



International Conference

# GEO4CIVHIC

**Most Easy, Efficient and Low Cost  
Geothermal Systems for Retrofitting  
Civil and Historical Buildings**

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**Grand Hotel Excelsior** - Great Siege Road, La Valletta - Malta



# EXPLOITATION AND EUROPEAN MARKET OPPORTUNITIES

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# Levelized Cost of Energy

lifetime costs of an energy producing plant

$$LCOE = \frac{\text{lifetime costs of an energy producing plant}}{\text{lifetime energy produced by the plant}}$$

present financial-value

$$LCOE = \frac{\text{present financial-value}}{\text{present energy-value}}$$

$$LCOE = \frac{capex + \sum_{t=1}^n \frac{opex_t}{(1+r)^t} - \frac{endvalue_n}{(1+r)^n}}{\sum_{t=1}^n \frac{energy_t}{(1+r)^t}}$$

# Methodology

For each virtual and real case study :

1. Present **status of energy** use of existing building is identified.
2. Renovation of **building envelop** and **energy management** → Internal Rate of Return (IRR).
3. Retrofit of **heating and cooling system**
  - ✓ Geo4CivHic GSHP solution
  - ✓ Gas heating & Chiller cooling systems
4. The capital costs and annual operation costs are estimated for each solution.
5. The levelized cost of thermal and cooling energy (LCOE) delivered to the building for each solution is calculated.
6. CO<sub>2</sub> emissions are calculated for each solution in terms of **Total Equivalent Warming Impact** of heat pumps (**TEWI**).
7. LCOEs are calculated again considering the value of CO<sub>2</sub> emissions.

# Assumptions

- Discount factor depending on long term loan interest in country considered
- 20 years life span of heating and cooling system
- 80 years life span of BHE → 75% Residual BHE value
- 100 years life span of building after last renovation
- Local natural gas and electricity prices updated (winter 2023)
- National electricity emission factors (2021)
- Typical natural gas emission factor 0,2047 kg CO<sub>2</sub>/kWh<sub>-th</sub>
- Projected CO<sub>2</sub> market price 105,73 €/ton (*max value of EU trading scheme, March 2023*)
- Heat pumps TEWI considered
- Heat pumps efficiency and refrigerant charge reported by HiRef
- 0,93 gas boiler efficiency for heating and 2,87 chiller SPF for cooling

# Retrofitting envelop & energy management

Case study	Energy savings	HP capacity reduction	IRR	IRR with CO <sub>2</sub> value
Alexandroupolis Museum, Greece	17%	16%	11,2%	12,8%
Palacete de la Cruz Roja, Valencia, Spain	8%	-	9,6%	11,5%
EfdeN House, Bucharest, Romania	77%	65%	5,9%	7,0%
Ex Ospedale Geriatrico, Padova, Italy	67%	62%	7,0%	7,7%
Mariënheuvel, Soest, Netherlands	46%	69%	4,8%	5,5%
La Vall 9 Bellpuig, Spain	59%	69%	11,8%	13,3%
Private house, Mechelen, Belgium	44%	48%	9,4%	10,6%

- Retrofitting envelop, replacing lights with LED and installing a BEMS results in energy savings up to 77% and heat pump capacity reduction up to 69%
- All resulting IRR values are above the corresponding discount factor
- Adding CO<sub>2</sub> value in the calculations → improves IRR values

# Retrofitting heating and cooling system

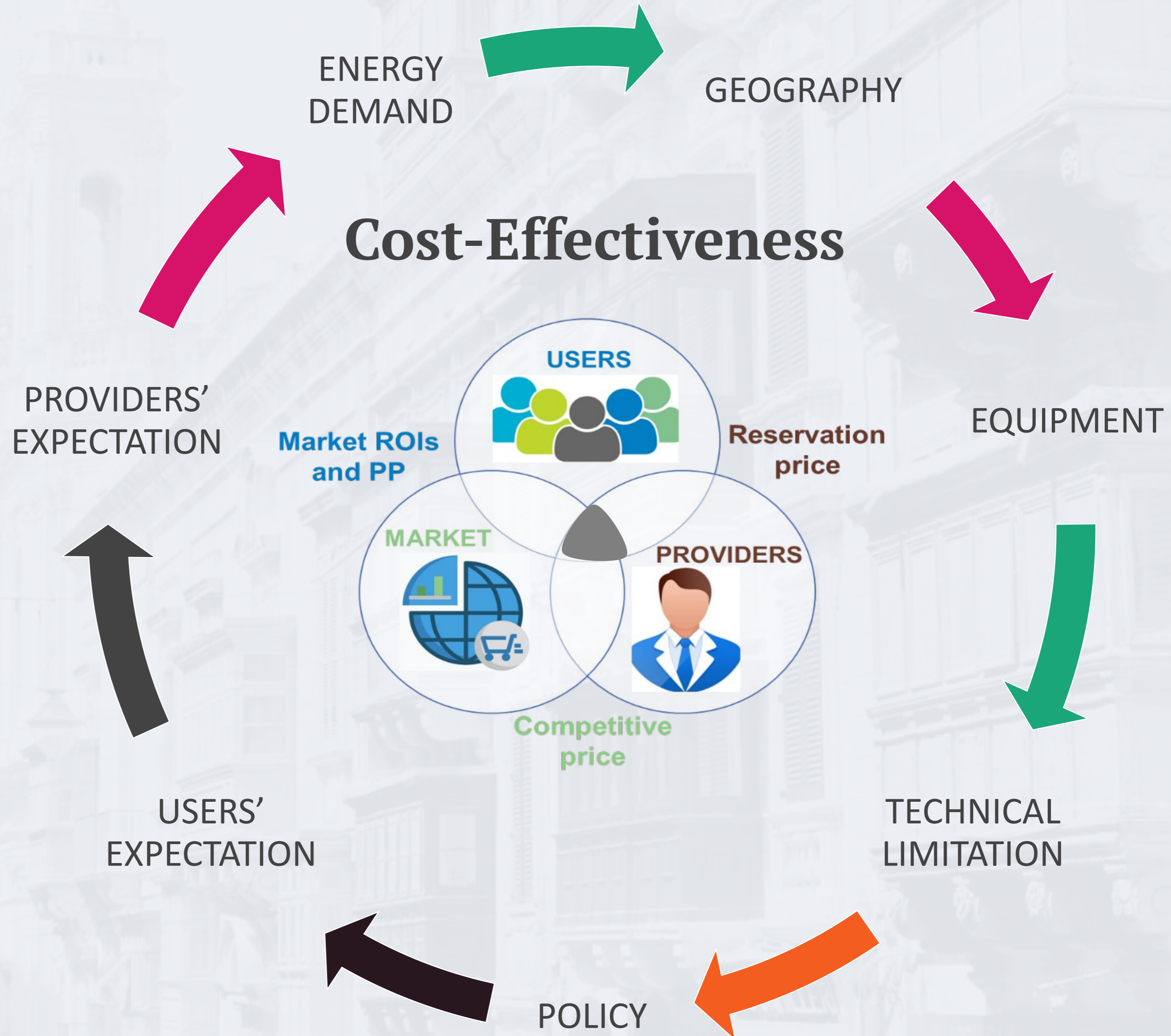
## Median values of LCOE, €/kWh<sub>-th</sub>

Indoor heating & cooling system	Gas boiler + chiller	Geo4CivHic GSHPs
Fan Coil Units (FCUs)	0,245	0,214
Floor heating	0,289	0,275
Radiators	0,216	<b>0,284</b>

## Median values of LCOE, €/kWh<sub>-th</sub> with CO<sub>2</sub>

Indoor heating & cooling system	Gas boiler + chiller	Geo4CivHic GSHPs
FCUs	0,268	0,226
Floor heating	0,309	0,280
Radiators	0,236	<b>0,292</b>

- **GEO4CIVHIC** systems due to their increased efficiency, **can effectively compete with a base system**, such a gas boiler and air source chiller, when coupled to low terminal units such as **FCUs** and **floor heating**.
- In **high temperature systems** with **radiators**, where usually only heating and domestic hot water are needed without any cooling, the energy efficiency advantage of the **GEO4CIVHIC** systems **is reduced considerably** and the resulting median LCOE becomes higher than that of the base system



# Methodology

**Cost effectiveness** and performance of the solutions from a **market point of view**.

Understanding if at their current costs the solutions can be priced at levels that offer:

## USERS



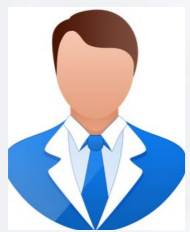
— Utility that is expected for end **USERS** (expected **market ROI's** and **payback periods** for such solutions)

## MARKET



— While still being **competitively priced** with respect to **conventional solutions** in the **MARKET** and, finally,

## PROVIDERS



— Yielding **sufficient returns** for the **PROVIDERS** that potentially will **commercialize the solutions**.

# Three levels of analysis

MARKET



USERS



**1.** An analysis of **competing conventional solutions** for all demo-cases with their adjusted costs and payback levels → to gain an **understanding of the MARKET** and **end USER expectations** with respect to financial KPIs.

- ✓ **CAPEX** → with subdivision of cost
- ✓ €/kwh saved
- ✓ **ROI and PP**
- ✓ 30 years NPV

$$NPV = \sum_{t=1}^n \frac{\Delta E_t}{(1+r)^t} - (I_0 + \sum_j \frac{C_m}{(1+r)^j} + \sum_j \frac{C_r}{(1+r)^j})$$

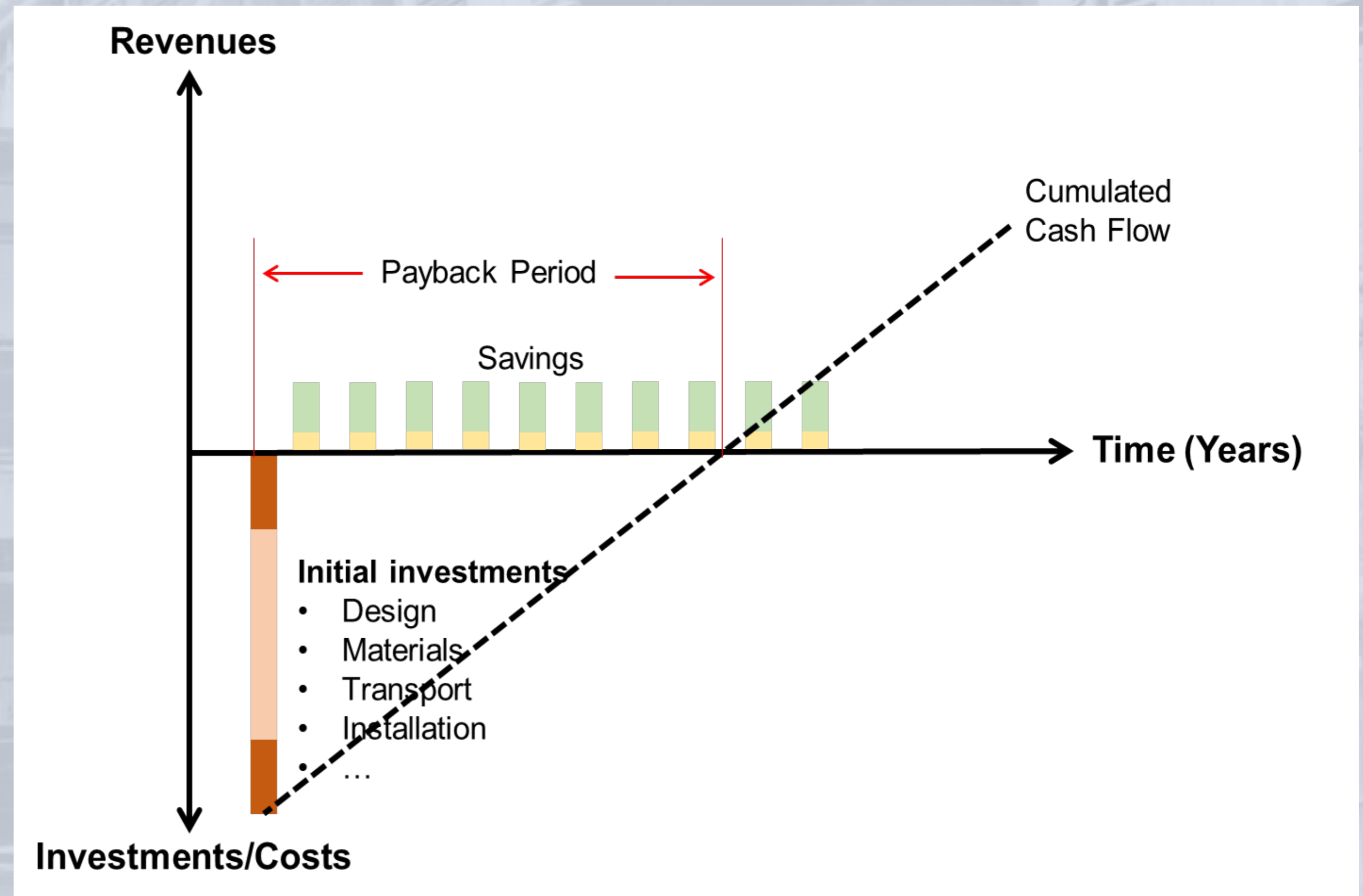
$\Delta E_t$  = Annual monetary gain

$r$  = discount rate (opportunity cost)

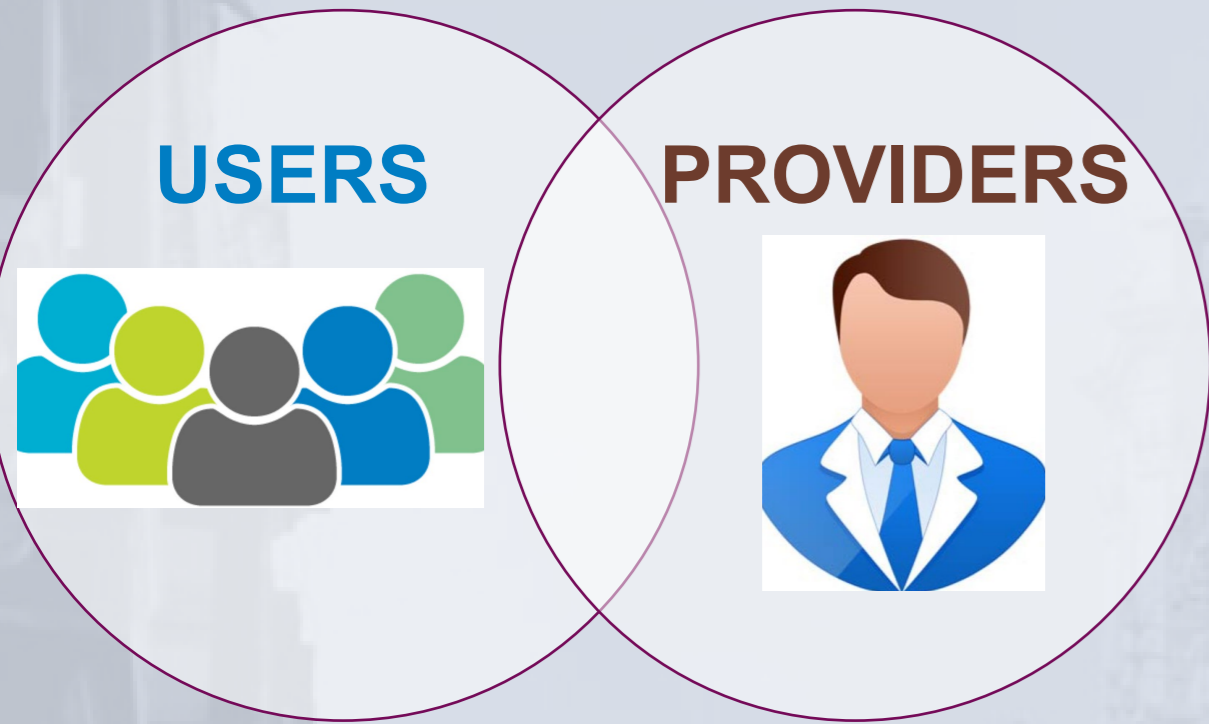
$I_0$  = Investment cost (CAPEX)

$C_m$  = annual maintenance cost (OPEX)

$C_r$  = replacement cost (OPEX)



# Three levels of analysis

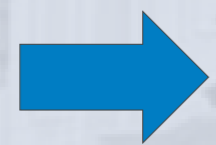


## 2. Point of view of end **USERS** → “Reservation Price”

→ On the demand side, it is the **highest price** that a **USER** is willing to pay; on the supply side, it is the **lowest price** a **PROVIDER** is willing to accept for a good or service.

→ **Conditioned** by the **expected utility** of such investment which in turn is defined in our analysis in terms of **threshold PP and ROI**. By using all the relevant information, we are able to compute the threshold product and service costs for implementing **GEO4CIVHIC solutions** according to different targeted payback periods using the simple payback period equation.

$$PP = \frac{\text{Initial Investment}}{\text{€ Savings}}$$



$$\text{€ Savings} * PP = Y$$

*PP = Target Payback Period*

*Y = Reservation Price*

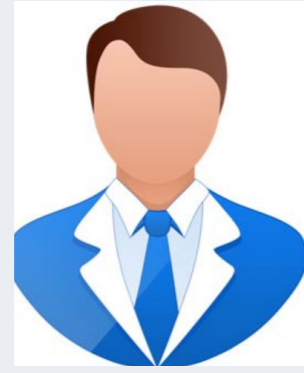
*€ Savings = Obtained yearly savings in pilot as calculated in the previous level characterizing the economic performance of solutions in different demo sites*

# Three levels of analysis

MARKET

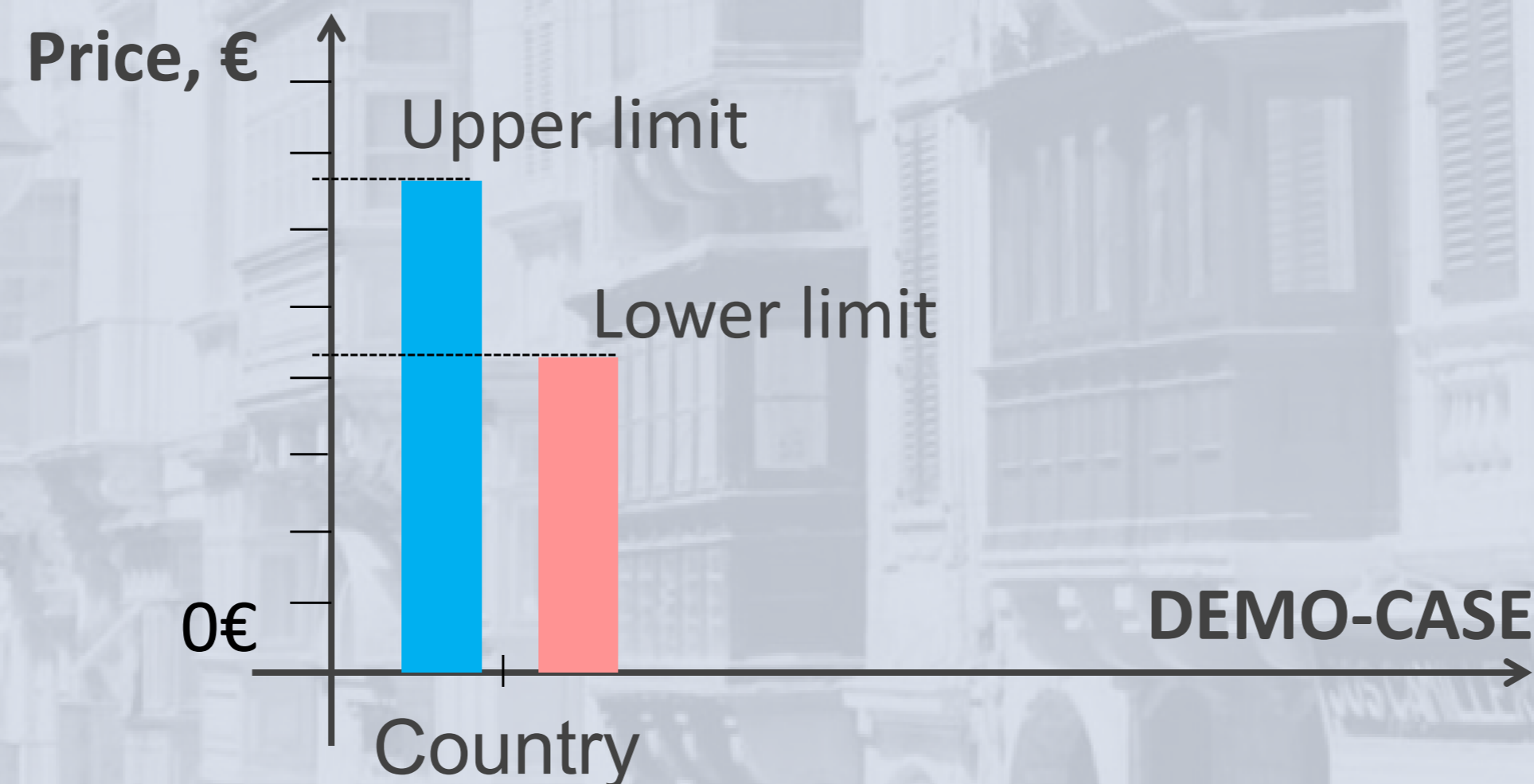


PROVIDERS

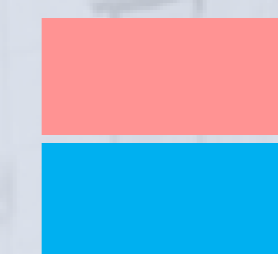


**3.** Contextualisation of possible **MARKET** prices of the solutions with respect to the manufacturing & installation costs using each **DEMO-CASE**. The results take the outputs of the past 2 levels to contextualise them in terms of.....

- **Possible pricing policies** (Upper limits imposed by Reservation Price and competitor pricing as well as **Lower limits** imposed by PROVIDERS fixed and variable cost structures).
- **Required market penetration levels** for the partners potentially taking the solutions to market to achieve sufficient returns over the CAPEX.

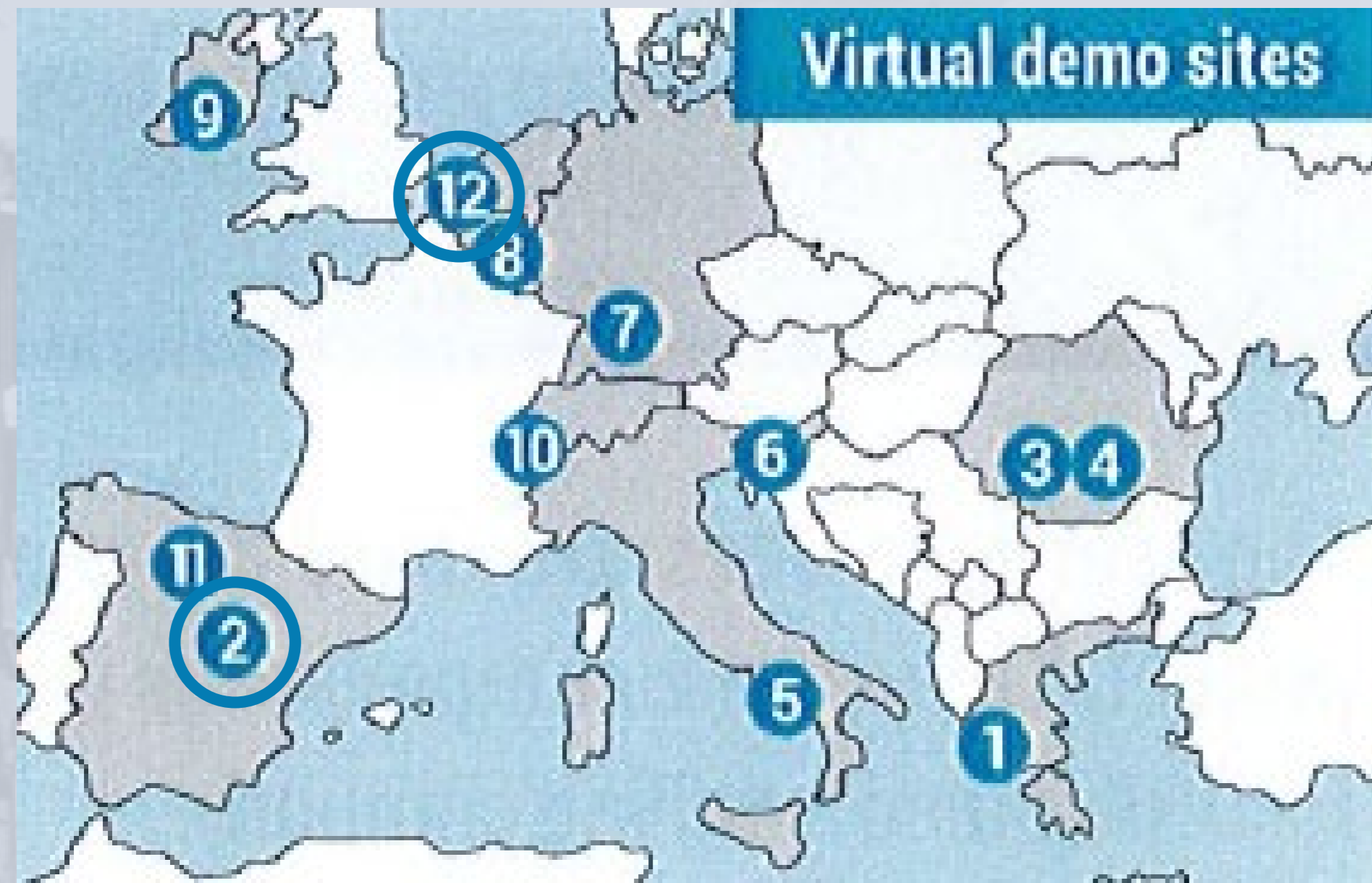


REF:



Manufacturing & installation cost  
Reservation price

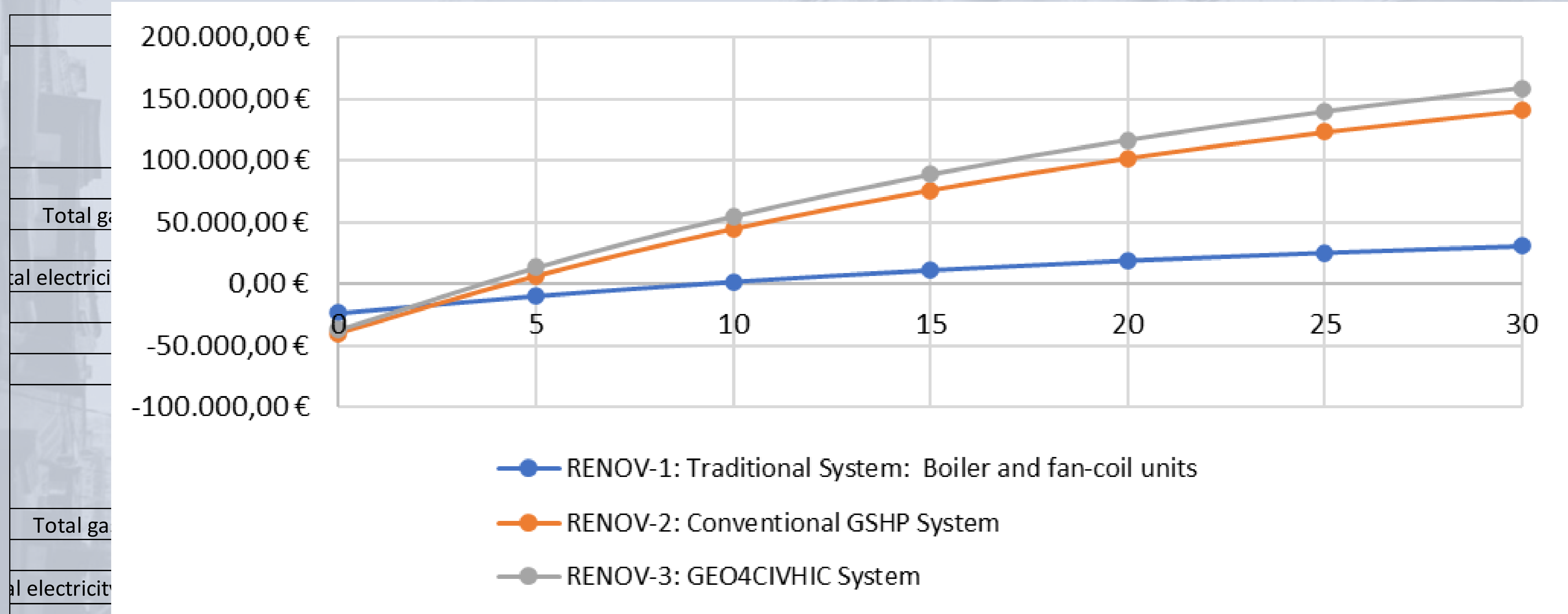
# Demo cases



		Real demo sites				Virtual demo sites											
Location		1 Malta	2 Italy	3 Belgium	4 Ireland	1 Greece	2 Spain	3 Romania	4 Romania	5 Italy	6 Croatia	7 Germany	8 Belgium	9 Ireland	10 Switzerland	11 Spain	12 Holland
Age	Existing			X		X		X	X						X	X	X
	Historic	X	X		X		X			X	X	X	X	X			
Climate	Warm	X				X	X									X	
	Mild Warm		X					X	X	X	X						
	Mild Cold			X								X	X				X
	Cold				X									X	X		

# Results: Valencia, Spain (Virtual demo-case: Historical building)

Characteristics:  
Administrative

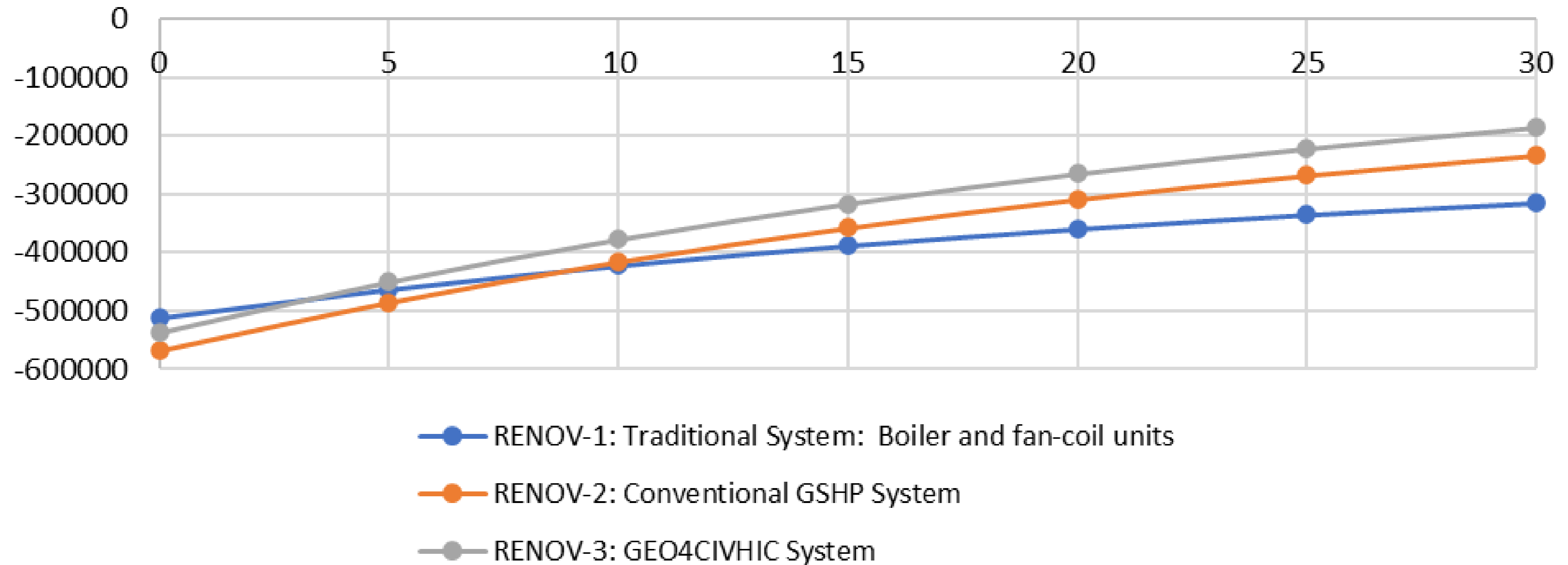


Price of electricity €/kwh	0,2407	0,2407	0,2407
Operation cost (€/yr)	13491,6323	6156,422256	5317,822185
Maintenance cost (€/yr)	2500	2500	2500
Investment costs (€)	26614	50973	48424

	RENOV-1: Traditional System: Boiler and fan-coil units	RENOV-2: Conventional GSHP System	RENOV-3: GEO4CIVHIC System
Calculated PP (Yr)	8	5	4
Energy savings (€/Yr)	1632,4192	8967,629244	9806,229315
Discounted ROI (30 year)	115,54%	276,07%	327,58%

# Results: Soest, Netherlands (Virtual demo-case: Civil building)

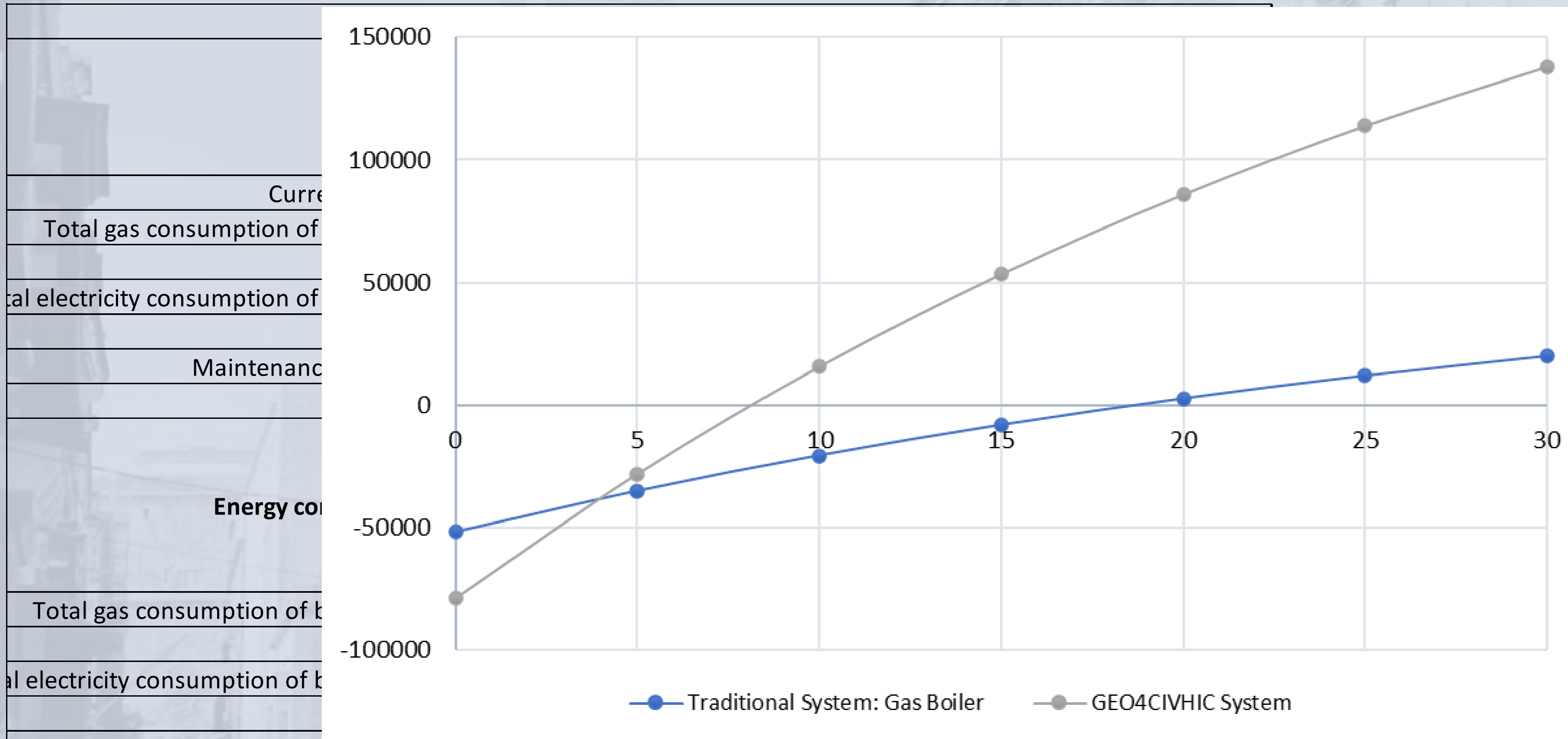
CS:  
I for elderly



	RENOV-1: Traditional System: Boiler and fan-coil units	RENOV-2: Conventional GSHP System	RENOV-3: GEO4CIVHIC System
Price of electricity €/kwh	0,4472	0,4472	0,4472
Operation cost (€/yr)	11664,8895	11140,02303	11140,02303
Maintenance cost (€/yr)	15000	8000	7000
Investment costs (€)	523276	586434	557112
Calculated PP (Yr)	18	32	29
Discounted ROI (30 year)	60,26%	-39,89%	33,28%
Energy Savings (€/Yr)	10824,8415	11349,70797	11349,70797

# Results: Ferrara, Italy (Real demo-case: Historical building)

**Building characteristics:**  
 Building use: Historic hall  
 Climate: Mild Warm  
 Surface: 220 m<sup>2</sup>

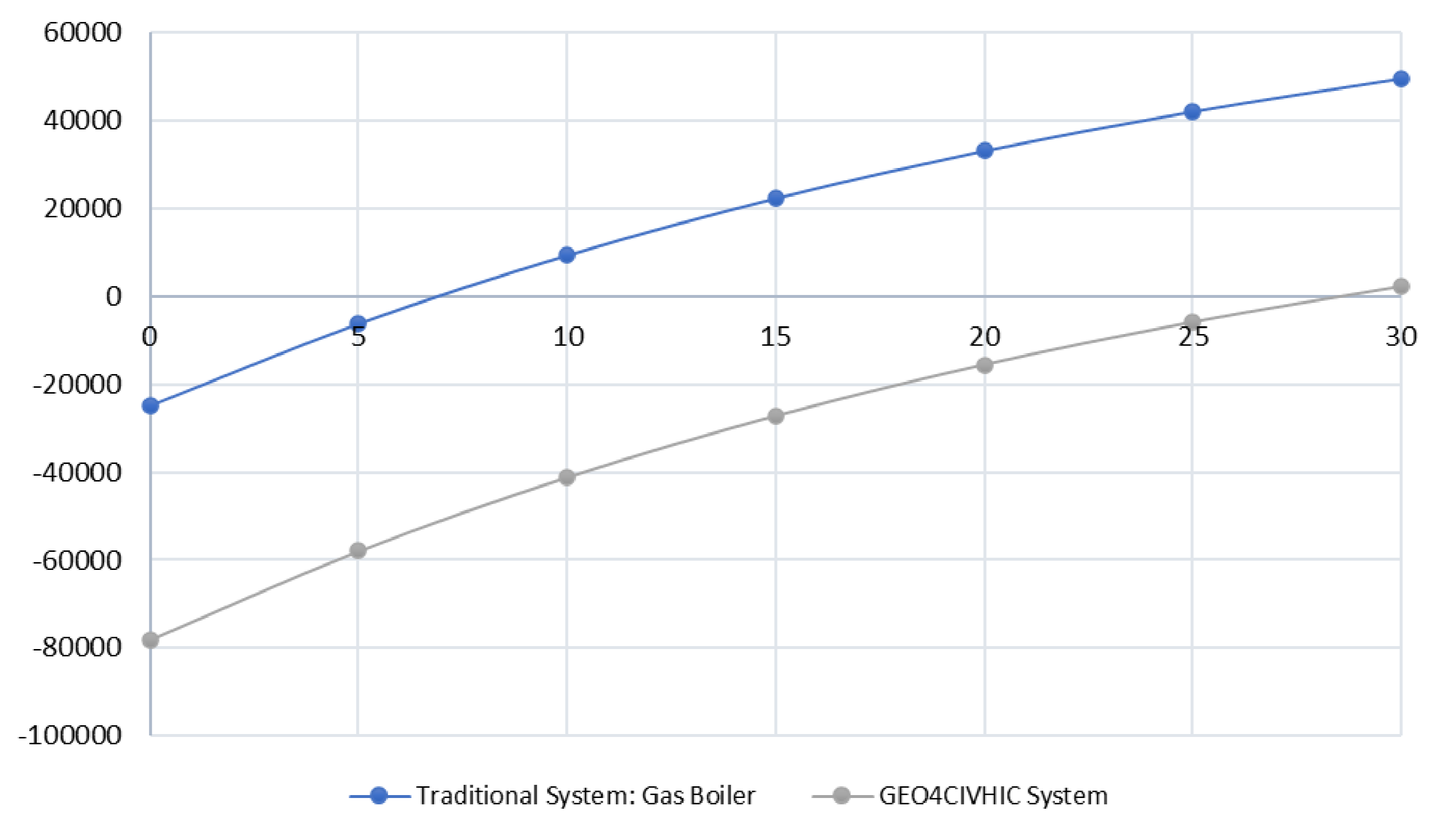


Operation cost (€/yr)	12726	0	5454
Maintenance cost (€/yr)	280,00		122,50
Investment costs (€)	55501,00		60005,00

	RENNOV-1	RENNOV-2	RENNOV-3
System: Boiler and fan-coil units	RENNOV-1	RENNOV-2	RENNOV-3
Conventional GSHP System	RENNOV-1	RENNOV-2	RENNOV-3
GEO4CIVHIC System	RENNOV-1	RENNOV-2	RENNOV-3
Energy Savings			
Energy savings (€/Yr)	3669,96	2917	10942,76423
Calculated PP (Yr)	15	8	
Discounted ROI (30 year)	35,88%	153,44%	

# Results: Mechelen, Belgium (Real demo-case: Civil building)

Current
Total gas consumption of building
Total electricity consumption of building
Maintenance cost
Energy consumption
Total gas consumption of building
Total electricity consumption of building



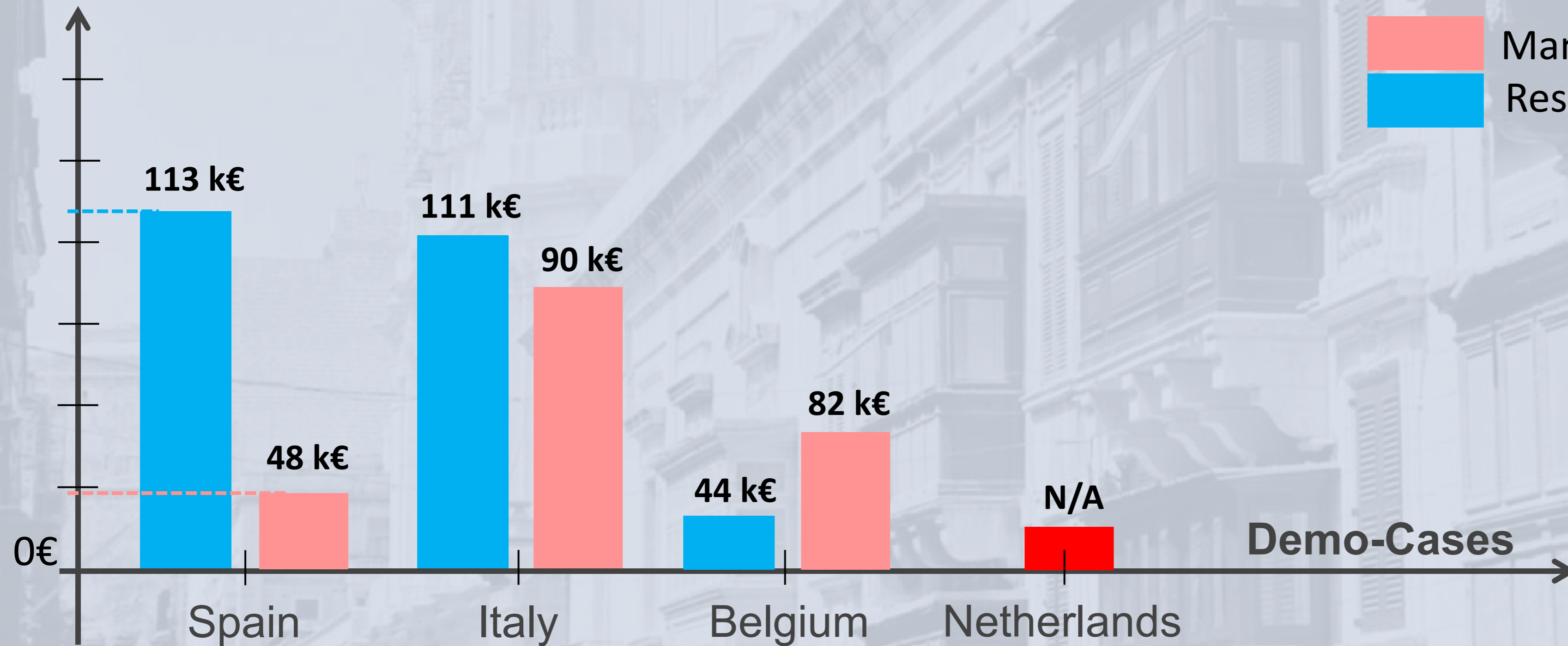
**Building characteristics**  
 Building use: Residential  
 Climate: Mild Cold  
 Surface: 170 m<sup>2</sup>

Operation cost (€/yr)	2941	0	2635
Maintenance cost (€/yr)	60,00		40,00
Investment costs (€)	28975,00	82625,00	2625,00
		<b>RENOV-1: Traditional System: Boiler</b>	<b>RENOV-2: Conventional GSHP System</b>
			<b>RENOV-3: GEO4CIVHIC System</b>

Energy Savings		7	REN OV-1	REN OV-2	REN OV-3
Energy savings (€/Yr)		171,38%	4076,31	19619	2,62% 0
Energy savings (€/Yr)					4382,556736

# Contextualisation: Upper and Lower limits

Price, €



REF:

- Manufacturing & installation cost
- Reservation price → PP= 10 Years

Demo-Cases

	Spain	Italy	Belgium	Netherlands
Target PP (yr)	10	10	10	10
Total Annual cash flow savings (€/yr)	11.3062,23	11.100,26	4.492,5	-683
Reservation price (€)	113.062,23	111.100,26	44.925,5	-6830
Margin	230%	123%	54%	N/A

- Energy savings + Maintenance savings
- Total target PP X Total savings
- Reservation price / Investment cost

# Market Opportunities for the solutions



- ❖ TRL levels, alongside
- ❖ FDCF Statements

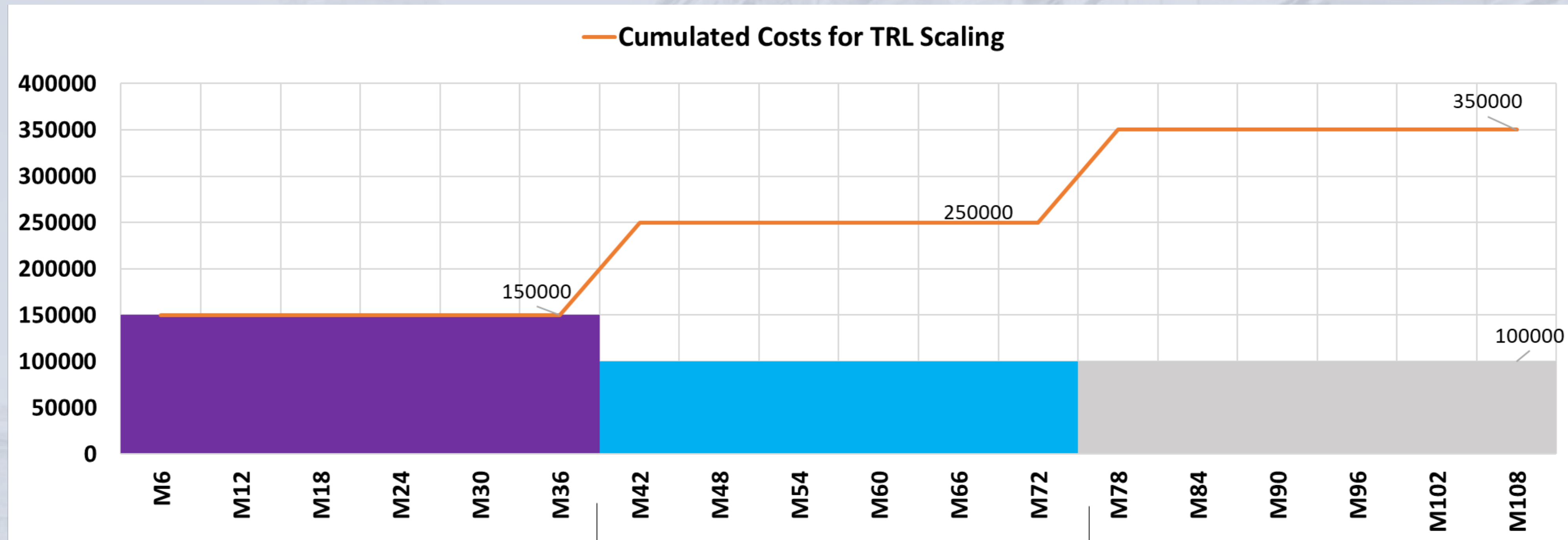
- MARKET entry strategies
- Decision-making
- Risk mitigation
- Resource allocation,
- Investor communication

It ensures that financial projections are realistic, aligned with technology maturity

- ❖ TRL's increase (time and resources allocation to take the KERs to the market).
- ❖ FDCF Statements for each KER with respect to the future generated cash flows of the KER owners

N°	Title	KER	Exploitation Potential	Type	IP owner	IP contributor
<b>HEAT PUMP Technology</b>						
1	Plug and play heat pump with variable or fixed speed drivers	KER	Commercial	Product	Galletti-Hiref	UNIPD-DII, CNR-ITC,CRES
2	Heat pump for high temperature application and dual source application	KER	Commercial	Product	Galletti-Hiref	UNIPD-DII, CNR-ITC,CRES
3	High temperature Heat Pumps for renovated Civil and Historical Buildings	KER	Commercial	Product	Galletti-Hiref	UNIPD-DII, CNR-ITC
<b>DRILLING Technology</b>						
4	Versatil and compact drilling rig unit Joy 3P GEO4CIVHIC	KER	Commercial	Product	Hydra	Hydra
5	Semi-automatic feeder for drilling rods and co-axial tubes mounting	KER	Commercial	Product	Hydra	Hydra
6	<b>Compact Vibration-rotation drilling components</b>					
6.a	Compact Vibration-rotation drilling head and drill bit. (VD 80)	KER	Commercial	Product	TKI	Hydra
6.b	Compact Vibration-rotation drilling head and drill bit. (VD 150)	KER	Commercial	Product	TKI	Hydra
6.ab.1	Vibratory hammer drill with regard to its excitation cell	KER	Commercial	product	TKI	TKI
6.ab.2	Unbalance shafts with regard to changes in frequency and eccentric moment with constant centrifugal force and constant hydraulic input parameters	KER	Commercial	product	TKI	TKI

# TRL scaling roadmap for KER 1 (time and resources allocation)



- TEST OF PERFORMANCE AND FUNCTION  
 - Design and install the real demo-site

▶ **TRL 7:**  
**System prototype demonstration in operational environment**

- START OF PRE SERIES PRODUCTION  
 - Marketing dissemination of the new prototype

▶ **TRL 8:**  
**System complete and qualified**

- START OF SERIES PRODUCTION  
 - Industrialization of the new prototype

▶ **TRL 9:**  
**Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies)**

# Conclusions

Analysis from the **point of view of end USERS** implementing the solution and a “reservation price” → **P.P. of 2-15 years** are observed for alternate commercial offerings → **Conditioned** by different building typologies and uses as well as energy prices being applied

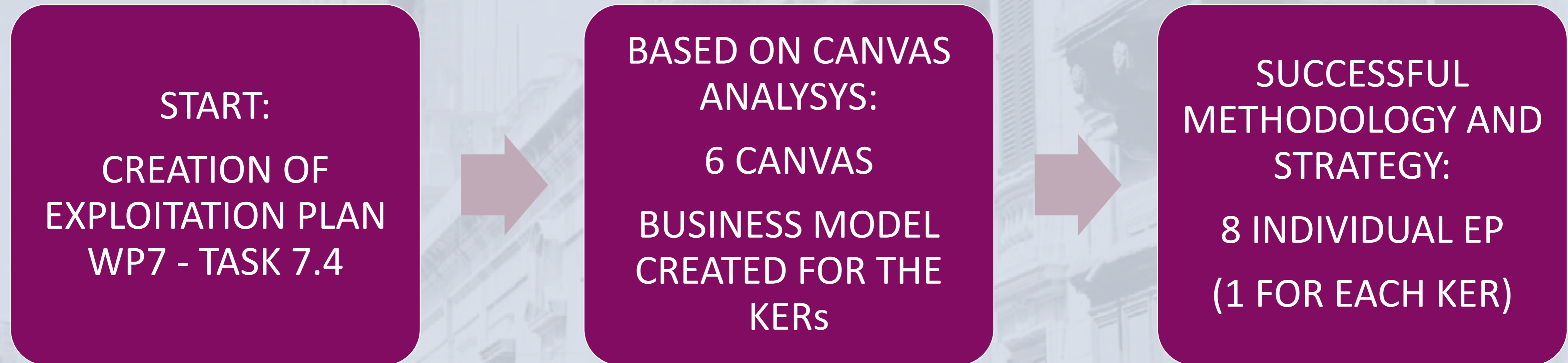
Predictably, some of the driving factors towards **higher economic performance** of the GEO4CIVHIC solutions are **low electricity prices** and **high gas prices**, areas with **high heating and cooling demand** and the **scale of the building** where it is being implemented.

The solutions, **despite higher initial investment** costs offer substantially **improved economic KPIs** than traditional retrofits such as gas boilers in terms of discounted **ROIs** and **NPVs**.

Financial assessments have been conducted using a combination of **Technology Readiness Level (TRL)** and **Future Discounted Cash Flows (FDCF)** analysis → Valuable information on **how these GEO4CIVHIC products can be effectively commercialized in the MARKET in the future**.

This insight remains relevant even as the overarching concept of the business plan takes shape, based on the chosen business model.

# Exploitation Plan to increase the commercial attractiveness and the penetration of GSHP systems



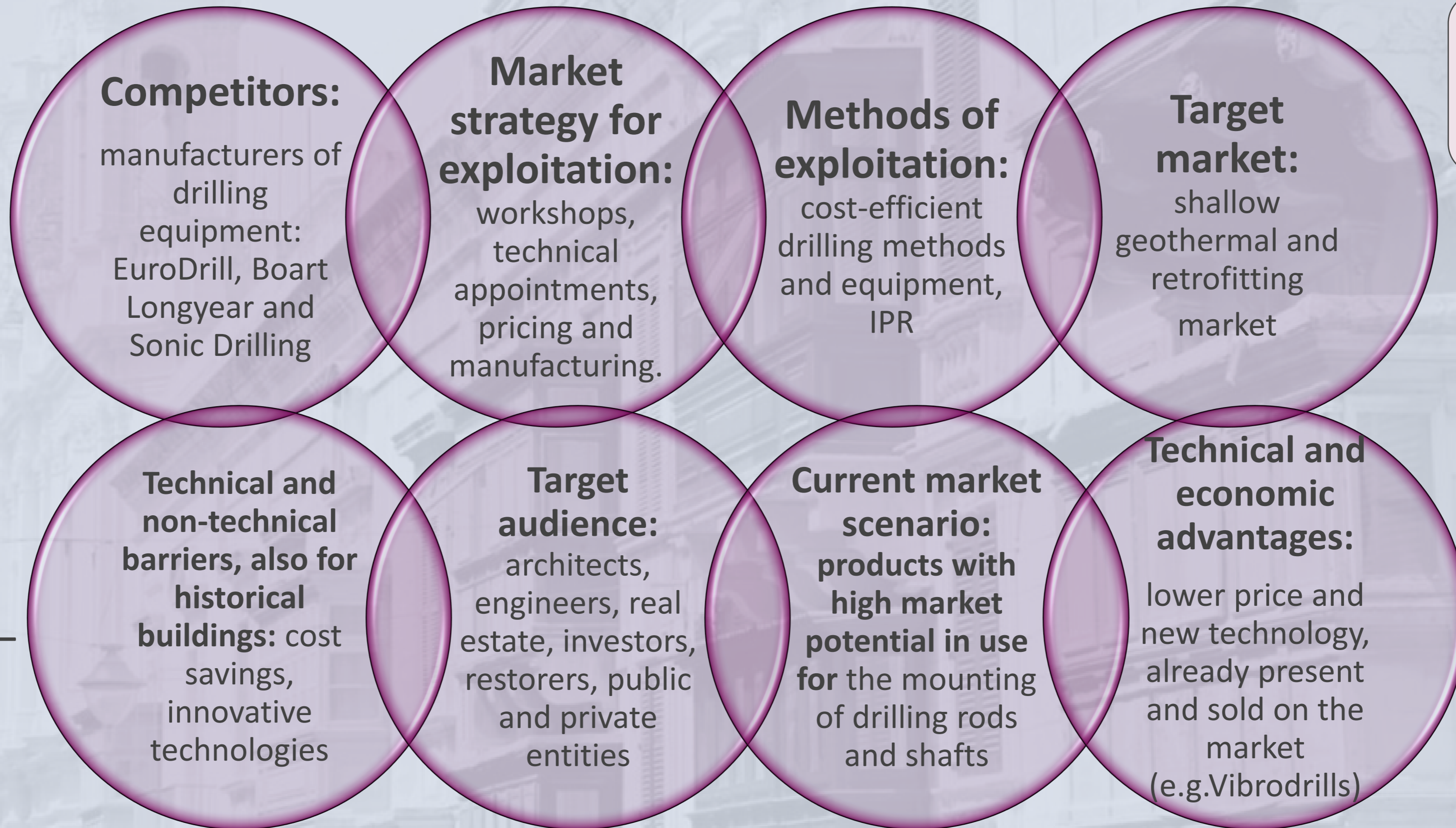
## Objectives:

1. Creating an EP for commercial attractiveness and touching the market with the developed products and services: **market analysis and obtaining 6 Canvas models for business model creation.**
2. Identifying stakeholders and strategic approach for these categories: **database stakeholders created.**
3. Applying the GEO4CIVHIC Business Model Creation to EP: **8 individual EP and partners are already selling products&services.**

# Market data analysis – European and national level

## CANVAS ANALYSIS

## BUSINESS MODEL



### Energy efficiency targets:

Annual investments demand up to **68 billion euros** for building retrofits until **2023**, **4.25 trillion euros** for energy efficiency investments across the economy between 2011 and 2050 – **80%** reduction in EU greenhouse gas emissions.

1. No competitors identified on the retrofit market.
2. The market offers an optimistic feed-back for receiving the products.
3. Products already present and sold on the market.

# Exploitation Plan – Channels/Identified stakeholders & Targeted actions

KER	Exploited by	Channels/Identified stakeholders	Targeted actions for commercialization
1, 2, 3	Galletti-Hiref	Architects, Engineers, Constructors, Historical buildings owners (private and public), Restorers, R.E Investors	<ul style="list-style-type: none"> <li>- Manufacturing, Sales and Distribution after the end of the project</li> <li>- Workshops with specialists and non-specialists</li> <li>- Communication campaign</li> <li>- Further research / <b>Patent release</b> – agreement for exploitation</li> </ul>
4, 5	Hydra	Drillers involved in shallow geothermal installations	<ul style="list-style-type: none"> <li>- Manufacturing, Sales, Consultancy, Training, Distribution</li> <li>- Further research</li> <li>- Participating at targeted events and demonstration activities - <b>Patent release</b></li> </ul>
6	TKI	Geothermal drilling business up to 120m depth Europe-wide and geothermal drilling companies	<ul style="list-style-type: none"> <li>- Manufacturing VibroDrills, further research is going on even without Geo4Civhic money, sales and marketing is going on worldwide, training of customers, servicing the VibroDrills</li> <li>- 5 units of new VibroDrills VD80 and 3 units of VD105 already sold.</li> <li>- The machines are running all over Europe</li> <li>- Technical appointments with civil and industrial engineers of drill rig manufacturers (OEM business) and with drilling companies in the geothermal drilling business – <b>Trade secrets</b></li> </ul>
7	RED-HYDRA	Architects, Engineers, Constructors, Historical buildings owners (private and public), Restorers, R.E. Investors	<ul style="list-style-type: none"> <li>- Manufacturing, Sales and distribution after the end of the project</li> <li>- Workshops with specialists and non-specialists</li> <li>- Communication campaign</li> <li>- Further research – <b>patent</b></li> </ul>
8	Individual KER owner	All categories of stakeholders	<ul style="list-style-type: none"> <li>- Implementing GEO4CIVHIC integrated solutions - <b>Non-equity strategyc alliance</b></li> </ul>

# Individual Exploitation Plan Results

- All the 19 project partners initiated **different strategies** for the Individual Exploitation plan.
- The owners and contributors customized **their individual exploitation plan** according to their **specific business model** and the **market demand** specific in their country.
- **Financial analysis data** regarding KERs is confidential and already detailed in D7.6, but the main conclusion is that the technologies developed in GEO4CIVHIC project have a huge **potential on market commercialization**.
- DLH, SOL, CRES, SUPSI – express the **interest** to further use **projects results** in further research and/or in other projects.
- Each **KER** has its own individual exploitation plan as seen in **D7.5** and it is based on the **strategic pillars**: key activity, target, stakeholders, area of impact, objectives, dimension, scale up, method of protection, roles, benefits, strategies, methods of exploitation, outcomes future impact.
- The **growth of financial indicators** show that the technologies developed in the project stand for a positive impact on the market **for the next 10 years**.
- The **products developed** in the GEO4CIVHIC project are **safer, faster, that the drilling can be performed by a lower number of workers and ensuring lower costs** (*e.g. the products developed by TKI are 50% cheaper than the competitors'; TKI has double the experience the other competitors on the market have; the products developed by Galletti generate the possibility to match high temperature water – with multi sources units*).
- The **actions** that are included in the **exploitation plans** are continuously **reviewed and updated** for assuring the future activity for the projects' results for minimum **4 years after the end of the project**.

# THANK YOU

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