to renewable energy financing, infrastructure and expansion remain. Initiatives that educate the public about the short-term costs and long-term benefits, share best practices, and incentivize energy suppliers can all help build trust and promote use (Kingdom of Denmark, 2015).

England is encouraging homeowners in the energy transition with ambitious legislation, such as the Climate Change Act (2008) and the Energy Bill (2024), through which the government is investing in clean energy and creating green jobs through Great British Energy (Walker et al., 2024). Financial support, such as grants, tax breaks and the Energy Company Obligation (ECO), helps homeowners with energy efficiency measures. Although England previously privatized its energy supply, the government is again making crucial decisions to accelerate the transition (Boot, 2015). In doing so, it is combining regulation, financial support and social benefits for a sustainable future.

Germany is also actively helping homeowners phase out natural gas as part of the larger Energiewende; the transition to renewable energy. To help homeowners, Germany offers subsidized energy advice and practical help. Subsidies and low-interest loans are making renewable heating technologies, such as heat pumps, more affordable. At the same time, new laws such as the control of residential appliances by the regional grid operator since 2024 (Siemes, 2024) and the ban on new oil-fired boilers from 2026 encourage more sustainable options (Amelang, 2023).

In Sweden, the government stimulates energy transition through close cooperation between municipalities and heat companies, connecting heat networks to minimize costs and use renewable heat sources. Furthermore, Sweden introduced "price dialogues", in which customers participate annually in the pricing, increasing support while ensuring stable and fair prices. This leads to greater customer satisfaction and a transparent, sustainable energy supply (Ennatuurlijk, 2022).

Countries such as Finland and Switzerland have also made significant steps in their energy transition (Moin, 2024). Outside of Europe, countries such as Canada and the United States are also actively promoting renewable energy. They are using initiatives that offer financial incentives, such as grants and loans, to support homeowners in the transition to sustainable solutions. In the U.S., there are special programs for low-income homeowners, such as the Low-Income Home Energy Assistance Program (LIHEAP) (Office for Social Services, 2024). Canada uses the Canada Greener Homes Grant and Loans (Canada, 2025), which provides homeowners with financial assistance for energy-saving measures, such as improving insulation, replacing windows or installing heat pumps. In addition to financial incentives, the policy also focuses on removing barriers, such as lack of knowledge or confidence, through information campaigns and tailored guidance. Countries in Asia such as China and Japan are also participating in the energy transition. China has instituted financial subsidies and tax incentives and is trying to put pressure on energy producers and provinces (De Weert, 2023). Japan has programs such as the Eco-Housing Pilot Program, which encourages homeowners to develop or repair homes to meet high energy efficiency criteria. In addition, the Japanese government encourages training and awareness initiatives to help homeowners understand the long-term benefits of energy-efficient solutions (Shigyo, 2024).

These countries can teach the Netherlands that the transition to renewable energy involves strong governmental support, collaboration, and strategic planning. A successful energy transition requires clear policy objectives, significant investments in infrastructure and technology, and the ability to overcome barriers such as financing and innovation. Denmark's experience demonstrates that the shift is achievable, but that ongoing cooperation and investment are required to achieve sustainable energy goals.

For now, it seems that the government has already taken initiatives to encourage homeowners to participate in the energy transition. If, despite the better information, sustainability is not happening fast enough, it is necessary to tighten the climate policy for the sustainability of the built environment, for example by introducing a sustainability obligation when purchasing a home, as in Belgium, where residents must improve the energy label to a sustainable label within 5 years of purchase (Vlaanderen, 2023).

#### **4.4 Conclusion**

The purpose of this chapter was to find an answer to sub-question 3. Examining current policies in the Netherlands provides insight into the country's current situation and the effectiveness of current initiatives. By comparing different projects, similar barriers and incentives can be identified, which will help in making the next policy.

Ultimately, this chapter has discussed several initiatives focused on sustainability in the Netherlands that seek to improve the energy efficiency of homes while creating natural gas-free neighborhoods, such as the SVOH, ISDE and SAH and future WCW and WIGW. These projects show a major effort by national governments, local municipalities and housing associations to promote sustainable practices and innovation in the transition away from natural gas. But it appears that several programs have recognized problems such as high initial costs, technological complexity, and conflicting stakeholder perspectives, highlighting the importance of effective communication and collaboration in achieving long-term energy transition goals.

The Dutch government mainly focuses on financial interventions. Yet the PAW demonstrated that a comprehensive, well-rounded approach to interventions is necessary. Although new laws are being introduced, the uncertainty surrounding these changing regulations is creating confusion among homeowners, leaving them uncertain about what to expect. Other countries working on the energy transition are also showing that financial interventions alone are not enough to make the transition successful. An integrated approach, combining financial incentives with social benefits and regulation while incentivizing homeowners and building trust, proves to be effective. In addition, initiating collaborations between different stakeholders plays a crucial role. This approach can also be applied in the Netherlands to accelerate and strengthen the energy transition. Future policies could provide clarity and stability and ensure long-term solutions that are not subject to abrupt changes, as in the case of the solar panel subsidy, which was discontinued and no longer benefits homeowners. To avoid such problems, future policies for a natural gas-free transition must include not only financial aspects but also long-term social, legal and technical considerations. The next chapter discusses how municipalities have made use of various initiatives and provides insight into how the literature and desk research connect with the experiences of the interviewees.

## Chapter 5 Interview analysis

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This chapter begins with an introduction to the interviews, followed by insights into the policies of the municipalities from the interviews as well as a description of the case studies. It then briefly explains the barriers and interventions to participation in the energy transition from the interviews. Next, the conditions offered by municipalities are also described. The worst practice interventions from the interviews are also discussed. The chapter ends with a conclusion on the main findings of the interviews.

### 5.1 Introduction to the interviews

To test the interventions identified in the literature, interviews were organized. The interviews were approved by the Ethical Review Committee of TU/e. Interviews were conducted with individuals from municipalities, energy cooperatives and the Netherlands Enterprise Agency (RVO). Participants in the energy transition were specifically sought for the interviews. These individuals were primarily found online, through research projects and their roles related to energy transition. Approximately 30 people were contacted, of whom some either did not respond or indicated that they lacked the time or interest to participate. Ultimately, 10 people agreed to be interviewed, which means slightly over 30% of those approached participated. The interviewees represented various organizations. Some municipalities had pilot projects, such as those in the PAW (Programma Aardgasvrije Wijken), but not all. Four of the interviewees worked for municipalities involved in building district heating networks; one municipality was transitioning to fully electric systems, and two were preparing for natural gas-free transitions. Additionally, two interviewees worked for energy cooperatives, and one interviewee was employed by RVO, supervising multiple pilot districts.

Of the interviews conducted, two were in person, while the remainder took place via Teams. A presentation was prepared to guide the semi-structured interviews, ensuring consistency in the topics covered and the flow of the discussions. The presentation began by outlining the purpose, problem statement, and goals of the research. It included a review of findings from the literature, with respondents asked whether they had encountered the identified interventions in practice. This approach aimed to validate the literature against real-world experiences and to uncover additional strategies interviewees may have used to encourage resident participation in the transition to natural gas-free living. The presentation was structured around three key phases of the transition process: motivation and awareness, information gathering, and decision-making. For each phase, both best practices and common challenges were discussed, providing a detailed picture of what works well and what obstacles are typically encountered. Special attention was given to the barriers faced by low-income homeowners and the interventions that might help overcome them. In addition, the customer journey framework of Hamilton was used to explore the interviewees' experiences. The conversation also touched on the specific interventions designed to raise awareness and encourage participation in the gas-free transition.

No interviews were conducted with residents in this part of the study. Although this was initially considered, it was decided to focus on gathering insights from experts and policymakers, as the primary goal was to explore interventions that could be used in policy to promote the transition to natural gas-free living. While interviews with residents could have been used to make recommendations, this approach was deemed less effective for the objectives of this study, as the perspectives of experts and policymakers were deemed more directly relevant to identifying practical and scalable interventions for policy development.

A summary of all questions asked during the interviews can be found in Appendix A. Additionally, in Appendix B, an overview of the timelines of the projects can be found.

## 5.2 Insight into the municipalities from the interviews

As part of this research, from the interviews, seven municipalities were selected for in-depth analysis based on insights from interviews. The other 3 interviews were not useful as specific case studies because 2 were energy cooperatives and thus not whole neighborhoods and one municipality was still in the beginning of the orientation phase so no concrete experiences yet. The project areas are spread across the Netherlands, each at different stages and pursuing unique goals, but all working toward the common goal of becoming natural gas-free. Table 7 includes information on the project areas within these municipalities, covering aspects such as the number of housing units, the average property (WOZ) value, whether residents initiated the project, and whether it qualifies as a "Programma Aardgasvrije Wijken" (PAW) neighborhood. All data in the table were gathered through the interviews, while the WOZ values were sourced from the Dutch statistics website, AlleCijfers.nl.

Table 7 List of project areas discussed in the interviews

	Number of dwellings in the project area	Average WOZ-value of dwellings in the project area	Project co-initiated by residents	Construction period homes in project area	Pilot project natural gas-free neighborhood (PAW)
Stadseiland, Arnhem	1200	€ 382.000	Yes	2002-2015	No
Lariks, Assen	428	€ 202.000	No	1960's	Yes
Selwerd, Groningen	473	€ 227.000	No	1960 – 1979	Yes
Muiderberg, Gooise Meren	1250	€ 574.000	Yes	1950-1980	No
Limbrichterveld-Noord, Sittard	366	€ 246.000	No	1960-1979	Yes
Panoramabuurt, Vlissingen	641	€ 159.000	No	1945-current	Yes
Benedenbuurt, Wageningen	363	€ 375.000	Yes	1930-1955	Yes

Based on the interviews, the studied projects in natural gas transition in this research can be considered successful or unsuccessful. These projects' success varies widely and can be interpreted in different ways. See Figure 11 for a visualization.

### 5.2.1.1 Successful projects

- Some projects are considered successful because they have achieved the goal of being "natural gas-free ready." In one of the project areas, a large proportion of homes have already undergone renovations to enable the transition from natural gas.
- Other projects are considered successful because of high approval of resident involvement and for alternative heat solutions. For example, several areas achieved more than 70% approval from residents to switch to a district heating system (heat grid) or another alternative heat source. This high level of acceptance is crucial for project feasibility and public support.
- Some projects are also classified as successful because the infrastructure for alternative heating, such as district heating, has already been installed and the first homes have completely switched from natural gas. This progress shows tangible movement toward the natural gas-free goal and serves as a foundation for future phases of the project.

### 5.2.1.2 Unsuccessful projects

- In contrast, projects that fail often struggle due to insufficient community support. For instance, one of the projects was entirely halted despite the municipality's extensive efforts, as residents showed little to no backing for the initiative. This lack of resident support made it impossible to move forward with the planned infrastructure changes.
- Another example of failure occurred in a project where, despite active resident participation, the energy supplier unexpectedly withdrew from the project at the last moment. This

withdrawal has brought the entire initiative to a standstill, highlighting the risk of relying heavily on external partnerships.

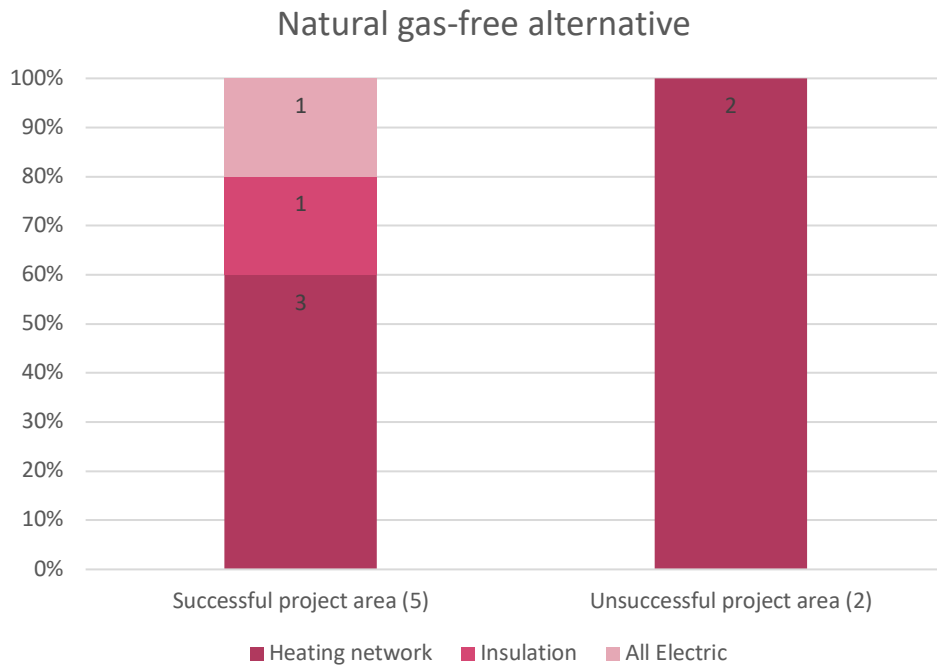


Figure 11 Successful and unsuccessful projects for a natural gas-free alternative

#### 5.2.1.3 Alternative heat source

The alternative heat sources to natural gas chosen in the different neighborhoods were also examined; see Figure 12. The majority of the projects use waste heat from industry, which is a common choice given that the neighborhoods are located near industrial areas. In addition, one project area is switching completely to all-electric, with each home being equipped with an individual heat pump. Another area is choosing a collective heat pump, and yet another district is implementing aquathermal as a renewable heat source. A feasibility study is currently underway for one of the neighborhoods, so it is still unknown which heat source will ultimately be selected.

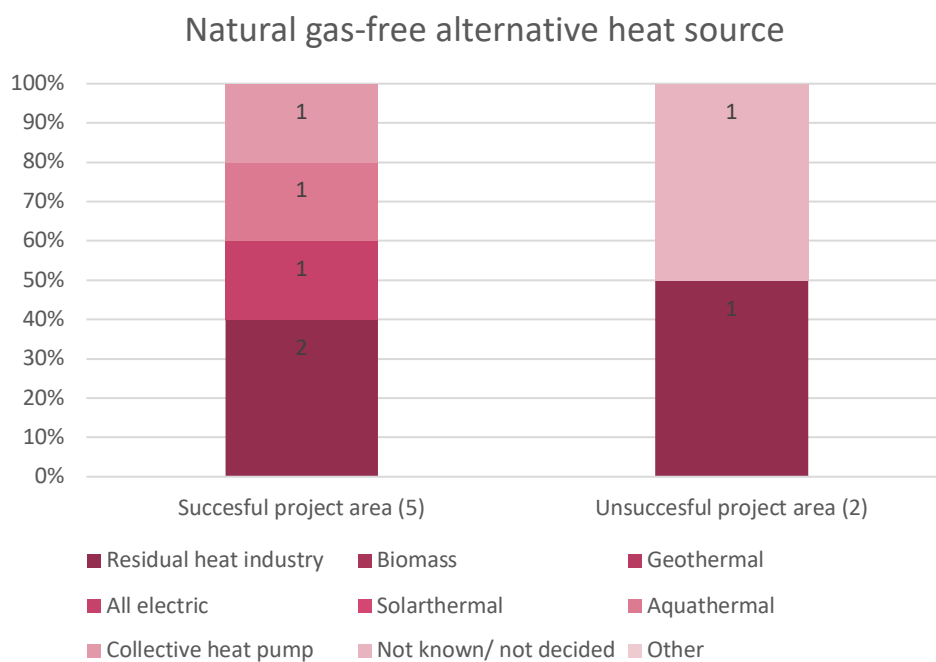


Figure 12 Natural gas-free alternative heat source

### 5.3 Case studies from the interviews





Seven case studies emerged from the 10 interviews, which are explained in the following section. The case studies are providing a good picture of best and worst practices in phasing out natural gas projects. The neighborhoods are all different and therefore have different approaches. Each case study has a table of key interventions for each motif. Previous interventions are included in each case study; for example, in case study 1 help with applying for grants is mentioned; this is also the case in the following case studies. The case studies in this study are a small sample; therefore, it is not the complete truth, but the different case studies indicate similarities, which are mentioned at the end of the section.

#### 5.3.1 Casestudies

##### 5.3.1.1 Case study 1 – Vulnerable neighborhood

Table 8 Case study 1

The first case study focuses on a socially vulnerable neighborhood where multiple problems converge. The condition of the homes is so poor that a complete transition to natural gas-free living is financially unfeasible. Therefore, the municipality decided to first insulate the homes and make them ready for a future natural gas-free transition (PONG-ready). This approach will ensure incremental sustainability while keeping the immediate costs manageable.

Financial 	Zero investment costs for residents, nothing changes on a monthly basis
Comfort 	Each resident approached separately, assistance with subsidy application
Trust 	Flexible - subsidy in advance, self-construction allowed
Environment 	Insulation





In addition to overdue housing maintenance, many residents in this neighborhood have limited “mental space” to engage in sustainability and natural gas phase-out. This is compounded by socioeconomic challenges, limiting willingness and ability to participate in the energy transition.

The municipality has responded to this with an approach that completely unburdens residents and does not impose direct costs on them. The municipality put a lot of effort into a personal approach. In addition, part of the subsidy was provided in advance to encourage involvement and participation. This combination of customization, financial support and practical unburdening proved essential to overcoming both the physical and social barriers in this neighborhood. The municipality had a complete directorial role; the project took a lot of time and money, but it succeeded in the end.

##### 5.3.1.2 Case study 2 – Vulnerable neighborhood

Table 9 Case study 2

The second case has many similarities to the first but is distinguished by the municipality's decision to make the homes completely natural gas-free. Although the homes in this neighborhood were in slightly better condition, the transition still required a significant investment of time and money.





	Zero costs, free induction hob, rate guarantee by municipality
	Personal advice about adjustments and energy costs
	Neighborhood renewal, heating network is in place, heating company 100% owned by the municipality
	Source mix: residual heat, collective heat pump

The municipality capitalized on several aspects to encourage residents to participate in the project. For example, a broad program was created that focused not only on energy transition, but also on broader neighborhood renewal, where the improvement of residents' front gardens was included during the works. A key measure was the provision of a rate guarantee, which protected residents from unexpected cost increases. In addition, a full directorial role was taken by the municipality: residents only had to sign, while the municipality took charge of the entire process—from financing to implementation. These complementary interventions, such as neighborhood renewal and minimizing burdens on residents, played a crucial role in increasing willingness to participate.

### 5.3.1.3 Case study 3 – Vulnerable neighborhood

Table 10 Case study 3

Case 3 is an example of a worst practice in energy transition implementation projects. In this neighborhood, the municipality had not yet made a final choice for a future heat source. Instead, it tried to determine this through a support measurement. Although this sounded like a participatory approach on paper, it turned out differently in practice.

	Subsidy not clear Uncertainty about future heating costs
	Information from energy coaches
	No more trust
	Undecided





A major problem in this case study was the lack of continuity in project leadership. The frequent turnover of project leaders undermined residents' trust in the process. Moreover, the decision to place responsibility for decision-making largely with the residents created too much uncertainty. The lack of clarity about the future heat source, combined with the absence of a clear governing role for the municipality, reinforced feelings of distrust and frustration.

This ultimately resulted in a failed support vote, with 70% of residents voting against the proposal. The case study shows that a lack of direction, clear communication and consistent leadership are major obstacles to the successful realization of energy transition in neighborhoods.

### 5.3.1.4 Case study 4 – Mixed neighborhood

Table 11 Case study 4

The next case study concerns a residents' initiative, where the participation rate was exceptionally high because the project was started entirely from the residents themselves. As a result, little extra effort needed to be made to encourage resident involvement. However, the late involvement of the municipality brought significant challenges, especially in the technical and legal areas.

	Free heating network to the door, other investment €2K for resident
	Information from energy coaches
	Residents' initiative Subsidy in advance based on quotation Desired construction ownership situation unknown
	Source: Collective heatpump





The municipality was initially missing as a crucial link in the process, since issues such as the ownership structure of the heat company and responsibility for connecting the heat source to the homes were not established in a timely manner. The heat source is located outside the neighborhood, which requires additional technical measures and coordination, a task that lies primarily with the municipality.

These gaps in organization and the lack of clear agreements led to long lead times. As a result of these technical and legal complications, the project was eventually paused. This case has elements of both best practice and worst practice, as despite a strong resident initiative, the active and timely involvement of the municipality is essential to successfully realizing such projects. Pausing this project due to organizational and legal obstacles is considered a missed opportunity.

### 5.3.1.5 Case study 5 – Mixed neighborhood

Table 12 Case study 5

The next case study concerns a project that began with an incomplete and not fully thought-out plan, largely due to time constraints. This led to a difficult start, as the offer for residents was not fully developed when it was presented. This left the municipality behind from the beginning in building trust and support among residents.

	Free heating network to the door, other investment €3.3K for resident
	Very active participation/information campaign
	Subsidy in advance based on quotation Heating company consists of municipality and a undecided party
	Source: residual heat industry

Nevertheless, the municipality made significant efforts to promote participation, with an approach that lasted four years. Various initiatives such as model homes, neighborhood festivals, cooking workshops, longlists and speed dates were organized to





engage and enthuse residents. Through this intensive and creative participation strategy, the municipality eventually succeeded in getting enough residents on board with the project.

However, just before construction of the heat grid could begin, the energy supplier pulled out. This led to the collapse of the business case, so the project had to be paused. The municipality is currently looking for a new partner to continue the project. This case has elements of both best practice and worst practice as it illustrates how a bad start can be offset by strong participatory efforts, but also how external factors such as the withdrawal of an energy supplier can be a major obstacle to the progress of a project.

### 5.3.1.6 Case study 6 – Prosperous neighborhood

Table 13 Case study 6

This case study focuses on an energy cooperative that aims to take ownership of both the heating company and the heating grid. What makes this approach unique is its focus on inclusivity and choice for residents. The cooperative strives to involve as many residents as possible and gain consent to the construction of the heat grid but does not impose an obligation to actually join afterwards. An example of this freedom of choice is that when a home is sold, the new residents are not required to connect to the heat grid. This lowers the threshold for participation and offers residents flexibility, which contributes to support for the plans.

	Zero costs for residents
	Each resident is approached individually Volunteers investigate details
	Energy cooperative owner of heating company and heating network Option to opt out
	Source: Aquathermal





Participation is also being used in innovative and creative ways. For example, the cooperative works with schools, actively involving children in the project. In this way, awareness is raised, and children take the story home with them, which contributes to family involvement. Residents are also approached individually, leaving room for personal needs and questions. By focusing on freedom of choice and personal approach, the cooperative succeeds in creating support and motivating residents to participate in the heat transition.

### 5.3.1.7 Case study 7 – Prosperous neighborhood

Table 14 Case study 7

The final case study shows how a well-thought-out approach by the municipality led to a project that is considered a best practice. The municipality employed two key strategies that contributed to the success of this project.

First, the municipality clearly communicated from the beginning what was and was not possible in the different neighborhoods of the city. In this neighborhood, for example, it was decided that no heat grid would be constructed. Instead, the municipality came up with an alternative offer: residents could participate in the municipality's sustainability project, or choose not to participate, but with a clear deadline to still take measures independently.

	Residents bear costs (€7 to €15K after subsidy) Municipal loan 1.2%
	Three variants of unbundling: from light to total
	One-time offer with clear deadline
	All electric

In addition, the municipality focused strongly on unbundling residents by offering different packages. These packages ranged from advice only to a total package to after installation. While this approach entailed additional costs for some residents, it simultaneously provided the flexibility to serve residents with diverse needs and capabilities. In larger areas, providing choice proves essential to increasing participation. This approach demonstrates that a combination of clear communication, flexibility and unbundling can be effective in encouraging involvement in the energy transition.

### 5.3.2 Best and worst practices from the case studies

The following best and worst practices can be derived from the case studies. Best practices focus on trust, unburdening and choice for residents. Worst practices have uncertainty and too many goals at once. Table 15 summarizes the best and worst practices from the case studies.

Table 15 Best and worst practices from the case studies

Best practice	Worst practice
<ul style="list-style-type: none"> <li>▪ Clear policy vision</li> <li>▪ Technically/legally in order</li> <li>▪ (e.g. heating network is already being constructed; heating company in the hands of the municipality/cooperative; first insulation, then heating network, ...)</li> <li>▪ Zero costs up to the front door</li> <li>▪ Extensive unburdening</li> <li>▪ CO<sub>2</sub>-neutral and sustainable heat source</li> <li>▪ Taking diversity into account               <ul style="list-style-type: none"> <li>○ Within policy vision, as much freedom of choice as possible (do it yourself or buy, subsidy possible in advance, choose the level of advice)</li> <li>○ Tailor-made offer (e.g. Low incomes - subsidy together fill in, high incomes - guidance with offer evaluation)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Uncertainty about policy plans</li> <li>▪ A build-up of challenges               <ul style="list-style-type: none"> <li>○ e.g. poorly maintained homes, insulation not before home is renovated,</li> <li>○ e.g. heating network not technically/legally in order.</li> </ul> </li> <li>▪ Uncertainty about heating costs</li> </ul>

Several commonalities and best practices can be identified from the case studies discussed. Successful interventions rely on a clear policy vision that establishes clarity regarding expectations, objectives, and deadlines, with case study 7 as a great example. Providing this structure ensures that all stakeholders understand the overarching goals and the steps needed to achieve them. Additionally, it is crucial for the plans to be well-prepared from a participatory, technical, and legal perspective. This includes clear strategies for engaging with residents, consistent and transparent communication, and resolving legal or technical aspects early on. For example, having the heating network already under construction or placing the heating company in the hands of a municipality or cooperative creates a solid foundation. Sequencing actions logically, such as starting with insulation before implementing the heating network, also enhances the efficiency and credibility of the project.

Minimizing costs for residents is another key element, alongside ensuring extensive unburdening, as seen in case studies 1, 2, 5, and 6. Projects that reduce financial barriers for homeowners and provide comprehensive support are more likely to succeed. Additionally, selecting a CO<sub>2</sub>-neutral, natural gas-free, and sustainable heat source from the outset ensures alignment with environmental goals and fosters long-term sustainability (all case studies except case study 1, as the project was ready for natural gas-free use).

A standout takeaway from the cases is the importance of acknowledging diversity and providing flexibility within the policy vision. Tailored approaches that cater to the varied needs of residents are essential. For instance, offering freedom of choice, such as the option to "do it yourself" (case study 1) or purchase a complete solution, or to be able to choose their preferred level of support, ranging from basic advice to fully managed solutions (case study 7).

Finally, creating tailored offers for different income groups is vital. For lower-income homeowners, this might involve direct subsidies and hands-on support to complete applications. For higher-income homeowners, personalized guidance during the evaluation of offers may be more appropriate.

A number of worst practices also emerged from the cases reviewed. Uncertainty in policy plans is a major barrier to the energy transition (case study 3). Poorly maintained homes often delay insulation efforts because renovations are needed first (as seen in case study 1). Unresolved technical or legal issues, such as incomplete heating networks or unclear ownership structures, also undermine trust in project feasibility (case study 4 and 5).

In addition, uncertainty about future heating costs creates fear of financial strain, especially among low-income homeowners (case study 3). Without transparent pricing or clear financial support mechanisms, residents are less likely to participate. Addressing these uncertainties through clear plans, legal and technical readiness, and transparent communication of costs is critical to building trust and ensuring project success.

#### **5.4 Best practice interventions from the interviews**

Best practice interventions are a particular way of working that works best to achieve a particular outcome. Moreover, a best practice is to describe a method that is considered the most effective way to perform specific tasks, processes, or functions, or an intervention that has shown evidence of effectiveness in a particular setting and is likely to be replicable in other situations (Mold & Gregory, 2003). The interviews suggest that there is no one way to encourage low-income homeowners to switch to natural gas-free. Each neighborhood or district requires an individual approach. To make the process run smoothly and encourage as many homeowners as possible to switch to energy-efficient measures, the following interventions are possible. During the interviews it was clearly indicated that the target group is homeowners with low incomes, so the following interventions are based on this target group. It appears that support on a structural basis is and remains necessary to realize a successful project.

The following interventions emerge in almost all interviews after which specific interventions are described. An overview of the interventions found from the interviews is presented in table 16. The best practice interventions are structured according to the two frameworks used: the left column shows the stages of the social customer journey, while the motives are listed in the first horizontal row. This structure provides a clear and methodical way of categorizing and analyzing the research findings by mapping the measures against both the stages of the customer journey and the underlying motivations.

Appendix C contains an in-depth examination of the expert interview findings. This appendix highlights barriers that were discussed during interviews. Additional interventions not reported in the literature are also identified for both homeowners and mixed property. The conditions of municipal offerings are then named. Finally, worst-practice interventions are discussed. Appendix D contains a list of interviewed municipalities and organizations.

##### **5.4.1 Financial interventions**

The interviewees almost all indicate that financially this is a very important intervention which is consistent with the literature. They indicate the following financial interventions:

- Financial interventions are the most important since they remove the primary source of concern for low-income homeowners. The main financial incentive that municipalities have planned is to add additional financing from the municipality to government subsidies. Municipalities offer subsidies in a number of different ways:
  - Firstly, municipalities implement a variety of subsidy programs to support energy transition projects aimed at achieving natural gas-free neighborhoods. At the national level, there are grants specifically designed to facilitate these initiatives, providing foundational financial support for neighborhoods pursuing energy

transformation. The municipalities help people in neighborhoods apply for national grants.

- In addition to national grants, neighborhoods participating in the “Natural Gas-Free Neighborhoods Program” (PAW) may be eligible for additional funding. These additional PAW grants allow municipalities to allocate resources more effectively, increasing overall support for local gas-free initiatives.
- Municipalities also have the option to introduce their own subsidy programs, often supplementing national and PAW grants. Some cities are particularly proactive, offering substantial financial incentives that cover up to 80% or even 100% of project costs, which encourages residents to take immediate action towards energy transition. Municipalities also offer to pay these grants to residents before the work is completed, so that they themselves do not have to advance money for home improvements.
- Moreover, specific subsidies and financial support mechanisms are available to address various aspects of the transition.
  - For instance, municipalities may provide connection cost subsidies that cover part or all of the expenses associated with connecting to new energy sources.
  - There are also transition-support subsidies aimed at easing the switch from gas appliances to electric alternatives, such as electric cookers.
  - Additionally, special discounts on heating network fees are offered to homeowners connected to district heating systems, helping to alleviate financial burdens during the transition period.
- Some municipalities have set up special sustainability loans to encourage homeowners to switch to energy-efficient measures. Nevertheless, the importance of providing assistance and guidance in project planning cannot be overemphasized, such as help with choosing a quotation and insight into current and future costs.
- Next, providing accurate cost breakdowns is critical for effective planning and decision-making. Offering help and guidance in navigating the grant application process has proven to be an important intervention, as assistance in completing grant applications not only makes for smoother transactions but also better bid evaluation.
- Furthermore, some municipalities are dedicated to maintaining financial openness and accountability by explaining the tariffs and complying with them. They offer residents detailed cost comparisons and attempt to keep charges that are not only understandable but also enforceable. Local governments hope to empower individuals and promote informed decision-making in community development efforts by creating a transparent and accessible environment.
- Lastly, municipalities encourage a collective purchasing campaign for heat pumps to lower the costs for homeowners as well as gas contract guarantee scheme for compensation for gas costs.

#### 5.4.2 Trust interventions

The interviewees indicate that there are several interventions in the field of information dissemination and increasing trust:

- Firstly, municipalities make extensive use of local information points to engage residents, such as model homes, community centers, or energy counters where people can ask questions and see what their home might look like after renovations. They also organize various events like drop-in evenings, themed sessions, Q&As, "apple pie talks," consultation hours, resident panels, and neighborhood surveys to raise awareness and assess resident interest.
- Additionally, municipalities use brochures, flyers, newsletters, dedicated websites, and participation platforms with unique branding to enhance visibility and connect with homeowners. They also support community festivals or neighborhood events, often tied to

Dutch holidays like Christmas and Sinterklaas, to engage residents in a more informal and approachable way.

- Customized advice is also very important; kitchen table meetings are used for this purpose, but municipalities also indicate that community building, a public support measurement and a sounding board group are essential. Cooking workshops, natural gas-free workshops, and events to introduce people to natural gas-free living and cooking are also interventions for increasing the trust in adopting to natural gas free.
- Municipalities are strongly committed to deploying energy ambassadors with a sustainable handyman service and ambassadorships, in the form of a sustainable house tour where people can see what it is like to live in a natural gas-free home among residents who already live natural gas-free. Some municipalities also organize heat walks with heat scans to indicate cold points in the home and make residents aware of where measures are needed. This has a direct effect on comfort and therefore also on trust in the sustainability.
- Organizing short-term sustainability actions so that residents see that something is happening and supporting (existing) neighborhood initiatives contributes to trust in the neighborhood.
- Municipalities also engage energy consultation groups to ask for advice on how residents experience the energy transition and what perspectives they have on the transition.
- Promoting knowledge of natural moments, such as the need to replace an old central heating boiler, encourages customers to examine alternate energy sources and make more informed, sustainable decisions.
- Gaining trust and appealing to early adopters are critical for increasing community participation and driving development by low-income homeowners. Establishing a recognized face as a trustworthy point of contact is critical in community development activities in the form of an energy desk in the neighborhood where people can come by with questions. This can be from the municipality, the energy supplier or even the housing association.
- Municipalities that have gained experience indicate that encouraging people to participate in the energy transition requires a personal approach, involving residents in the projects and allowing residents to think along and participate from the start and giving them choices.

#### **5.4.3 Comfort interventions**

Key interventions for comfort include:

- Many municipalities have embraced the concept of energy trainers, fixers, and consultants, frequently offering free energy scans or reports performed by independent specialists. These assessments provide homeowners with information about prospective energy-efficiency initiatives for their properties.
- In some municipalities, the municipality or a consultant hired by the municipality handles the subsidy application for the resident. Consultancy companies are also hired to provide energy advice and help with estimating quotes to relieve pressure and tension.
- However, many municipalities believe that ambassadors will play an important role in the energy transition. A model home also contributes to comfort, so homeowners can see and feel what the home looks like after energy-efficient renovation. Ambassadors, made up of satisfied locals who share their good post-project experiences, act as powerful advocates, inspiring others to join the transition. Workshops for natural gas free living and cooking are organized for this same reason.
- To assist homeowners in their decision-making and streamline the process, one of the municipalities has created both a long and short list of suppliers, which they have sent to residents. Additionally, they organized "speed date" sessions with suppliers to help homeowners make their final choice.

- Unburdening is a great incentive because it reduces the stress and hassle for homeowners. As described above, municipalities help unburden homeowners by coordinating quote requests and guiding them in choosing trustworthy contractors for the work.
- Municipalities develop a plan for the neighborhood or district together with residents and other stakeholders, in which residents have a say in which energy system is installed in the neighborhood or street, which helps to create support and helps determine the success of the project.
- A final incentive related to comfort is that residents have the opportunity to participate in and contribute to the neighborhood's redevelopment once the heating network has been installed and the streets have been excavated. This involvement allows them to influence the post-construction improvements, enhancing their living environment.

#### **5.4.4 Environment interventions**

Interventions discussed in the interviews for environment are:

- It appears that the experience of the municipalities is that low-income homeowners do not perceive the environment as an incentive, because generalized low-income people do not seem to be concerned about it. Almost all municipalities indicated in the interviews that the environment is not a motive for low-income homeowners, because low-income homeowners are concerned with other things than the environment and sustainability in their daily lives.
- Interventions deployed by municipalities help raise awareness of the need for sustainability among homeowners by providing insight into their energy consumption and behavior and by sharing energy-saving tips. Furthermore, interventions focused on environment are mostly related to another motive (financial, trust, or comfort).

Table 16 Interventions for energy renovation from the expert

Interventions	Financial	Trust	Comfort	Environment
<i>Motivation</i>	<b>Subsidies</b> <ul style="list-style-type: none"> <li>- Subsidy for cooker</li> <li>- Municipal subsidy in addition to national subsidy</li> <li>- Subsidy in advance, based on an advance quotation</li> <li>- Subsidy for heating network connection costs</li> </ul> <b>Loans</b> <ul style="list-style-type: none"> <li>- Special sustainability loans</li> <li>- Special loan from municipality 1.2%</li> </ul> <b>Discounts</b> <ul style="list-style-type: none"> <li>- Percentage discount on fixed heating network costs</li> <li>- Connection to network and heating set installation for free (worth 6K)</li> </ul>	<b>Participation</b> <ul style="list-style-type: none"> <li>- Branding</li> <li>- Information desk</li> <li>- Community building</li> <li>- Festival/ neighborhood parties linked to Dutch public holidays</li> <li>- Supporting (existing) neighborhood initiatives</li> </ul> <b>Homeowners' involvement</b> <ul style="list-style-type: none"> <li>- Resident panel</li> <li>- Public support measurement</li> </ul> <b>Communication</b> <ul style="list-style-type: none"> <li>- Clear communication which alternative to natural gas</li> <li>- Clear gas end date in neighborhood</li> <li>- Neutral digital place where all information is available</li> <li>- Trusted advisors</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Workshops for living/cooking natural gas free</li> </ul> <b>Information and advice</b> <ul style="list-style-type: none"> <li>- Municipalities offer help with home improvements</li> <li>- Energy coaches</li> <li>- Energy fixers</li> <li>- Energy advisors</li> <li>- Energy scan/ report</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Awareness</li> <li>- Behavior</li> </ul>
<i>Information search</i>	<b>Financial assistance</b> <ul style="list-style-type: none"> <li>- Gas contracts guarantee scheme for compensation for gas costs</li> <li>- Offer cost comparison</li> </ul>	<b>Information and advice</b> <ul style="list-style-type: none"> <li>- Consultative group energy cooperation</li> <li>- Neighborhood/ participation platforms (Digital) newsletter, website, flyers, letters, magazine</li> <li>- Energy desk in the neighborhood where people can come by with questions</li> <li>- Model home in the neighborhood where residents can see what the home looks like after renovation</li> </ul>	<b>Supplier assistance</b> <ul style="list-style-type: none"> <li>- Long- and shortlist suppliers</li> <li>- Speed dates with suppliers before choosing</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Saving tips</li> </ul>
<i>Evaluation</i>	<b>Financial assistance</b> <ul style="list-style-type: none"> <li>- Help with insight into current and future costs</li> <li>- Collective purchasing campaign</li> </ul>	<b>Communication</b> <ul style="list-style-type: none"> <li>- Provide a contact person during the project</li> <li>- Be transparent about costs</li> </ul>	<b>Comfort assistance</b> <ul style="list-style-type: none"> <li>- A consultant company provides energy advice and assistance in quote evaluation</li> <li>- Municipality/consultant arranges the subsidy application for the resident</li> </ul>	
<i>Decision</i>	<b>Financial assistance</b> <ul style="list-style-type: none"> <li>- Guidance in completing the subsidy application</li> <li>- Help with choosing a quotation</li> </ul> <b>Communication</b> <ul style="list-style-type: none"> <li>- Special offer with clear expiration date</li> </ul>	<b>Communication</b> <ul style="list-style-type: none"> <li>- Respond to natural moments (replace CV boiler)</li> </ul>	<b>Unburdening</b> <ul style="list-style-type: none"> <li>- Focus on unburdening</li> <li>- Guidance in completing the subsidy application</li> </ul>	
<i>Satisfaction</i>		<b>Service</b> <ul style="list-style-type: none"> <li>- WOAB (home subscription)</li> </ul>	<ul style="list-style-type: none"> <li>- Continuous support and maintenance services</li> </ul>	
<i>Sharing</i>		<b>Education</b> <ul style="list-style-type: none"> <li>- Ambassadors who already adopted natural gas free</li> <li>- Sustainable housing route to see how house will look after measures</li> </ul>	<b>Education</b> <ul style="list-style-type: none"> <li>- Model home in the neighborhood</li> </ul>	
<i>Specific for low-income homeowners</i>	Interventions mentioned above are all for low-income homeowners			

#### 5.4.5 Interventions specific for low-income homeowners

As mentioned earlier, the target audience for the interviews was clearly defined as low-income homeowners. During these interviews, participants were specifically asked which interventions they felt were most applicable to low-income homeowners based on their experiences. The consensus was that financial and trust-building interventions were considered most crucial for this target group. Furthermore, all the interventions mentioned are applicable to low-income homeowners and these interventions have been frequently used in the phasing out of natural gas projects.

#### 5.4.6 Interventions related to the customer journey from interviews

Throughout Hamilton's customer journey, the interventions found during the interviews play an important part at each level. Figure 13 is an overview of the interventions associated with the phase of the customer journey. During the motivation phase, financial interventions such as municipal grants, special sustainability loans, and subsidies for specific costs (e.g., connection fees for the heating networks) can encourage homeowners to begin considering renewable energy solutions. In addition, to increase awareness among homeowners, support from energy consultants and practical tools in the form of opening model homes and organizing workshops contribute to a positive experience and evaluation of the product. During the information search phase, information points, newsletters, and neighborhood platforms provide valuable information and increase consumer trust in new technologies. In the evaluation phase, energy coaches, energy consultants, and energy reports help homeowners interpret and evaluate available home reports and offers from for example the municipality. In the decision phase, assistance in completing grant applications and advice on supplier selection makes it easier for homeowners to make the decision to invest in energy-efficient measures. In the satisfaction phase, keeping in touch with homeowners about how things are going now after the adjustments leads to a reduction in complaints, contributing to a better final phase. Finally, in the sharing phase, model homes, neighborhood initiatives and festivals strengthen community spirit and motivate customers to share their positive experiences, which in turn can attract other homeowners to join.

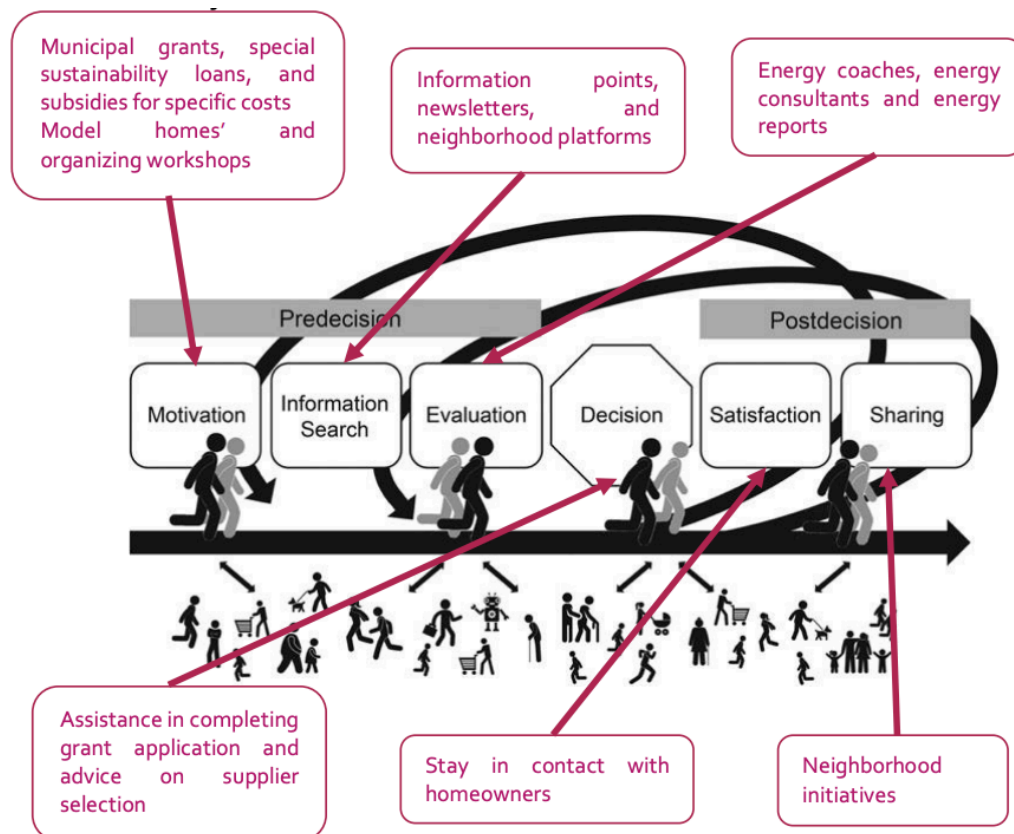


Figure 13 Overview of interventions on phase in customer journey

## 5.5 Conclusion

The results from this chapter help answer sub-questions 1 and 2. Although the previous chapters focused on the literature and current policies, the interviews provide additional information.

Therefore, this chapter provides a brief addition to sub-question 1. Based on the interviews, financial constraints emerge as the main barrier, compounded by concerns such as fear of loans and the inconvenience associated with renovations. Furthermore, trust and comfort are also experienced as barriers, but environment is not mentioned.

Furthermore, the focus of the interviews was mainly on interventions, which answers sub-question 2. It appears that the most important interventions for low-income homeowners are primarily financial interventions, including grants and sustainability loans, which stand out as key motivators, easing the financial burden and encouraging participation. Furthermore, interventions to build trust are also important, such as community involvement and open communication, which are crucial to removing mistrust and gaining support for energy transitions. Interventions to improve comfort, such as energy consultants and model homes, which seek to reduce uncertainty and enable informed decision-making, are also mentioned in the interviews.

While environmental considerations may not motivate low-income housing as much, there are efforts to incorporate sustainability into larger community development programs. Identifying best practices and recognizing worst practices highlights the need for adapted methods and successful implementation techniques in promoting sustainable energy solutions. Key worst practice interventions include inaccurate or constantly changing information, ever-changing plans and confusing communication from the municipality to residents.

## Chapter 6 Further analysis and synthesis

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This chapter presents the results of the study. The chapter begins with a summary of the findings from the literature and expert interviews. Next, a comparison of best and worst practices is presented. The findings are then compared to current policies. The chapter concludes with a conclusion.

### 6.1 Confluence of findings from literature review and expert interviews

This section combines the findings from the literature review with the insights gained from the interviews. The literature provides a theoretical framework and an overview of existing information, whereas the interviews offer useful practical experiences and personal viewpoints. This combination identifies both theoretical and practical components of the problem, resulting in a deeper knowledge of the barriers and potential solutions. While the literature largely discusses broad, overarching interventions, the interviewees focused on unique, localized solutions and experiences.

The first similarity between the literature and the interviews is that both sources clearly indicate that financial motives are the biggest driver for homeowners, especially those with low incomes. Both the literature and the interviews emphasize that financial incentives are essential to encourage homeowners to take sustainable measures. While the literature states that loans can be an effective intervention to support homeowners, the interviews reveal that low-income individuals are often reluctant to take out loans. This represents an important difference between theoretical recommendations and practical reality. However, there is agreement on the importance of subsidies, grants and other forms of financial support. Both sources view these as essential tools for promoting household participation and making the switch to renewable energy more attractive and affordable.

Another important similarity between the literature and the interviews is the importance of trust and participation. The literature shows that trust in stakeholders, such as government and suppliers, is essential to the success of sustainability projects. The participation of residents is often mentioned in the literature as a crucial factor in creating support and increasing commitment to the energy transition. Trust and participation were also confirmed as very important motives in the interviews. Although in some municipalities' participation seems to have less priority, because in these municipalities the residents themselves are eager to participate in the transition to natural gas-free living. Here the residents themselves led the transition, and the focus of the municipality is on other aspects. In other municipalities where this is not the case, focusing on the active involvement of residents proved crucial to achieving the desired results. Consequently, many municipalities used many measures to increase trust and participation. Especially in lower-income neighborhoods, involving residents is essential because they are often skeptical about changes that may affect their financial situation or comfort.

Although most interviewees were not familiar with the concept of the customer journey according to Hamilton's model, the interviews indicated that most people are probably still in the motivation phase. This means that they are not yet fully motivated or prepared to switch to natural gas-free living. This indicates that municipalities should take this into account in the interventions they will deploy. Both the literature and the interviews indicate that the customer journey is often perceived as complex and time-consuming. Applying for permits, subsidies, and going through administrative procedures are often mentioned as major bottlenecks. These bureaucratic obstacles can discourage homeowners from taking sustainable steps. Both theoretical and practical sources therefore stress that simplifying these processes is essential to increasing homeowner participation and accelerating the energy transition.

The literature does not identify the environment as a barrier, but it does describe the environment as an important motive for switching to renewable energy. This turns out to be the biggest contradiction between the literature and the interviews because almost all interviews showed directly that for low-income homeowners the environment plays no role whatsoever in their decision whether or not to phase out natural gas. For that matter, the environment is not a barrier either, as the interviews show. For this group, financial considerations, such as cost savings and affordability, are central. They have little affinity for the broader energy transition or environmental goals and make their decisions primarily based on immediate financial benefits, such as lower energy bills or subsidies. This highlights the importance of financial incentives over environmental awareness in engaging lower-income homeowners in the energy transition.

Another contradiction is that both the literature and the interviews show that increasing comfort can be an important motivation for residents to make their homes more sustainable. The literature mentions various measures such as requesting free advice and municipal assistance to improve comfort that homeowners can already do themselves, but the interviews show that many homeowners are not aware of the possibility of achieving significantly more living comfort through sustainable measures in addition to financial benefits and do not know where to find this help or that this help even exists.

Especially recent developments in the Netherlands regarding the negative news about completed natural gas-free projects in some municipalities were mentioned in the interviews as demotivating. This was seen as a major barrier for homeowners to make the switch to alternative energy sources. In contrast to the literature, which often does not mention these challenges, concerns about these failed projects emerged strongly in the interviews. This highlights the need to take these negative experiences seriously when planning future transition projects.



The interviews also mention specific examples that contribute to increasing living comfort, such as the use of energy fixers, energy coaches and advisors. These practical interventions, which help residents optimize their energy use and improve their homes, are less prominent in the literature. This points to a difference between the theoretical approach and the practical implementation, where practical experiences are more focused on direct, personal support for homeowners. Both the literature and the interviews therefore indicate that comfort is an important motive, but the interpretation of this motive is different in both cases.

The literature emphasizes that building codes, such as energy efficiency standards, are essential to the transition to natural gas-free buildings. Targeted policies and environmental certifications can also contribute. Interestingly, these interventions, while important, are not mentioned in any of the interviews, with the exception of energy policies to reduce CO<sub>2</sub> emissions by switching to renewable energy and being natural gas-free by 2050.

## **6.2 Comparison of best and worst practice interventions**

With both the best and worst practices identified, they can be compared to get insight into key success factors and discover potential challenges. Both types of methods focus on critical components of interventions to encourage homeowners to phase out natural gas. The best and worst practices emerge from the literature analysis and interviews. Table 17 compares best and worst practices for each intervention. The text boxes on either side show examples from the case studies and link them to the interventions, indicating whether they are best- or worst-practice examples.

Table 17 Overview best and worst practice

	 <b>Best practice</b>	<b>Intervention</b>	<b>Worst practice</b> 	
	Strong, tailored financial incentives that meet the needs of different homeowners	Financial assistance	No financial incentives, which reduces motivation to participate	
Case study 1: Extensive care, each resident approached individually, assistance with subsidy applications	Clear and consistent communication throughout the project from the start	Communication	Lack of communication, leading to confusion and frustration	Case study 4: Technical and legal obstacles caused delays
	Collaboration with all stakeholders; municipality, energy cooperation, contractors, residents	Collaboration	Limited or no collaboration, resulting in disjointed efforts and lack of a unified approach	
Case study 4: Initiative comes from the residents and residents play a central role in cooperation with the municipality	Inclusive participation of homeowners and local community in project development and implementation	Participation	Exclusion of residents from participation, reducing sense of ownership and acceptance	Case study 3: No clear offer and lack of governing role municipality
	High level of homeowner involvement from the start in decision-making processes	Homeowner involvement	Late involvement of residents, making them feel excluded	
Case study 4, 5, 6: Using creative ways to reach residents	Providing clear, accessible information and advice about the project	Information and advice	Lack of accessible information, leaving residents unsure about project details	Case study 5: Informing residents too quickly and incompletely, which made residents feel ignored, which led to resistance
	Education of residents about possible interventions and home improvements	Education	No educational support, causing residents misinformed of potential improvements and benefits.	
	Sharing examples of local successes to build confidence (model home)	Examples from the area	No examples for homeowners, which means they have no insight into changes after adjustments	
Case study 5: Model home in the neighborhood where people could come and take a look	Ongoing support and personal guidance tailored to the needs of homeowners	Support & guidance	No guidance causing homeowners to become unmotivated and 'lost'	
	Stick to a well-structured, predictable schedule as much as possible	Project planning	Constant changes in planning, causing uncertainty and loss of confidence	
	Personal approach with one-on-one consultation for homeowners	Personal approach	Impersonal approach with minimal direct communication, which damages community and trust	Case study 3: Changing project managers created distrust and uncertainty among residents
	Consistent contacts to build good relationships and trust with homeowners	Consistency in contacts	Constantly changing contacts, making it difficult for homeowners to know who to contact and to rely on	
Case study 5: Municipality organized speed dating that residents gained trust	Reliable partnerships with transparent and trusted contractors	Reliability of partners	Unreliable partners, which raises doubts about the quality and safety of the project	Case study 5: No good agreements, so business cases fell through
	Help with suppliers through long lists and speed dates	Supplier assistance	Lack of guidance from suppliers, leaving homeowners unsure which suppliers they will hire	
	Offering support for comfort improvements to enhance living conditions	Comfort assistance	Lack of comfort-related guidance, no change in comfort and no motivation	
	Setting clear standards and norms for quality and sustainability	Norms	Absence of established norms, leading to varying quality and unmet sustainability goals	

In both best and worst practices, communication is considered essential. Communication is important with homeowners, project managers, and contractors. In best practices, communication is organized in a timely, transparent manner. Successful project planning focuses on properly setting and achieving set goals and shows that it is crucial to deviate from the plan as little as possible, but if adjustments are needed, this should be communicated in a timely and careful manner. In contrast, a worst practice often arises when communication is too early, unclear or not well thought out. If the route becomes unclear and too much chaos ensues, it leads to project failure. One example is a municipality that had 7 different project leaders in 4 years, where residents no longer had trust in the project, and the project dropped as a result. In both cases, communication is a key factor for success or failure. Consistent communication with homeowners through a dedicated point of contact helps maintain trust and ensure smooth communication. Frequent changes in contact people can cause confusion and weaken the relationship. Another best practice is to set clear deadlines, which is also part of communication. This way, homeowners know where they stand and the plans for the neighborhood stand and can make their own timely decisions regarding phasing out natural gas in their homes or take up the municipality's offer.

Another important aspect of communication is the relationship between homeowners and project managers, which plays a pivotal role in ensuring the success of the initiative. Best practices focus on involving homeowners early, as early involvement in decision-making fosters a sense of ownership and commitment from homeowners, whereas late or retrospective involvement can lead to feelings of exclusion and disengagement. Again, clear and consistent communication throughout the project helps keep homeowners informed and avoid confusion and frustration. Without this transparency, homeowners may feel they are being kept in the dark, which damages their trust in the project. Moreover, it appears that cooperation between different stakeholders is important. A well-organized division of roles with different stakeholders is an important point for a successful project. A best practice is the cooperation of different stakeholders, where roles are well divided, each party has clear responsibilities and clarity is created. A worst practice is when there is chaos in the division of roles. For example, a project with eight different project leaders over four years led to distrust among residents, which seriously hindered progress. Furthermore, best practices emphasize the importance of rewarding residents for their efforts. Not compensating them for their contribution is a common worst practice, which can lead to a lack of motivation and participation.

Additionally, in both practices, it is recognized that clear goals and realistic planning are essential, which is done through communication. In best practices, goals are strictly monitored, and adjustments are reported on time. Worst practices fail precisely by deviating too much from the planning or missing decision moments.

Next, a personalized approach, including one-on-one consultations, is important because it strengthens the relationship between homeowners and the project team. Personal communication makes homeowners feel heard and valued, which fosters a sense of community. In contrast, an impersonal approach can alienate homeowners and undermine trust. In addition, ongoing support and personal guidance are also essential to keep homeowners engaged and confident throughout the project. Individualized support helps homeowners face challenges and feel encouraged and supported. If this support is lacking, homeowners may feel abandoned and overwhelmed, which can lead to dropping out or postponing the project.

Furthermore, participation is a topic in best and worst practices. In successful projects, it has been shown that a large part of the success factor has to do with initiatives that come from the residents themselves, with the municipality playing a supporting role, which contributes to more involvement and ownership. Best practices stimulate participation by actively involving residents and appreciating their efforts. In worst practices, there is often a lack of involvement or compensation, which

demotivates residents. Both indicate that resident participation is an essential element, but the way in which this is implemented determines the success.

Effective information and advice interventions play a crucial role in motivating homeowners to participate in sustainability projects. Best practices involve providing clear, personalized guidance that is easy for homeowners to understand and access. By using multiple communication channels—such as workshops, brochures, online resources, and in-person consultations—projects can reach a broad audience and build trust. In contrast, interventions that rely on generic or overly technical information and a single communication method often leave residents feeling confused or overwhelmed, resulting in lower participation rates. Additionally, educational interventions are equally important in encouraging sustainable practices. Successful initiatives use interactive workshops, demonstrations and practical guides that make energy-saving techniques both relatable and actionable for homeowners. Engaging local experts or community members in these sessions can further increase relevance and appeal. Sharing examples of successful local projects, such as model homes, can build trust and reduce skepticism. Without such examples, homeowners may be hesitant to get involved, unsure of the project's success. Additionally, providing follow-up support helps sustain homeowners' motivation and ensures long-term engagement. On the other hand, passive, overly theoretical presentations without practical relevance or any follow-up often fail to inspire participants to act on the information provided.

When tailored to individual needs, financial assistance plays an important role in motivating homeowners to participate. These incentives can be anything from subsidies, discounts or free products, making the project more accessible and encouraging involvement. In contrast, the lack of financial incentives can lead to reduced motivation and hinder participation. The interviews even indicated that without financial support for homeowners, especially those with low incomes, the projects are already not feasible because these people do not have money left over for investments in their homes. In addition to financial incentives, offering comfort and supplier assistance are effective strategies to encourage homeowners to phase out natural gas. The absence of these incentives, however, significantly reduces motivation and interest, especially among those who may not be aware of the available comfort improvements and reliable suppliers. Poor communication or delays from contractors can leave homeowners frustrated and disengaged, causing the project to stagnate while comfort improvements allow residents to see what the improvements will bring, which only encourages more adoption of energy efficiency measures. Providing proactive guidance is essential to make homeowners aware of how these upgrades can enhance their living conditions while contributing to environmental goals. Targeted policies, which ensure that support is effectively directed to those who need it most, will also help to reach these residents. Communication with and reliability of contractors is also important. Best practices are working with reliable and transparent partners to ensure high quality and safe work. Worst practices leave residents waiting for contractors and leave residents with nothing to do with them, causing the project to stagnate.

Finally, implementing clear standards is a best practice as they give homeowners a sense of security and trust, especially when it comes to suppliers and comfort upgrades. These standards ensure consistent quality and promote sustainable practices by setting reliable standards that help both suppliers and residents make responsible choices. Standards around quality and sustainability assure homeowners that the products and services they choose meet certain benchmarks, increasing the overall credibility of the project. This approach not only increases resident trust but also encourages long-term commitment and a commitment to energy-efficient living.

### 6.3 Comparison with current policy

The literature review and interviews indicate that there are several aspects of current policy that could be improved to optimize homeowner engagement in housing projects. By comparing best and worst practices with the existing policy, the following areas for improvement emerged.

Firstly, financial incentives play a crucial role in motivating homeowners to participate in the project. As seen in previous chapters of this research, there are already several initiatives in the Netherlands for homeowners to make their homes more sustainable. However, current policies often provide standard incentives without tailoring them to the specific needs of different homeowners and interviewees indicated that some residents are not reached anyway who would be entitled to the initiatives, making them less effective for a diverse target group of homeowners. Best practices recommend personalizing incentives and guidance to better fit participants' individual financial and emotional needs. Since the literature review and interviews indicate that financial support is a strong motivator, it should not be discontinued but rather strengthened and tailored to different situations.

Although the Dutch government has already made considerable efforts to achieve energy targets—with subsidies such as the SVOH and soon the WIW and WGIW, and initiatives such as the PAW—both the literature and interviews show that these interventions are not enough on their own. In addition, the government states that municipalities have a directing role in energy transition but do not yet support it enough. The government should further help the municipalities is by recording and unifying the offer to homeowners. First, because low-income homeowners often do not know where to find the subsidies and therefore miss out on them, even though these schemes are intended for them. Second, it is necessary to deploy additional interventions to effectively encourage homeowners to participate in the energy transition. A complete and clear offer is essential here. In addition to financial incentives, legal and technical aspects must also be explicitly named so that homeowners are better informed and feel supported. This not only provides more certainty for them but also enables municipalities to steer more precisely. Although a uniform approach is not feasible because of the differences between neighborhoods and residents, it is necessary to develop a national guideline. Such a guideline should provide clarity on the long-term goals and requirements of the energy transition, giving both municipalities and residents greater certainty about the steps to be taken. Interviews revealed that both residents and municipalities struggle with the uncertainty created by the lack of consistency from the government. This uncertainty leads to reluctance to make decisions, which slows the pace of the energy transition. Creating a clear national framework can help reduce these obstacles, speed up the process, and increase homeowner involvement.

Not only the financial incentives need to be tailored, but the entire process needs to be made understandable and personalized for all residents. In doing so, the current communication strategy can also often prove inconsistent, with only occasional updates and ever-changing project leaders. This often leads homeowners to confusion and uncertainty about project progress and content. Best practices highlight the importance of frequent, transparent communication, where homeowners are regularly informed of both successes and obstacles within the project. This ongoing provision of information can increase trust in the project and reduce frustrations.

Lastly, policies to accelerate the sustainability of the built environment could be more focused on helping homeowners by providing better information. The interviews showed that municipalities often have information about existing policies, but that residents often do not know about them or do not know where to find them, leaving them in the first phase of the social customer journey. It has also been written before that applying for subsidies is a difficult process. The distribution of information about sustainability measures and interventions should therefore be improved.

In comparison with other countries, the Netherlands can do the following. In addition to financial interventions, the Netherlands could focus more on raising awareness, stimulating motivation among homeowners, and strengthening collaborations with various stakeholders. Important additional steps include putting pressure on energy suppliers to make more sustainable choices and strengthening the governing role of municipalities. This requires clear policy objectives, significant investment in infrastructure and technology, and the ability to overcome barriers such as financing and innovation. Denmark's experience shows that a successful energy transition is achievable, provided there is continued cooperation and investment. Dutch policy can benefit from this by embracing this integrated approach and approaching the challenges of energy transition from multiple perspectives.

#### **6.4 Conclusion**

This chapter focused on answering sub-question 4. From the convergence of the findings from the literature review and the expert interviews, it became clear that they were largely similar. The interviewees validated the importance of financial, trust-related, and comfort-related interventions, as emphasized by both sources. While the literature primarily discusses broad, overarching interventions, the interviewees provided insight into more local and context-specific solutions based on their unique experiences.

The findings show that a single intervention in supply is not enough to have a major impact. Instead, municipalities must use a variety of tailored interventions to effectively encourage residents to participate in the transition. The overview of best and worst practices provides a picture of the many interventions that municipalities can implement. It identifies which measures should be emphasized and warns of inefficient or harmful techniques that may impede progress. Furthermore, the section comparison with current policies provided an answer to sub-question 3. According to the study, current Dutch initiatives are on track. However, there are still opportunities for improvement to enhance homeowners' involvement in transitioning away from natural gas. By examining practices in other countries undergoing energy transitions, the Netherlands could develop a more comprehensive approach. This could include setting ambitious goals, increasing awareness and motivation among homeowners, fostering collaborations between various stakeholders, and providing stronger support for municipalities in their coordinating role. This synthesis of possible solutions demonstrates the importance of evaluating the data from multiple approaches and current policies, as well as comparing best and worst practices. These interventions are transformed into actual, actionable best practices. These findings provide input for the presentation to RVO and NPLW, as well as a solid foundation for applying the findings in practice.

## Chapter 7 Conclusion

The final chapter of this research brings together the key findings and insights. The chapter opens by answering the sub-questions, systematically addressing the results of each sub-question. The chapter then answers the main research question, summarizing the core conclusions of the study. Following this, the limitations are discussed. The chapter concludes with recommendations, distinguishing between recommendations for future research and recommendations for practice.

### 7.1 Conclusion sub-questions

To answer the main research question, the sub-questions are again named and answered below.

**Sub-question 1:** *What barriers do low-income homeowners face when participating in the energy transition and phasing out natural gas in Dutch municipalities?*

Both literature and expert interviews were used to answer this question. It is clear from these sources that the main barriers for low-income homeowners to switch to natural gas-free alternatives are primarily related to financial and trust motives. Financial barriers include a lack of money and limited access to financing options, making sustainable upgrades unfeasible for many homeowners. Trust issues stem from a lack of trust in government policies due to inconsistent and unclear communication. Political instability and fear of changing regulations exacerbate this, leading to uncertainty for homeowners. In addition, many low-income homeowners struggle to meet their basic needs, leaving little mental or financial capacity to consider energy-saving measures.

Other major barriers include a lack of knowledge and awareness of available subsidies and alternatives, worsened by the complexity of application procedures for these programs. Comfort and convenience also play a role. Comfort and convenience also play a role, as many homeowners are reluctant to make changes that could temporarily disrupt their living situation. Low-income homeowners experience barriers in all phases of the social customer journey, but especially during the motivation and information phases. This is because they often find themselves in these phases and due to the barriers, they often do not move forward in the process, dropping out before reaching other phases.

The typically long lead times for building heat grids, compounded by unforeseen delays, further diminish trust and motivation among residents. Hassle and inconvenience during the work and uncertainty about the cost and revenue after the work are also barriers for homeowners. The lack of technical support during and after the installation of energy-saving measures leaves homeowners feeling unsupported and discouraged.

Interestingly, environmental considerations do not seem to be a significant barrier for low-income homeowners, as they are generally motivated more by immediate financial and practical considerations than by long-term ecological benefits.

**Sub-question 2:** *What are the interventions by Dutch municipalities to help low-income homeowners participate in the energy transition and phase out gas?*

In the Netherlands, several interventions are implemented by municipalities to help low-income homeowners participate in the energy transition and phase out natural gas. The interventions in this research were found through literature review and expert interviews and were structured using two frameworks: the social customer journey and the motives for making choices. The key interventions identified focus on three main motives, which are financial, trust, and comfort-based.

Firstly, the research has found that financial interventions are very important for low-income homeowners. Best practices include offering a variety of subsidies such as grants and discounts or providing small free energy-efficient measures. Group purchasing programs are another effective strategy, helping residents' lower costs through collective action. Additionally, providing homeowners with clear and detailed cost breakdowns or suppliers ensures transparency as well as aiding in effective planning and decision-making.

Building trust among residents is essential for successful energy transition initiatives. Municipalities can achieve this by actively involving homeowners in phasing out natural gas projects and sharing peer success stories to inspire homeowners to join. Public awareness campaigns are used to increase knowledge in the neighborhood; through brochures, flyers, newsletters, dedicated websites, and branded participation platforms homeowners are informed which helps increase visibility and foster connection with homeowners. Events such as drop-in evenings, themed Q&A sessions, consultation hours, and neighborhood surveys create open communication, allowing homeowners to voice concerns, ask questions, and share their interests.

Interventions related to comfort are intended to decrease the stress and hassle associated with energy transition. Simplifying application processes and offering practical help, often known as "unburdening," has been found extremely beneficial. Customized advice tailored to each homeowner's specific circumstances increases trust and involvement. Energy ambassadors, who serve as trusted local consultants in the neighborhood, play an important role in assisting and guiding homeowners through the process. Interventions such as model homes and energy counters in the neighborhood provide practical venues for homeowners to experiment with energy-saving solutions and visualize the results. Although the literature states that the environment is an incentive, the interviews show that this is not the case.

Interventions for low-income homeowners are primarily focused on the decision-making stage of the social customer journey. This is because low-income homeowners frequently confront substantial barriers at this stage, such as financial constraints, a lack of knowledge, and mistrust of government policies. Tailored interventions in this phase, including clear communication, accessible subsidies, and technical assistance, are critical for guiding and encouraging these homeowners to take the necessary steps toward the energy transition.

In addition to best practices, the study also revealed some worst practices. First, loans as an important financial tool have proven ineffective because many low-income homeowners are unable or unwilling to take on new debts. Loans, among other financial interventions, may be acceptable, but only a small number of homeowners are willing to take on additional debt. Some low-income homeowners do not know about subsidies and do not apply for them. Difficult and time-consuming grant applications also deter homeowners from applying, while unstable financial programs that do not offer clear long-term benefits further undermine trust. Financial and technical assistance that does not explicitly target low-income homeowners often excludes this vulnerable group, preventing their effective participation.

Poor communication is another major problem, with municipalities sending conflicting or unclear messages that undermine trust. A specific example is involving local residents in exploring alternative energy sources, such as heat networks, without offering any compensation, which has led to irritation and disinterest. In addition, the poor performance of natural gas-free programs in some municipalities has raised concerns among homeowners, further reducing participation rates. Finally, the lack of effective campaigns to inform and engage citizens and the failure to address the need for behavioral change have greatly hampered the effectiveness of many programs.

While the literature focuses primarily on various single interventions, municipalities have recognized that interventions must address multiple aspects simultaneously to ensure success. Experience shows

that projects that do not pay sufficient attention to participation often fail. Conversely, projects that emphasize participation but neglect the legal or technical aspects often fail as well. Therefore, municipalities must adopt a comprehensive approach that includes participation, legal certainty, technical feasibility and financial accessibility to achieve long-term success. By combining these financial, trust, and comfort-based interventions, municipalities can effectively stimulate low-income homeowners to join the energy transition.

**Sub-question 3:** *How are barriers and interventions for participation in the energy transition currently being addressed in policy implementation?*

In the Netherlands, policy implementation is currently addressing several barriers and interventions to involvement in the energy transition. First, the government has addressed fundamental barriers such as financial constraints and a lack of knowledge through several initiatives and assistance programs. One notable example is the PAW (natural gas-free neighborhood pilots), which seeks to experiment with alternative energy systems in residential areas in the Netherlands. Other initiatives by the Dutch government include SVOH, ISDE and SAH, whereby The ISDE helps make homes more sustainable by providing subsidies for the installation of heat pumps, solar boilers, electric cooking facilities, home insulation or connections to heat grids and the SVOH focuses on the preservation and maintenance of rental housing where landlords and mixed housing owner organizations can apply for incentives under the SAH to disconnect rental housing from natural gas.

Additionally, the government is working on new legislation, such as the WCW and WGIW, to further promote the energy transition. The WCW aims to regulate and facilitate collective heat systems while providing fair access and pricing for customers. The WGIW offers municipalities instruments and legal frameworks to help them transition to sustainable and common heat solutions. These legal frameworks aim to provide clear regulations and financial incentives for municipalities and homeowners to make the shift to natural gas-free homes. Provinces and municipalities are also playing an important part in this transformation by developing neighborhood energy transition plans for phasing out natural gas and supporting and funding local initiatives. While these actions have eliminated some of the most significant barriers, legal and technological challenges remain, particularly when installing complex systems like heat grids. If these components are underestimated or overlooked, it greatly hinders progress.

Furthermore, the government as well as municipalities are working on raising awareness through public information campaigns, encouraging homeowners to participate at every stage in the social customer journey — from awareness and information gathering to decision-making and implementation. By incorporating these awareness-raising activities and addressing multiple stages in the customer journey, municipalities hope to remove obstacles that might prevent homeowners from participating in the energy transition.

Concluding on this sub-question, this question contributes to the research to understand current policy and what initiatives the government has already introduced. The Dutch government has made significant progress in implementing policies aimed at supporting the energy transition and phasing out natural gas. However, further efforts are needed to overcome existing barriers and achieve the established energy goals. More focus on legal and technical aspects, clearer communication, and increased support at all stages of the customer journey will be necessary to ensure the success of these policies. A national framework should also be developed that, in addition to homeowners, supports municipalities to provide clarity in the energy transition.

**Sub-question 4:** *Which interventions are likely to be most successful for Dutch low-income homeowners?*

The research looked at best and worst practice interventions. Best practice interventions are interventions that are deployed and help the project toward success. These interventions will have to be included in the municipality's offer to the homeowner in order to get as many people as possible on board. The research focuses on how municipalities can effectively contribute to energy transition and natural gas-free homes, with a specific focus on low-income homeowners. The following best practices have been identified that municipalities and policymakers must address when designing and implementing policies for a natural gas-free future. Effective policies should:

1. **Develop a clear policy vision**  
Municipalities should set a clear vision with concrete goals, agreements and deadlines. This gives residents trust and an overview of the transition process.
2. **Draw up a concrete and complete offer**  
A detailed offer is crucial. Consider legally and technically prepared plans, such as the location and construction of a heat network, ownership issues (municipality or cooperative), and a logical phasing, whereby insulation measures are first taken before heat networks are connected.
3. **Unburdening residents**  
Intensive support, such as energy advice, help with subsidy applications and guidance on bids, lowers barriers for residents. This makes the transition more accessible, especially for homeowners with fewer resources or knowledge.
4. **Guarantee CO<sub>2</sub>-neutral heat sources**  
The availability of sustainable and natural gas-free heat is essential to get residents on board with the transition and contribute to climate goals.
5. **Reduce costs for residents**  
It is important to minimize costs for residents, ideally even zero euros to the front door. This is especially crucial for low-income groups, so as not to burden them financially.
6. **Provide customization and choice:**  
Policy interventions should be flexible and tailored to the diversity within the target group. For example, freedom of choice can be offered in how residents implement the measures: do it themselves or purchase, obtain subsidies in advance, and determine how much advice they want to receive.
  - For low incomes: intensive guidance on subsidies and practical support.
  - For higher incomes: advice and support in evaluating bids and implementation.
7. **Support residents' initiatives**  
Especially in projects where the initiative really comes from the residents, it is important that the municipality provides a supporting role, with the municipality acting as a supporting link between the resident initiative and other parties.
8. **Do not underestimate the power of neighbors in neighborhoods**  
In addition to supporting residents' initiatives, it is also very important to rely on the power of neighbors and ambassadors, because they have a direct impact on fellow residents by building trust and sharing positive experiences. Ambassadors can serve as role models and increase engagement by answering questions and sharing success stories.

To make the energy transition successful, it is important for municipalities to avoid specific worst-practice interventions. These approaches increase the likelihood of failure, discourage residents and can lead to delays and inefficiencies. Below are some worst practice interventions that municipalities are better off avoiding:

1. **Lack of clarity on policy plans**

When policies remain vague, without clear goals, timelines or expectations, confusion arises among residents. Lack of transparency can lead to mistrust and reluctance to participate in the energy transition.

2. Accumulation of challenges

Combining multiple major challenges without a step-by-step approach often leads to complications and delays. Examples include:

- Addressing poorly maintained homes without insulating them first before installing natural gas free alternatives. If the home is not yet insulated the new source will not work.
- Introducing heat networks while technical or legal aspects (such as ownership structure or financing) are not yet worked out.

3. Uncertainty about costs

If the costs for renewable heat or other measures remain unclear, residents feel financially insecure. This hinders their willingness to invest and participate in municipal programs. By avoiding these pitfalls and focusing on clear communication, a phased approach and financial certainty, municipalities can contribute to an inclusive and efficient energy transition.

## 7.2 Conclusion main research question

***"What policies can municipalities best use to encourage low-income homeowners to switch to natural gas-free alternatives: based on motives and best practices?"***

The sub-questions all contributed to answering the main research question. Returning to this main question, the overall conclusion is as follows: municipalities can best facilitate the transition to natural gas-free living by using a combination of financial, comfort-enhancing, and trust-building interventions. Although the findings from the literature and the interviews generally overlapped, there were some reasonable differences primarily in the environment motive. Whereas the literature indicated that environment could serve as an incentive, all interviews explicitly mentioned that environment was not seen as a motive at all by low-income homeowners. Therefore, it is important to focus on, as mentioned, financial, trust and comfort interventions. Financial interventions focus on providing grants, loans or other financial support to make sustainability affordable. Trust interventions build trust through reliable information, transparency and involvement of trusted parties and by providing accurate information. Comfort interventions improve thermal comfort in the home after renovations and reduce inconvenience and hassle during renovations.

The analysis of the sub-questions reveals that the barriers and interventions for low-income homeowners in the Netherlands are well-documented, with extensive research already conducted on these topics. The interviews confirm this. Municipalities should use this information and take these barriers and interventions into account when making their policies, because by eliminating certain common barriers, trust is increased among homeowners, increasing the likelihood of a successful project.

Moreover, it is clear that Dutch municipalities have made huge advances in adopting these policies. However, it has been found that the amount of understanding and commitment differs significantly across municipalities, emphasizing the need for better consistency and coordination in the approach to energy transition across areas. Furthermore, it has been found that the offer and associated interventions are highly dependent on the municipality's chosen alternative heat source. By this is meant that if the municipality chooses to build a heat grid, different interventions are likely to be needed to encourage residents than if the municipality chooses an individual heat source. Thus, this should first be clear to the municipality and communicated to residents before the offer is presented.

Additionally, municipalities should also take into account the social customer journey, whereby it should also first be made clear which phase of this journey the municipality is in. Each stage of the journey also involves different interventions. When the municipality is in the motivation stage, interventions aimed at public awareness campaigns and information sharing are of great importance. When the municipality is in the decision phase, interventions such as assistance in completing grant applications and advice on supplier selection makes it easier for homeowners to decide how to invest in energy-efficient measures. This adds value in the process, as by including this in the offer to homeowners, the needs and desires of residents can be better addressed, thus also helping the success of the project.

In addition, it is also important to create targeted policies that specifically target groups. In this research that is low-income households, but from both the literature and interviews it seems that still some people do not know about subsidies or where to find them. Also, the application process needs to be made easier. Municipalities will therefore have to make efforts to reach these people through proper communication and collaboration with appropriate parties.

What emerges most from this study is that there is no standard procedure for phasing out natural gas. Each neighborhood, with its unique composition of residents and type of homes, requires a customized approach. Customization is essential, with interventions carefully tailored to the specific needs and circumstances of the neighborhood. While customization is inevitable, municipalities can learn from the best and worst practices of other municipalities. Keeping the financial, trust and comfort motives of residents in mind as well as sharing these best practices and pitfalls can ease the process, increase efficiency and increase the likelihood of success. As NPLW and RVO are already mapping these success projects and disseminating information, this should be expanded for smoother cooperation. This underscores the importance of knowledge exchange and cooperation between municipalities to jointly accelerate and strengthen the transition to a natural gas-free generation.

### **7.3 Limitations**

Looking back on the completed research, the following limitations can be stated:

#### **7.3.1.1 Absence of resident perspectives**

Despite gathering substantial material from the literature and expert interviews, one significant disadvantage of the current research is the lack of interviews with homeowners of natural gas-free neighborhoods. Without these firsthand perspectives, the research lacks depth and may have provided more nuanced insights into best and worst practices. This constraint is especially noteworthy because recognized practices may be unique to specific regions, communities, or demographic groupings. Local policies, community dynamics, and economic considerations all have an impact on the efficacy of these initiatives, making it difficult to generalize results without additional adaptation.

To gain a complete understanding, it is important to conduct interviews with residents in the neighborhoods as well. In addition to speaking with municipal experts, it's essential to gather insights from individuals such as low-income homeowners who live in or have transitioned to natural gas-free neighborhoods. This will help identify key factors that motivate homeowners to switch and can provide a more complete picture of barriers and ultimately best practices.

#### **7.3.1.2 Variations in project approach**

Although most of the project areas in which the interviews were conducted are considered successful, each project area took a unique approach. Due to the small sample size, the effects of different approaches could not be fully captured, which may have influenced the reliability of the results and limited the generalizability of the findings to a broader context. Differences in the implementation of

gas-free projects—such as budget, schedule, and especially resident participation—lead to varying results. These variations make it difficult to establish standardized best practices applicable to all projects. Although there are some failures, most of the projects seems to be successful in their own way, making it extra difficult to arrive at a uniform approach.

It will not be possible to design a single perfect policy for energy efficiency interventions, as local contexts require tailored solutions. Each municipality or community has unique characteristics and needs, necessitating customized approaches and surveys. Additionally, a combination of interventions is often necessary, and the effectiveness of these interventions can vary significantly from one place to another. For example, Denmark's success in distributed generation is attributed to proactive energy policies and innovative initiatives, which may not be directly replicable in other regions due to different local conditions and challenges (Vleuten et al., 2006). This underscores the importance of context-specific strategies and the difficulty of developing universally applicable policies.

#### 7.3.1.3 Influence of changing external factors and newness

Finally, changing external factors are a major limitation of this research. Energy laws, subsidies, and technologies are constantly changing, meaning that interventions that seem effective today may become less impactful or even obsolete in the future as new regulations or incentives are introduced. Moreover, best and worst practices may show positive results in the short term, while their long-term effectiveness remains uncertain. Some methods show their full impact or, conversely, shortcomings only after several years. Due to the limited time frame of this study and the relative newness of this topic on phasing out natural gas, the long-term effectiveness of these interventions cannot be adequately assessed.

Additionally, one of the biggest limitations is that development of natural gas-free neighborhoods is quite new in the Netherlands, so many municipalities do not yet know what offerings they will provide to neighborhoods to make the transition, as they are still researching this. There is also no national policy to make neighborhoods natural gas-free, so municipalities have to create their own policies and programs to transition away from natural gas consumption. This decentralized approach can cause variances in implementation and effectiveness among regions.

### 7.4 Recommendations

The above limitations lead to several recommendations. The recommendations can be divided into two parts: recommendations for future research and recommendations for practice. The recommendations are explained below.

#### 7.4.1 For future research

##### 7.4.1.1 Hypotheses for future research

From the findings of this research, the following hypotheses or a variation of these for possible future research can be established:

**H1:** Financial interventions act as motivators for low-income homeowners

The first hypothesis for future research states that low-income homeowners are primarily motivated by financial benefits when considering switching to natural gas-free solutions. Although this study and other research have shown that financial interventions work as motivators, future research could examine the relationship between different financial considerations, which is more preferred or how financial interventions are related to preferred over other interventions. The hypothesis is that financial incentives outweigh other factors, such as comfort improvements, technological innovations or interventions to build trust.

**H2:** Low-income homeowners benefit best from combined interventions

Getting low-income homeowners to participate in the energy transition requires a combination of different interventions, addressing a variety of motives. Follow-up research

could focus on which combinations of different interventions are most effective for low-income homeowners, and which are not. It could also look at how the different interventions can best be offered, such as how they are communicated to homeowners. This can be looked at through different techniques and frameworks, and perhaps with interdisciplinary research from different sectors such as communication- and behavioral research, as focusing on only a few interventions will not achieve the desired goal of being natural gas-free by 2050 and multiple sectors need to work together to achieve this.

**H3: Low-income homeowners have limited awareness in the customer journey**

It is further assumed that low-income homeowners are usually in the first phase of the “social customer journey,” namely the motivation or awareness phase. At this stage, homeowners are often not yet aware of energy-saving options and the need to switch to natural gas-free alternatives, so they are not yet actively pursuing alternatives to natural gas. Future research could focus on how to further raise awareness of the energy transition among homeowners, in addition to using government and ambassadors.

**7.4.1.2 Different perspectives to explore**

Future research should include in-depth interviews or focus groups with homeowners in neighborhoods where natural gas phase-out is planned. This new research can acquire an improved understanding of the project's potential by gathering different perspectives from residents, energy providers, and suppliers, in addition to municipalities. Engaging these stakeholders early in the process—beginning with the research phase—is essential to the success of the project.

Engaging in conversations with residents and other actors can provide additional insights into which interventions are preferred when phasing out natural gas. In addition, residents’ needs and preferences can vary widely, particularly across income groups or housing types. Capturing these nuanced differences can be challenging, and a one-size-fits-all approach to best practices may not be feasible. Moreover, involving residents who already have experience with the energy transition can provide valuable knowledge about the impact and effectiveness of different measures. These insights provide a more nuanced picture of the benefits and challenges of the transition. Ultimately, this approach can help to better align future interventions with the actual needs and priorities of the community.

**7.4.1.3 Expansion and completion of the research**

Since this study serves as an initial foundation for future research, the following recommendations are suggested to help achieve the desired results by conducting research to understand the attitudes of homeowners - especially those with low incomes - toward sustainability. This will uncover more key motivators and barriers regarding energy-efficient home improvements that will contribute to greater depth. Next, an experiment can also be conducted to back up homeowners' preferences when considering sustainable home improvements. This approach can provide deeper insight into decision-making processes in a more engaging, practical context.

Finally, it may be useful to include homeowners in mixed-ownership buildings as a separate target group, as their needs and decision-making factors may differ. These strategies enable a more nuanced understanding of the perspective of homeowners and support more tailored, effective interventions for sustainable development.

**7.4.2 For practice**

Based on the findings of the research, several recommendations can be made for municipalities, housing associations and other stakeholders involved in phasing out natural gas. Recommendations for practice mainly concern the creation and completion of future policy and the improvement of cooperation between different parties.

#### 7.4.2.1 Create complete policies and come up with a good offer

Municipalities could create a comprehensive and tailored offering for residents, which includes both short and long-term planning, clear ownership structures, natural gas-free alternatives, heat sources, and individualized solutions. It is crucial to account for the specific needs of the neighborhood residents when developing these offerings. A combination of interventions—ranging from financial support and technical advice to trust-building measures and community engagement—could be integrated to ensure maximum participation in the energy transition. This approach could help create an inclusive, effective, and coordinated process that allows for meaningful contributions from all stakeholders.

#### 7.4.2.2 Include homeowners from the start

To guarantee a successful energy transition, municipalities could involve homeowners from the start and maintain clear and consistent communication throughout the process. Homeowners could also be empowered to make their own decisions by allowing them to contribute their ideas. Through consultations, neighborhood panels or surveys involving residents in decision-making, they will feel part of the whole process, increasing their participation. As a result, it is recommended that municipalities guarantee that homeowners are involved at all times and give them a vote in decision-making and how the transition should go in a way that is most beneficial to them. This increases homeowners' trust and involvement in the entire process.

Therefore, it is important for municipalities to ensure that residents are always well informed by providing them with updates, timelines and feedback. By using different communication channels, such as newsletters, websites and social media platforms, we ensure that people are always informed and engaged, reducing uncertainty.

As is known, planning is crucial, but it is also critical that municipalities try to accommodate some of the preferences of homeowners whenever possible. This flexibility combined with linking opportunities such as sewage replacement and redevelopment and improvement of the street as well as model homes and demonstration projects will help residents understand the transition and its benefits, increasing their willingness to participate. Additionally, it is important to focus on achieving short-term goals and visible successes to ensure that momentum and motivation are maintained throughout the initiative's stated goals.

Finally, it is important that municipalities recognize and reward homeowners who contribute voluntarily to the transition. Offering incentives, compensation for the work, recognition, or other forms of appreciation will encourage continued participation and foster a sense of community.

#### 7.4.2.3 Collaboration with various parties to ensure a smoother energy transition

Lastly, it is recommended to work with householders from the beginning and act as a team in the energy transition. One of the most important bases of success in the energy transition is homeowner involvement early on, as well as the creation of a permanent team of stakeholders. This team could include members from the municipality, residents' initiatives, energy companies, contractors, and social organizations. The goal of this collaboration is to create an integrated approach in which the residents' desires and needs are always prioritized. Bringing diverse stakeholders together allows for a broader perspective on the difficulties and potential solutions. Establishing shared goals and responsibilities not only makes the process more efficient but also creates trust among the residents involved. Furthermore, inclusive collaboration provides support and raises the likelihood of a successful project.

Although several proposals have been made above, their practical implementation can be difficult due to a variety of obstacles and combining the interests of different stakeholders. It is important to recognize that real-world applications may be complex and not always clear-cut. Recognizing these limitations provides a more realistic perspective on the feasibility of the proposed recommendations.

All in all, this research has generated valuable insights into the various interventions used in projects focused on phasing out natural gas. These findings offer practical guidance that can be applied to upcoming PONG projects, helping to shape effective strategies and actions. The outcomes provide useful knowledge for developing and implementing new policies, particularly for projects aimed at supporting low-income homeowners in the transition away from natural gas.

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# Appendixes

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## Appendix A – Interview text and questions

This appendix contains the text of the invitation for the interviews and the list of questions used in the interview.

### Text question for interview

Dear Madam, Sir,

My name is Annick Pans, and I am currently working on my master thesis at TU Eindhoven Faculty of Architecture on “The best practices in natural gas-free supply to homeowners”, with a special focus on addressing low energy households and speckled property.

I understand that you are involved in the renovation to natural gas-free in the neighborhood ... in city .... as neighborhood coordinator. I would like to ask you if you would make time for an interview and thus contribute to my thesis.

The interview will be based on a conceptual model from theory. This concerns a homeowner's customer journey to an alternative, more sustainable home, in this case natural gas-free. In the interview I will present - based on the literature - different steps of the customer journey (motivation/awareness, information, evaluation and decision) as well as the obstacles and incentives that homeowners may experience during the customer journey. For my thesis, I am looking for your experience on how residents were guided during the customer journey to natural gas-free in the .... neighborhood.

I would like to hear if you are open to this and when you are available for an interview, e.g. date .....

Thank you in advance.

Kind regards,  
Annick Pans  
Master student TU/e

### Questions interviews

This is an overview of all possible questions that can be asked. I am aware that this is too many questions for an interview. During the interviews, a selection will be made based on how the conversation goes:

#### Introduction

1. Who are you and how/how long have you been involved in this project?
2. What was the initial motivation of the municipality to begin natural gas-freeing this neighborhood?
3. What kind of neighborhood is it?

#### Theoretical framework

4. What step in the customer journey is your project at?
5. Does your community have something of a customer journey or other way of engaging people?
6. Do you recognize the customer journey and motivations?

#### Motivation/Awareness

7. Are you familiar with these barriers and incentives or do you have any additions?
8. What best practices are being used in your community to reduce these barriers?

9. In what ways is the municipality trying to make residents aware of the benefits and necessity of making their homes natural gas-free?
  - a. What specific measures are these?
10. How are low-income residents specifically targeted to increase their motivation to participate in the project?
  - a. Are there community programs or initiatives specifically aimed at supporting low-income residents in making their homes more sustainable?

### **Information collection**

11. Are you familiar with these barriers and incentives or do you have any additions?
12. What best practices are being used in your community to reduce these barriers?
13. How does the municipality involve low-income residents in the process of making neighborhoods natural gas-free?
14. In what ways is information provided to residents regarding the process of making neighborhoods natural gas-free?
  - a. Are there specific channels or initiatives used to reach and inform low-income residents?
  - b. How does the municipality ensure that this information is accessible to low-income residents?
  - c. How is access to information and support ensured for low-income residents, including those who may have language barriers or limited digital skills?
15. How does the city ensure that low-income residents are adequately informed about the benefits, options and steps involved in making neighborhoods natural gas-free?

### **Evaluation**

16. Are you familiar with these barriers and incentives or do you have any additions?
17. What best practices are being used in your community to reduce these barriers?
18. How does the municipality evaluate the current level of residents' awareness and acceptance of natural gas-free neighborhoods?
19. Are specific measures being taken to reduce (energy) poverty among low-income residents as part of making neighborhoods natural gas-free?

### **Decision**

20. Are you familiar with these barriers and incentives or do you have any additions?
21. What best practices are being used in your community to reduce these barriers?
22. What specific measures are these?
23. On what criteria does the municipality base decisions about which neighborhoods to target first as part of the project?
24. Are socioeconomic factors taken into account when selecting neighborhoods and making decisions?
25. In what ways does the municipality offer financial assistance or subsidies to low-income residents to help alleviate the costs of transitioning to natural gas-free homes?

### **Usage/loyalty**

26. What are residents' reactions now that natural gas-free is in use?

### **Collaboration with parties**

27. What parties is the municipality working with in implementing the project of making neighborhoods natural gas-free?
28. In what ways are these partners helping to support residents, especially those on low incomes, during the process?

### **Progress of the project**

29. How is the project currently progressing and what milestones have already been achieved?
30. Have there been challenges in engaging low-income residents and how have they been addressed?

### **Future plans**

31. What have you as a community learned at this point?
  - a. Are there any known steps that the municipality is still going to take to further improve the customer journey of low-income residents?
32. How does the municipality plan to continue working with partners and residents to successfully complete the project?
33. How will the experiences and feedback of low-income residents be included in the policy-making process regarding natural gas-free neighborhoods?

## Appendix B – Timeline overview

Figure 14 provides an overview of the processes and timelines that different municipalities have followed in the transition to natural gas-free neighborhoods. The timelines show how the steps are structured and where the differences in approach lie. Every neighborhood has different residents, and therefore a different approach. Key decision moments in these processes include:

### Start and finish

The start and intended finish of the project

### Offer

Establishing an offer for residents

### Technical feasibility

Determining the technical feasibility of measures, such as building a heat grid or insulating homes

### Legal feasibility

Ensuring that legal frameworks are in place, such as the ownership structure of a heat company or grid management

### Business case

Developing a financially feasible model for the proposed measures

### Choice of neighborhood and measures

Identifying appropriate neighborhoods based on urgency, municipal plans, feasibility and resident needs as well as identifying and implementing specific measures, such as home insulation or installation of renewable heat sources

### Construction

The actual implementation of infrastructure, construction of heating network and housing modifications

### Financial/Subsidies

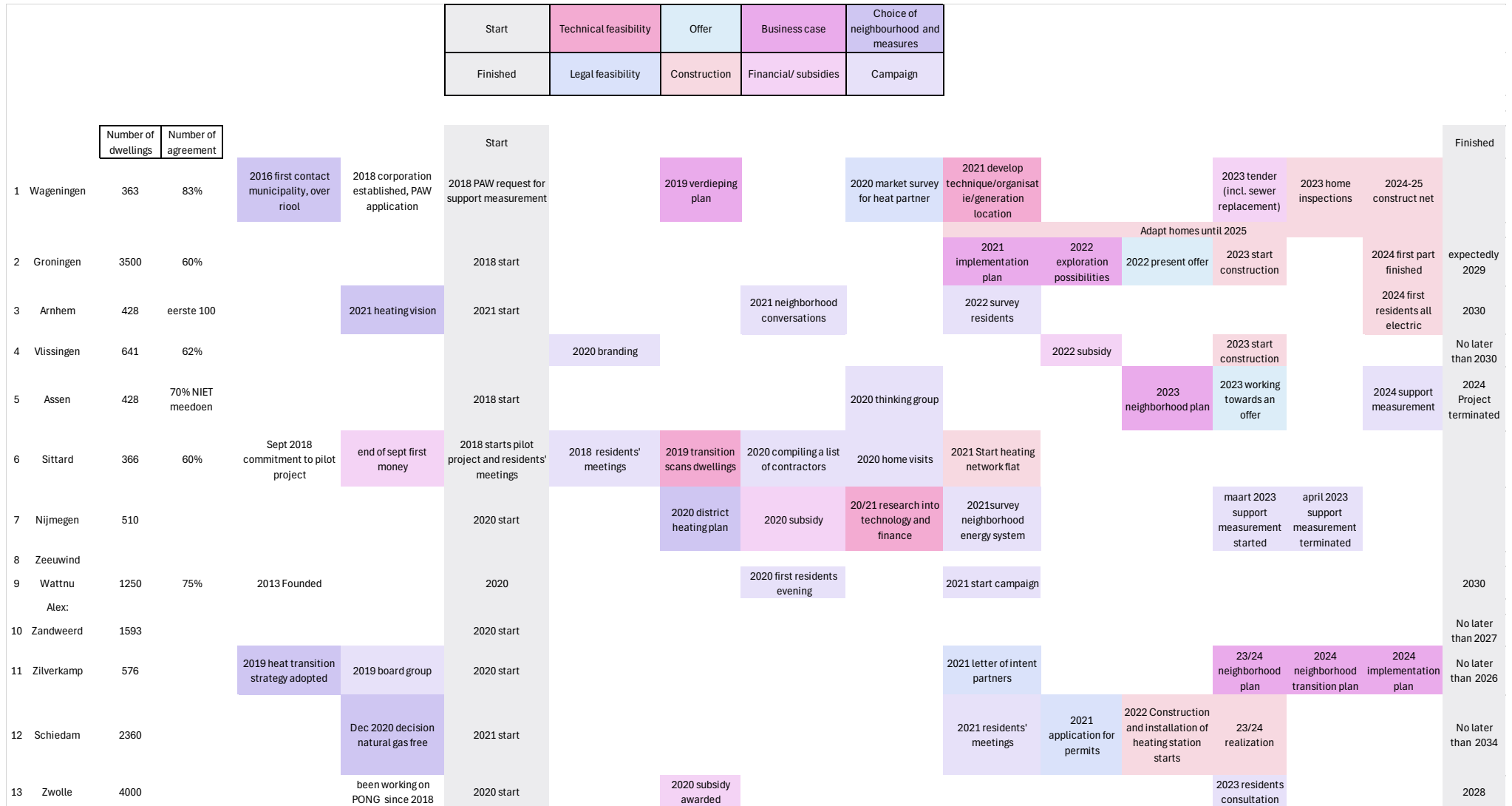
Arranging grants and financial support for residents.

### Campaign

Conducting a campaign to build support and inform residents.

The timeline provides insight into how these decisions were made in different sequences and at different speeds, depending on the local context. For example, some municipalities established technical and legal feasibility early on, while others did not take these steps until later in the process. This affected not only the speed of the project, but also the level of participation and trust among residents. It again indicates that there is no set approach that can be applied to every project, but that each neighborhood should have its own tailored approach with specific interventions.

Figure 14 Timeline overview



## **Appendix C – Further analysis from the expert interviews**

This appendix consists of deep analysis of the findings of the expert interviews. This appendix describes the barriers discussed in the interviews. Additional interventions not found in the literature are also named, both for homeowners even and mixed property. Next, the conditions of municipalities' offerings are named. Finally, worst practice interventions are described.

### **Barriers to adopting to energy efficient measures from the interviews**

During the interviews, the interviewees were asked about the barriers that homeowners experience during the energy transition. The role of the municipality during phasing out natural gas is also to unburden residents. The interviewees all indicated roughly the same barriers, with financial, trust and comfort being all important motives, especially for low-income homeowners. The biggest barrier appears to be financial support, and that people have difficulty financing sustainability. Fear of loans, hassle and shame also play a major role among low-income homeowners. Homeowners' lack of trust in the government, municipalities, energy companies and technology are also barriers. In addition, homeowners are often reluctant due to uncertainty and concerns about hassles during renovations, especially among the elderly, leading to resistance to change. Low-income homeowners' fear of inconvenience is also a barrier to not adopting energy efficiency measures. The environmental motive is the least important and does not seem to be a barrier.

### **Interventions to adopting to energy efficient measures from the interviews**

#### **Other interventions**

In addition to the above interventions, which generally arise in all conversations, a number of striking interventions have been identified. In general, municipalities participate in the energy transition, yet there are differences in approach between municipalities as well as the extent of municipalities' involvement.

- A striking intervention that did not emerge from the literature is that one of the municipalities discussed is working on plans to set up an energy cooperative. While residents from the area usually start this initiative, this municipality wants to set it up itself and be able to provide support where necessary. The energy cooperative functions as a partner in the energy transition, whereby the policy is determined democratically, and whereby residents become co-owners of the energy-efficient measure and share in the proceeds and profits are used to increase the quality of life in the neighbourhood. The starting point is also that this energy cooperative is smaller in scale and that residents run it together with the municipality. The advantages of a heating network are that local heat is used, and that the neighbourhood becomes independent of gas, the energy bill remains affordable and at the same time contributes to a better climate. If residents join one energy cooperative, as co-owners of the heating network, the profits flow back to the neighbourhood.
- One specific intervention targeting the heating company involves a municipality, in collaboration with an energy cooperative, organizing a customer council twice a year. This council brings together heating customers, uniting them as a collective entity to represent their interests. During these meetings, the current status of heating services is discussed, allowing residents to voice their opinions.
- Additionally, another municipality has developed a longlist and subsequently a shortlist of local suppliers deemed reliable. While the Consumer and Market Authority Act prohibits municipalities from selecting suppliers for private homeowners, this approach effectively lowers the barriers for homeowners, making it easier for them to find trustworthy providers.
- Lastly, some of the municipalities are using the transition to natural gas-free as a linking opportunity to also address the streets and neighborhood in the form of neighborhood renewal. Because the street has to be opened up before the work is done anyway, during

repair work the streets can be redesigned, more greenery added, and the streetscape improved. In consultation with residents, streets are redesigned and public space improved and possibly amenities added to encourage meeting and reserve space for a possible collective heat pump. Often this is also taken together to improve flooding and heat stress.

### **Mixed property**

Amongst homeowners a specific group can be distinguished - owners of dwellings which previously belonged to housing associations. Housing organizations in the Netherlands sometimes sell their properties as part of their portfolio management plans. This strategy enables them to fund new projects, renovate current properties, and maintain their financial stability (Ministerie van Binnenlandse Zaken and Koninkrijksrelaties, 2024). Between 2017 and 2021, housing associations sold and demolished almost 75.000 social rental dwellings (Kro-Ncrv, 2023). Many of these dwellings are geographically located in between the social housing properties. Housing associations are expected to make their dwellings more sustainable, primarily by improving the EFG labels before 2028 (Aedes, 2023). Owner-occupied properties located in their complexes, make this difficult. Renovations are most efficient if done by complex, but this may not be feasible from a planning perspective as the natural moment for renovation of the dwellings of the corporation and the private homeowners are not always synchronized. At the same time, the owners of the former housing association dwellings lack the technical knowledge and financial means to renovate their home and make them more sustainable.

In complexes with homeowners' associations where housing associations and private homeowners are present, 70% of the tenants must consent before sustainability measures can be implemented (Aedes, 2024). If private owners do not participate, the entire process of sustainability may not continue. This is a major problem in mixed ownership complexes (Rodesk, 2023). Moreover, once the renovations are completed, the homes participating in collective renovations look the same as the other homes in the complex. Participating in renovations for sustainability prevents socioeconomic divisions at the street or neighborhood level during collective renovations. By participating in the renovation, private homes retain their value (overdue maintenance and low energy labels reduce assessed value). In addition, the renovation contributes to residential comfort and reduces monthly energy costs. Housing associations can be a driving force in this process for integrated plans for complexes including mixed properties, by forming partnerships (Cope, 1999), carrying out energy-saving initiatives, raising awareness and education, and campaigning for regulations that encourage sustainability. Sometimes the housing associations finance part of the effort to make the mixed properties more sustainable, but there are also municipalities where the municipality or the province helps with financing. All of this is aimed at enhancing sustainability and quality of life in mixed-ownership areas.

Because many low-income homeowners live in mixed property, i.e. between housing corporation properties, this topic was raised in the interviews. The municipalities and energy cooperation's indicate that they are aware that making mixed property more sustainable is a major challenge but generally have no insight into specific interventions aimed at making mixed property more sustainable. Residents in mixed ownership are treated the same as other residents. However, the municipalities do see opportunities to set up a project to get homeowners involved when the housing association connects their homes to the heat network.

## Conditions offer municipalities

Municipalities are offering homeowners the opportunity to participate in sustainability initiatives at a significantly reduced price. This is driven by the municipalities' strong desire to ensure the success of these projects. However, there are specific conditions attached to this offer:

- The offer is typically a one-time opportunity with a clear expiration date. With this clear deadline, residents can choose whether to participate.
- The offer includes a clear and credible message detailing the route through which the neighborhood will phase out gas, communicated prior to the social offer.
- For the municipality to provide an offer to residents, and set up an electricity grid, there must be enough free space in the grid and in the neighborhood. There should also be a modern three-phase connection, which is more likely to be available in newer neighborhoods. Even if the municipality wants to switch to another alternative source, this should be well researched beforehand, before the offer is made, so that clarity can be offered to residents. In other words, the municipality must have a clear plan and offer before they inform the residents. The plan may deviate afterwards, but it must be known in outline and be made public and transparent to the residents.

Additionally, some municipalities offer variations to provide extra incentives for residents, such as:

- Option not to participate and clarify consequences of not participating.
- Receiving advice only: providing free energy performance advice (EPA).
- Option to tackle the transition to natural gas-free living independently, with municipal subsidies.
- Home subscription service (WOAB): a subscription service where all aspects of the heating transition up to and including installation are taken care of for a fee.

## Worst practice interventions from the interviews

In contradiction to the best practices, there are also municipalities that have implemented interventions that have not been successful and also worsen the process, which can be labeled as "worst" practices. Identifying these worst practices is crucial to understanding which approaches need improvement to develop more effective interventions and optimize the customer journey. This section discusses these interventions.

### Financial interventions

Worst practice financial interventions consist of:

- Grants provided only after project completion can be a barrier to people who do not have the financial resources to cover the initial costs, because homeowners do not have the money to invest.
- Loans don't work in practice, especially for low-income homeowners. Low-income homeowners do not want to borrow for various reasons, and they do not want to take out an additional loan. Other financial interventions are needed to get people to participate.
- Difficult and time-consuming grant application procedures are a worst practice because they discourage many people from trying to get a grant at all. Many low-income homeowners lack the knowledge to navigate these complex processes, which leads to them missing out on potential grants they might otherwise be eligible for. Additionally, there is a widespread fear that even if they do apply, they may misunderstand the requirements and end up having to repay funds they were not entitled to in the first place. This fear of financial repercussions is a significant barrier and should be taken seriously when designing grant programs.
- Unstable financial plans that do not offer clear long-term benefits can deter people. Municipalities have learned to stay clear about costs. Even though these can change often, it is important to keep homeowners informed. In contrast, bringing new different information too often is confusing and reduces trust in the municipalities and the project, as seen below.

## Trust interventions

Worst practice trust interventions include:

- Low-income homeowners are especially hard to reach, and support is often unevenly accessible. Financial and technical support that does not specifically target low-income homeowners can exclude this group and hinder their participation. The advice from municipalities is to use welfare organizations or other places where residents come together, such as a community center, library, or food bank to reach this target group.
- Inconsistent or odd communication from government or support organizations can lead to distrust and confusion among residents. Municipalities have found that homeowners have no need to participate in the energy transition. The lesson here is to communicate exactly what steps will be done in a timely and upfront manner. Investing in tools to reach all the people in the neighborhood is very important.
- Continuing with this, the interviews often focused on recent developments in the Netherlands, particularly the disappointing results of completed natural gas-free projects in certain municipalities. These setbacks were highlighted as demotivating factors for both residents and local governments. Rather than encouraging further participation in the energy transition, these negative experiences have created skepticism and reluctance among homeowners to undertake similar initiatives. The lack of success in these projects underscores the need for more effective planning, communication and support to ensure that future efforts are both successful and motivating.
- Another worst practice in creating trust was involving neighborhood residents in exploring the feasibility of alternative energy sources, such as a heat grid, without providing any form of compensation. In some municipalities, interested residents were given the responsibility to explore energy transition options for their neighborhood, with minimal guidance or support from the municipality. However, this volunteer-based approach has proven ineffective. The process requires a lot of time, effort and expertise, while residents often have other personal and professional commitments. Municipalities have since learned that paying residents for their time and contributions is crucial for active and meaningful participation. Without the proper involvement of residents early on, the success of such projects is jeopardized from the start.

## Comfort interventions

Worst practice comfort interventions are:

- The first worst practice comfort intervention is not to underestimate the legal and technical aspects of installing a heat grid or other alternative energy source. In municipalities where residents are very active and participation in the project is high, these unforeseen barriers make the process take longer. This must be well communicated to residents. The advice is therefore: get a good procurement lawyer who is familiar with procedures, risk management, contracts and conflicts.
- The lack of technical support during and after the implementation of energy-saving measures and the lack of model homes or demonstrations in the neighborhood can also lead to frustration and dissatisfaction and can make it difficult for residents to imagine how the changes might work in their own homes. Municipalities have learned to invest in this as well in order to achieve as much as possible.
- The lead time of building a heat grid is usually long. Unforeseen circumstances cause delays. In practice, this means that in some municipalities the street has been open for several years, which is not pleasant for the residents. Also, not all municipalities have taken advantage of the linking opportunities, which means that the street has to be reopened within 5 years for other work such as replacing cables or sewers. This is not conducive to the project, the costs and certainly not for the residents, especially the elderly. The advice from the interviews is to keep the street open as little as possible and to close it again if necessary, and to allow residents to participate in the design of the public space.

## **Environment interventions**

Worst practice environment interventions involve:

- As described above, the lack of effective campaigns to make residents aware of the importance and benefits of energy conservation can lead to a lack of interest and commitment.
- Few municipalities recognize the importance of behavior change strategies. Interventions that overlook the need to shift residents' behaviors tend to be less effective. A key lesson for other municipalities is to invest in these strategies, as without addressing behavior change, energy-saving measures are unlikely to have a meaningful impact, particularly among low-income homeowners.
- Municipalities often do not fully realize that, beyond communication and participation, other crucial elements must be effectively prepared and utilized to encourage homeowners to engage in the energy transition. Therefore, it is essential to assemble a multidisciplinary team with expertise in various areas to ensure a comprehensive approach.

## Appendix D – List of interviews

This appendix reports the findings from the various interviews. Each interview describes an introduction, the offering, the interventions designed to encourage and make residents aware of natural gas-free, broken down into awareness, information gathering and decision and evaluation, and best or worst practice. This appendix is a separate document due to price sensitivity and possible retracing of the interviewees.

### List of interviews

#### Municipality

	<i>Municipality</i>	<i>Neighborhood</i>
1	Vlissingen	Panoramabuurt
2	Nijmegen	Zwanenveld
3	Sittard-Geleen	Limbrichterveld
4	Arnhem	Stadseiland
5	Groningen	Selwerd-Zuid
6	Wageningen	Benedenbuurt
7	Assen	Lariks

#### Energy cooperation

	<i>Energy cooperation</i>	<i>Municipality</i>	<i>Neighborhood</i>
8	Zeeuwind	Zeeuwind	-
9	Wattnu	Gooise meren	Muiderberg

#### RVO

	<i>Contact person</i>
10	Accountholder