Energizing investment

A financial analysis of individual vs, collective sustainable energy technologies in housing at a neighbourhood level

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Course: Graduation Laboratory
Date: 28-10-2024

P5

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Introduction

Open Design Group Design@50 Learning and teaching Research

impact of the built environment on climate char and of climate change on the built environmen

Why is the built environment important to climate change? We all live and work in buildings, and they provide us with shelter and warmth, belonging and protection. However the built environment is responsible for a huge 39% of all global carbon emissions, far higher than any other individual sector. This 39% can be divided into two distinct impacts: operational carbon, which is from heating, lighting and cooling our *existing* buildings, which is responsible for 28% of our emissions; and embodied carbon, which is from the materials our *new* buildings ar their transport and construction processes, and also fro materials and components over the life of the building a demolition and end of life processes – this is responsibl emissions.

As the Climate Changes, Pressure Is Growing to Make Buildings More Efficient

Governments are weighing both regulations and incentives to cut emissions and energy use in new construction.

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Climate Change Is Speeding Toward Catastrophe. The Next Decade Is Crucial, U.N. Panel Says.

A new report says it is still possible to hold global warming to relatively safe levels, but doing so will require global cooperation, billions of dollars and big changes.

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Climate change impacts

Focus areas: Education Topics: climate literacy, climate impacts, education Share:

Though we often think about human-induced climate change as something that will happen in the future, it is an ongoing process. Ecosystems and communities in the United States and around the world are being impacted today.

SEA TO SKY: EDUCATION RESOURCE DATABASE //

Keep exploring! Find even more resources on climate change impacts in our searchable resource database.

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- Data in the Classroom (MS/HS) ›
- HEART Force: Colorado environmental hazards collection
- Sea level rise learning module (MS/HS) ›

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Problem statement

There has been a recent **surge of interest in integrating sustainable technology** into the built environment. Existing studies have primarily **focused on the financial value of <u>individual</u> technologies** in retrofitting of existing buildings. However, there is a significant gap in knowledge regarding the **strategies that can be employed individually or collectively** to enhance the financial value of sustainable technologies in the retrofitting of existing buildings.

Research aim

This study aims to examine the **optimal financial value** for implementing **Sustainable Energy Technologies (SETs)** at the **neighborhood level** and will analyze whether implementing SETs on a building-by-building basis or at the neighborhood level, or a combination of both, is preferable.

Research question

"How can investment in individual and/ or collective Sustainable Energy Technologies (SETS) generate financial value for the investors in retrofit of housing at a neighbourhood level?”

Sub questions:

SQ1	What sustainable energy technologies (SETS) can be used in the housing sector for individual and collective purposes?
SQ2	What factors determine whether individual or collective Sustainable Energy Technologies (SETS) should be implemented in housing?
SQ3	What method can be used to determine the financial value of individual and collective Sustainable Energy Technologies (SETS)?
SQ4	What are the specific advantages and disadvantages of individual compared to collective Sustainable Energy Technologies (SETS) in financial terms?
SQ5	Based on the evaluation, what are the recommendations for achieving optimal financial value?

Theoretical underpinnings

Financial value

The measurable benefits and returns generated by a monetary investment. It includes benefits such as reduced costs, increased property value and potential income from energy savings or generation.

Economic viability of energy efficiency

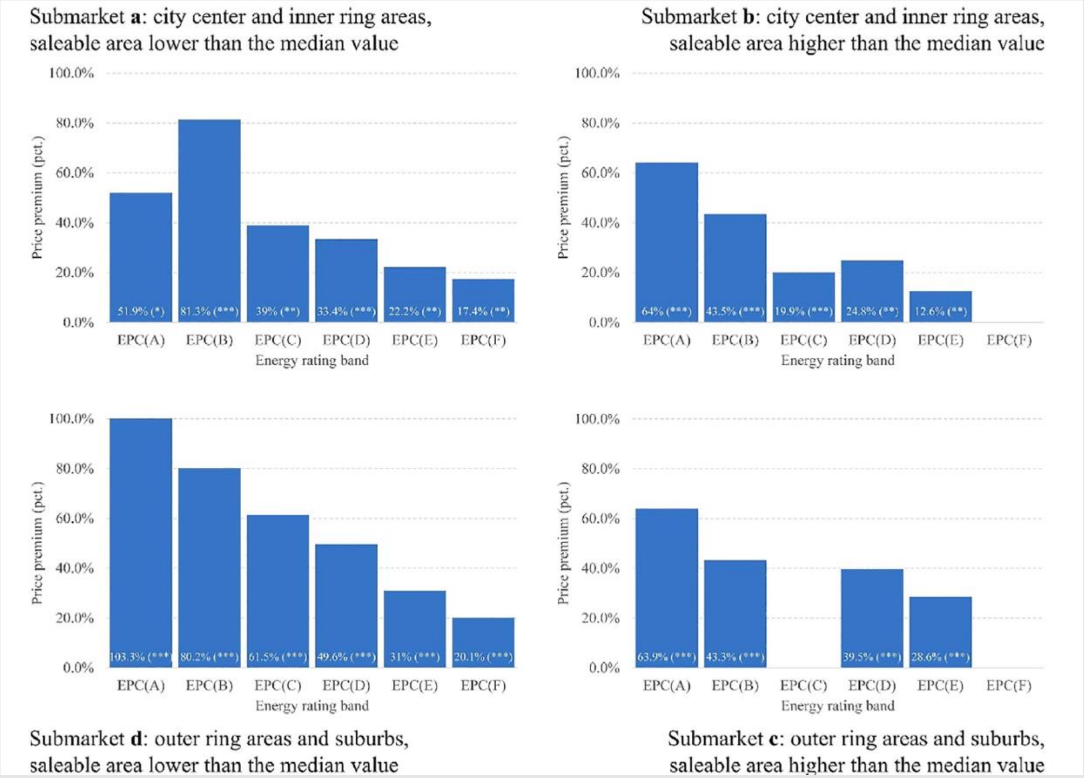
Significant increase in importance over recent decades (Copiello & Donati, 2021)

Price premiums for energy efficiency -> There is a additional amount buyers are willing to pay for energy-efficient properties

- *Padua, Italy: EPC labels A and B command 61.7% and 61.1% higher prices than label G (Copiello & Donati, 2021)*

The magnitude of the price premium is contingent upon a number of variables, including:

- **Location:** Higher premiums in urban areas
- **EPC Labels:** Higher ratings lead to higher premiums
- **House Characteristics:** Size, location, maintenance state
- **Market Conditions:** Mortgage rates, credit availability



Economic viability of energy efficiency

The economic viability of energy efficiency investments is contingent upon the relationship between the cost and price premiums (Copiello & Donati, 2021).

Marginal Cost (MK): Increases with energy performance improvements

Marginal Benefits (MB): Decrease with higher energy labels

MB = MK; **investments beyond this point are not economically justifiable**

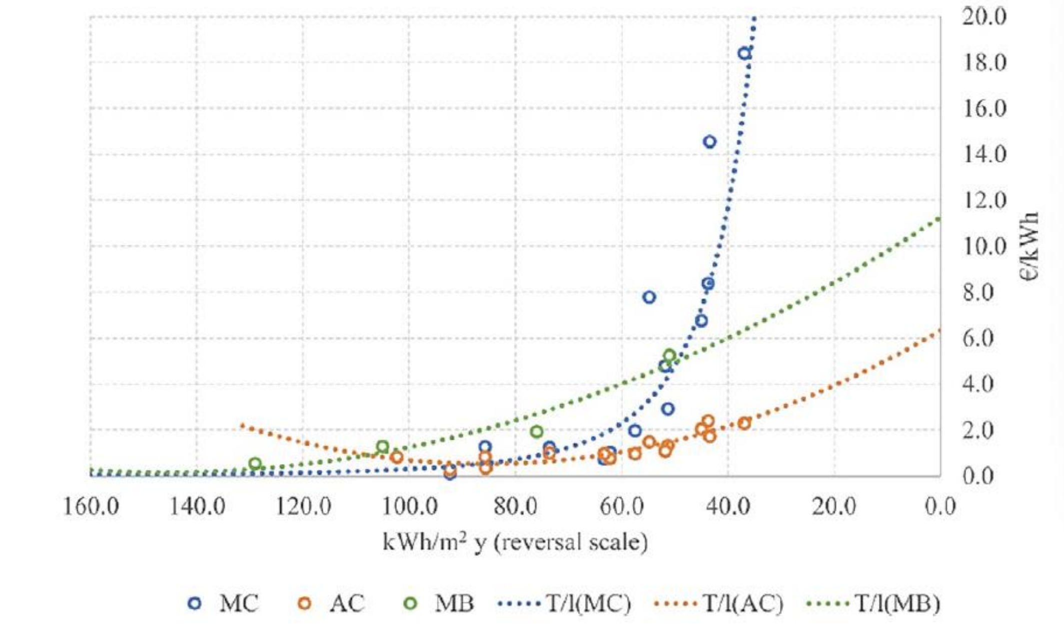


Fig. 8. Marginal costs, average costs, and marginal benefits.

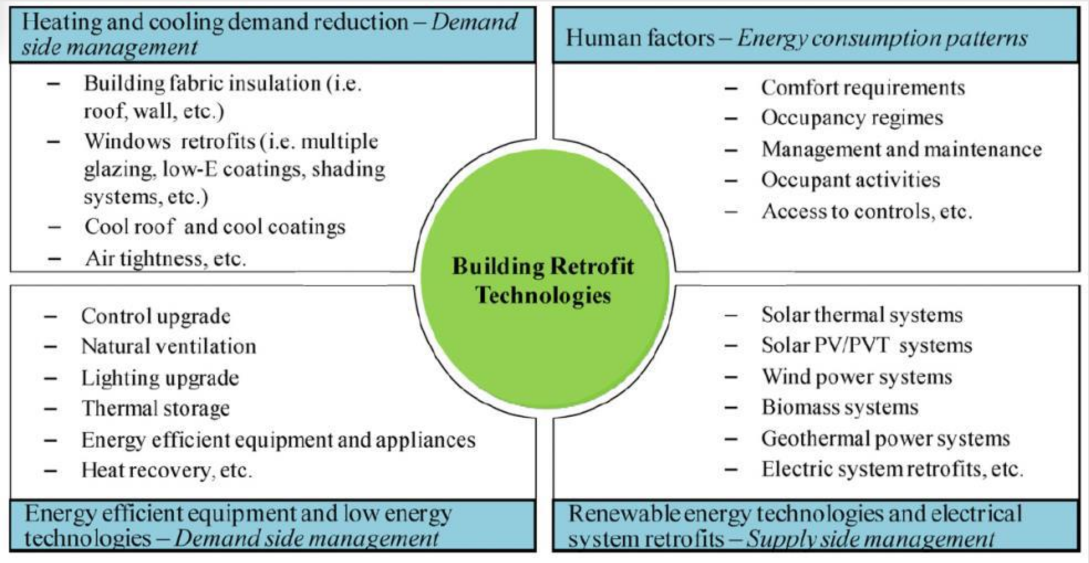
Sustainable energy technologies (SETs)

SETS encompass a diverse range of innovative solutions and systems designed to generate, store, and utilize energy in environmentally friendly and renewable ways. These technologies aim to reduce dependence on traditional fossil fuels, mitigate climate change, and promote energy efficiency.

SETs landscape

Out of the literature the SETS can be categorised into three categories:

1. Supply-side,
2. Demand-side
3. Changing consumption



Main categories of building retrofit technologies. (Ma et al., 2012)

SETs Intervention levels

Intervention Level	Examples
Building-level Interventions	Insulation materials, energy-efficient lighting, HVAC
Neighbourhood Interventions	District heating, shared renewable energy systems
Urban areas Interventions	Sustainable transportation, energy efficiency initiatives

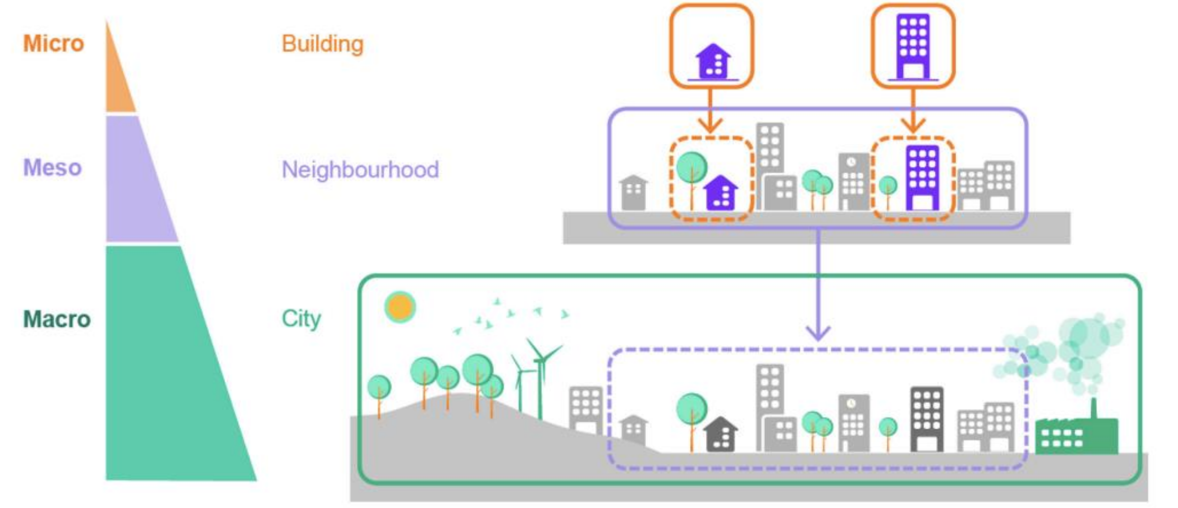
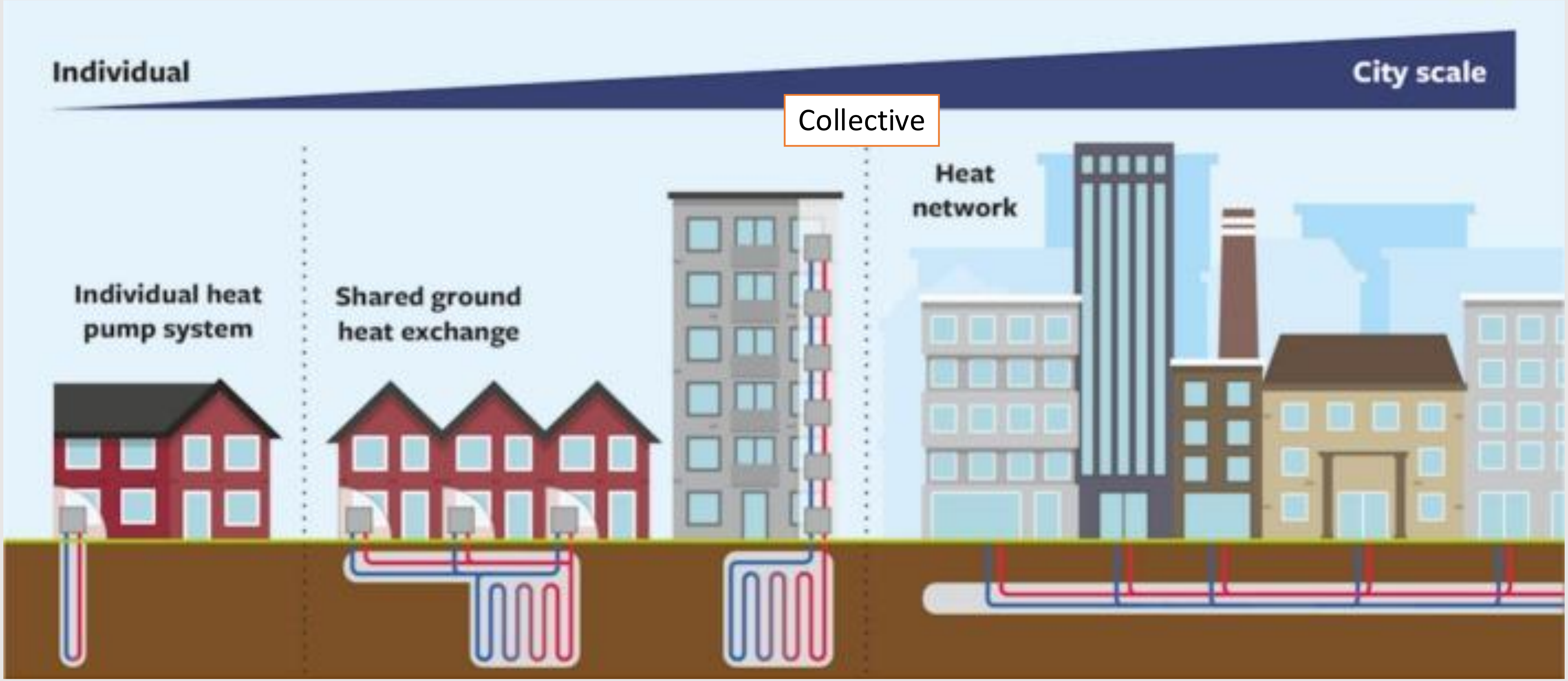


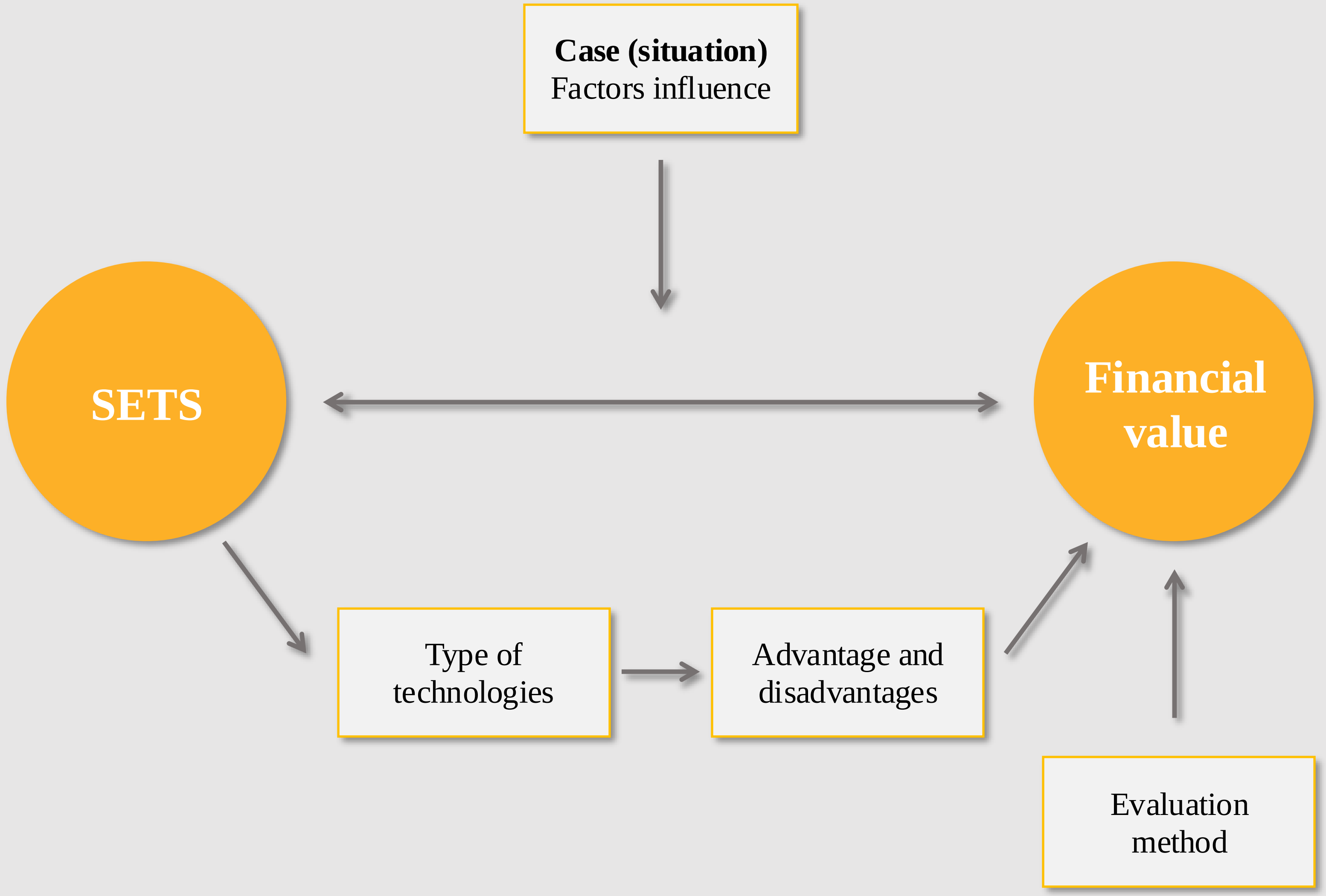
Figure 1. Identification of the neighborhood scale. Source: IREC (2021), adapted from [20].

Individual and collective technologies



Source: https://www.sciencedirect.com/science/article/pii/S2214629624002354

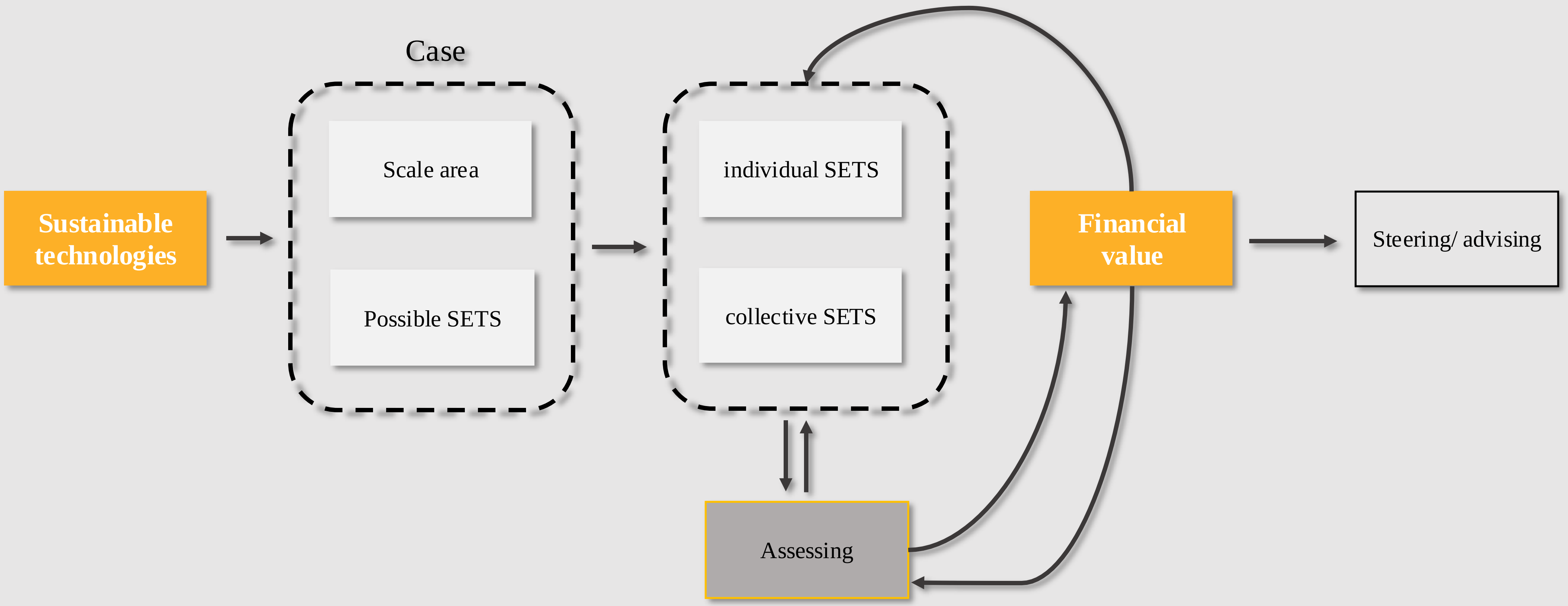
Framework



Case (situation)
Factors influence
SETS
Financial value
Type of technologies
Advantage and disadvantages
Evaluation method

Methodology

Research sequence



Case selection: UT Enschede

Calslaan Oud **Campus Avenue High**

10 student complex at the UT Enschede.

Diverse Sustainable Technologies: ✓

Individual and Collective Purposes: ~

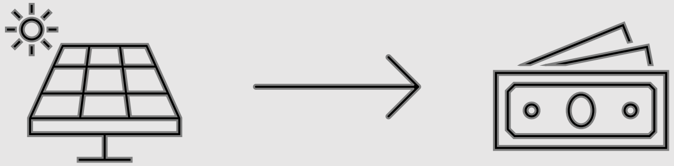
Regional Dynamics (Netherlands) ✓

Duration Variation ✓

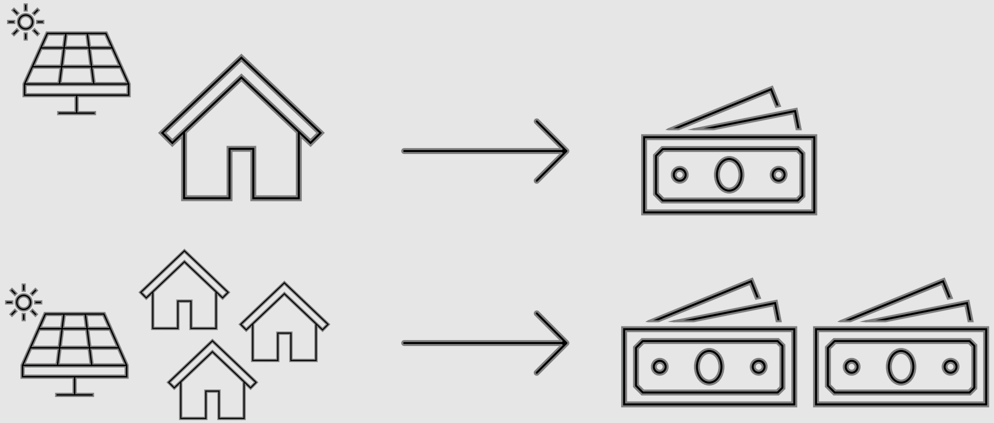
viac

hypotheses

Hypothesis 1: posits that the integration of sustainable technologies will have a financial impact.



Hypothesis 2: Financial value differences between individual building level innervations SETs and collective SETs at the neighbourhood level.



Data analysis

Make use of the Total cost of ownership (TCO) model

Adapted from VIAC a installation advice company

Project/ technology info

TCO energy system heating individual versus collective			
Project Date Version			
	Calslaan	Campuslaan hoog	Collectief
Definition	Individual closed-loop geothermal heat pump (GHP)	Individual closed-loop geothermal heat pump (GHP)	Collective closed-loop geothermal heat pump (GHP)
Number of properties	**240**	**205**	**445**
Buildings	**7**	**3**	**10**

Energy consumption

Source: VIAC- Vabi

Comparison of energy consumption based on estimated energy demand and efficiencies									
	GHP individual (Calslaan)			**GHP individual (Campuslaan)**			**GHP collective**		
	Heat requirement in kWh	**Yield (SCOP)**	**On the meter**	**Heat requirement in kWh**	**Yield (SCOP)**	**On the meter**	**Heat requirement in kWh**	**Yield (SCOP)**	**On the meter**
Overview of heat requirements + tap water (circulation pipe 22 mm. maintained)	*Ag*	*Wb [kWh/m²]*	*Tapwater*	*Ag*	*Wb [kWh/m²]*	*Tapwater*	*Ag*	*Wb [kWh/m²]*	*Tapwater*
Heat consumption Calslaan 3A	1.747	64,0	31.408 kWh				1.747	64,0	31.408 kWh
Heat consumption Calslaan 3B	1.747	51,0	31.408 kWh				1.747	51,0	31.408 kWh
Heat consumption Calslaan 3C	1.747	66,0	31.408 kWh				1.747	66,0	31.408 kWh
Heat consumption Calslaan 3-401	369	78,0	11.799 kWh				369	78,0	11.799 kWh
Heat consumption Campluslaan 49				2.262	69,0	35.547 kWh	2.262	69,0	35.547 kWh
Heat consumption Campluslaan 51				2.539	71,0	35.547 kWh	2.539	71,0	35.547 kWh
Heating (source: reference EPA-W calculation)	344.941	4,0	86.235 kWh	336.345	4,0	84.086 kWh	681.336	4,0	170.334 kWh
	43.206	2,5	17.283 kWh	71.094	2,5	28.438 kWh	177.116	2,5	70.846 kWh
Total Electricity heating, hot water and cooling			**103.518 kWh**			**112.524 kWh**			**265.298 kWh**
Total Heat W installations off-take district heating									
Estimation of household consumption			100.964 kWh			86.417 kWh			187.398 kWh
Total electricity after aging PV			204.482 kWh			198.941 kWh			452.696 kWh

Energy cost

Source: Based on existing contract

Energy costs on average for installation (resident costs)									
Number of homes in project	240			205			445		
Electrical energy for heating and hot water	103.518 kWh	0,38 € / kWh	€ 39.336,78	112.524 kWh	0,38 € / kWh	€ 42.759,13	265.298 kWh	0,38 € / kWh	€ 100.813,34
Electricity for ventilation, lighting and domestic consumption	100.964 kWh	0,38 € / kWh	€ 38.366,41	86.417 kWh	0,38 € / kWh	€ 32.838,62	187.398 kWh	0,38 € / kWh	€ 71.211,24
Total energy costs for household for Electricity (excl. fixed costs)			**€ 77.703,19**			**€ 75.597,75**			**€ 172.024,58**
Cost per household			*€ 323,76*			*€ 368,77*			*€ 386,57*
Total energy costs for household Heat network + Electricity			**€ 77.703,19**			**€ 75.597,75**			**€ 172.024,58**
Total cost per household			€ 323,76			€ 368,77			€ 386,57

Operational expenses

Source: VIAC based on references

Maintenance and replacement						
	GHP individual (Calslaan)		**GHP individual (Campuslaan)**		**GHP collective**	
Kosten per jaar per onderdeel incl. BTW	number	Costs/home	number	Costs/home	number	Costs/home
WTW met één zone CO_2	240	€ 43.431,45	205	€ 37.097,70	445	€ 80.529,15
Gesloten bron bij warmtepomp op bodemsysteem *	29,19	€ 8.172,97	24,80	€ 6.943,55	56,25	€ 15.750,00
Warmtepompboiler op buitenlucht	45,41	€ 13.222,05	46,29	€ 13.479,74	91,70	€ 26.703,04
Onderhoud en vervanging van technische installaties in SV ruimte	1	€ 203,28	1	€ 203,28	1	€ 203,28
Onderhoud en vervanging van centrale warmtepompen	29,19	€ 10.548,58	24,80	€ 8.961,81	56,25	€ 20.328,00
Monitoring gesloten bodemenergiesysteem	1	€ 500,00	1	€ 500,00	1	€ 500,00
Inschatting kosten voor inlezen warmtemeters en watermeters	25,95	€ 871,78	13,23	€ 444,39	39,70	€ 1.333,92
PV panelen per stuk	0	€ 0,00	0	€ 0,00	0	€ 0,00
Totaal voor onderhoud en vervanging		**€ 76.950,12**		**€ 67.630,46**		**€ 145.347,39**
Totaal energie + onderhoud en vervanging voor W installatie incl. BTW (TCO)		**€ 154.653,31**		**€ 143.228,21**		**€ 317.371,97**

Initial investment costs

Source: RVO and Arcadis

Estimation of investment costs						
	GHP individual (Calslaan)		**GHP individual (Campuslaan)**		**GHP collective**	
Cost per part excl. VAT	number	Costs/home	number	Costs/home	number	Costs/home
Collective Ground Source Heat pump (closed source)	0	€ 0,00	0	€ 0,00	445	€ 3.917.832,50
BAK Warmtenet Ennatuurlijk collective connection for nos 49+51 Determined based on €480,000 for WEQ = €1034.48 per WEQ.	0	€ 0,00	0	€ 0,00	0	€ 0,00
Indirectly fired boiler (1 per house number) incl. central heating connections	0	€ 0,00	0	€ 0,00	0	€ 0,00
Individual Ground Source Heat pump (closed source)	240	€ 5.260.726,08	205	€ 4.493.536,86	0	€ 0,00
HR-107 combiketel	0	€ 0,00	0	€ 0,00	0	€ 0,00
PV-panelen monokristallijn (225Wp/m², 435Wp/paneel)	0	€ 0,00	0	€ 0,00	0	€ 0,00
Total estimate cost excl. VAT		**€ 5.260.726**		**€ 4.493.537**		**€ 3.917.833**
Total estimate cost incl. VAT spread over 15 years		**€ 424.365**		**€ 362.479**		**€ 316.038**

Overview costs

Total overview			
	GHP individual (Calslaan)	**GHP individual (Campuslaan)**	**GHP collective**
Energy charges incl. (incl. VAT)	**€ 77.710**	**€ 75.600**	**€ 172.030**
Total before maintenance and replacement (incl. VAT)	**€ 76.960**	**€ 67.640**	**€ 145.350**
Total before investment costs for heat generation (1/15th part) (incl. VAT)	**€ 424.370**	**€ 362.480**	**€ 316.040**
Total investment cost (incl. BTW)	**€ 5.260.730**	**€ 4.493.540**	**€ 3.917.840**
Total simplified TCO costs per year	**€ 579.040**	**€ 505.720**	**€ 633.420**

Data analysis: formula

$$\text{Total cost of ownership } (TCO) = \frac{initial\ investmen\ cost}{15} + Operational\ cost + energy\ cost$$

Data analysis – formula + data

Database: Koste kerngetallen | RVO

ARCADIS

Database

Rijksdienst voor Ondernemend Nederland

Interal document: VIAC instalation advisors *
Consumere price index (CPI)

VIAC x CPI

Interal document: Document: Provisional energy tariffs 2024 *
Calculation software: vabi

VIAC x vabi

Total cost of ownership (TCO) = Initial investment costs / 15 years + Operational expenses + Energy cost

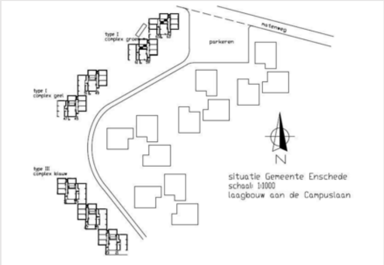
Research findings

The case – Campus UT Enschede

Calslaan Oud

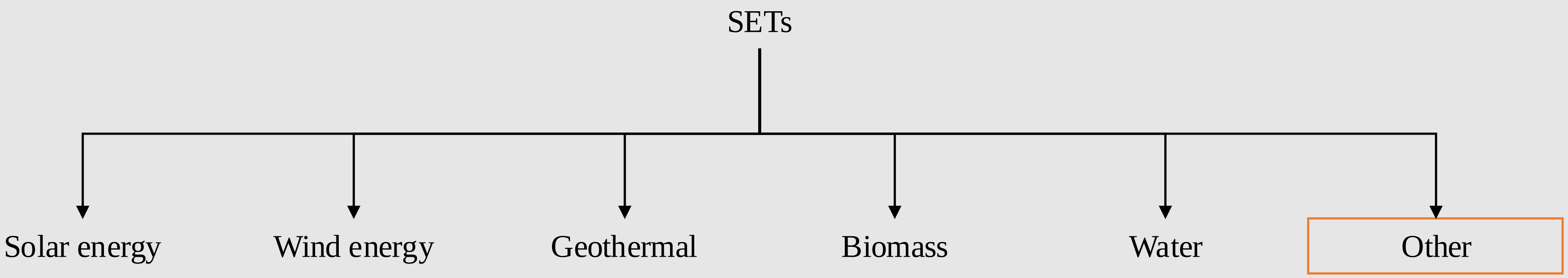
Name	Gaslaan Oud
Number	7 buildings (total 240 rooms)
Addresses	Calslaan 1t/m 13 (3 groups per building +1 penthouse)
Surface	23 square metres
Heat demand	45-90 kWh/m2
Total	248400 - 496800 kWh

Campus Avenue High



Name	Campuslaan hoog
Number	3 buildings (total 205 rooms)
Addresses	Campus Avenue 21-21, 45-51, 59-65
Surface	22 square metres
Heat demand	45 kWh/m2
Total	202950 kWh

SETs sources out of the theory



Sustainable Energy Technologies (SETs) sources. Adapted from: Beccali et al, 1998; Krukanont & Tezuka, 2007; Dicorato et al, 2008; Tsoutsos et al, 2009

SETs longlist

SQ 1: What sustainable energy technologies (SETS) can be used in the housing sector for individual and collective purposes?

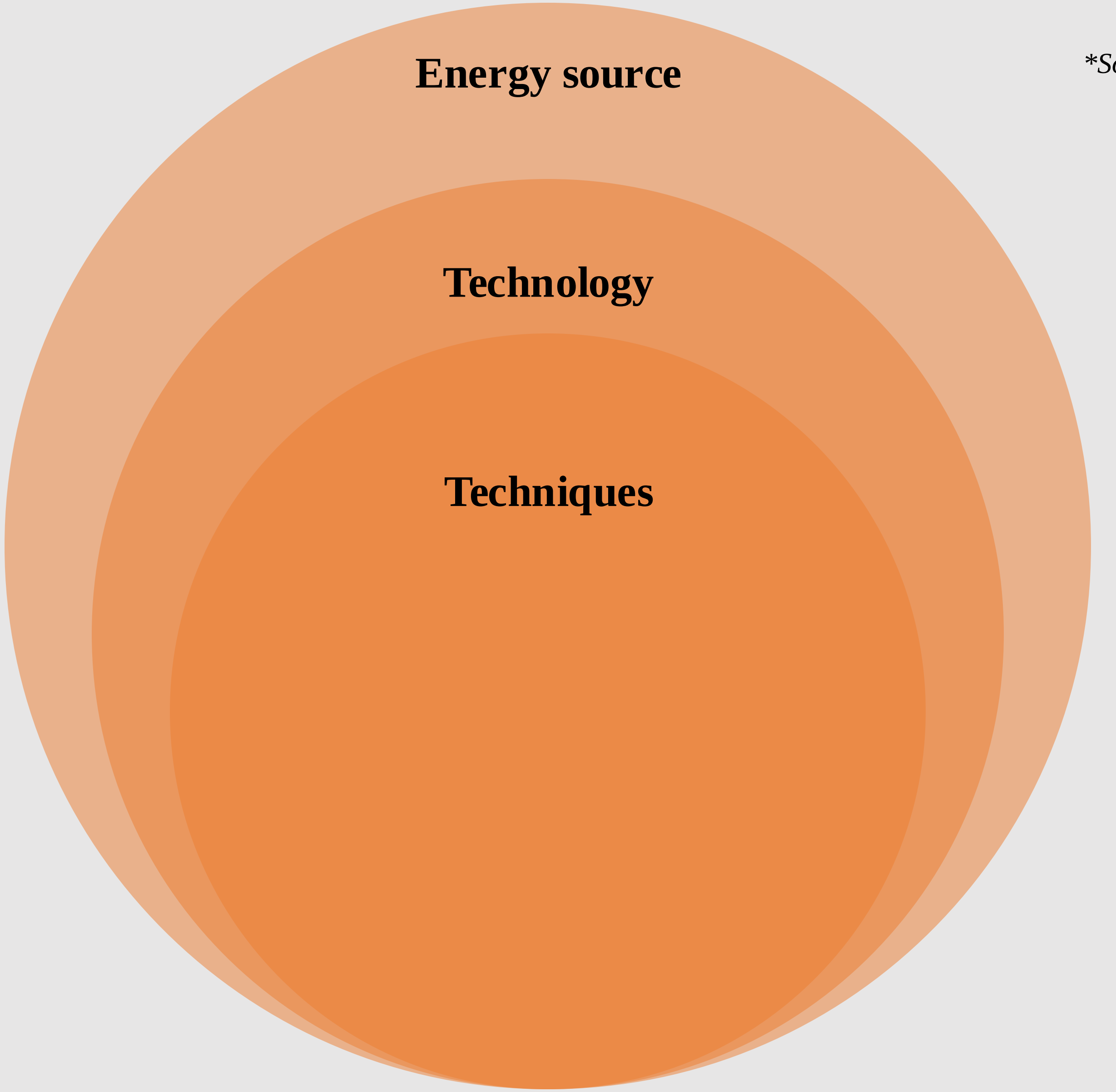
Individual Sustainable Energy Technologies (SETS)

Energy source	Technology	Techniques	Energy carrier
Solar energy	Photovoltaics (PV)	• Monocrystalline solar panels: Use single-crystal silicon for high efficiency. • Polycrystalline solar panels: Made from multiple silicon crystals, are less efficient but cheaper. • Thin-film solar panels: Use layers of semiconductor materials applied to a substrate, offering a flexible solution with varying efficiencies. • Building-integrated photovoltaics (BIPV): Incorporate PV materials into building structures, like windows or facades.	Electricity
	Solar water heating systems	• Flat-plate collectors: Insulated, weatherproofed boxes containing a dark absorber plate under one or more transparent or translucent covers. • Evacuated tube collectors: Use transparent tubes that encase absorber plates, providing insulation and higher efficiencies. • Thermosiphon systems: Utilize the tendency of water to circulate as it is heated, without the need for pumps.	Heat
Wind energy	Wind turbines (small-scale) / Horizontal-axis wind turbines (HAWTs)	• Pitch control: Adjusting the angle of the blades to control the rotor speed. • Yaw control: Rotating the turbine around a vertical axis to align with the wind direction. • Active stall control: Adjusting the blade pitch to reduce the aerodynamic force on the blade.	Electricity
	Vertical-axis wind turbines (VAWTs)		Electricity
Geothermal	Open-loop WKO systems	• Direct use systems: Use the geothermal water directly for heating without a heat pump. • Ground source heat pumps: Use the stable ground temperature to heat in winter and cool in summer.	Heat
	Closed-loop WKO systems		Heat
Biomass	Biomass boilers	• Combustion: Burning biomass to heat water and create steam for turbines or heating. • Gasification: Converting biomass into a combustible gas mixture for more efficient energy recovery. • Anaerobic digestion: Breaking down biomass in the absence of oxygen to produce biogas.	Electricity
Water	Micro-hydro power systems	• Impulse turbines: Use the velocity of water to move the turbine and are used in high head, low flow situations. • Reaction turbines: Use the pressure of water to generate energy and are typically used in low head, high flow settings.	Electricity
Other	Air-to-Air heat pump	• Air-Source Heat Pumps: extract heat from the outdoor air using a refrigerant cycle and transfer it indoors to provide space heating. They can also be reversed to provide cooling during warmer seasons.	Heat
	Air-to-Water heat pump	• Air-source heat pumps: Extract heat from the outdoor air and transfer it indoors for space heating. • Water heating: Utilize heat from the outdoor air to heat water for domestic use. • Defrosting mechanisms: Implement systems to prevent frost buildup on outdoor coils during cold weather.	Heat

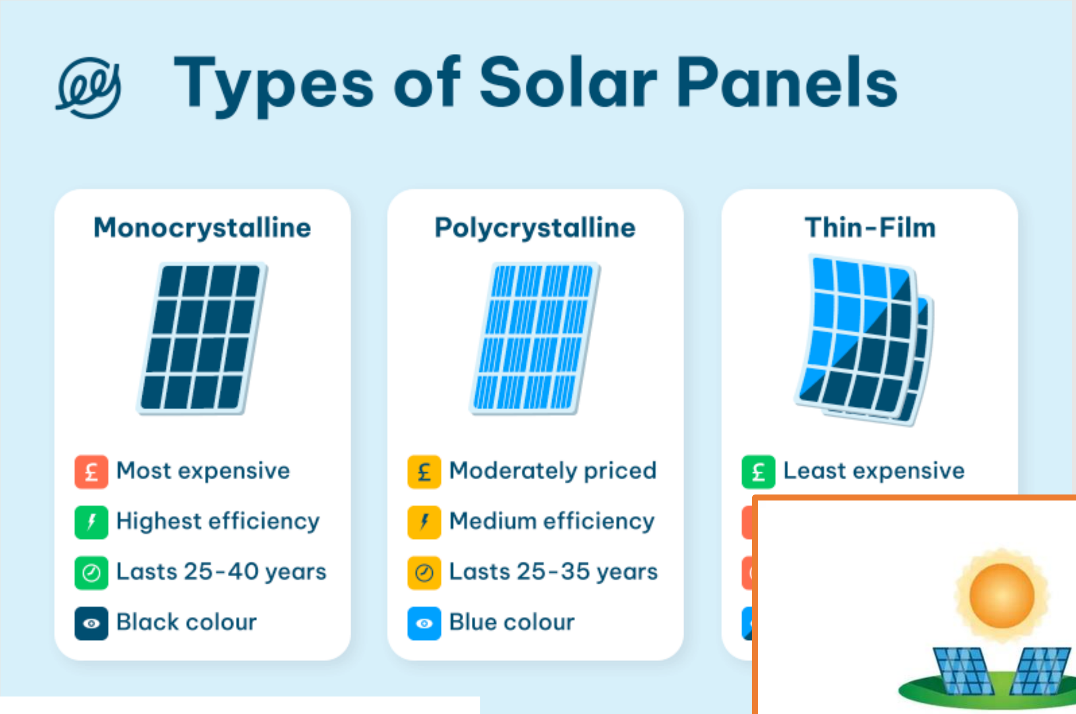
Collective Sustainable Energy Technologies (SETS)

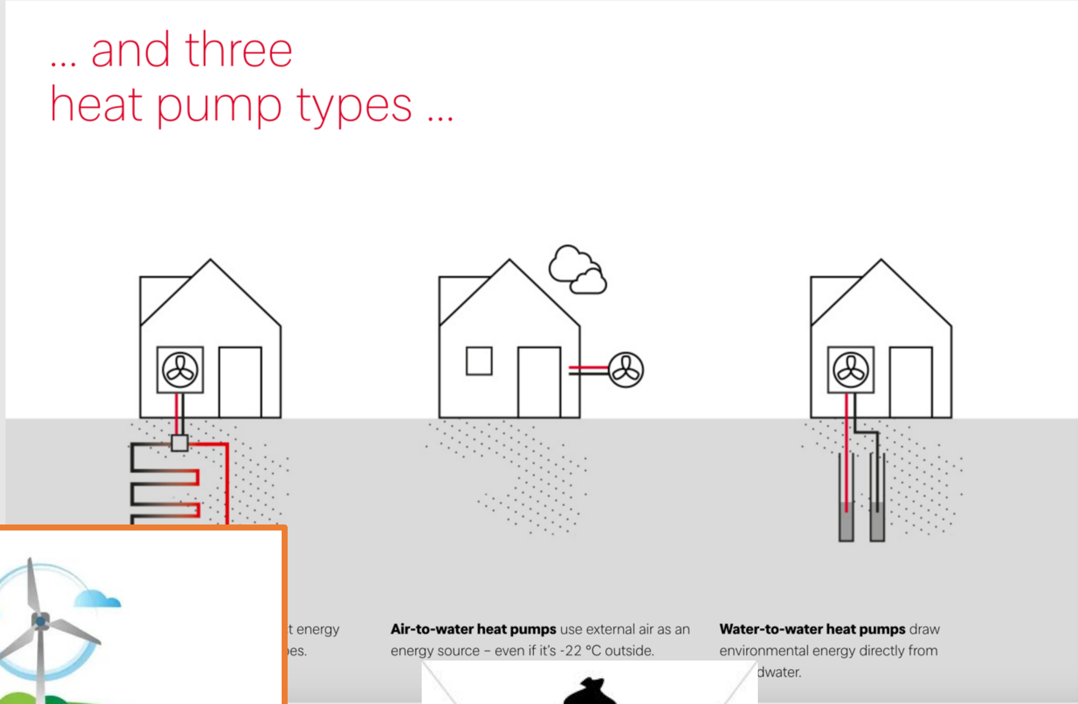
Energy source	Technology	Techniques	Energy carrier
Solar energy	Concentrated Solar Power (CSP)	• Parabolic troughs: Use parabolic mirrors to focus sunlight on a receiver tube. • Solar power towers: Use a field of mirrors that track the sun and focus light on a central receiver. • Dish Stirling systems: Use parabolic dish mirrors to focus light on a Stirling engine for power generation.	Electricity
	Community solar projects/ Photovoltaics (PV)	• Net metering: Allows community members to feed excess energy into the grid and receive credit. • Virtual net metering: Participants receive bill credits for their share of the power produced.	Electricity
Wind energy	Community wind farms/ Horizontal-axis wind turbines (HAWTs)	• Pitch control: Adjusting the angle of the blades to control the rotor speed. • Yaw control: Rotating the turbine around a vertical axis to align with the wind direction. • Active stall control: Adjusting the blade pitch to reduce the aerodynamic force on the blade.	Electricity
	Community wind farms/ Vertical-axis wind turbines (VAWTs)		Electricity
Geothermal	Geothermal power plants	• Dry steam plants: Directly use steam from geothermal reservoirs to turn turbines. • Flash steam plants: Lower the pressure of hot water to create steam for turbines. • Binary cycle power plants: Use the heat from geothermal water to vaporize a secondary fluid with a lower boiling point to turn turbines.	Electricity
	Open-loop WKO systems	• Direct use systems: Use the geothermal water directly for heating without a heat pump. • Ground source heat pumps: Use the stable ground temperature to heat in winter and cool in summer.	Heat
	Closed-loop WKO systems		Heat
Biomass	Biomass power plants	• Pyrolysis: Heating biomass in the absence of oxygen to produce bio-oil for energy.	Electricity
Water	Conventional hydropower	• Kaplan turbines: Adjustable blades for variable flow conditions, often used in run-of-river installations. • Francis turbines: Used in a wide range of head and flow conditions, common in conventional hydropower.	Electricity
	Run-of-river hydropower		Electricity
	Wave energy	• Oscillating water columns: Use air displacement by wave-driven water in a column to drive turbines. • Point absorbers: Float on the surface and absorb energy from all directions.	Electricity
	Ocean thermal energy conversion (OTEC)	• Closed-cycle OTEC: Uses warm surface water to vaporize a working fluid, which drives a turbine to generate electricity. • Open-cycle OTEC: Vaporizes seawater itself to drive the turbine. • Hybrid systems: Combine both closed and open cycles for increased efficiency.	Electricity
	Tidal power	• Barrage systems: Use dams to capture the potential energy from the rise and fall of tides. • Tidal stream generators: Underwater turbines that capture kinetic energy from tidal currents.	Electricity
Other	District heating (stadverwarming) (Sustainability depends on the source of heat)	• Combined heat and power (CHP): Simultaneous production of electricity and useful heat, improving overall efficiency. • Heat networks: Distribute heat generated from various sources to multiple buildings.	Heat

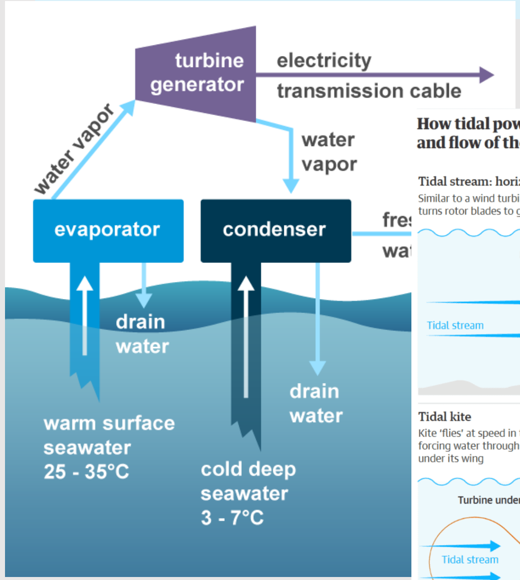
individual and collective SETs. Source: Own table

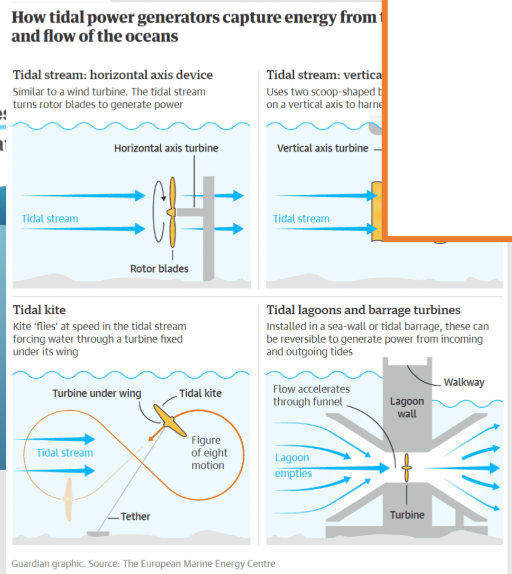


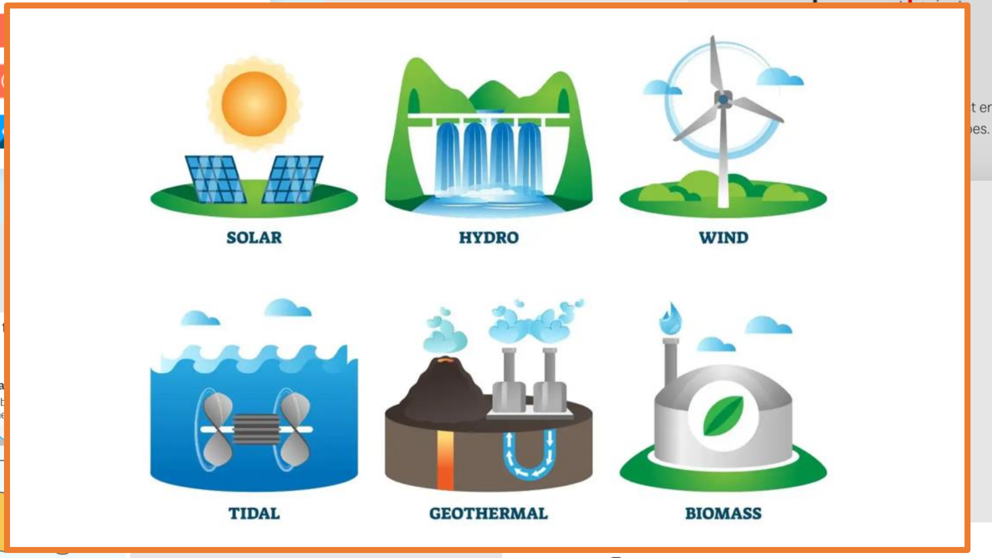
**Some genarete heat others genarete energy*

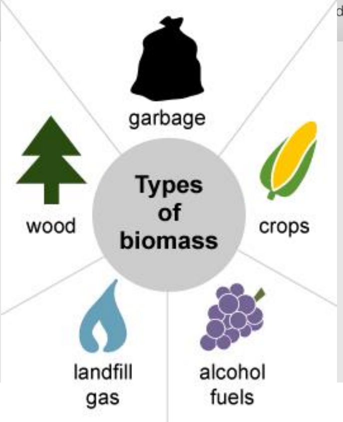

Types of Solar Panels
Monocrystalline
Most expensive
Highest efficiency
Lasts 25-40 years
Black colour
Polycrystalline
Moderately priced
Medium efficiency
Lasts 25-35 years
Blue colour
Thin-Film
Least expensive

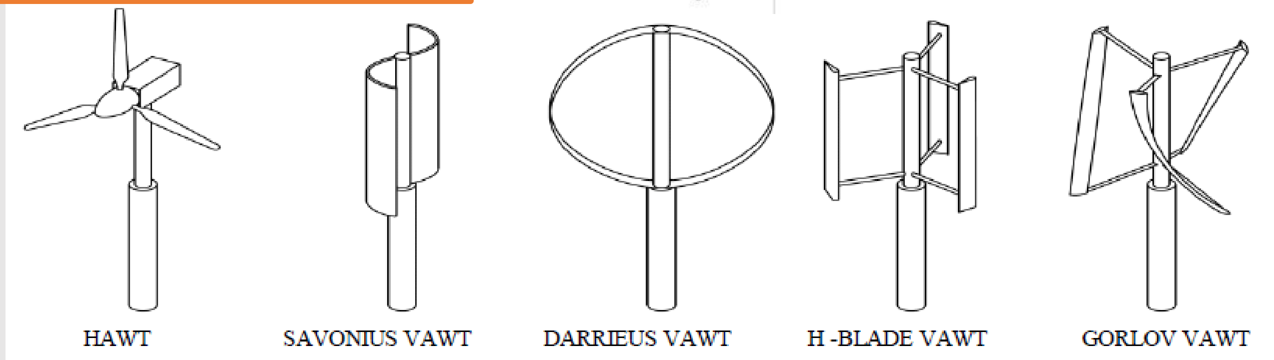

... and three
heat pump types ...
Air-to-water heat pumps use external air as an energy source – even if it's -22 °C outside.
Water-to-water heat pumps draw environmental energy directly from


turbine generator
electricity
transmission cable
water vapor
water vapor
evaporator
condenser
drain water
drain water
warm surface seawater 25 - 35°C
cold deep seawater 3 - 7°C


How tidal power generators capture energy from
and flow of the oceans
Tidal stream: horizontal axis device
Similar to a wind turbine. The tidal stream turns rotor blades to generate power
Horizontal axis turbine
Tidal stream
Rotor blades
Tidal stream: vertica
Vertical axis turbine
Tidal stream
Tidal kite
Kite 'flies' at speed in the tidal stream forcing water through a turbine fixed under its wing
Turbine under wing
Tidal kite
Tidal stream
Figure of eight motion
Tether
Tidal lagoons and barrage turbines
Installed in a sea-wall or tidal barrage, these can be reversible to generate power from incoming and outgoing tides
Walkway
Flow accelerates through funnel
Lagoon wall
Lagoon empties
Turbine
Guardian graphic. Source: The European Marine Energy Centre


SOLAR
HYDRO
WIND
TIDAL
GEOTHERMAL
BIOMASS


garbage
wood
Types of biomass
crops
landfill gas
alcohol fuels


HAWT
SAVONIUS VAWT
DARRIEUS VAWT
H -BLADE VAWT
GORLOV VAWT

Sub question 1

SQ 1: What sustainable energy technologies (SETS) can be used in the housing sector for individual and collective purposes?

Deepening the technology	Energy source → technologies → Techniques
	Energy carrier: Saving vs generating
Versatility	SETs offer diverse avenues for energy production, catering to different needs and contexts within the housing sector.
Integration	Combining multiple SETs in hybrid energy systems enhances reliability, efficiency, and resilience.
Innovation	Ongoing advancements in technology continue to enrich the sustainable energy landscape, offering novel solutions for future housing projects.

Evaluation criteria for sustainable energy planning

SQ2: What factors determine whether individual or collective Sustainable Energy Technologies (SETS) should be implemented in housing?

Indicator	Criteria
Technical	Energy Production Capacity
	Technological Maturity
	Reliability
	Safety
Economical	Investment Cost
	Operation and Maintenance Cost
	Service Life
	Payback Period
Environmental	Impact on Ecosystem
	CO_2 Emission
Social	Social Benefits
	Social Acceptability
Legal & regulations	

List of evaluation criteria for sustainable energy planning. Adapted from: Demirtas (2013)

limitations and considerations

Technical Limitations:

- Integration of SETs into existing buildings
- Diverse building structures - orentitation

Economic Considerations:

- Upfront costs vs long-term benefits (and ownership)
- Uncertainties in energy prices

Environmental Implications:

- SET production and transportation
- End-of-life management
- Land use considerations

Social and Cultural Factors:

- Resistance to change
- aesthetic, noise concerns

Regulation and Legal Factors:

- Regulatory frameworks
- Contractual agreements for collective approach

Source: Ellabban et al., 2014; Piacentino et al., 2019; Turkenburg et al., 2000; Wang et al., 2009

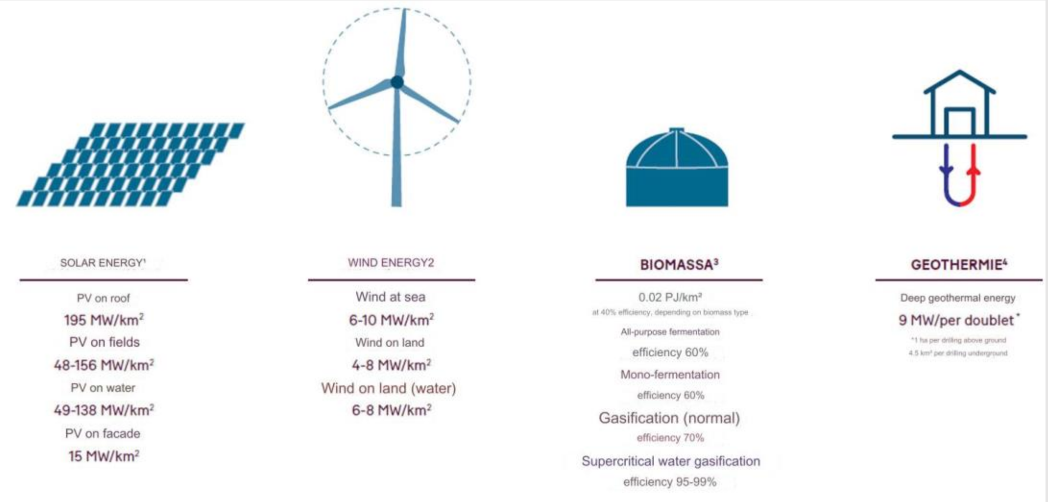
limitations and considerations

Technical Limitations:

- Integration of SETs into existing buildings
- Diverse building structures - orentitation

Compass Bearing

Roof Pitch (degrees)	-90 East	-75	-60	-45	-30	-15	0 South	15	30	45	60	75	90 West
Vertical 90	56	60	64	67	69	71	71	71	71	69	65	62	58
80	63	68	72	75	77	79	80	80	79	77	74	69	65
70	69	74	78	82	85	86	87	87	86	84	80	76	70
60	74	79	84	87	90	91	93	93	92	89	86	81	76
50	78	84	88	92	95	96	97	97	96	93	89	85	80
40	82	86	90	95	97	99	100	99	98	96	92	88	84
30	86	89	93	96	98	99	100	100	98	96	94	90	86
20	87	90	93	96	97	98	98	98	97	96	94	91	88
10	89	91	92	94	95	95	96	95	95	94	93	91	90
Flat 0	90	90	90	90	90	90	90	90	90	90	90	90	90



Source: https://www.bjmgerard.nl/category/energie-en-klimaat/energie/windenergie/page/3/

limitations and considerations

Economic Considerations:

- Upfront costs vs long-term benefits (and ownership)
- Uncertainties in energy prices

Waar ben je naar op zoek?

Consumentenbond

Producttests Geldzaken Juridisch Advies Alle thema's

Home > Nieuws

Consumenten dreigen door kabinetsplannen massaal af te haken van zonne-energie

Nieuws | Het wetsvoorstel 'beëindiging van de salderingsregeling' dat het kabinet op Prinsjesdag presenteerde, zit vol onzekerheden voor zonnepaneelhouders. Het zorgt er bovendien voor dat consumenten massaal afhaken van zonne-energie. De Consumentenbond roept Kamerleden op om bij behandeling van het voorstel, tegen te stemmen.

Joyce Donat Woordvoerder
Gepubliceerd op: 17 september 2024

Consumers at risk of dropping out of solar power due to cabinet plans

Net binnen Algemeen Economie Sport Media en Cultuur Achterklap Shop

Grote ingreep tegen overbelasting stroomnet: meer gas en pauzeren laadpalen

Door Thijs Rösken

25 apr 2024 om 13:11
Update: 5 maanden geleden

1.7K reacties Delen

Het demissionaire kabinet en netbeheerders komen met maatregelen om overbelasting van het stroomnet in de provincie Utrecht tegen te gaan. Opvallend is dat het gebruik van gas niet wordt geschuwd. Verder moeten slimme laadpalen uitschakelen tijdens piekmomenten.

Major intervention against power grid overload: more gas and pause charging stations

Source: https://www.consumentenbond.nl/nieuws/2024/consumenten-dreigen-door-kabinetsplannen-massaal-af-te-haken-van-zonne-energie
https://www.nu.nl/economie/6310462/grote-ingreep-tegen-overbelasting-stroomnet-meer-gas-en-pauzeren-laadpalen.html

limitations and considerations

Environmental Implications:

- SET production and transportation
- End-of-life management
- Land use considerations

Figure 1.27 ⊳ Demand for critical minerals for selected clean electricity supply and electrification technologies in the APS, 2022 and 2030

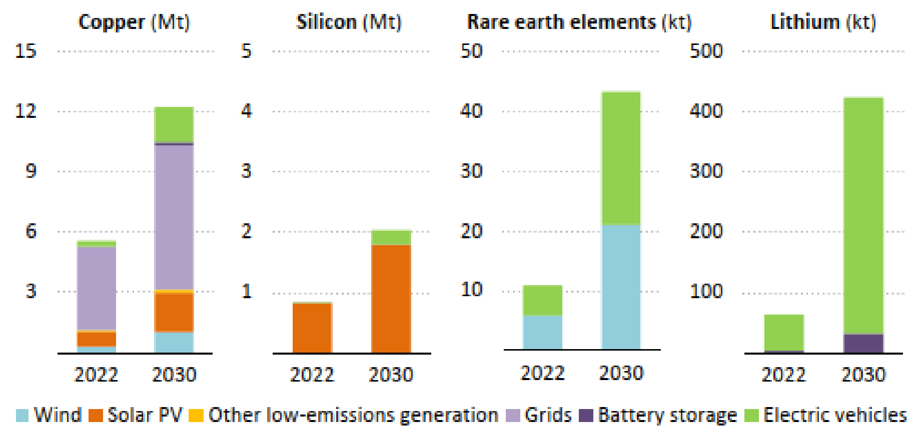


Table 1.1 ⊳ Primary risks associated with key clean electrification technologies

	Wind	Solar PV	Nuclear	Battery storage	Demand response	Grids	Electric vehicles	Heat pumps
Regulatory and policy risks								
Regulatory frameworks	Medium	Low	Medium	Medium	High	Medium	Medium	Medium
Policy support	Low	Low	Medium	Low	High	Low	Low	Low
Permitting and certification	Medium	Medium	High	Low	Low	High	Medium	Low
Supply chain risks								
Critical minerals	High	Medium	Low	High	Low	Medium	High	Low
Manufacturing	High	Low	Medium	Medium	Low	Low	Low	Medium
Skilled labour	Medium	Medium	High	Low	Low	High	Low	Medium
Financial risks								
Costs of financing	High	Medium	High	Medium	Low	High	Medium	Medium
Revenue and savings predictability	Medium	Low	Low	Medium	Medium	Low	Low	Low
Overall risks	High	Low	Medium	Medium	Medium	High	Low	Medium

Note: Grids refers to electricity networks, including transmission and distribution.

Source: International Energy Agency | World Energy Outlook 2023

limitations and considerations

Social and Cultural Factors:

- Resistance to change
- aesthetic, noise concerns

NIEUWS REGIO SPORT SHOW PLAY PODCAST PUZZEL ABONNEREN INLOGGEN

Binnenland Buitenland Politiek Economie Bizar Wetenschap Reizen Opinie Quiz

PREMIUM

Erik Roelofsen meet het geluid bij een willekeurige warmtepomp. © Henri van der Beek

Warmtepompen leiden tot burenruzies: 'Die goedkope uit Aziatische landen maken meestal meer herrie'

Het geluid van warmtepompen leidt regelmatig tot ernstige burenruzies. De afgelopen jaren zijn er al tientallen rechtszaken over gevoerd. Slechte installaties blijken de boosdoener. „Een warmtepomp is geen dingetje dat je bij AliExpress koopt en door Beun de Haas laat installeren."

JE BENT NIET (MEER) INGELOGD

LOG IN OF MAAK BINNEN 1 MINUUT EEN ACCOUNT AAN

NET BINNEN

- 11:37 PREMIUM Deze arts is er speciaal voor toeristen: opvallend genoeg zijn het niet d...
- 11:25 'Nazi-tweet', opruiing en 'haatvideo': Forum voor Democratie is vooral in de...
- 11:00 Jonge gamers zijn er wild van: een 'ouderwetse' papieren krant maken
- 09:47 Pro-Palestijnse demonstranten blokkeren ingang Universiteit Utrecht,...
- 09:41 Duitse politie grijpt in bij vechtsportevenement met Nederlandse...

BEKIJK MEER ARTIKELEN

HET WOORD

Speel hier gratis puzzels, quizzen en spelletjes

MEEST GELEZEN

Heat pumps lead to neighbour quarrels: 'Those cheap ones from Asian countries usually make more noise'

NIEUWS REGIO SPORT SHOW PLAY PODCAST PUZZEL ABONNEREN INLOGGEN

Wijzig Nieuwkoop ▸ Net Binnen 112 nieuws Van de lezer Uit-tips Eten en drinken Regiosport Aanbiedingen Vacatures

Op meerdere plekken in het land zijn inmiddels zonnevelden aangelegd. © Caspar Huurdeman

Angst voor brandgevaar en horizonvervuiling: omwonenden tegen zonnepark op voormalige stort

'Geen windpark op de voormalige vuilnisbelt aan de Lange Meentweg in Woerdense Verlaat', dat vinden omwonenden van het stuk land dat is aangewezen als mogelijke locatie voor het opwekken van zonne-energie. De buurt is tegen en heeft de gemeente een petitie aangeboden.

Rik Sneijder 04-10-24, 07:00

LOG IN OF MAAK BINNEN 1 MINUUT EEN ACCOUNT AAN

NET BINNEN

- 10:59 Bladkorven moeten overlast van herfstbladeren voorkomen in Woerden
- 09:00 PREMIUM Zwammerdam nog ongeslagen in derde klasse na gelijkspel...
- 07:02 Weektips: dit is er te doen in Woerden (7 - 10 oktober)
- 06-10 PREMIUM Zuid-Afrikaanse matchwinner, tijdelijke staking en dit...
- 06-10 Dit is hoe de eerste teams uit Nieuwkoop dit weekeinde speelden

BEKIJK MEER ARTIKELEN

KLIK HIER Volg AD Groene Hart op Instagram!

AD WEBWINKEL

SnowWorld Skipas Van €38,50 voor €25,95

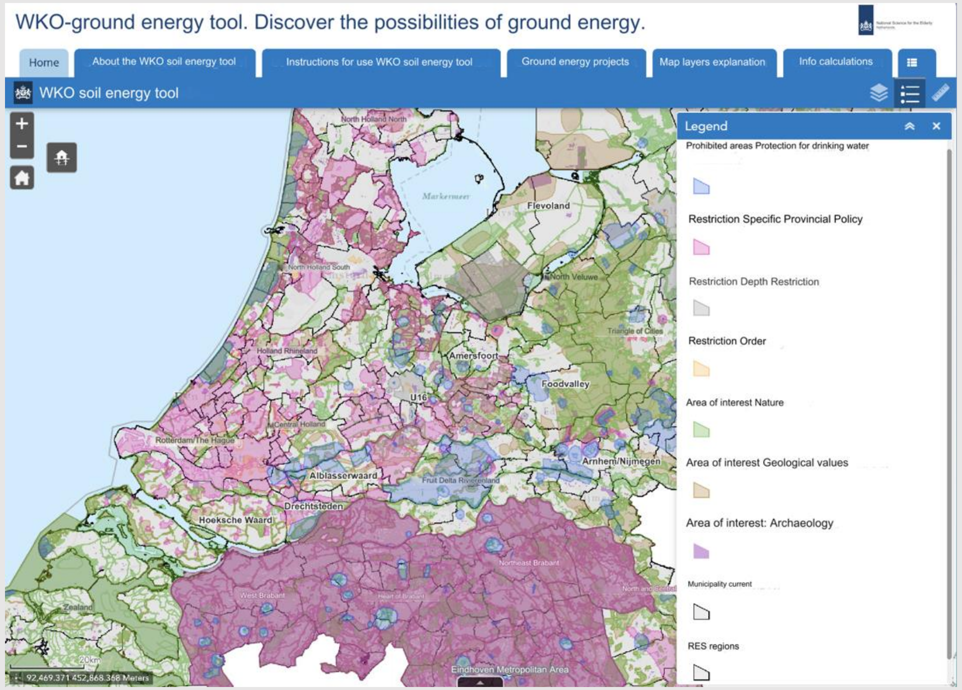
Fears of fire danger and horizon pollution: Local residents against solar farm on former landfill

Source: https://www.ad.nl/binnenland/warmtepompen-leiden-tot-burenruzies-die-goedkope-uit-aziatische-landen-maken-meestal-meer-herrie~a7e5f3c74/

limitations and considerations

Regulation and Legal Factors:

- Regulatory frameworks
- Contractual agreements for collective approach



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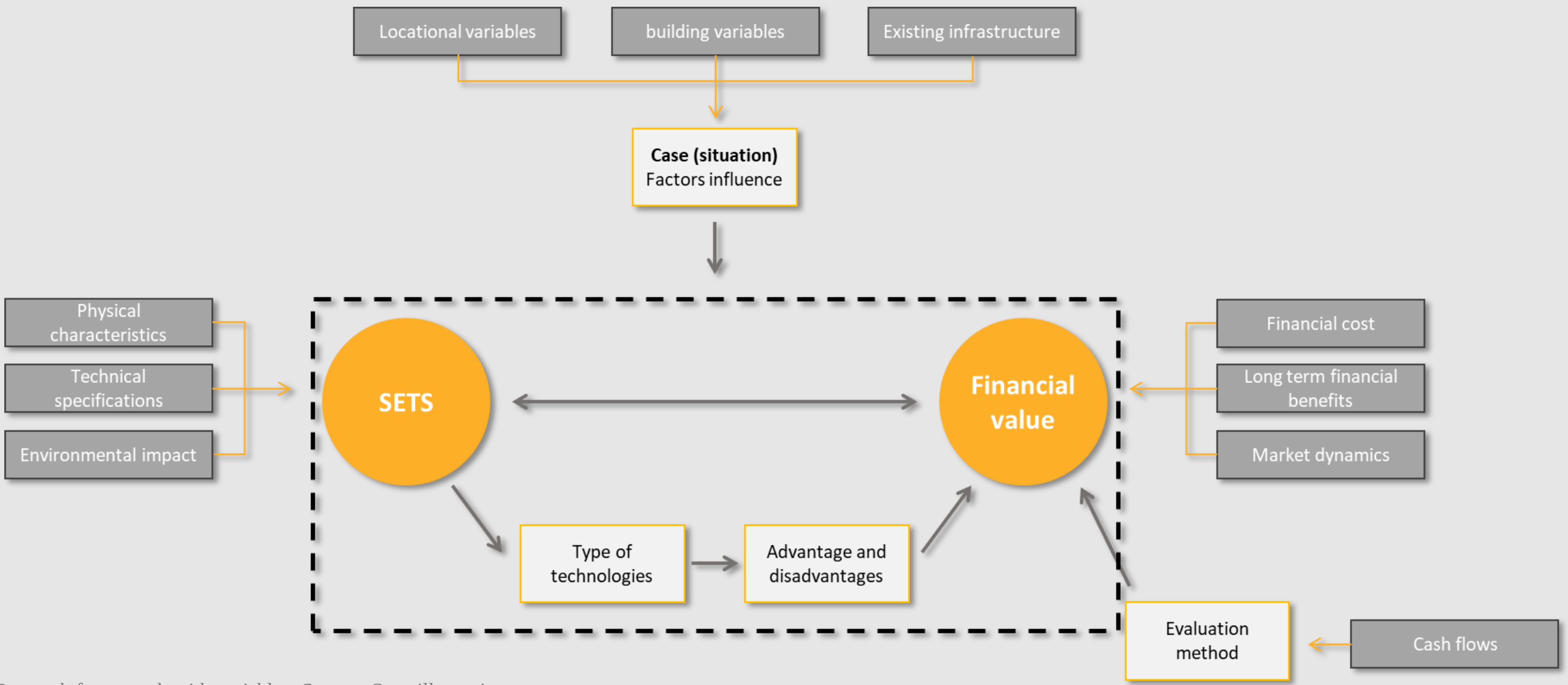
Permitting and certification	Medium	Medium	High	Low	Low	High	Medium	Low

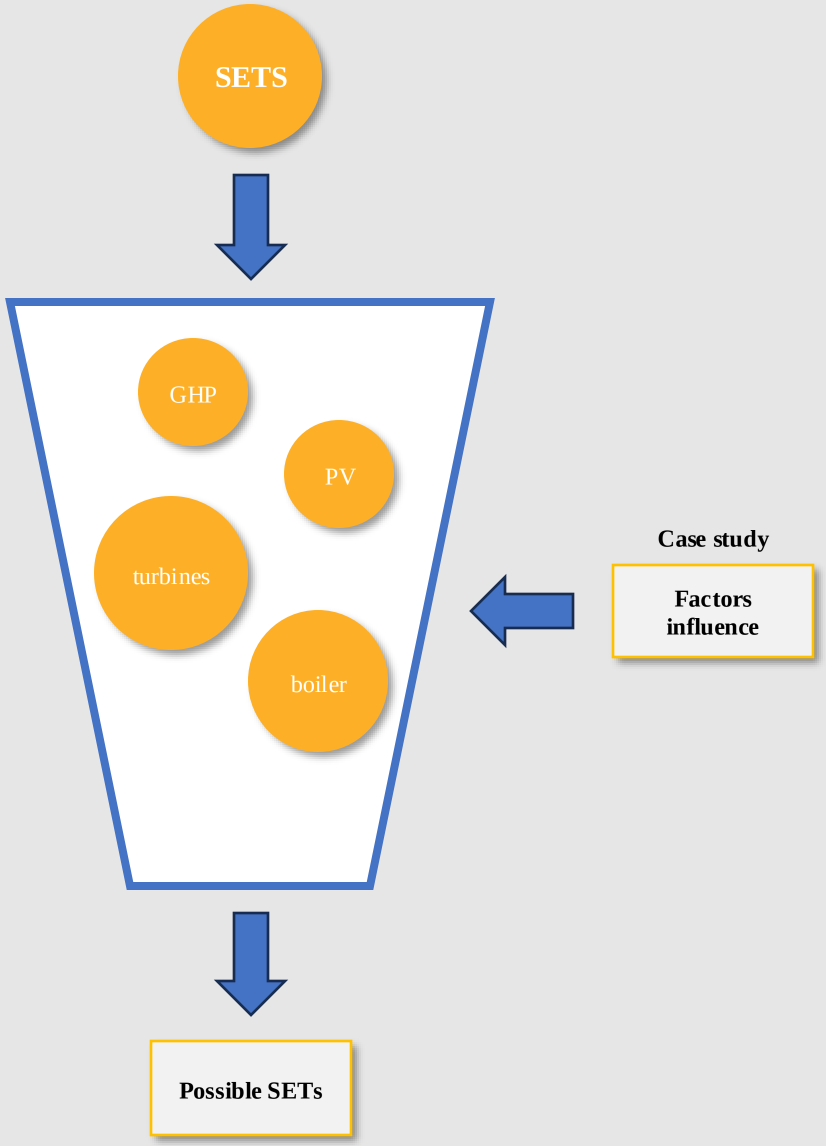
Source: https://wkotool.nl/
International Energy Agency | World Energy Outlook 2023

Factors influencing individual vs. collective



Research framework with variables. Source: Own illustration

From longlist to shortlist



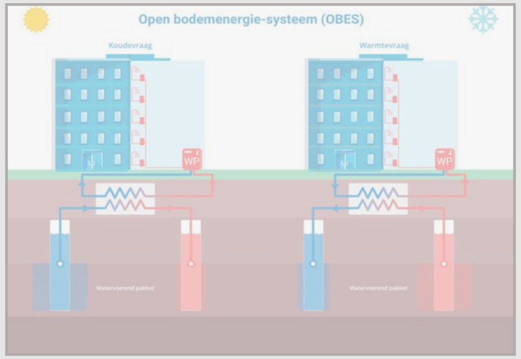
From longlist to shortlist

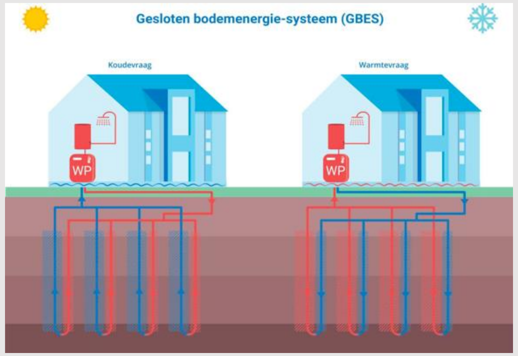
But still for the case is this short list not so short….

Narrowed the scope

- SETs
  - Solar energy
    - Photovolaics (pv)
    - Solar water heating
  - Wind energy
  - Geothermal
    - Open-loop GHP
    - Closed-loop GHP
      - Individual
      - Collective
  - Biomass
  - Water
  - Other

+

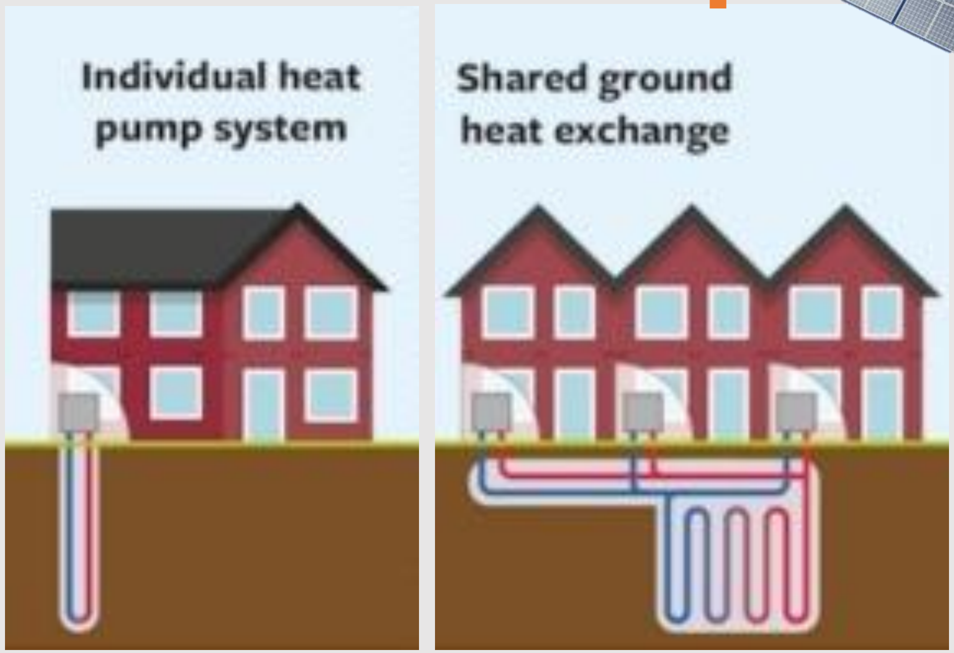


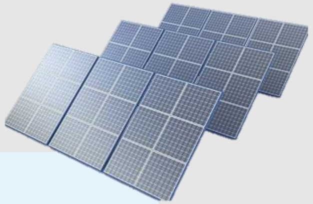


Source: (BodemenergieNederland, 2023).

So for the UT Enschede

$$\text{Total cost of ownership } (TCO) = \frac{initial\ investmen\ cost}{15} + Operational\ cost + energy\ cost$$

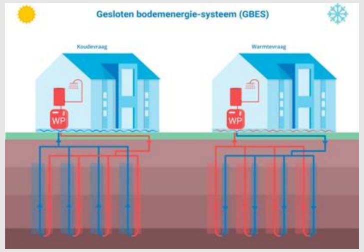




TCO

GHP

	GPD **individual** combined		GHP **collective**
Energy charges incl. (incl. VAT)	€ 153.310		€ 172.020
Total maintenance and replacement (incl. VAT)	€ 144.600		€ 145.350
Total investment costs (1/15th part) (incl. VAT)	€ 786.850		€ 316.040
Total investment cost (incl. BTW)	€ 9.754.270		€ 3.917.840
Total TCO costs per year	**€ 1.084.760**		**€ 633.420**



Renter: Prefer individual lower maintain cost and energy prices

Investor: Prefer collective lower investment cost

Overall: Prefer collective lower total cost of ownership

But what will happen if we added PV panels?

Initial Investment Costs

Operational Expenses

Energy Cost

Total cost of ownership

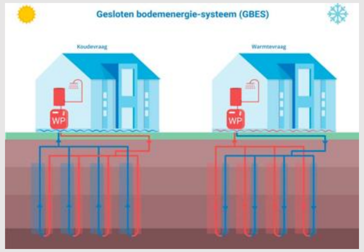
Renter: With or without PV?

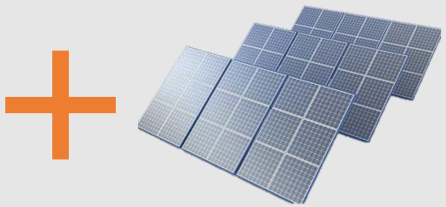
Investors: With or without PV?

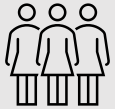
Overall With or without PV?

TCO

	GHP		GHP + PV	
	GPD individual combined	GHP **collective**	GPD **ind** + PV combined	GHP **collective** + PV
Energy charges incl. (incl. VAT)	€ 153.310	€ 172.020	€ 40.770	€ 59.470
Total maintenance and replacement (incl. VAT)	€ 144.600	€ 145.350	€ 148.030	€ 152.350
Total investment costs (1/15th part) (incl. VAT)	€ 786.850	€ 316.040	€ 872.920	€ 420.650
Total investment cost (incl. BTW)	€ 9.754.270	€ 3.917.840	€ 10.821.160	€ 4.987.890
Total TCO costs per year	**€ 1.084.760**	**€ 633.420**	**€ 1.061.720**	**€ 632.490**







Renter: Prefer individual GHP + PV lower energy prices and just bid higher maintain cost

Investor: Prefer collective GHP lower investment cost

Overall: Prefer collective GHP + PV lower total cost of ownership

TCO – per units

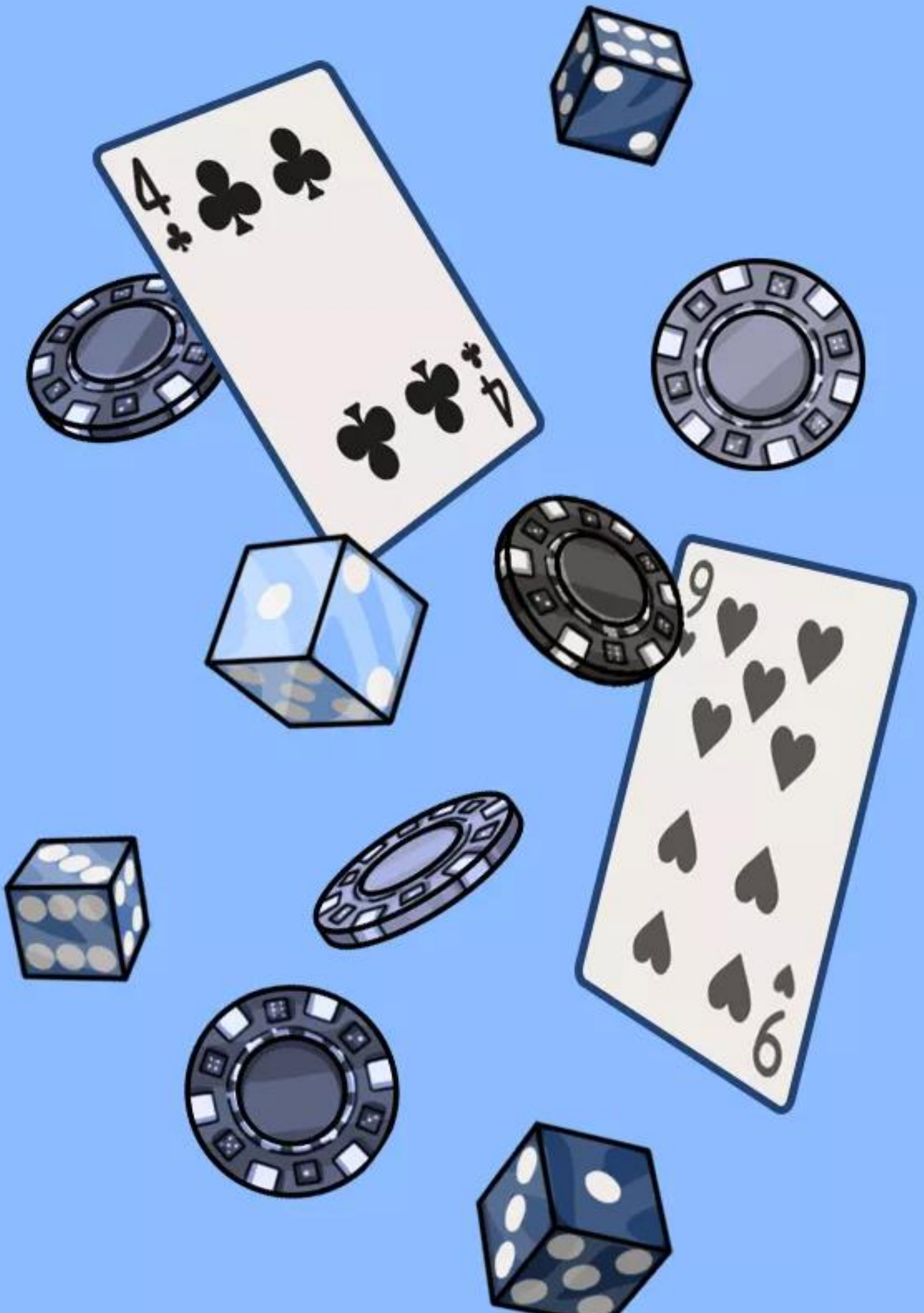
	GHP per unit		GHP + PV per unit	
	GPD individual combined	GHP **collective**	GPD **ind** + PV combined	GHP **collective** + PV
Energy charges incl. (incl. VAT)	€ 345	€ 387	€ 92	€ 134
Total maintenance and replacement (incl. VAT)	€ 325	€ 327	€ 333	€ 342
Total investment costs (1/15th part) (incl. VAT)	€ 1.768	€ 710	€ 1.962	€ 945
Total investment cost (incl. BTW)	€ 21.920	€ 8.804	€ 24.317	€ 11.718
Total TCO costs per year	**€ 2.438**	**€ 1.423**	**€ 2.386**	**€ 1.421**

Monte Carlo Simulation

GHP

	GPD individual combined		GHP collective	
Energy charges incl. (incl. VAT)	€	153.310	€	172.020
Total maintenance and replacement (incl. VAT)	€	144.600	€	145.350
Total investment costs (1/15th part) (incl. VAT)	€	786.850	€	316.040
Total investment cost (incl. BTW)	€	9.754.270	€	3.917.840
Total TCO costs per year	**€**	**1.084.760**	**€**	**633.420**

- **Monte Carlo simulation** added to TCO calculation to model uncertainties in cost parameters.
- 1,000 trials
  - *Energy costs:* Normally distributed, 10% standard deviation, based on model and fixed contract.
  - *Operational costs:* Triangular distribution, variations due to maintenance, service contracts, and unforeseen issues.
  - *Investment costs:* Normally distributed, 10% standard deviation, based on RFO and Arcadis data.
- Outcome: Distribution of potential TCO estimates, providing insight into the probability of different cost projections.



Monte Carlo Simulation

[män-tē ‘kär-‘lō sim-yə-‘lā-shən]

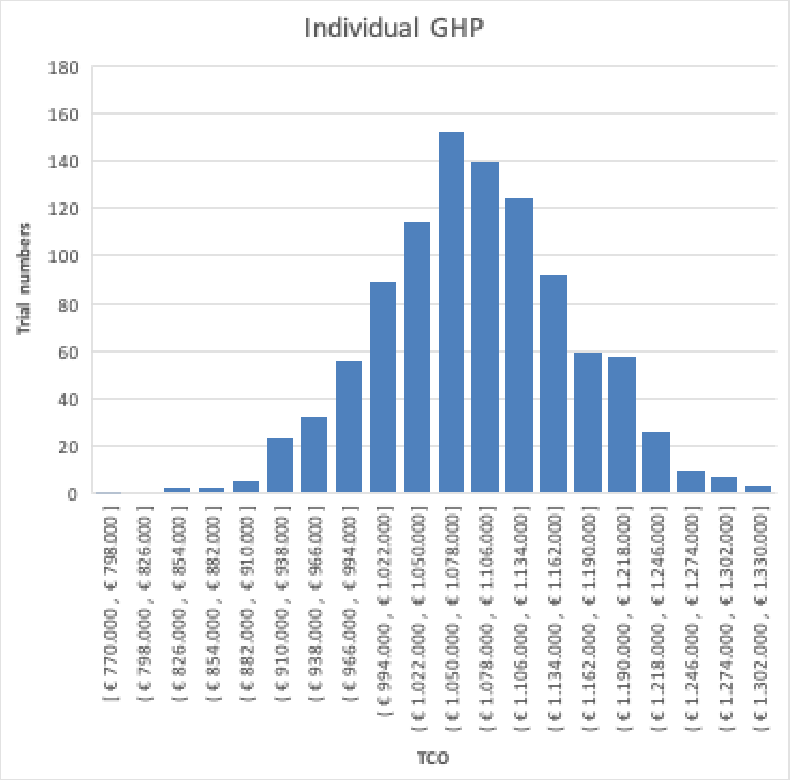
A model used to predict the probability of a variety of outcomes when the potential for random variables is present.

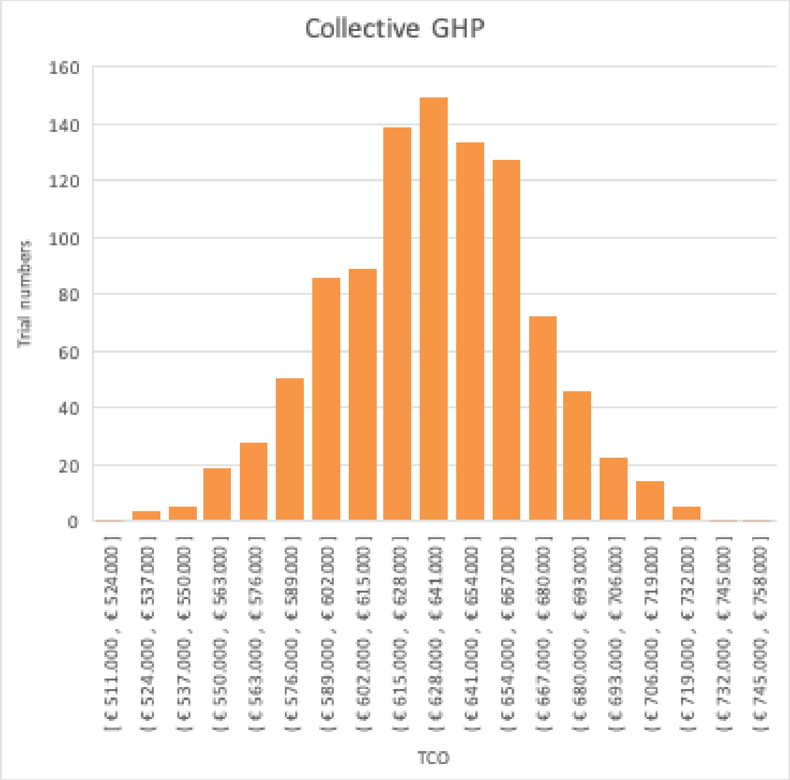
Monte Carlo Simulation

Monte Carlo-simulatie

	Invidueel GHP					Collective GHP				
Trial number	Total energy cost	Total investment cost	Total operational cost	**TCO**	Rounded	Total energy cost	Total investment cost	Total operational cost	**TCO**	Rounded
1	€ 122.787	€ 333.381	€ 133.572	€ **589.740**	€ 590.000	€ 172.656	€ 182.449	€ 143.847	€ **498.952**	€ 499.000
2	€ 170.869	€ 440.580	€ 147.026	€ **758.475**	€ 758.000	€ 158.666	€ 142.270	€ 135.229	€ **436.165**	€ 436.000
3	€ 163.518	€ 384.469	€ 150.744	€ **698.731**	€ 699.000	€ 148.483	€ 136.542	€ 149.402	€ **434.426**	€ 434.000
4	€ 135.103	€ 421.578	€ 145.175	€ **701.856**	€ 702.000	€ 180.505	€ 166.184	€ 140.847	€ **487.536**	€ 488.000
5	€ 148.647	€ 359.849	€ 134.605	€ **643.101**	€ 643.000	€ 145.375	€ 149.982	€ 147.251	€ **442.608**	€ 443.000
6	€ 138.309	€ 463.535	€ 135.560	€ **737.404**	€ 737.000	€ 154.792	€ 159.728	€ 149.862	€ **464.382**	€ 464.000
7	€ 200.444	€ 412.718	€ 135.939	€ **749.101**	€ 749.000	€ 163.185	€ 137.621	€ 148.450	€ **449.257**	€ 449.000
8	€ 131.780	€ 360.480	€ 152.851	€ **645.111**	€ 645.000	€ 168.104	€ 148.769	€ 146.473	€ **463.346**	€ 463.000
9	€ 160.900	€ 346.251	€ 149.923	€ **657.073**	€ 657.000	€ 167.173	€ 148.804	€ 148.958	€ **464.935**	€ 465.000
10	€ 187.238	€ 359.466	€ 139.350	€ **686.053**	€ 686.000	€ 155.490	€ 182.578	€ 151.390	€ **489.458**	€ 489.000
11	€ 184.383	€ 377.097	€ 153.207	€ **714.686**	€ 715.000	€ 174.781	€ 163.153	€ 134.859	€ **472.793**	€ 473.000
12	€ 155.942	€ 438.323	€ 147.660	€ **741.925**	€ 742.000	€ 168.453	€ 171.166	€ 144.480	€ **484.099**	€ 484.000
13	€ 130.784	€ 419.766	€ 149.225	€ **699.775**	€ 700.000	€ 185.640	€ 143.348	€ 143.424	€ **472.413**	€ 472.000
14	€ 159.644	€ 361.955	€ 125.394	€ **646.993**	€ 647.000	€ 156.732	€ 196.178	€ 144.948	€ **497.857**	€ 498.000
15	€ 121.666	€ 355.498	€ 148.521	€ **625.685**	€ 626.000	€ 199.636	€ 143.540	€ 150.482	€ **493.658**	€ 494.000
16	€ 152.221	€ 378.512	€ 144.037	€ **674.770**	€ 675.000	€ 194.821	€ 141.154	€ 143.850	€ **479.825**	€ 480.000
17	€ 130.679	€ 372.443	€ 136.174	€ **639.296**	€ 639.000	€ 151.580	€ 138.081	€ 145.233	€ **434.894**	€ 435.000
18	€ 170.259	€ 386.021	€ 149.467	€ **705.747**	€ 706.000	€ 152.469	€ 171.007	€ 139.151	€ **462.627**	€ 463.000
19	€ 121.129	€ 329.923	€ 149.672	€ **600.724**	€ 601.000	€ 193.240	€ 145.026	€ 139.077	€ **477.343**	€ 477.000
20	€ 141.708	€ 448.737	€ 144.171	€ **734.616**	€ 735.000	€ 154.851	€ 147.180	€ 142.118	€ **444.148**	€ 444.000
21	€ 160.102	€ 308.064	€ 145.796	€ **613.961**	€ 614.000	€ 197.183	€ 164.061	€ 141.382	€ **502.627**	€ 503.000
22	€ 153.502	€ 368.210	€ 138.140	€ **659.852**	€ 660.000	€ 180.951	€ 143.124	€ 144.681	€ **468.755**	€ 469.000
23	€ 133.216	€ 416.385	€ 140.771	€ **690.372**	€ 690.000	€ 206.642	€ 148.578	€ 149.124	€ **504.344**	€ 504.000
24	€ 148.799	€ 502.511	€ 133.887	€ **785.197**	€ 785.000	€ 196.037	€ 142.832	€ 139.937	€ **478.807**	€ 479.000
25	€ 140.636	€ 433.746	€ 139.717	€ **714.099**	€ 714.000	€ 170.174	€ 131.370	€ 145.365	€ **446.909**	€ 447.000
26	€ 184.878	€ 378.317	€ 144.519	€ **707.714**	€ 708.000	€ 142.646	€ 134.832	€ 151.262	€ **428.740**	€ 429.000
27	€ 170.556	€ 426.784	€ 126.732	€ **724.073**	€ 724.000	€ 176.686	€ 149.642	€ 145.142	€ **471.470**	€ 471.000
28	€ 139.538	€ 388.928	€ 135.526	€ **663.992**	€ 664.000	€ 144.878	€ 143.637	€ 149.998	€ **438.513**	€ 439.000
29	€ 180.004	€ 403.985	€ 151.706	€ **735.695**	€ 736.000	€ 175.598	€ 158.832	€ 143.074	€ **477.504**	€ 478.000
30	€ 160.816	€ 456.384	€ 136.725	€ **753.925**	€ 754.000	€ 151.595	€ 151.836	€ 145.456	€ **448.887**	€ 449.000
31	€ 151.134	€ 332.306	€ 157.385	€ **640.825**	€ 641.000	€ 192.437	€ 152.686	€ 147.877	€ **493.001**	€ 493.000
32	€ 163.409	€ 326.676	€ 139.420	€ **629.505**	€ 630.000	€ 137.126	€ 175.231	€ 138.567	€ **450.924**	€ 451.000
33	€ 150.615	€ 428.545	€ 142.649	€ **721.809**	€ 722.000	€ 178.390	€ 183.833	€ 138.191	€ **500.415**	€ 500.000
34	€ 161.353	€ 399.159	€ 147.396	€ **707.907**	€ 708.000	€ 171.816	€ 175.883	€ 134.281	€ **481.980**	€ 482.000
35	€ 152.355	€ 410.482	€ 138.583	€ **701.420**	€ 701.000	€ 175.657	€ 191.190	€ 141.594	€ **508.441**	€ 508.000

Monte Carlo Simulation





Individual GHP

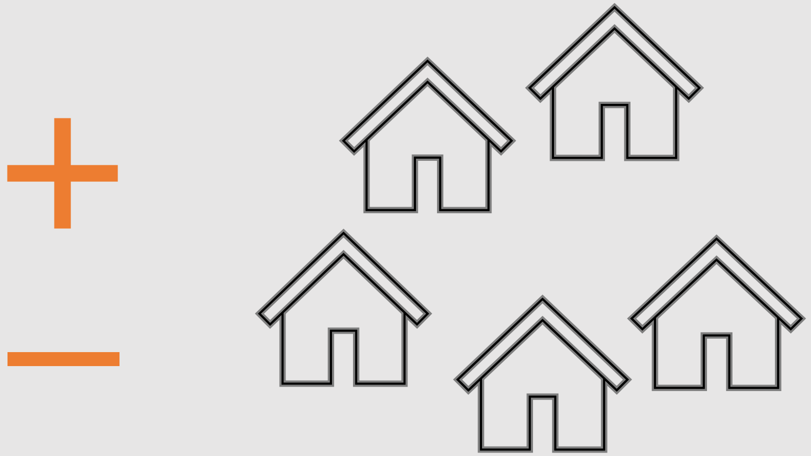
Average TCO	€	1.084.873
Minimum TCO	€	770.165
Maximum TCO	€	1.312.709
Standard deviation	€	79.187

Collective GHP

Average TCO	€	634.162
Minimum TCO	€	510.852
Maximum TCO	€	752.779
Standard deviation	€	35.882

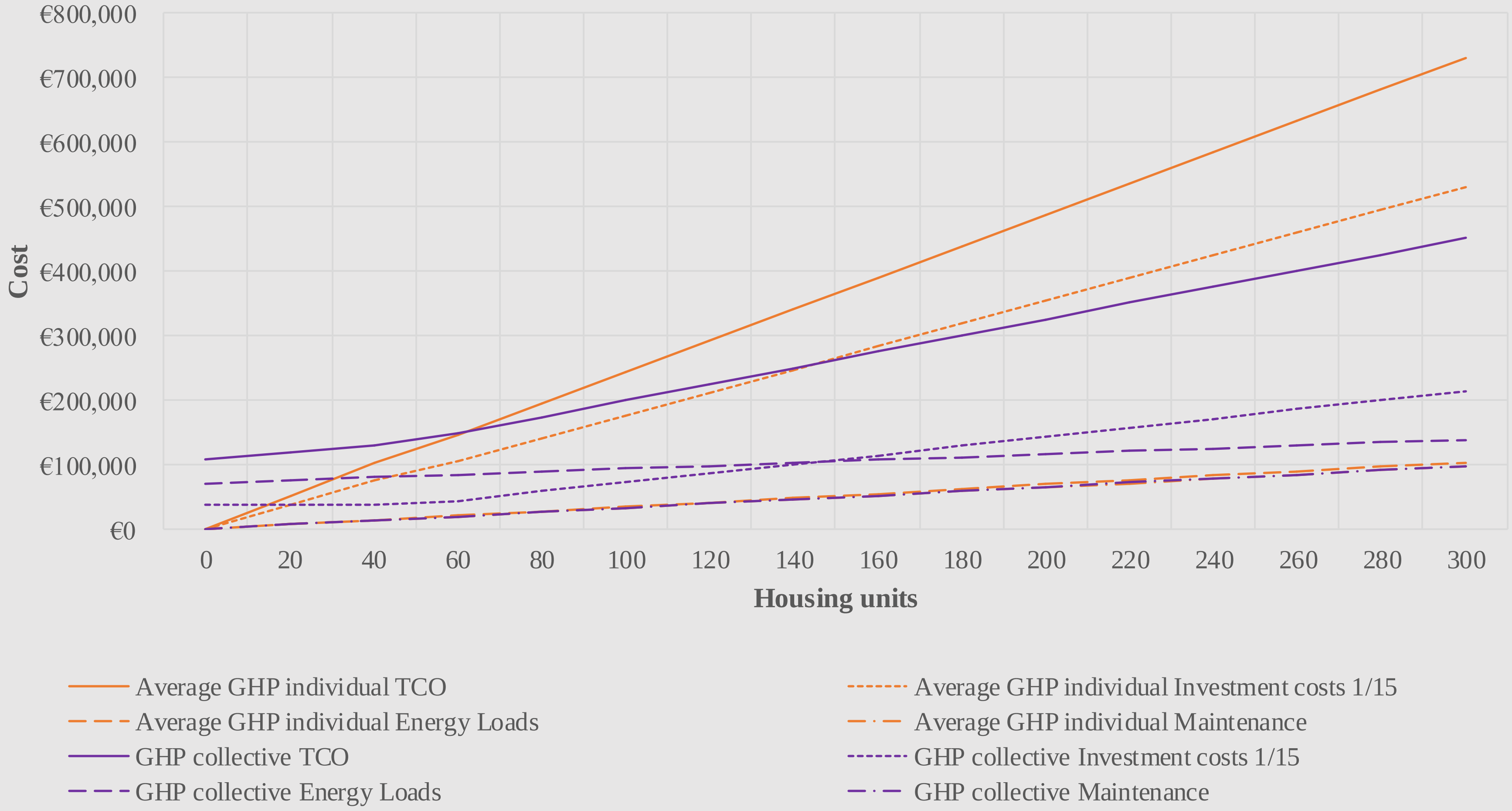
Based on the TCO sensitivity analyses have been made

For the individual VS collective closed loop GHP



So what if we add more or less housing?

Impact of housing units on the Total Cost of Ownership (TCO)

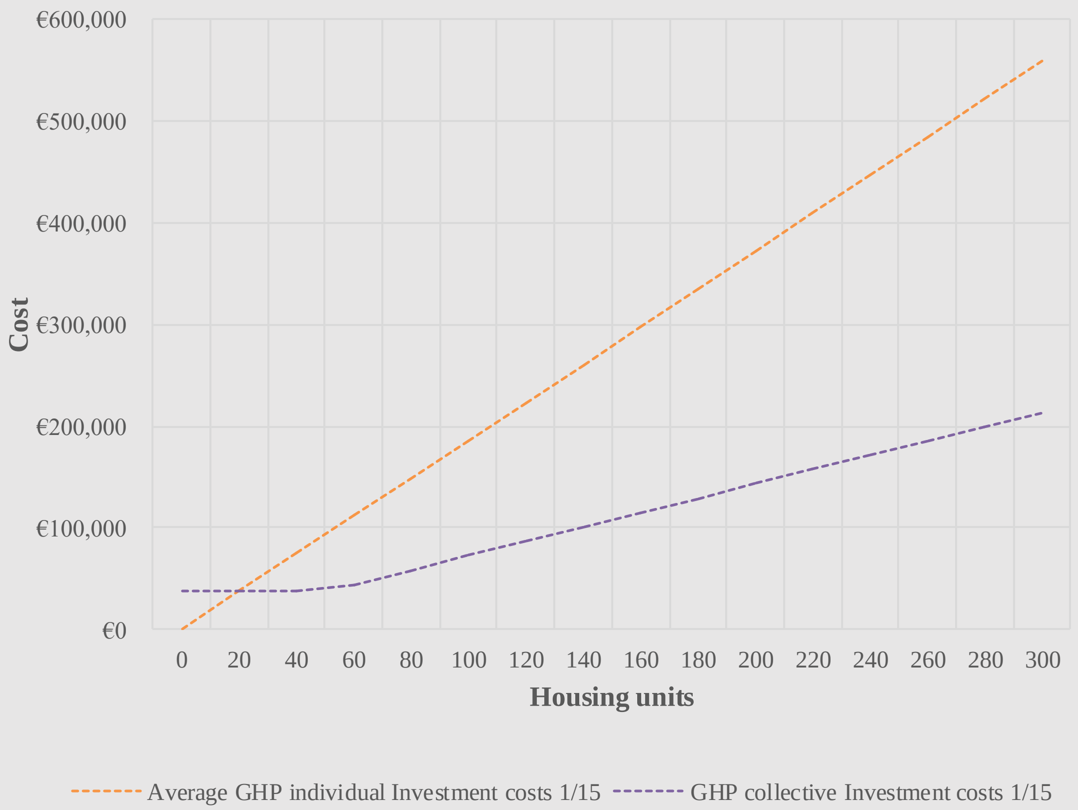


Ground source heat pump individual vs collective

Orange are individual ground source heat pump

Purple are collective ground source heat pump

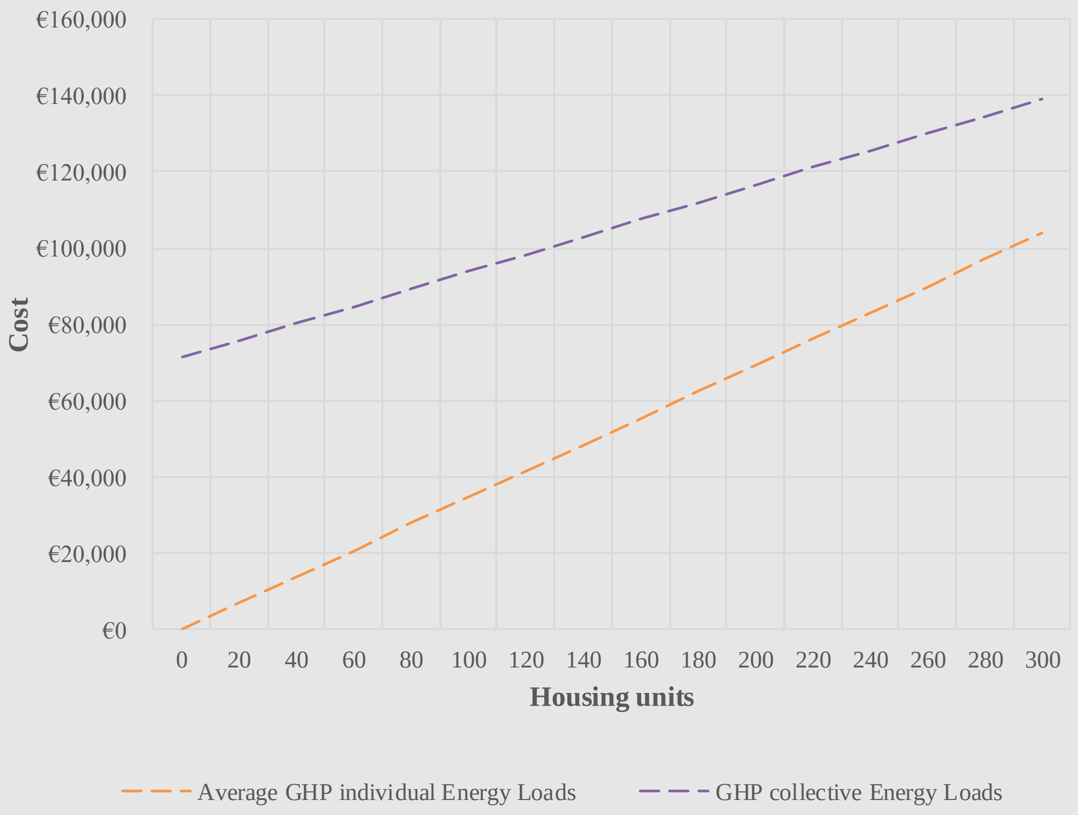
TCO vs units – Investment cost

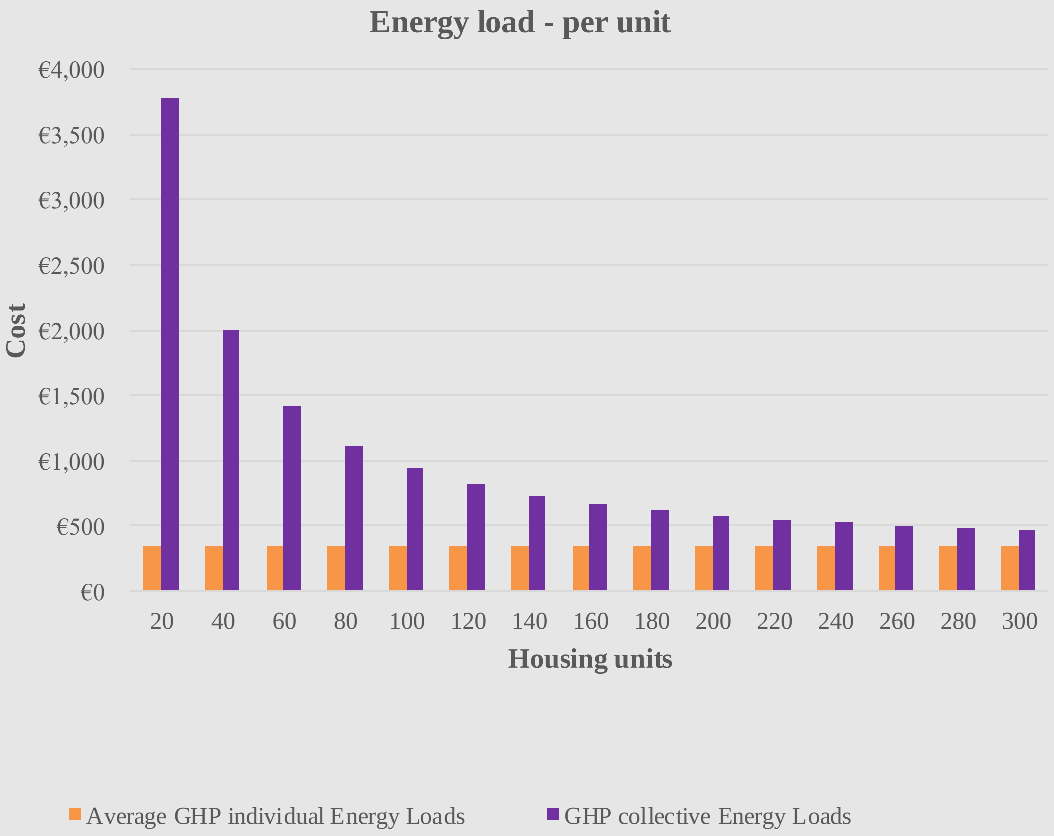


TCO vs units – Energy cost

Data transparency:

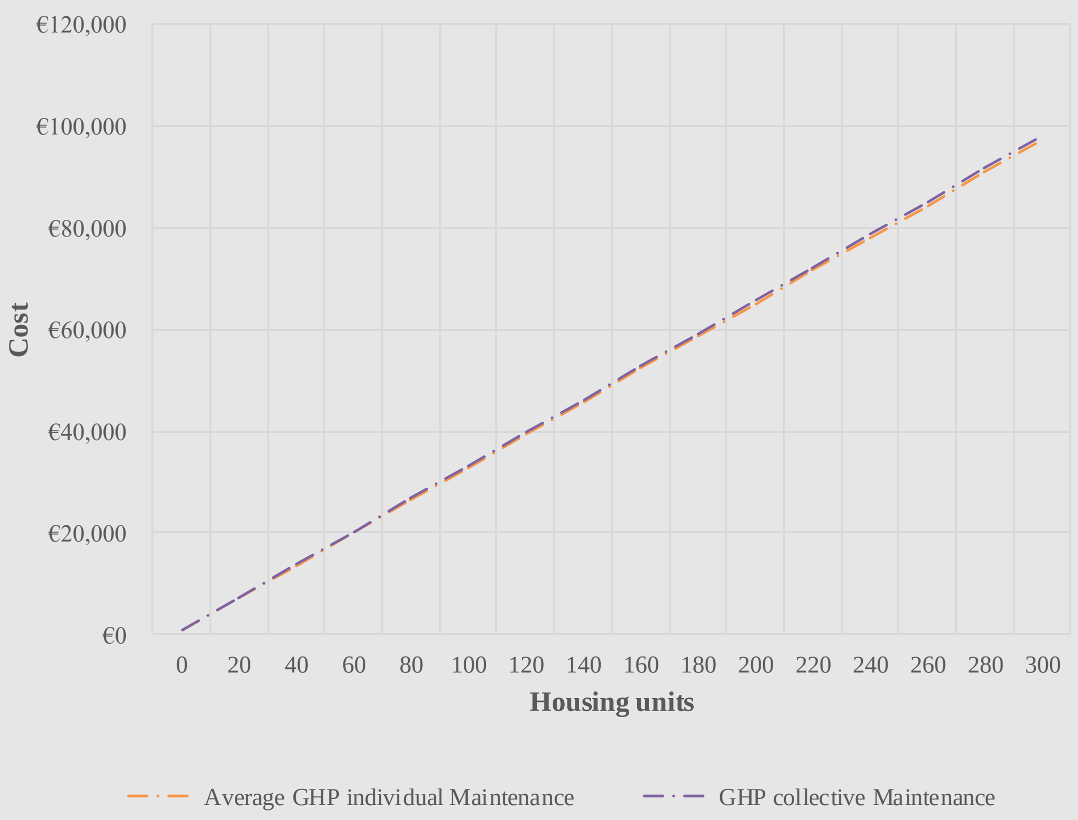
* Including 10% train loss surcharge with collective (Vink, personal communication, April 14, 2024)



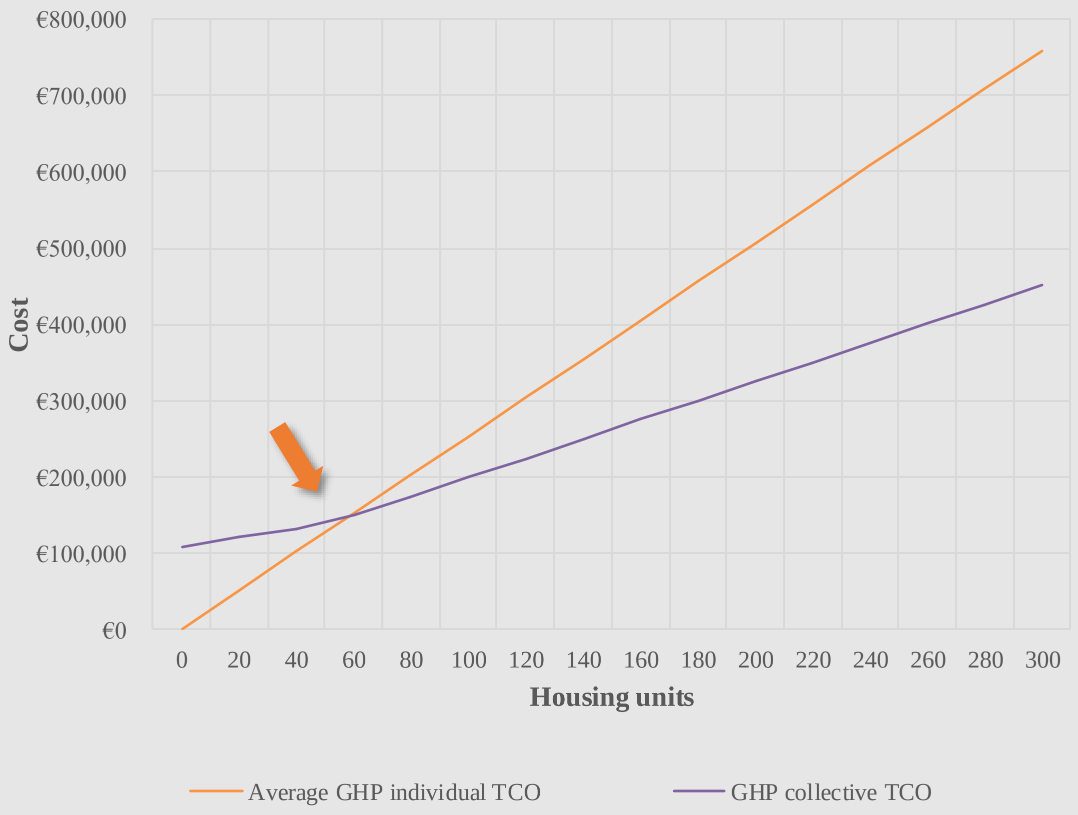


TCO vs units – Operational cost

Data transparency:
The maintenance costs are based on device power (Vink, personal communication, April 14, 2024)



TCO vs units – TCO



Recommendations for investors, end-users, and policymakers

SQ 5: Based on the evaluation, what are the recommendations for achieving optimal financial value?

Investors

- Opportunity for long-term value
- Leveraging financial mechanisms

End-users

- Cost-benefit analysis
- Maintenance and operational considerations
- Behavioral impacts
- Behavior changes interventions

Policymakers

- Economic viability
- Regulatory support
- Market transformation
- Monitoring and evaluation
- Promoting Interconnection and Grid Integration

Discussion, conclusion and limitations

Discussion

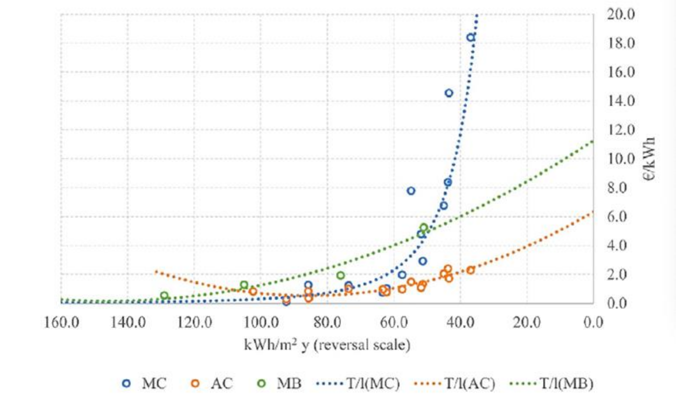
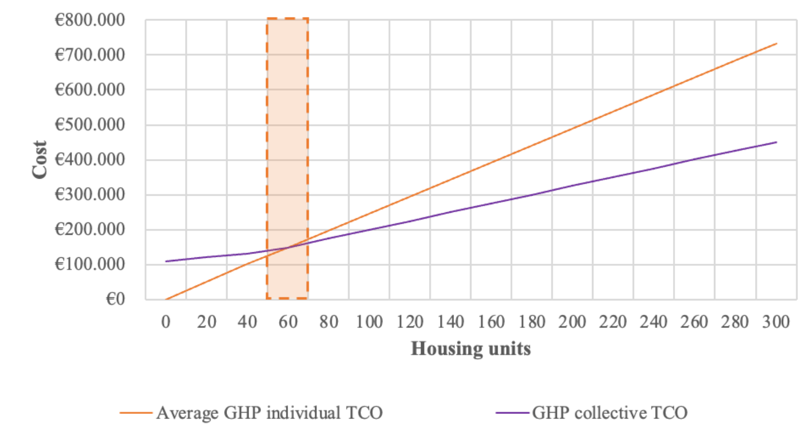


Fig. 8. Marginal costs, average costs, and marginal benefits.



		GPD individual combined		GHP collective		GPD ind + PV combined		GHP collective + PV
Energy charges incl. (incl. VAT)	€	345	€	387	€	92	€	134
Total maintenance and replacement (incl. VAT)	€	325	€	327	€	333	€	342
Total investment costs (1/15th part) (incl. VAT)	€	1.768	€	710	€	1.962	€	945
Total investment cost (incl. BTW)	€	21.920	€	8.804	€	24.317	€	11.718
Total TCO costs per year	€	**2.438**	€	**1.423**	€	**2.386**	€	**1.421**

Prior research Sustainable technologies increase building value (Choi, 2009; Shan et al., 2017).

SETs integration proves financially viable in TCO.

However, smaller complexes adopt collective systems early (60 units).

And in contrast of previous studies, High initial costs hinder quick returns and constituted a significant obstacle to immediate financial gain.

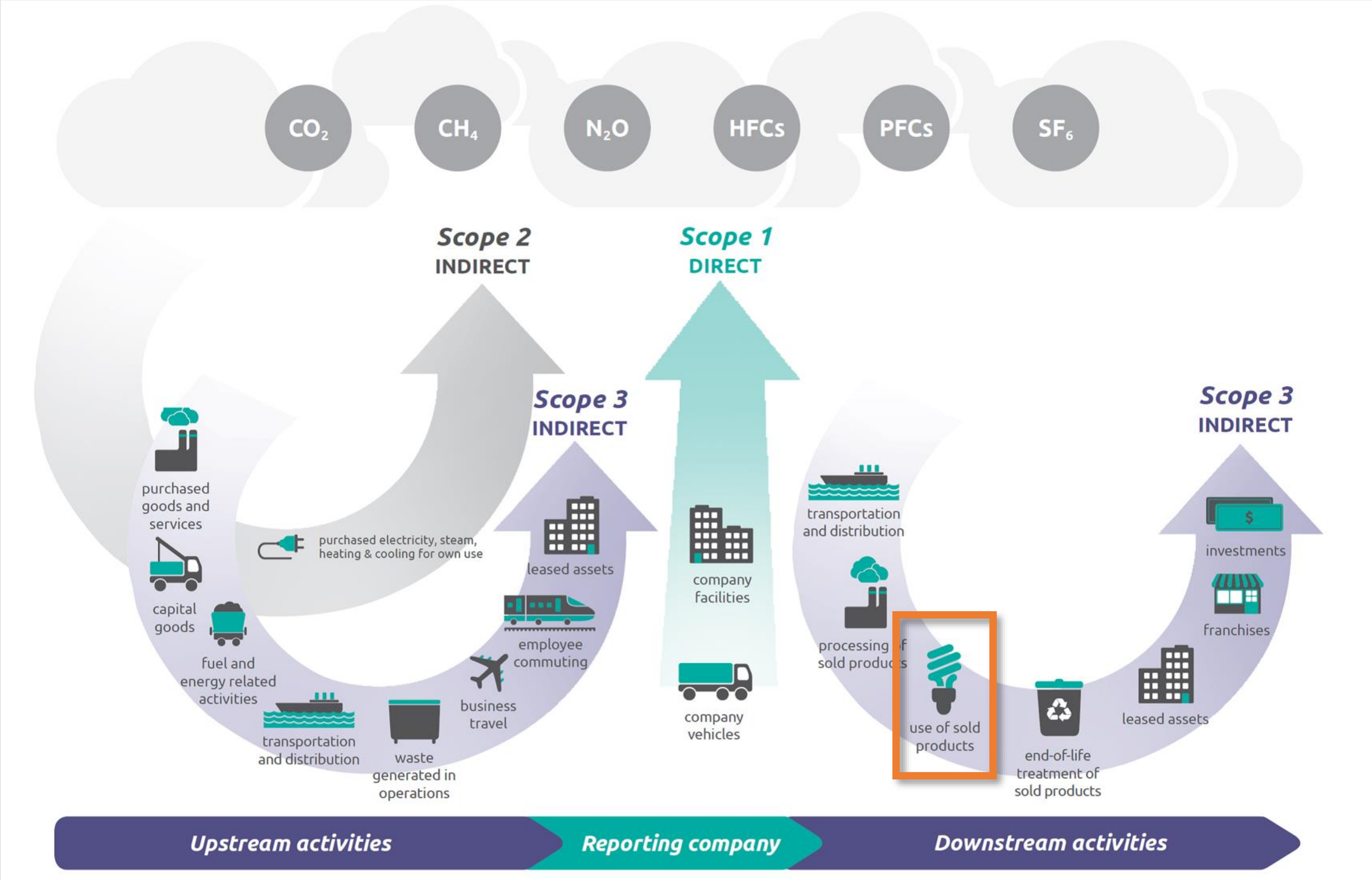
Discussion: Recent development

Recent development of scope 3

- Looking into the lifecycle of building
- Becoming important to take in account the use

The study can contribute to scope 3:

- SETs integration reduces Scope 3 emissions, aligning with sustainability goals.
- Variability in reduction based on technology and scale.



Conclusion

For the UT Enschede

- Best choose **collective closed-loop ground source heat pump with pv panels**

	GHP		GHP + PV	
	GPD **individual** combined	GHP **collective**	GPD **ind** + PV combined	GHP **collective** + PV
Energy charges incl. (incl. VAT)	€ 153.310	€ 172.020	€ 40.770	€ 59.470
Total maintenance and replacement (incl. VAT)	€ 144.600	€ 145.350	€ 148.030	€ 152.350
Total investment costs (1/15th part) (incl. VAT)	€ 786.850	€ 316.040	€ 872.920	€ 420.650
Total investment cost (incl. BTW)	€ 9.754.270	€ 3.917.840	€ 10.821.160	€ 4.987.890
Total TCO costs per year	**€ 1.084.760**	**€ 633.420**	**€ 1.061.720**	**€ 632.490**

Conclusion

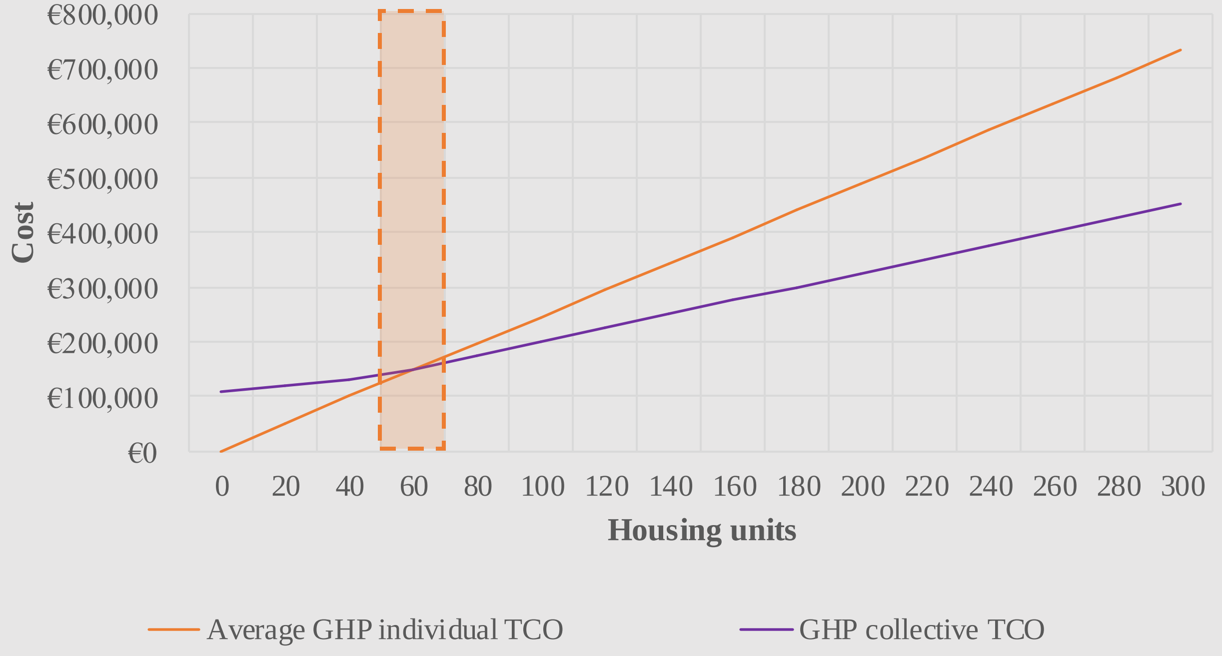
Individual vs. Collective SETs:

- **Individual**
  - offer customization;
  - more resilient to energy price fluctuations.

- **Collective**
  - cost-efficient beyond 60 units due to economies of scale.
  - less space and material use

Financial value

Initial investement cost gets higer ↑ ➞ Operatioanl cost gets higer ↑ ➞ energy cost will be lower ↓
= long term benefit



“ Collective systems become more cost-effective beyond ~60 units, highlighting the importance of scale and policy support in SETs implementation. ”

Limitations

Data
Data Data Data
Dataa….

Data and Methodological Constraints	**Reliance on VIAC and Vabi models;** may not align with future needs. Due to climate change
	Use of fixed rates; market dynamics and location can cause volatility.
	Derived from reference projects; may not reflect case variations.
Stakeholders and Financial Responsibility	**Complex Financial Dynamics;** Initial investments by who? (private, government, social housing).
	Lower energy costs for users but higher investor cost.
Broader Contextual Limitations	**Price Fluctuations;** Sensitivity to changes in electricity and gas prices.
	Material Scarcity and Scalability (IEA, 2021); Limited availability of critical materials may increase costs.
	Environmental Impacts (Farghali et al., 2023); Production processes of SETs may have negative environmental effects.
	Technological Obsolescence (IEA, 2021); Rapid advancements may render current technologies obsolete.
	Adaptation to Changing Conditions; Climate change and evolving energy demands may require design adjustments.

Closing statement

There is **<u>no</u> one-size-fits-all** solution. The potential of the technology and its operational specifics are highly **context-dependent**. Consequently, the financial value is also contingent upon this factor.

Furthermore, a significant proportion of costs are contingent upon future events, and as evidenced by recent instances of war and pandemics, **the future can be highly unpredictable**.

Finally, it is important to consider the **financial picture in conjunction with other factors**. However, it is also necessary to consider the broader context in which we live, as described by the Triple Bottom Line (*people*, *planet*, *profit*) in its theoretical framework. Although the focus is on renewable energy sources, it is also important to consider the materials used in technology.

"Switching to renewable energy is like eating your vegetables – it's good for you and the planet, even if it wasn't your first choice.“

Thank you for listing