

Replacement of fossil-fuel boilers in urban residential houses

results from a feasibility study for the city of Vienna, 2021

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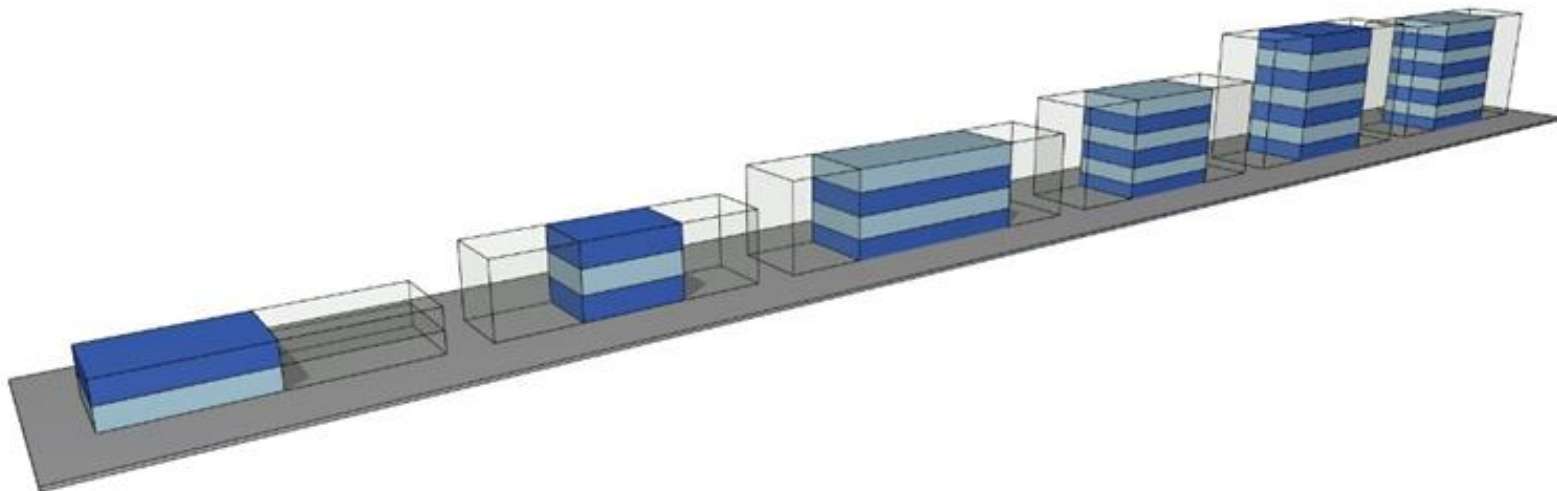
klimaaktiv program renewable heat

IBR&I Institute of Building Research and Innovation, Vienna, Austria

eight existing buildings in Vienna



six parametric buildings

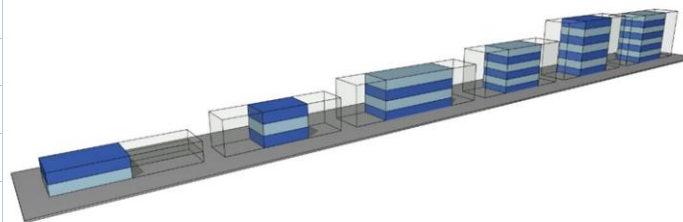


Energy demand key indicators

	Construction period	Usable floor space in m ²	Number of residential units	Heating demand (excl. WW) according to EAW kWh/m ² _{BGR}	Heating consump SH+WW in kWh/m
Building 1	1962	10,500	116	46	65
Building 2	1892	1,185	13	107	110
Building 3	1900	1,800	15	140	130
Building 4	Ca. 1975	4,200	60	n/a	70
Building 5	1955	Ca. 8,300	139	35	65
Building 6	1953	Ca. 9,400	157	80	90
Building 7	Ca. 1900	804	10	n/a	65
Building 8	Ca. 1800	900	15	130	100

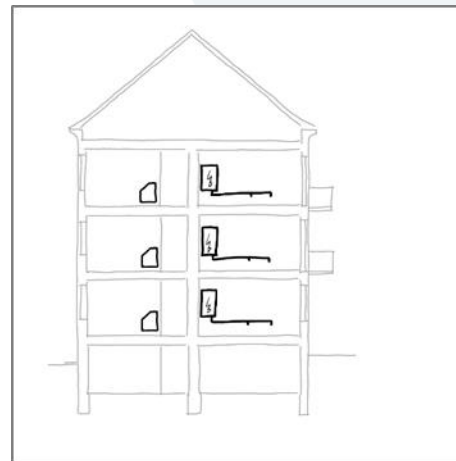
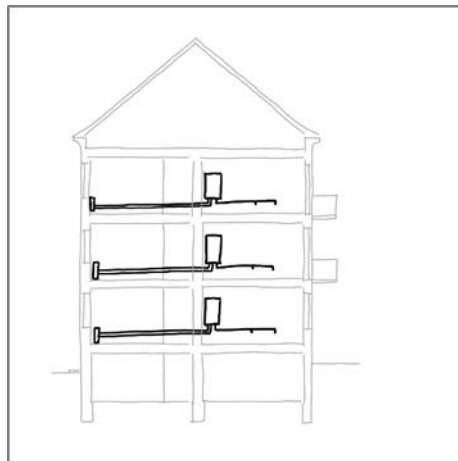
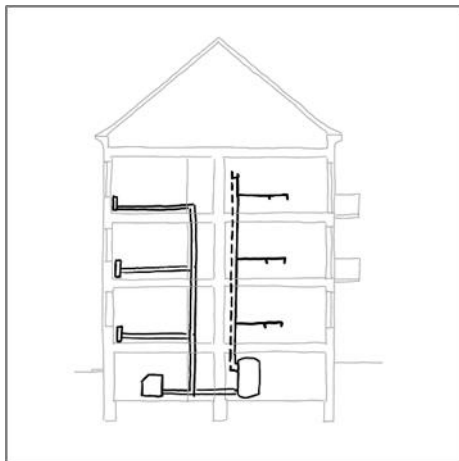


	Construction period	Gross floor space in m ²	Storeys	Heating demand (excl. WW) according to EAW in kWh/m ² _{BGR}	Heating demand incl. WW kWh/m ² _{BGR}
1 MFH post-war, refurbished	1945-1960	445	2	45	55
2 MFH Wilhelminian, partly refurbished	vor 1900	445	3	78	73
3 GWB Wilhelminian, not refurbished	vor 1900	1,469	4	133	96
4 GWB post war, refurbished	1945-1960	1,470	6	32	46
5 GWB Wilhelminian, partly refurbished	vor 1900	1,715	7	61	65
6 GWB post war, refurbished	1945-1960	1,960	8	30	45



Three initial situations:

Central gas heating | Gas combi heaters | Gas convectors

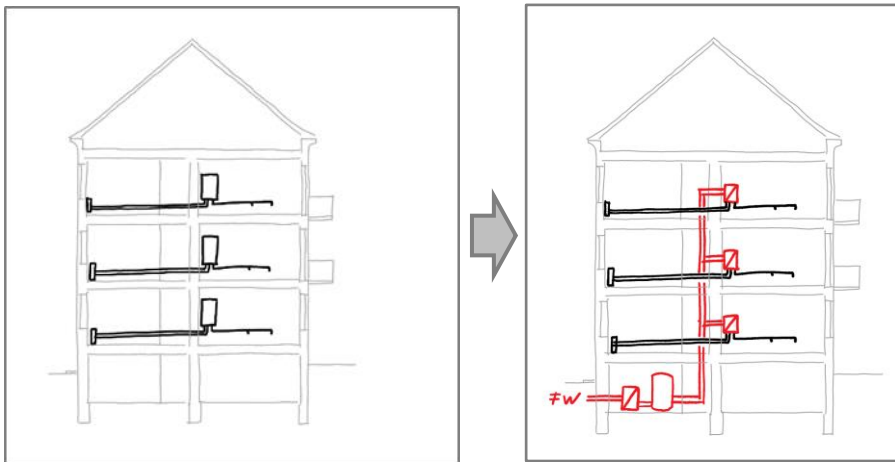


Basis for the following summary of results

- Summary of results in the form of **basic measures, challenges** and **opportunities**
- The planning of measures and the cost estimate apply to an existing building with **20 flats of 70 m²_{NFA} each**, thus with **1,400 m²_{NFA}** with a heating load incl. hot water of approx. **60 W/m²_{NFA}** and thus **84 kW** with a heating demand incl. hot water of approx. **90 kWh/m²_{GFA}a** and thus **158 MWh/a**.
- Cost estimates apply to the production of the components net, Vienna, 2020, with an inherently wide range of possible deviation

Replacement of gas boilers with district heating

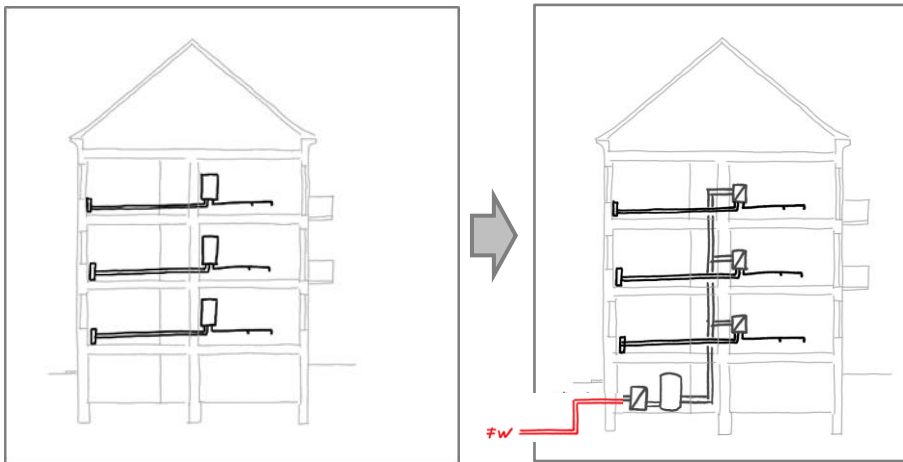
Basic measure



- District heating (DH) inlet ≤ 15 m
- Construction of DH transfer station
- Installation of the standpipe with flat units or with domestic hot water standby-storage-tanks
- Use of existing radiators
- 85 EUR/m²_{NFA} or 6.000 EUR/Apt

Replacement of gas boilers with district heating

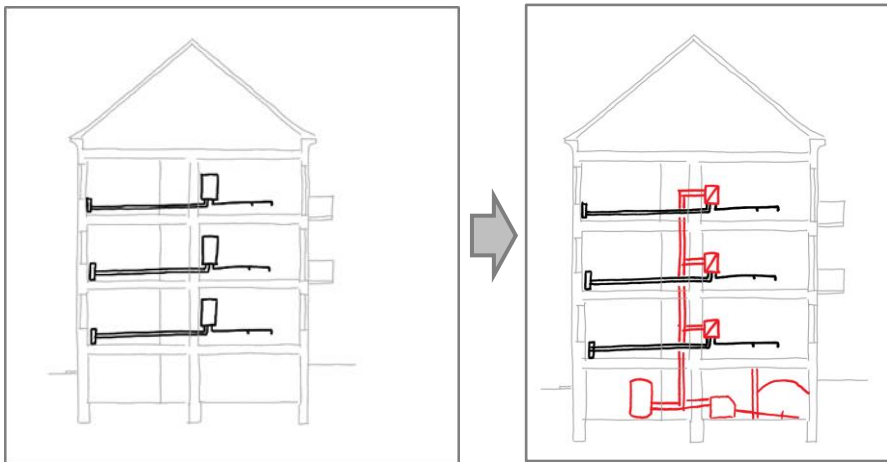
Challenge 1 - long connection line



- District heating inlet ≤ 15 m
- Assumption of additional 20 m connection length
- +12 EUR/m²_{NFA} or +840 EUR/Apt

Replacement of gas boilers with a central pellet boiler

Basic measure



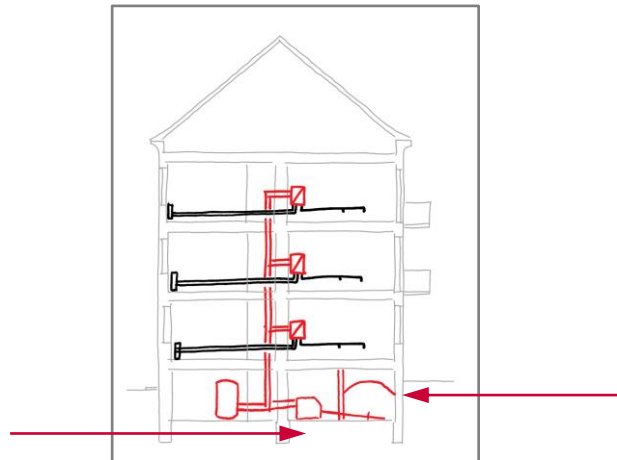
- Construction of a central pellet boiler
- Construction of a pellet storage room of approx. 30 m³ volume
- Installation of the standpipe with flat units or with domestic hot water standby-storage-tanks
- Use of existing radiators
- 100 EUR/m²_{NFA} or 7.000 EUR/Apt

Replacement of gas boilers with a central pellet boiler

Basic measure



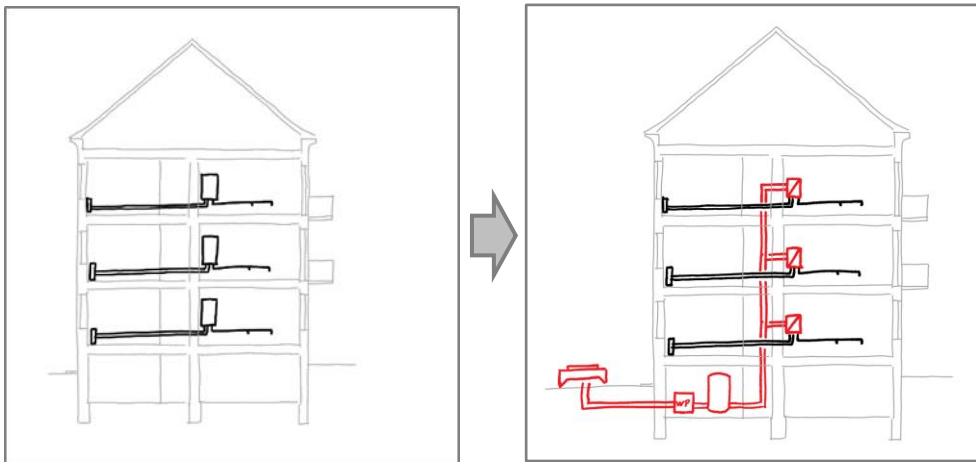
90 kW pellet boiler
source: Fröling



Pellet room extraction
source: Fröling

Replacement of gas boilers with an air source heat pump

Basic measure



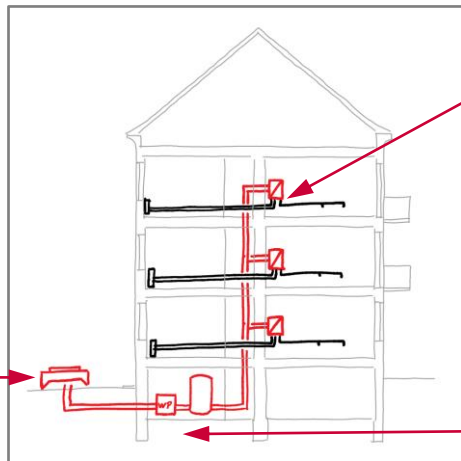
- Installation of a central Air-to-Water HP
- Installation of one or more outdoor units
- Installation of the standpipe with flat units or with domestic hot water standby-storage-tanks
- Use of existing radiators
- 160 EUR/m²_{NFA} or 11.200 EUR/Apt

Replacement of gas boilers with an air source heat pump

Basic measure



60 kW air-glycol heat exchanger
or 60 kW refrigerant evaporator
or 90 kW monobloc HP in outdoor setup
installation area approx. 10 m²
photo source: Günter



Flat unit

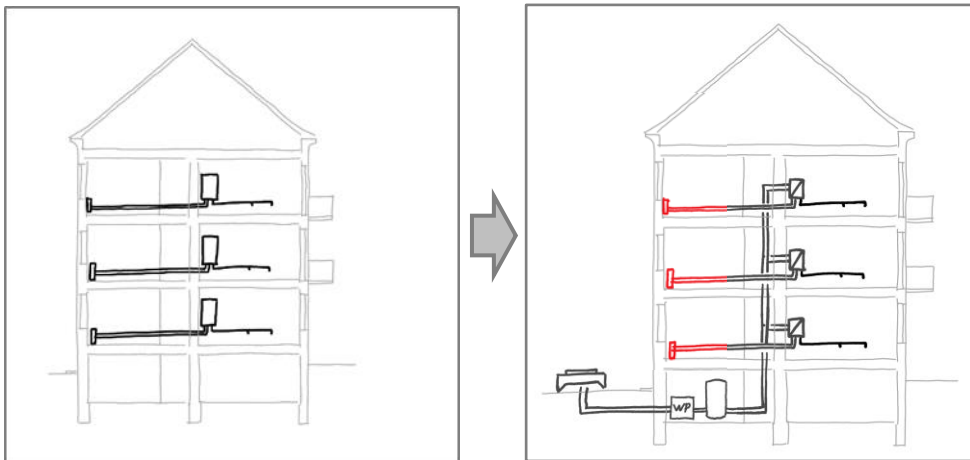
ca. 50 x 30 x 20 cm
source: Danfoss



Heat pump up to 100 kW
source: Ochsner

Replacement of gas boilers with an air source heat pump

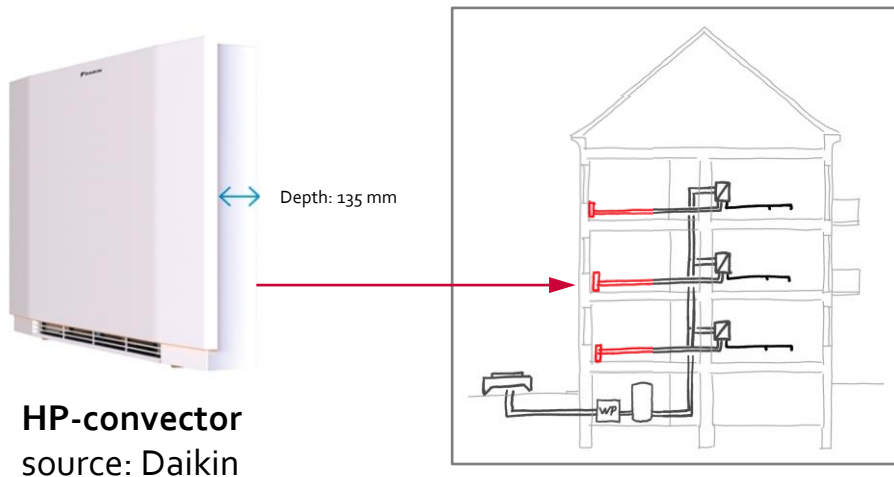
Challenge 1 - Radiators need to be replaced



- The radiators are not compatible with the HP
- Replacement of radiators with low-temperature radiators with supply temperature $< 50^{\circ}\text{C}$
- $+35 \text{ EUR/m}^2_{\text{NFA}}$ or $+2.500 \text{ EUR/Apt}$

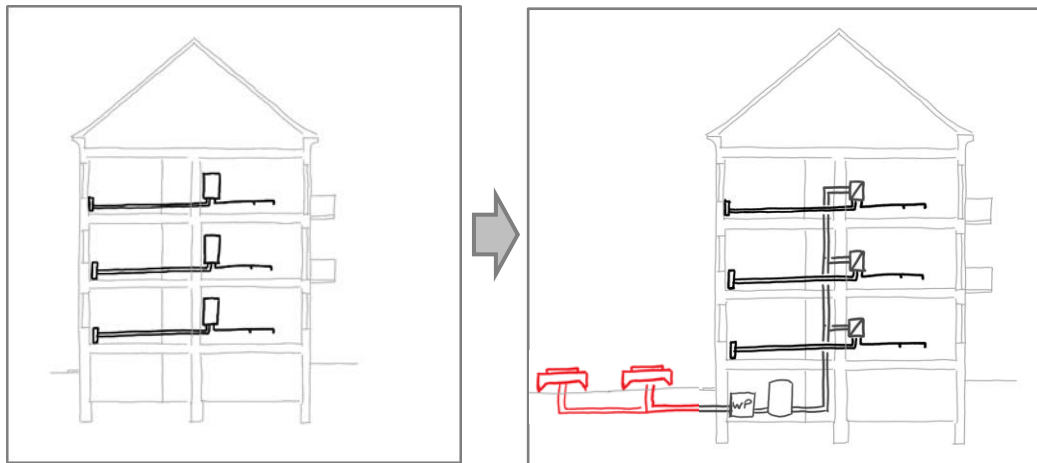
Replacement of gas boilers with a central heat pump

Challenge 1 - Radiators need to be replaced



Replacement of gas boilers with a central heat pump

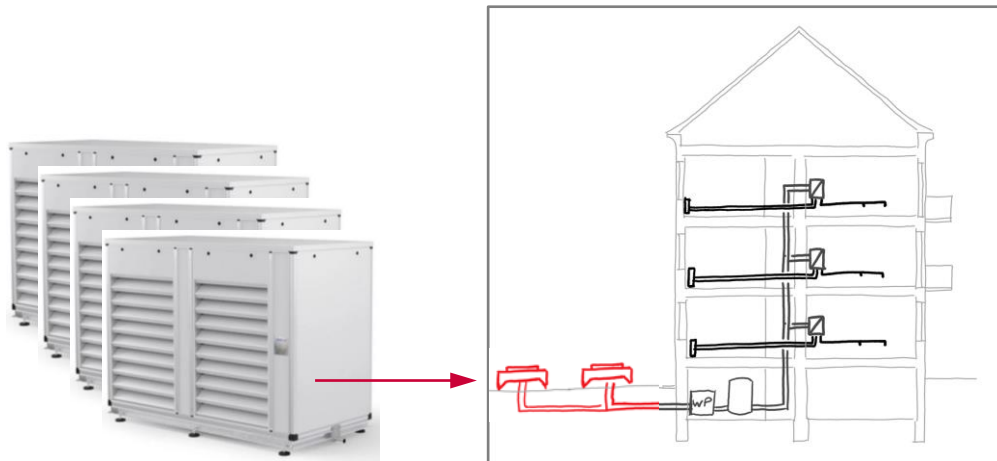
Challenge 2 - Sound-sensitive outdoor space



- There is a particularly sound-sensitive outdoor space
- Enlargement and/or enclosure of the outdoor units
- +30 EUR/m²_{NFA} or +2.100 EUR/Apt

Replacement of gas boilers with a central heat pump

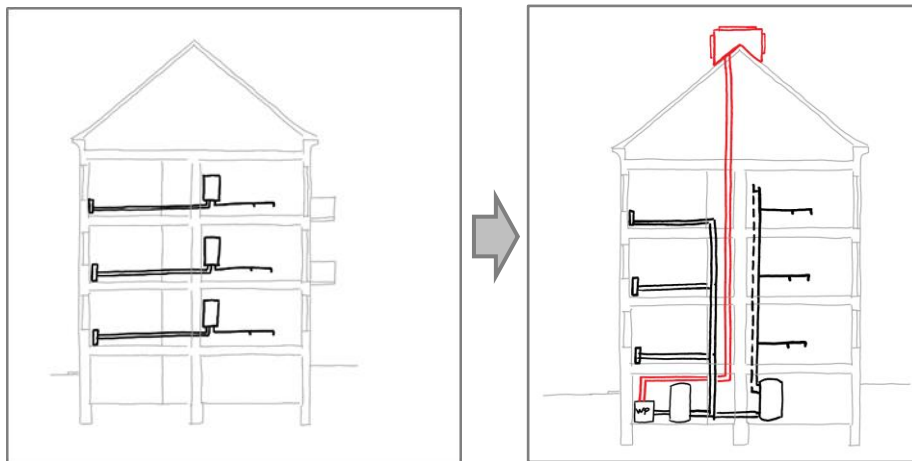
Challenge 2 - Sound-sensitive outdoor space



Sound insulation housing
source: kellner engineering gmbh

Replacement of gas boilers with a central heat pump

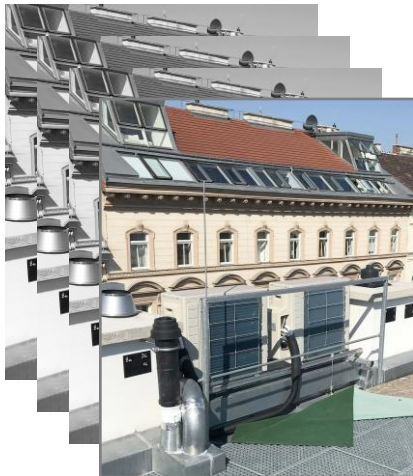
Challenge 3 - No space for outdoor units



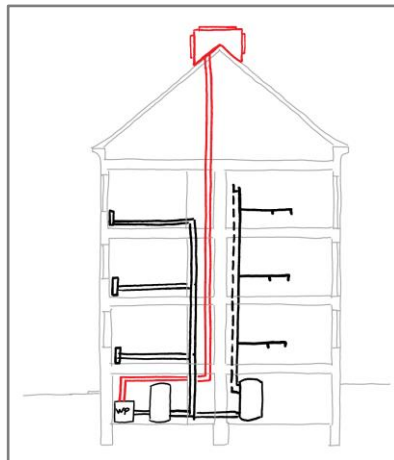
- There are no suitable options for installing the outdoor units on open spaces
- Installation of the outdoor units on the roof or similar
- +40 EUR/m²_{NFA} or +2.800 EUR/Apt

Replacement of gas boilers with a central heat pump

Challenge 3 - No space for outdoor units



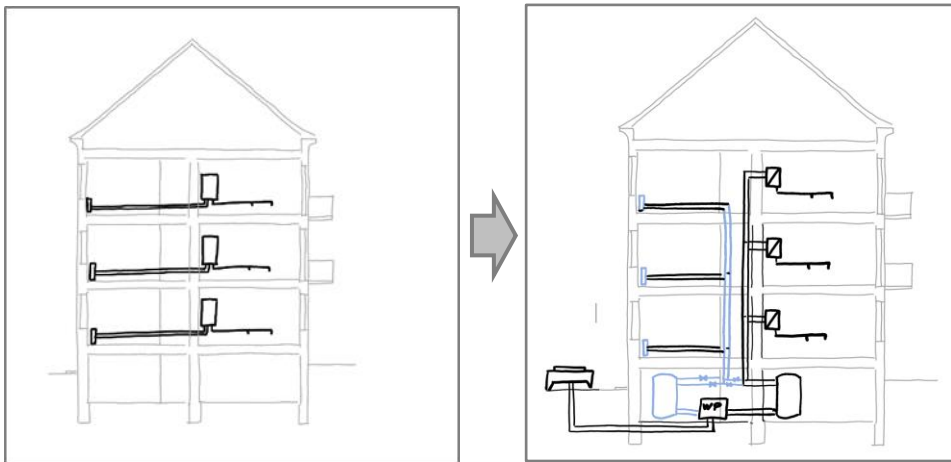
Roof-mounted evaporator, approx. 60 kW
source: kellner engineering gmbh



Sound insulation housing retrofitting
source: kellner engineering gmbh

Replacement of gas boilers with a central heat pump

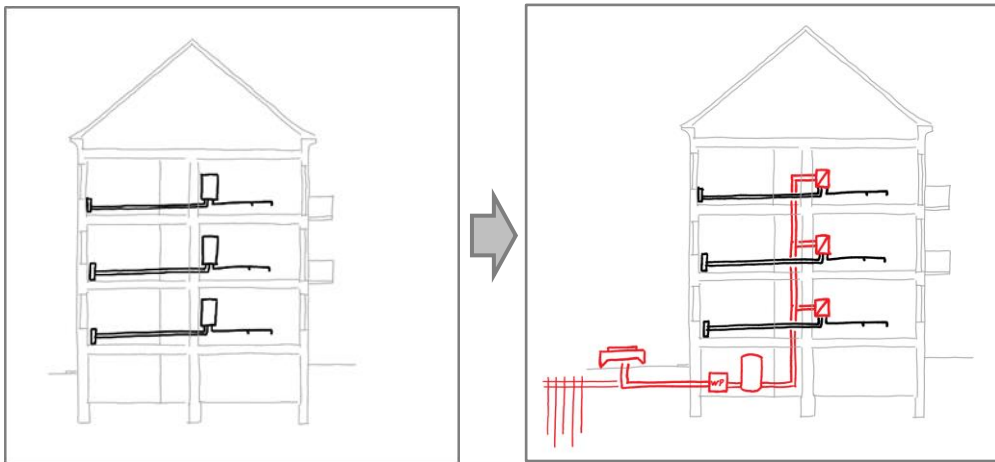
Chance for summer temperature control from warm water production



- A cold storage tank is built
- An additional pair of standpipes is installed
- Individual radiators are replaced with convectors
- +60 EUR/m²_{NFA} or +4.200 EUR/Apt

Replacement of gas boilers with a geothermal heat pump

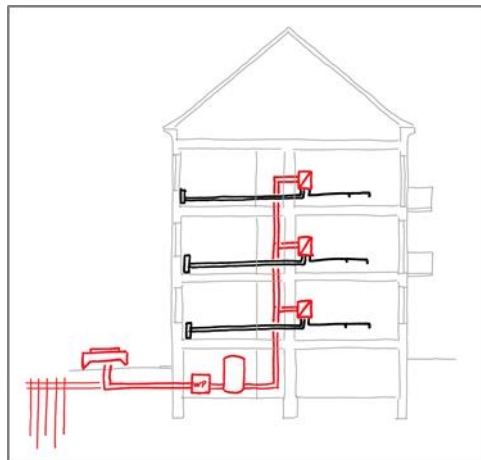
Basic measure



- Installation of a central brine-to-water heat pump
- Installation of ground probes in the magnitude of 0.7 m probes or per m² usable area; additional installation of an outdoor air unit
- Installation of the standpipe with flat units or with domestic hot water standby-storage-tanks
- Use of existing radiators
- 200 EUR/m²_{NFA} or 14.000 EUR/Apt

Replacement of gas boilers with a central geothermal heat pump

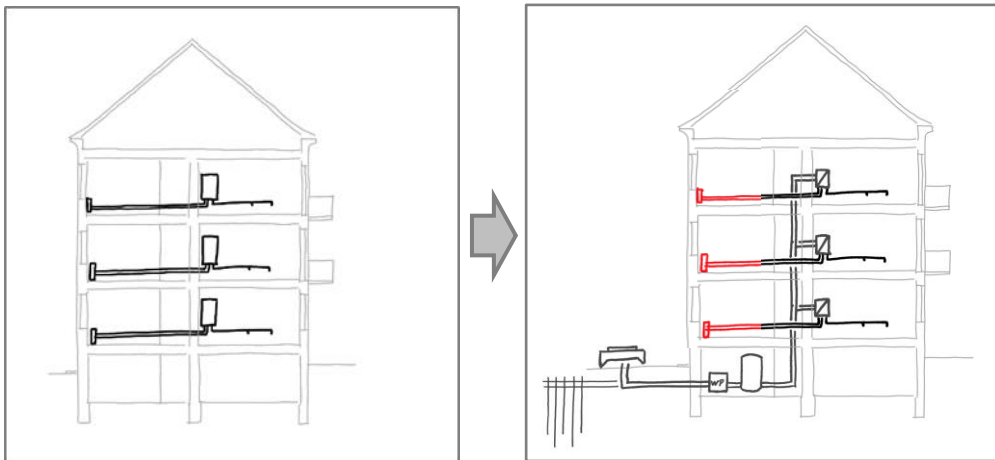
Basic measure



Earth probe drilling equipment and probe head
source: personal photos and internet

Replacement of gas boilers with a central geothermal heat pump

Challenge 1 - Radiators need to be replaced



- The radiators are not compatible with the HP
- Replace the radiators with low-temperature radiators with supply temperature $< 50^{\circ}\text{C}$
- $+33 \text{ EUR/m}^2_{\text{NFA}}$ or $+2.500 \text{ EUR/Apt}$

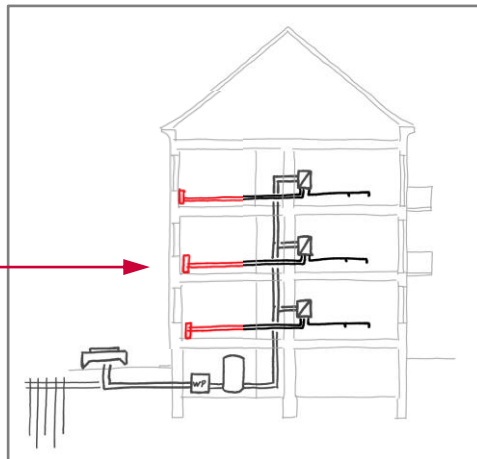
Replacement of gas boilers with a central geothermal heat pump

Challenge 1 - Radiators need to be replaced



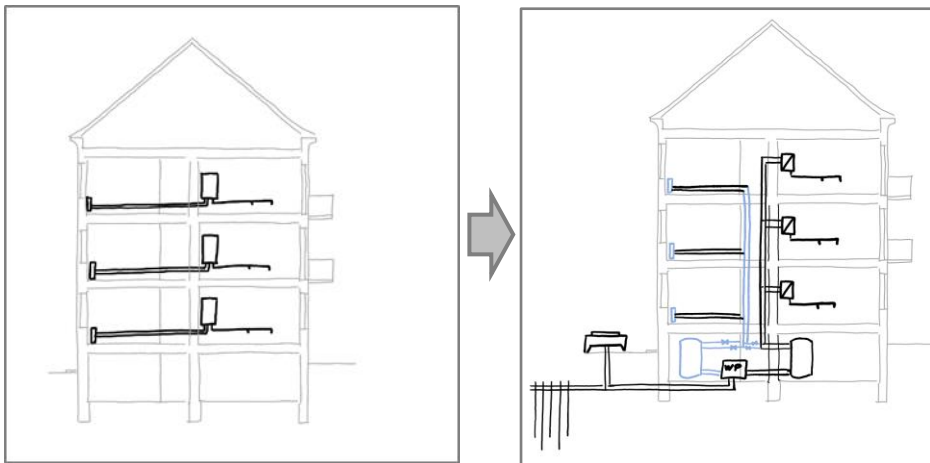
Depth: 135 mm

HP convector
source: Daikin



Replacement of gas boilers with a geothermal heat pump

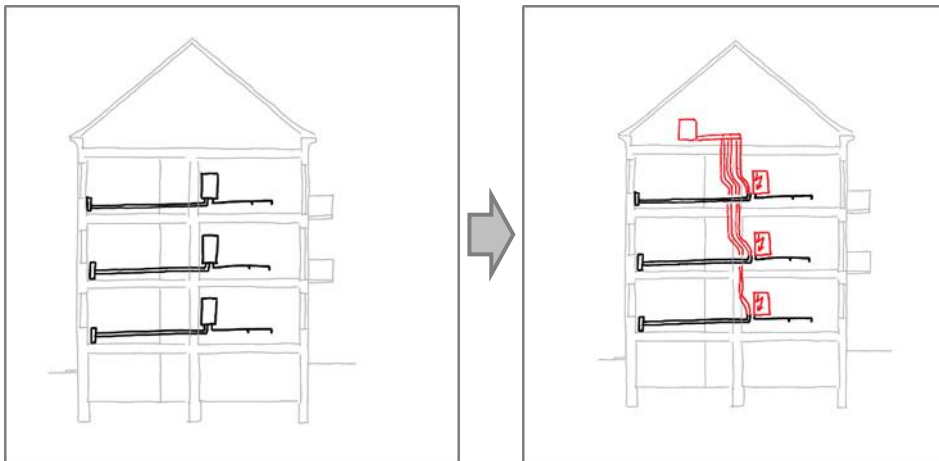
Chance for summer temperature control from geothermal heat



- A cold storage tank is built
- An additional pair of standpipes is installed
- Individual radiators are replaced with convectors
- +60 EUR/m²_{NFA} or +4.200 EUR/Apt

Replacement of gas boilers with a community boiler*

Basic measure



- A gas boiler, the "community boiler", is being constructed in the attic
- Heating pipes are pulled through the abandoned chimneys and connected with the existing radiators
- Electric hot water tanks with integrated heating heat-exchangers are made
- 70 EUR/m²_{NFA} or 4.900 EUR/Apt

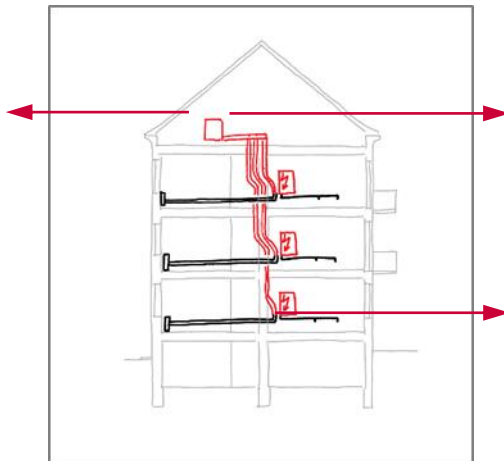
* System and terminology: SOZIALBAU

Replacement of gas boilers with a community boiler

Basic measure



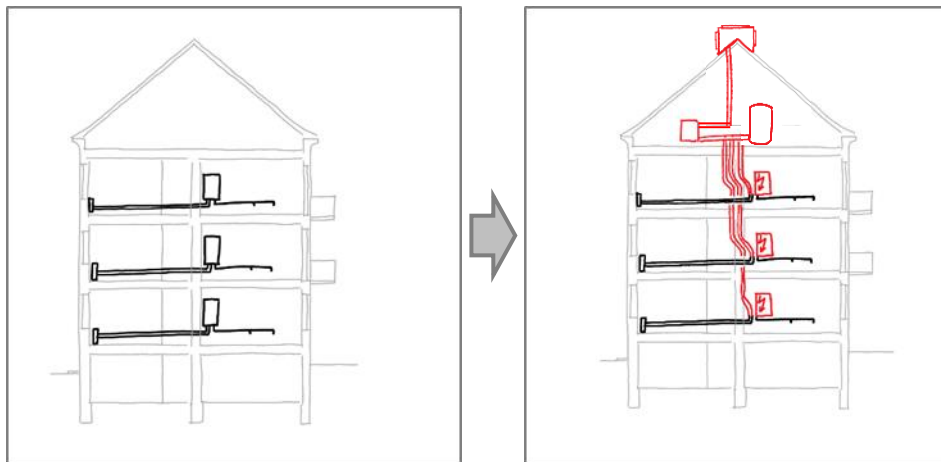
Distributor in the attic
source: SOZIALBAU



Pipe ducting in the chimney
source: SOZIALBAU

Replacement of gas boilers with a community boiler

Chance to exchange for an air source heat pump*

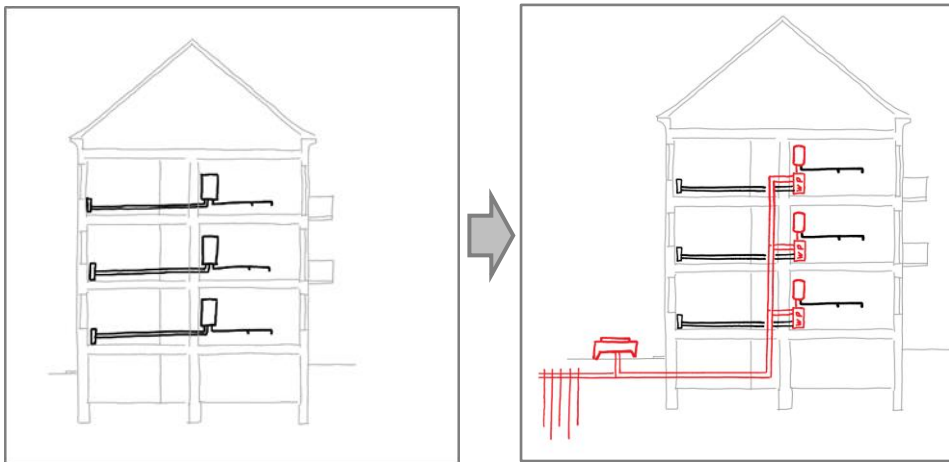


- In the attic, one or more air source heat pumps with load-balancing-storage are installed to replace the "community boiler"
- 110 EUR/m²_{NFA} or 7.700 EUR/Apt

* In exchange for the community boiler according to SOZIALBAU

Replacement of gas boilers with decentralised heat pumps

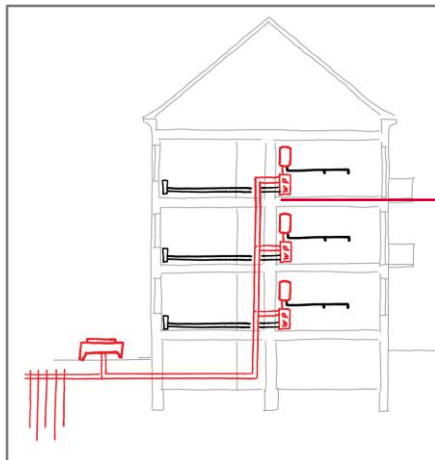
Basic measure, variation 1: Brine-to-water HP



- Micro heat pumps and a hot water standby tank are installed in every apartment
- Additionally, a pair of standpipes, an air-glycol heat exchanger and a geothermal probe field of the magnitude of $0.7 \text{ m}^2_{\text{NFA}}$ will be installed
- $210 \text{ EUR/m}^2_{\text{NFA}}$ or 14.700 EUR/Apt

Replacement of gas boilers with decentralised heat pumps

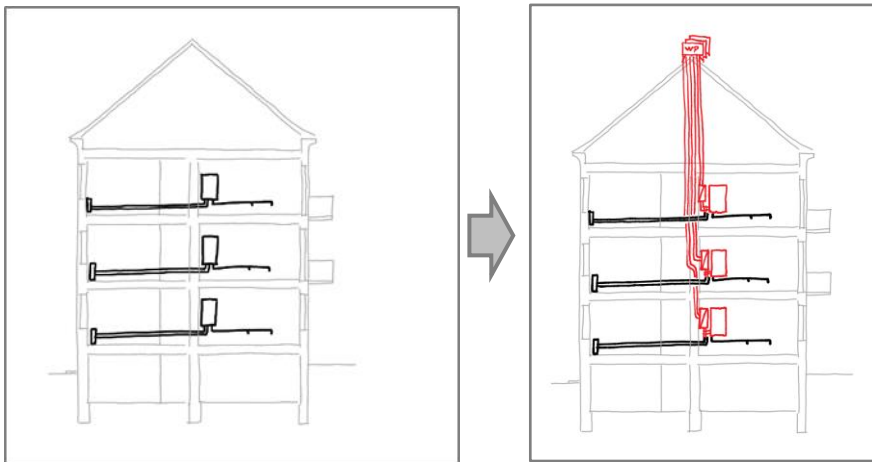
Basic measure, variation 1: Brine-to-water HP



Mini brine-to-water heat pump
source: Vaillant

Replacement of gas boilers with decentralised heat pumps

Basic measure, variation 2: Air-water HP



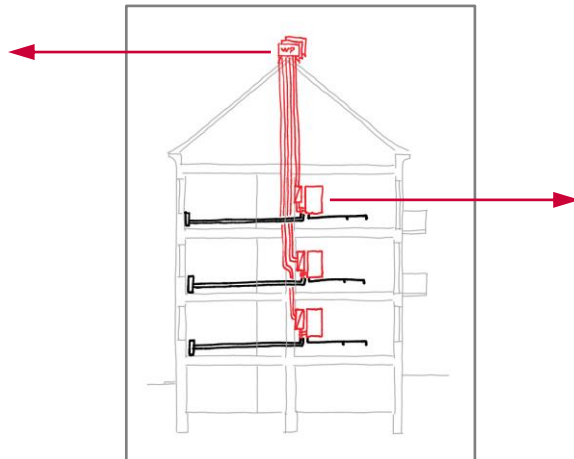
- A HP with approx. 4 kW and a warm water standby-storage-tank are installed in each flat
- On the roof, an outdoor unit with a refrigerant evaporator or a brine-to-air heat exchanger is setup for each HP
- The heat pumps are connected to the flats via the chimneys
- 190 EUR/m²_{NFA} or 13.300 EUR/Apt

Replacement of gas boilers with decentralised heat pumps

Basic measure, variation 2: Air-water HP



**Outdoor unit
(evaporator)**
source: Daikin

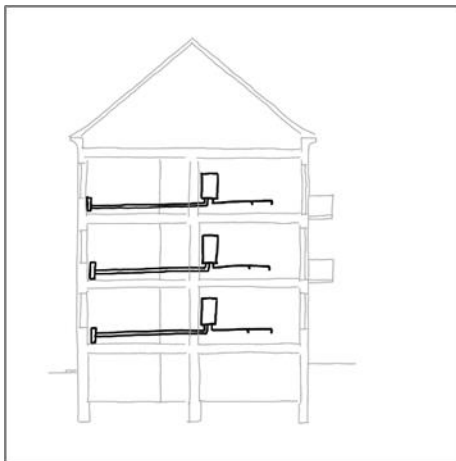


Mini air-to-water heat pump
source: Daikin



Warning:
Split units on façade
Quelle: <https://qz.com>

Gas boiler replacement Solution overview



6.3	Conversion of existing gas floor heating systems	EUR/m ² _{WNF}	EUR/Apt
6.3.1	Replacement of gas boilers with district heating		
6.3.1.1	Basic measure	85	6,000
6.3.1.2	Complication: Long connection pipe	+ 12	+ 840
6.3.2	Replacement of gas boilers with a pellet boiler		
6.3.2.1	Basic measure	100	7,000
6.3.3	Replacement of gas boilers with an air source heat pump		
6.3.3.1	Basic measure	160	11,200
6.3.3.2	Complication: Unsuitable radiators	+ 35	+ 2,500
6.3.3.3	Difficulty: Sound-sensitive location	+ 30	+ 2,100
6.3.3.4	Difficulty: Lack of space	+ 40	+ 2,800
6.3.3.5	Chance: cooling with warm water	+ 60	+ 4,200
6.3.4	Replacement of gas boilers with a geothermal heat pump		
6.3.4.1	Basic measure	200	14,000
6.3.4.2	Complication: Unsuitable radiators	+ 35	+ 2,500
6.3.4.3	Chance: cooling with geothermal heat	+ 60	+ 4,200
6.3.5	Replacement of gas boilers with a community boiler		
6.3.5.1	Basic measure	70	4,900
6.3.5.2	Chance: exchange for air source heat pump	+ 110	+ 7,700
6.3.6	Replacement of gas boilers with decentralised HP		
6.3.6.1	Basic measure, variation 1: Brine-to-water HP	210	14,700
6.3.6.2	Basic measure, variation 2: Air-W-WP	190	13,300

Conclusions

- The conversion of gas heaters is technically possible without exception. There are challenges, but no technical impossibility.
- Obstacles, on the other hand, appear in the framework of housing law.
- What is needed is a political decision to end the gas supply of buildings for heating purposes, which is long-term, without exception.