International Conference

GEO4CIVHIC

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

15th November 2023

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

Co-funded by the European Union

GEO4CIVHIC

Environmental Impact & Standards for Shallow geothermal systems in historical buildings

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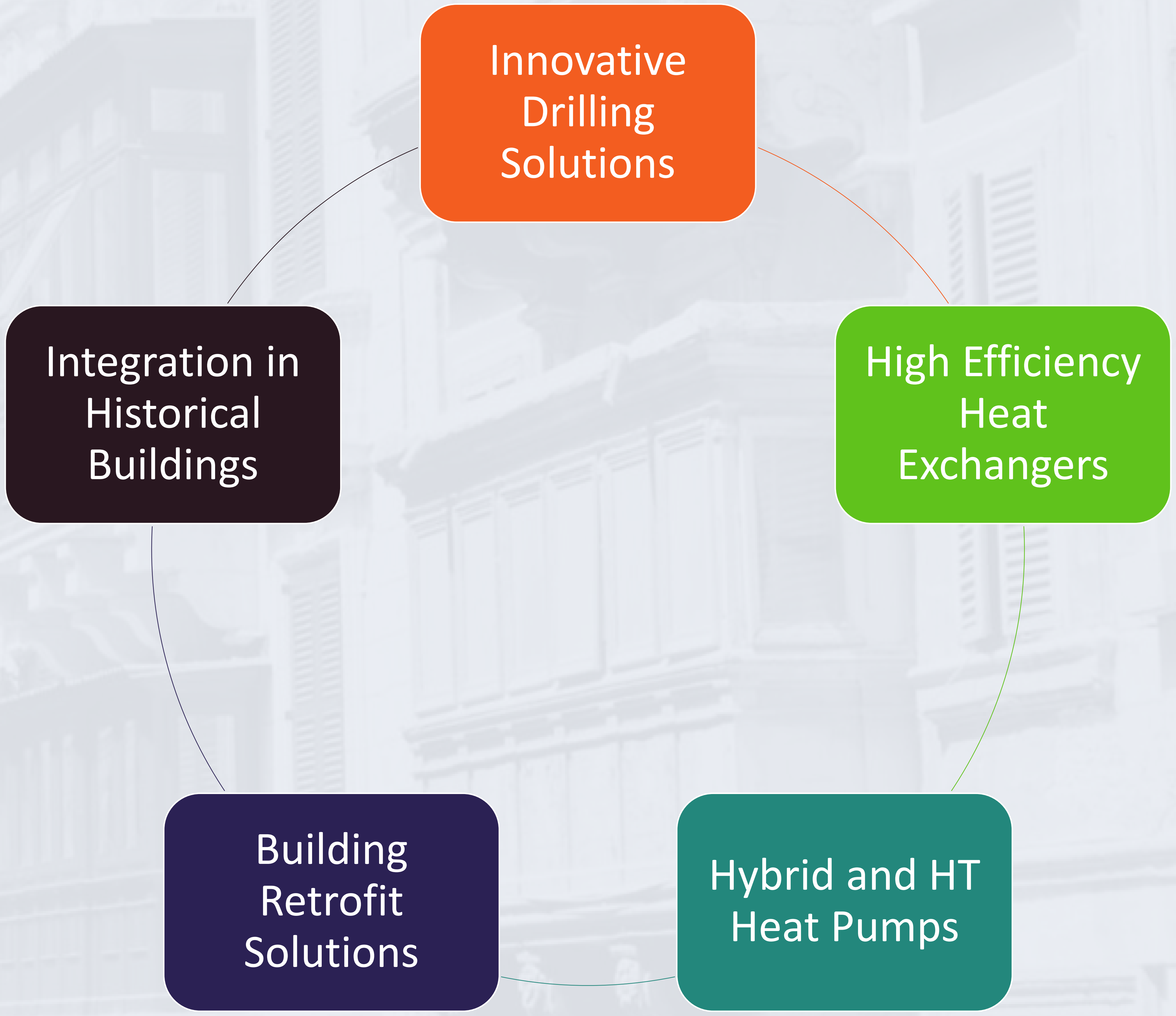
Environmental Impact of New Technologies

- Assess Environmental Impacts at Real Case Study Sites
- Perform LCA
- Compare with market alternatives
- Demonstrate Environmental Benefits in the Built Environment
- Recommendations to European & local Standards



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Environmental Impact Of Project Technologies – Assessment Methodology

Construction Phase → Drilling Process → Heat Exchanger Installation → Plant Room & Retrofit

Operational Phase → CO_2 emission saving → Ground Temperatures → Building Comfort

Baseline Condition
- Define the receiving environment

Proposed Development
- Define Impacts on Receiving Environment

Assess Impact & Mitigation Measures
- Define Residual Impacts

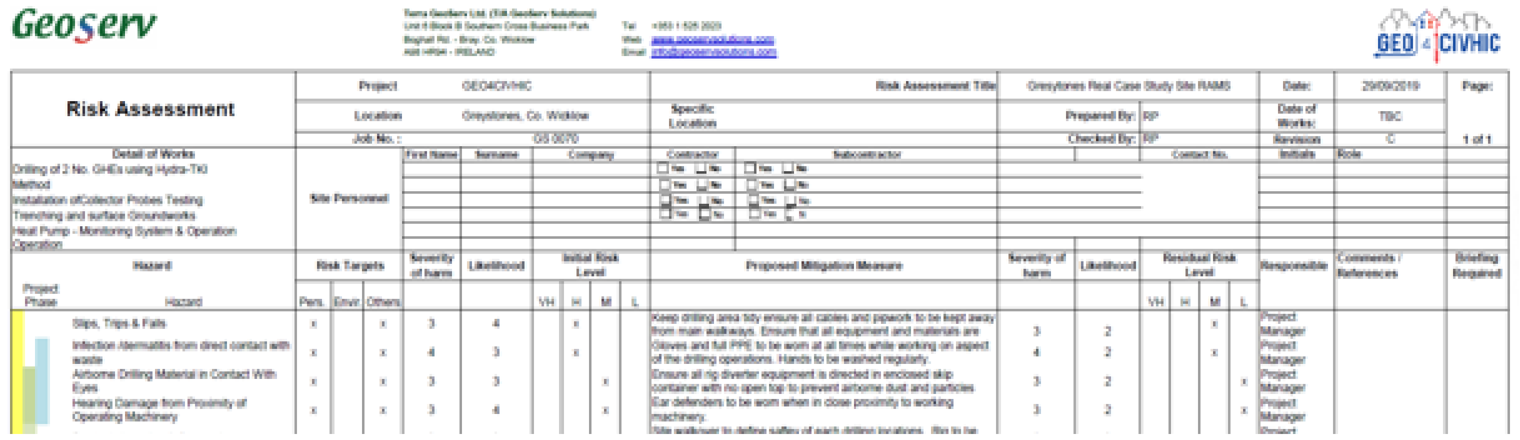
RISK ASSESSMENT

Live Risk Register

Site specific

Working Document

for risk mitigation



Site Specific Measurements

Topics	
1	Summary of the Development
2	Project Description
3	Soils & Geology
4	Hydrology & Hydrogeology
5	Air Quality & Climate
6	Traffic and transportation
7	Noise & Vibration
8	Landscape and Visual
9	Cultural Heritage

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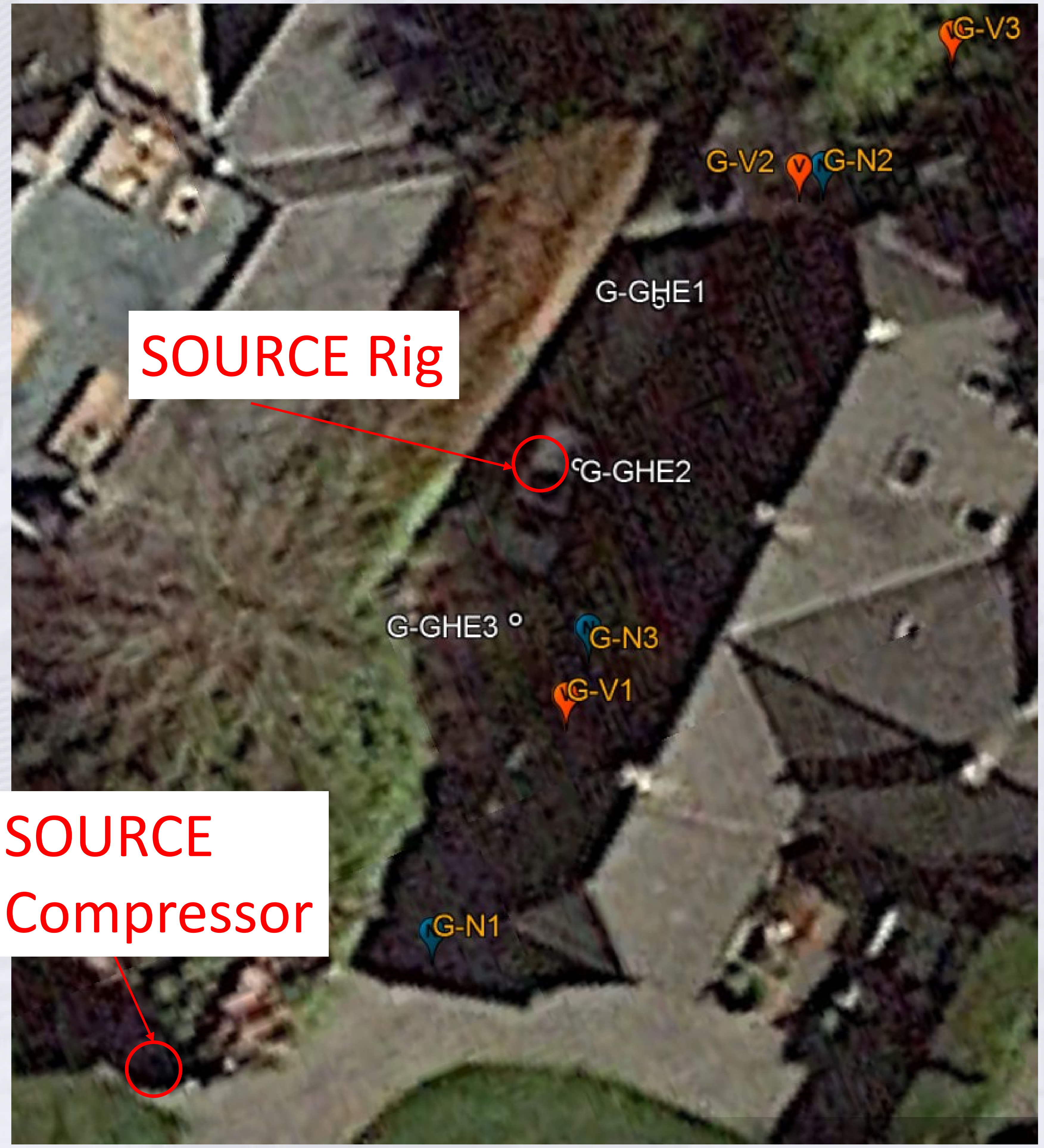
Environmental Impact Assessment

Construction Phase Noise – Example from Ireland

Measurements from Greystones

Monitoring Point	Activity	Distance (m)	dBA (Max)
Baseline			55.6
G-N1	Drilling	14	112.3
G-N2	Drilling	10	110.4
G-N3	Drilling	8	99.3



Drilling GH2

2 No. Noise sources (rig/compressor)

Noise twice the baseline limit

Site configuration and presence of walls

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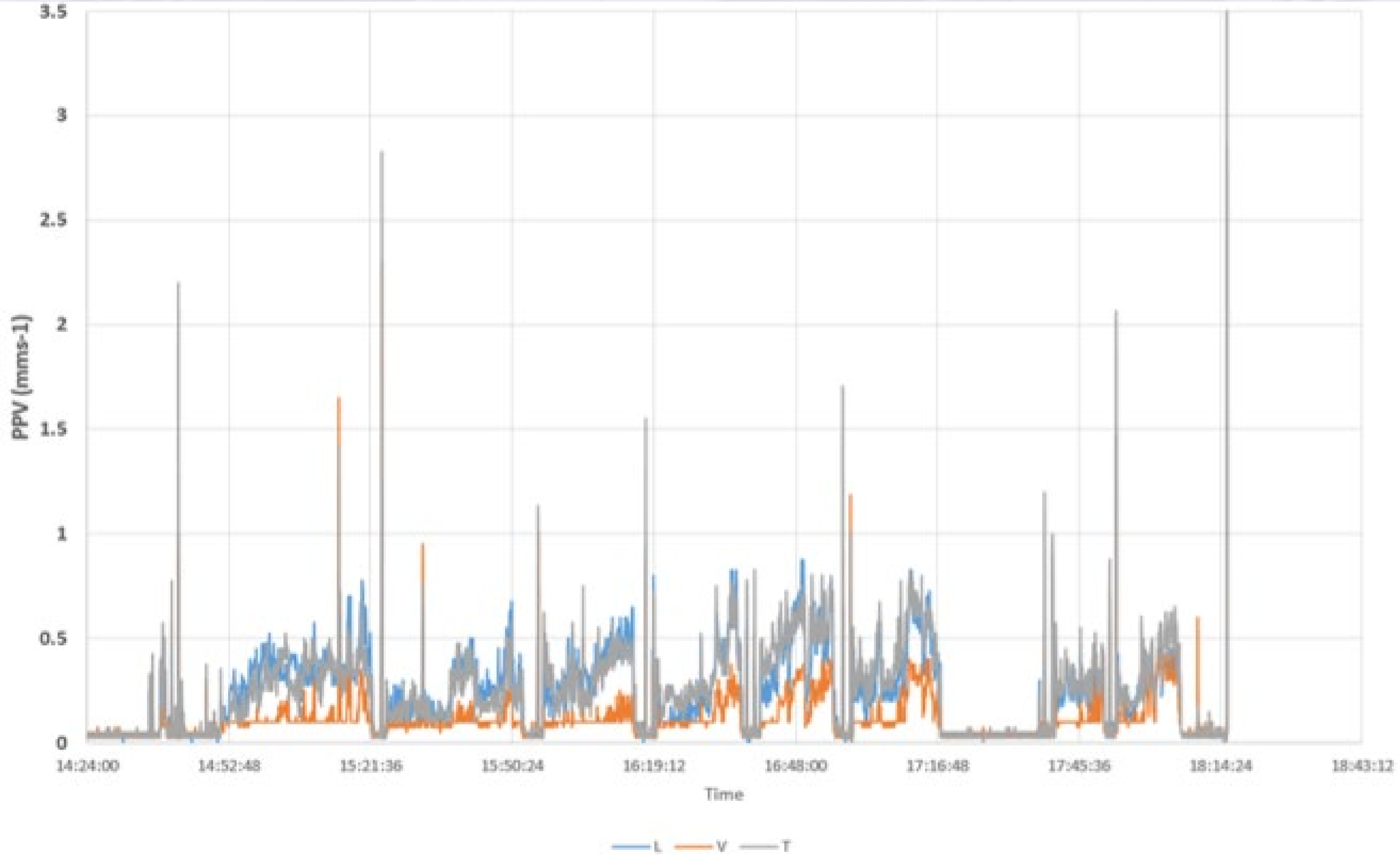
Environmental Impact Assessment

Construction Phase Vibration – Example from Malta

Close presence of building structures at Msidia Bastion - Malta Case Study

Hydra –TI Vibrodrill Method

All PPV values within DIN & BS standards for buildings & sensitive structures



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Environmental Impact Assessment

Overall Results from 4 Case Study sites

Impact Assessment Matrix

Probability of Occurrence	Significance of Potential Impacts			
	Significant / Profound	Moderate	Slight	Imperceptible
High	High	High	Medium	Low
Medium	High	Medium	Low	Near zero
Low	Medium	Low	Low	Near zero
Negligible	Low	Near zero	Near zero	Near zero

Conclusions

EIA key aspects	Malta – Msida Bastion	Ferrara Porta Degli Angeli	Battel - Belgium	Greystones - Ireland
Soils and Geology	Imperceptible	Imperceptible	Imperceptible	Imperceptible
Hydrology and Hydrogeology	Imperceptible	Imperceptible	Imperceptible	Low
Air quality	Low	Improved	Improved	Moderate Im-provement
Vibration	Low	Imperceptible	Imperceptible	Low
Noise	Low	Imperceptible	Low	Moderate
Traffic and Transportation	Low	Low	Low	Low
Landscape and Visual	Imperceptible	Imperceptible	Imperceptible	Imperceptible

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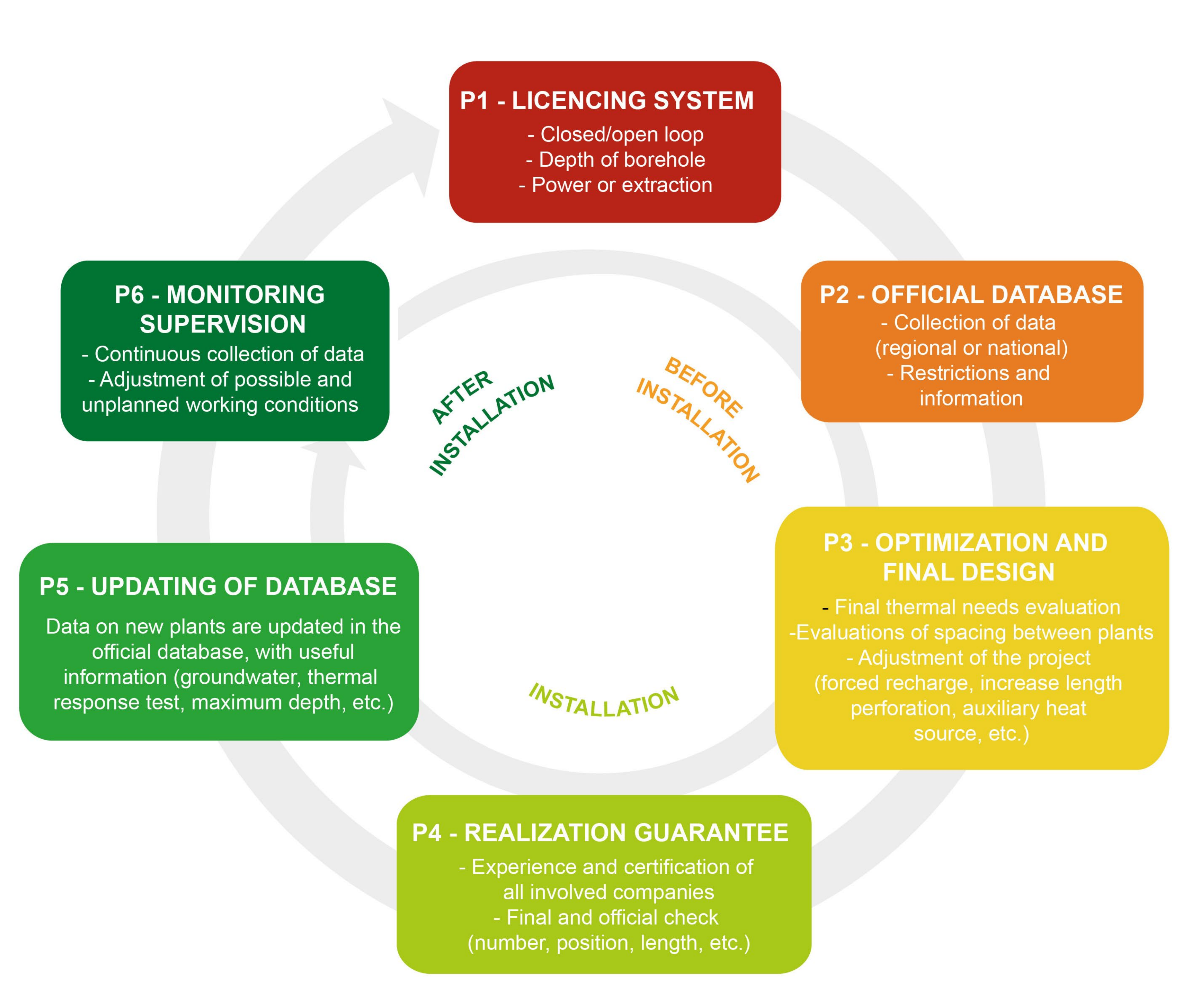
Environmental impact & Thermal Interference

Operation Phase - Proximity of heat exchangers in urban areas

1. Licensing system: clear system of procedure (national, regional,..).
2. Database shows restrictions and information (and near systems).
3. Optimization and final design (application of normative, standards, regulations, ..).
4. Certification and check of involved company (guarantee of the realization).
5. Update of the realized information into the database.
6. Monitoring shows if the system is working as planned



Public Deliverable

Paper on «Open Research»

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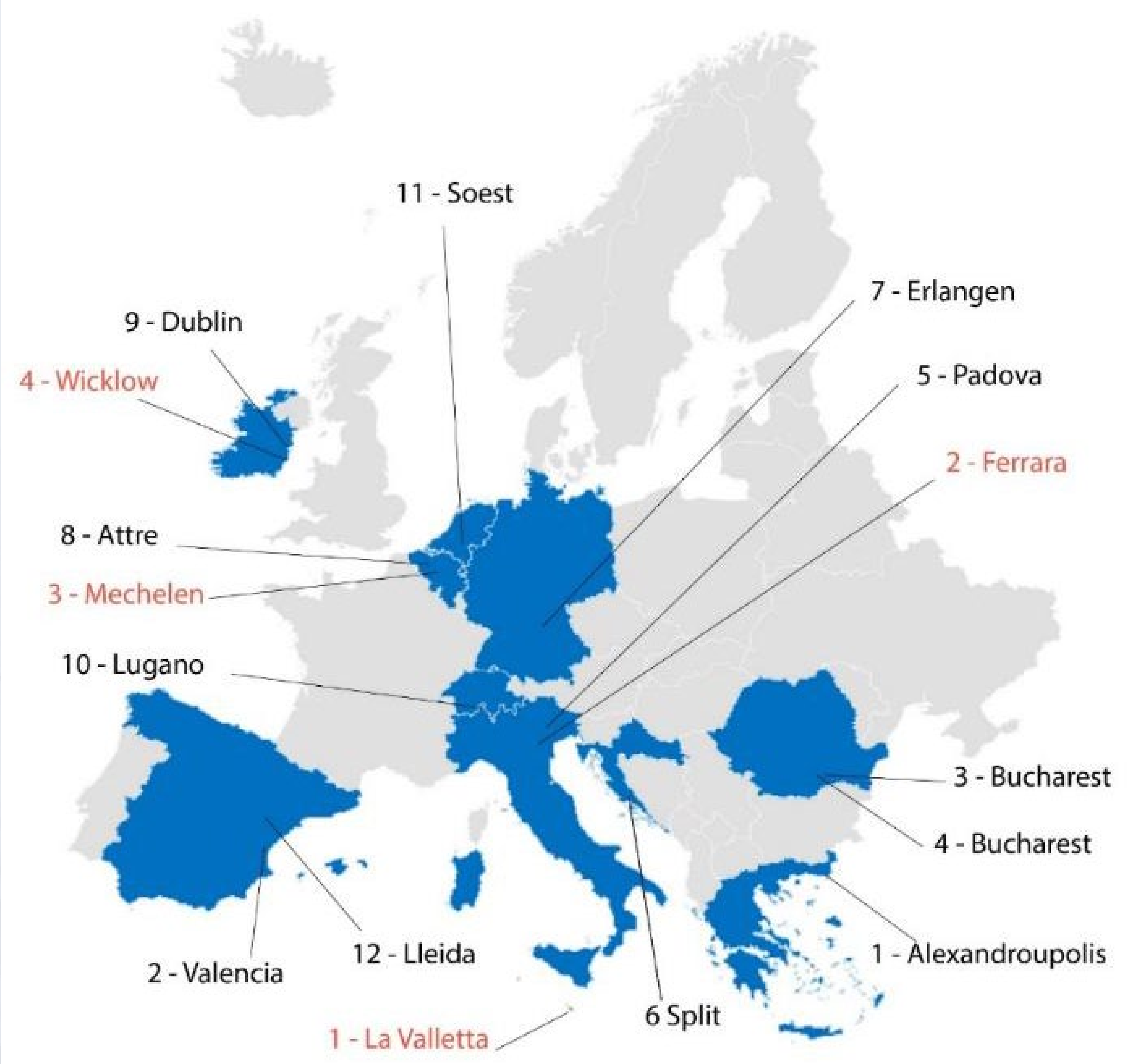
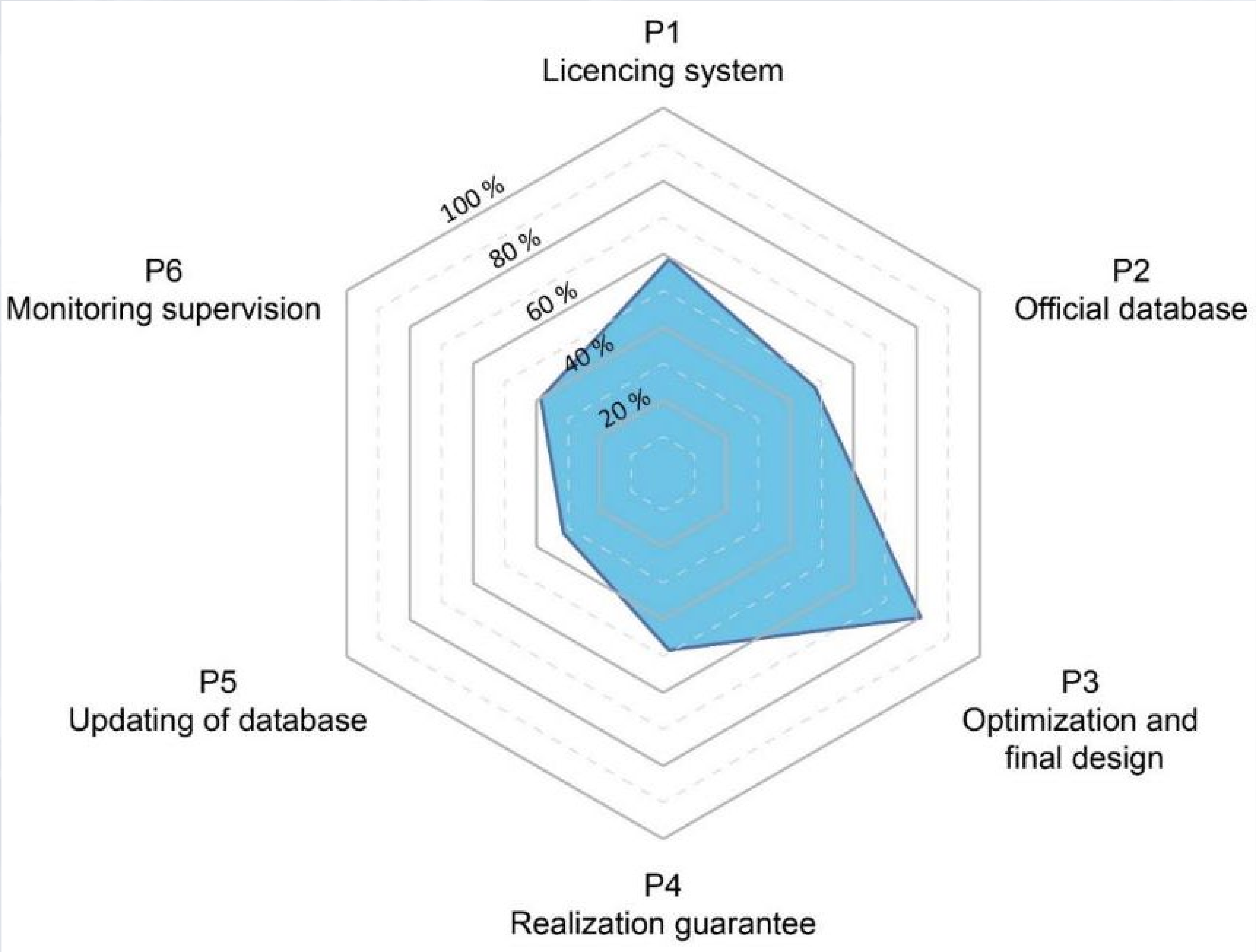
Environmental impact & Thermal Interference

The procedure has been applied to the GEO4CIVHIC case studies (12 pilot and 4 real), showing strengths and weaknesses





Development of 'ETHICAL' Freeware Tool for assessing Interference as part of the project

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LCA& Evaluation Of Carbon Footprint – Impact Categories

Objectives:

- Analyze The Environmental Impacts Of Project Developments
- Compare The Results With Traditional Technology
- Create Environmental Profiles Against Impact Categories
- Demonstrate The Benefits In Terms Of Reduction Of CO_2 Emissions
- Check Compatibility With LCA Standards

Environmental Impact Categories			
Indicator		**Unit**	**Source**
Global warming potential	**Fossil**	kg CO_2 eq	IPCC 2013
	Biogenic	kg CO_2 eq	
	Land transformation	kg CO_2 eq	
	TOTAL	kg CO_2 eq	
Ozone depletion		kg CFC-11 eq	CML-IA
Acidification potential		kg SO_2 eq	CML-IA
Eutrophication potential		kg PO43- eq	CML-IA
Photochemical ozone formation		kg C_2H_4 eq	CML-IA
		kg NMVOC eq	LOTOS-EUROS
Depletion of abiotic resources - elements		kg Sb eq	CML-IA
Total use of primary energy (Non-Renewable)		MJ	Cumulative energy demand
Total use of primary energy (Renewable)		MJ	Cumulative energy demand
Net use of fresh water		m^3	Flujos de inventario
Water scarcity potential		m^3 eq	AWARE

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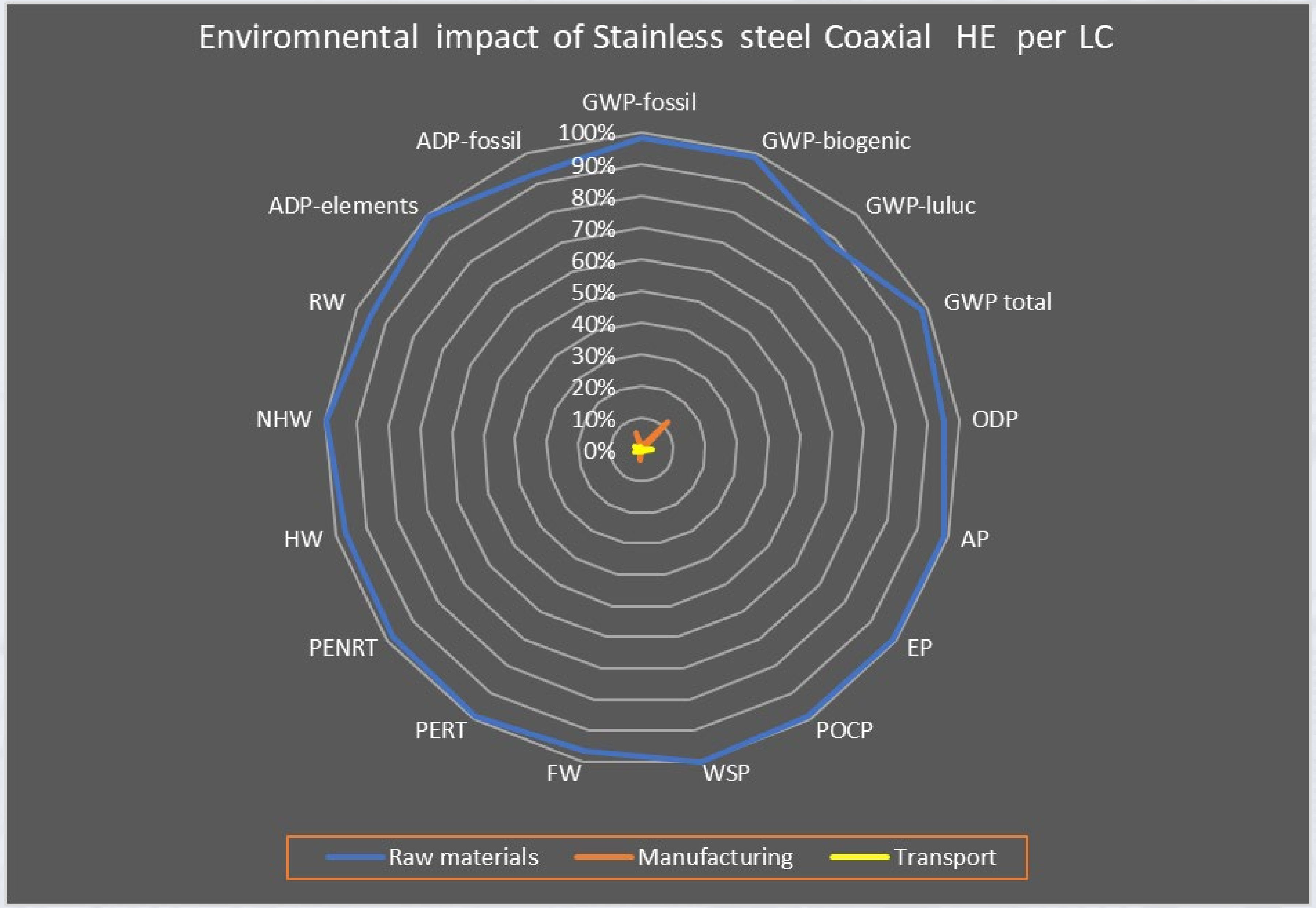
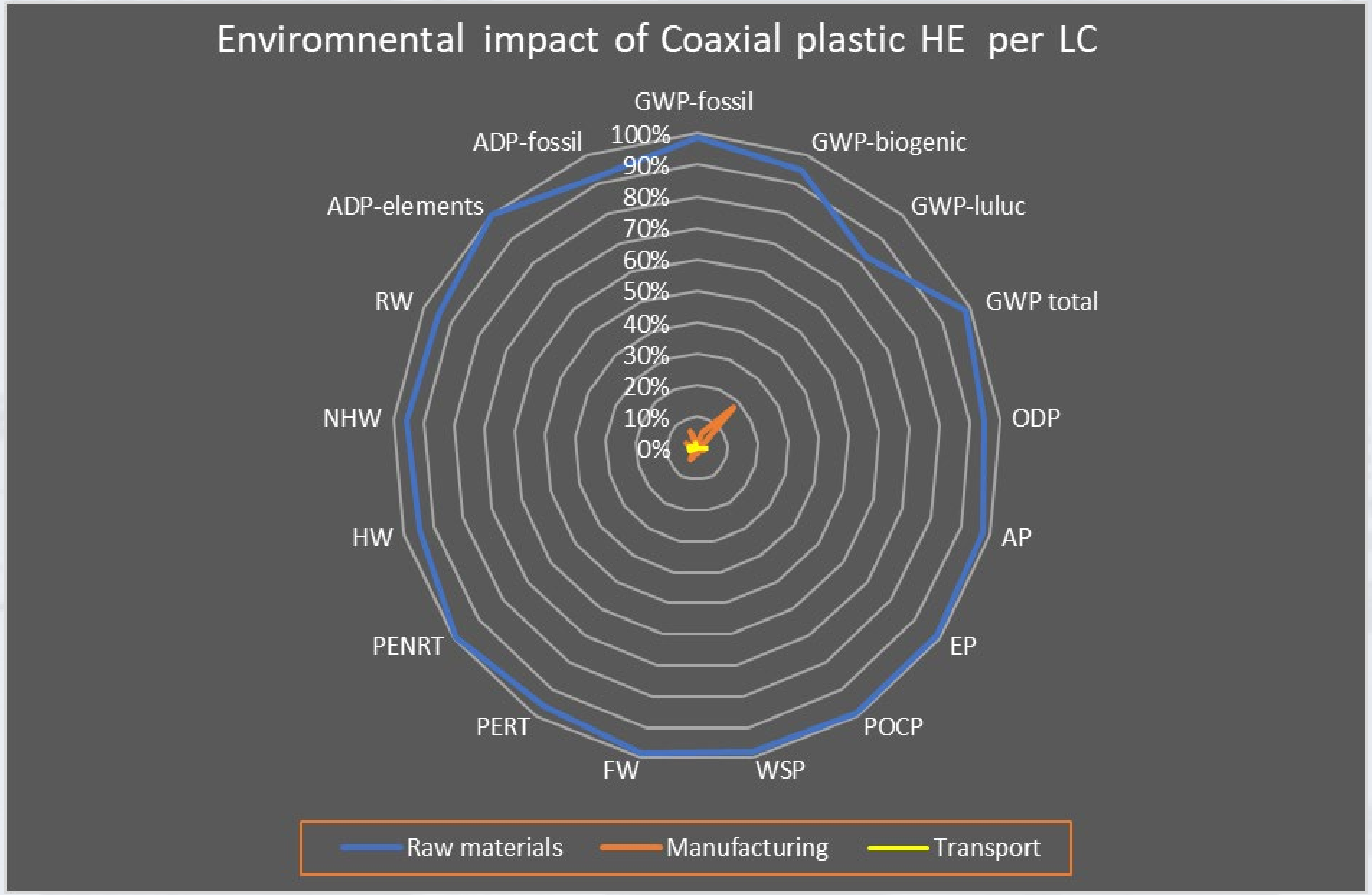
LCA & Evaluation Of Carbon Footprint – Heat Pumps & Heat Exchangers

HEs – Stainless Steel Coaxial has higher impact due to raw materials than the Coaxial Plastic HE





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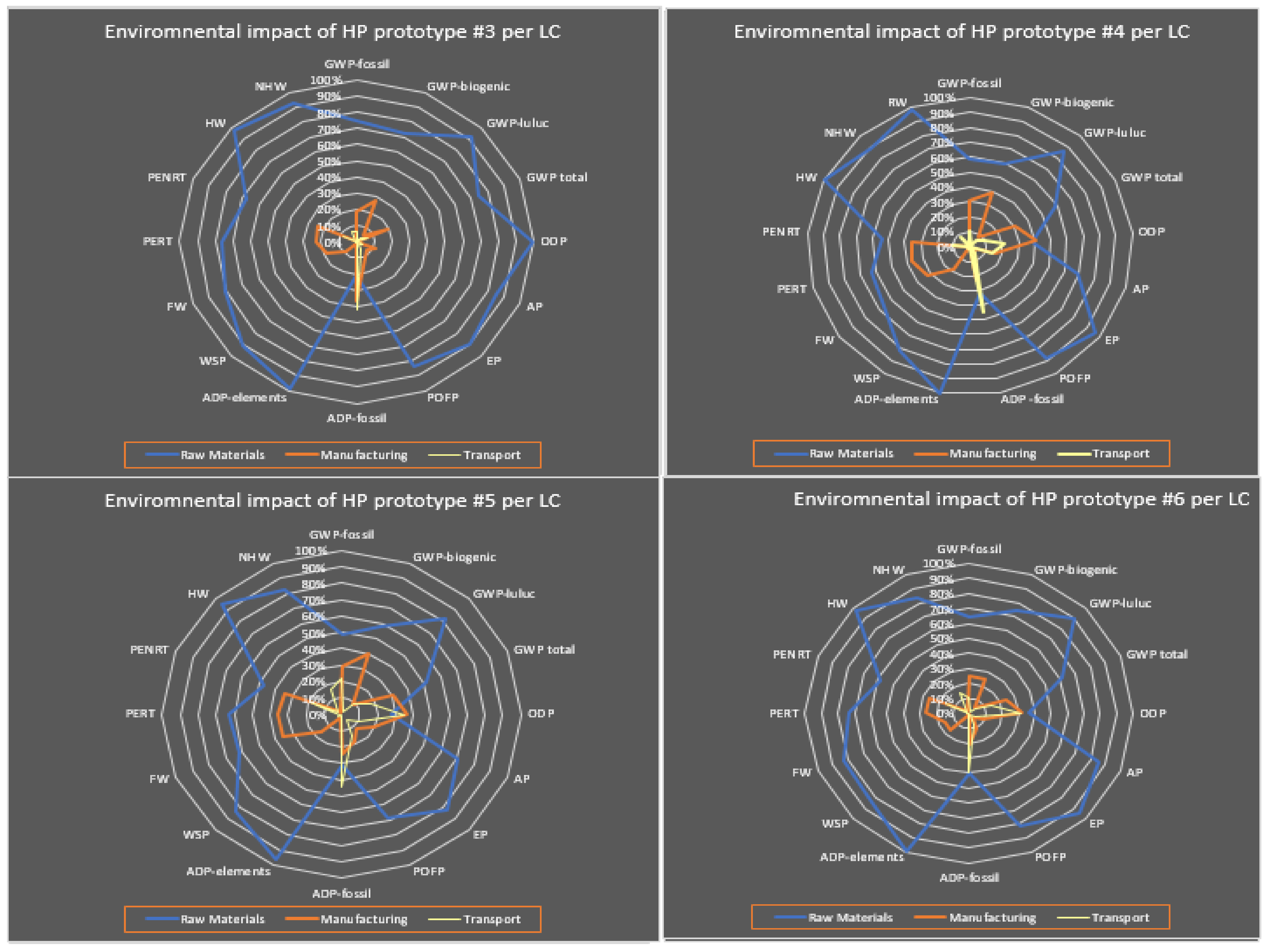
LCA & Evaluation Of Carbon Footprint – Heat Pumps & Heat Exchangers

HPs - prototype 6 (Ferrara) has higher environmental impact due to the quantity of raw materials and energy used during the manufacturing process.

Prototype 5 (Battel) contributes the least.



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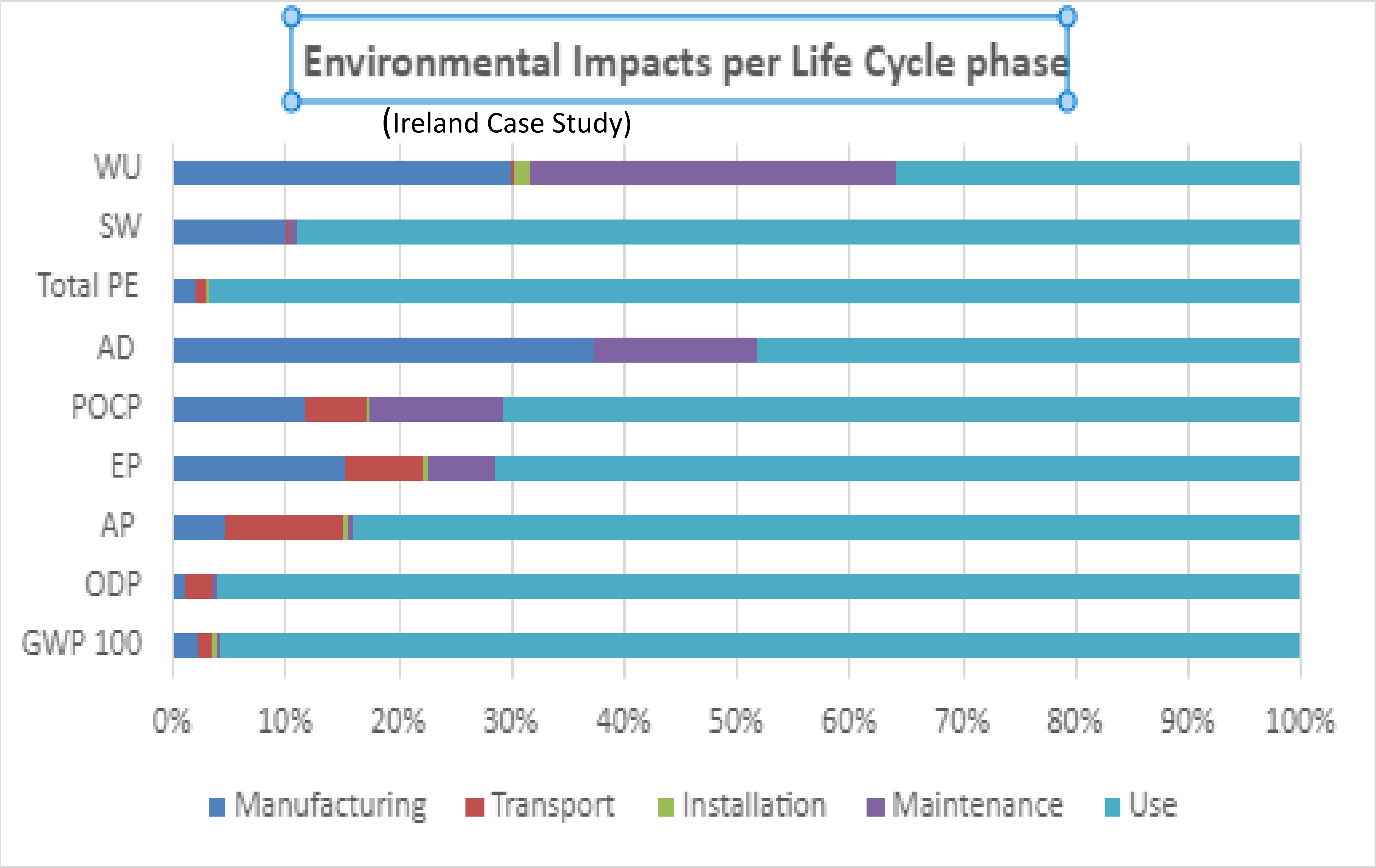
LCA & Evaluation Of Carbon Footprint LCA Case Study site Conclusions

The life cycle phase that has a higher environmental impact is the **operational phase**. This is due to the energy consumption of the heat pump during the service life period considered (50 years).

The **manufacturing phase of the HE** has the second highest impact, due to the steel raw materials.

The **installation, transport & maintenance phases** are not significant in terms of environmental impacts of the whole lifecycle.

Operational phase GHG emissions for the GSHP systems a range between **130 to 150 gCO_2 eq/kWh_{th}** for thermal energy generation.



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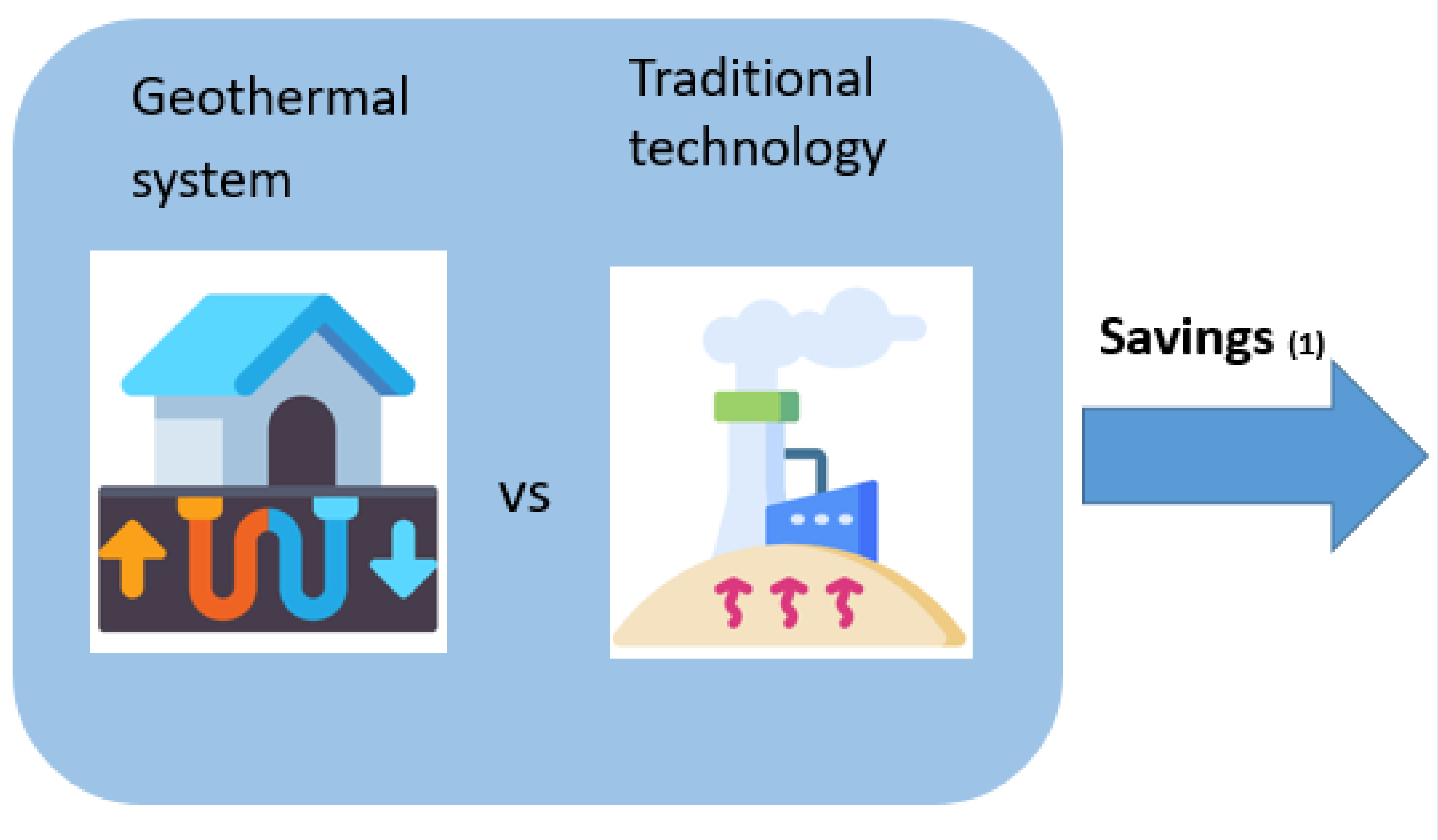
LCA & Evaluation Of Carbon Footprint - Environmental Benefits of project technologies



ANNUAL SAVINGS (2)			
UNITS	IRELAND	BELGIUM	MALTA
gCO2/kWh th	90	198	134
kWh penr/kWh th	0,36	0,64	0,60

ANNUAL SAVINGS (3)			
UNITS	IRELAND	BELGIUM	MALTA
gCO2/kWh th	184	125	131
kWh penr/kWh th	0,62	0,63	0,51

(1) Annual Savings achieved during the operation phase
(2) Annual Saving considered the **local electricity mix**
(3) **European electricity mix** has been considered in order to standardise the results

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European Standards in GSHPs & Historical Buildings

- Comprehensive Review of Standards & Guidelines in over 10 countries developed for SGEs since the 1980s
- Current situation of standards/guidelines on SGE at European level
- Active participation in CEN WG TC 451 on the development of (pr)EN 17522 and implications for GEO4CIVHIC technology
- Assessment of Relevance of national standards/guidelines for the GEO4CIVHIC technologies
- Review of CEN workshop Agreements completed as part of other projects (GEOFIT – prCWA XXXX:2022)
- Recommendations for the project technologies on:
  - for future activities in CEN and
  - national frameworks

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European Standards in GSHPs & Historical Buildings

Over 30 standards in 10 EU countries for GSHPs alone

Additional Discussion of National Standards on the following topics:

- Building Performance & Retrofit — 5 No. ISO/EN Standards (EPBD)
- Ground Source Heat Pump Systems — 5 No. for GSHPs, 4 No. for HPs, 1 No. for Drilling
- Historical Buildings — 2 No Principal Standards

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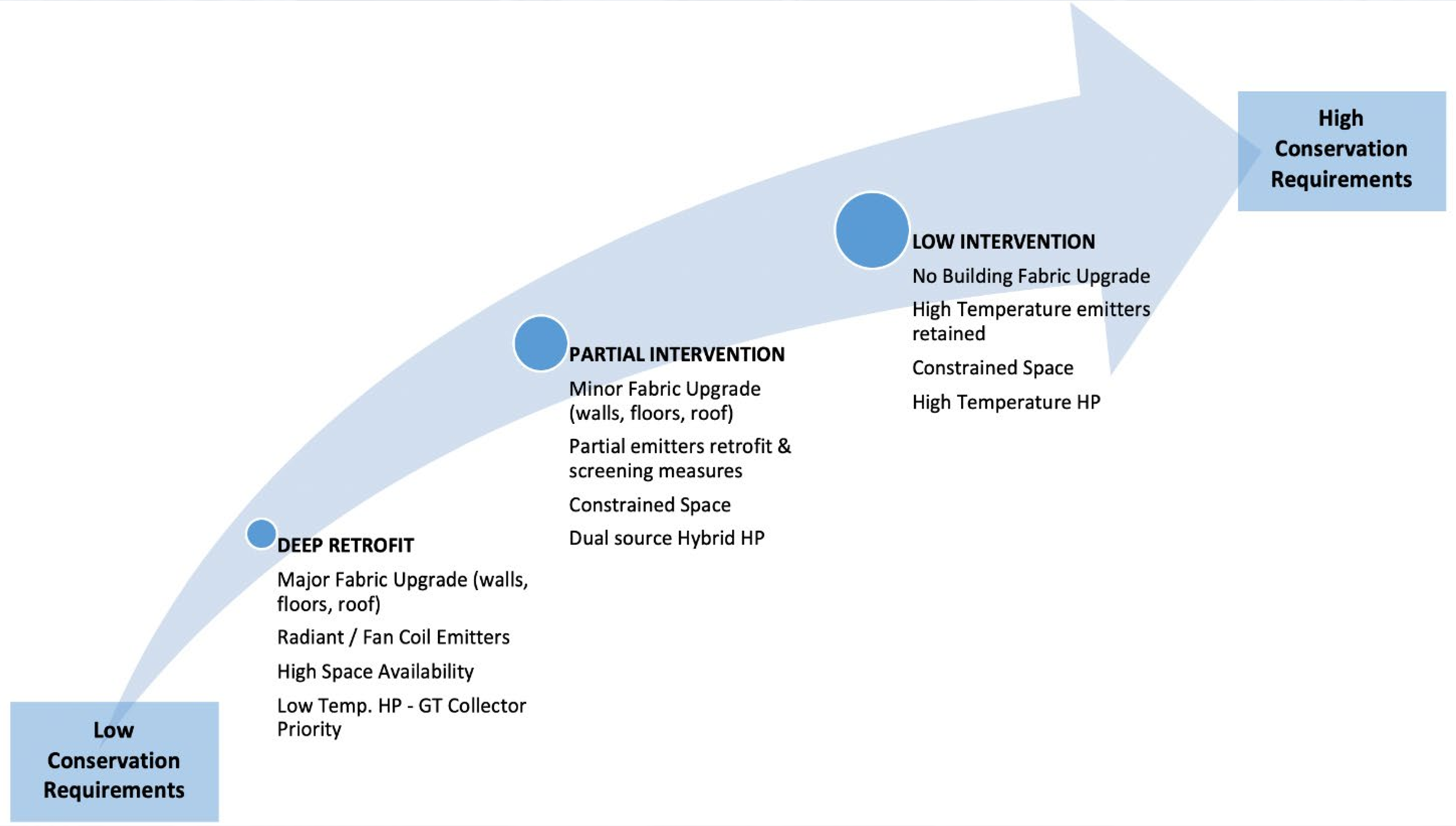
GSHPs & Historical Buildings

- Building character and historical listing grade;
  - External & Internal Element listing
  - Visual Impact
- Location of the site (dense urban areas) including surface area distribution and space;
- Building fabric and construction elements;
- Energy demand profile for heating/cooling
- Secondary side temperatures requirement;
- Subsurface characterisation;
  - Archaeology & Artefacts
  - Biodiversity
  - Existing Infrastructure
- Geothermal collector design specification;
- Management system and control strategy for operation.



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GSHPs & Historical Buildings

Recommendations for Integration into Historical Buildings:

Design & Retrofit

- Hygrothermal RA & U-Value Measurements
- Insulation Level
- Detailed Building Survey
- Secondary Emitters
- Temperature Requirements
- Geothermal System Design

Heat Pump Selection

- Plant Room Integration Options
- Secondary Temperature
- Space Availability
- Dual vs Single Source
- Hight Temperature Requirement

GSHP in Urban Setting

- Geothermal Field Space
- Rig Selection
- Drilling Method
- Neighbouring Systems
- Underground Infrastructure

Permits & Licensing

- Historical Buildings Intervention consents
- Planning & Construction permits
- Geothermal Permits for implementation

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THANK YOU

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