

# From static energy audits to dynamic living labs: A multi-stage audit system for carbon-neutral thermal spas in Austria

GEU.MAT

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Carina Seidnitzer-Gallien, Philip Gradl, Matthias Haas,  
Valentin Kaisermayer, Roman Stelzer, Sebastian Dragosits,  
Christian Berghofer, Christian Rotter, Johann Haas

# Energy-Intensive Thermal Baths

## THE CHALLENGE

~42

thermal baths in Austria

>20%

of operating costs is energy expenditure

75%

of spas use hydrothermal geothermal resources (32°C-104°C)

50–70 kt

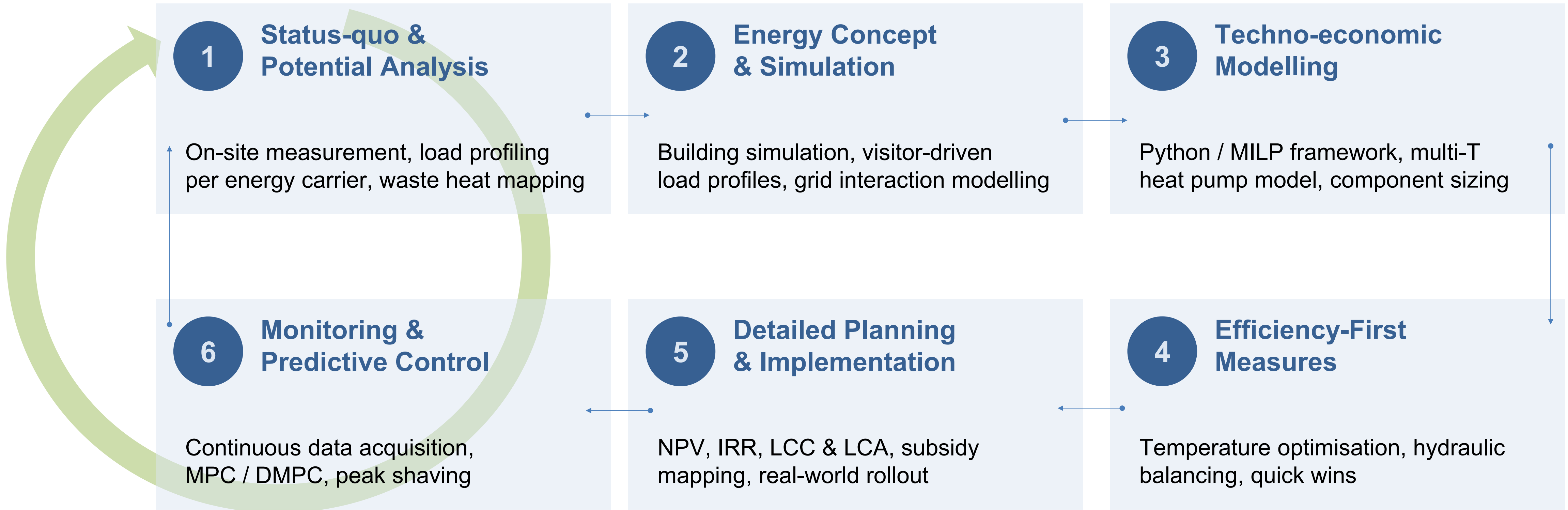
total CO<sub>2</sub>-emissions per year

⚠ **Research Gap:**

Static, one-time audits cannot capture simultaneous heating/cooling demands, visitor-driven stochastic loads, and temporally variable waste heat streams — a structural mismatch with this building typology.

# A Six-Phase Circular Audit Framework

CIRCULAR • CONTINUOUS • ADAPTIVE



∪ *Iterative feedback loop: Field Measurement → Validated Simulation → Real-World Control → Model Refinement*

# Results and testing at two demonstration sites

EMPIRICAL EVIDENCE

## Living Lab 1 · H2O Hoteltherme



Heat demand (biomass) ~6.4 GWh/a

Electricity (grid) ~3.4 GWh/a

Waste heat potential (splashing water) ~1.8 MWh/d

Waste heat potential (HVAC exhaust/summer) ~5.6 MWh/d

Control strategy **MPC**

## Living Lab 2 · Sonnentherme



Heat demand (nat. gas) ~16 GWh/a

Electricity (PV & grid) ~4.8 GWh/a

Waste heat potential (splashing water) ~4-5 MWh/d

Waste heat potential (chiller/summer) ~2.6 MWh/d

Control strategy **DMPC**

### Beyond static audit paradigms

This work advances a self-improving, data-driven audit cycle — iteratively linking field measurement, validated simulation models, and real-world MPC/DMPC implementation.

## Efficiency increases of geothermal energy systems with heat pumps

### Research



### Demonstration partners



### Planer & Technology provider



Project-Website



Kontakt

Carina Seidnitzer-Gallien  
[AEE INTEC \(lead\)](mailto:c.seidnitzer-gallien@aee.at)  
[c.seidnitzer-gallien@aee.at](mailto:c.seidnitzer-gallien@aee.at)