GAS «WITHDRAWAL» IN THE COMFORT HEATING SECTOR: CHALLENGES FOR MUNICIPALITIES AND CITIES

CYCLE DE FORMATION ÉNERGIE – ENVIRONNEMENT
UNIVERSITÉ DE GENEVE

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eicher+pauli

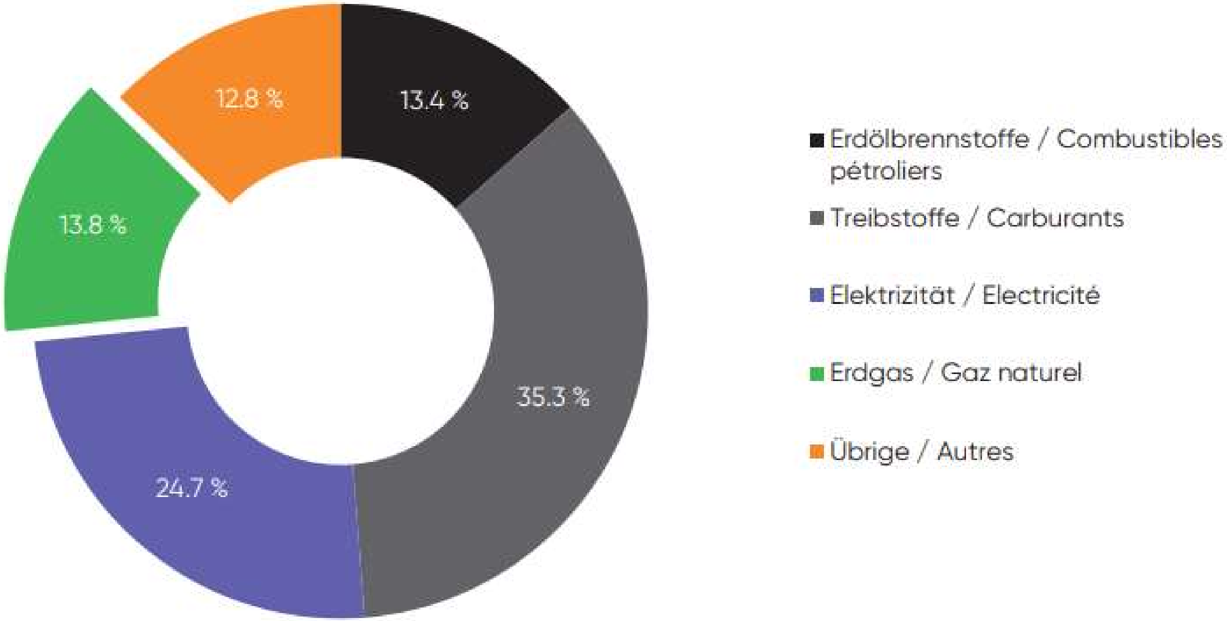
OUTLINE

1. The future of the gas infrastructure in Switzerland
2. Present Situation in Zurich
3. Study 1: Cost-benefit analysis scenarios regarding the expansion of district heating networks
4. Study 2: Combination and coordination of gas withdrawal and expansion of district heating

THE FUTURE OF THE GAS INFRASTRUCTURE IN SWITZERLAND

NATURAL GAS CONSUMPTION SWITZERLAND

Final energy consumption by energy source (2019)

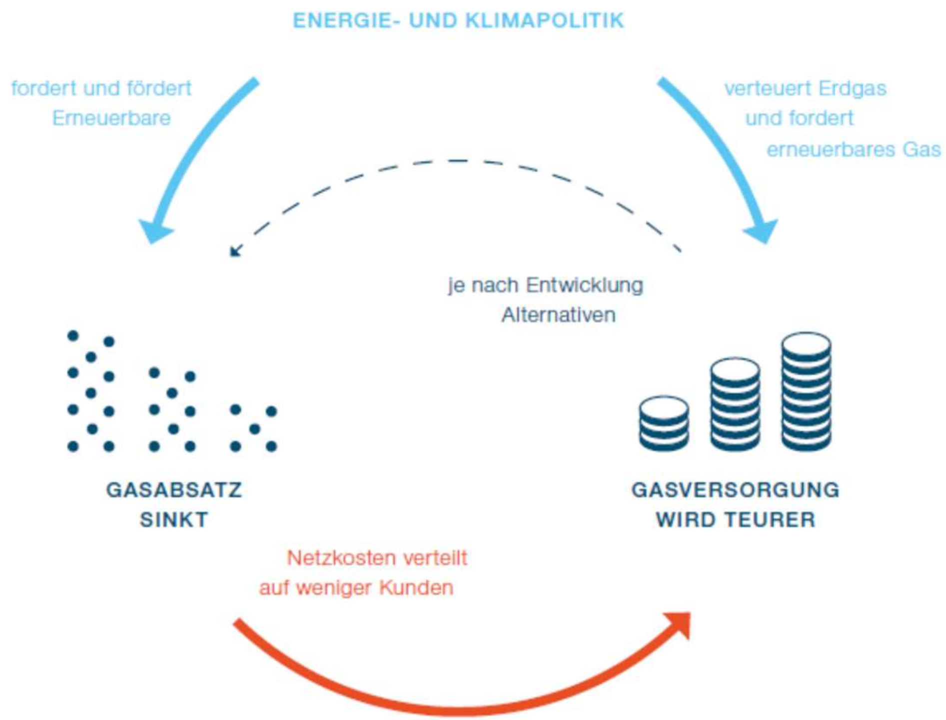


- **Total natural gas consumption 34 TWh/a**
- **Biogas < 2%**

- Natural gas is primarily a fossil fuel and is responsible for a fifth of the energy-related CO_2 emissions in CH. In view of the Federal Council's net zero target for 2050, consumption must therefore be drastically reduced.

Source: Jahresstatistik VSG 2019

LONGTERM ECONOMIC EFFICIENCY OF THE ENTIRE GAS DISTRIBUTION NETWORK



Energy and climate policy have the effect of:

- Increasing natural gas price
- Decreasing natural gas demand
- Increasing natural gas supply costs

➢ **Demand for natural gas will decline in the longer term**

Source: Zukunft der Gas-Infrastruktur - Metropolitanraum Zürich (metropolitanraum-zuerich.ch)

CAN WE USE GAS DISTRIBUTION NETWORKS FOR STORAGE OF EXCESS ELECTRICITY?

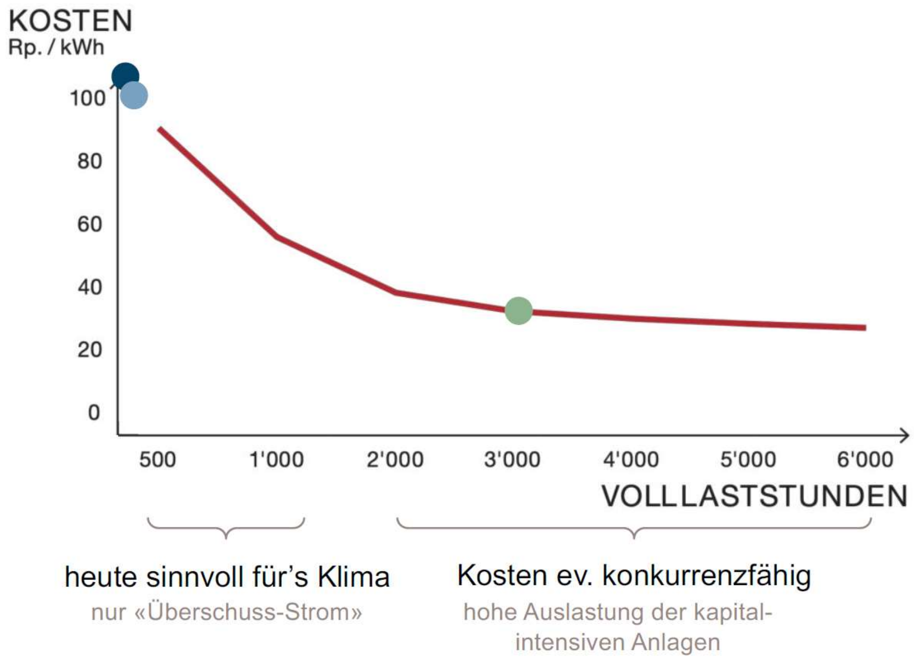
STORED QUANTITY OF AVERAGE GAS SUPPLY

Source: Zukunft der Gas-Infrastruktur - Metropolitanraum Zürich (metropolitanraum-zuerich.ch)

POTENTIAL OF BIOGAS / SYNGAS IN CH

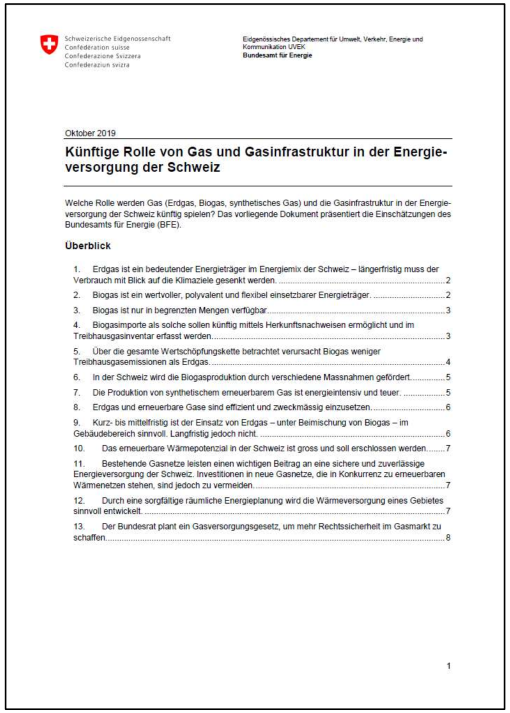
Potential of Swiss biogas:
10-15% of today's total gas demand

Synthetic gas
From a climate point of view, the production of syngas only makes sense with "excess electricity" from renewables, but costs are high when operating hours are low



Source: [Zukunft der Gas-Infrastruktur - Metropolitanraum Zürich (metropolitanraum-zuerich.ch)](metropolitanraum-zuerich.ch)

CONCLUSIONS - POSITION OF THE SFOE


Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation UVEK
Bundesamt für Energie

Oktober 2019

Künftige Rolle von Gas und Gasinfrastruktur in der Energieversorgung der Schweiz

Welche Rolle werden Gas (Erdgas, Biogas, synthetisches Gas) und die Gasinfrastruktur in der Energieversorgung der Schweiz künftig spielen? Das vorliegende Dokument präsentiert die Einschätzungen des Bundesamts für Energie (BFE).

Überblick

1

- In the longer term, natural gas consumption must be reduced
- The potential of biogas is limited
- The production of synthetic gas is energy intensive and expensive
- Natural gas and renewable gases should be used efficiently and appropriately
  - ➢ In the longer term, the use of gas in buildings is not appropriate as renewable alternatives are available
  - ➢ Renewable gases should be used for high temperature processes in industry and in the transport sector
- Investments in gas networks which compete with renewable heating networks should be avoided

Source: Positionspapier BFE: Künftige Rolle von Gas und Gasinfrastruktur in der Energieversorgung der Schweiz

The ultimate goal is clear, but getting there is a challenge

PRESENT SITUATION IN ZÜRICH

With special thanks to Dr. Silvia Banfi, energy officer of the City of Zurich, for the permission of using her slides

CLIMATE POLICY GOALS OF ZÜRICH

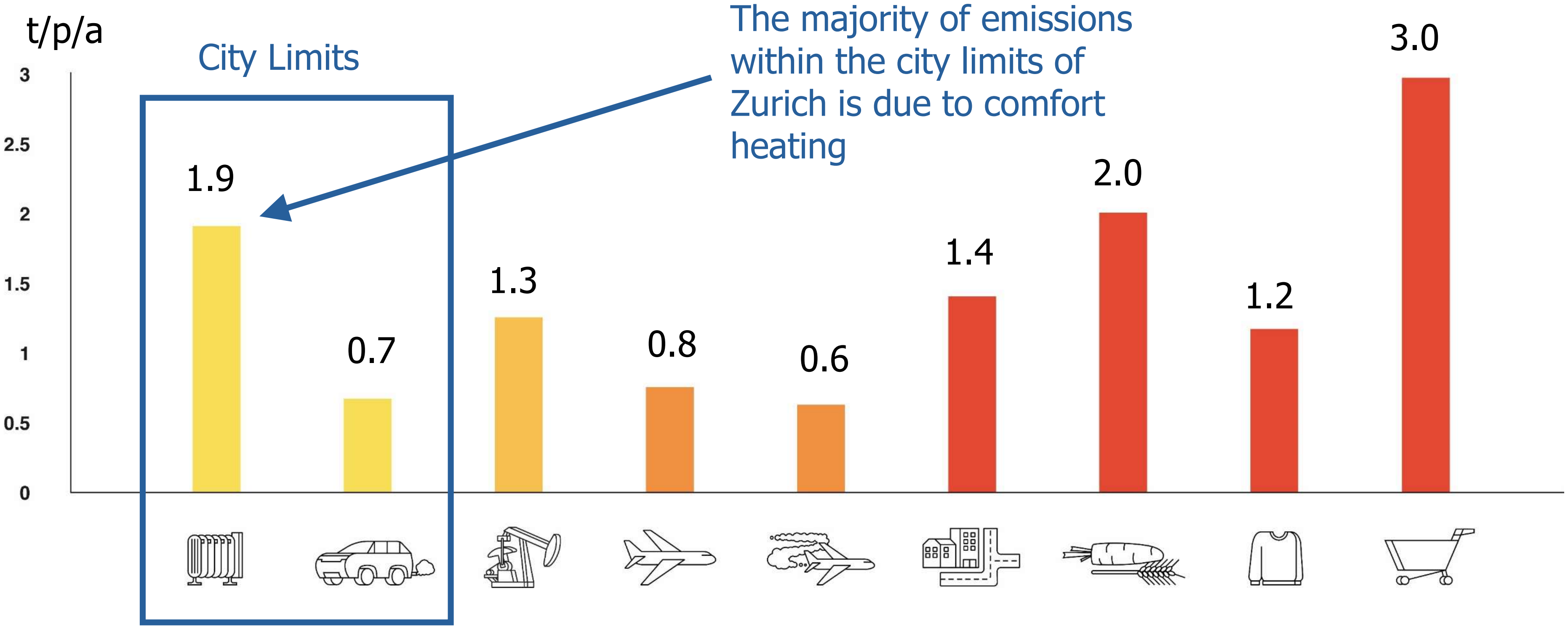
Basis: Decided in 2008 by referendum to embed the 2000W society goals in the municipal regulations

- Limit the energy demand to 2000 W and 1 t CO_2 per inhabitant by 2050
- Promote renewable energies and energy efficiency
- Promote environmentally friendly nutrition
- Eliminate investments in nuclear power plants by 2034 at the latest

Zurich is currently considering adjusting its climate protection target to net zero greenhouse gases emissions by 2030 (various political initiatives)

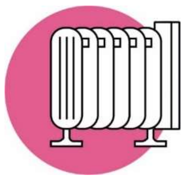
GREENHOUSE GAS EMISSIONS

13 t per Person



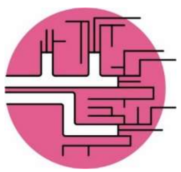
LEVERS FOR GREENHOUSE GAS REDUCTION

Main approach to be taked by the city:



- Substitution of oil and gas heating systems

- Energetic optimization of buildings (building envelope and PV)



- Expansion of district heating
- Withdrawal of gas distribution networks

THE CHALLENGE

Currently 80% of comfort heat is supplied by fossil energy

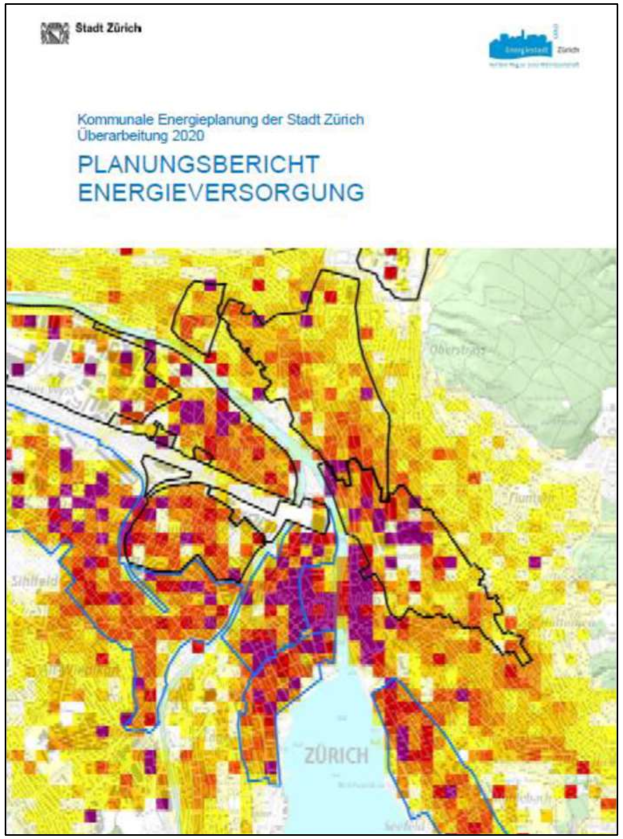
14’700 by gas heating
6’900 by oil heating

?

45%	**district heating**
27%	**ground source heat pumps**
23%	**air-to-water heat pumps**
5%	**Biogas and wood fired heating**

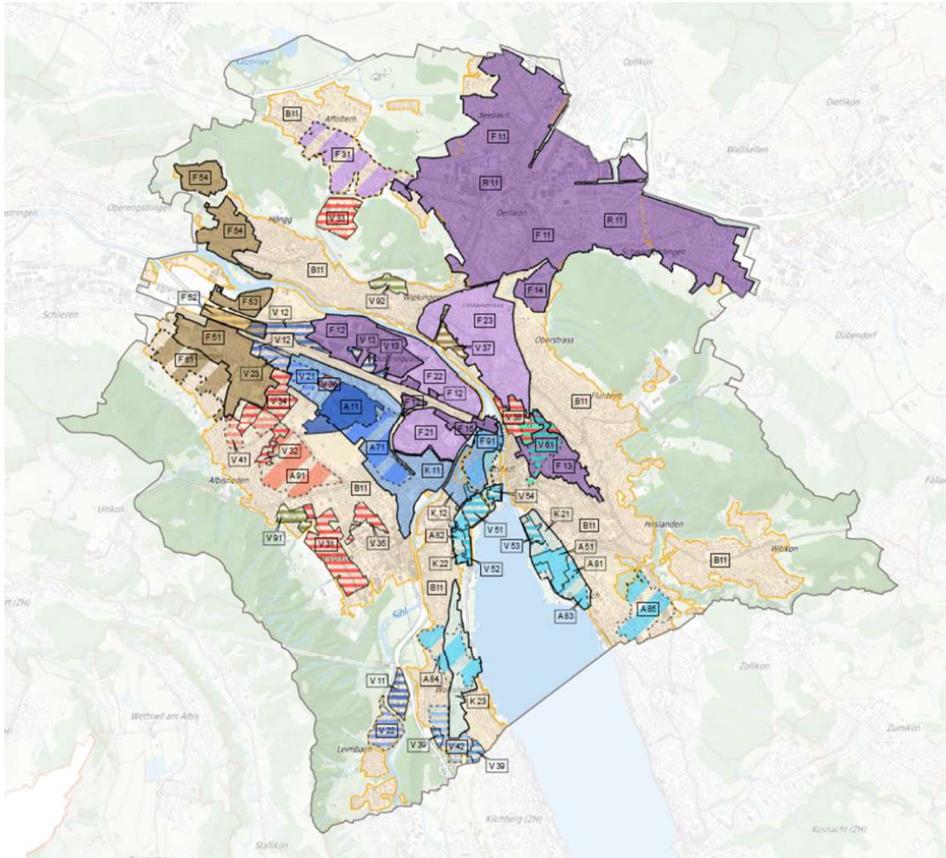
Natural gas grids are located in areas with high density, therefore, substitution of natural gas goes together with expansion of district heating networks

MUNICIPAL ENERGY PLANNING



- Significant expansion of district heating capacity (25% to 60% of city area)
- Gas supply removed completely or partially from the priority areas targeted for district heating
- Exclusions:
  - System-relevant transport pipelines
  - Pipelines to gas filling stations and district heating supply centers
  - Partial supply of buildings

EXPANSION OF DISTRICT HEATING



Energy planning map 2019 (Existing and planned areas)

- District heating from waste incineration
- Ground water
- Lake water
- Waste water
- Waste/Excess heat

IMPORTANT PLAYERS GAS / DISTRICT HEATING MARKET IN ZURICH

Stadt Zürich
Entsorgung + Recycling

energie360°

ewz

Sector coupling

Liberalization of energy market

energie360°

Stadt Zürich
Entsorgung + Recycling

ewz

- Transformation from traditional role to energy service provider
- Competitive situation
- Dual role of the gas supplier (e360°)

STUDY 1:

COST-BENEFIT ANALYSIS SCENARIOS REGARDING THE EXPANSION OF DISTRICT HEATING NETWORKS IN THE CITY OF ZURICH

Financed by:
Tiefbauamt Stadt Zürich

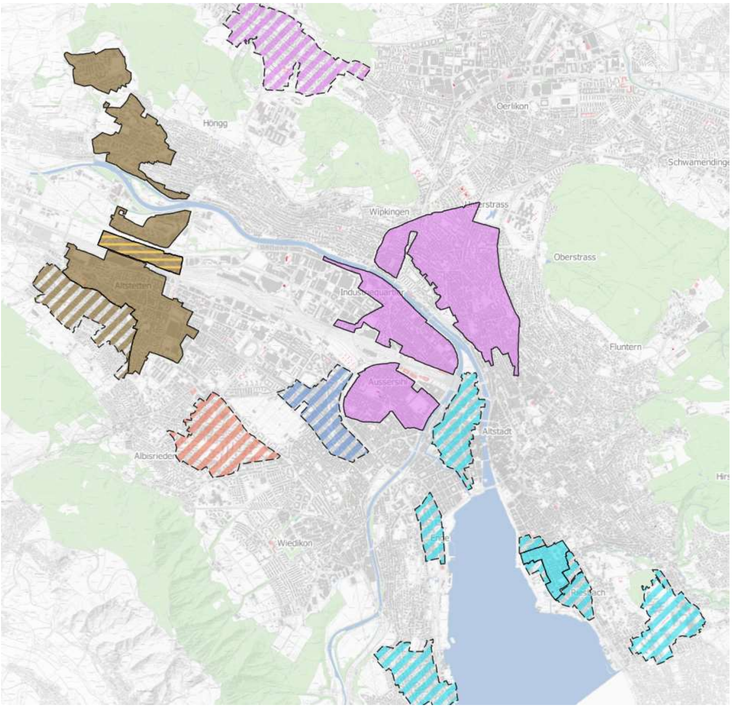
Consortium:
Infras (Dr. Rolf Iten, Donald Sigrist, Lena Windler)
eicher+pauli (Dr. Andrea Grüniger, Dr. Hanspeter Eicher)

MANDATE AND RESEARCH QUESTIONS

Mandate from the city council:
Cost-benefit analysis of expansion scenarios for thermal networks until 2030 / 2040 / 2050 - taking into account qualitative and quantitative aspects

Research questions:
How do the costs and benefits of different expansion scenarios of thermal networks differ? What are the total costs the city must pay for the expansion of thermal-network based energy supply?

AREAS CONCERNED



Characteristics of new planned areas

- 12 km^2
- 11’800 buildings
- 1’100 MWh/ha/a average heat density
- 1’300 GWh/a heat demand (ca. 1/3 for the city)
- 870 GWh (67%) currently supplied by natural gas
- 14 new piping networks
- > 100 km of pipeline
- 10 new energy generation centres

QUANTITATIVE ASSESSMENT

SCENARIOS

	Network expansion completed		
	2030	2040	2050
forced	x	x	x
Non-forced	x	x	

- **Forced:** When network expansion is completed, the net zero target is reached. This means that gas withdrawal is complete and the fossil share in the district heating supply mix (peak coverage) is eliminated.
- **Non-forced:** Once the network expansion has been completed, there is a transitional period until final gas decommissioning, decarbonisation of peak load coverage and achievement
- **Sensitivities:** Final rate of connection for district heating (70/85%)

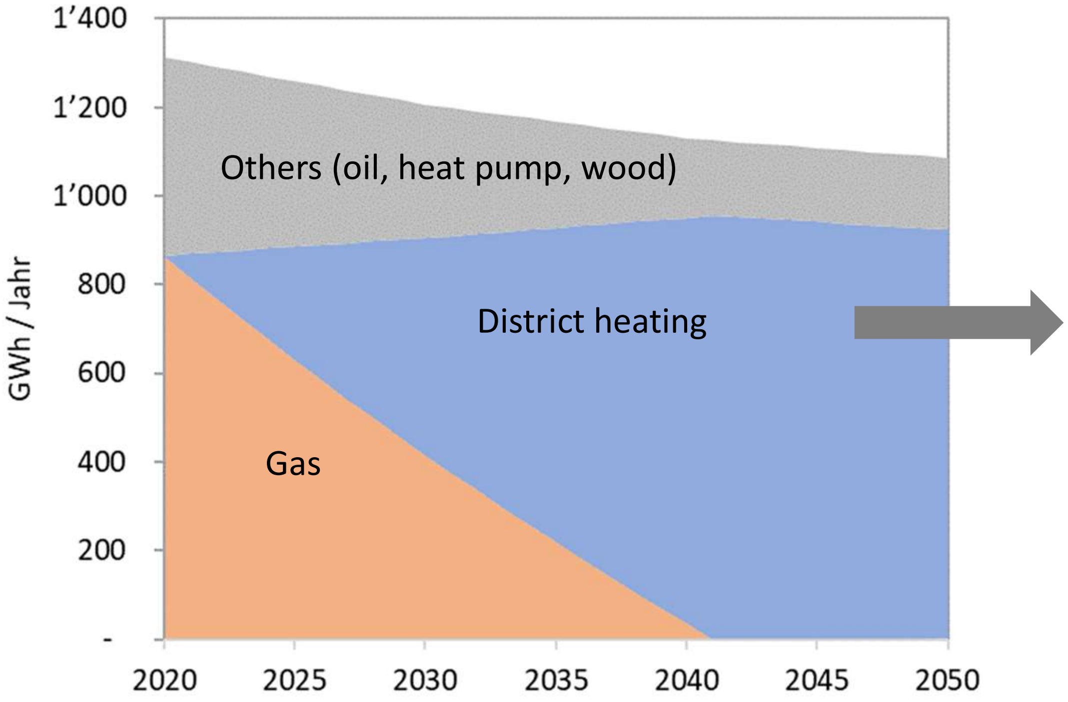
QUANTITATIVE ASSESSMENT

INVESTIGATED ASPECTS

- Development of gas and heat sales
- Residual value (non-amortizable costs) of gas infrastrucure
- Compensation expenses for gas heating systems
- CO_2 emissions
- Investment volume of energy generation centres and heating networks

EXAMPLE OF SCENARIO

SCENARIO 2040, FORCED



Cumulated values 2020-2050:

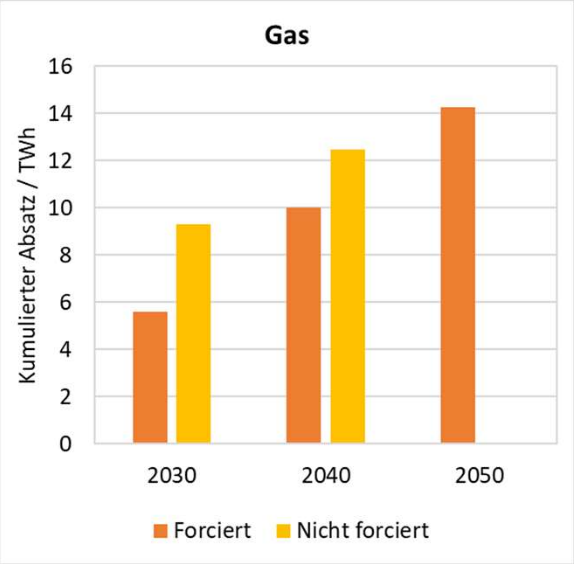
Gas:	10 TWh
District heating:	19.4 TWh
CO_2-Emissionen*:	2.7 Mio $t_{CO2\ equ.}$

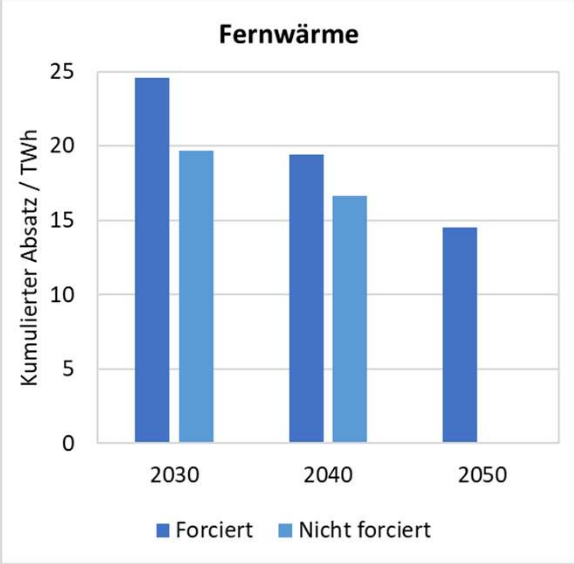
* CO2 emissions of “others” not considered, as this is not to be allocated to DH expansion.

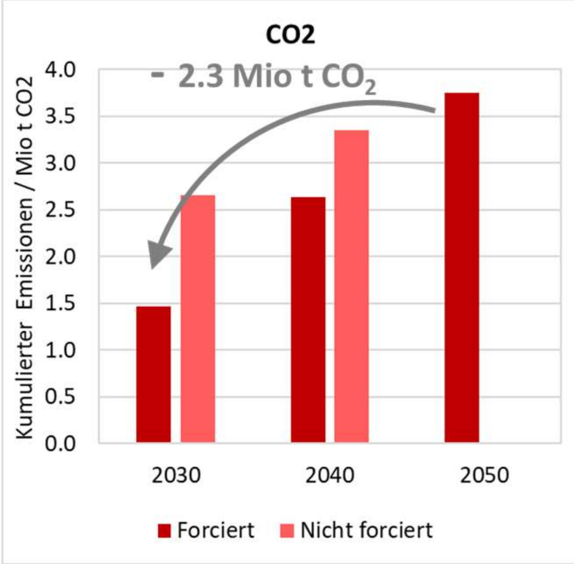
Data only refers to **planned** areas (existing district heating areas not included)

HEAT SALES AND CO_2

CUMULATED VALUES 2020-2050







- Difference of 2.3 Mio t CO2eq between extreme scenarios corresponds to **damage costs** of **460 Million CHF***
- Forced variants are preferable

- * 200 CHF/t according to UBA method convention 3.0 (German Federal Environment Agency)

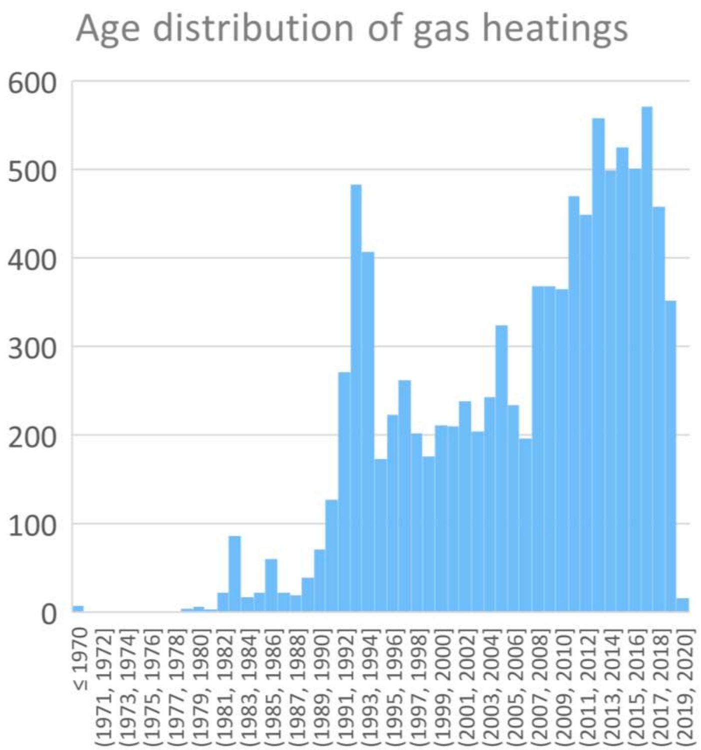
INVESTMENT COSTS

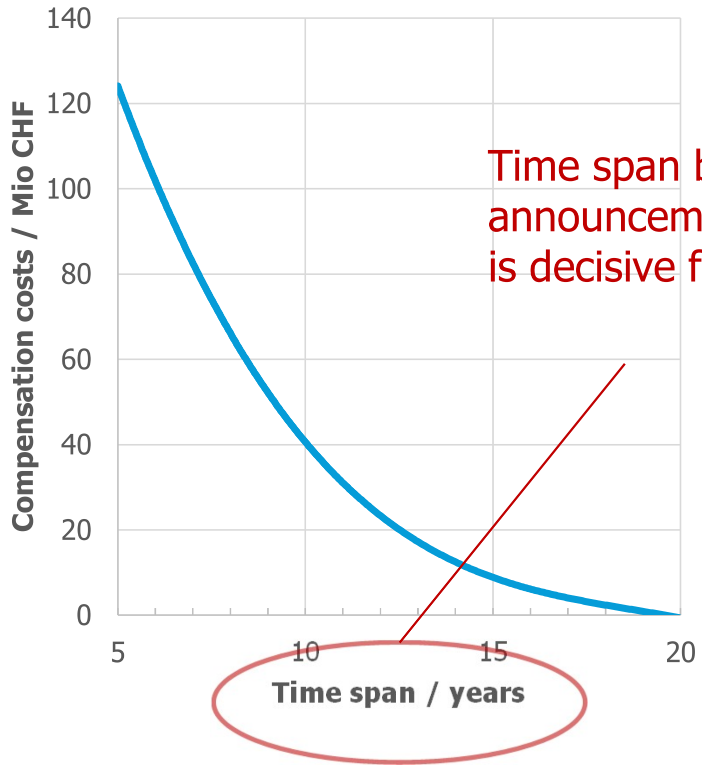
In Mio. CHF	ERZ Area	Others	Total
Energy generation centers	180	420	600
Distribution (network)	400	430	830
Total	580	850	**1'430**

- Figures represent estimates of nominal costs
- No discounting, no price developments
- Fast expansion is not more expensive than slow expansion
- Ecological and economic destruction of residual values (pipes and surfaces) not taken into account
- Additional investment costs by private homeowners: approx. CHF 500 million
- Excluding investments already made (in existing energy generation centers)

COMPENSATION COSTS

COSTS TO BE PAID TO HOMEOWNERS IN CASE OF GAS WITHDRAWAL





Time span between official announcement and final gas withdrawal is decisive for compensation costs

SUMMARY QUANTITATIVE PART

	Grid expansion szenarios		
	2030	**2040**	**2050**
Szenario-dependent (cumulated values 2020-2050)			
Gas sales volume	5.6 TWh	10 TWh	14 TWh
Thermal grids sales volume	25 TWh	19 TWh	15 TWh
CO_2 emissions CO_2 damage costs	1.5 TWh 300 Mio CHF	2.7 TWh 540 Mio CHF	3.8 TWh 760 Mio CHF
Compensation costs	65 Mio CHF	2 Mio CHF	0 Mio CHF
Not szenario-dependent			
Residual value gas grid (book value)	30 Mio CHF		
Investment costs energy generation centres	600 Mio CHF		
Investment costs thermal networks	830 Mio CHF		

QUALITATIVE PART

RESULTS OF INTERVIEWS WITH EXPERTS

Betroffene Akteure	Kategorie	2030	2050
Bevölkerung	1. Lärmemissionen	orange	green
	2. Luftqualität	grey	grey
	3. Klimaschutz	green	orange
	4. Akzeptanz in der Bevölkerung	orange	green
	5. Zurückstellung anderer Projekte (z.B. Veloinfr./Bäume)	orange	green
Wirtschaft	6. Verkehrsbehinderungen	orange	green
	7. Umsatzeinbussen Gewerbe	orange	green
	8. Kapazitäten Tiefbaubranche	orange	green
Stadt und Energiedienstleister	9. Koordination der städtischen Werke	orange	green
	10. Benötigte Ressourcen (personell/finanziell)	orange	green
	11. Technisches und wirtschaftliches Risiko*	orange	green

OVERALL ASSESSMENT OF THE SCENARIOS (1)

	Scenarios		
	2030	**2040**	**2050**
Feasibility			
Technical feasibility	-/+	++	+++
Construction coordination	--	+	+++
Political feasibility /acceptance by population	--	++	++
Impact			
Contribution to climate protection	+++	++	+
Local environmental pollution/economy	-	- / +	+
Achieving other objectives	--	- / +	++

OVERALL ASSESSMENT OF THE SCENARIOS (2)

	Scenarios		
	2030	**2040**	**2050**
Human resources			
Human ressources city / energy service provider	--	-/+	+
Availability of specialists	--	-/+	-/+
Financial resources			
Investment costs	-	+	+
Construction coordination	---	+	++
Avoided damage costs (CO_2)	+++	+	-
Risk of incorrect planning	-	-/+	+
Compensation costs gas devices	--	+	+

CONCLUSIONS

- The qualitative analyses lead to the conclusion that scenario 2030 is not reasonably feasible and that other policy objectives would have to be put on hold.
- The quantitative analyses show that with the later grid expansion scenarios the cumulative reduction of CO_2 emissions is lower. An expansion until 2030 would require to invest about 1.4 billion CHF within a very short time period.
- Forcing the rate of connection while at the same time choosing a medium network expansion scenario (approximately 2040) could prove to be optimal.
- For a more precise definition of the time horizon for network expansion, the overall planning (already underway) is central.

STUDY 2:
COMBINATION AND COORDINATION OF GAS WITHDRAWAL AND EXPANSION OF THERMAL NETWORKS

Financed by:
City of Zurich (Felix Schmid, energy officer deputy) and public utility companies

Consortium:
eicher+pauli (Dr. Andrea Grüniger, Dr. Hanspeter Eicher, Sven Trecco)
Infras (Dr. Rolf Iten)

Monitoring group:
Felix Schmid and deputies of Energie 360°, ewz, ERZ, UGZ, TAZ

INITIAL SITUATION

Within the «planned areas» for district heating the gas supply network has to be withdrawn. This is a challenge, especially from the point of view of civil engineering. The question to be answered within this study was:

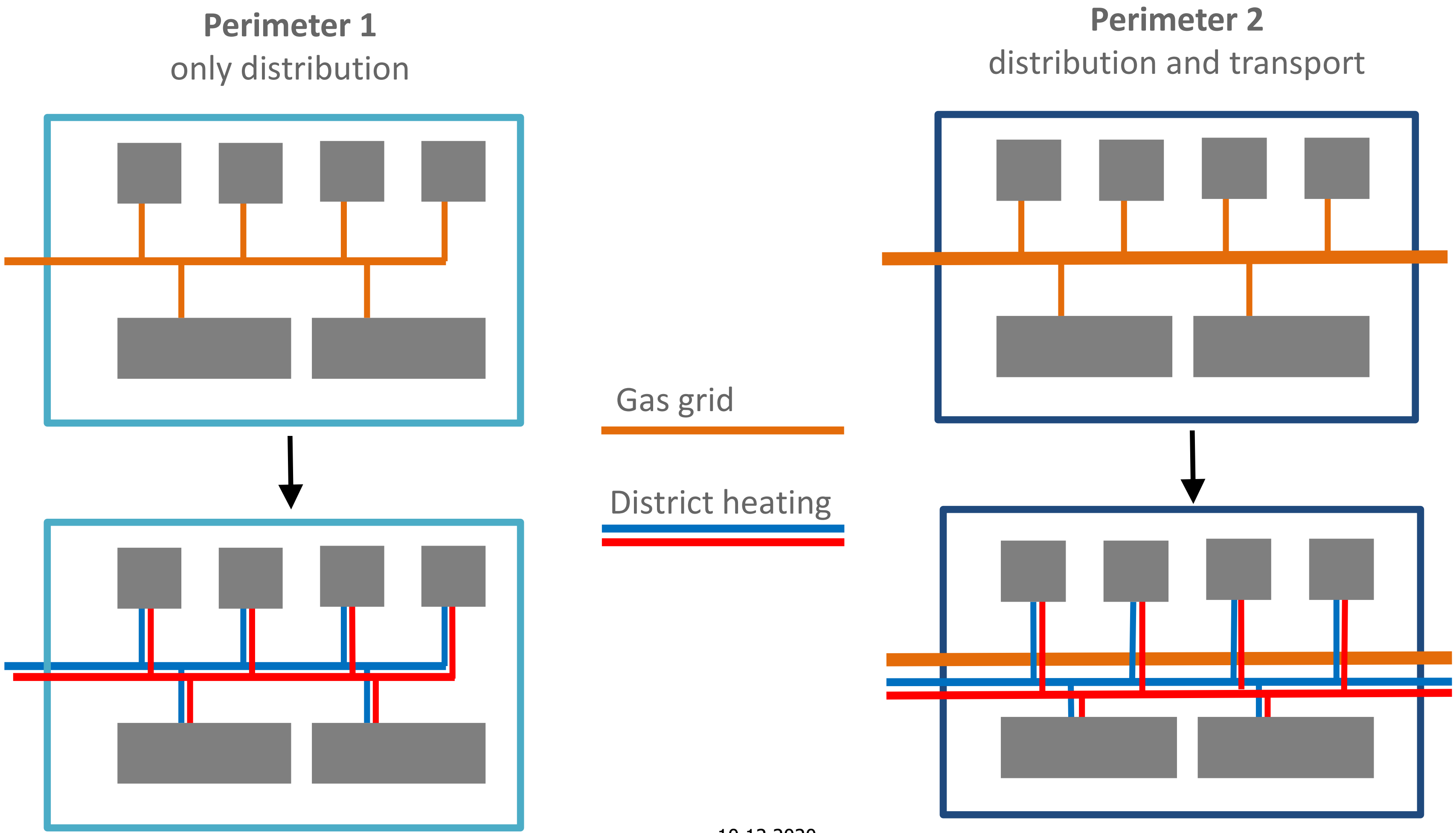
? **When a district or perimeter is connected to district heating: Would it make sense and be possible to shut down the gas network and connect gas customers to district heating at the same time/simultaniously?**

+ **Savings in civil engineering**
+ **Avoided CO_2 emissions and damage costs**

↔

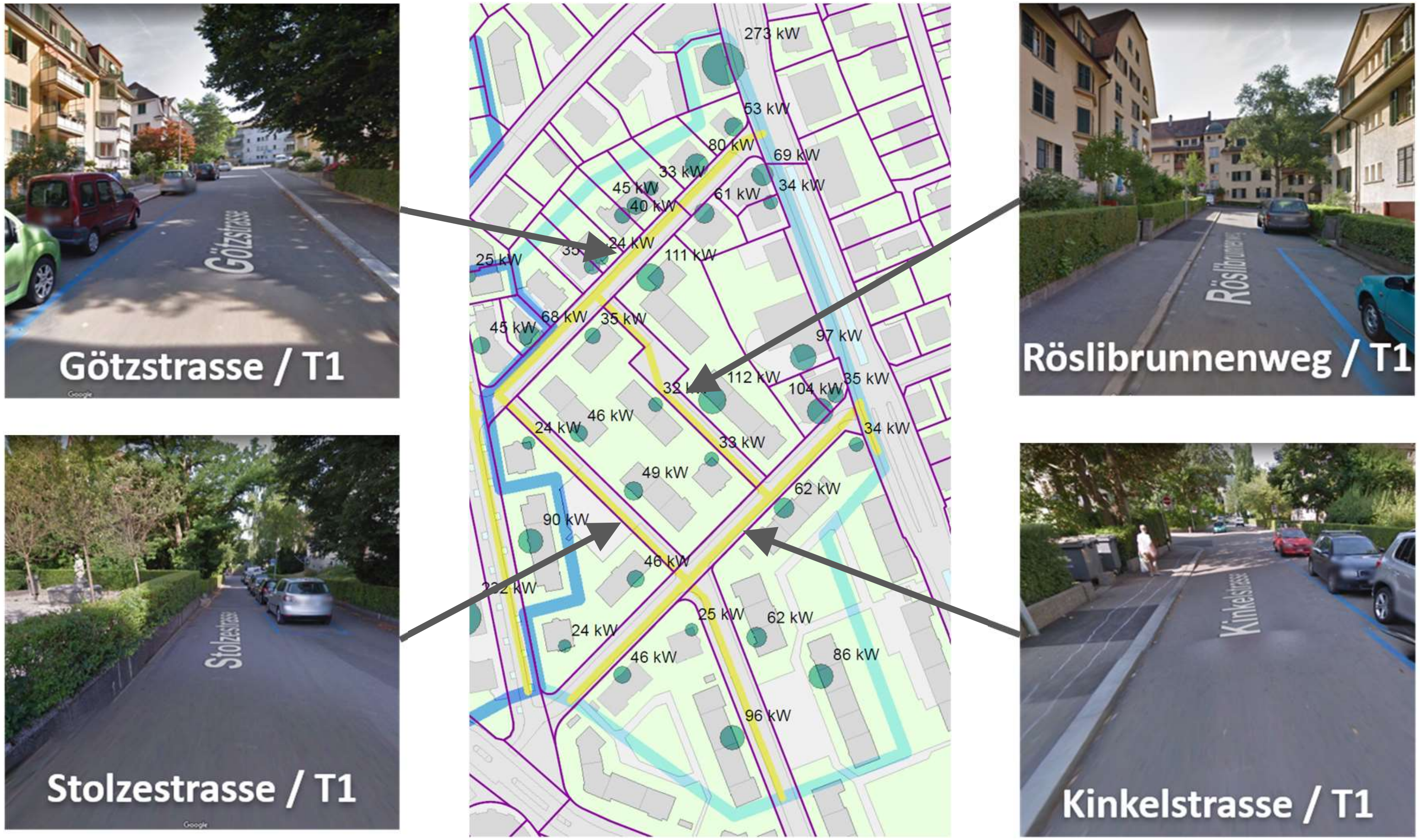
- **Early depreciation of gas network infrastructure**
- **Higher compensation costs for gas devices**
- **Costs of temporary installations**

STUDY SETTING



PERIMETER 1

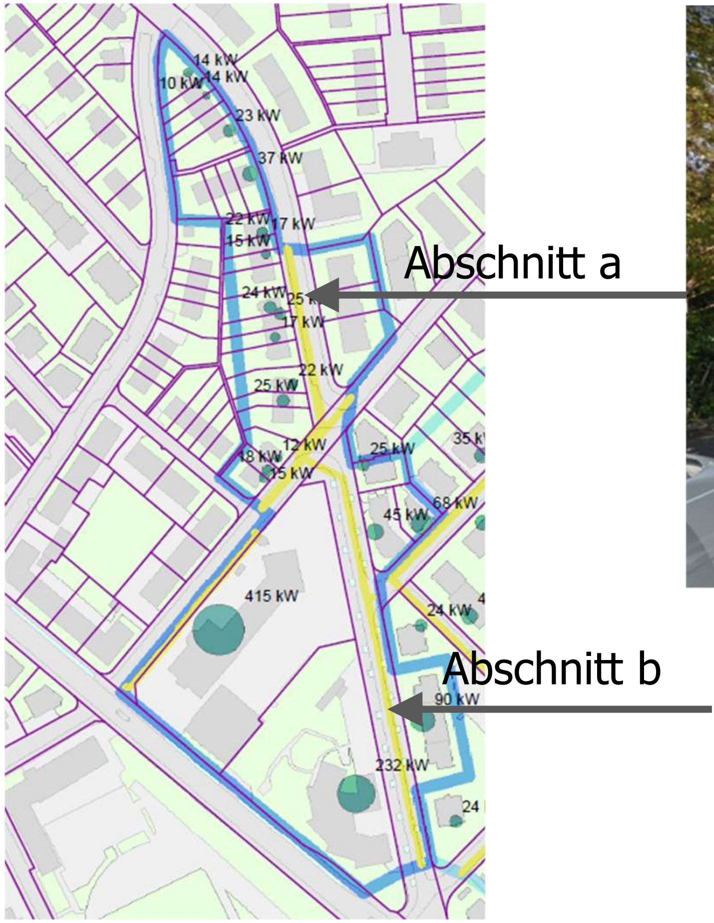
PERIMETER WITH DISTRIBUTION FUNCTION



Tx = Traffic density

PERIMETER 2

PERIMETER WITH DISTRIBUTION AND TRANSPORT FUNCTION

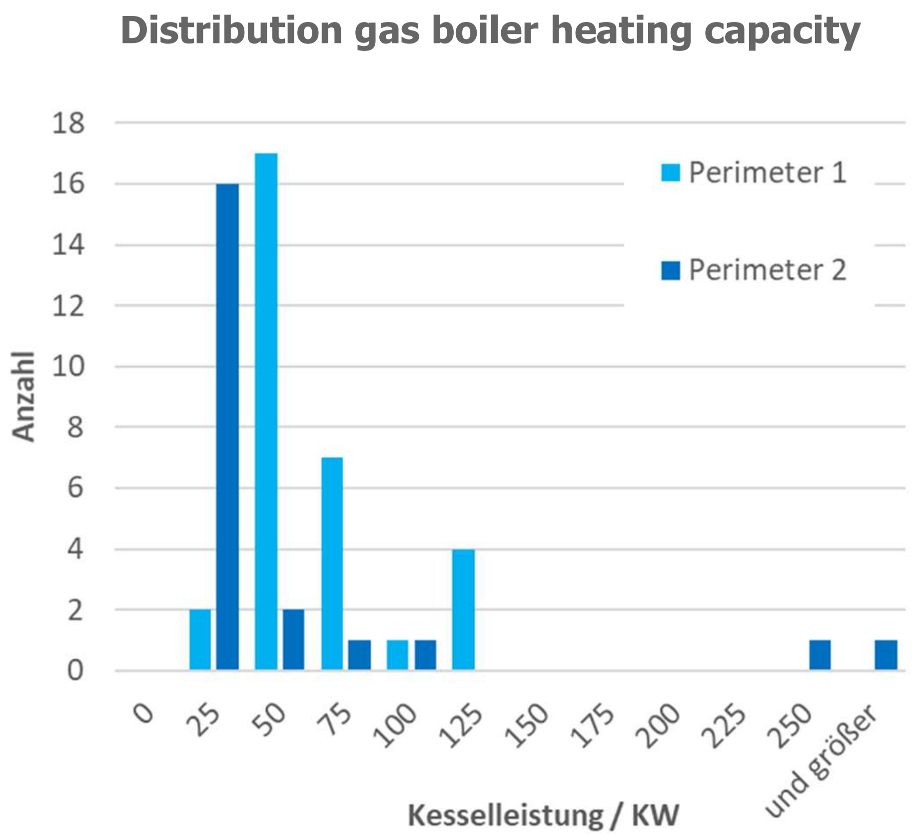


HEAT SALES DATA

	Perimeter 1	Perimeter 2	Quelle / Bemerkung
Gaskunden	31	22	Absatzdaten e360°
Ölkunden	2	10	EnerGIS
Wärme Gas	3’330 MWh/a	1’850 MWh/a	Absatzdaten e360° / Kesselwirkungsgrad 0.9
Wärme Öl	260 MWh/a	510 MWh/a	Daten aus EnerGIS
Wärme total	3’590 MWh/a	2’360 MWh/a	Nur Öl und Gas
Länge Gasnetz	695 m	570 m	e360°
Lin. Wärmedichte	ca. 5 MWh/m/a	ca. 4 MWh/m/a	aufgrund Länge Gasnetz (ohne Anschlussleitungen an Zentralen)

Only oil and gas customers taken into acccount

PERIMETER CHARACTERISTICS



Gebietscharakter Perimeter 1:

- Quartierstrassen T1
- Blocksiedlungen
- Typischerweise Kesselleistung um 50 kW
- Ölheizungen 7% von Gesamtwärmebedarf

Gebietscharakter Perimeter 2

- Durchgangsstrasse T3
- Viele Reihen-EFH, Kesselleistung < 25 kW
- Schulhaus Riedtli, 600 kW
- Ölheizungen 21% von Gesamtwärmebedarf

SCENARIOS / MODEL ASSUMPTIONS

	Reference (REF)	Direct transfer(GR)
Jahr 0	Anfangszustand bei beiden Szenarien gleich (aktuelle Absatzzahlen)	
Jahr 1	Erschliessung der Strasse mit FW: Anschluss von: • 25% Gaskunden • 20% Ölkunden • 33% vom Rest Abschluss von Vorverträgen und Vorbereitung Hausanschlüsse	Erschliessung der Strasse mit FW: • gleichzeitige Stilllegung Gasnetz Anschluss von: • 90% bestehenden Gaskunden • 60% bestehenden Ölkunden
	Sukzessiver Anschluss über 15 Jahre	Keine weiteren Anschlüsse an FW
Jahr 15	Stilllegung Gasnetz Anschlussgrad im Endzustand: • 90% ehemalige Gaskunden • 60% ehemalige Ölkunden	
Jahr 16	Endzustand bezüglich Absatzzahlen bei beiden Szenarien gleich**	

** Unterschiede zwischen Szenarien bezüglich Anzahl Hausanschlüsse aufgrund unterschiedlicher Entwicklung Gemeinschaftsanschlüsse

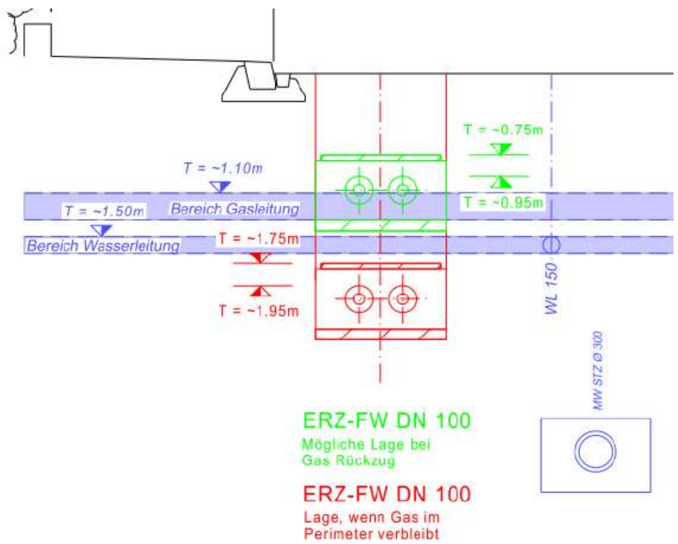
COST CATEGORIES

Cost consideration from a macroeconomic perspective:

- Investment costs for main pipes (incl. provisional arrangements)
- Investment costs for house connections
  - Direct
  - Prepared
  - Unprepared
- Non amortisable costs for gas pipes
- Non amortisable costs for gas equipment (compensation payments)
- CO_2 damage costs

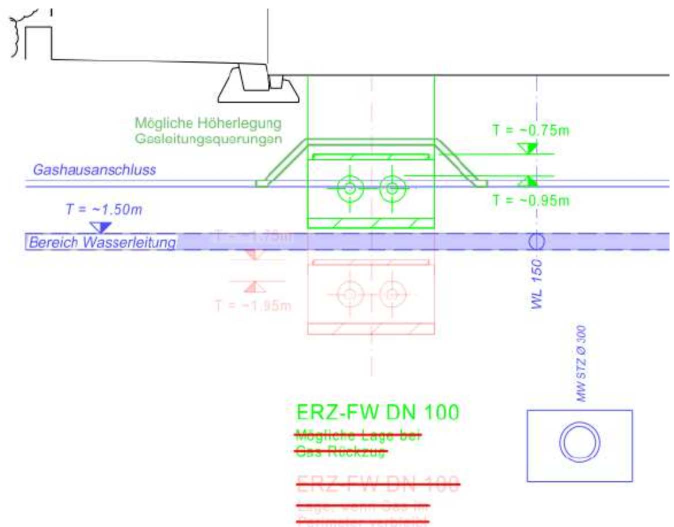
INVESTMENT COSTS MAIN PIPES

Variante A
Prämisse: Keine Koexistenz möglich
(aktuelle TED Norm)



Einsparungen bei Variante Gasrückzug aufgrund optimierter Höhenlage, was beim Referenzszenario nicht möglich ist (Vorgabe keine Koexistenz)

Variante B
Prämisse: Koexistenz möglich
(revidierte TED Norm, in Vernehmlassung)



Optimierung Höhenlage auch bei Referenzszenario möglich. Notwendigkeit von punktuellen Umlegung Gasleitungen (Einmündung von Strassen, Hausanschlüsse)

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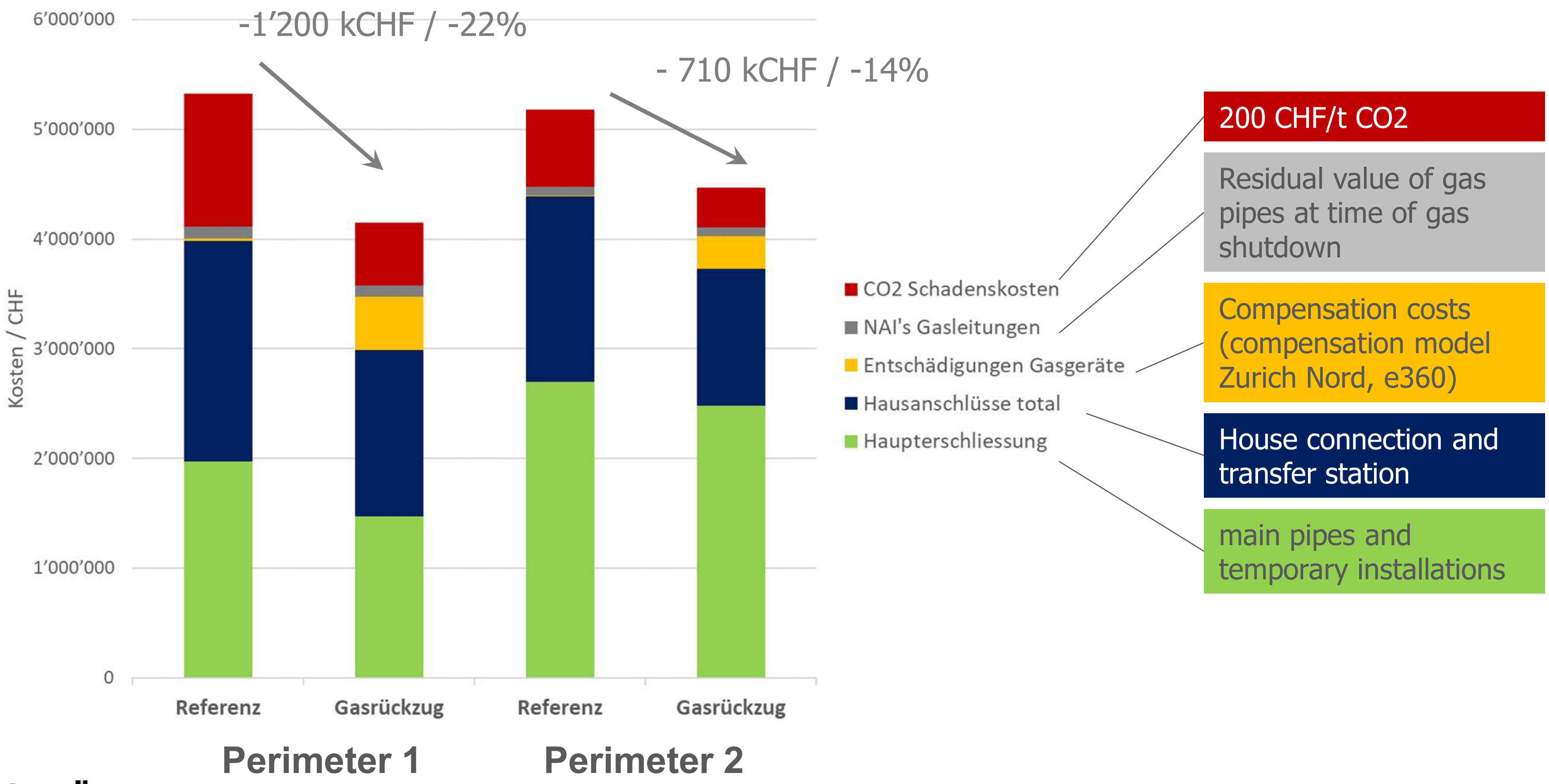
OVERVIEW TOTAL COSTS



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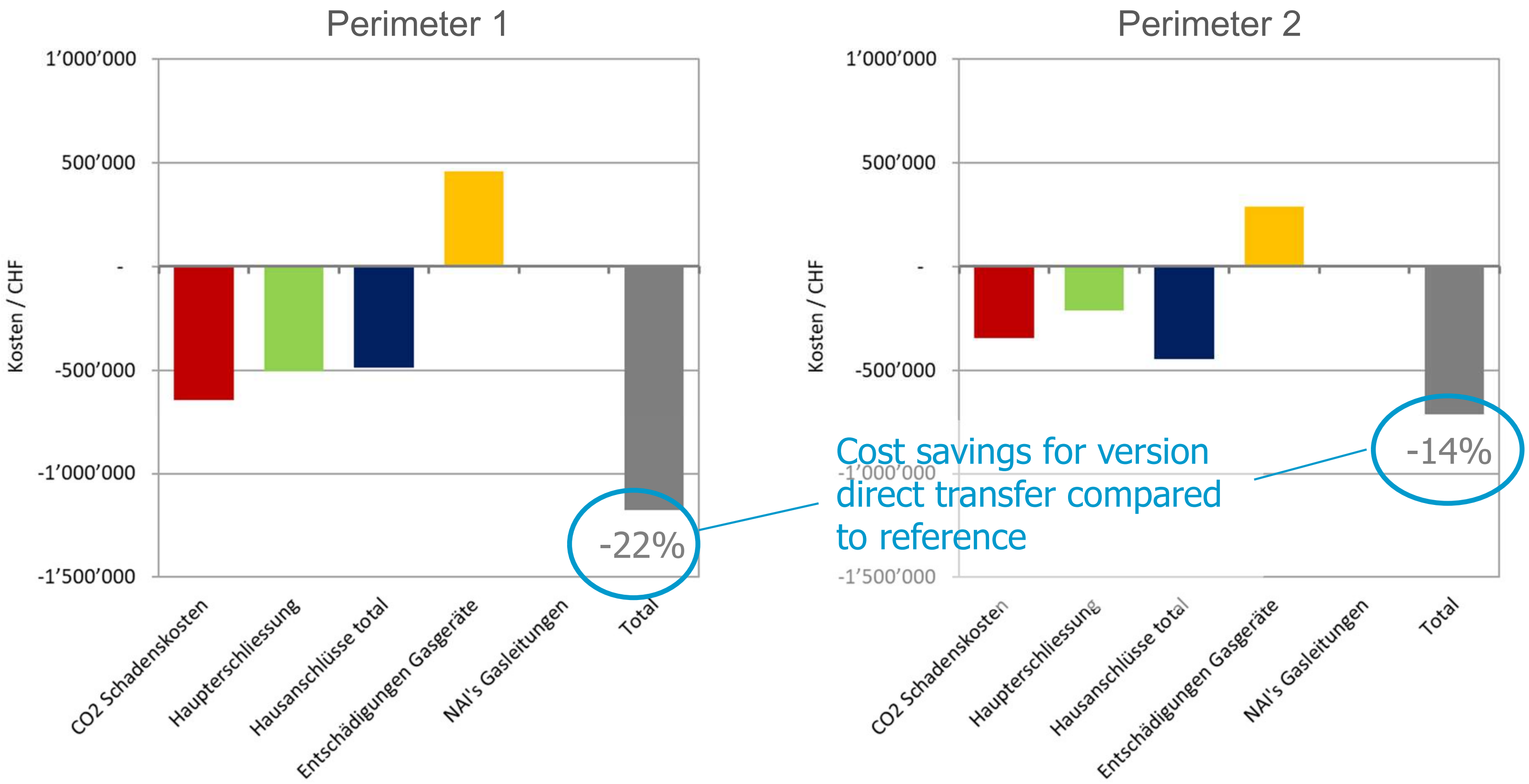
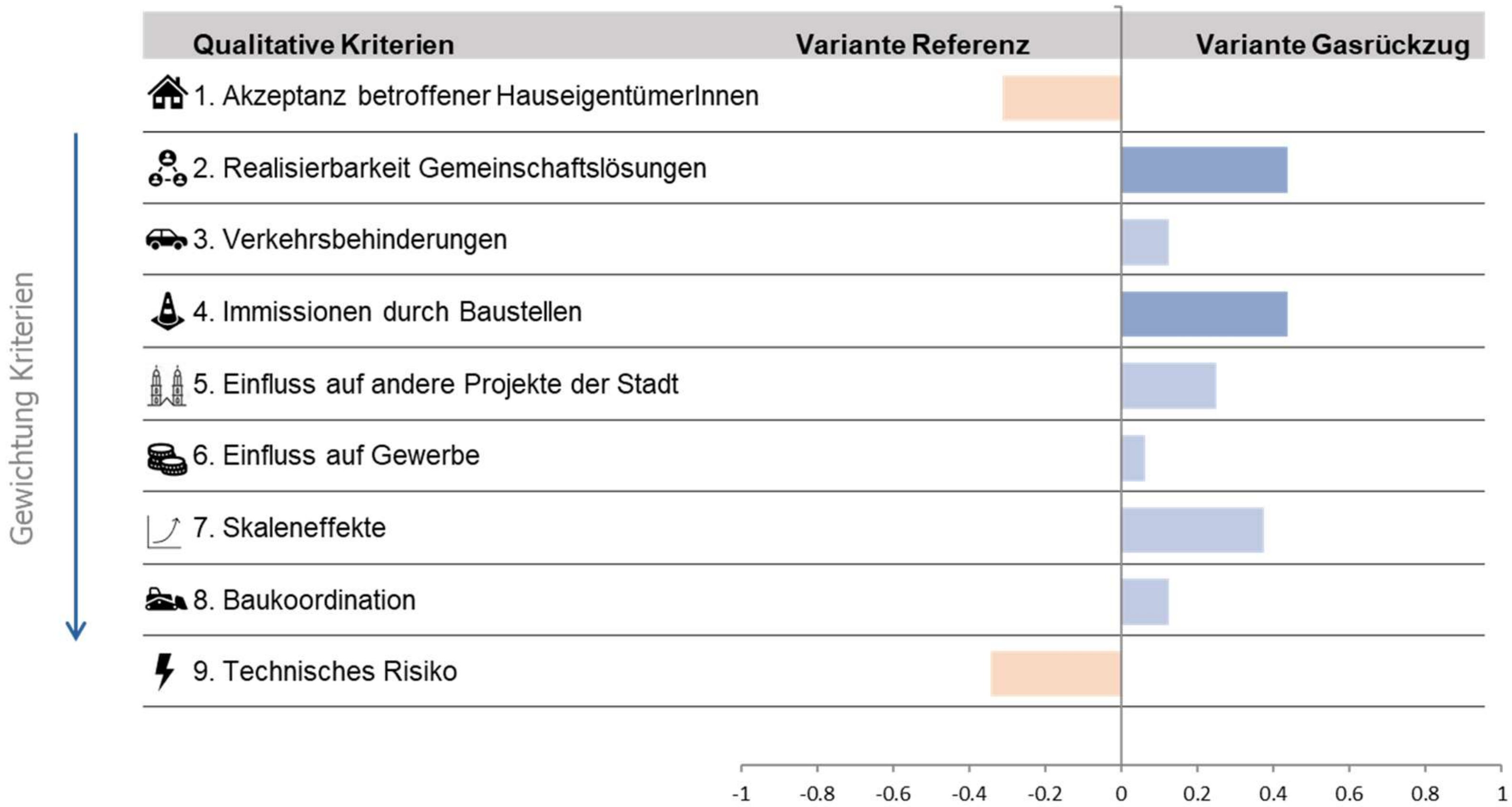
DIFFERENTIAL COSTS

Comparison of scenarios (costs direct transfer – costs reference)



QUALITATIVE EVALUATION OF SCENARIOS



CONCLUSIONS

The **quantitative cost analysis** shows that the variant with simultaneous shutdown of the gas supply brings cost advantages from a macroeconomic point of view, which also stand up to various sensitivity considerations.

The assessment of **qualitative aspects** by a group of experts shows that, for the majority of the assessed aspects, the variant “direct transfer” is classified as slightly advantageous. However, the majority of respondents classify the most strongly weighted criterion "acceptance" as negative for this scenario.

Altogether, the analyses performed exemplarily for the two perimeters indicate the advantages for the approach with direct transfer. **It is therefore recommended to consider this approach as a procedure under the consideration of the specific situation in each case.**