SDHp2m

… from policy to market

Advanced policies and market support measures for mobilizing solar district heating investments in European target regions and countries

D2.1 REPORT ON OPINION POLL RESULTS

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PREFACE

In WP2 an opinion poll among end-users, municipalities and energy providers about the image and interests in ‘green DHC’ was conducted. In the following sections we will present the results for Germany, Austria and France. For data collection of end-users we used an access-panel of Respondi. Data of about 500 end-users was collected for each country. In addition data of municipalities was collected by official lists in Germany and France. The data of municipalities in Austria was collected by an informal list of the Austrian partners. Data of Energy providers were collected by informal lists in Germany and Austria. Energy providers were not part of research in the French survey.

Besides sociodemographic data the questionnaire consists of data about experience with different forms of heating systems, images of different heating systems, attitudes about providers, price and sustainability of heating systems, scenarios about the future and discrete choice sets with varying prices and different selections of heating systems.

In the following report the received data will be analysed by country. In the first part the experience and images as well as the future scenarios will be shown. In the second part a market segmentation of the end-users will be analysed and in the third part the willingness to pay for different heating systems will be calculated.

1. GERMANY

In the following chapter the experience of the consumers, municipalities and energy providers as well as their images of different heating systems will be described. Furthermore the attitudes towards district heating in the near future will be analysed. Afterwards a market segmentation for consumers and municipalities will be conducted.

1.1. Sample

The end-user survey was carried out between June, 24 and June, 28. After 4 days of field time data of 490 end-users was collected. In addition data of municipalities, energy providers and real estate companies were collected between July 10 and September 30. We received data from 274 municipalities (response rate (RR) = 6.1%), 59 energy providers (RR = 6.6%) and 6 real estate companies (RR = 1%). Due to the low response rate, the real estate companies was not be considered for further analysis.

The socio-demographic characteristics of the survey are presented in Table 1.

Table 1. Demographics of end-users, municipalities and energy providers in Germany

Consumer (490)		Municipalities (n=274)		Energy provider (n=59)	
Gender					
Male	49.2%				
Female	50.8%				
Income		Party affiliation of mayor		Areas of interest	
< 1,300€	21,2%	Independent	38.3%	District heating	70.2%
1,300-2,600€	36.9%	CDU/CSU	32.6%	Gas boilers	75.4%
2,600-3,600€	23.5%	SPD	18.9%	Electricity heating	42.1%
3,600-5000€	12.4%	Others	10.2%	Contracting	64.9%
>5,000€	5.9%				
Age		Position		Households	
18-30	22.5%	Mayor	22.6%	<10.000	34.7%
31- 45	26.4%	Administration (general)	19.2%	10.000 – 20.000	24.5%
46-65	43.1%	Administration (specific)	43.7%	20.000 – 100.000	30.6%
> 65	8%	Others	14.5%	>100.000	10.2%
Place of residence		Demographics			
Small town (pop. <5,000)	16.4%	Small town (pop. <5,000)	36.4%		
Small City (5,000 – 20,000)	19.8%	Small City (5,000 – 20,000)	37.5%		
Medium City (20,000 –100,000)	22.9%	Medium City (20,000 –100,000)	18.9%		
Big City (> 100,000), centre	18.8%	Big City (> 100,000)	7.2%		
Big City (> 100,000), periphery	22.1%				

1.2. Image of different heating systems

In the following chapter the self-report of experience of the consumers, municipalities and energy providers as well as their images of different heating systems will be described.

1.2.1. Consumers

The self-reporting of experience with different heating systems among German consumers is pretty low. The consumers have most experience with gas boiler systems followed by district heating systems. However, about half of the sample claims that they have no or just little experience with this kind of heating system. For heat pumps the amount of people with no or little experience went up to two out of three (Figure 1).

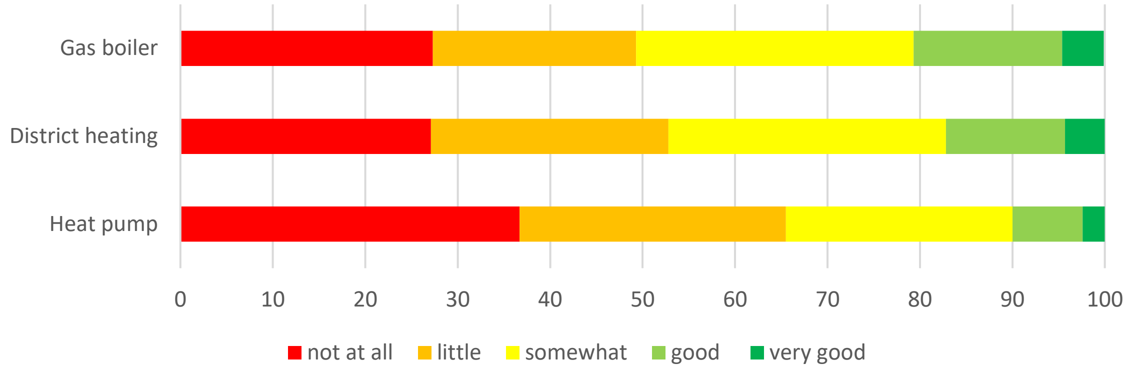

Figure 1. Experience with different Heating Systems among German Consumers (n=490)

Concerning the image of different heating systems the consumers were asked to rate gas boiler systems, heat pumps and district heating on a semantic differential. The results can be seen in Figure 2. The results indicate that a heat pump is seen the most modern and eco-friendly form of heating systems, but also as the least reliable and the most expensive one.

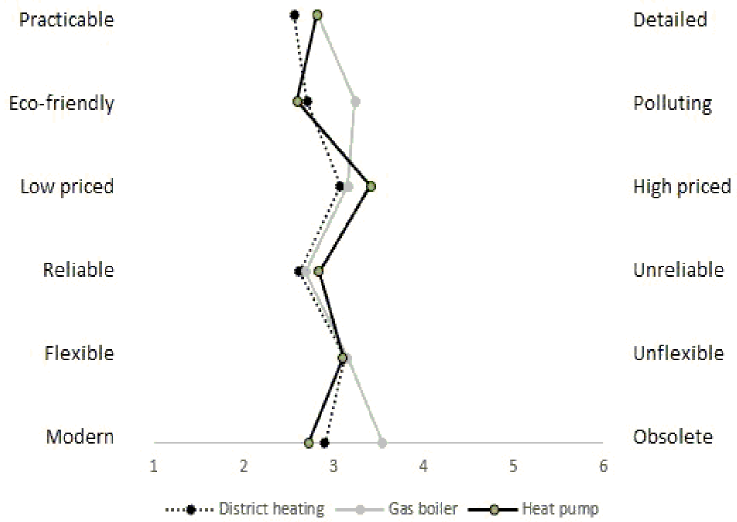

Figure 2. Semantic differential for heating systems. Consumers, Germany (n=490)

Gas boilers have an image as polluting and obsolete systems, while district heating seems to have an image as a good compromise between a good practicability, a low price a high reliability but also eco-friendliness and modernity.

1.2.2. Municipalities

The self-report of experience shows that the representatives of the municipalities on average have good experience with the heating systems (Figure 3). Concerning the fact, nearly half of the respondents claim to work in the administration that is specialised on heating and energy the good knowledge is not surprising.

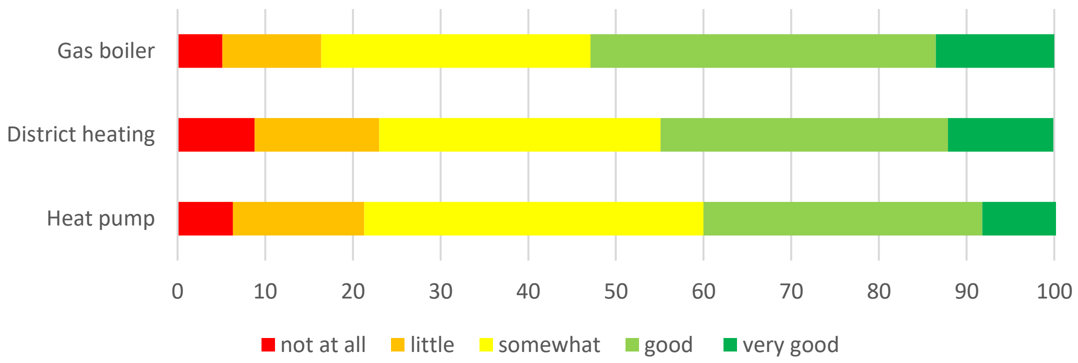

Figure 3. Experience with different Heating Systems among German Municipalities (n=274)

Concerning the image of different heating systems the results are close to the results of the end-users. Gas boilers are seen as the most practicable, reliable and flexible alternative with the lowest price, but also as polluting and obsolete. District heating and heat pumps are very close together. District heating is seen as a bit more reliable and with a lower price, while heat pumps have a more flexible image (Figure 4).

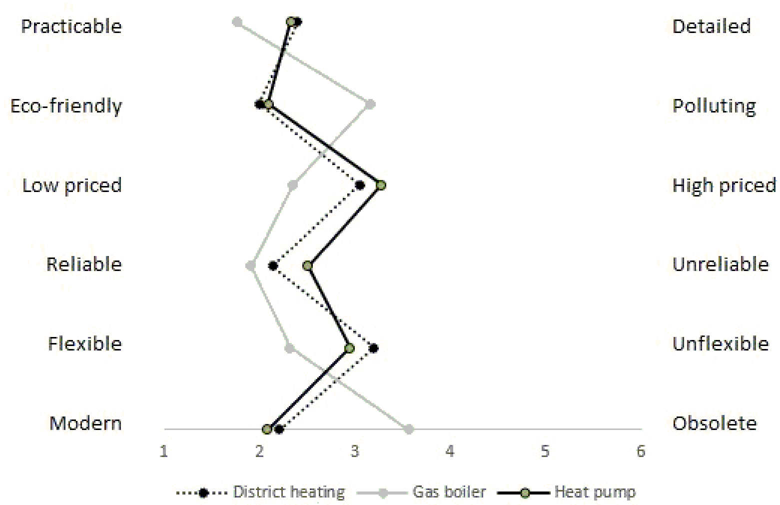

Figure 4. Semantic differential for heating systems. Municipalities, Germany (n=274)

1.2.3. Energy provider

It is not surprising that the respondents from the energy providers have the most experience with the different heating systems. Different to end-users and municipalities they have more experience with district heating than with gas boiler (Figure 5).

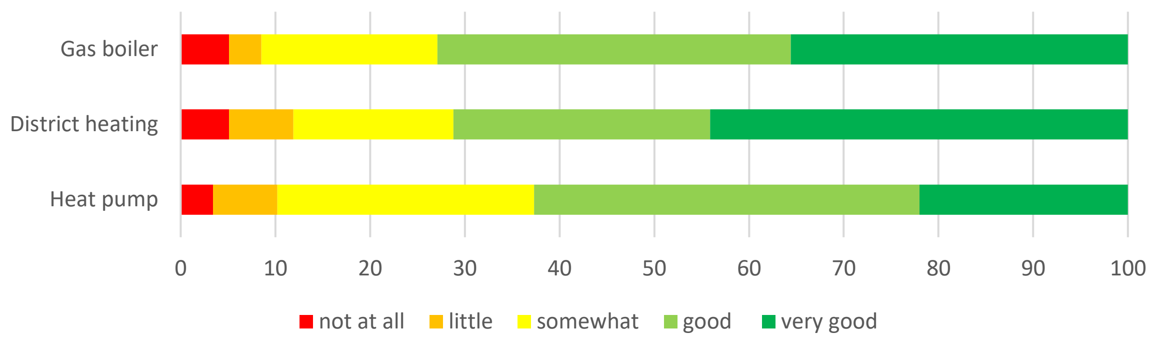

Figure 5. Experience with different Heating Systems among German Energy Providers (n=59)

Concerning the image of heating systems the energy providers in Germany also have a positive image of gas boilers, except of eco-friendliness and modernity. Different to end-users and municipality district heating has in all items a better image than heat pumps (Figure 6).

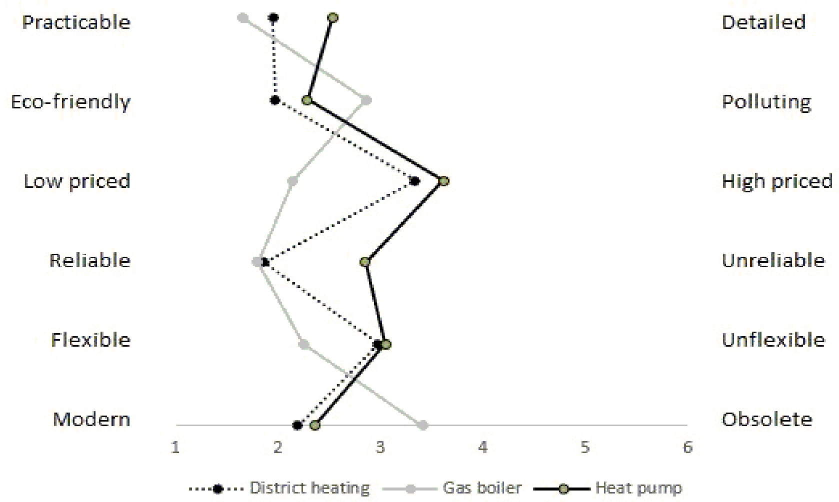

Figure 6. Semantic differential for heating systems. Energy providers, Germany (n=59)

1.3. Market segmentation of consumers and municipalities

During the survey attitudinal statements were given on a five-point rating scale from “important (1)” to “unimportant (5)”. Overall, 13 variables were used to learn about the attitudes of the consumers towards local providers, sustainability and economics of heating systems. For market segmentation of the consumers and municipalities these 13 variables were reduced to a lower number of latent variables, by means of principle component analysis. The aim is to display the high quantity of variables while simultaneously obtaining a low loss of variance. The number of factors was determined by the Kaiser-criterion (Eigenvalue > 1). For easier interpretation of the factors, varimax rotation was applied. Finally, Cronbach’s alpha scores were used as a measure for internal scale reliability

After that, k-means clustering was performed on the factors. The target criterion was the minimization of variance within the clusters and clearance was the squared Euclidean distance. As it is not possible to determine the number of clusters within k-means analysis, this step was performed through the Ward method beforehand. Additionally, outliners were eliminated by the single linkage clustering. Initially, the dendrogram and the elbow-criterion were observed to determine the final number of clusters.

1.3.1. Consumers

Table 2 shows the factor scores after varimax rotation. The analysis resulted in a three- factor solution: preference for price and financial security (F1), preference for local providers (F2) and responsibility for the environment and sustainability (F3). Overall, 67.1 % of the total variance was explained through the factors and Cronbach’s alpha scores were above 0.75 for all factors, which is considered “good” regarding internal scale reliability.

Factor 1 combines positive attitudes towards price and financial security. The variables reflecting these factors mainly include reasonable pricing, transparency and stable prices. Further variables of this factor are high trust in the provider and high security of the supply. The second factor identifies mainly locally attitudes towards the important characteristics of heating systems. Direct contact to a local provider and a long-term partnership belong to factor 2. F3 pools items which reveal the importance of sustainability like low pollution of a high share of renewable energies.

Table 2. Factor analysis of consumer attitudes in Germany

Factor Loadings From Principal Component Factor Analysis: Communalities, Eigenvalues, Percentages of Variance, and Alpha-Value for Items of Preferences of heating systems (N=490), KMO=.902

Item	Factor loading 1 Price and financial Security	2 Localism	3 Sustainability	Communality
Reasonably priced heating system	**.85**	.09	.09	.73
Reasonably priced initial outlay	**.79**	.20	.10	.68
High security of supply	**.75**	.13	.34	.69
Low fluctuations in prices	**.70**	.33	.12	.61
Transparent accounting	**.68**	.22	.31	.61
High trust in provider	**.52**	.44	.40	.61
Local contact person	.26	**.81**	.03	.73
Local provider	.00	**.76**	.32	.68
Direct contact to the provider	.32	**.68**	.19	.61
Long-term partnership	.21	**.67**	.24	.55
Low pollution	.16	.21	**.85**	.80
High share of renewable Energy	.17	.22	**.83**	.77
Future efficiency of energy source	.44	.22	**.63**	.64
Eigenvalue	6.10	1.48	1.14	
Variance explained in %	46.89	11.35	8.73	
α	.88	.79	.82	

Note. Boldface indicates highest factor loadings.

Based on the three factors, four clusters were identified after eliminating 5 outliers (see figure 7). The results confirm the existence of different consumer segments regarding attitudes towards heating systems.

The first "The Hedonists" represents 24.12% of the sample. These consumers do not take care about "Price and financial security". A local provider and environmental aspects on the other hand have some influence, but not as high as for "Price sensitive Ecologists (Cluster 3) or the "Localists" (Cluster 4).

The second cluster "The price Sensitives" consists of people that take care of "Price and financial security" but not about environmental aspects. Local providers are not unimportant but the price is the main criteria. This cluster represents 13.4% of the sample.

The third cluster, "The price sensitive Ecologists" (21.65%), is characterized by high scores for the factors "Price and financial security" and the factor "Sustainability". A local provider does not play a major role in the decision making process.

The fourth, and largest cluster, "The Localists" represents 40.82% of the sample. These consumers are also sensible for the price and for environmental aspects, but in comparison to the other clusters they differ in their preference for a local provider.

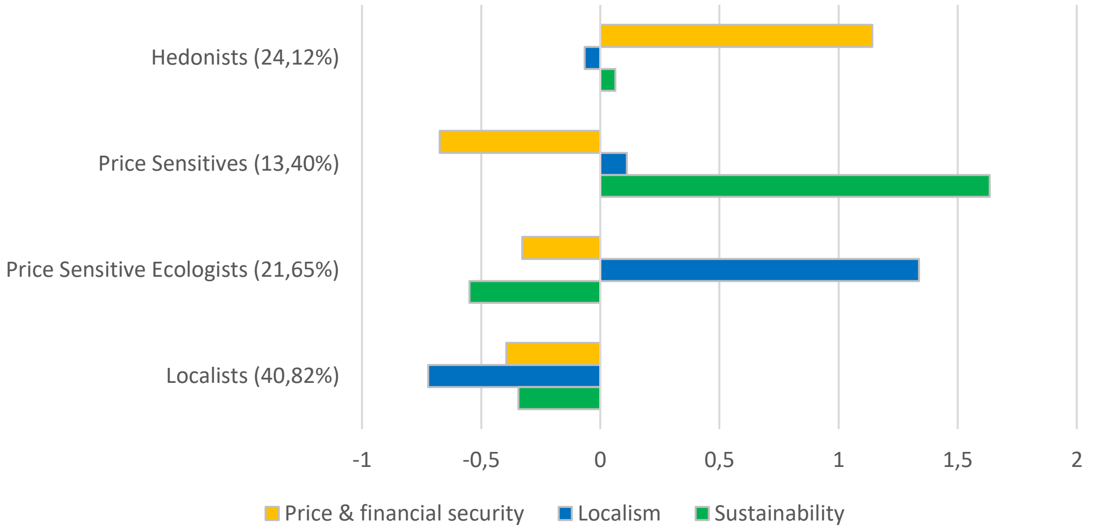

Figure 7. Cluster centers of the k-means cluster analysis for consumers in Germany. Lower numbers represent a higher attitude towards the factors compared to the average.

1.3.2. Municipalities

Table 3 shows the factor scores after varimax rotation. The analysis resulted in a three- factor solution: preference for price and financial security (F1), preference for local providers (F2) and responsibility for the environment and sustainability (F3). Therefore the factors are similar to the factors of the consumers. Overall, 57.1 % of the total variance was explained through the factors and Cronbach's alpha scores were around 0.75 for all factors, which is considered "good" regarding internal scale reliability.

Factor 1 combines positive attitudes towards price and financial security. The variables reflecting these factors mainly include reasonable pricing, transparency and stable prices, as well high security of the supply. The second factor identifies mainly locally attitudes towards the important characteristics of heating systems. Direct contact to a local provider and a long-term partnership belong to factor 2. There is a small difference regarding "high trust in provider". For the consumers these item belongs to price and financial security, while municipalities subsume this item to localism. F3 pools items which reveal the importance of sustainability like low pollution of a high share of renewable energies.

Table 3. Factor analysis of municipality attitudes in Germany

Factor Loadings From Principal Component Factor Analysis: Communalities, Eigenvalues, Percentages of Variance, and Alpha-Value for Items of Preferences of heating systems (N=274), KMO=.804

Item	Factor loading 1 Price and financial Security	2 Localism	3 Sustainability	Communality
Reasonably priced heating system	**.81**	.04	.00	.65
Reasonably priced initial outlay	**.79**	.13	-.03	.65
Low fluctuations in prices	**.59**	.37	-.04	.48
Transparent accounting	**.54**	.25	.29	.44
High security of supply	**.52**	.14	.42	.47
Local contact person	.01	**.79**	.01	.63
Direct contact to the provider	.15	**.75**	.09	.59
Long-term partnership	.27	**.65**	.04	.50
High trust in provider	.36	**.59**	.23	.53
Local provider	.03	**.54**	.40	.46
High share of renewable Energy	-.11	.13	**.86**	.76
Low pollution	.06	.11	**.81**	.67
Future efficiency of energy source	.44	.02	**.63**	.60
Eigenvalue	4.21	1.74	1.47	
Variance explained in %	32.41	13.38	11.28	
α	.74	.75	.72	

Note. Boldface indicates highest factor loadings.

Based on the three factors, four clusters were identified without the need of eliminating outliers (see figure 8). The results confirm the existence of different segments regarding attitudes towards heating systems.

The first cluster “The price Sensitives” consists of people that take care of “Price and financial security” but not about local aspects. Sustainability has an average importance, but the price is the main criteria.This cluster represents 23.21% of the sample.

The second, and largest cluster, “The price sensitive Localists” represents 35.16% of the sample. These municipalities are also sensible for the price and for environmental aspects, but in comparison to the other clusters they differ in their high preference for a local provider.

The third cluster, “The Ecologists”, represents 28.21% of the sample and is characterized by low scores for the factors “Price and financial security” and high scores for the factor “Sustainability”. A local provider does not play a major role in the decision making process.

The fourth cluster “The Non-Ecologists” does not take care about “Sustainability”. A local provider and financial aspects on the other hand have some influence, but not as high as in cluster 1 or 2. This cluster represents 16.48% of the sample

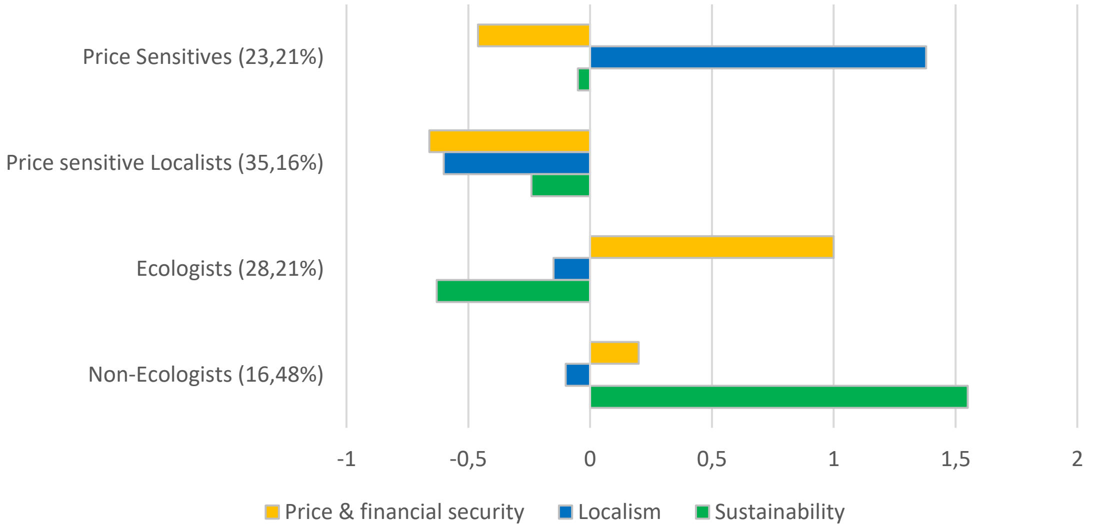

Figure 8. Cluster centers of the k-means cluster analysis for municipalities in Germany. Lower numbers represent a higher attitude towards the factors compared to the average.

1.4. Desirability and Probability of Scenarios

Additionally the consumers were asked to rate two scenarios based on their opinion about desirability and probability. The results can be found below:

Scenario1:

"Till 2030 a strong development of district heating in urban agglomerations can be recognized. District heating will be the most preferred heating system in urban areas. A high degree of renewable energies will reduce the CO_2–emission significantly."

- Please rate the desirability/probability of this scenario:
- Please estimate: How many households will be provided with district heating until 2030?

The results to these questions can be seen in Figure 9 and Figure 10.

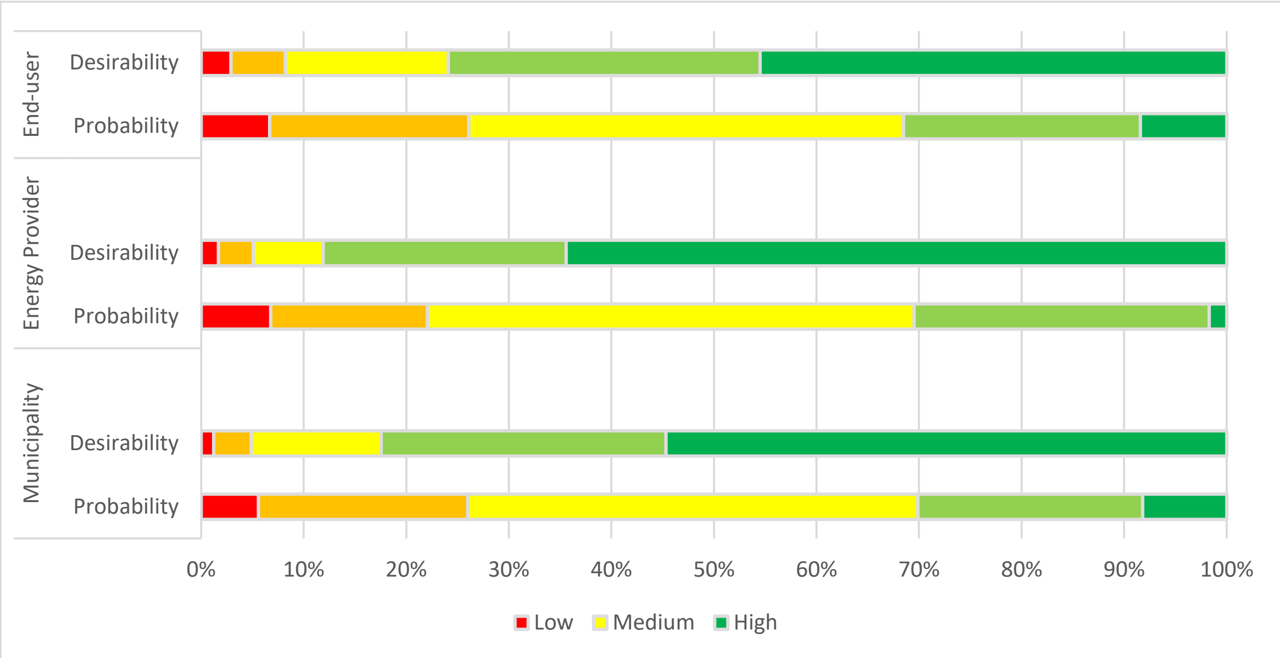

Figure 9. Desirability and Probability of Scenario 1 for Consumers, Municipalities and Energy Providers in Germany

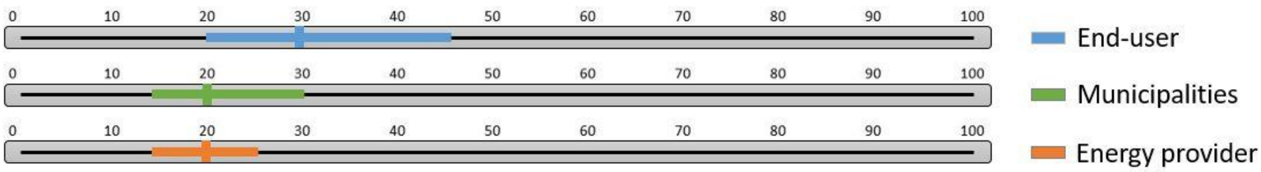

Figure 10. „Please estimate: How many households will be provided with district heating until 2030?" Bars represent the Median and the interquartile range.

The results for the first scenario indicate that a strong development of district heating that goes along with a reduction of CO_2 –emission is highly desirable for consumers, energy providers and municipalities. However, the probability of this scenario is not seen as high as the indicated desirability.

In addition the estimations for the year 2030 show a median of only 20% of household by energy providers and municipalities and 30% by the consumers (Figure 9).

Figures 11 and 12 show the results for the second scenario:

"District heating plays a major role in 2030. The assembly and disassembly costs shall be allocated to the general public to promote further development."

- Please rate the desirability/probability of this scenario:
- In your opinion: What is the maximum amount of assembly and disassembly costs that shall be allocated to the general public in percent?

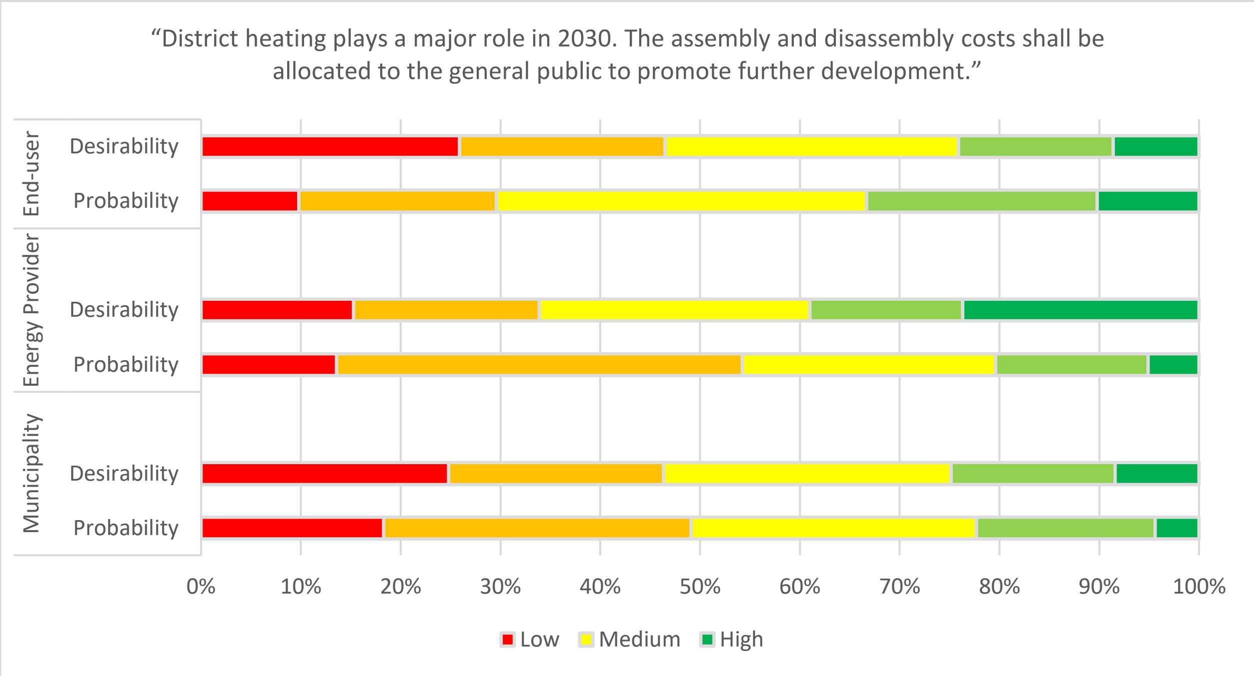

Figure 11. Desirability and Feasibility of Scenario 2 for Consumers, Municipalities and Energy Providers in Germany

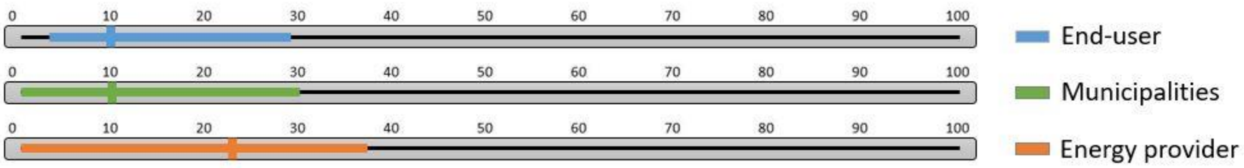

Figure 12. "In your opinion: What is the maximum amount of assembly and disassembly costs that shall be allocated to the general public in percent?" Bars represent the Median and the interquartile range.

The results show that the energy providers state the highest desirability for this scenario, but the lowest probability. Consumers and municipalities are not as convinced as the energy providers that the assembly and disassembly costs should be allocated to the general public. Nonetheless, the consumers estimate a higher probability of this scenario than the municipalities.

Figure 12 confirms the findings of the desirability and feasibility. We can see very similar results for consumers and municipalities concerning the share of the maximum amount of assembly and disassembly cost that should be allocated to the general public. For both groups the median is at 10% of the total amount and the interquartile range between 0% and 30%. On the other hand we can see the energy providers with a median of 22.5% and an interquartile range between 0% and 37.5%.

1.5. Willingness to pay for district heating

1.5.1. Discrete-Choice-Experiments

Discrete choice models empirically model choices made by people among a finite set of alternatives. Such models have been used to examine, e.g., the choice of which car to buy or where to go to college among numerous other applications. Daniel McFadden won the Nobel Prize in 2000 for his pioneering work in developing the theoretical basis for discrete choice.

In the discrete choice experiment of this study the respondent's task was to choose the most preferred heating option among a set of alternatives which consisted of different attributes and attribute characteristics (see Table 4). The participants had to make altogether twelve choice decisions.

Table 4. Choice set example

	alternative 1	**alternative 2**	**alternative 3**
	Gas	District heating from renewables	Heat pump
annual operation costs per m^2	**8 €**	**10 €**	**8 €**
investment costs (without 3,000 € for ventilation system)	**6.000 €**	**6.000 €**	**8.000 €**
primary energy factor	**1,1**	**0,0**	**0,8**
CO_2-emissions	**20**	**0,4**	**13,0**
price risk	**high**	**low**	**high**

Discrete choice models statistically relate the choice made by each person to the attributes of the person and the attributes of the alternatives available to the person. In our study, the choice of which heating alternative a person choose (district heating fossil or from renewables, heat pump, gas) is statistically related to the attributes of each available heating option (e.g. costs, CO_2-emissions, price risk). The models estimate the probability that a person chooses a particular alternative. From the estimates which base on multinomial logit models one can infer forecasts on how people's choices will change under changes in attributes of the alternatives (e.g. higher investment or annually costs) and/or demographics or attitudes of the individuals. In this study we calculated so-called odds ratios and the willingness-to-pay for demonstrating the preferences the respondents have for the considered heating alternatives.

The mentioned odds ratios are used to compare the relative odds of choice probability of a heating alternative in comparison to the competing heating alternatives. The odds ratio can also be used to compare the magnitude of various heating alternative on the choice probability.

- OR=1 heating alternative does not affect odds of choice probability
- OR>1 heating alternative associated with higher choice probability
- OR<1 heating alternative associated with lower choice probability

Furthermore the willingness-to-pay for the option ‘district heating’ and ‘heat pump’ in comparison to the reference alternative ‘gas’ were calculated on the basis of market share simulations.

The choice experiments were analysed with logit models using the software NLogit 4.0. Multinomial Logit (MNL) models were estimated to gain insight into the data. In choice analysis, it is assumed that the utility U_i of choosing alternative *i* out of a choice set of *J* alternatives is composed of the observed utility V_i capturing the effect of the variables tested in the experiments, and the random error term ε_i capturing the unobserved utility (Hensher et al., 2015). The observable component V_i is assumed to be a linear relationship of observed attribute levels *x* of each alternative *j* and their corresponding weights *(ß).* In this study, all cost attributes represented metric variables. The heating options ‘gas’, ‘district heating fossil fuels’, ‘district heating renewables’ and ‘heat pump’ entered the model as dummy-variables with the option ‘gas’ set to zero as reference. The costs were included as metric variables and assumed to have a squared effect on the observable component of the utility as follows:

$$U_{\mathrm{i}} = \beta_{\mathrm{ac}}\text{annual costs}^2 + \beta_{\mathrm{ic}}\text{investment costs}^2 + \beta_{\mathrm{dc-renew}}\,district\ heating\ renewabels + \beta_{\mathrm{dc-fossil}}\,district\ heating\ fossil\ fuels + \beta_{\mathrm{heat\ pump}}\,heat\ pump + \varepsilon_i$$

The probability (*Prob*) that alternative *i* is chosen out of a choice set of *J* alternatives is given by (Hensher et al., 2015):

$$\mathrm{Prob_i} = \frac{\mathrm{expV_i}}{\sum_{\mathrm{j}}^{\mathrm{J}} \mathrm{expV_j}}$$

1.5.2. Germany - consumers

The estimation results for Germany demonstrate that ‘district heating from renewable energies’ is the most preferred heating alternative whereas the reference base alternative ‘gas’ is least preferred (see Table 5). The second place takes ‘district heating from fossil fuels’ followed by the option ‘heat pump’. The described effects are all highly significant in comparison to the reference base ‘gas’ and differ significantly from each other. As expected the cost parameters (‘variable costs’ & ‘investments cost’) are negative and significant. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for the final estimation.

Table 5. Estimation results Germany (N=490)

Coefficients		
	Estimate	**Std. Error**
district heating renewable⁺	2.02***	5.37e-02
district heating	1.03***	7.52e-02
heat pump	0.26***	4.19e-02
variable costs[2]	-1.50e-02***	6.79e-04
investment costs[2]	-4.62e-06***	1.03e-06
Log-Likelihood	-5200.6	

Significance codes: 0=***, 0.001=**, 0.01*

⁺The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 5 the odds ratios for the four heating options were calculated (see Figure 13). The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters. In comparison to the reference base 'gas' (odds ratio=1) the alternative 'district heating from fossil fuels' revealed a 47 % higher choice probability in the discrete choice experiments. It follows 'heat pump' with a 59 % higher choice probability. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than eight times stronger preferred than 'gas'.

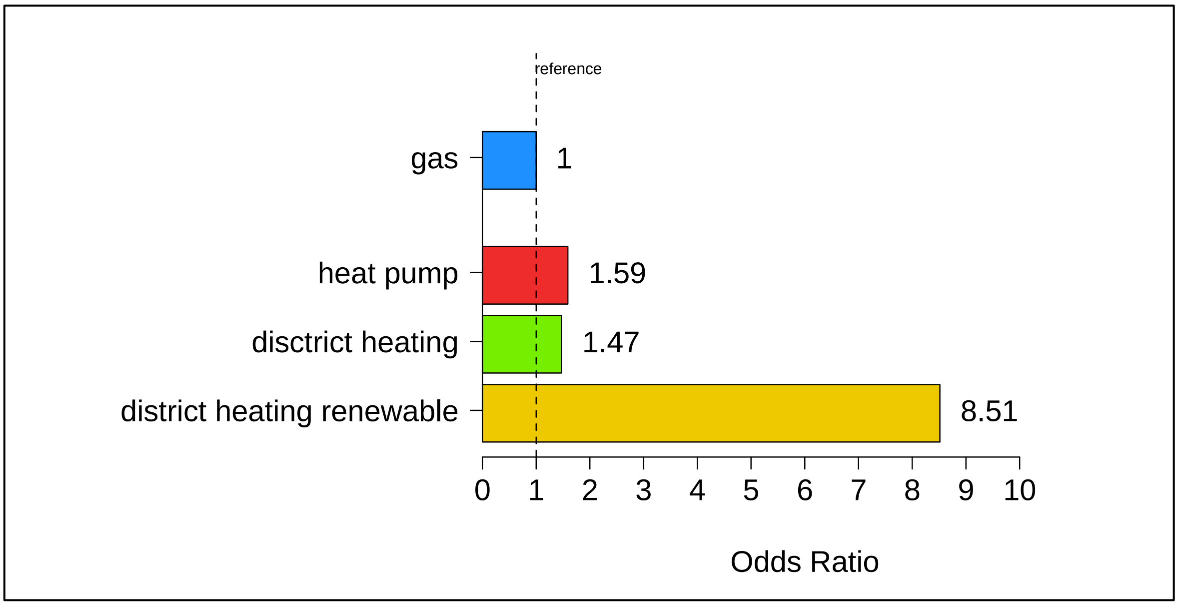

Figure 13. Odds ratios for the analyzed heating alternatives

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 6,000 €. The variable costs for the base option ‘gas’ were set to 6 €/m²/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two alternatives were hypothesized.

Figure 14 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 7.1 € higher variable costs per m²/year for ‘district heating from renewable energies’ than for ‘gas’. The WTP for ‘district heating from fossil fuels’ is circa 40 % lower with 4.2 €. The WTP for the alternative ‘heat pump’ is 1.3 €.

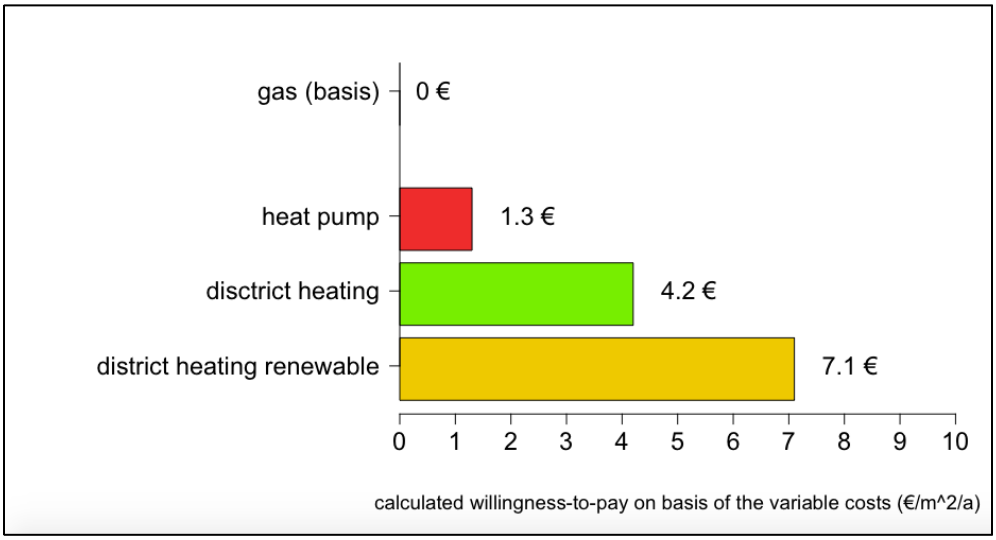

Figure 14. WTP for the analyzed heating alternatives

1.5.3. Conclusion

The results clearly show that 'district heating from renewable energies' is the most favorite heating option for the consumers. The ranking of the other alternatives is 'district heating from fossil fuels', 'heat pump' and 'gas'. It is to highlight that the participants revealed a significant additional WTP for 'district heating' just for the fact that is from renewable energies. The WTP is 2.9 € higher for this option than for 'district heating from fossil fuels'.

1.5.4. Germany - municipality

The estimation results for Germany demonstrate that 'district heating from renewable energies' is the most preferred heating alternative for the municipalities whereas the reference base alternative 'gas' is least preferred (see Table 6). The second place takes 'heat pump followed by the option 'district heating from fossil fuels'. The described effects are all highly significant in comparison to the reference base 'gas' and differ significantly from each other. As expected the cost parameters ('variable costs' & 'investments cost') are negative and significant. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for the final estimation.

Table 6. Estimation results Germany (N=274)

Coefficients		
	Estimate	**Std. Error**
district heating renewable^{+}	2.14***	7.52e-02
district heating	0.39***	1.04e-01
heat pump	0.46***	6.35e-02
variable costs^{2}	-1.01e-02***	9.37e-04
investment costs$^{2/1000}$	-4.01e-07***	6.23e-08
Log-Likelihood	-2768.5	

Significance codes: 0=***, 0.001=**, 0.01*

$^{+}$The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 6 the odds ratios for the four heating options were calculated (see Figure 15). The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters. In comparison to the reference base 'gas' (odds ratio=1) the alternative 'heat pump' revealed a 66 % higher choice probability in the discrete choice experiments. It follows 'district heating from fossil fuels with a 34% higher choice probability. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than eight times stronger preferred than 'gas'.

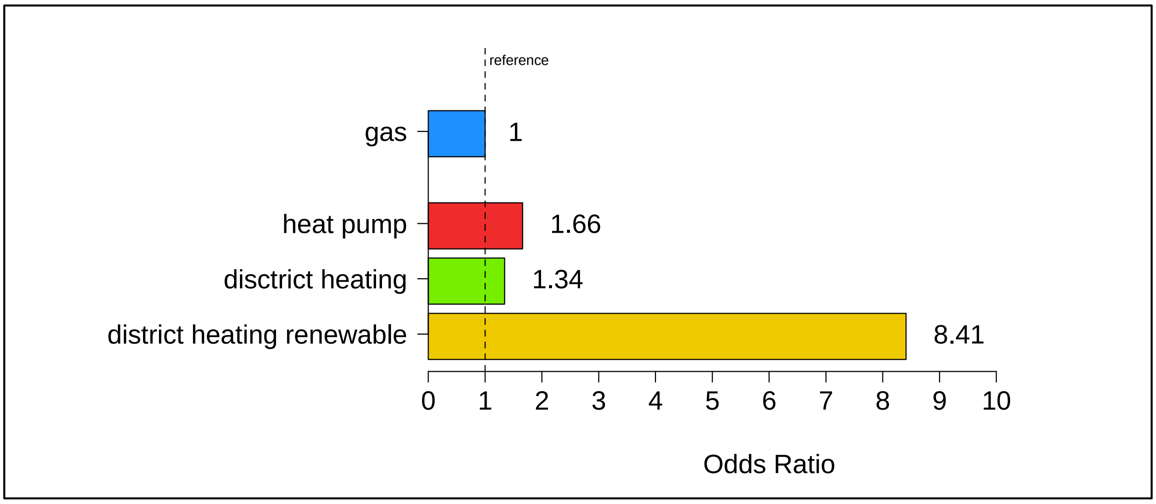

Figure 15. Odds ratios for the analyzed heating alternatives

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 30,000 €. The variable costs for the base option 'gas' were set to 6 €/m^2/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two alternatives were hypothesized.

Figure 16 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 9.7 € higher variable costs per m^2/year for 'district heating from renewable energies' than for 'gas'. The WTP for 'heat pump is much lower with 3.0 €. The WTP for the alternative 'district heating from fossil fuels' is 2.7 €.

1.5.5. Conclusion

The results clearly show that 'district heating from renewable energies' is the most favorite heating option for the municipalities. The ranking of the other alternatives is 'heat pump', 'district heating from fossil fuels' and 'gas'. It is to highlight that the participants revealed a significant additional WTP for 'district heating' just for the fact that is from renewable energies. The WTP is 7 € higher for this option than for 'district heating from fossil fuels'.

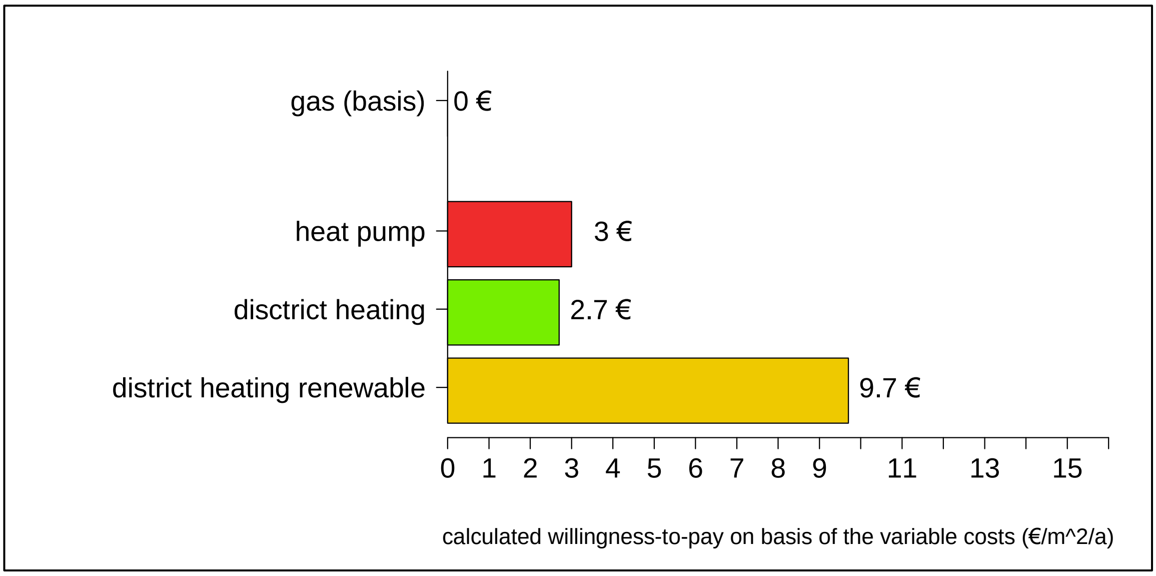

Figure 16. WTP for the analyzed heating alternatives

1.5.6. Germany - energy provider

The estimation results for Germany demonstrate that 'district heating from renewable energies' is the most preferred heating alternative (see Table 7). The second place takes 'district heating from fossil fuels' followed by the option 'gas'. The described effects are all highly significant in comparison to the reference base 'gas' and differ significantly from each other. As expected the cost parameters ('variable costs' & 'investments cost') are negative and significant. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for the final estimation.

Table 7. Estimation results Germany (N=59)

Coefficients		
	Estimate	**Std. Error**
district heating renewable+	1.89***	1.50e-01
district heating	0.85***	2.14e-01
heat pump	-0.05	1.42e-01
variable costs[2]	-1.72e-02***	2.17e-03
investment costs[2]	-8.69e-07***	1.33e-07
Log-Likelihood	-612.75	

Significance codes: 0=***, 0.001=**, 0.01*

+The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 7 the odds ratios for the four heating options were calculated. The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters (see Figure 17). In comparison to the reference base 'gas' (odds ratio=1) the alternative 'district heating from fossil fuels' revealed a 234 % higher choice probability in the discrete choice experiments. The option 'heat pump' is less preferred than the reference 'gas'. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than six times stronger preferred than 'gas'.

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 30,000 €. The variable costs for the base option 'gas' were set to 6 €/m^2/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two alternatives were hypothesized.

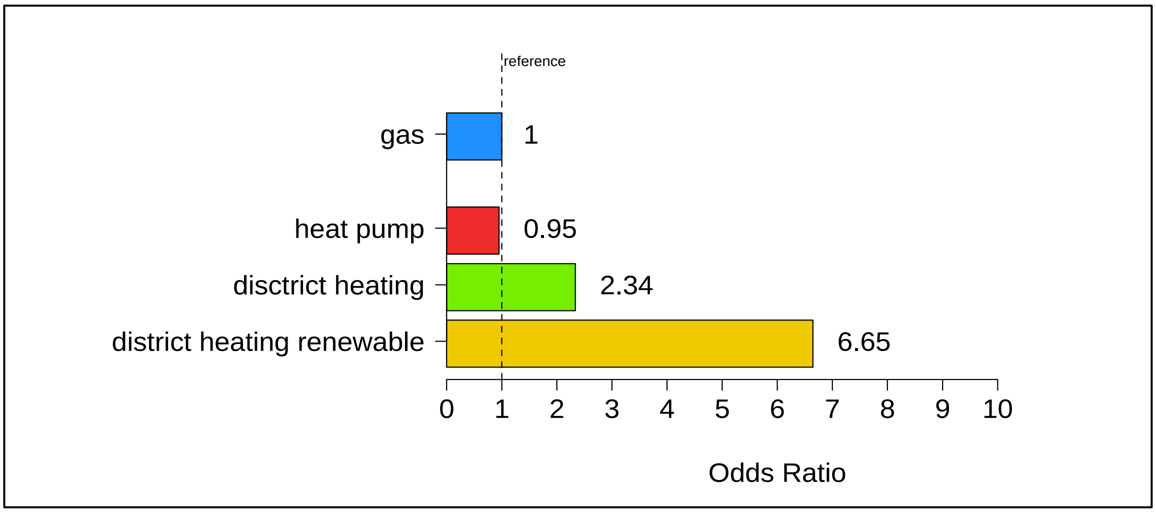

Figure 17. *Odds ratios for the analyzed heating alternatives*

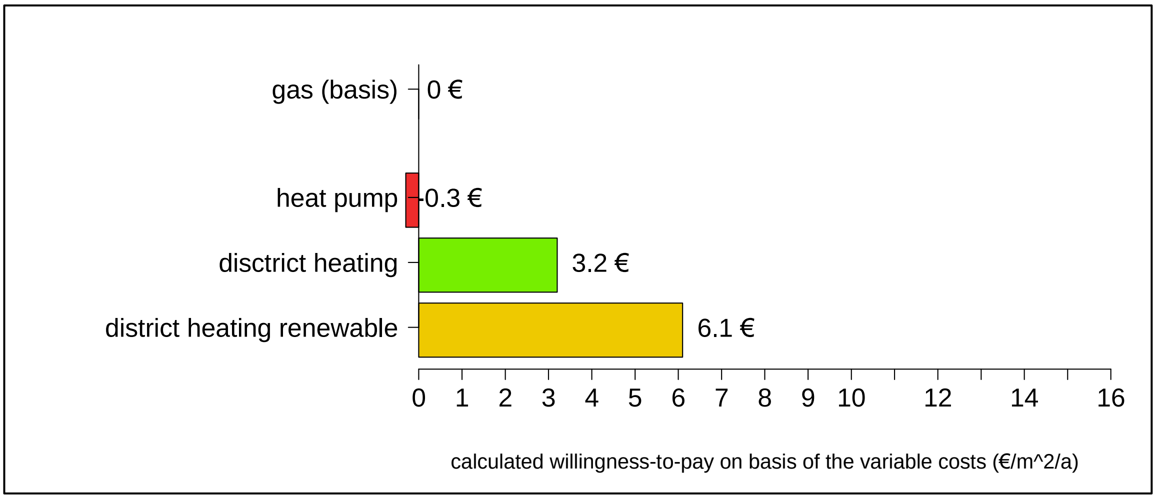

Figure 18. WTP for the analyzed heating alternatives

Figure 18 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 6.1 € higher variable costs per m^2/year for 'district heating from renewable energies' than for 'gas'. The WTP for 'district heating from fossil fuels' is circa 50 % lower with 3.2 €. The WTP for the alternative 'heat pump' is negative with 0.3 €.

1.5.7. Conclusion

The results clearly show that 'district heating from renewable energies' is the most favorite heating option for the energy providers. The ranking of the other alternatives is 'district heating from fossil fuels', 'gas' and 'heat pump'. It is to highlight that the participants revealed a significant additional WTP for 'district heating' just for the fact that is from renewable energies. The WTP is 2.9 € higher for this option than for 'district heating from fossil fuels'.

1.5.8. Discussion and Conclusion

Thue study revealed that all analysed groups show a significant WTP for ‘district heating from renewables’. Whereas consumers and energy supplier expressed to pay in addition 2.90 €/m^2/a extra if ‘district heating’ comes from renewables the municipalities stated to pay 7 € more. This peculiarity is may be due to the fact that municipalities receive extra funds and low priced credits from the KfW for the construction of district heating from renewables.

2. AUSTRIA

In the following chapter the experience of the consumers, municipalities and energy providers as well as their images of different heating systems will be described. Furthermore the attitudes towards district heating in the near future will be analysed. Afterwards a market segmentation for consumers and municipalities will be conducted.

2.1. Sample

The data of the end-users was collected between June, 24 and June, 28. After 4 days of field time data of 520 end-users was collected. In addition data of municipalities and energy providers were collected by a closed database between July 18 and October 15. We received data from 23 municipalities 27 energy providers. Due to the low response rate, market segmentation was not possible for municipalities and energy providers.

The socio-demographic characteristics of the survey are presented in Table 8.

Table 8. Demographics of end-users, municipalities and energy providers in Austria

End-user (n=520)		Municipality (n=23)		Energy provider (n=27)	
Gender					
Male	49.2%				
Female	50.8%				
Income		Party affiliation of mayor		Areas of interest	
< 1,300€	20,8%	ÖVP	65.2%	District heating	85.2%
1,300-2,600€	37.1%	SPÖ	30.4%	Gas boilers	51.9%
2,600-3,600€	22.5%	Don't know	4.3%	Electricity heating	48.1%
3,600-5000€	13.8%			Contracting	63.0%
>5,000€	6.3%				
Age		Position		Households	
18-30	27.5%	Mayor	9.1%	<10.000	42.1%
31- 45	36.7%	Administration (general)	45.4%	10.000 – 20.000	0,0%
46-65	32.0%	Administration (specific)	36.4%	20.000 – 100.000	21.1%
> 65	3,8%	Others	9,1%	>100.000	36,8%
Place of residence		Demographics			
Small town (pop. <5,000)	34.0%	Small town (pop. <5,000)	27.3%		
Small City (5,000 – 20,000)	17.9%	Small City (5,000 – 20,000)	27.3%		
Medium City (20,000 – 100,000)	9.2%	Medium City (20,000 – 100,000)	0%		
Big City (> 100,000), centre	15.0%	Big City (> 100,000)	45,5%		
Big City (> 100,000), periphery	23.8%				

2.2. Image of different heating systems

In the following chapter the self-report of experience of the consumers, municipalities and energy providers as well as their images of different heating systems will be described.

2.2.1. Consumers

The self-reporting of experience with different heating systems among Austrian consumers is pretty low. The consumers have most experience with district heating systems. However, about one-third of the sample claims that they have no or just little experience with this kind of heating system. For heat pumps the amount of people with no or little experience went up to two out of three (Figure 19).

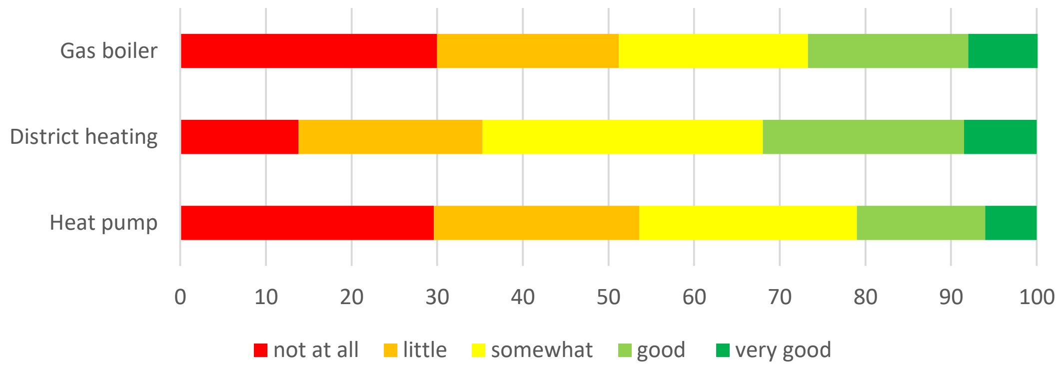

Figure 19. Experience with different Heating Systems among Austrian Consumers (n=520)

Concerning the image of different heating systems the consumers were asked to rate gas boiler systems, heat pumps and district heating on a semantic differential. The results can be seen in figure 20. The results indicate that a heat pump is seen as the most modern and eco-friendly form of heating systems, but district heating is also considered very positive. Gas boilers have an image as polluting and obsolete systems, while district heating seems to have an image as a good compromise between a good practicability, a low price a high reliability but also eco-friendliness and modernity.

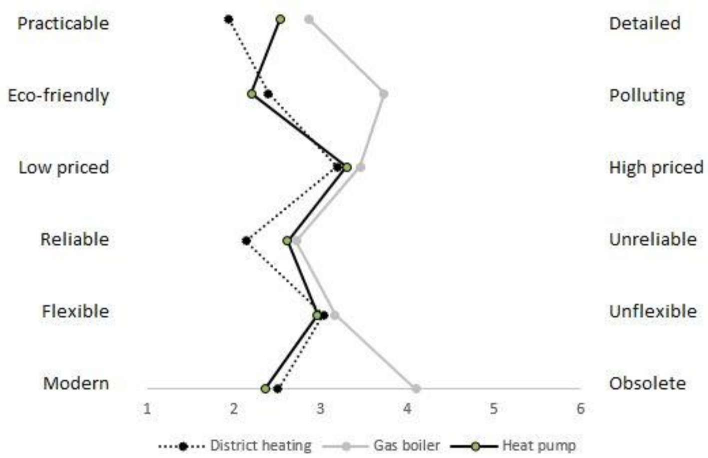

Figure 20. Semantic differential for heating systems. Consumers, Austria (n=520)

2.2.2. Municipalities

The self-report of experience shows that the representatives of the municipalities on average have good experience with the heating systems (Figure 21). Concerning the fact, more than 2 out of 3 of the respondents claim to work in the administration that is specialised on heating and energy the good knowledge is not surprising.

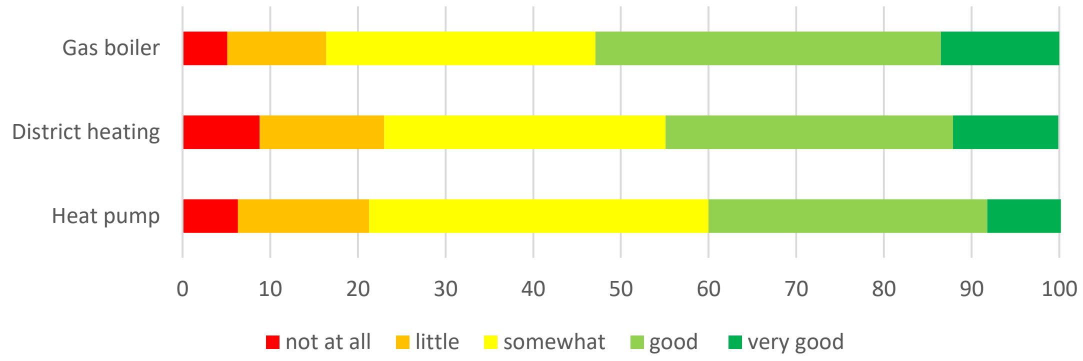

Figure 21. Experience with different Heating Systems among German Municipalities (n=274)

Concerning the image of different heating systems the results are different to the results of the consumers. Gas boilers are seen as the heating system with the lowest price and the highest flexibility. Nevertheless, gas boilers have a bad image as polluting and obsolete. District heating and heat pumps are very close together. District heating is seen as a bit more reliable and practicable, while heat pumps have a slightly more flexible image (Figure 22).

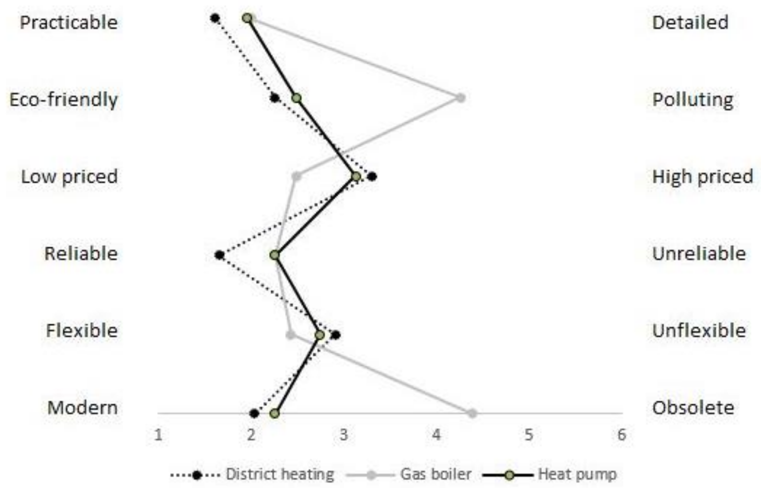

Figure 22. Semantic differential for heating systems. Municipalities, Austria (n=23)

2.2.3. Energy provider

It is not surprising that the respondents from the energy providers have the most experience with the different heating systems. Different to end-users and municipalities they have more experience with district heating than with gas boiler (Figure 23). Nonetheless, the high experience with district heating could be explained by the sampling procedure with a closed list of participants that was provide by an Austrian partner

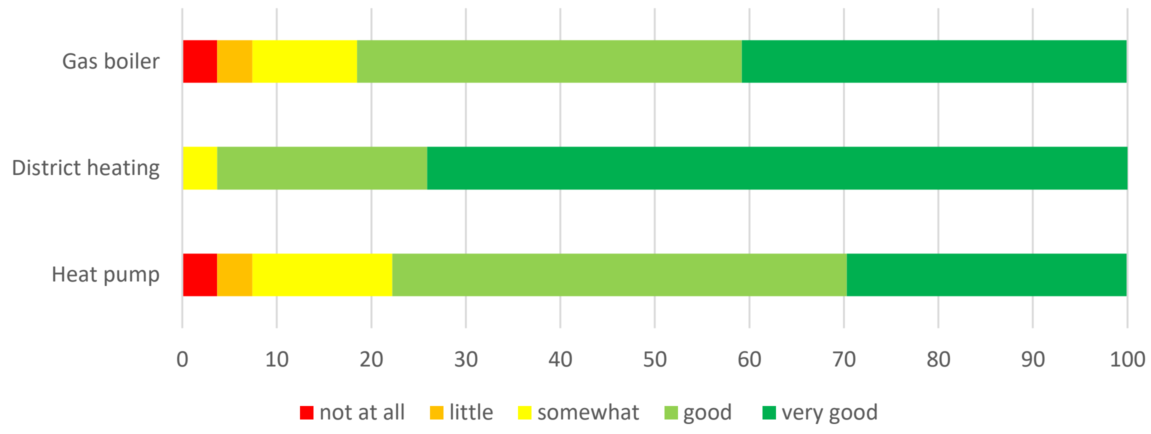

Figure 24. Experience with different Heating Systems among Austrian Energy Providers (n=27)

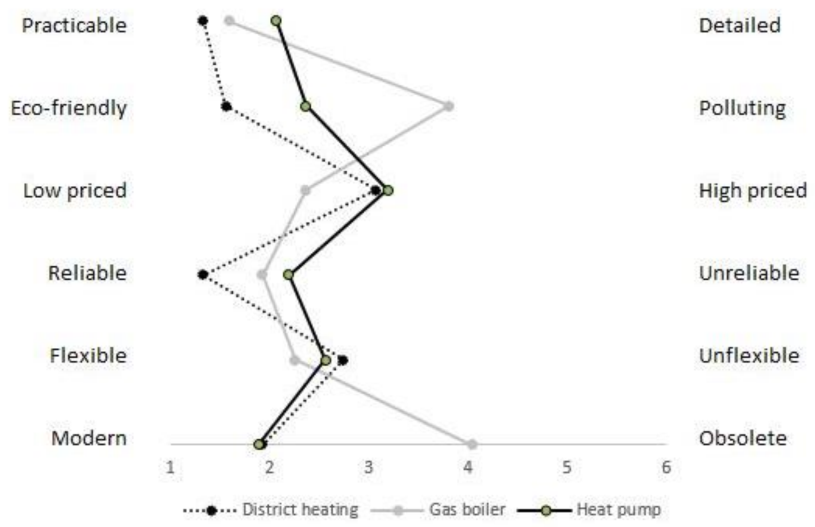

Figure 23. Semantic differential for heating systems. Energy providers, Austria (n=27)

Concerning the image of heating systems the energy providers in Austria also have a positive image of gas boilers, except of eco-friendliness and modernity. Nonetheless, district heating has the best image in practicability, eco-friendliness and reliability. Different to end-users and municipality district heating has in all items a better image than heat pumps, except for flexibility (Figure 24).

2.3. Market segmentation of consumers

During the survey attitudinal statements were given on a five-point rating scale from “important (1)” to “unimportant (5)”. Overall, 13 variables were used to learn about the attitudes of the consumers towards local providers, sustainability and economics of heating systems. For market segmentation of the consumers and municipalities these 13 variables were reduced to a lower number of latent variables, by means of principle component analysis. The aim is to display the high quantity of variables while simultaneously obtaining a low loss of variance. The number of factors was determined by the Kaiser-criterion (Eigenvalue > 1). For easier interpretation of the factors, varimax rotation was applied. Finally, Cronbach’s alpha scores were used as a measure for internal scale reliability

After that, k-means clustering was performed on the factors. The target criterion was the minimization of variance within the clusters and clearance was the squared Euclidean distance. As it is not possible to determine the number of clusters within k-means analysis, this step was performed through the Ward method beforehand. Additionally outliners were eliminated by the single linkage clustering. Initially, the dendrogram and the elbow-criterion were observed to determine the final number of clusters.

2.3.1. Consumers

Table 9 shows the factor scores after varimax rotation. The analysis resulted in a three- factor solution: Responsibility for the environment and sustainability (F1), preference for a local partnership (F2) and preference for price and financial security (F3). Overall, 59.6 % of the total variance was explained through the factors and Cronbach’s alpha scores were above 0.74 for all factors, which is considered “good” regarding internal scale reliability.

Factor 1 pools items which reveal the importance of sustainability like low pollution of a high share of renewable energies. The second factor identifies mainly locally attitudes towards the important characteristics of heating systems. Direct contact to a local provider and a long-term partnership belong to factor 2.

Factor 3 combines positive attitudes towards price and financial security. The variables reflecting these factors mainly include reasonable pricing, transparency and stable prices. Further variables of this factor are high trust in the provider and high security of the supply.

Table 9. Factor analysis of consumer attitudes in Austria

Factor Loadings From Principal Component Factor Analysis: Communalities, Eigenvalues, Percentages of Variance, and Alpha-Value for Items of Preferences of heating systems (N=520), KMO=.845

Item	Factor loading 1 Sustainability	 2 Localism	 3 Price and financial Security	Communality
High share of renewable Energy	**.83**	.23	.00	.74
Low pollution	**.80**	.23	.03	.69
Future efficiency of energy source	**.73**	.15	.25	.62
Transparent accounting	**.44**	.14	.42	.39
Local contact person	.04	**.81**	.16	.68
Direct contact to the provider	.16	**.78**	.17	.67
Long-term partnership	.21	**.67**	.12	.51
Local provider	.41	**.59**	-.01	.52
High trust in provider	.38	**.48**	.33	.49
Reasonably priced heating system	.04	.05	**.80**	.65
Low fluctuations in prices	.19	.20	**.71**	.58
Reasonably priced initial outlay	-.10	.20	**.69**	.52
High security of supply	.40	.04	**.63**	.57
Eigenvalue	4.67	1.67	1.28	
Variance explained in %	35.94	12.81	9.82	
α	.80	.74	.77	

Note. Boldface indicates highest factor loadings.

Based on the three factors, three clusters were identified without the need of eliminating outliers (see Figure 25). The results confirm the existence of different consumer segments regarding attitudes towards heating systems.

The first, and smallest cluster, “The Hedonists” represents 25.87% of the sample. These consumers do not care that much about price and local providers and just like the average about environmental concerns.

The second cluster, “The price sensitive Localists”, is characterized by high scores for all factors “Price and financial security”, the factors “local provider” and the factor “Sustainability” in which localism is the most important factor.

The third cluster “The Ecologists” consists of people that take care of environmental aspects. People in this cluster exhibit a relatively high sense of responsibility for environmental issues, but do not care about a local provider.

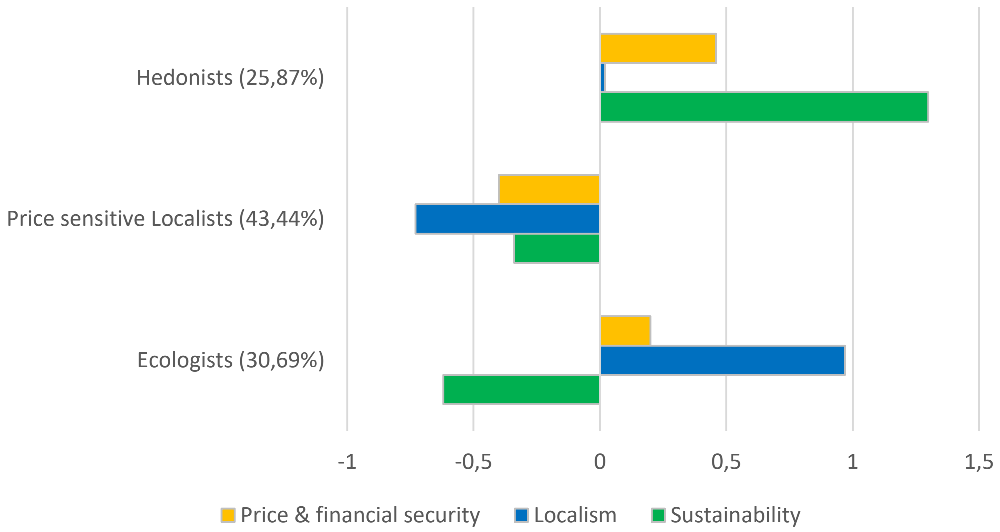

Figure 25. Cluster centers of the k-means cluster analysis for consumers in Austria. Lower numbers represent a higher attitude towards the factors compared to the average.

2.4. Desirability and Probability of Scenarios

Additionally the consumers were ask to rate two scenarios based on their opinion about desirability and probability. The results can be found below:

Scenario1:

"Till 2030 a strong development of district heating in urban agglomerations can be recognized. District heating will be the most preferred heating system in urban areas. A high degree of renewable energies will reduce the CO_2–emission significantly."

- Please rate the desirability/probability of this scenario:
- Please estimate: How many households will be provided with district heating until 2030?

The results of these questions can be seen in Figure 26 and Figure 27.

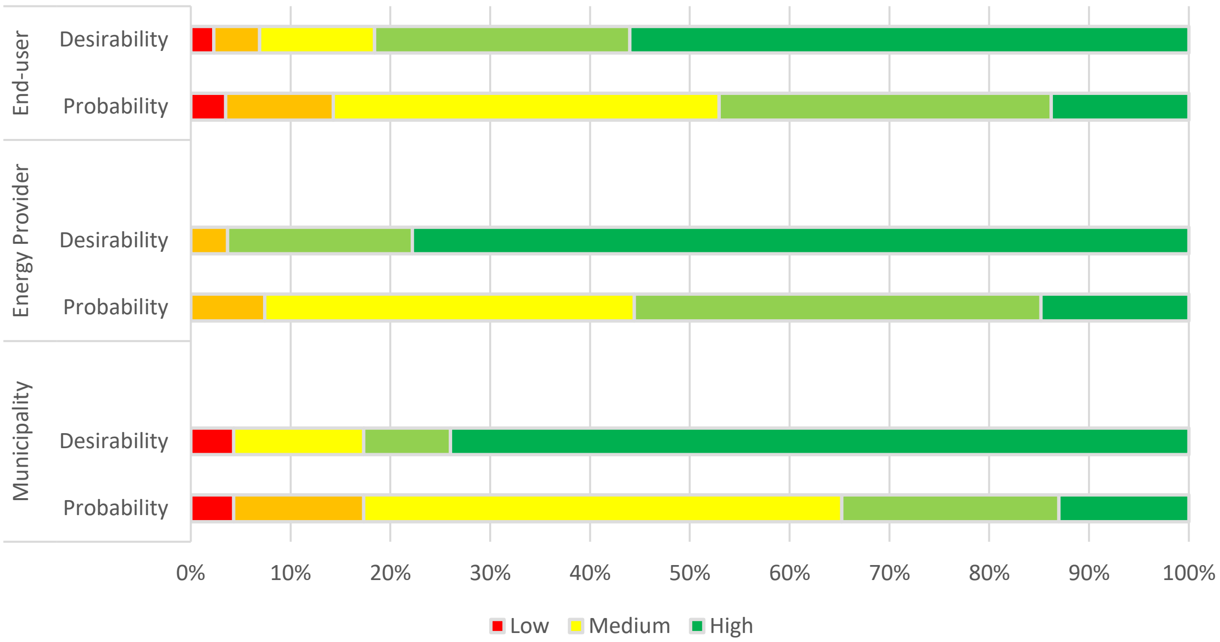

Figure 26. Desirability and Probability of Scenario 1 for Consumers, Municipalities and Energy Providers in Austria

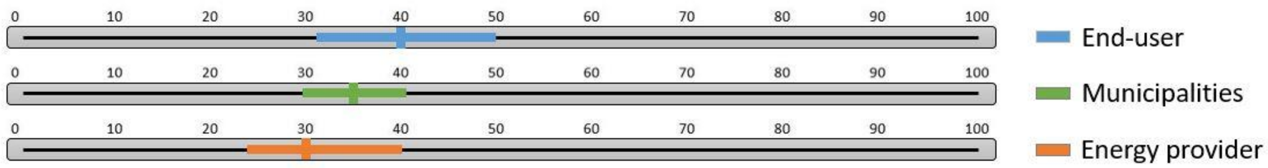

Figure 27. „Please estimate: How many households will be provided with district heating until 2030?" Bars represent the Median and the interquartile range.

The results for the first scenario indicate that a strong development of district heating that goes along with a reduction of CO_2 –emission is highly desirable for consumers, energy providers and municipalities. However, the probability of this scenario is not seen as high as the desirability was chosen. The estimations for the year 2030 show a median of 30% of household by energy providers, 35% by municipalities and 40% by the consumers (Figure 26).

Figures 28 and 29 show the results for the second scenario:

"District heating plays a major role in 2030. The assembly and disassembly costs shall be allocated to the general public to promote further development."

- Please rate the desirability/probability of this scenario:
- In your opinion: What is the maximum amount of assembly and disassembly costs that shall be allocated to the general public in percent?

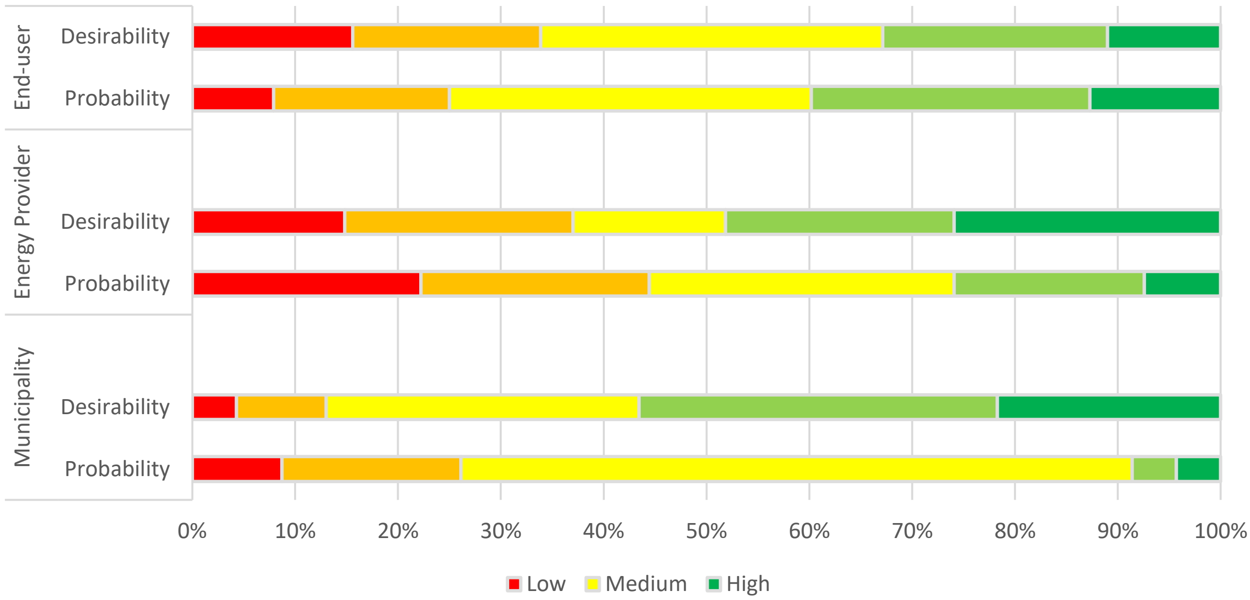

Figure 28. Desirability and Feasibility of Scenario 2 for Consumers, Municipalities and Energy Providers in Austria

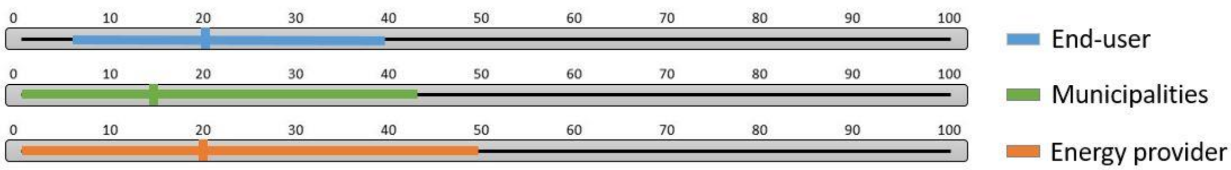

Figure 29. "In your opinion: What is the maximum amount of assembly and disassembly costs that shall be allocated to the general public in percent?" Bars represent the Median and the interquartile range.

The results show that the muinicipalities state the highest desirability for this scenario, but the lowest probability. Consumers and energy providers are not as convinced as the municipalities that the assembly and disassembly costs should be allocated to the general public. Nevertheless the consumers estimate a higher probability of this scenario than the energy providers.

Figure 29 reconfirms the findings of the desirability and feasibility. We can see very similar results for consumers and energy providers in the share of the maximum amount of assembly and disassembly cost that should be allocated to the general public. For both groups the median is at 20% of the total amount and the interquartile range between 7.5% and 40% (consumers) and between 0% and 50% (energy providers). On the other hand we can see the municipalities with a median of only 15% and an interquartile range between 0% and 42.5%.

2.5. Willingness to pay for district heating

2.5.1. Discrete-Choice-Experiments

Discrete choice models empirically model choices made by people among a finite set of alternatives. Such models have been used to examine, e.g., the choice of which car to buy or where to go to college among numerous other applications. Daniel McFadden won the Nobel Prize in 2000 for his pioneering work in developing the theoretical basis for discrete choice.

In the discrete choice experiment of this study the respondent's task was to choose the most preferred heating option among a set of alternatives which consisted of different attributes and attribute characteristics (see Table 10). The participants had to make altogether twelve choice decisions.

Table 10. Choice set example

	alternative 1	**alternative 2**	**alternative 3**
	Heat pump	Gas	District heating from fossil fuels
annual operation costs a m^2	**6 €**	**10 €**	**12 €**
investment costs (without 3,000 € for ventilation system)	**8.000 €**	**6.000 €**	**6.000 €**
primary energy factor	**0,8**	**1,1**	**0,7**
CO_2-emissions	**13,0**	**20**	**14,0**
price risk	**high**	**high**	**low**

Discrete choice models statistically relate the choice made by each person to the attributes of the person and the attributes of the alternatives available to the person. In our study, the choice of which heating alternative a person choose (district heating fossil or from renewables, heat pump, gas) is statistically related to the attributes of each available heating option (e.g. costs, CO^2-emissions, price risk). The models estimate the probability that a person chooses a particular alternative. From the estimates which base on multinomial logit models one can infer forecasts on how people's choices will change under changes in attributes of the alternatives (e.g. higher investment or annually costs) and/or demographics or attitudes of the individuals. In this study we calculated so-called odds ratios and the willingness-to-pay for demonstrating the preferences the respondents have for the considered heating alternatives.

The mentioned odds ratios are used to compare the relative odds of choice probability of a heating alternative in comparison to the competing heating alternatives. The odds ratio can also be used to compare the magnitude of various heating alternative on the choice probability.

- OR=1 heating alternative does not affect odds of choice probability
- OR>1 heating alternative associated with higher choice probability
- OR<1 heating alternative associated with lower choice probability

Furthermore the willingness-to-pay for the option 'district heating' and 'heat pump' in comparison to the reference alternative 'gas' were calculated on the basis of market share simulations.

The choice experiments were analysed with logit models using the software NLogit 4.0. Multinomial Logit (MNL) models were estimated to gain insight into the data. In choice analysis, it is assumed that the utility U_i of choosing alternative *i* out of a choice set of *J* alternatives is composed of the observed utility V_i capturing the effect of the variables tested in the experiments, and the random error term ε_i capturing the unobserved utility (Hensher et al., 2015). The observable component V_i is assumed to be a linear relationship of observed attribute levels *x* of each alternative *j* and their corresponding weights *(ß).* In this study, all cost attributes represented metric variables. The heating options 'gas', 'district heating fossil fuels', 'district heating renewables' and 'heat pump' entered the model as dummy-variables with the option 'gas' set to zero as reference. The costs were included as metric variables and assumed to have a squared effect on the observable component of the utility as follows:

$$U_\mathrm{i} = \beta_{\mathrm{ac}}\mathrm{annual\ costs}^2 + \beta_{\mathrm{ic}}\mathrm{investment\ costs}^2 + \beta_{\mathrm{dc-renew}}\,district\ heating\ renewabels + \beta_{\mathrm{dc-fossil}}\,district\ heating\ fossil\ fuels + \beta_{\mathrm{heat\ pump}}\,heat\ pump + \varepsilon_i$$

The probability (*Prob*) that alternative *i* is chosen out of a choice set of *J* alternatives is given by (Hensher et al., 2015):

$$\mathrm{Prob_i} = \frac{\mathrm{expV_i}}{\sum_{\mathrm{j}}^{\mathrm{J}} \mathrm{expV_j}}$$

2.5.2. Austria – consumers

The estimation results for Austria demonstrate that 'district heating from renewable energies' is the most preferred heating alternative whereas the reference base alternative 'gas' is least preferred (see Table 11). The second place takes 'district heating from fossil fuels' followed by the option 'heat pump'. The described effects are all highly significant in comparison to the reference base 'gas' and differ significantly from each other. As expected the cost parameters ('variable costs' & 'investments cost') are negative and significant. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for final estimation.

Table 11: Estimation results Austria (N=520)

Coefficients		
	Estimate	**Std. Error**
district heating renewable+	2.24***	5.65e-02
district heating fossil	1.06***	7.69e-02
heat pump	0.67***	4.30e-02
variable costs²	-1.33e-02***	6.64e-04
investment costs²	-3.85e-06***	1.06e-06
Log-Likelihood	-5802.6	

Significance codes: 0=***, 0.001=**, 0.01*

+The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 11 odds ratios were calculated (see Figure 30). The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters.

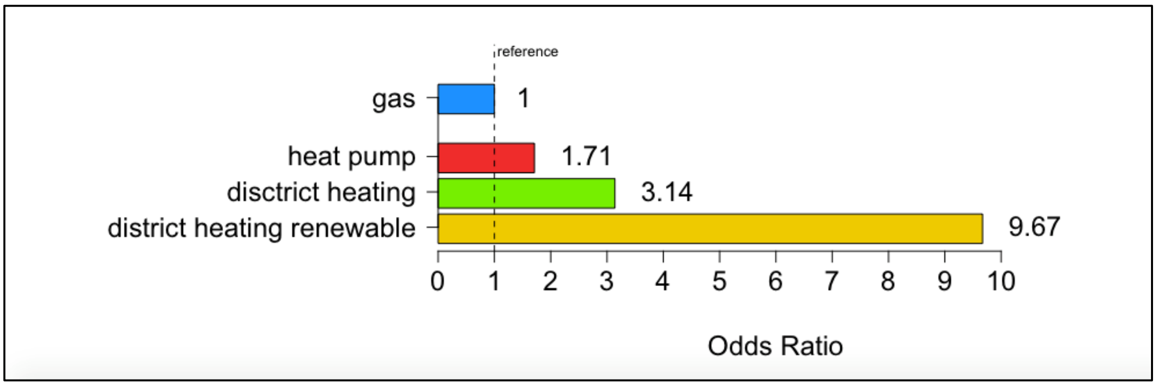

Figure 30. Odds ratios for the analysed heating alternatives

In comparison to the reference base 'gas' (odds ratio=1) the alternative 'heat pump' revealed a 71% higher choice probability in the discrete choice experiments. It follows 'district heating from fossil fuels' which was more than three times stronger preferred than 'gas'. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than nine times stronger preferred than 'gas'.

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 6,000 €. The variable costs for the base option ‘gas’ were set to 6 €/m²/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two heating alternatives were hypothesized.

Figure 31 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 8.4 € higher variable costs per m²/year for ‘district heating from renewable energies’ than for ‘gas’. The WTP for ‘district heating from fossil fuels’ is circa 50 % lower with 4.8 €. The WTP for the alternative ‘heat pump’ is 3.3 €.

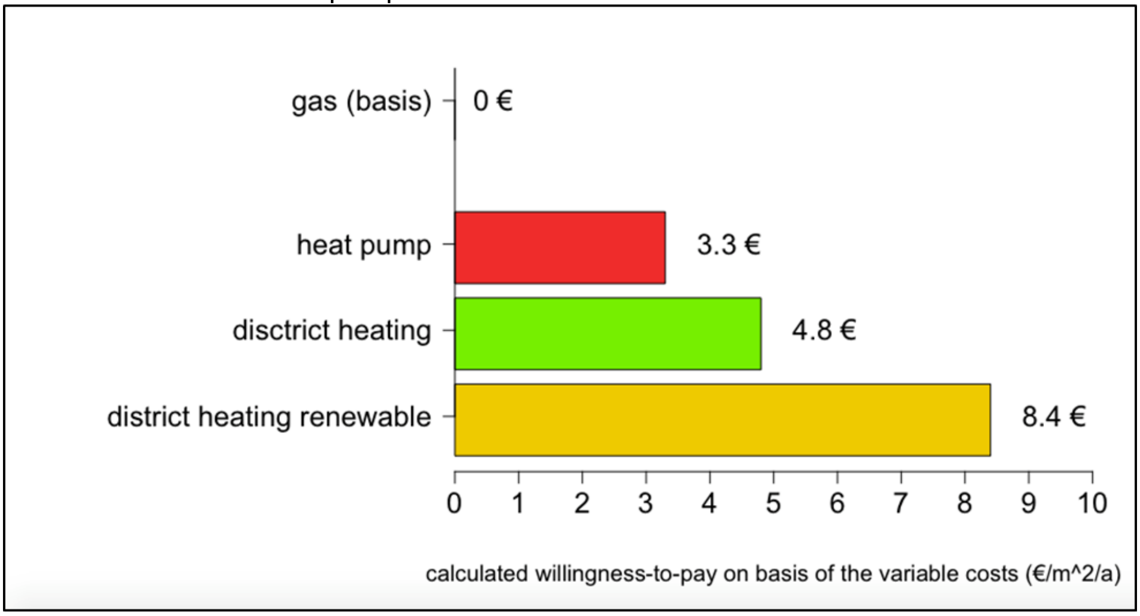

Figure 31. WTP for the analyzed heating alternatives

2.5.3. Conclusion

The results clearly show that ‘district heating from renewable energies’ is the most favorite heating option for the consumers. The ranking of the other alternatives is ‘district heating from fossil fuels’, ‘heat pump’ and ‘gas’. It is to highlight that the participants revealed a significant additional WTP for ‘district heating’ just for the fact that is from renewable energies. The WTP is 3.6 € higher for this option than for ‘district heating from fossil fuels’.

2.5.4. Austria – municipality

The estimation results for Austria demonstrate that ‘district heating from renewable energies’ is the most preferred heating alternative whereas the reference base alternative ‘gas’ is least preferred (see Table 12). The second place takes ‘district heating from fossil fuels’ closely followed by the option ‘heat pump’. The described effects for the heating systems are all highly significant in comparison to the reference base ‘gas’ and differ significantly from each other. As expected the cost parameters (‘variable costs’ & ‘investments cost’) are negative. Nonetheless, the effect of the investments costs was not significant what may be is due to the low sample size and the applied selection process for the sample. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for final estimation.

Table 12: Estimation results Austria (N=23)

Coefficients		
	Estimate	**Std. Error**
district heating renewable⁺	4.48***	5.15e-01
district heating fossil	2.12***	5.49e-01
heat pump	2.02***	3.59e-01
variable costs[2]	-9.85e-02*	4.16e-03
investment costs[2]	-6.45e-09	1.82e-08
Log-Likelihood	-160.31	

Significance codes: 0=***, 0.001=**, 0.01*

⁺The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 12 odds ratios were calculated. The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters (see Figure 32).

In comparison to the reference base 'gas' (odds ratio=1) the alternative 'heat pump' revealed a 7.5 times higher choice probability in the discrete choice experiments. It follows 'district heating from fossil fuels' which was more than 8.3 times stronger preferred than 'gas'. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than 88 times stronger preferred than 'gas'. This very high odds ratio is may be biased by the chosen sample selection.

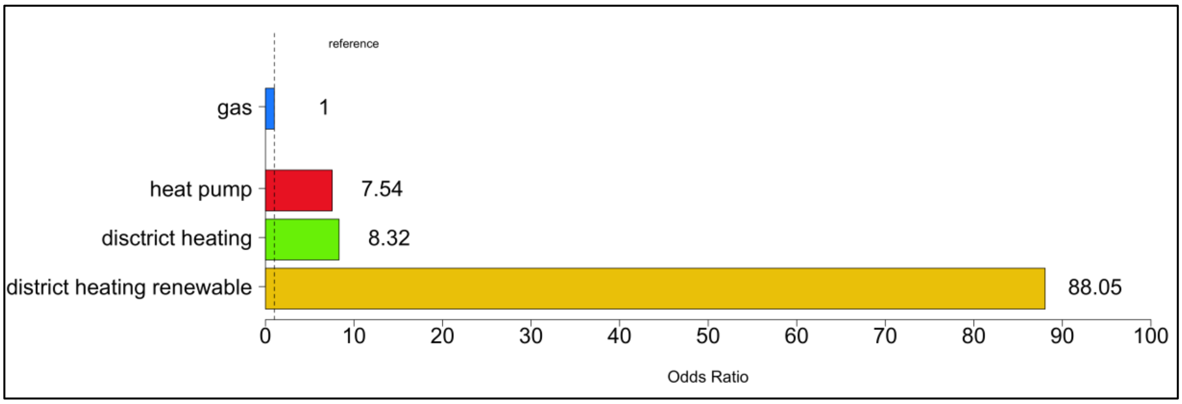

Figure 32. Odds ratios for the analyzed heating alternatives

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 30,000 €. The variable costs for the base option ‘gas’ were set to 6 €/m²/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two heating alternatives were hypothesized.

Figure 33 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 16 € higher variable costs per m²/year for ‘district heating from renewable energies’ than for ‘gas’. The WTP for ‘district heating from fossil fuels’ is circa 50 % lower with 9.8 €. The WTP for the alternative ‘heat pump’ is 9.5 €.

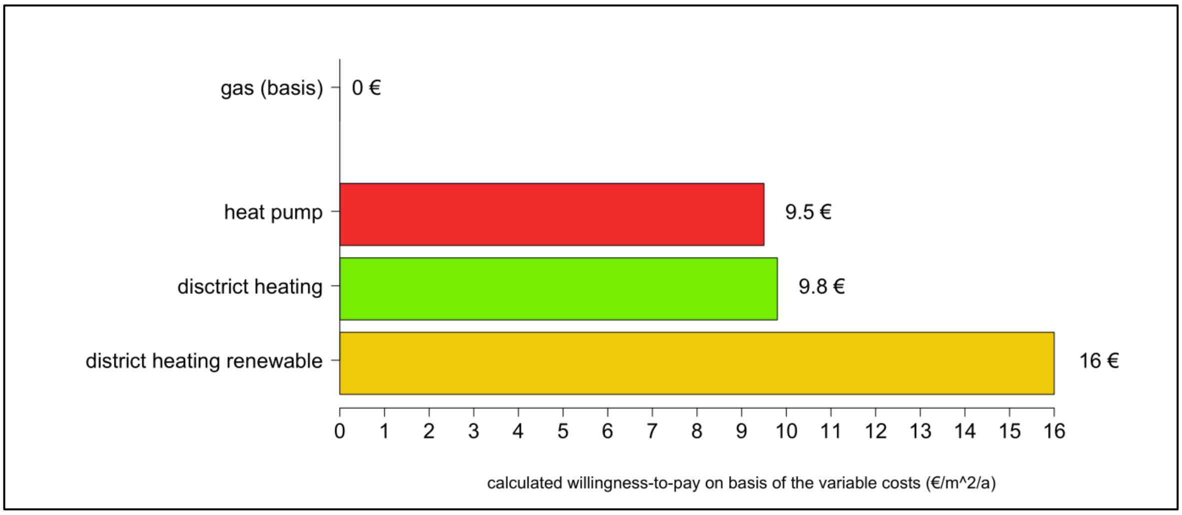

Figure 33. WTP for the analyzed heating alternatives

2.5.5. Conclusion

The results clearly show that ‘district heating from renewable energies’ is the most favorite heating option for the municipalities. The ranking of the other alternatives is ‘district heating from fossil fuels’, ‘heat pump’ and ‘gas’. It is to highlight that the participants revealed a significant additional WTP for ‘district heating’ just for the fact that is from renewable energies. The WTP is 6.2 € higher for this option than for ‘district heating from fossil fuels’.

2.5.6. Austria - energy provider

The estimation results for Austria demonstrate that ‘district heating from renewable energies’ is the most preferred heating alternative whereas the reference base alternative ‘gas’ is least preferred (see Table 13). The second place takes ‘district heating from fossil fuels’ closely followed by the option ‘heat pump’. The described effects for the heating systems are all highly significant in comparison to the reference base ‘gas’ and differ significantly from each other. As expected the cost parameters (‘variable costs’ & ‘investments cost’) are negative. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for final estimation.

Table 13: Estimation results Austria (N=27)

Coefficients		
	Estimate	**Std. Error**
district heating renewable+	3.49***	2.2e-16
district heating fossil	1.51***	0.01
heat pump	1.22***	1-91e-09
variable costs[2]	-1.95e-02***	5.61e-09
investment costs[2]	-4.53e-07*	0.04
Log-Likelihood	-228.94	

Significance codes: 0=***, 0.001=**, 0.01*

+The heating alternative ‘gas’ is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the ‘brand’ strength of the different heating options on the basis of the estimation results from Table 13 odds ratios were calculated. The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters (see Figure 34).

In comparison to the reference base ‘gas’ (odds ratio=1) the alternative ‘heat pump’ revealed a 3.4 times higher choice probability in the discrete choice experiments. It follows ‘district heating from fossil fuels’ which was more than 4.5 times stronger preferred than ‘gas’. It is to highlight that ‘district heating from renewables energies’ has by far the highest effect size. This alternative was more than 33 times stronger preferred than ‘gas’.

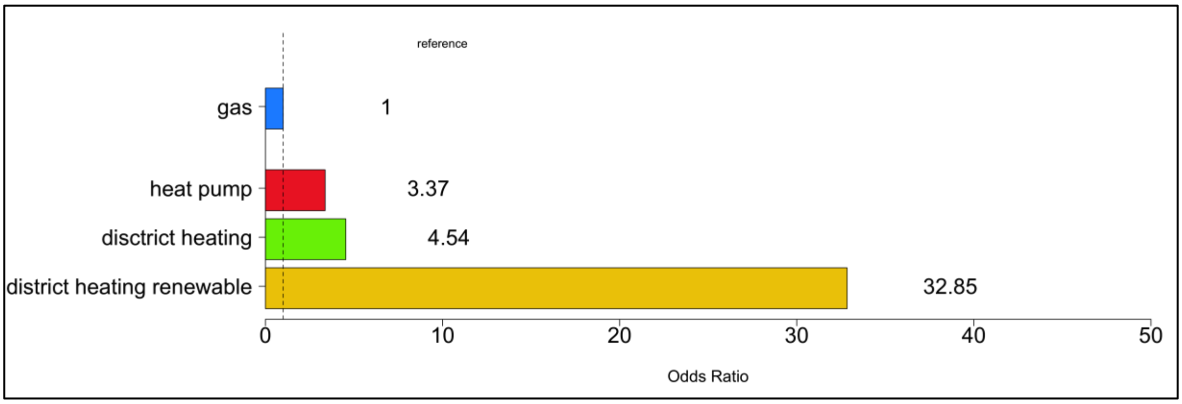

Figure 34. Odds ratios for the analyzed heating alternatives

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 30,000 €. The variable costs for the base option 'gas' were set to 6 €/m²/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two heating alternatives were hypothesized.

Figure 35 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 8.6 € higher variable costs per m²/year for 'district heating from renewable

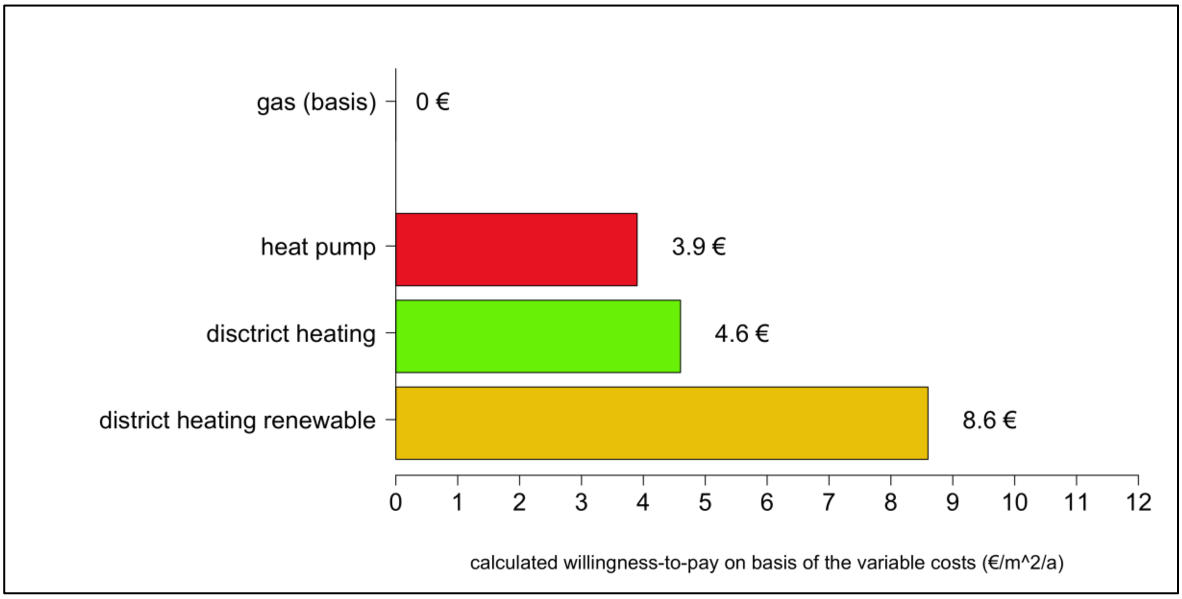

Figure 35. WTP for the analyzed heating alternatives

energies' than for 'gas'. The WTP for 'district heating from fossil fuels' is circa 50 % lower with 4.6 €. The WTP for the alternative 'heat pump' is 3.9 €.

2.5.7. Conclusion

The results clearly show that 'district heating from renewable energies' is the most favorite heating option for the energy providers. The ranking of the other alternatives is 'district heating from fossil fuels', 'heat pump' and 'gas'. It is to highlight that the participants revealed a significant additional WTP for 'district heating' just for the fact that is from renewable energies. The WTP is 4 € higher for this option than for 'district heating from fossil fuels'.

3. FRANCE

In the following chapter the experience of the consumers, municipalities and energy providers as well as their images of different heating systems will be described. Furthermore the attitudes towards district heating in the near future will be analysed. Afterwards a market segmentation for consumers and municipalities will be conducted.

3.1. Sample

The data of the consumers was collected between June, 24 and June, 28. After 4 days of field time data of 490 end-users was collected. In addition data of municipalities was collected between August, 7 and September, 30. We received data from 39 municipalities (response rate (RR) = 1%). Energy providers and real estate companies were not part of the research in France. Due to the low response rate, the municipalities will not be considered for market segmentation.

The socio-demographic characteristics of the survey are presented in Table 14.

Table 14. Demographics of consumers and municipalities in France

Consumers (n=490)		Municipalities (n=39)	
Gender			
Male	52.2%		
Female	47.8%		
Income		Party affiliation of mayor	
< 1,300€	14,7%	Independent	33.3%
1,300-2,600€	38.0%	LR	20.5%
2,600-3,600€	24.9%	PS	5.1%
3,600-5000€	15.9%	Others	15.4%
>5,000€	6.5%	Don't know	25.6%
Age		Position	
18-30	10.6%	Mayor	35.9%
31- 45	32.7%	Administration (general)	10.3%
46-65	46.7%	Administration (specific)	25.6%
> 65	10%	Others	28,2%
Place of residence		Demographics	
Small town (pop. <5,000)	35.7%	Small town (pop. <5,000)	64.1%
Small City (5,000 – 20,000)	22.4%	Small City (5,000 – 20,000)	25.7%
Medium City (20,000 –100,000)	23.5%	Medium City (20,000 –100,000)	7.7%
Big City (> 100,000), centre	7.8%	Big City (> 100,000)	2.6%
Big City (> 100,000), periphery	10.6%		

3.2. Image of different heating systems

In the following chapter the self-report of experience of the consumers, municipalities and energy providers as well as their images of different heating systems will be described.

3.2.1. Consumers

The self-reporting of experience with different heating systems among French consumers is much higher than in Germany or Austria regarding gas boilers and heat pumps. For district heating systems the experience is similar in all three countries. Only less than one third of the sample claims that they have no or just little experience with gas boilers or heat pumps. For district heating the amount of people with no or little experience went up to one half (Figure 36).

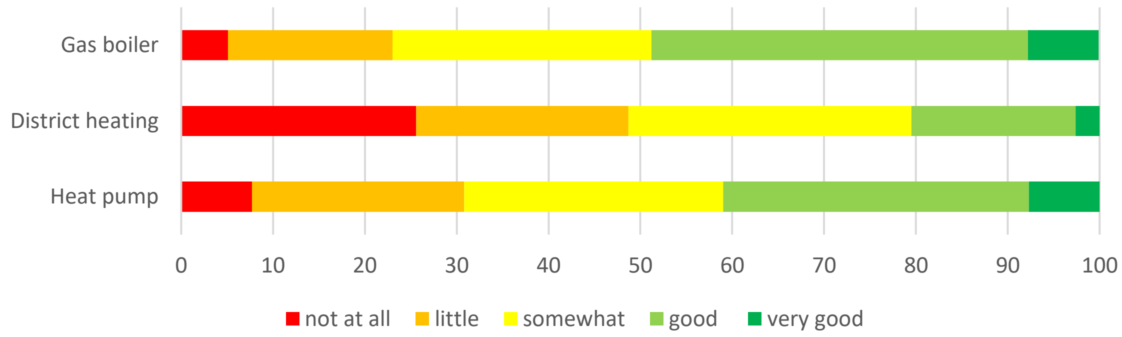

Figure 36. Experience with different Heating Systems among French Consumers (n=490)

Concerning the image of different heating systems the consumers were asked to rate gas boiler systems, heat pumps and district heating on a semantic differential. The results can be seen in figure 37. The results indicate that a heat pump the best image in all categories except of practicability, were gas boilers are seen as the best alternative. Gas boilers and district heating are very close, but district heating has a better image in eco-friendliness, price and modernity, while gas boilers are better in reliability and flexibility

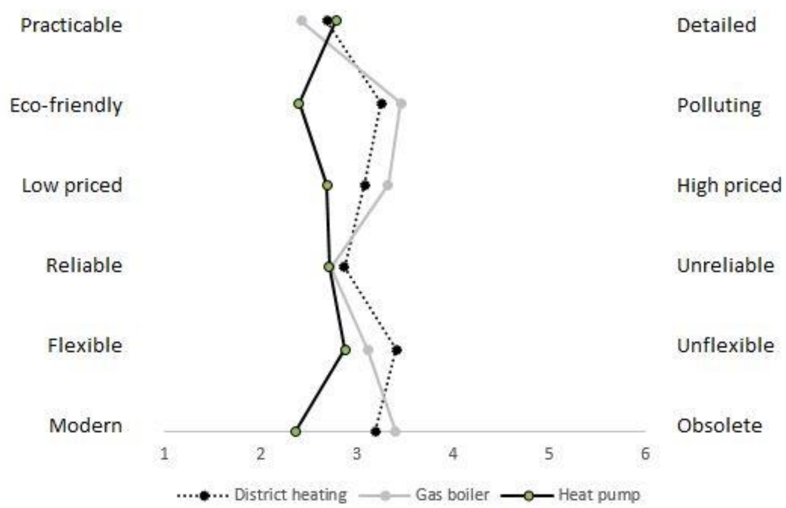

Figure 37. Semantic differential for heating systems. Consumers, France (n=490)

3.2.2. Municipalities

The self-report of experience shows that the representatives of the municipalities on average have good experience with the heating systems except of district heating (Figure 38). Concerning the fact, 25% of the respondents claim to work in the administration that is specialised on heating and energy the good knowledge is surprising.

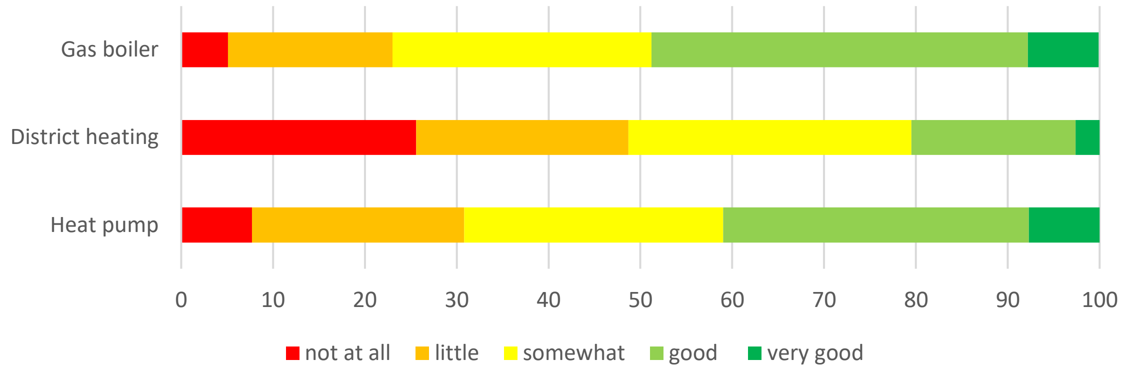

Figure 38. Experience with different Heating Systems among French Municipalities (n=39)

Concerning the image of different heating systems the results differ strongly to the results of the end-users. Gas boilers are seen as the most practicable, reliable and flexible alternative, but also as polluting and obsolete. District heating and heat pumps are very close together. District heating is seen as a bit more reliable and practicable (Figure 39).

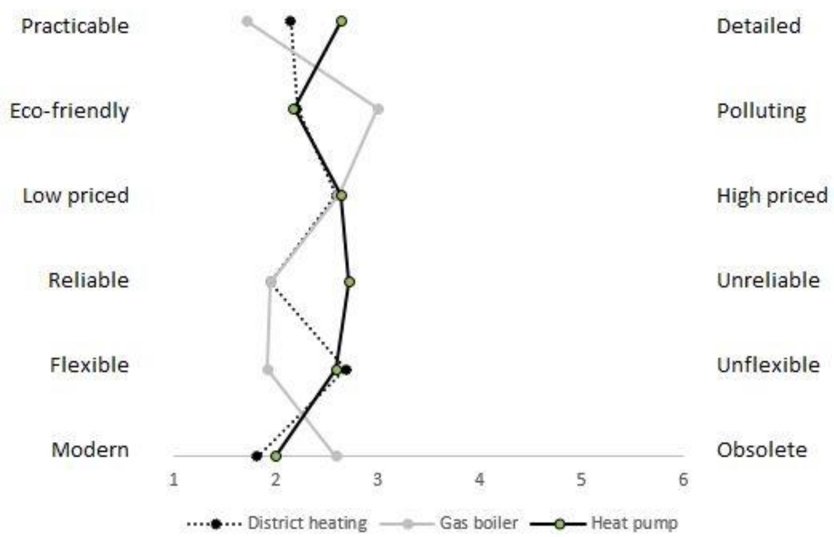

Figure 39. Semantic differential for heating systems. Municipalities, France (n=39)

3.3. Market segmentation of consumers

During the survey attitudinal statements were given on a five-point rating scale from “important (1)” to “unimportant (5)”. Overall, 13 variables were used to learn about the attitudes of the consumers towards local providers, sustainability and economics of heating systems. For market segmentation of the consumers and municipalities these 13 variables were reduced to a lower number of latent variables, by means of principle component analysis. The aim is to display the high quantity of variables while simultaneously obtaining a low loss of variance. The number of factors was determined by the Kaiser-criterion (Eigenvalue > 1). For easier interpretation of the factors, varimax rotation was applied. Finally, Cronbach’s alpha scores were used as a measure for internal scale reliability

After that, k-means clustering was performed on the factors. The target criterion was the minimization of variance within the clusters and clearance was the squared Euclidean distance. As it is not possible to determine the number of clusters within k-means analysis, this step was performed through the Ward method beforehand. Additionally outliners were eliminated by the single linkage clustering. Initially, the dendrogram and the elbow-criterion were observed to determine the final number of clusters.

Table 15 shows the factor scores after varimax rotation. The analysis resulted in a three- factor solution: preference for price and financial security (F1), preference for local providers (F2) and responsibility for the environment and sustainability (F3). Overall, 67.2 % of the total variance was explained through the factors and Cronbach’s alpha scores were above 0.8 for all factors, which is considered “very good” regarding internal scale reliability.

Factor 1 combines positive attitudes towards price and financial security. The variables reflecting these factors mainly include reasonable pricing, transparency and stable prices. Further variables of this factor are high trust in the provider and high security of the supply. The second factor identifies mainly locally attitudes towards the important characteristics of heating systems. Direct contact to a local provider and a long-term partnership belong to factor 2. F3 pools items which reveal the importance of sustainability like low pollution of a high share of renewable energies.

Table 15. Factor analysis of consumer attitudes in France

Factor Loadings From Principal Component Factor Analysis: Communalities, Eigenvalues, Percentages of Variance, and Alpha-Value for Items of Preferences of heating systems (N=491), KMO=.93

Item	Factor loading			Communality
	1 Price and financial Security	2 Localism	3 Sustainability	
Transparent accounting	**.79**	.21	.22	.72
Reasonably priced heating system	**.77**	.11	.36	.74
Low fluctuations in prices	**.77**	.12	.29	.69
High security of supply	**.73**	.29	.27	.69
Reasonably priced initial outlay	**.70**	.27	.15	.58
Local contact person	.21	**.81**	.02	.70
Direct contact to the provider	.41	**.70**	.03	.66
Local provider	-.08	**.70**	.45	.70
Long-term partnership	.18	**.64**	.24	.50
High trust in provider	.49	**.58**	.25	.63
Low pollution	.35	.15	**.80**	.79
High share of renewable Energy	.32	.18	**.77**	.74
Future efficiency of energy source	.51	.31	**.61**	.73
Eigenvalue	6.50	1.42	0.95	
Variance explained in %	49.96	10.92	7.31	
α	.88	.81	.85	

Note. Boldface indicates highest factor loadings.

Based on the three factors, four clusters were identified without the need of eliminating outliers (see Figure 40). The results confirm the existence of different consumer segments regarding attitudes towards heating systems.

The first, and biggest cluster, “The Generalists” represents 38.9% of the sample. These consumers are characterized by high scores for the factors “Price and financial security”, the factors “local provider” and the factor “Sustainability” in which localism is the most important.

The second cluster “The Price Sensitives” do not care about environmental concerns and concentrate on a low price.

The third cluster “The Price sensitive Ecologists” consists of people that take care of environmental aspects, but also about price and security. People in this cluster exhibit a relatively high sense of responsibility for the environment, but do not care about a local provider.

The fourth cluster, “The Hedonists”, is characterized by a low score for the factors “Price and financial security”, the factors “Localism” and “Sustainability” are just little below the average.

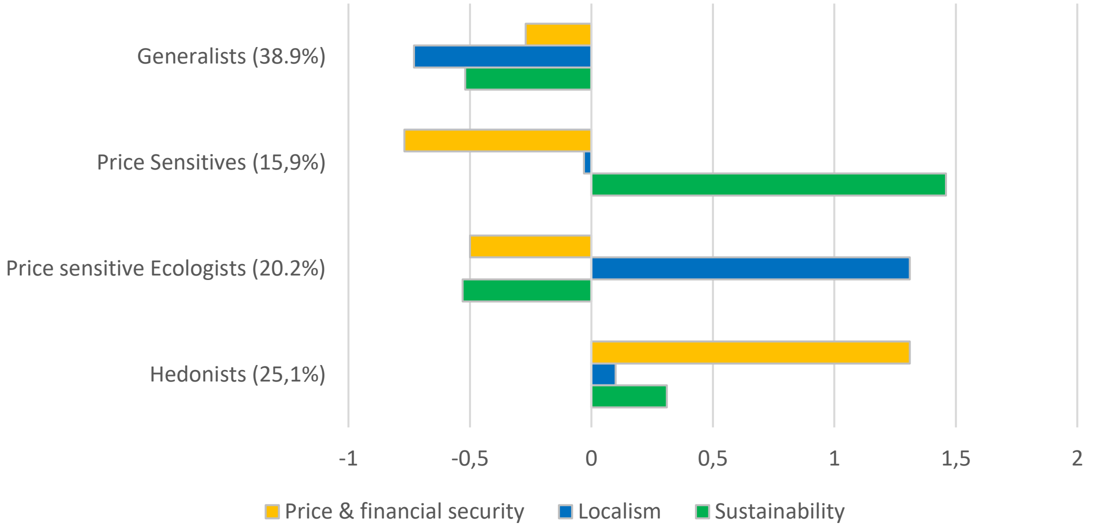

Figure 40. Cluster centers of the k-means cluster analysis for consumers in Germany. Lower numbers represent a higher attitude towards the factors compared to the average.

3.4. Desirability and Probability of Scenarios

Additionally the consumers and municipalities were ask to rate two scenarios based on their opinion about desirability and probability. The results can be found below:

Scenario1:

"Till 2030 a strong development of district heating in urban agglomerations can be recognized. District heating will be the most preferred heating system in urban areas. A high degree of renewable energies will reduce the CO_2–emission significantly."

- Please rate the desirability/probability of this scenario:
- Please estimate: How many households will be provided with district heating until 2030?

The results of these questions can be seen in Figure 41 and Figure 42.

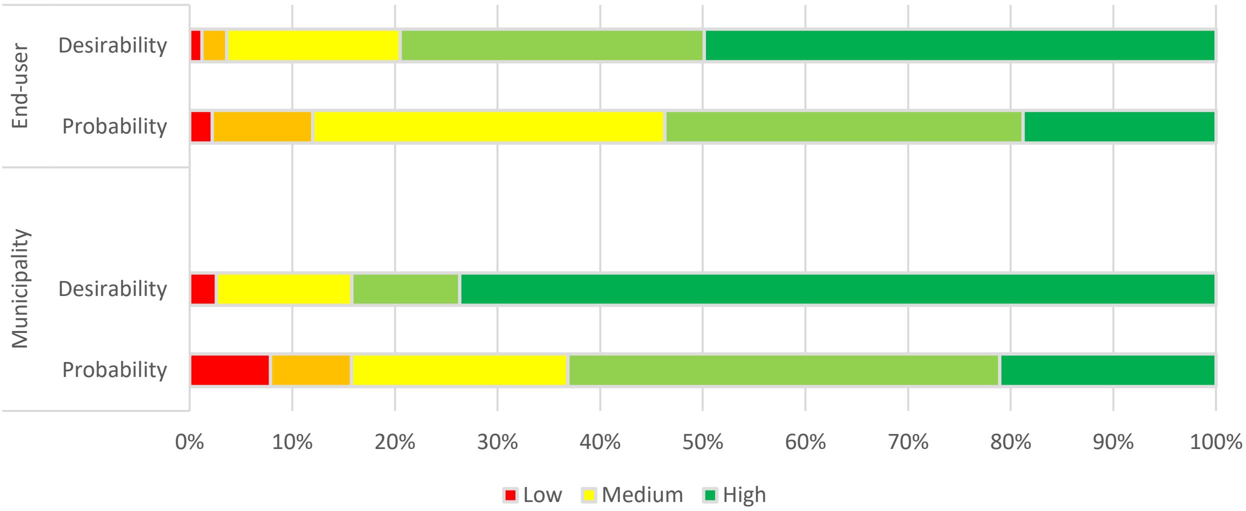

Figure 41. Desirability and Probability of Scenario 1 for Consumers and Municipalities in France

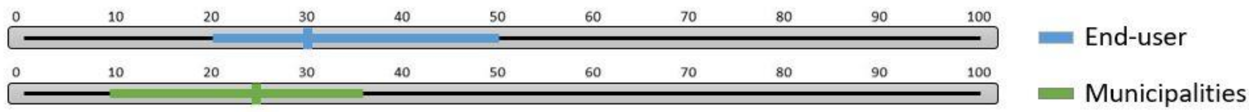

Figure 42. Please estimate: How many households will be provided with district heating until 2030?" Bars represent the Median and the interquartile range.

The results for the first scenario indicate that a strong development of district heating that goes along with a reduction of CO_2–emission is highly desirable for consumers and municipalities. In addition, the probability of this scenario is also seen higher than 50% (Consumers) or 60% (Municipalities). However, the estimations for the year 2030 show a median of only 30% of household by consumers and only 25% by municipalities (Figure 42).

Figures 43 and 44 show the results for the second scenario:

"District heating plays a major role in 2030. The assembly and disassembly costs shall be allocated to the general public to promote further development."

- Please rate the desirability/probability of this scenario:
- In your opinion: What is the maximum amount of assembly and disassembly costs that shall be allocated to the general public in percent?

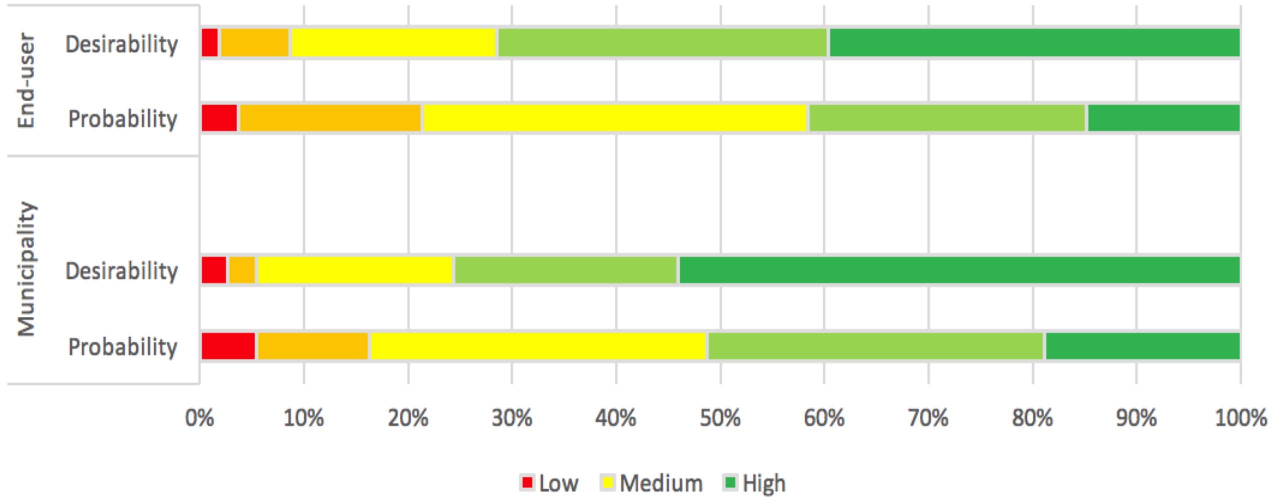

Figure 43. Desirability and Probability of Scenario 2 for Consumers and Municipalities in France

Figure 44. "In your opinion: What is the maximum amount of assembly and disassembly costs that shall be allocated to the general public in percent?" Bars represent the Median and the interquartile range.

Concerning Scenario 2 the results of the consumers and the municipalities are very similar for both desirability and probability. More than 70% in both groups think it is very desirable that the costs of district heating is allocated to the general public. This is much higher than in Germany or Austria. Also the probability is seen much higher with more than 40% (Consumers) or 50% (Municipalities).

Most surprising is the maximum share of costs that should be allocated to the general public. The French consumers state a median of 50% with an interquartile range from 27.5% to 65% and the municipalities state a median of 40% with an interquartile range from 20% to 70%. This results are again much higher than the results in Germany or Austria (Figure 44).

3.5. Willingness to pay for district heating

The estimation results for France demonstrate that 'district heating from renewable energies' is the most preferred heating alternative whereas the reference base alternative 'gas' is least preferred (see Table 16). The second place takes 'district heating from fossil fuels' followed by the option 'heat pump'. The described effects are all highly significant in comparison to the reference base 'gas' and differ significantly from each other. As expected the cost parameters ('variable costs' & 'investments cost') are negative and significant. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for the final estimation.

Table 16: Estimation results France (N=490)

Coefficients		
	Estimate	**Std. Error**
district heating renewable+	2.25***	5.86e-02
district heating	1.16***	7.88e-02
heat pump	0.52***	4.67e-02
variable costs^2	-1.32e-02***	7.13e-04
investment costs^2	-6.58e-06***	1.12e-06
Log-Likelihood	-5200.6	

Significance codes: 0=***, 0.001=**, 0.01*

+The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 16 odds ratios were calculated (see Figure 46). The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters.

In comparison to the reference base 'gas' (odds ratio=1) the alternative 'heat pump' revealed a 98 % higher choice probability in the discrete choice experiments. It follows 'district heating from fossil fuels' which was circa three times stronger preferred than 'gas'. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than nine times stronger preferred than 'gas'.

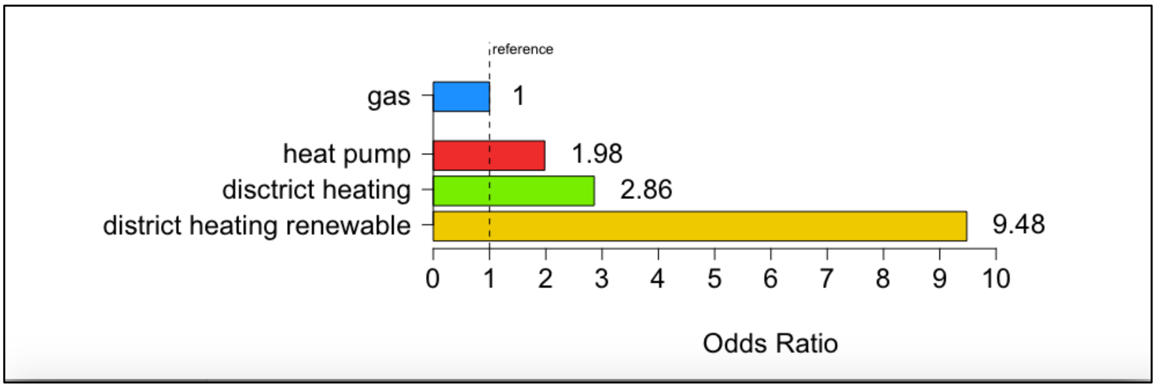

Figure 45. Odds ratios for the analyzed heating alternatives

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 6,000 €. The variable costs for the base option ‘gas’ were set to 6 €/m²/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two alternatives were hypothesized.

Figure 46 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 8.4 € higher variable costs per m²/year for ‘district heating from renewable energies’ than for ‘gas’. The WTP for ‘district heating from fossil fuels’ is circa 40 % lower with 5.1 €. The WTP for the alternative ‘heat pump’ is 2.7 €.

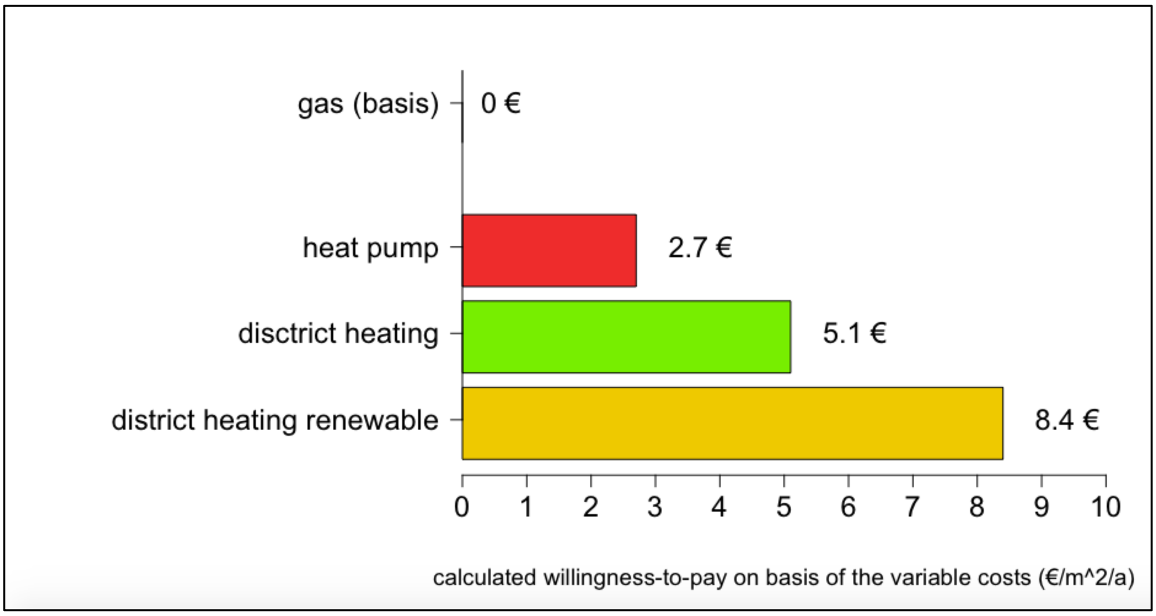

Figure 46. WTP for the analyzed heating alternatives

3.5.1. France – municipality

The estimation results for France demonstrate that 'district heating from renewable energies' is the most preferred heating alternative for the municipalities whereas 'heat pump' and 'district heating' are not significantly different from the base alternative 'gas' (see Table 17). As expected the cost parameters ('variable costs' & 'investments cost') are negative. In the model for these both variables their squared terms resulted in a better model fit and were therefore used for the final estimation.

Table 17: Estimation results France (N=39)

Coefficients		
	Estimate	**Std. Error**
district heating renewable+	2.95***	2.2e-16
district heating	0.38	0.26
heat pump	0.30	0.10
variable costs^{2}	-1.28e-02*	7.2e-06
investment costs$^{2/1000}$	-3.58e-08	0.84
Log-Likelihood	-311.39	

Significance codes: 0=***, 0.001=**, 0.01*

+The heating alternative 'gas' is the basis with an estimate value of zero to which the competing heating alternatives are compared

For a better overview of the 'brand' strength of the different heating options on the basis of the estimation results from Table 17 the odds ratios for the four heating options were calculated (Figure 47). The odds ratio displays directly the effect size and therefore allows a direct comparison of the parameters. In comparison to the reference base 'gas' (odds ratio=1) the alternative 'heat pump' revealed a 34% higher choice probability in the discrete choice experiments. It follows 'district heating from fossil fuels' with a 46% higher choice probability. It is to highlight that 'district heating from renewables energies' has by far the highest effect size. This alternative was more than 19 times stronger preferred than 'gas'.

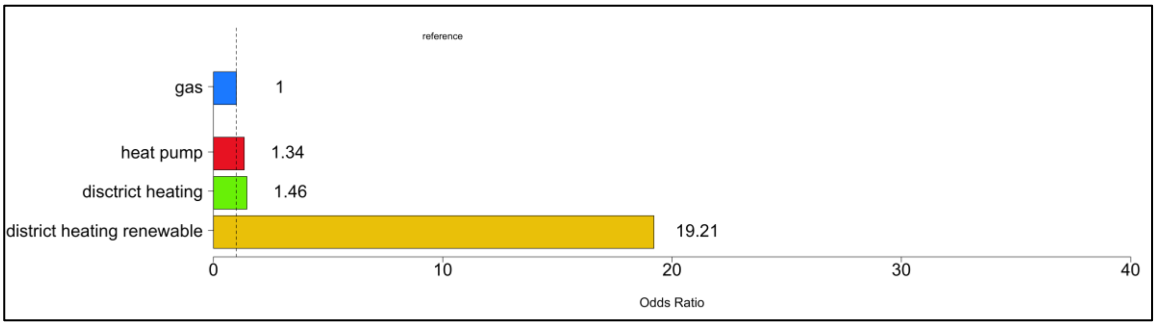

Figure 47. Odds ratios for the analyzed heating alternatives

For an economic evaluation of the described positive effect sizes market simulations were calculated with the help of the estimated cost parameters. Furthermore, for this purpose, investment costs for all heating alternatives were set equal to 30,000 €. The variable costs for the base option ‘gas’ were set to 6 €/m²/a whereas the variable costs for the other alternatives were successively increased (starting point 6 €) up to the point where they attained the same market share as the base alternative. For this simulation, a situation with only two alternatives were hypothesized.

Figure 48 illustrates the calculated willingness-to-pay in comparison to the reference basis. The participants are willing to pay 10.3 € higher variable costs per m²/year for ‘district heating from renewable energies’ than for ‘gas’. The WTP for ‘heat pump is circa much lower with 1.1 €. The WTP for the alternative ‘district heating from fossil fuels’ is 1.9 €.

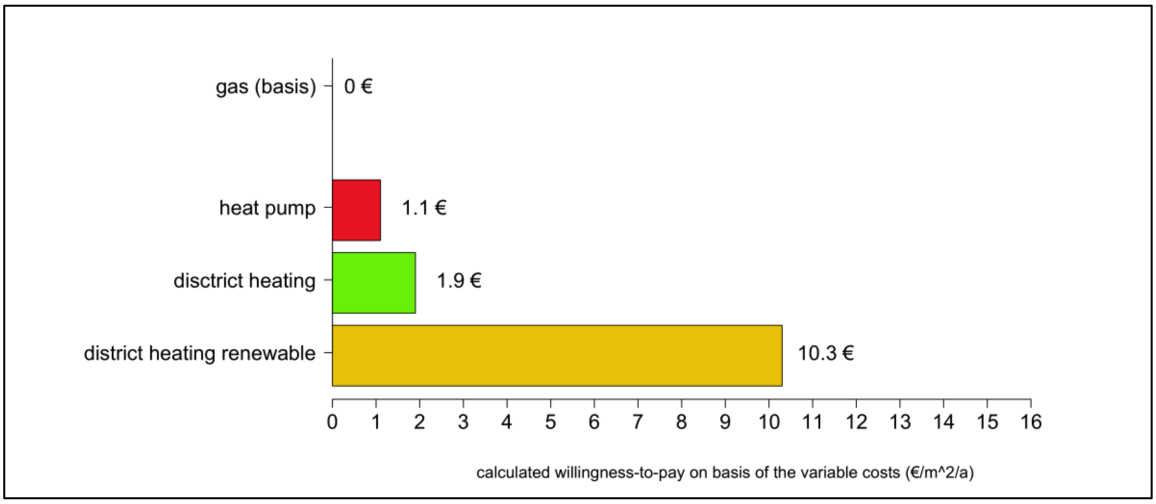

Figure 48. WTP for the analyzed heating alternatives

3.6. Conclusion

The results clearly show that ‘district heating from renewable energies’ is the most favorite heating option for the consumers. It is to highlight that the participants revealed a significant additional WTP for ‘district heating’ just for the fact that is from renewable energies. The WTP is 8 € higher for this option than for ‘district heating from fossil fuels’.