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Methodological approach for recovery and energetic requalification of historical buildings

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Summary - Keywords

Energy efficiency and energetic refurbishment of historical building heritage

- Historical buildings' energy performances
- Refurbishment strategies for active energy systems
- Heating & cooling systems in historical buildings

Heat pumps and Hydrothermal energy

- Hydrothermal energy in European Directives
- Heat pump solutions
- HP application to hydrothermal energy

Proposal for hydrothermal energy use in Trieste

- Proposal context
- Project concept
- Solutions' evaluation

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Historical buildings' energy performances

Historic heritage is frequently excluded in the scope of the regulatory framework concerning energy efficiency and environmental sustainability in buildings.

European Directive 2002/91/CE

Following **goals**:

- **reduction of emissions of GHG**;
- **increase of RES use**,

must also pass through upgrading the energy efficiency of existing buildings, **including high value historical - architectural built heritage**, subjected in Italy to D. Lgs. 42/2004 concerning the protection of cultural heritage.

In Europe, however, the legislation on preservation of historical built heritage doesn't consider their energy efficiency and following actions.

Historical buildings' energy performances

The primary issue in **upgrading energy efficiency in historical buildings** – concerning HVAC systems too – is to identify **performance** specifications that could be **objectively reached** in this context.

Goal:

Identification of performance levels

in order to:

Recognize its energy characterization

Maximize potential in passive use of energy

Historical buildings' energy performances

It would be appropriate to assess the effectiveness of complex actions on historical buildings (considering envelope and systems) focusing on **energy efficiency specific improvement** of **each subsystem**, not requiring the achievement of law performance levels.

BUILDING ENVELOPE

- opaque envelope
- windows and openings
- passive ventilation
- infiltration
- natural lighting

ENERGY SERVICES

- heating
- cooling
- mechanical ventilation
- hot water
- lighting
  - issue – emission
  - distribution
  - control and regulation
  - storage
  - generation

Historical buildings' energy performances

Referring to H & C plants, it could be hard to achieve renovation actions in all of them in order to **reach overall objectives in performance efficiency**:

- impossible or not economically advantageous action in one or more of energy subsystem;
- energy system, contemporary to the building, to be preserved.

The possible **targets** in improving energy efficiency in historic buildings, with maximum flexibility, **should be identified recognizing building similar in typology**, considering, if possible, what each single typology expresses in terms of…

characters	potential to enhance	constraints

in order to fulfill requirements arising from the needs of:

comfort IAQ conditions	durability of structure / surfaces	reduction of NRES use

Energy issues in historical buildings

In upgrading the energy efficiency in historical heritage is therefore necessary to equip them with **plant networks capable of meeting the needs of comfort and reduce energy consumption** appropriately to contemporary standards, related to the typological characteristics, distribution and technology of the building.

The energy balance terms to consider in the definition of the energy performance in H & C context

transmission heat transfer	ventilation heat transfer
internal heat inputs	solar heat inputs

has to consider, i.e., heat accumulation phenomena in thermal masses; this behavior is peculiar of historical heritage and governs indoor climatic conditions.

Refurbishment of existing energy systems strategies

Thus, an **effective** and according with architectural and cultural characteristics **renovation** starts with the **analysis and understanding of the thermal behavior of the building** and the **interactions** it has **with the surrounding environment**.

It is possible to articulate a 3-tier-approach to achieve the goal of energy system plants' renovation in historical building, according to its valuable characteristics

III replacement / integration with new technologies

II recovery of existing facilities and plant spaces in original building

I upgrading the envelope performances evaluation / control of loads

Refurbishment of existing energy systems strategies

The inclusion of new technologies into total or partial replacement of existing system plants must be integrated into the existing structures, **without causing an intolerable formal, aesthetic or operational alteration**.

D. Lgs. 311/2006 + D. Lgs. 42/2004

Exclusion of buildings whose reduction of energy consumption goals involves an alteration of high-value characters

Renovation of technical facilities has to follow an adequate integration between new addictions and existing technical elements, in order to preserve historical content and considering the fundamental principles of

Minimum action

Reversibility

Refurbishment of existing energy systems strategies

About technical system plants in historical building heritage, some situations are distinguishable:

- Lack of technical facilities for a specific service. Thus, it is expected to be a considerable intervention, in which maximum attention has to be paid in positioning the different subsystem in the existing structure since the refurbishment project phase, considering any technical room, shaft, duct that can accommodate new distribution systems.
- Obsolescence of existing technical facilities. In this case there will be likely an element removal – if devoid of any historical value – and, consequently, the use of technical spaces for new plant elements.
- Partial possible reuse of existing technical facilities. This situation, occurring frequently for existing plants installed subsequently to the construction of the building, aims to the maintenance of elements acceptable – meeting specific performance requirements – and to the integration of these components in accordance with the new use.

Refurbishment of existing energy systems strategies

The insertion of new and modern technological elements in historical building is a sensitive operation, due to missing functional connection between new elements and existing structure; moreover, new operation phase for existing plants could not be practicable if plants themselves have to be preserved.

The inclusion of **new plant networks** is difficult because of following constraints

- preservation of integer structures
- preservation of facades
- preservation and thickness of floors
- spatial distribution of rooms and spaces

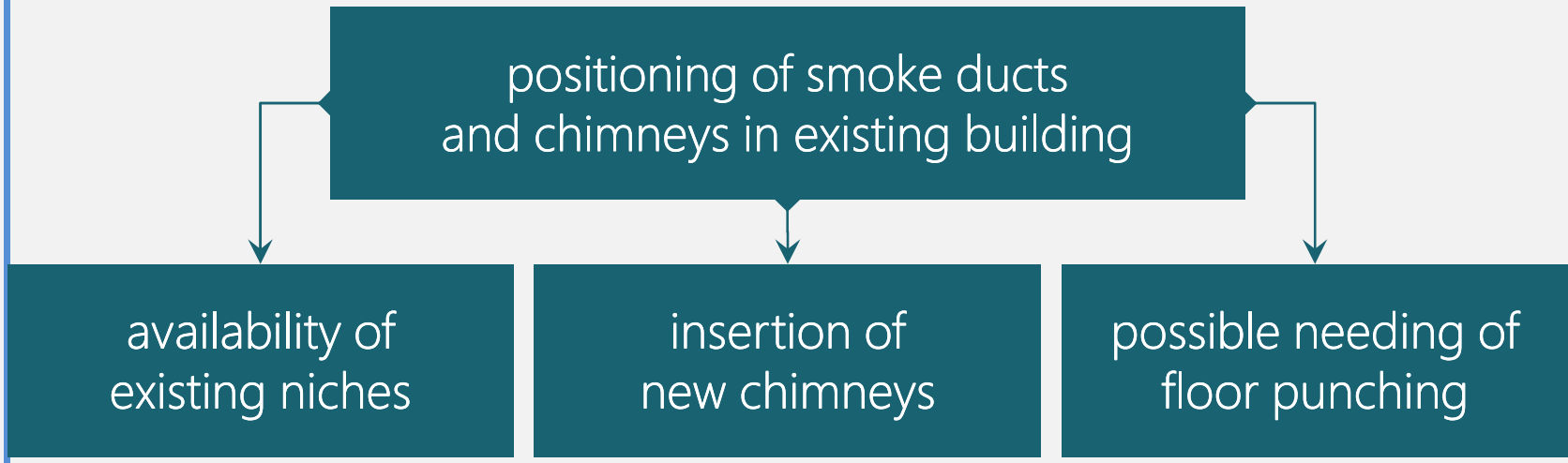
Refurbishment of existing H & C energy systems actions

New installation of energy systems in historical contexts must be examined in the project phase, according to criteria that govern the overall project. Several issues in planning new – or renewed – technical plants have to be considered, in particular

existing technical systems	possible upgrading of existing systems
location of production facilities	networks, pipes and ducts path
dimensions of technical spaces	countertops availability

Refurbishment of existing H & C energy systems actions

Heating service, achieved whether with **punctual systems** (fireplaces, stoves) or with **net-widespread ones** (using air or water as heat transfer fluid), presents anyway safety problem of **exhaust smoke evacuation** and, thus



Besides existing fireplaces and stoves represent an interesting situation as local integration of distributed systems.

Refurbishment of existing H & C energy systems actions

In new centralized H & C system project phase, several issues must be considered referring to each subsystem:

EMISSION	DISTRIBUTION	PRODUCTION
emitters' position operation conditions IAQ parameters visual impact	existing pipes / ducts pressure test needed technical spaces and paths availability static load control	technical spaces for facilities availability high consistency with existing subsystems safety in use visual impact

Intervention design concept derives from a compromise between the **needs** of comfort, durability, rational use of energy resources, and the possibility to use or obtain **adequate functional spaces** (technical rooms, skylights, existing net paths with appropriate performances, etc.), already identified in the architectural project.

Refurbishment of existing H & C energy systems actions

The first issue of choice and position of **emission** technical elements should be to preserve sensitive or valuable surfaces, thus considering their visual impact.

radiators / fan-coils		radiant floor
visual impact in historical context	o	practicable only with existing floor removal
dust moving by convection	o	applicable to specific height rooms;
only heating service (radiators)	o	relation with furniture
none humidity control	o	higher emission efficiency
best placement below windows	o	no dust movement driven
low installation costs	o	
flexible system (radiators)	o	

It is possible to combine multiple systems in the case of complex buildings, capable of working independently in specific thermal zones.

Refurbishment of existing H & C energy systems actions

A contemporary inclusion of new **distribution** paths can be carried out by

visible lines

- control of paths' visual impact
- architectural value preservation
- attention in different nets crosses

in-track lines

- availability and possible use of existing tracks
- valuable surfaces preservation
- structure scheme preservation

In both cases, crossings of vertical and horizontal partitions have to be made – whenever possible – in existing connections (windows' thresholds, baseboards, vertical shafts), by removing deteriorated pipes too.

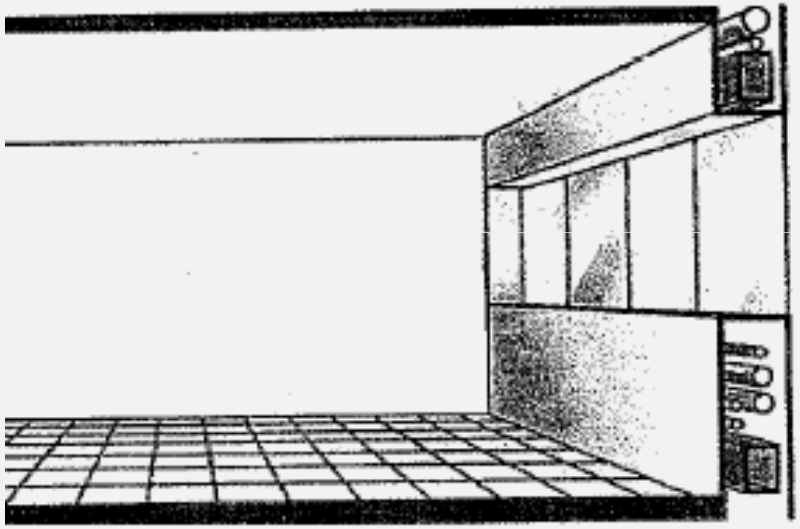
Moreover, grouping distribution lines is the best strategy to reduce tracks and drillings of partitions and floors.

easier maintenance

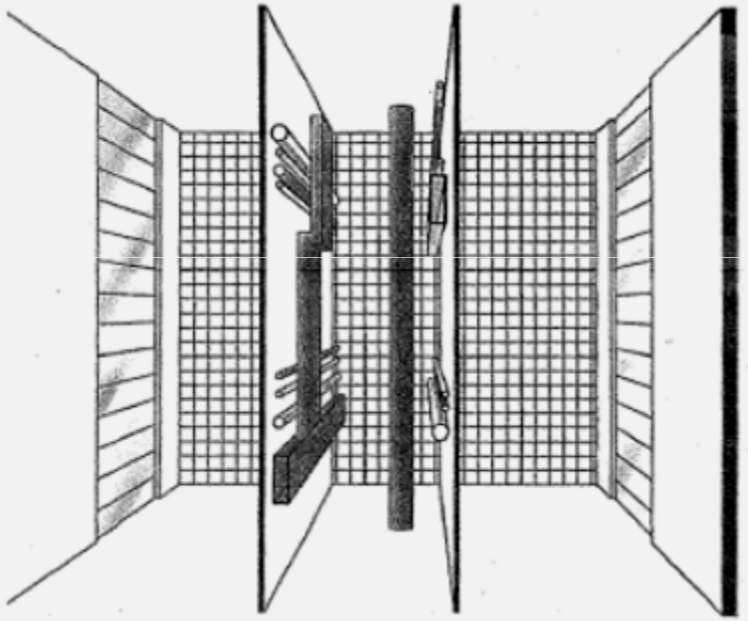
risk limitation

Refurbishment of existing H & C energy systems actions

An alternative solution may be represented by walls and or equipped corridors superimposed on the existing structures – not to be seen – that prevent tracks or punches needs.



net distribution on window technical spaces



equipped corridor

Refurbishment of existing H & C energy systems actions

In valuable situation, the position of **production facilities** must be defined first considering safety standards concerning thermal power plants.

Methane-powered equipment

- stringent limitations in position
- specific room needed
- sensitive situation about gas pipe
- exhaust fumes duct needed
- easy accessibility necessary
- existing stove changeover

Electricity-powered equipment

- visual impact problems (for air systems)
- specific room needed
- possible work during all year
- accurate evaluation of thermal loads to perform

In both cases, location acceptability is confirmed by availability of vertical empty ducts, stairs, technical spaces in which pipe and duct risers can be achieved.

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Hydrothermal energy in European Directives

Directive 2009/28/EC defines renewable energy (RE) those coming from renewable non-fossil sources, as

- wind energy
- solar energy
- aerothermal energy
- geothermal energy
- **hydrothermal and ocean energy**
- hydropower
- biomass and biogas
- landfill gases
- residual gases from sewage treatment

energy stored in the form of heat in surface water

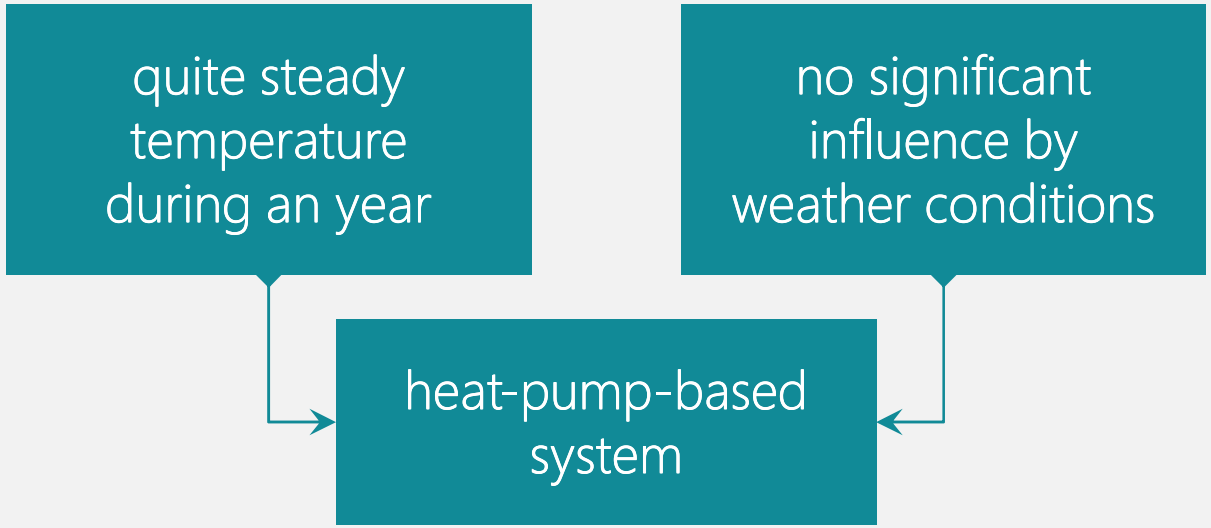
This definition doesn't take into account **energy contained in seas and oceans**.

Hydrothermal energy in European Directives

Actually, surface waters include including lakes, swamps, rivers, flowing wildly.

However, it is considered appropriate to **extend this definition** to **thermal energy stored in the seas and oceans** which, in appropriate conditions, is a valuable resource aimed at a possible exploitation.

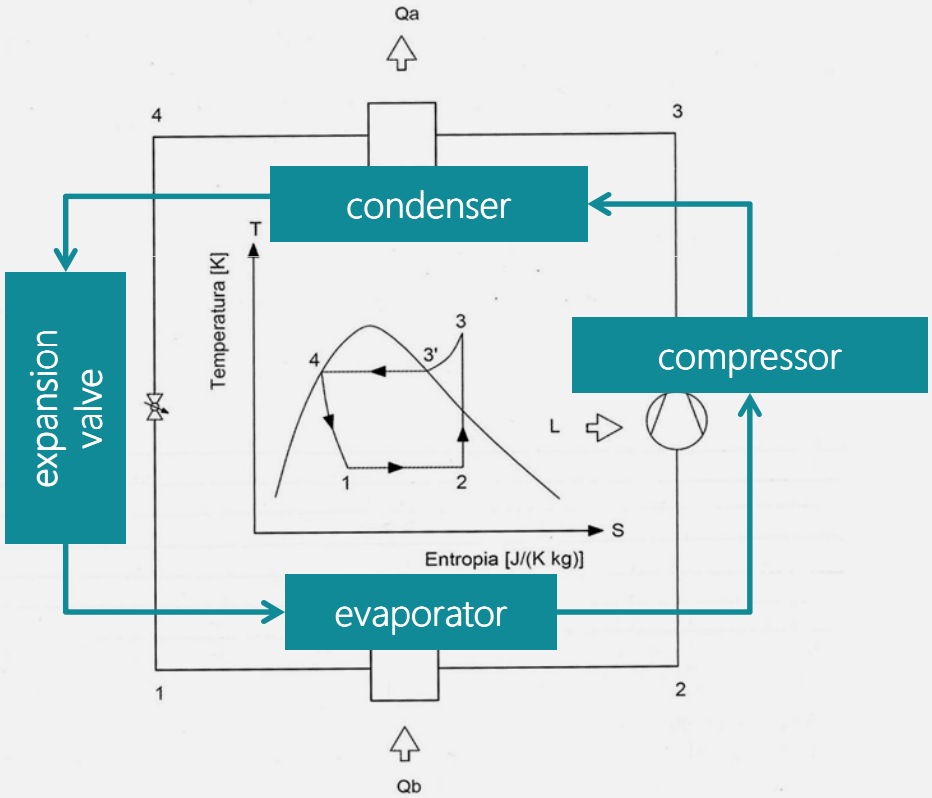
Considering the sea as a cold sink, some plus must be underlined:



Additional costs related to sea water supply system needs a careful evaluation.

Heat pump solutions

Hydrothermal energy utilization for heating and cooling services is **heat pump**, capable of extraction of thermal energy from this heat source, characterized by almost constant temperature throughout all year.



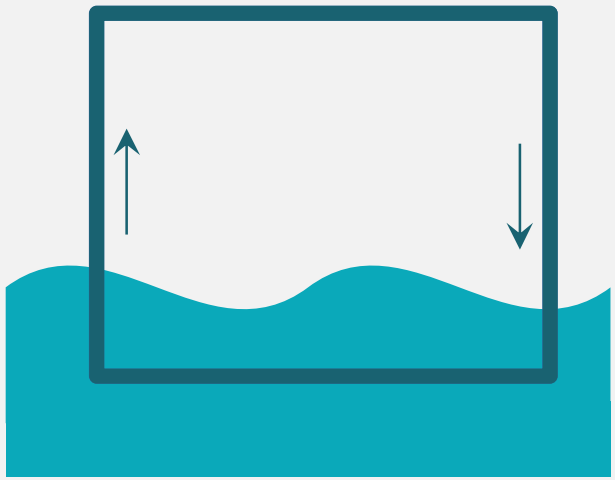
In particular, the reversible heat pumps allow absorption by, or transfer to, the cold sink thanks to the valve box or reverse, which **allows to switch the seasonal operation mode** of the machine from winter to summer without changing position of its technical elements.

- water-water-HP
- water-air-HP

HP application to hydrothermal energy

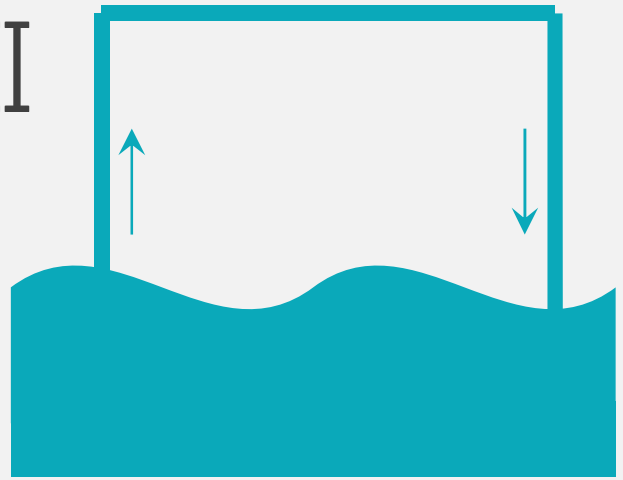
Heat extraction from sea water can occur through two major types of systems, said **closed-loop** or **open-loop**.

I



the ring - in which circulates heat transfer fluid - is immersed in the heat source (sea, ocean) and there is therefore no sampling of the primary water

II



the sea water is first pumped to special heat exchangers, in which heat transfer to a second water circuit technique occurs; water is then pumped back into the sea

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Proposal context

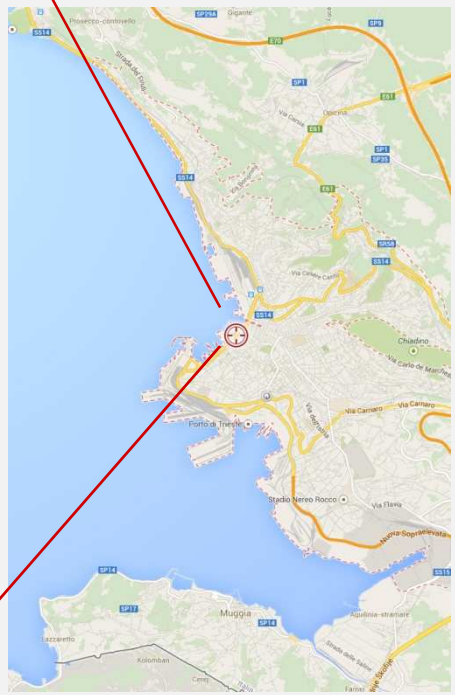
Basing on theoretical considerations above, it is identified the city of Trieste, and in particular the urban area in close proximity to the sea, as a possible place suitable to **hold appropriate engineering solutions and infrastructure for hydrothermal energy exploitation**.

In addition, this opportunity is associated with the need to enhance and preserve the **existing buildings**, and in particular high-value witnesses, through appropriate operations retrofit can increase the performance of the buildings and facilities, at the same time respect the constraints imposed by the operational principles of restoration.

Project concept

Proposal for hydrothermal energy use in Trieste

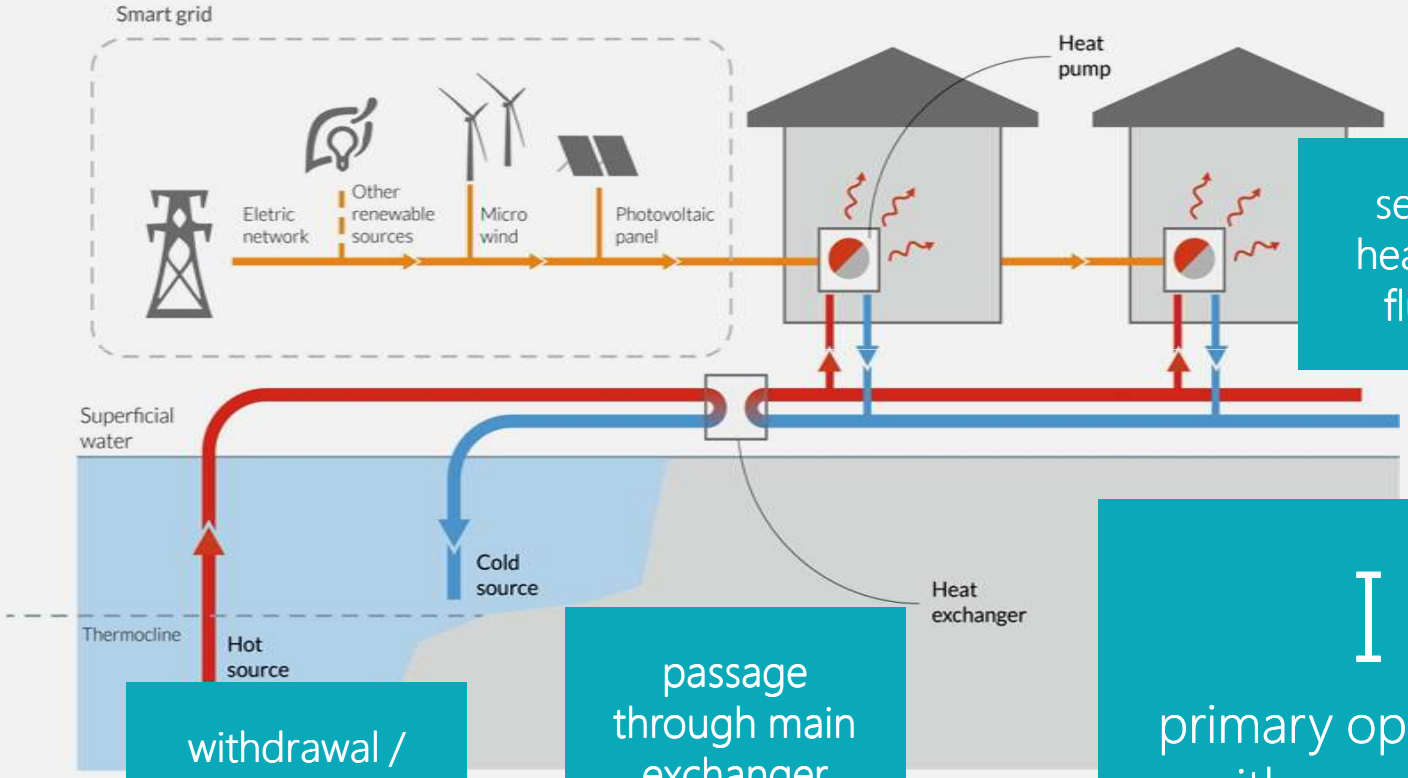
Project concept



There are **two main different systems** for hydrothermal energy transfer to users.

Proposal for hydrothermal energy use in Trieste

Project concept



secondary heat transfer fluid loop

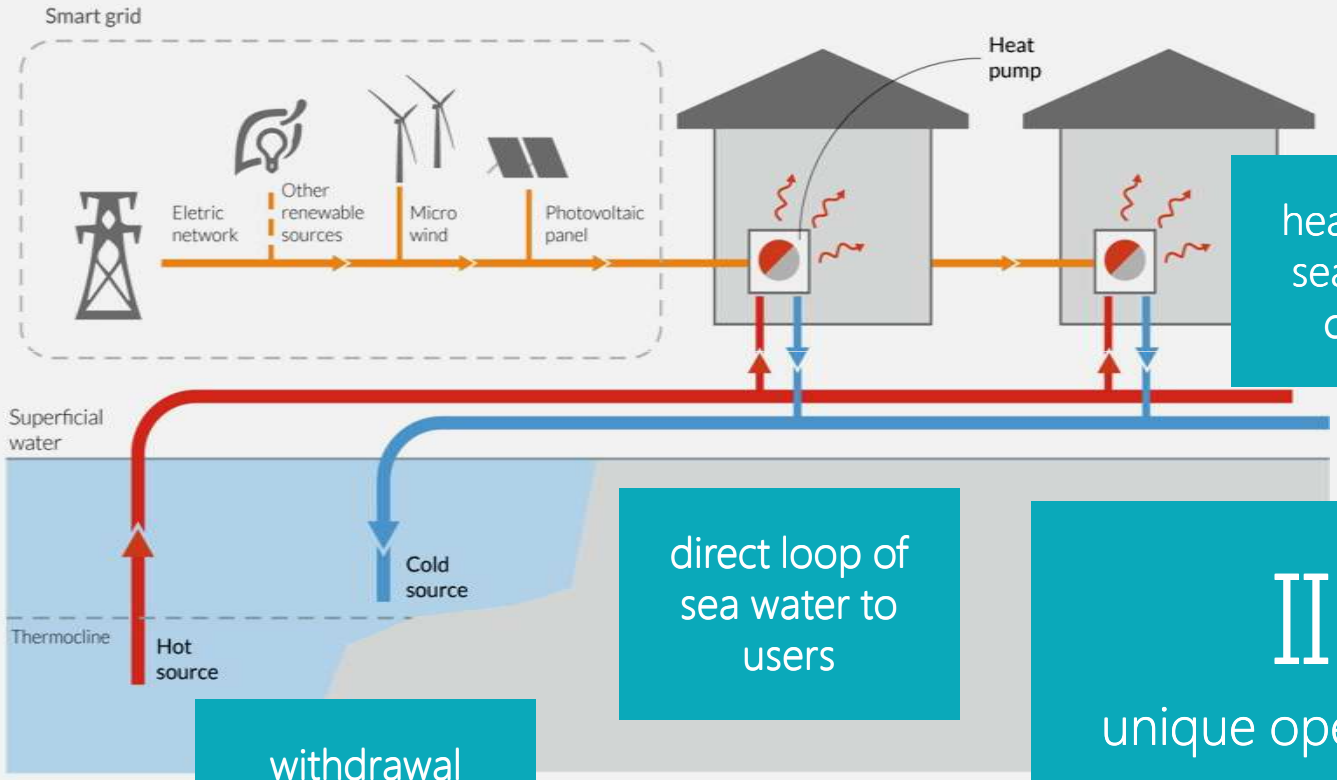
withdrawal / reintroduction of sea water

passage through main exchanger

primary open loop with secondary closed loop

Proposal for hydrothermal energy use in Trieste

Project concept



heat pumps / sea water as cold sink

direct loop of sea water to users

II

unique open loop

withdrawal of sea water / reintroduction

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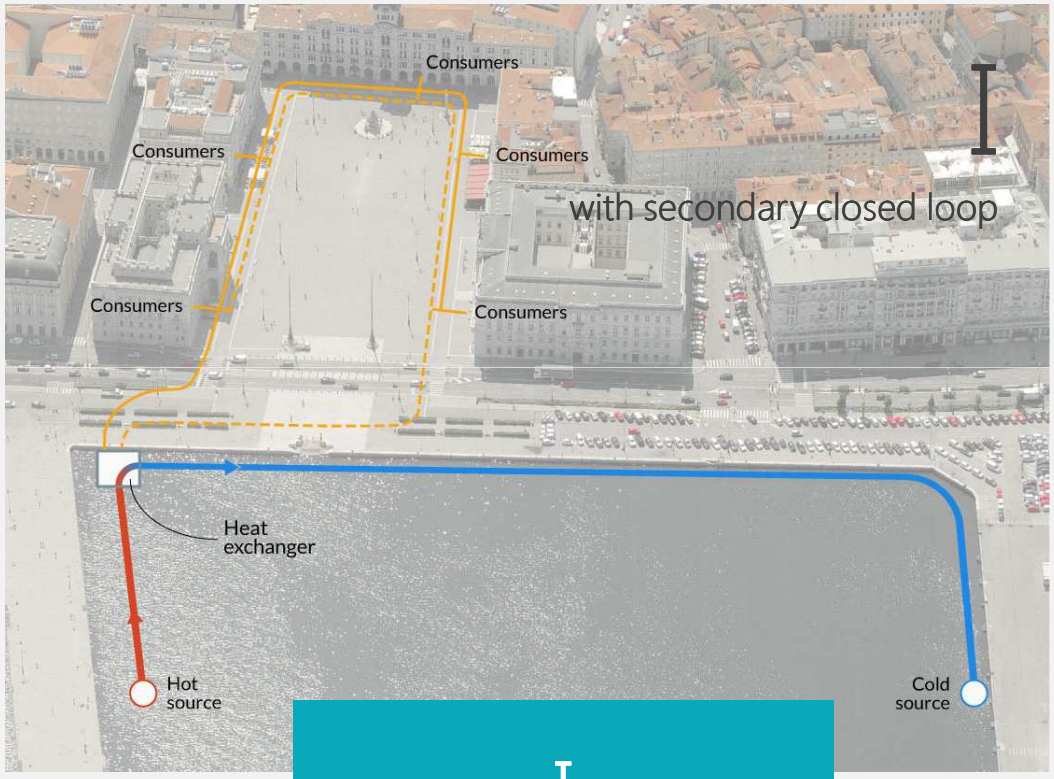
Proposal for hydrothermal energy use in Trieste

Solutions' evaluation



I

primary open loop
with secondary closed loop

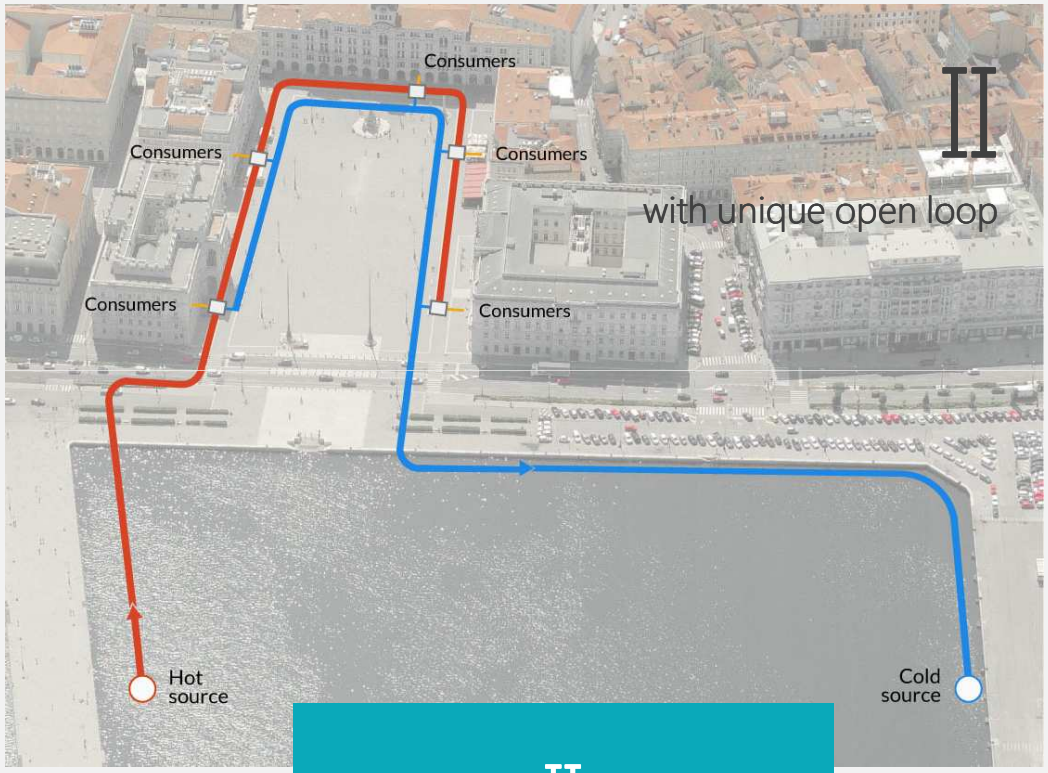
with secondary closed loop

Main features:

- Physical and chemical harmless
- Shorter sea water circuit
- Easiest and lower maintenance cost

Proposal for hydrothermal energy use in Trieste

Solutions' evaluation



II

unique open loop

Main features:

Reduce energy loss by main heat transfer

More scalable by active/disactive utilities

Difficult & expensive maintenance cost

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