GEOSUSTAINED

GEOTERMIA SUPERFICIAL

Aplicações de sistemas geotérmicos – Casos de estudo

DEVELOPMENT OF ENERGY GEOSTRUCTURES IN THE SMART CITY.

Basic Ecologic Fundamentals and Cases.

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Instituto Europeo de Innovación y Desarrollo Tecnológico
ENERES Sistemas Energéticos Eficientes

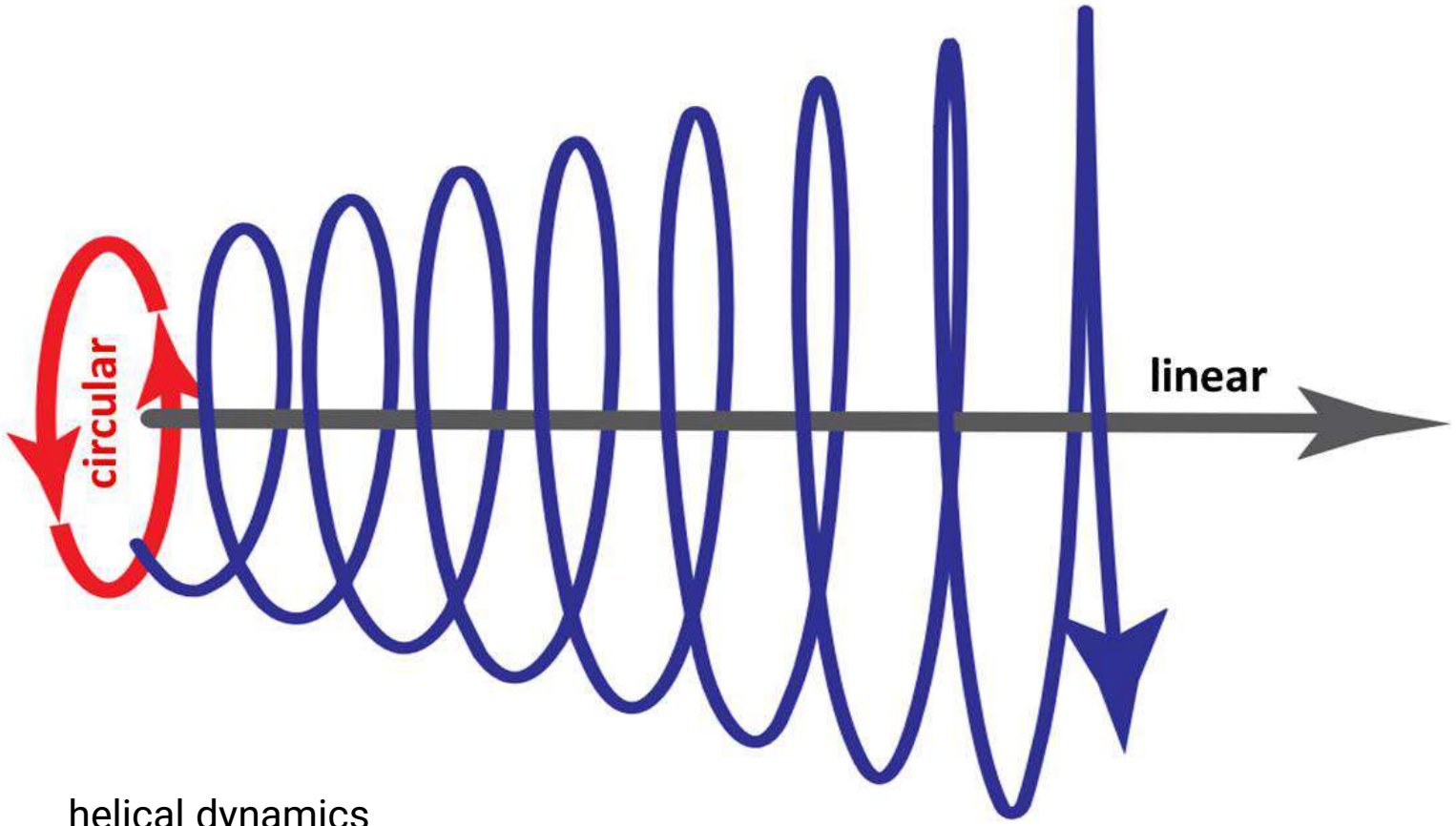
29 SETEMBRO 2023

DEVELOPEMENT OF ENERGY GEOSTRUCTURES IN THE SMART CITY. Logic fundamentals and cases.

CONTENTS

- Basic Logic Fundamentals.
- Cases.
  - Development of Energy Geostructures in building and urban infrastructure.
  - Urban Integration of energy systems in building and infrastructure under low temperature district heating and cooling district networks.

Shifting Paradigms



helical dynamics

Source: IEI Instituto Europeo de Innovación

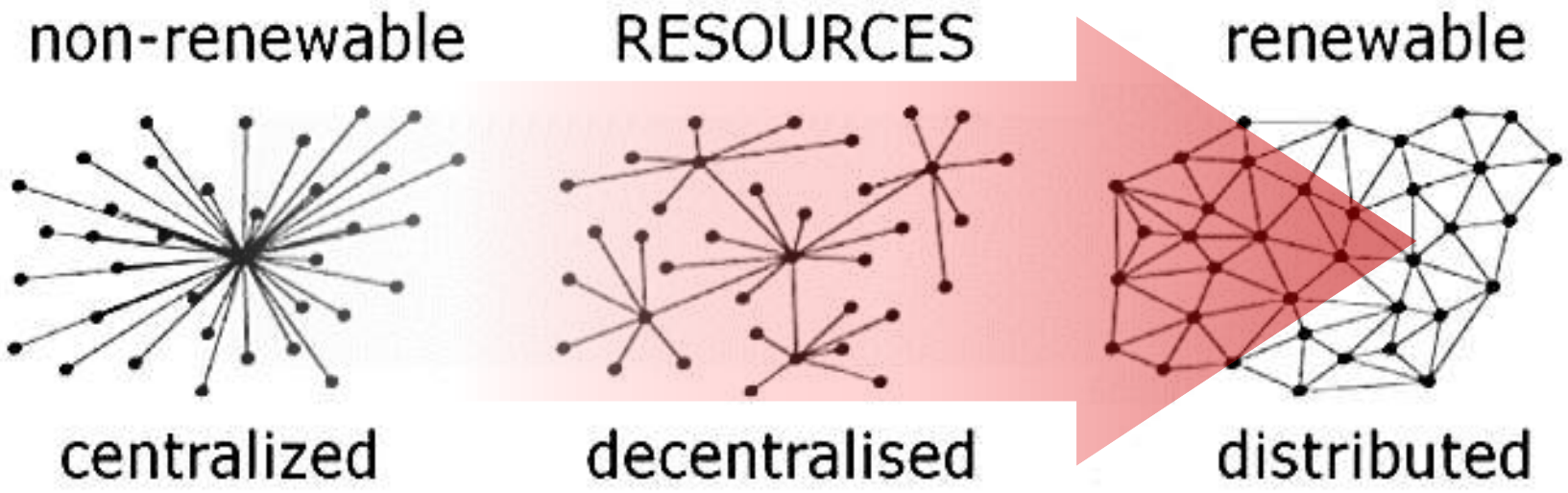
hybridization

process in which two complementary systems integrate to form a new system. Integration features depend on the appropriate base-pairing across the two single-stranded original systems.

taxonomy

criteria for economic activities that are aligned with a net zero trajectory

Shifting Paradigms



"The **Sustainable Product-Service Systems** (S.PSS) offer model applied to Distributed Renewable Energy (DRE) is a **win-win approach to diffuse them (DRE) in low and middleincome, all contexts, because it:**

- **Reduces/cuts both the initial investment cost of hardware purchasing and the life-cycle costs of maintenance, repair, upgrade, etc.**
- **While improving local skills and rising local employment, resulting in a key leverage for a sustainable development process aiming at democratizing the access to resources, goods and services.**

Shifting Paradigms

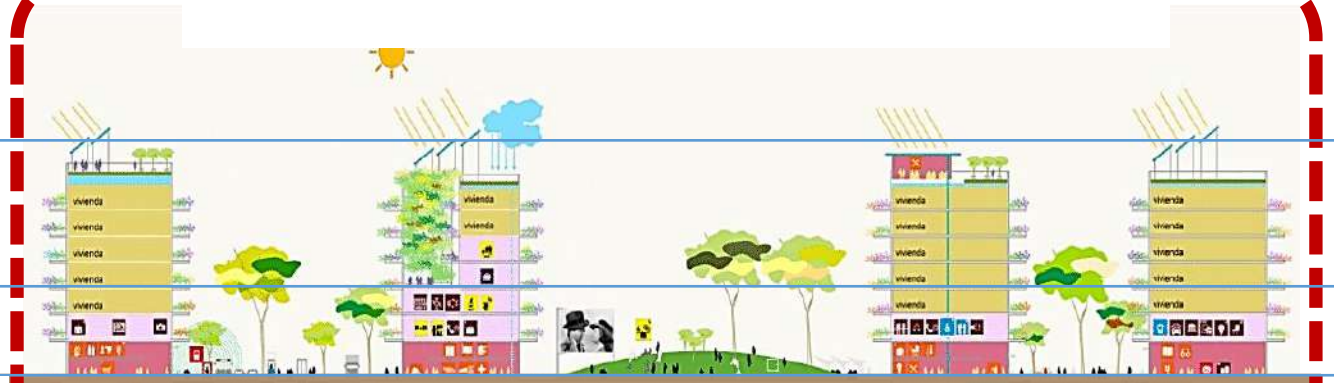
Less –

Entropy, exergy, pressure, speed, temperature, consumption, intensity, distance, metabolic rate, analytic, endotherm, cost.

More +

Flexibility, life expectancy, sociability, efficiency, systemic, inertial service, ectotherm, homeostatic.

INTEGRAL MANAGEMENT-SELF-REGULATION-INFORMATION



The three planes of ecological urbanism.

Aerial. Private. Complex. Gifted. Ecosystem. Healthy.

Surface. Social. Public. Complex. Gifted. Ecosystem. Healthy.

Source: Salvador Rueda Palenzuela

The ecological model of urban development is linked to the recovery of free spaces and ecosystem services that multiply the value of flight: commercial space, work and residential space, and the value of the subsoil: service space, exchange, storage and management of resources and energy, geostructures.

The three planes of ecological urbanism.

Aerial. Private. Complex. Gifted. Ecosystem. Healthy.

Surface. Social. Public. Complex. Gifted. Ecosystem. Healthy.

Underground. Public and Private Services. Interchange. Storage. Tramnsporte. Logistics. Energy. Management

Source: Salvador Rueda Palenzuela

The ecological model of urban development is linked to the recovery of free spaces and ecosystem services that multiply the value of flight: commercial space, work and residential space, and the value of the subsoil: service space, exchange, storage and management of resources and energy, geostructures.

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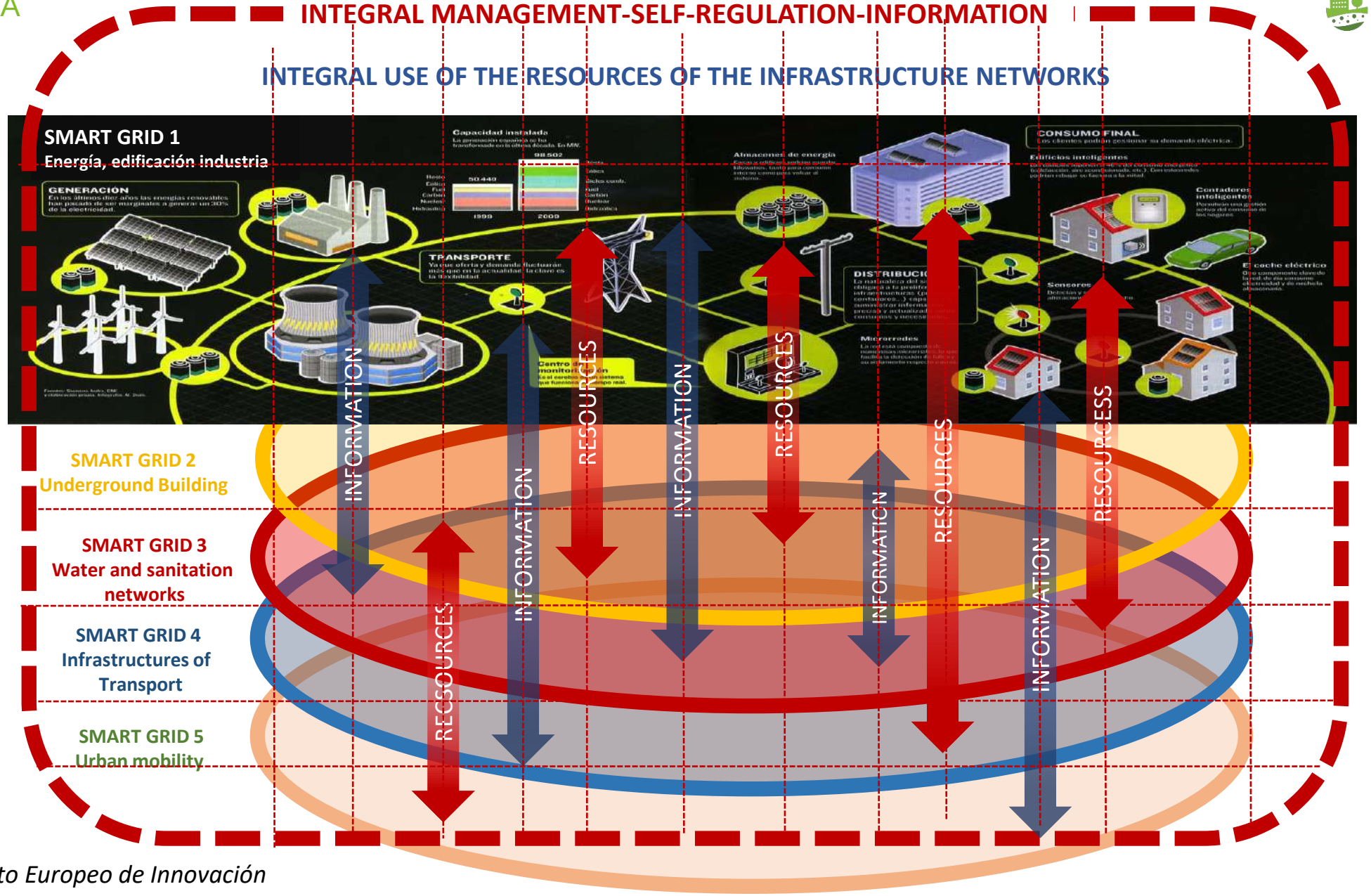
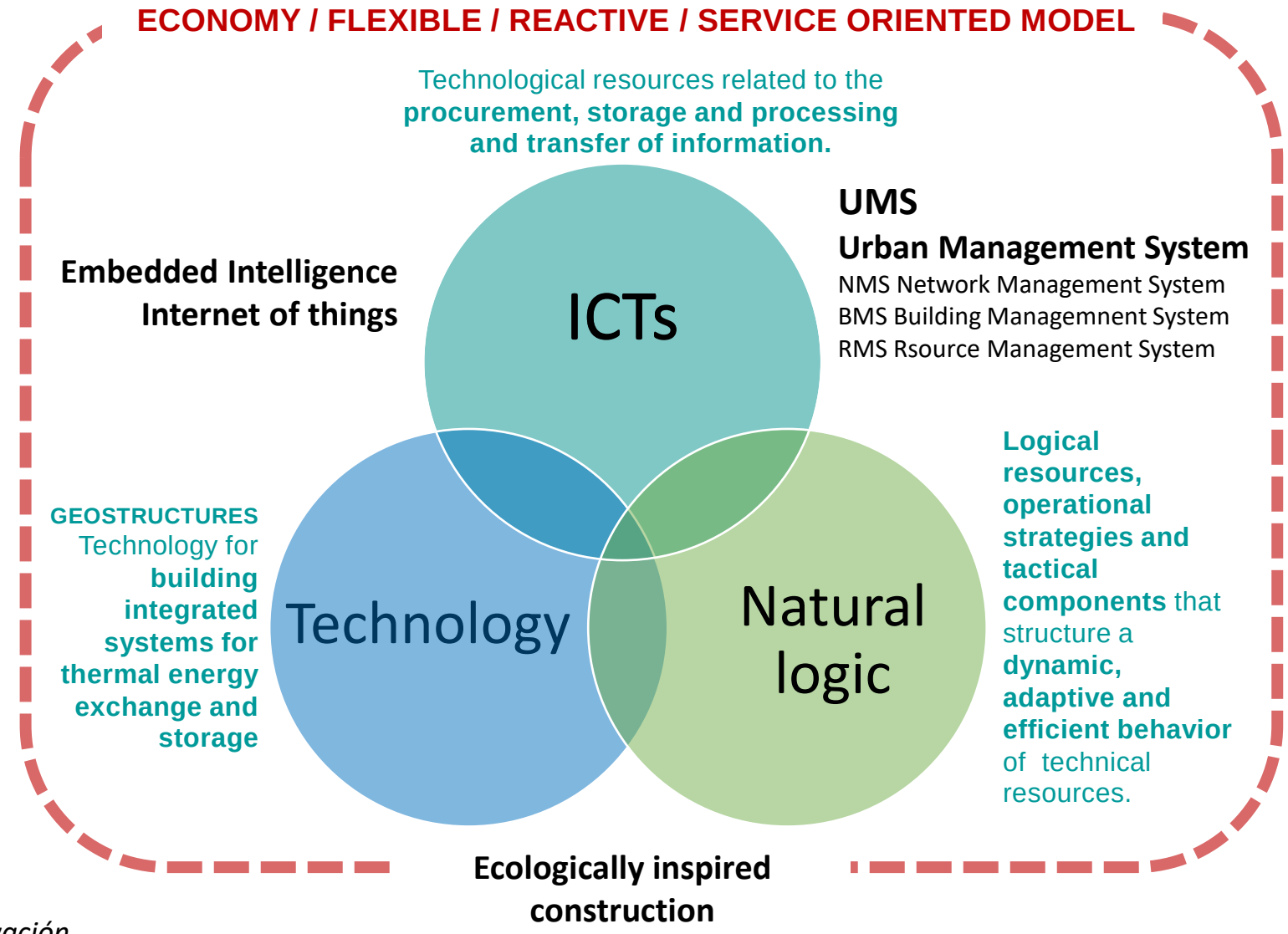


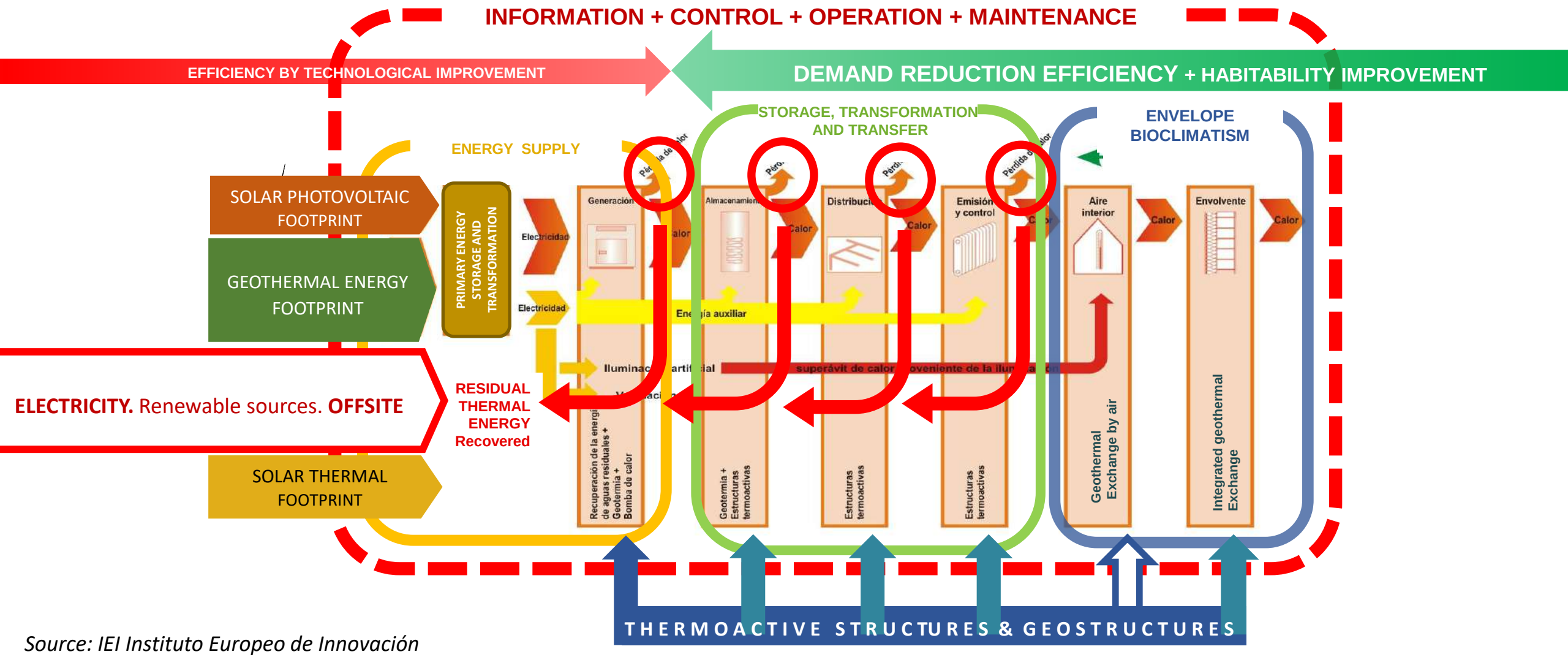
Source: IEI Instituto Europeo de Innovación

Architecture of an ecologically inspired built urban system



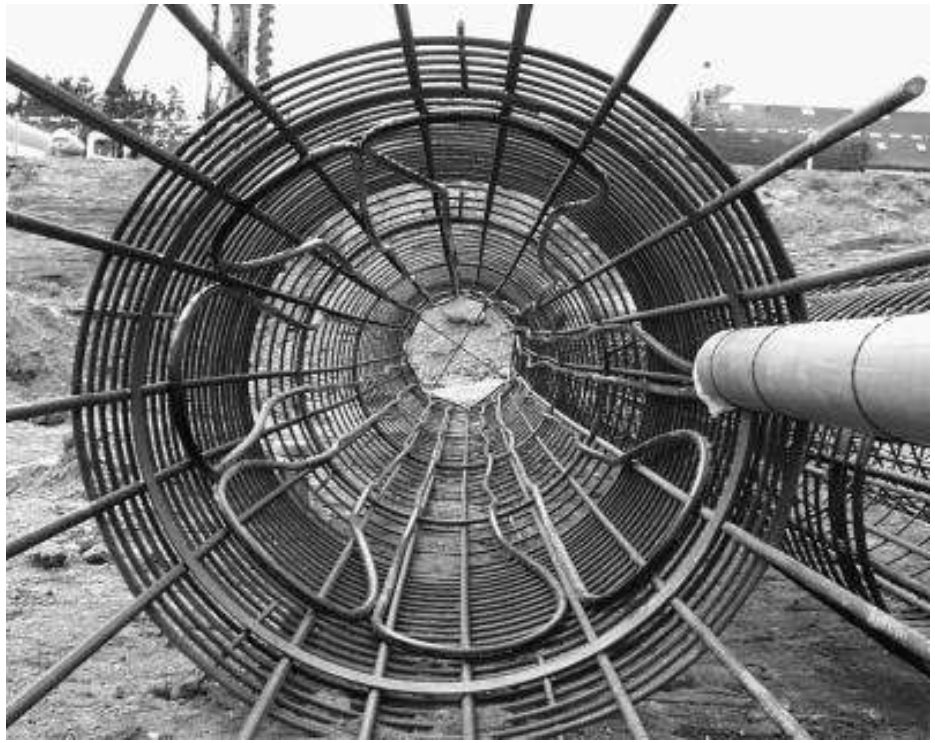
Source: IEI Instituto Europeo de Innovación

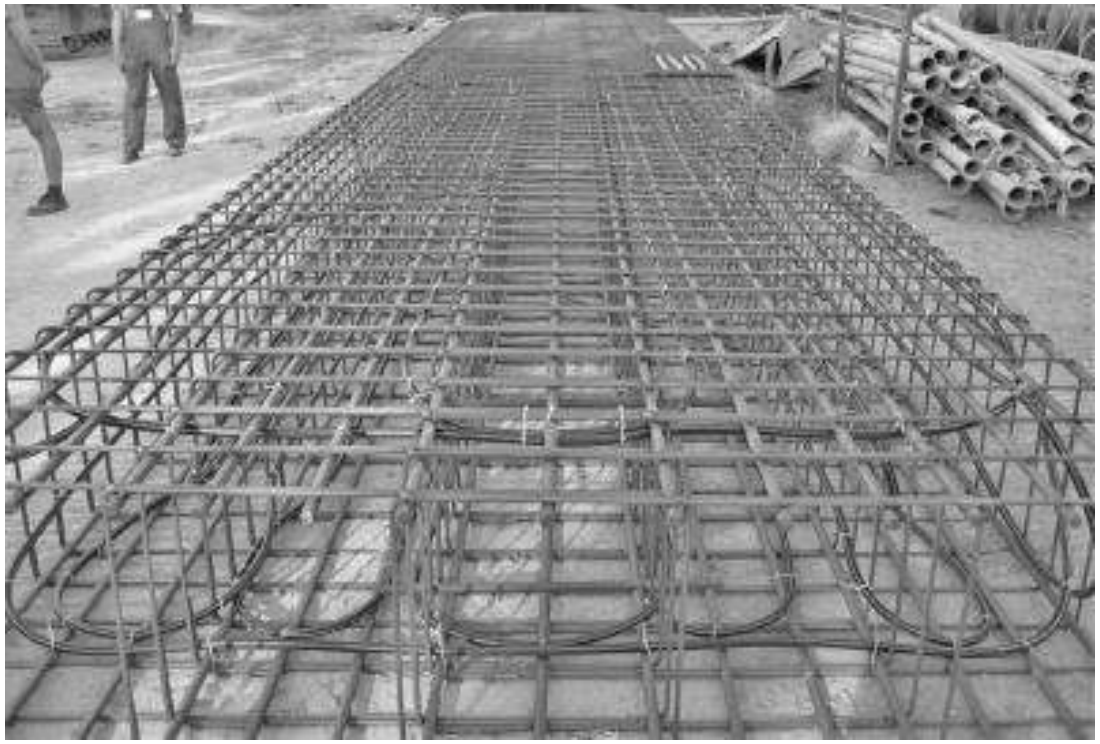
EXERGY DYNAMICS INTO THE BUILT SYSTEM. Vectors of efficiency increase. Role of geothermal and thermo-active structures.



Source: IEI Instituto Europeo de Innovación

Technology





Energy foundations and other thermo-active ground structures
H. BRANDL*

Brandl, H. (2006). Ge´otechnique 56, No. 2, 81–12

Source: IEI Instituto Europeo de Innovación

Technology

ENERGY GEOSTRUCTURES GEOTHERMAL POSTACTIVATION

ENERGY EFFICIENCY IN THE RECOVERY OF UNDERGROUND GEOSTRUCTURES

Fig. 51. Energy geotextile (geocomposite) installed in an energy tunnel (testing plant LT22 – Bierhäuselberg)

Energy foundations and other thermo-active ground structures. H. BRANDL

Source: enerdrape

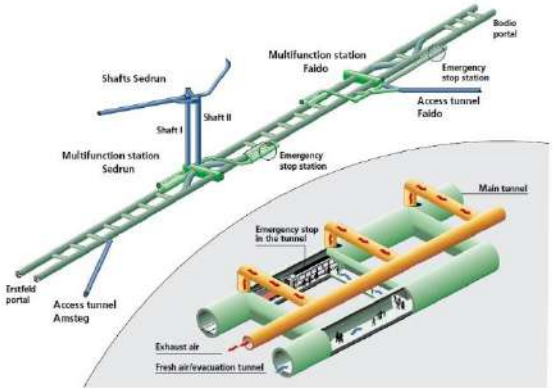
enerdrape
Empowers built surfaces

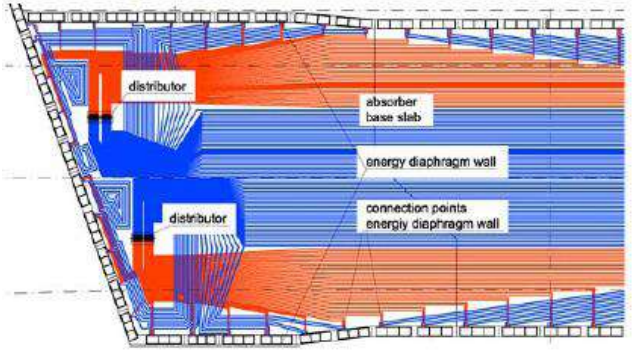
Cases.

- Development of Energy Geostructures in building and urban infrastructure.

- Urban Integration of energy systems in building and infrastructure under low temperature district heating and cooling district networks.

SMART GRID 4
Infrastructures of Transport





El intercambio energético en los túneles se realiza mediante la captación geotérmica a través de sus estructuras. Del agua drenada y del aire que circula a su través.

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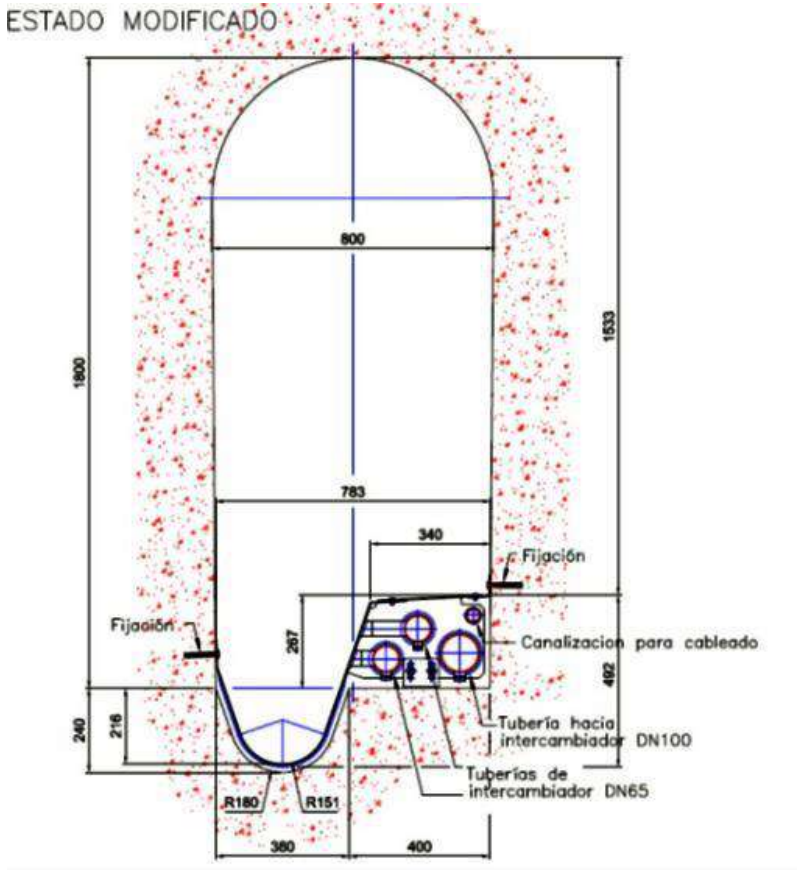
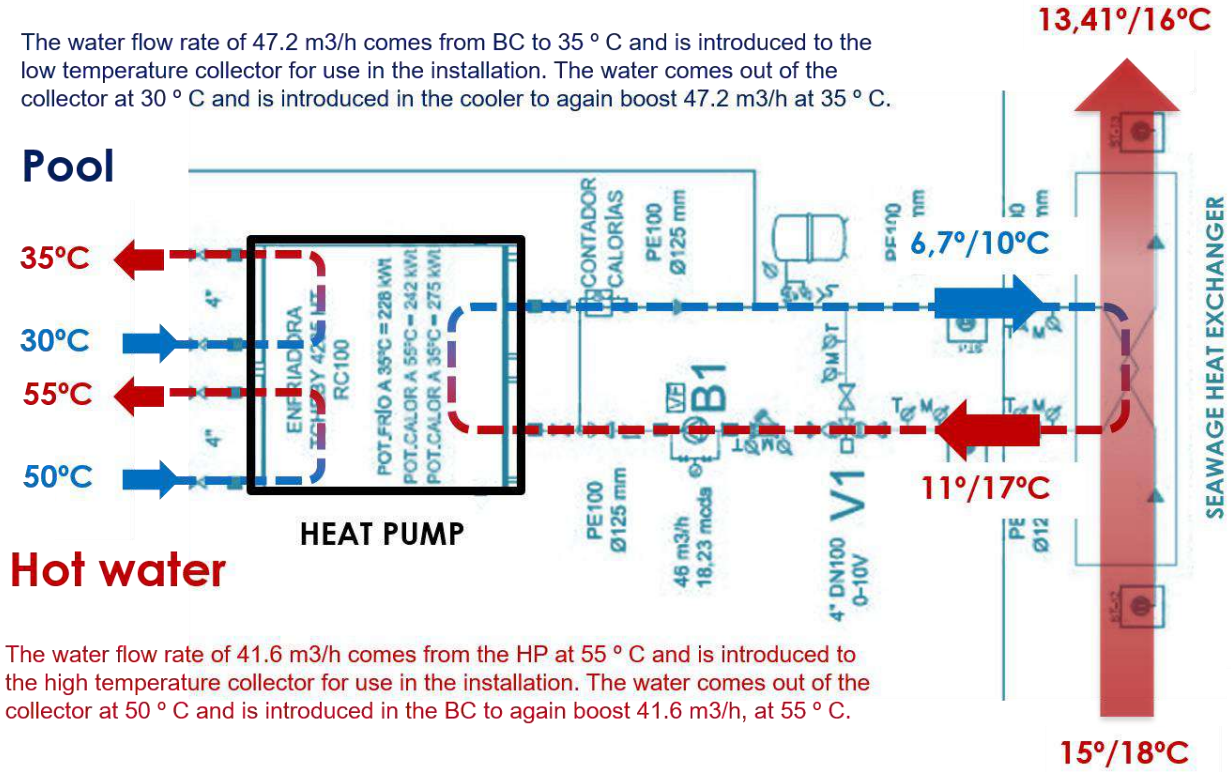
SMART GRID 3
Water and sanitation



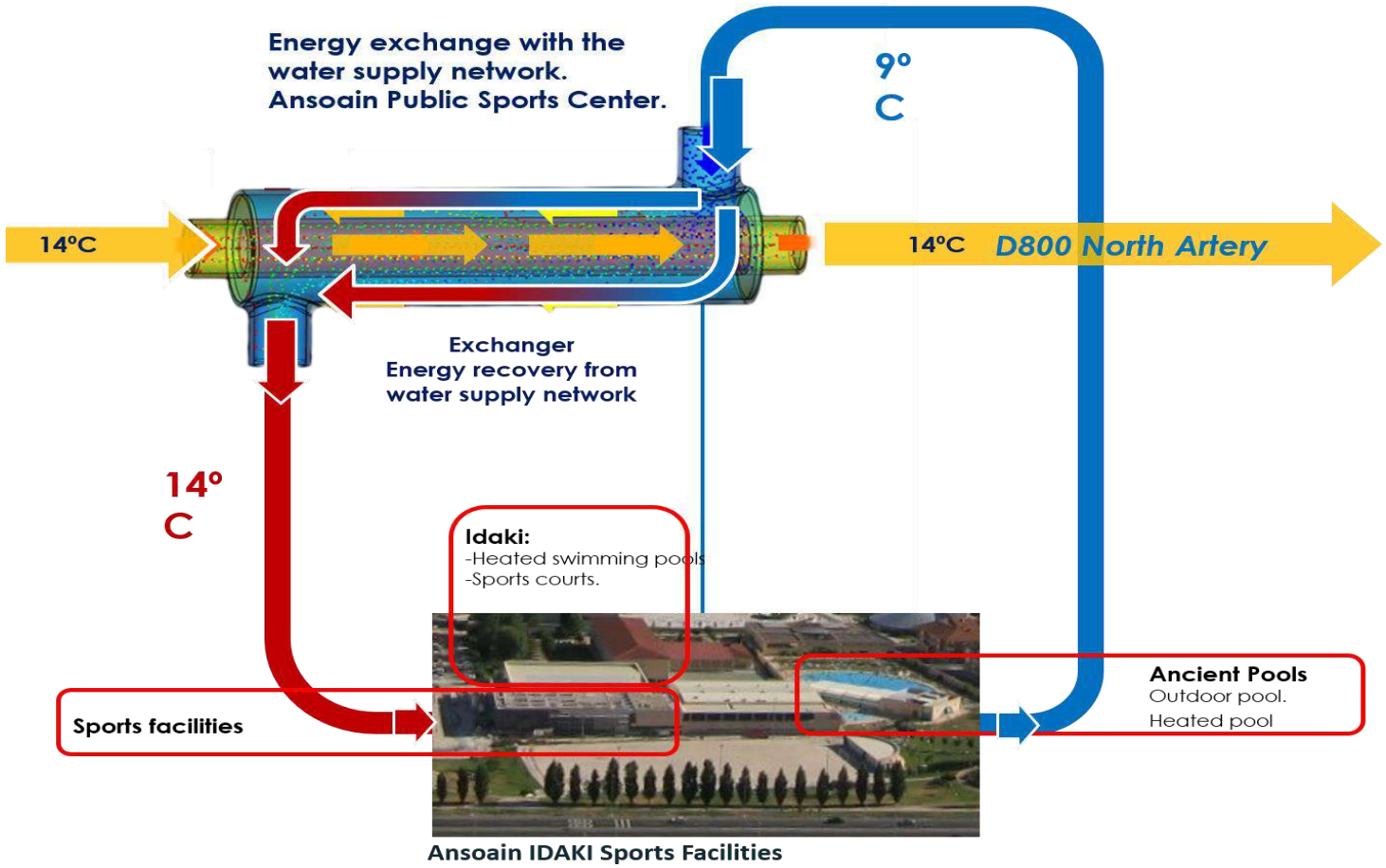
The water flow rate of 47.2 m3/h comes from BC to 35 ° C and is introduced to the low temperature collector for use in the installation. The water comes out of the collector at 30 ° C and is introduced in the cooler to again boost 47.2 m3/h at 35 ° C.



The water flow rate of 41.6 m3/h comes from the HP at 55 ° C and is introduced to the high temperature collector for use in the installation. The water comes out of the collector at 50 ° C and is introduced in the BC to again boost 41.6 m3/h, at 55 ° C.

Source: eneres

SMART GRID 3
Water and sanitation



Heat exchanger with the mains water supply

Water-water heat pump for heating and cooling with exchanged heat

Source: eneres

SMART GRID 5
Mobility infrastructure

THERMAL RESOURCE OF ROAD TRAFFIC.

Tramos			*SENTIDO 1*	*SENTIDO 2*
v [km/h]	= velocidad en el túnel	=	70,00	70,00
L [m]	= longitud del túnel	=	3.800,00	3.800,00
t [h]	= t permanencia en el túnel	=	0,05	0,05
P [kW/coche]	= potencia disipada/coche	=	30,00	30,00
N [coches/día]	= nº coches	=	31.799,00	37.573,00
Ecoches [kW h/día]			51.786,94	61.190,31
Horas uso [24h/día]	= 24			
Pcoches [kW/día]			2.157,79	2.549,60

Source: eneres

THERMAL RESOURCE OF DRAIN WATER.

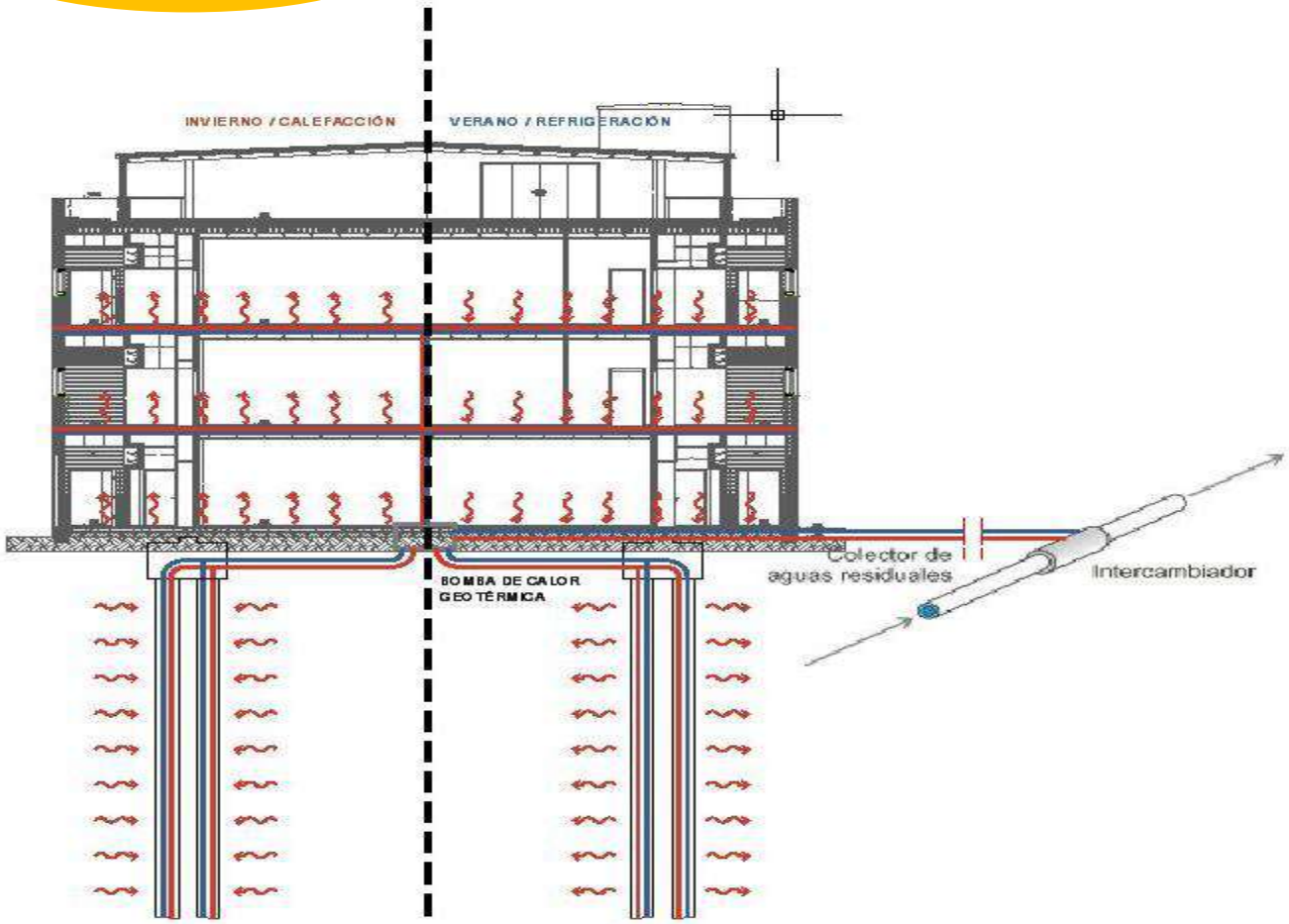
Bombeo de agua CT Tramo By-Pass

Zona	Código	Nº Bombas	POR BOMBA Q diseño (l/s)
CT3-A5	04FT01BD01	3	19,9
ISE 13 TR4	13NL50BD01	3	25,9
ESE 10 TR4	13XL86BD01	3	25,9
ISE 3 TR4	14NC42BD01	3	14
ESE 15 TR4	14RM10BD01	3	14
ESE 13 TR4	14RN14BD01	3	14
ESE 3 TR4	14XC47BD01	3	14
PV4-BYP	09NC70BD01	3	25,1
PV2-BYP	12NC27BD01	6	14,7
PV1-BYP	14NC00BD01	3	25,1

EVALUATION OF THE GEOTHERMAL RESOURCE OF THE TUNNEL VAULT.

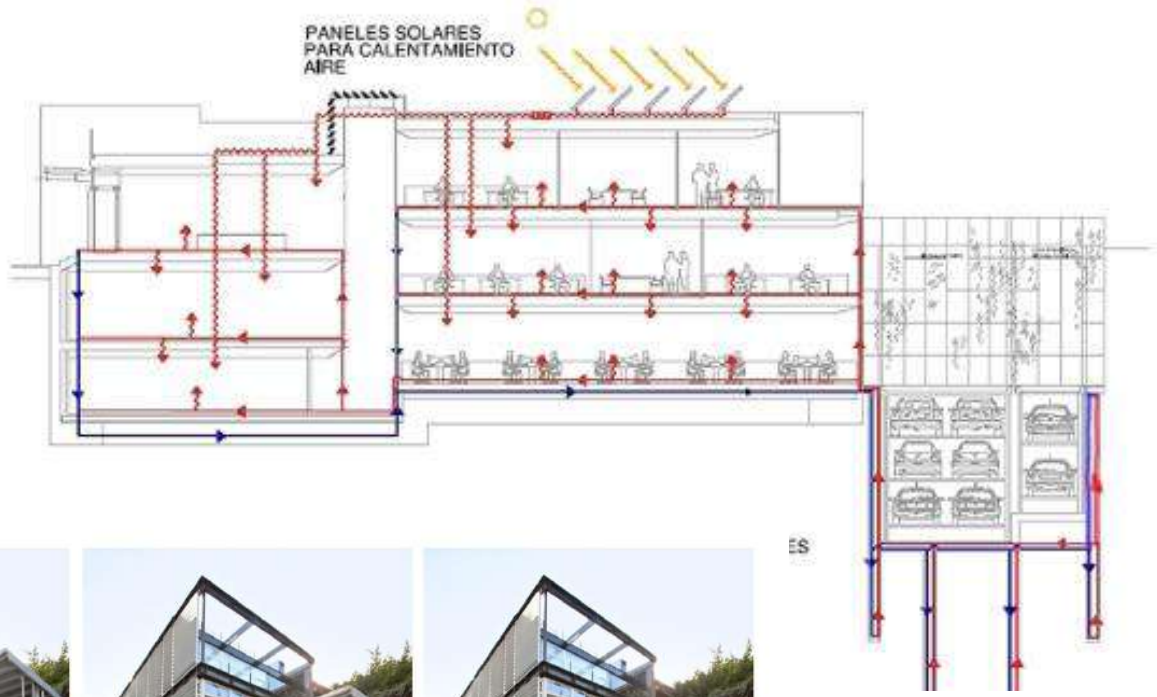
Tramos		*SENTIDO 1*	*SENTIDO 2*
H [m]	= Altura zona circulación	5,00	5,00
R [W/m2]	= Ratio de potencia muro	20,00	20,00
A [m2]	= Área de intercambio	38.000,00	38.000,00
Potencia [kW/día]		760,00	760,00

SMART GRID 3
Waste water + GEOSTRUCTURES



Source: eneres

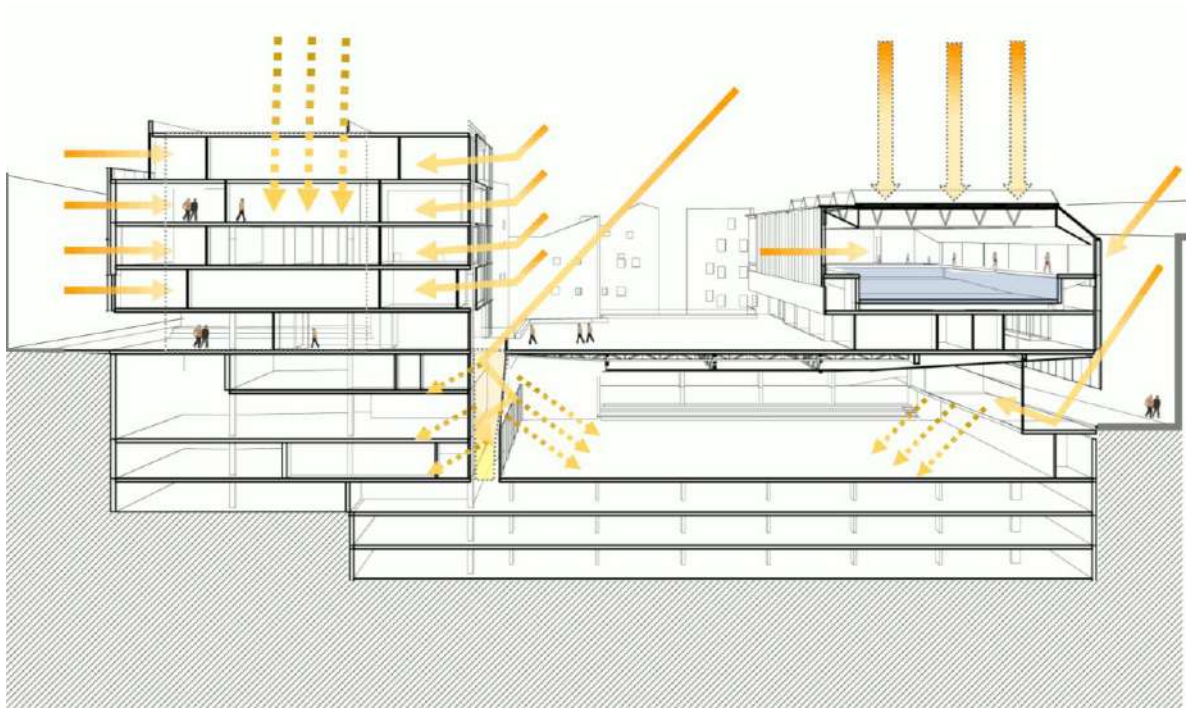
SMART GRID 2
Underground Building

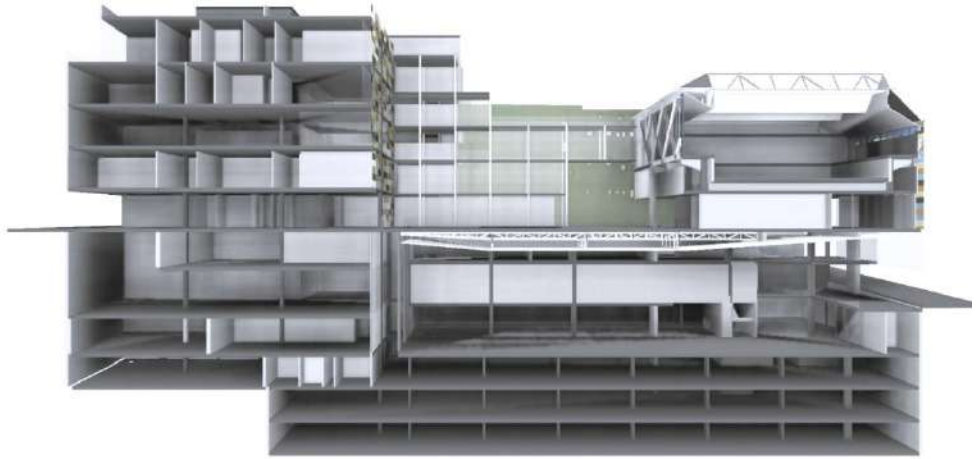


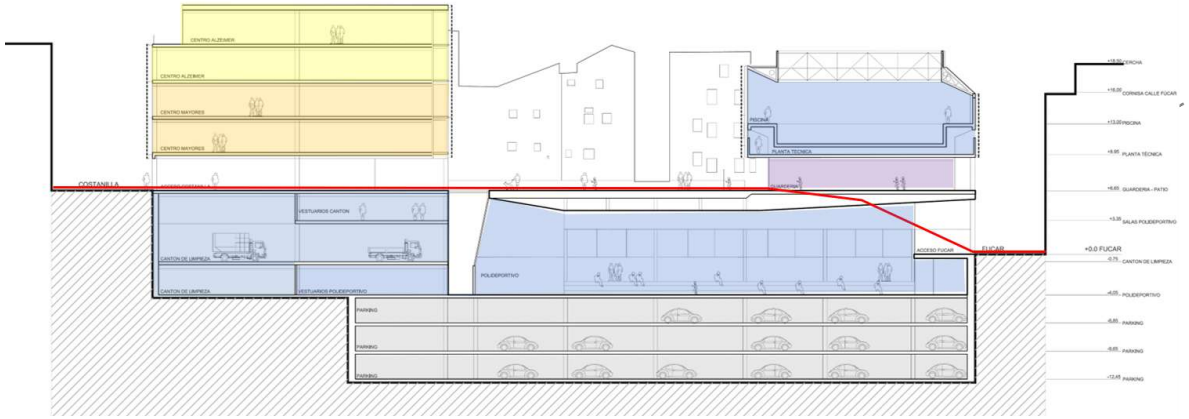
Source IEI Instituto Europeo de Innovación

SMART GRID 2
Underground Building

ENERGY GEOSTRUCTURES IN A PUBLIC MIXED USE BUILDING COMPLEX.
ENERGY EFFICIENCY IN THE HISTORICAL CENTER OF MADRID.







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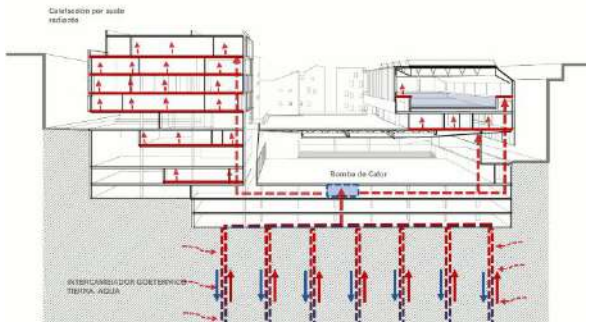
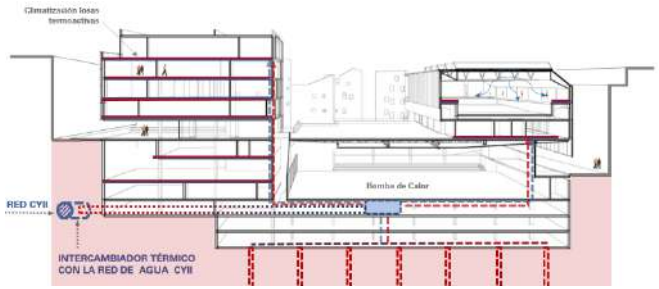
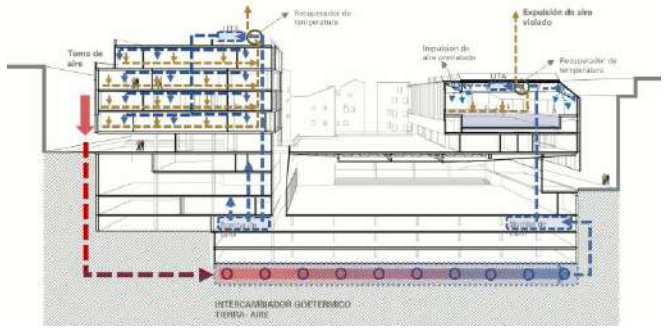


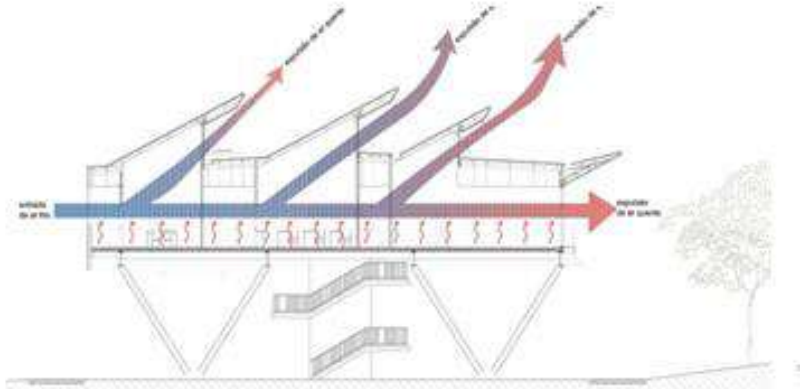


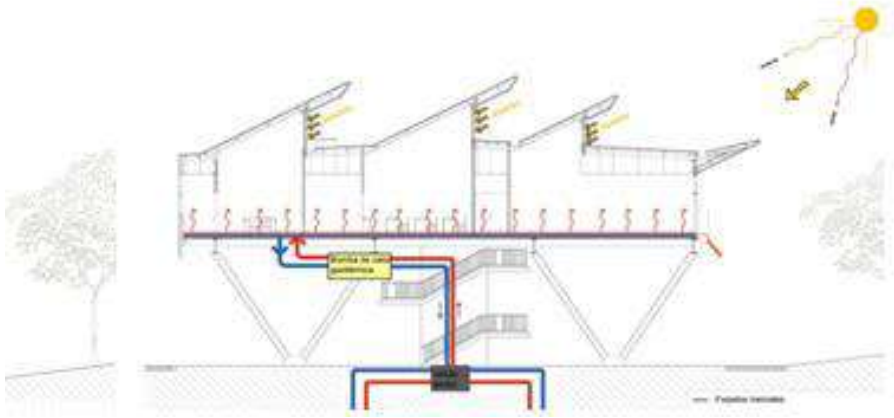


Source IEI Instituto Europeo de Innovación

THE CONTEXT OF BUILDING EFFICIENCY IN THE INTEGRATION OF GEOSTRUTURES AND THERMOACTIVE SYSTEMS.

The ideal scenery for the application of thermoactive systems and geostructures are low impact and low consumption buildings . When a low-demand architecture and the integration of geothermal exchange and thermoactive air conditioning systems are put into play, they contribute in a powerful and harmonic way to increase the integral efficiency and project it over to lifetime.





Source: eneres

OFFICE BUILDING. REHABILITATION. Apolonio Morales, 29 . Madrid. 2009

Source IEI Instituto Europeo de Innovación

climapark

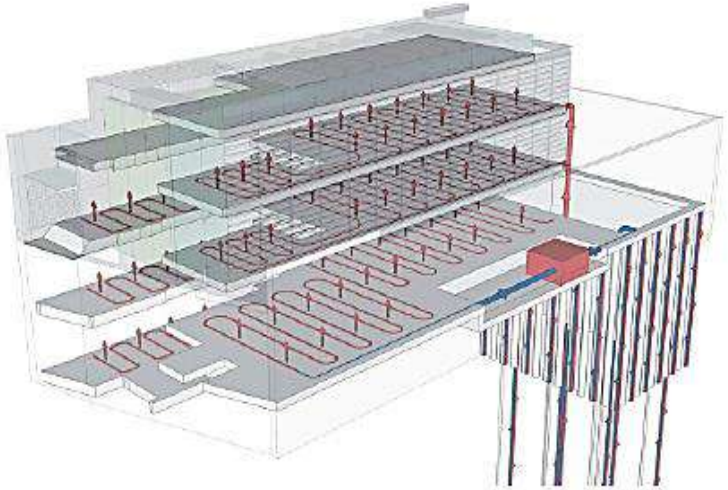
aparcamiento mecánico + estructuras geotérmicas termoactivas

OFFICE BUILDING. REHABILITATION. Apolonio Morales, 29 . Madrid. 2009

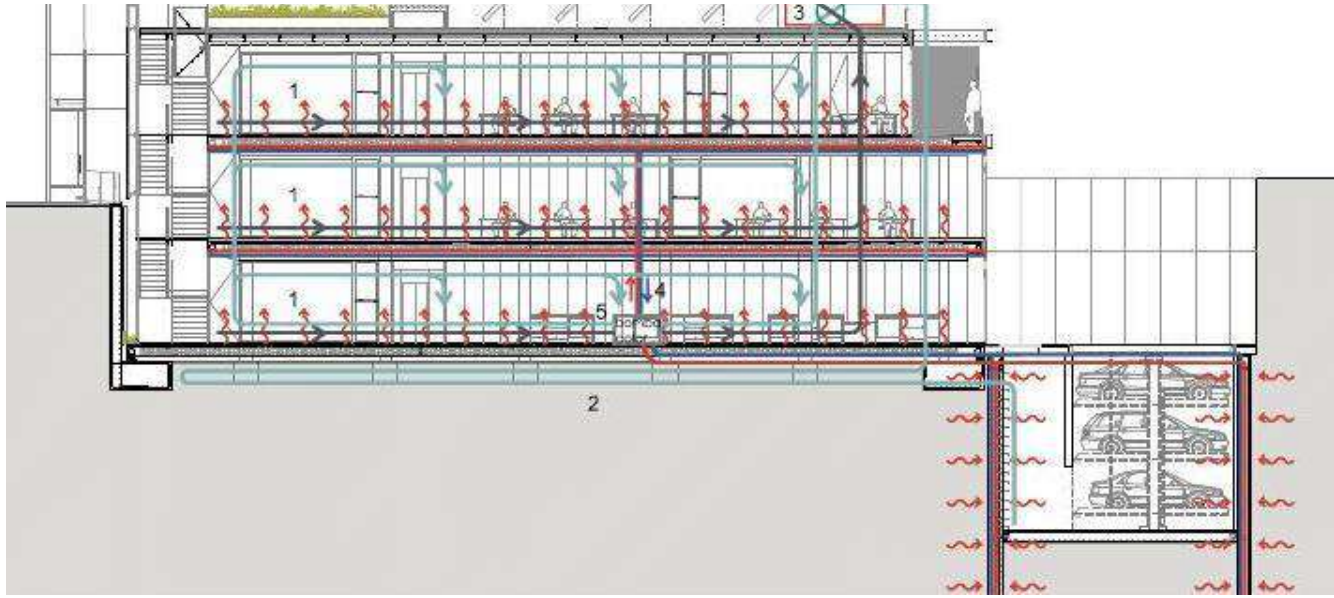
Estado previo a la rehabilitación.

Proyecto de Rehabilitación

PROYECTO DE REHABILITACIÓN EDIFICIO DE OFICINAS C\ APOLONIO MORALES 29 MADRID



Sistema inercial de captación geotérmica con pilotes termo activos y de climatización mediante losas termoactivas



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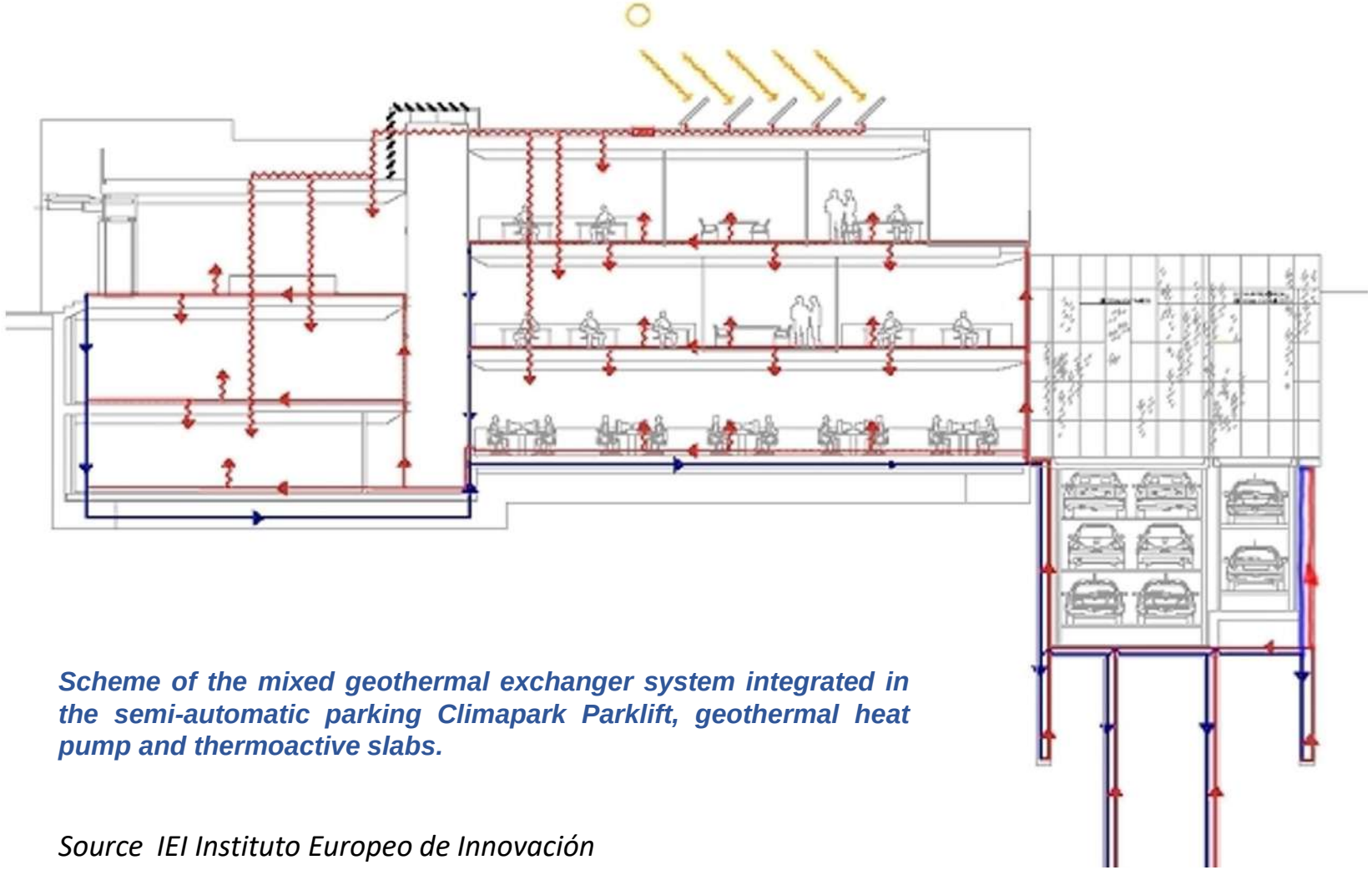
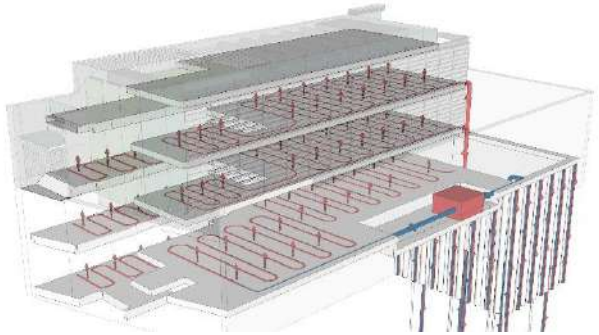
OFFICE BUILDING. REHABILITATION. Apolonio Morales, 29 . Madrid. 2009





Scheme of the mixed geothermal exchanger system integrated in the semi-automatic parking Climapark Parklift, geothermal heat pump and thermoactive slabs.

Source IEI Instituto Europeo de Innovación

OFFICE BUILDING. REHABILITATION. Apolonio Morales, 29 . Madrid. 2009

Source IEI Instituto Europeo de Innovación

OFFICE BUILDING. REHABILITATION. Apolonio Morales, 29 . Madrid. 2009

Source IEI Instituto Europeo de Innovación

OFFICE BUILDING. REHABILITATION. Apolonio Morales, 29 . Madrid. 2009

U.S. GREEN BUILDING COUNCIL — LEED PLATINO — USGBC

DÓNDE	RÉCORD	CATEGORÍA	VERSIÓN
Europa	Primera certificación Platino	LEED O+M Existing Building	v4.1
España	Mayor puntuación	LEED O+M Existing Building	Todas las versiones
España	Mayor puntuación	Todas las categorías	v4, v4.1

Apolonio Morales 29

Project ID	1000132420
Rating system & version	LEED V4.1 O+M: EB
Project registration date	06/18/2020

CERTIFIED SILVER GOLD PLATINUM

Standard Final Review Decision

CERTIFIED: 40-49, SILVER: 50-59, GOLD: 60-79, PLATINUM: 80+

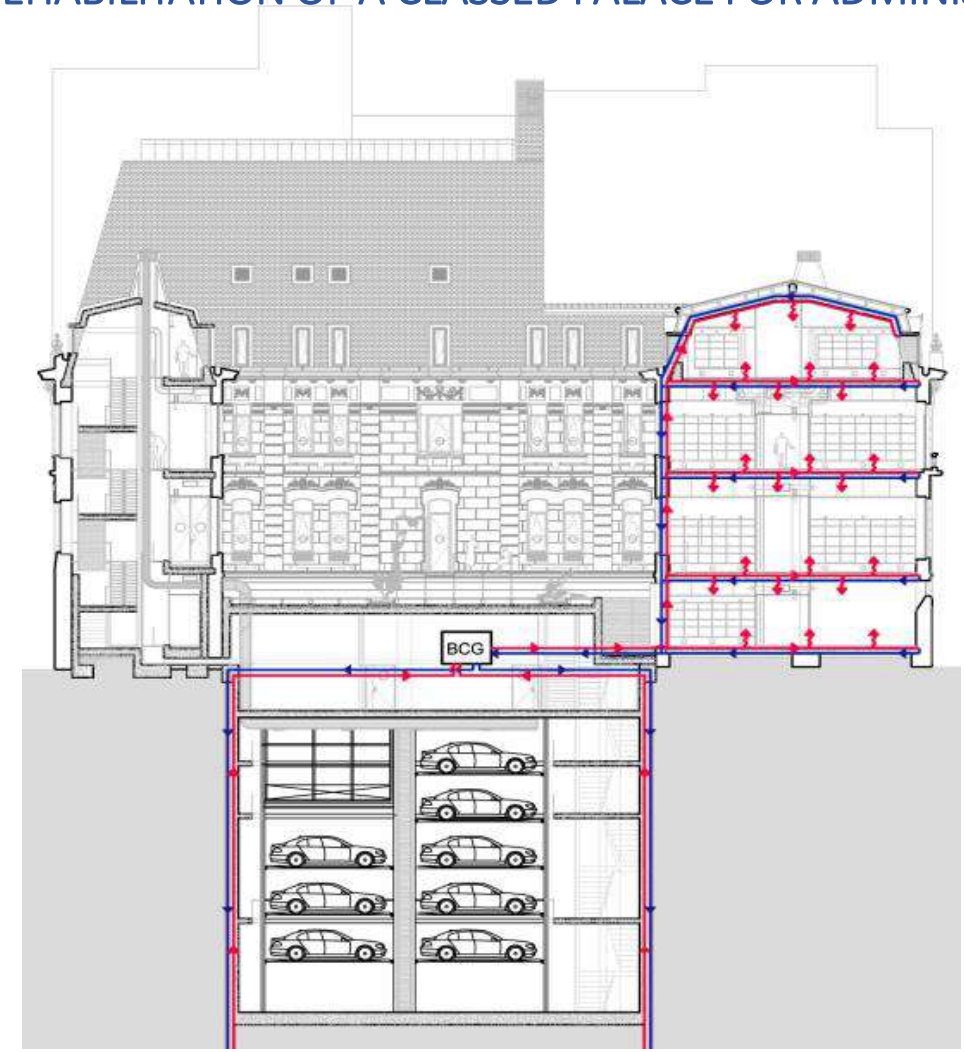
LEED V4.1 O+M: EXISTING BUILDINGS

ATTEMPTED: 91, DENIED: 2, PENDING: 0, AWARDED: 89 OF 100 POINTS

LOCATION AND TRANSPORTATION	14 OF 14
Transportation Performance	14 / 14
SUSTAINABLE SITES	3 OF 4
Rainwater Mgmt	1 / 1
Heat Island Reduction	1 / 1
Light Pollution Reduction	1 / 1
Site Mgmt	0 / 1
WATER EFFICIENCY	12 OF 15
Water Performance	12 / 15
ENERGY AND ATMOSPHERE	30 OF 35
Energy Efficiency Best Mgmt Practices	Y
Energy Performance	28 / 33
Fundamental Refrigerant Mgmt	Y
Grid Harmonization	1 / 1
Enhanced Refrigerant Mgmt	1 / 1
MATERIALS AND RESOURCES	8 OF 9
Purchasing Policy	Y
Facility Maintenance and Renovation Policy	Y
Waste Performance	8 / 8
Purchasing	0 / 1
INDOOR ENVIRONMENTAL QUALITY	21 OF 22
Minimum IAQ	Y
Environmental Tobacco Smoke Control	Y
Green Cleaning Policy	Y
Indoor Environmental Quality Performance	19 / 20
Green Cleaning	1 / 1
Integrated Pest Mgmt	1 / 1
INNOVATION	1 OF 1
Innovation	1 / 1
TOTAL	89 OF 100

Source IEI Instituto Europeo de Innovación

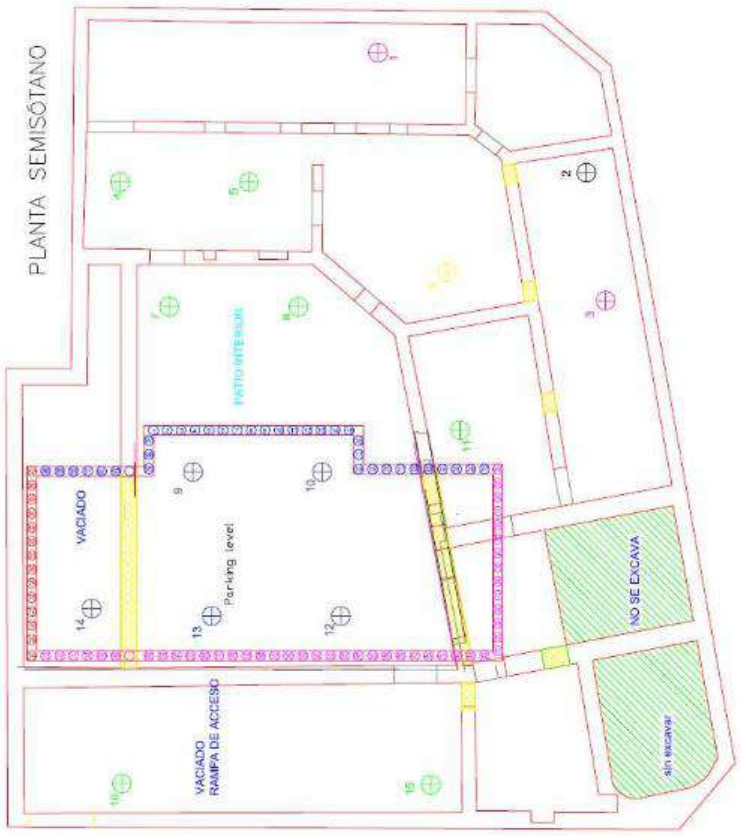
REHABILITATION OF A CLASSED PALACE FOR ADMINISTRATION OFFICES. CHAMBERÍ. MADRID. 2009/2010

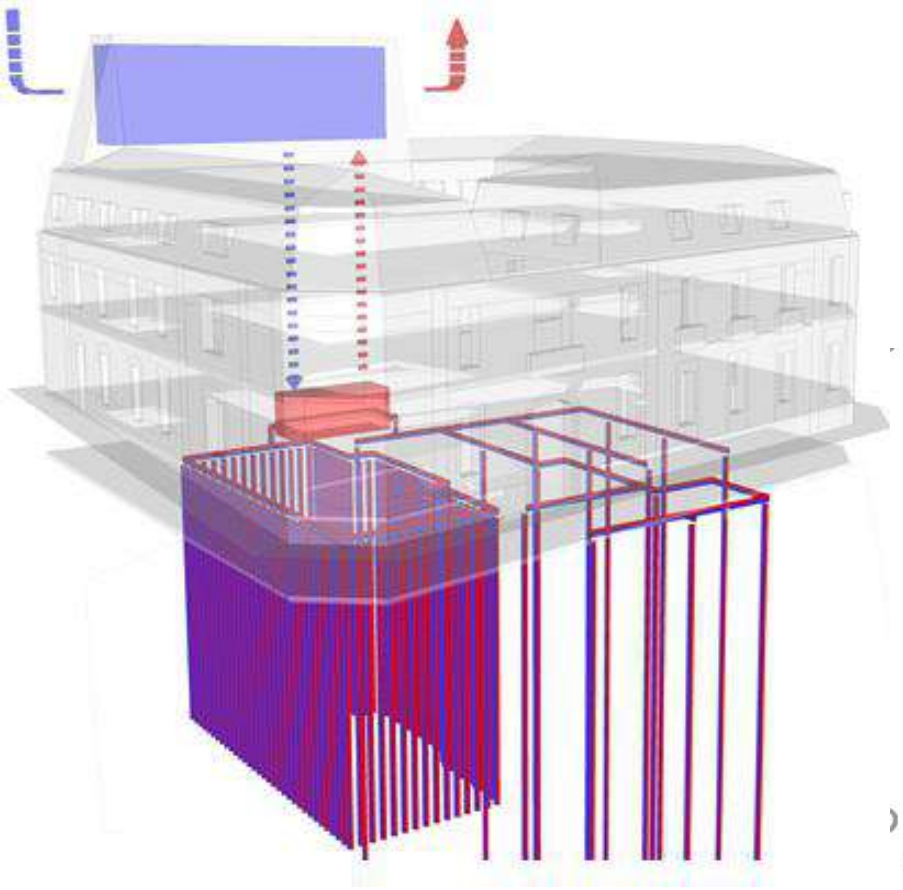


Geostructures integrated into new facilities, enhance the scope efficiency in the recovery process of this building, the first case in Spain to incorporate climate conditioning based on geothermal exchange and seasonal storage and the use of the horizontal concrete structure of the building as a thermoactive heating and cooling system, with daily storage, within a comprehensive rehabilitation process on a classed heritage building.

Source eneres

REHABILITATION OF A CLASSED PALACE FOR ADMINISTRATION OFFICES. CHAMBERÍ. MADRID. 2009/2010





Hybrid Geothermal Exchanger

The geothermal exchange and storage system resolves the efficient coverage of the building's demand and the management of bioclimatic resources.

A dashed screen of piles, with 45 thermoactive pilots for geothermal exchange and 14 vertical exchangers of 150 m depth.

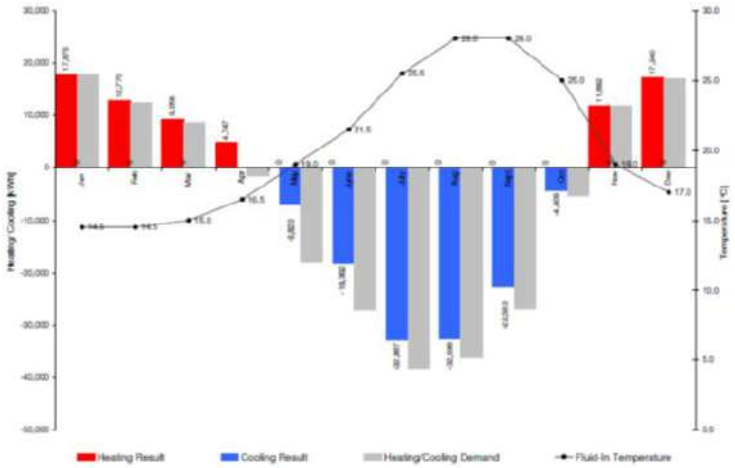


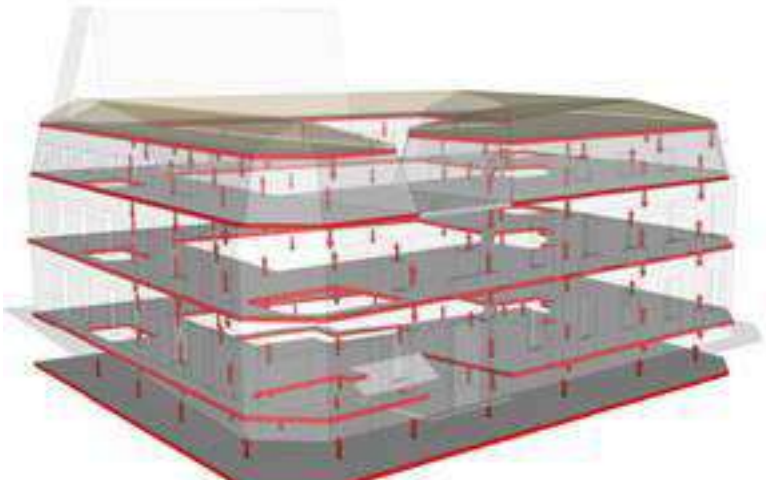
Diagram 3: monthly results for heating and cooling from the system

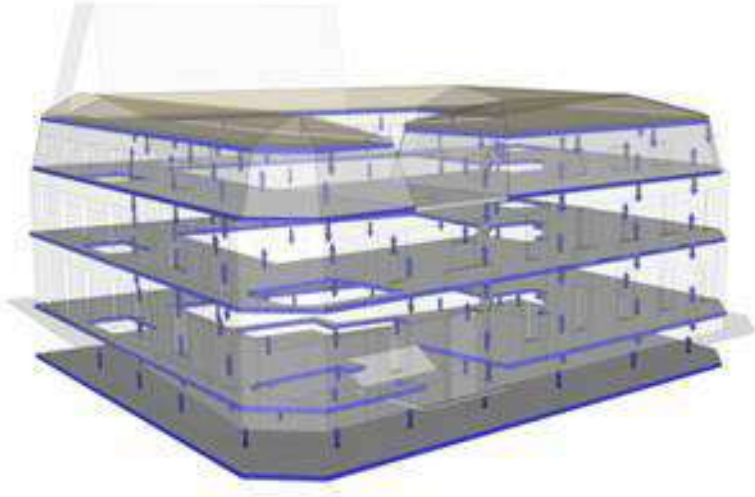
Source eneres

REHABILITATION OF A CLASSED PALACE FOR ADMINISTRATION OFFICES. CHAMBERÍ. MADRID. 2009/2010

Source eneres

REHABILITATION OF A CLASSED PALACE FOR ADMINISTRATION OFFICES. CHAMBERÍ. MADRID. 2009/2010





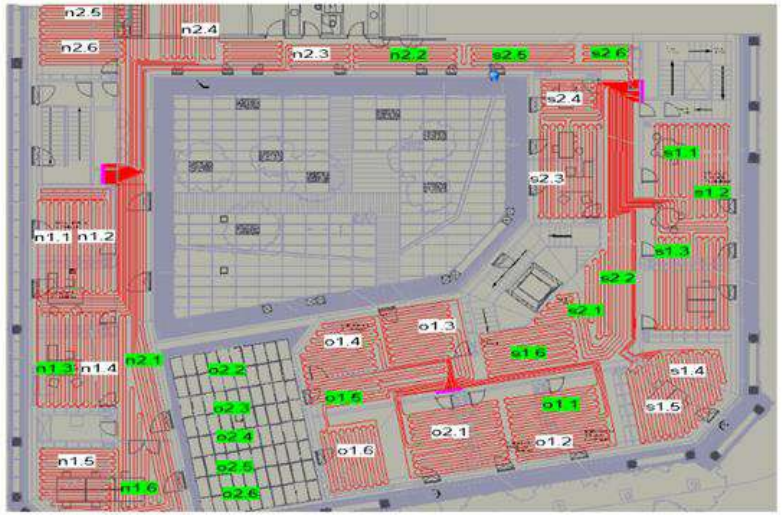
Thermoactive structures. The integral rehabilitation of the building includes the reconstruction of the slabs, replacing them by slabs of concrete, thermoactive slabs that operate as energy storage devices, transmitting or absorbing energy, allowing to solve the climate conditioning of the building, with great radiant comfort and very low consumption of primary resources.

Source : eneres

REHABILITATION OF A CLASSED PALACE FOR ADMINISTRATION OFFICES. CHAMBERÍ. MADRID. 2009/2010

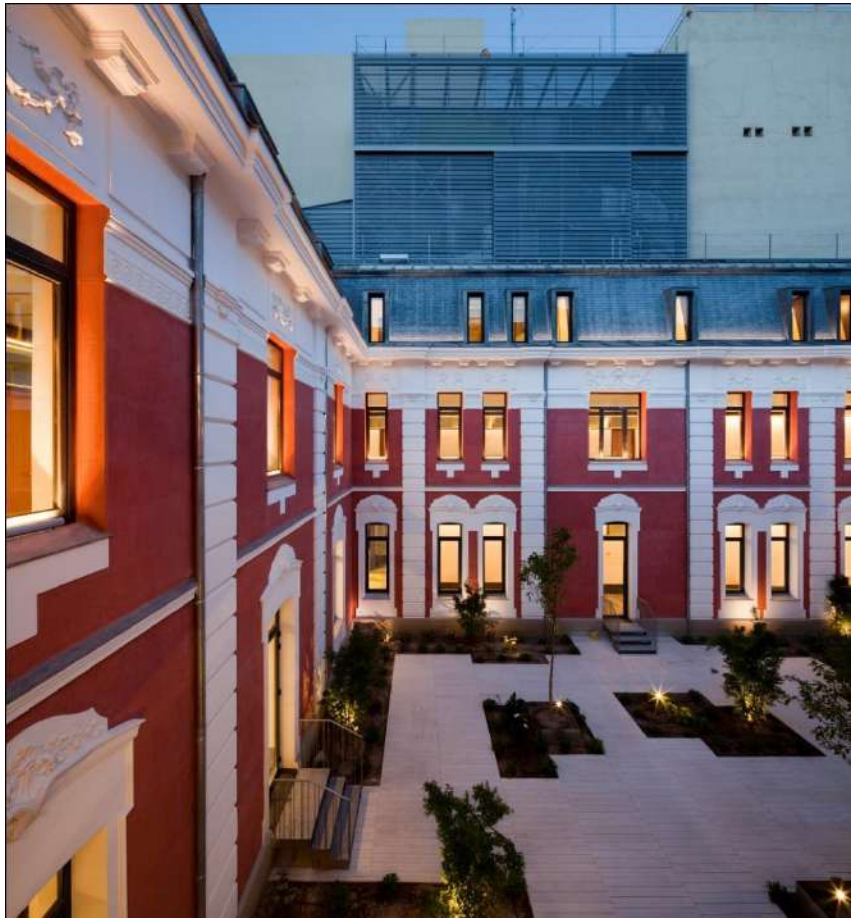
Management for efficiency.

A customized and integrated, information acquisition and management system, governs the building's energy systems, the measurement and verification of the parameters of comfort and consumption, and the operation and maintenance. It is oriented for the building to operate permanently within the maximum efficiency scenarios .



Source eneres

REHABILITATION OF A CLASSED PALACE FOR ADMINISTRATION OFFICES. CHAMBERÍ. MADRID. 2009/2010



HEADQUARTERS OF THE OFFICIAL ASSOCIATION OF ARCHITECTS. MADRID. 2023

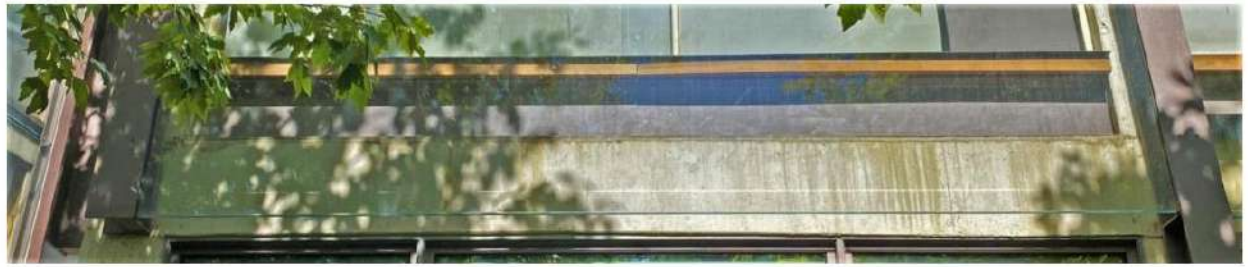
Guidelines for action. Proposal of systems for inertial, geothermal and thermoactive use.

Contemplating the opportunities for improvement that exist throughout the area of influence of the building and selecting and modulating the intensity of action on each of them with a rigorous real-time study of costs and benefits, we focus on the following:

- Interaction between the aerial and underground components of the building.
- Climatic, anthropic microclimatic and indoor climate potential for the reduction of demand through bioclimatism and the recovery of "passive“ interaction capacities between the building and its surroundings.
- Possibilities of interaction with the other buildings of the complex.

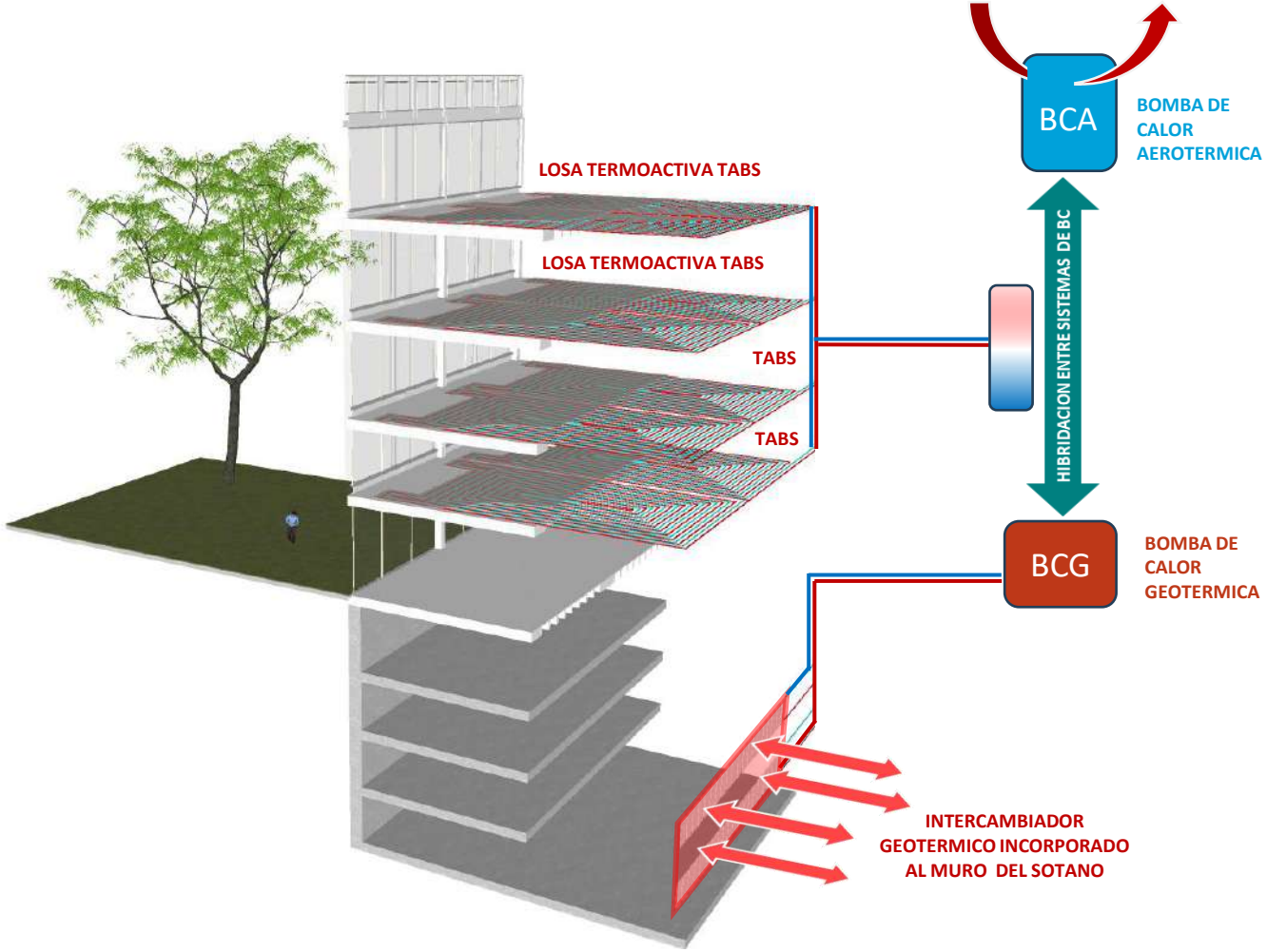
Source IEI Instituto Europeo de Innovación

HEADQUARTERS OF THE OFFICIAL ASSOCIATION OF ARCHITECTS. MADRID. 2023



Source IEI Instituto Europeo de Innovación

HEADQUARTERS OF THE OFFICIAL ASSOCIATION OF ARCHITECTS. MADRID. 2023

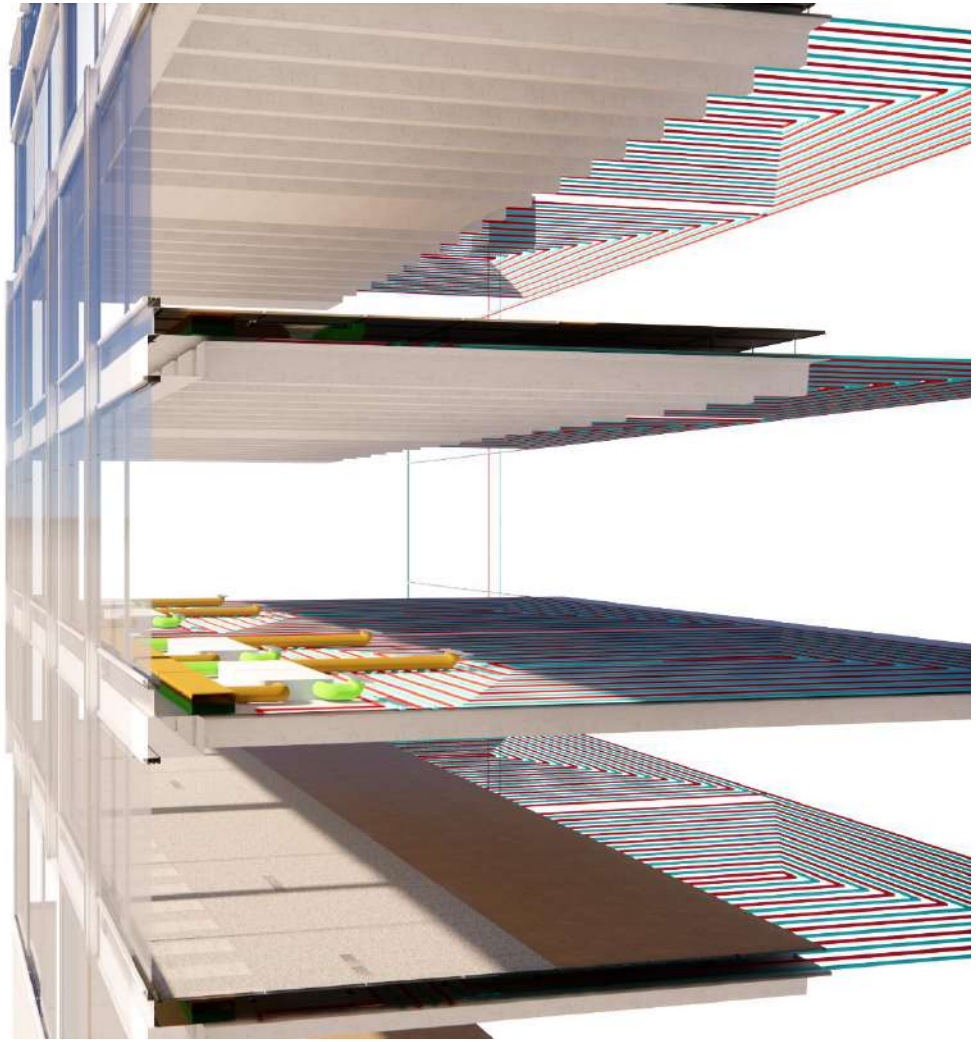


Source IEI Instituto Europeo de Innovación

HEADQUARTERS OF THE OFFICIAL ASSOCIATION OF ARCHITECTS. MADRID. 2023

Directrices de actuación.

Termoactivación de la masa estructural. TABS.

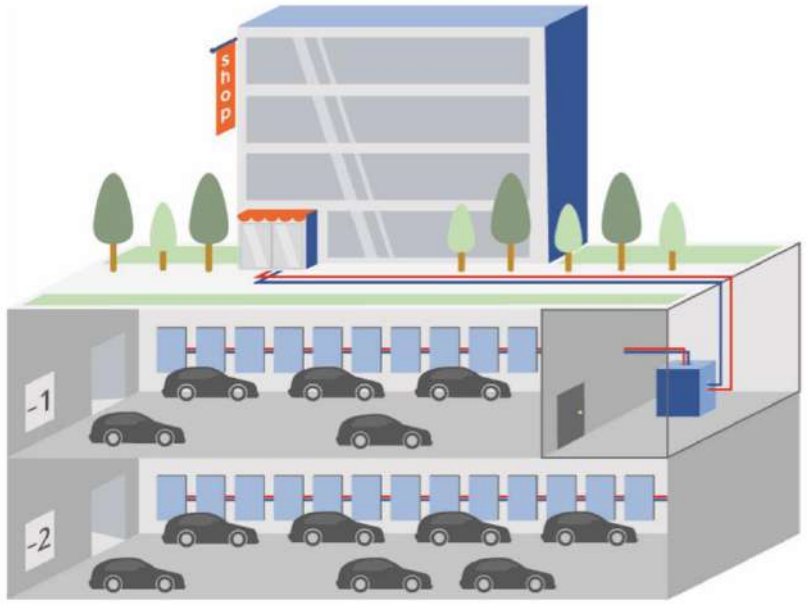


Source IEI Instituto Europeo de Innovación

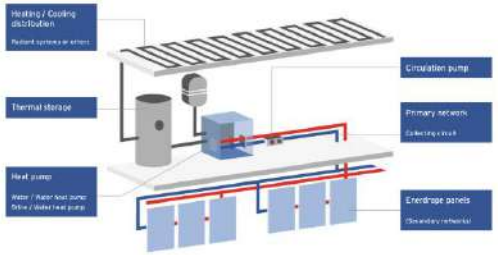
GEOSUSTAINED

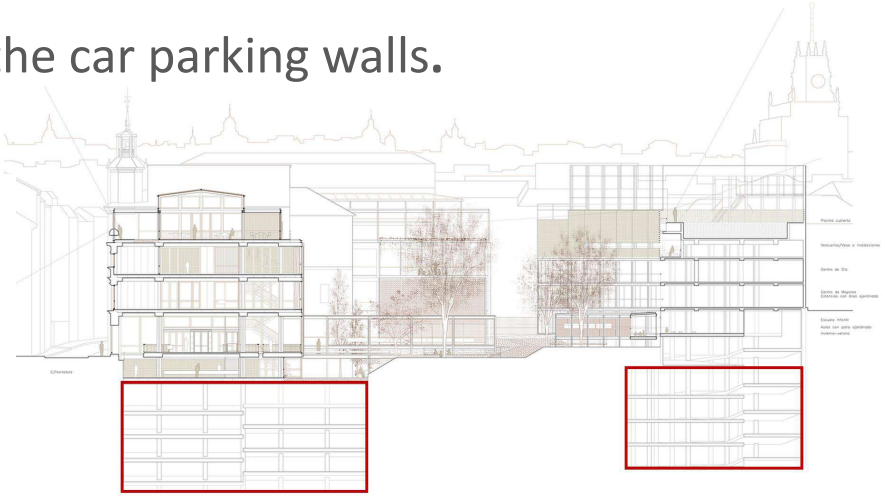
HEADQUARTERS OF THE OFFICIAL ASSOCIATION OF ARCHITECTS. MADRID. 2023

Guidelines for action. Geothermal post-activation of the walls of the car parking walls.



Coupling with fossil or other renewable sources to increase renewable energy share or efficiency

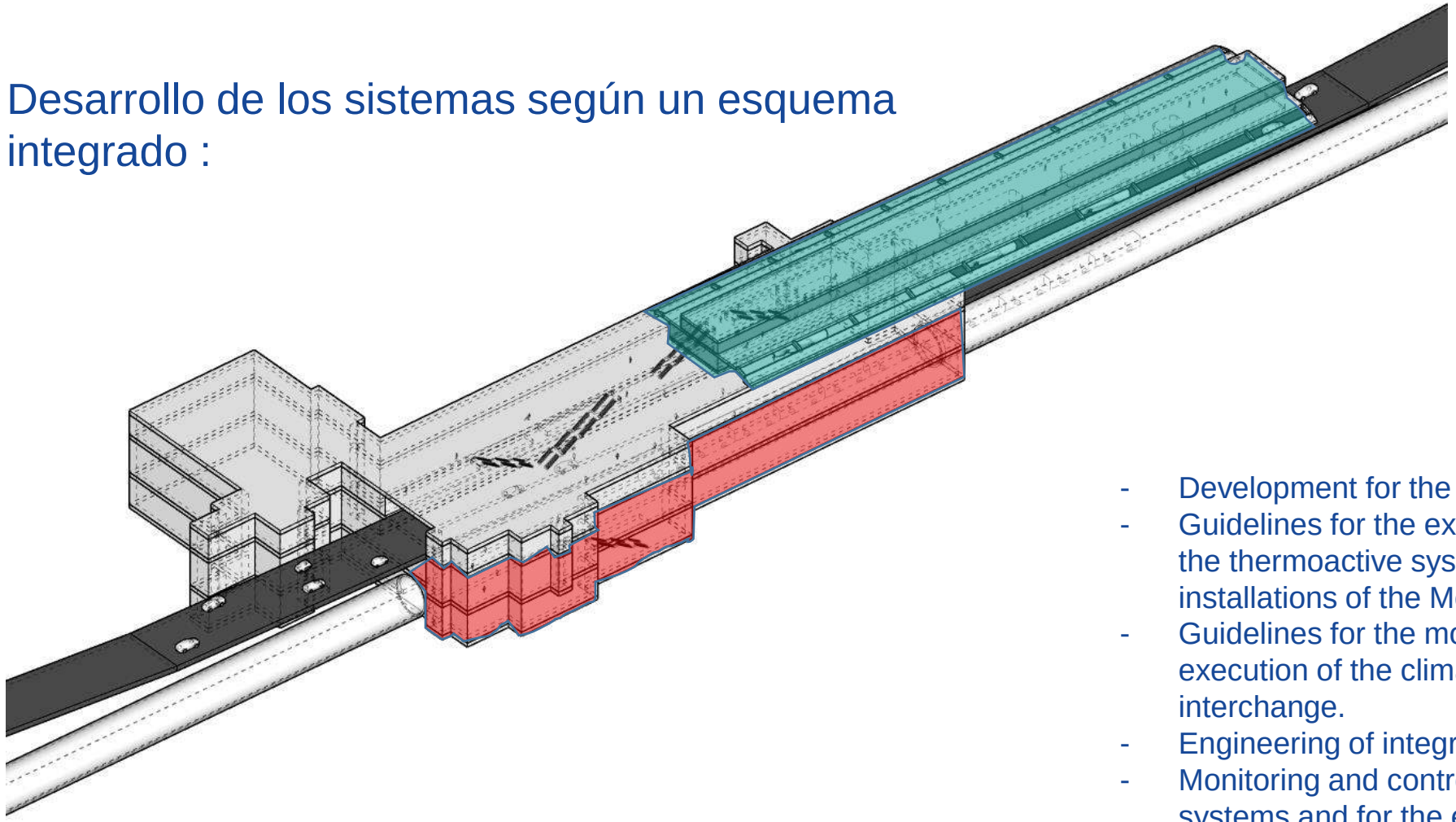


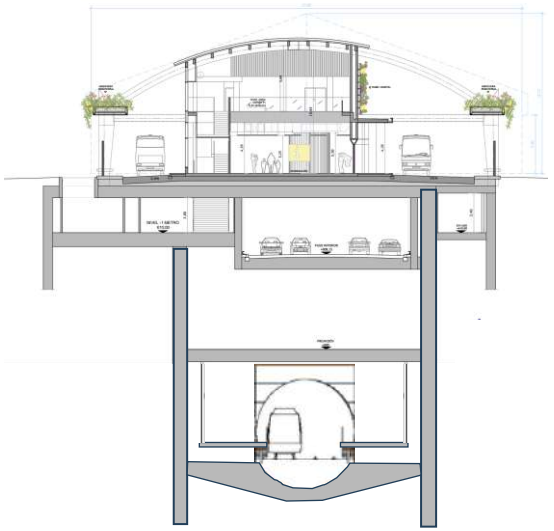


Source IEI Instituto Europeo de Innovación

GEPSTRUCTURES IN MADRID UNDERGROUND. MADRID. 2023

Desarrollo de los sistemas según un esquema integrado :

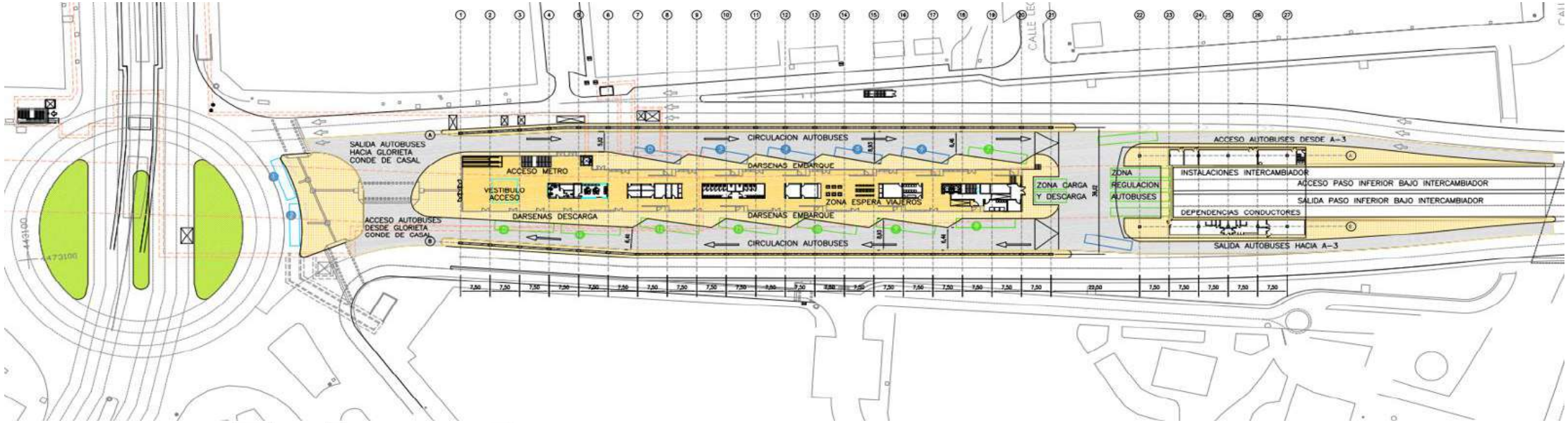


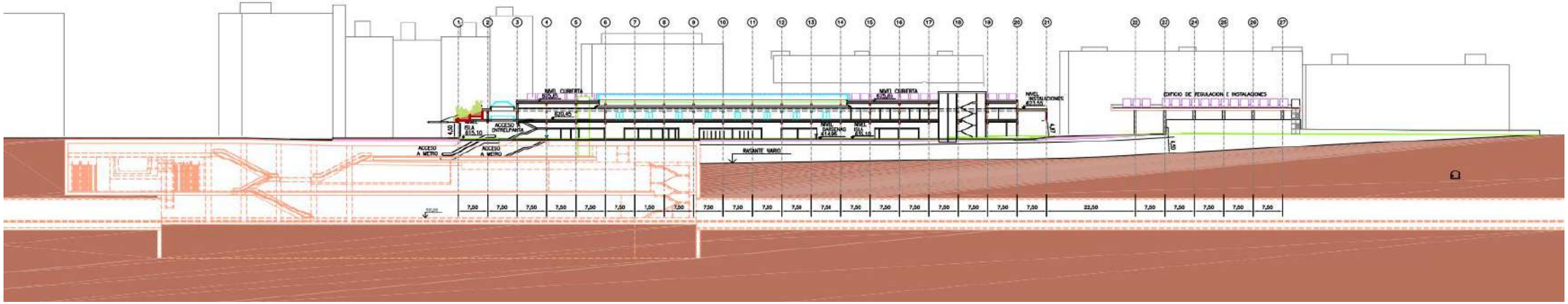


- Development for the execution of thermoactive systems.
- Guidelines for the execution of improvements in relation to the thermoactive systems of the systems of climate and air installations of the Metro station.
- Guidelines for the modification of the project for the execution of the climate and air systems of the transport interchange.
- Engineering of integration, operation and monitoring.
- Monitoring and control projects for the efficiency of the systems and for the evaluation of the thermo-structural behavior of the thermoactive systems.

Source IEI Instituto Europeo de Innovación

GEPSTRUCTURES IN MADRID UNDERGROUND. MADRID. 2023





Source IEI Instituto Europeo de Innovación

GEOSUSTAINED

GEPSTRUCTURES IN MADRID UNDERGROUND. MADRID. 2023

PROYECTO DE GESTION INTEGRADA DE LOS SISTEMAS

ESTACION METRO

INTERCAMBIADOR TRANSPORTE

FASE 1
INFORMACION

- Recopilación Análisis Síntesis
- Recopilación Análisis Síntesis

INTEGRACION AGENTES PROCESOS RESULTADOS

FASE 2
DETERMINACIÓN DE OBJETIVOS

- Especificación
- Especificación

INTEGRACION AGENTES PROCESOS RESULTADOS

FASE 3
DESARROLLO DE CONCEPTOS

- Concepción
- Concepción

INTEGRACION AGENTES PROCESOS RESULTADOS

FASE 4
INGENIERIA DE DETALLE

- Desarrollo
- Desarrollo

INTEGRACION AGENTES PROCESOS RESULTADOS

FASE 5
DIRECCIÓN DE EJECUCIÓN

- Ejecución
- Ejecución

INTEGRACION AGENTES PROCESOS RESULTADOS

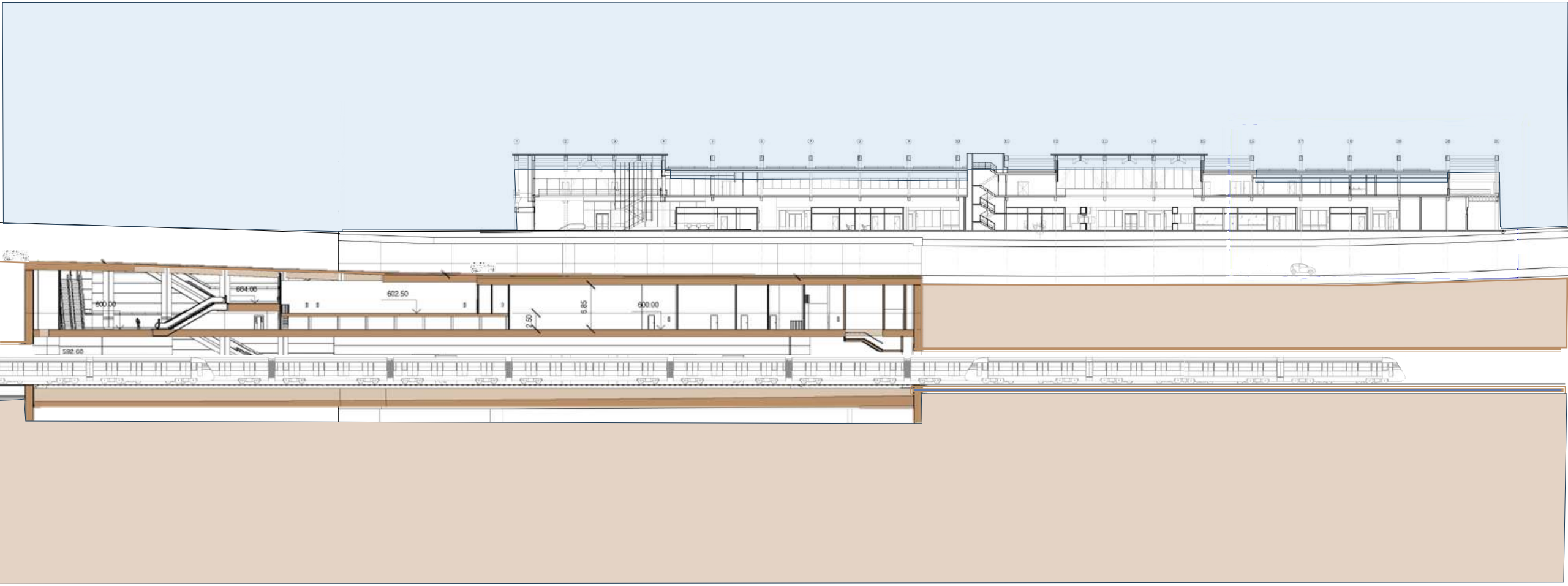
FASE 6
SEGUIMIENTO

- Ciclo de vida O+M / M+V
- Ciclo de vida O+M / M+V

INTEGRACION AGENTES PROCESOS RESULTADOS

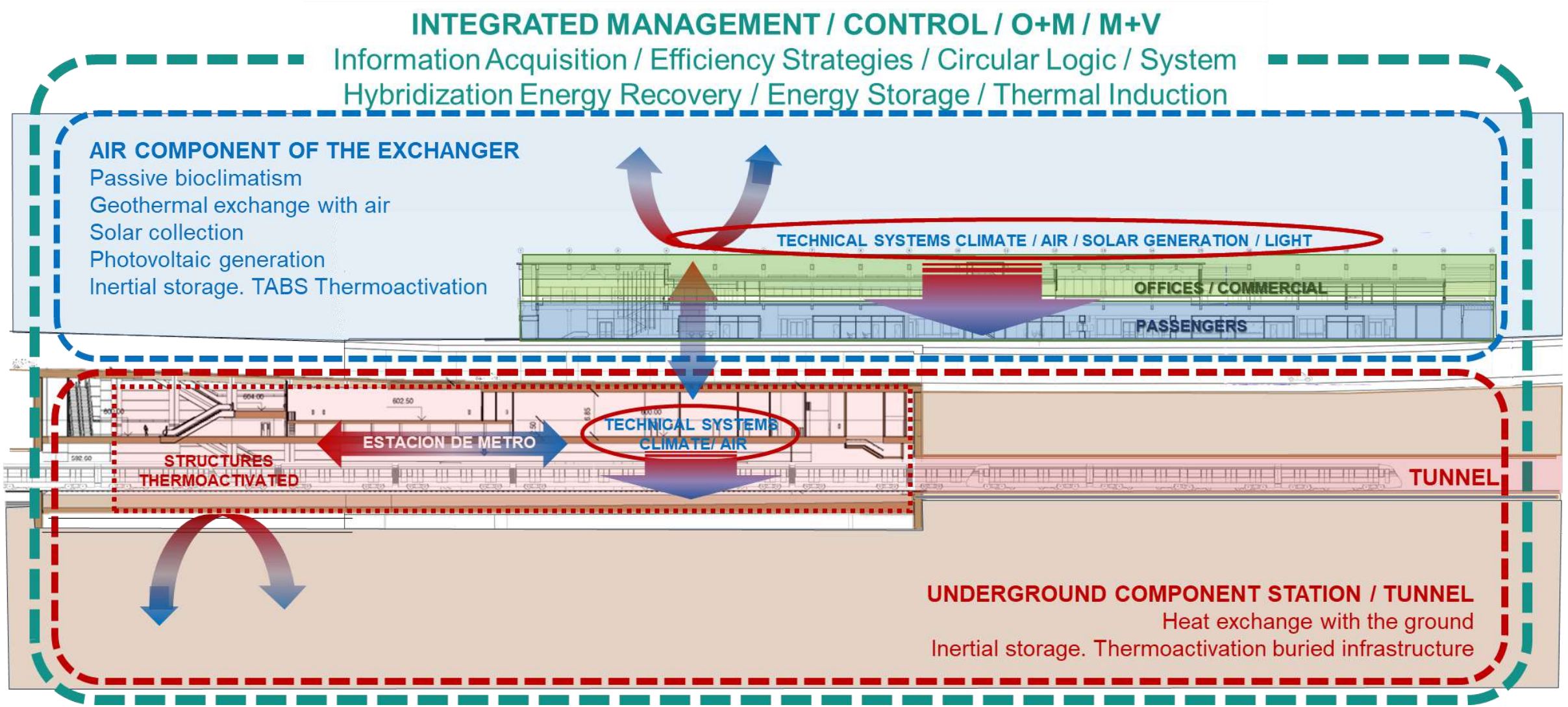
Source IEI Instituto Europeo de Innovación

GEOSTRUCTURES IN MADRID UNDERGROUND. MADRID. 2023



Source IEI Instituto Europeo de Innovación

GEOSTRUCTURES IN MADRID UNDERGROUND. MADRID. 2023

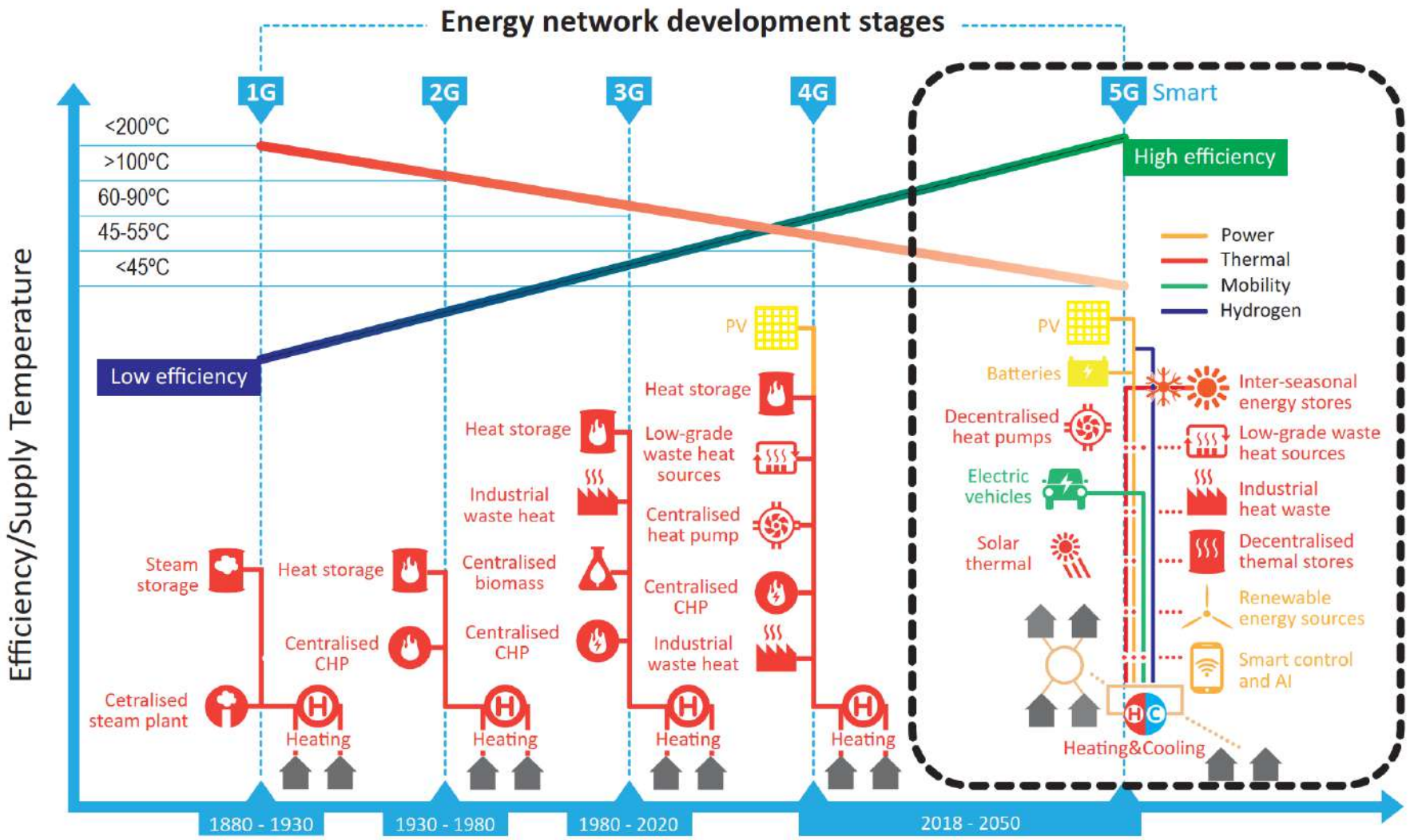


Source IEI Instituto Europeo de Innovación

URBAN NETWORK CASES

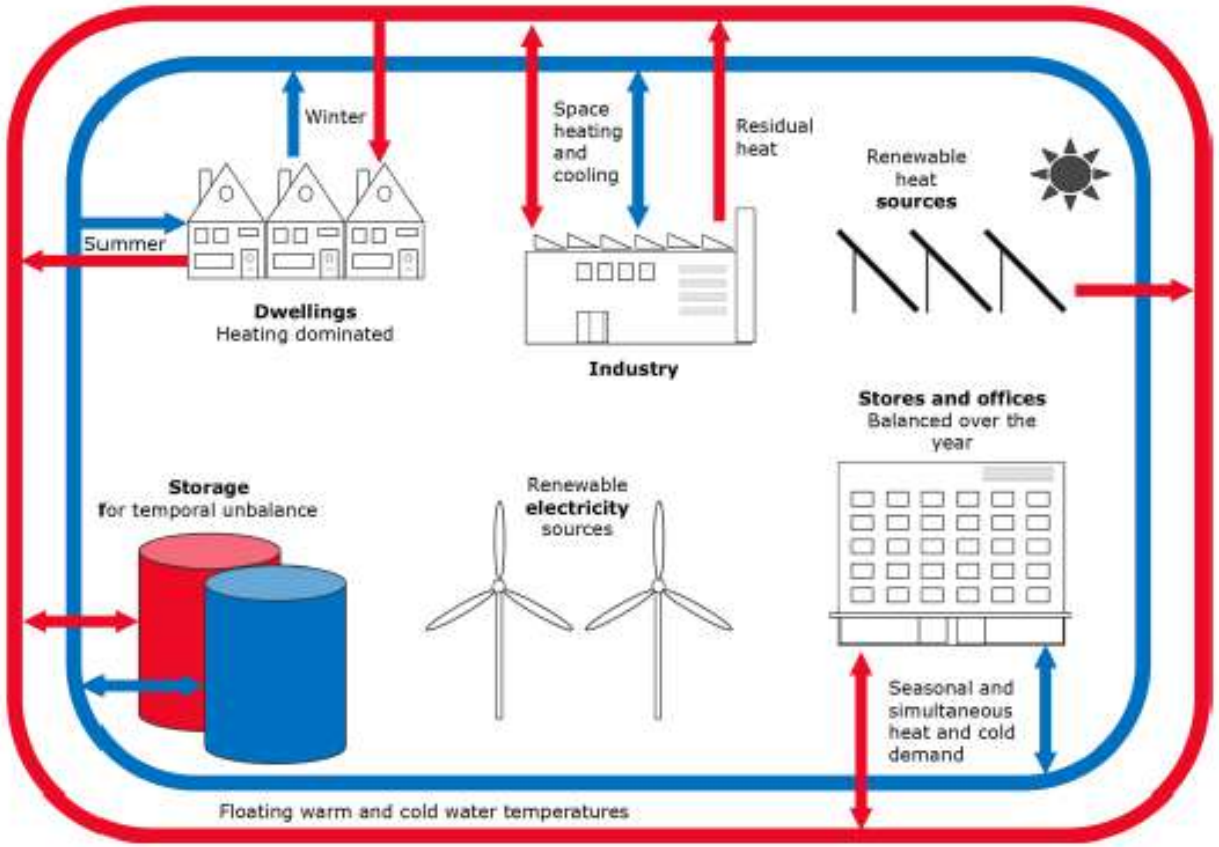
- Integration of energy systems in 5GHCN

5G NETWORKS AS URBAN INTEGRATION RESOURCE



Source IEI Instituto Europeo de Innovación

5G NETWORKS AS URBAN INTEGRATION RESOURCE



VS

Source Wikipedia

5G NETWORKS AS URBAN INTEGRATION RESOURCE

Survey of 53 Fifth-Generation District Heating and Cooling (5GDHC) Networks in Germany. Marco Wirtz,* Thomas Schreiber, and Dirk Mülle

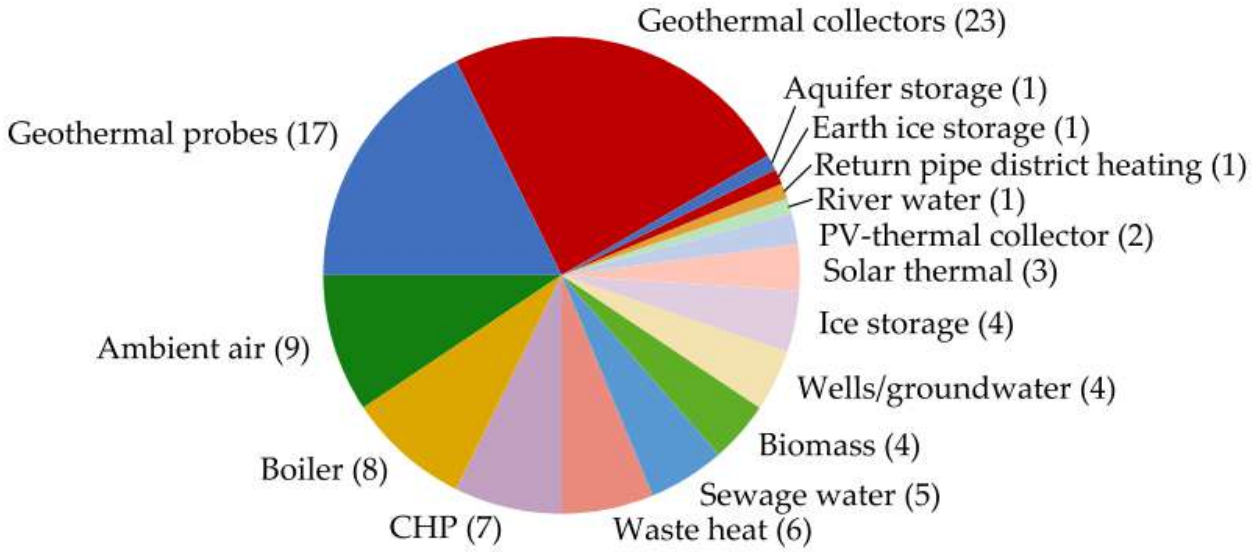
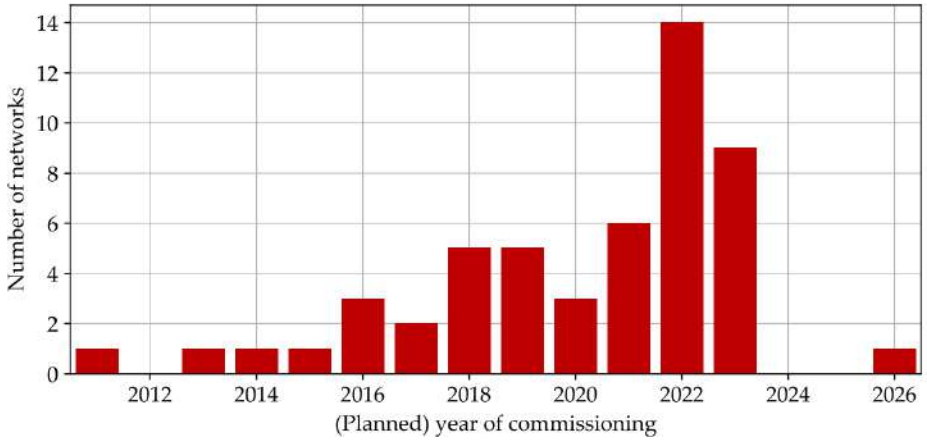


Figure 3. Heat sources for 5GDHC networks. The numbers in brackets indicate in how many districts this heat source is used.



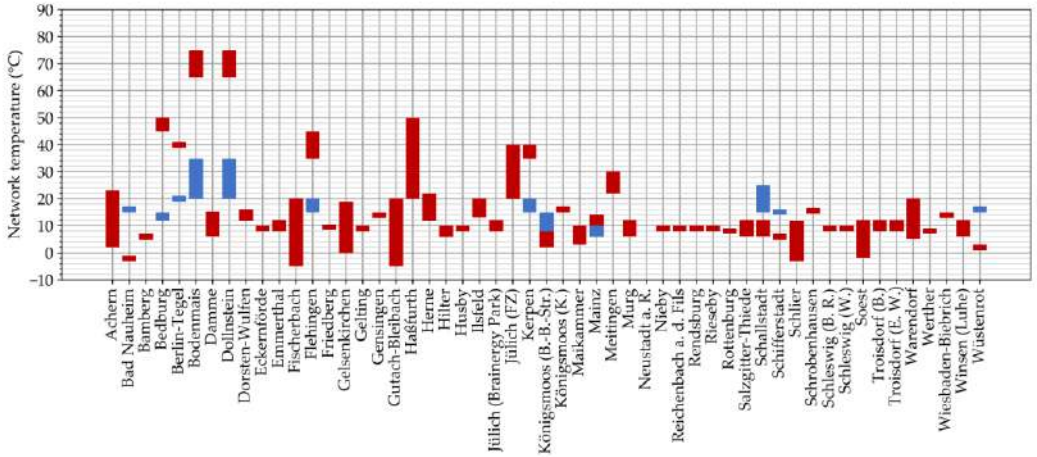
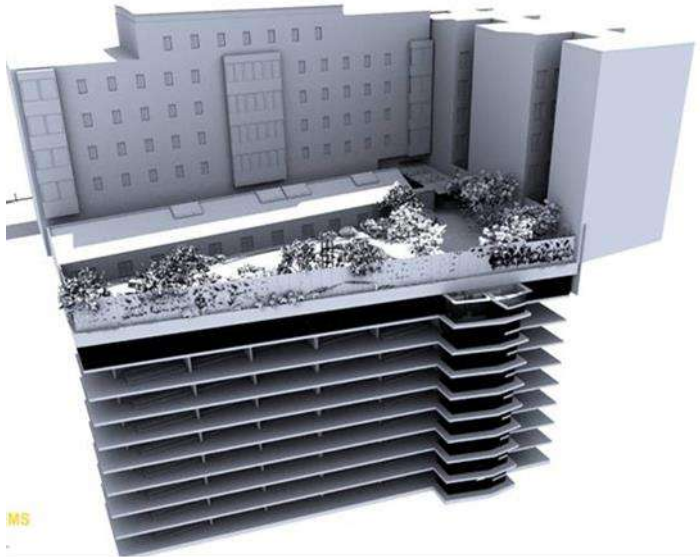


Figure 2. Operational temperatures. Blue intervals indicate summer operation mode. Averaged temperature values are visualized with an interval of 2 K. For open intervals (< or >), an interval of 10 K is visualized.

5G NETWORKS AS URBAN INTEGRATION RESOURCE

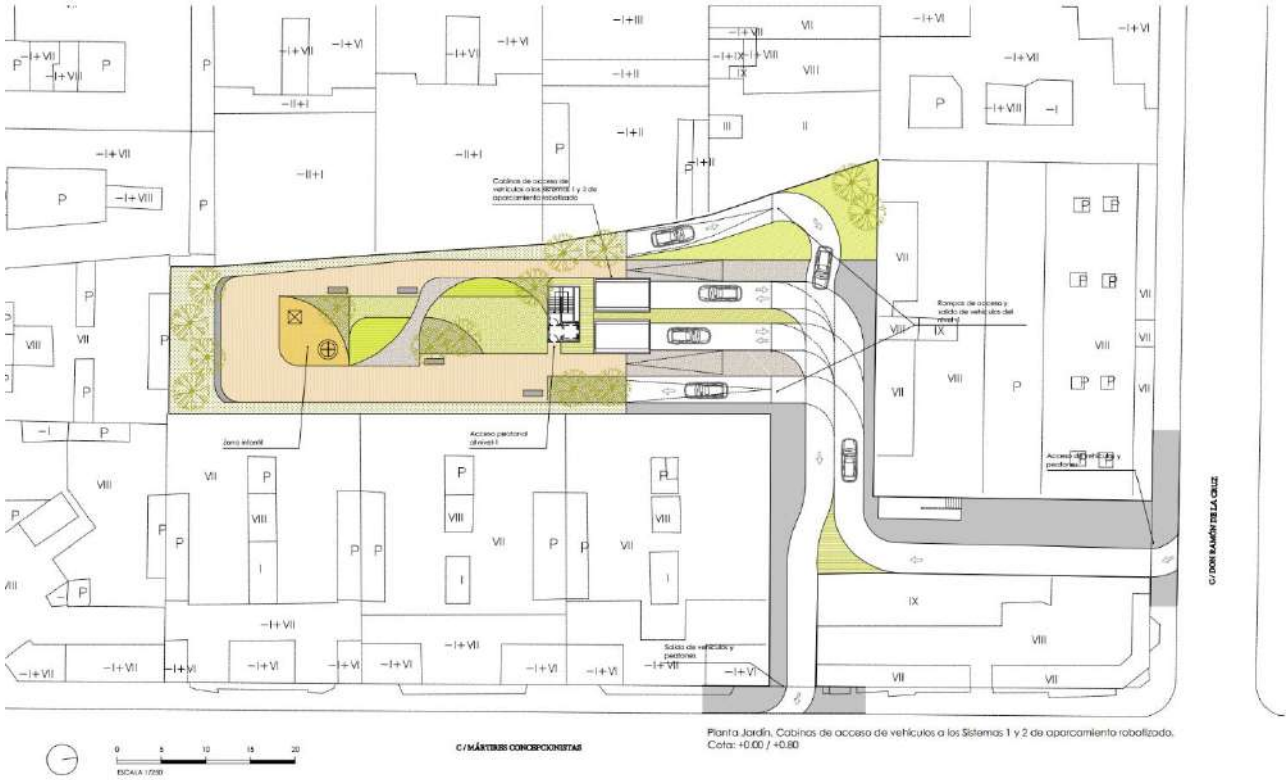
RESIDENTIAL PARKING AND DISTRICT HEATING AND COOLING . Barrio de Salamanca. Madrid 2020



Source IEI Instituto Europeo de Innovación

5G NETWORKS AS URBAN INTEGRATION RESOURCE

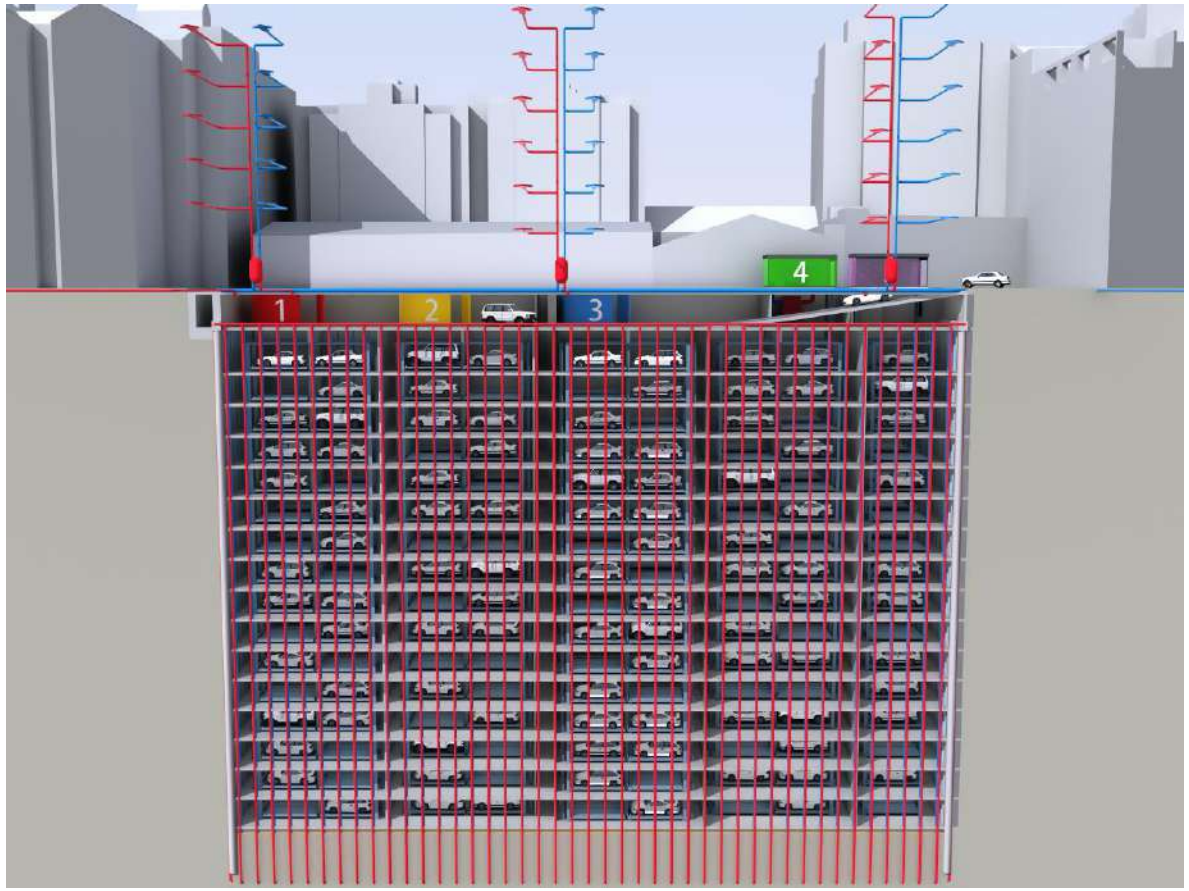
RESIDENTIAL PARKING AND DISTRICT HEATING AND COOLING . Barrio de Salamanca. Madrid 2020

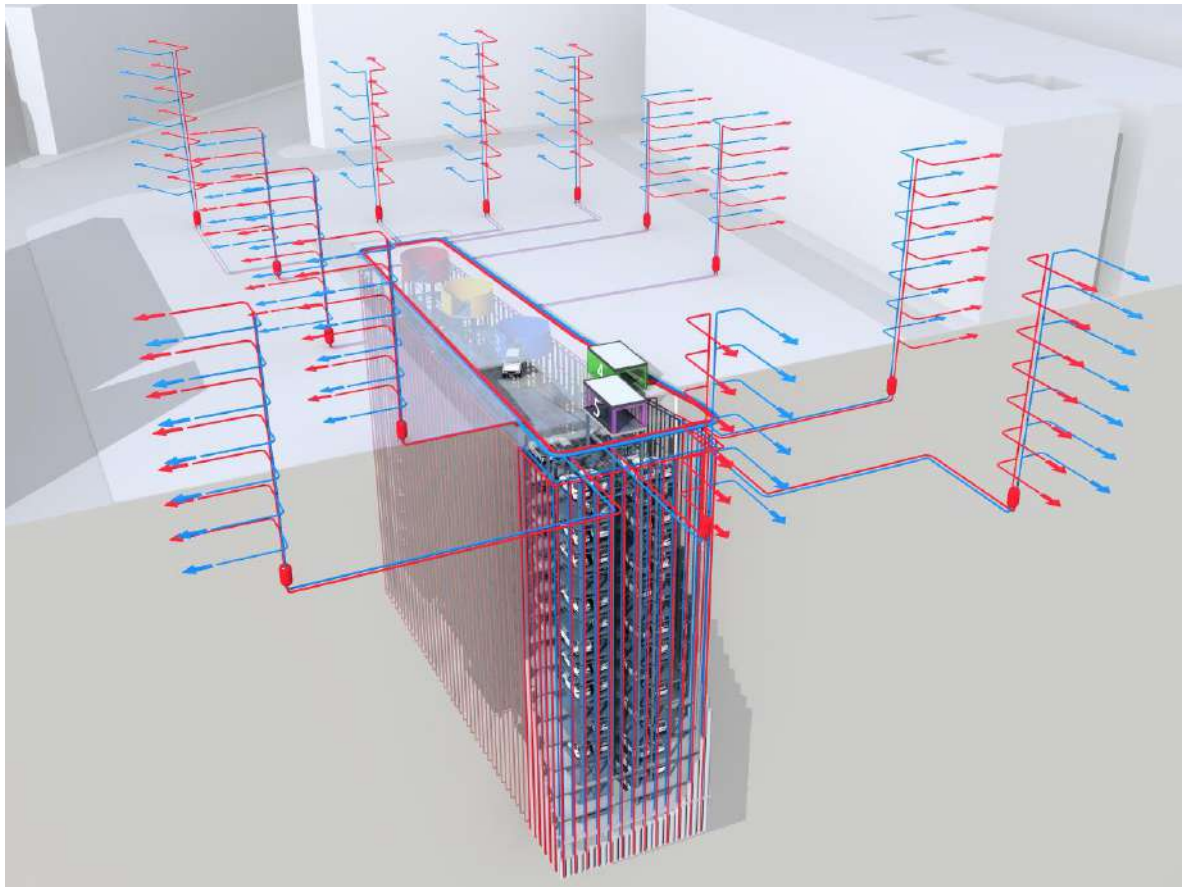


Source IEI Instituto Europeo de Innovación

5G NETWORKS AS URBAN INTEGRATION RESOURCE

RESIDENTIAL PARKING AND DISTRICT HEATING AND COOLING . Barrio de Salamanca. Madrid 2020



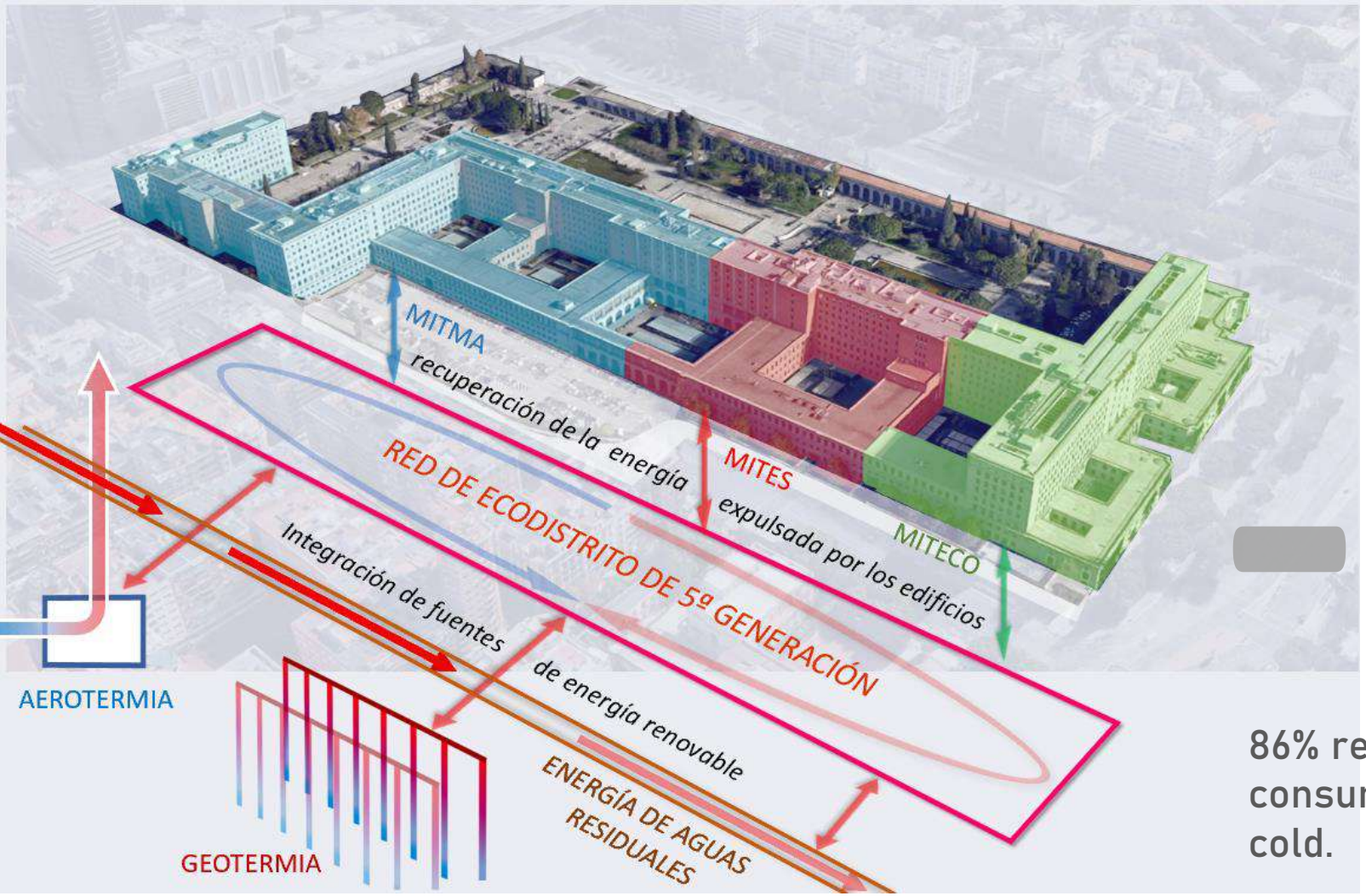


Source IEI Instituto Europeo de Innovación

GEOSUSTAINED

Integration of buildings and geothermal resources under 5GDHC

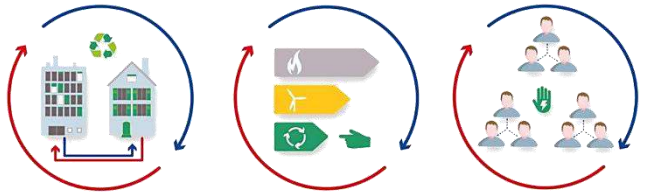
New Ministries Complex NNMM . Madrid 2022.



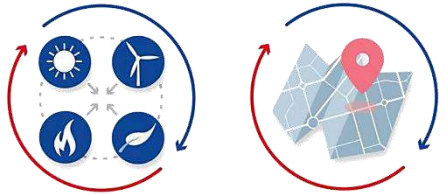
INTERCHANGE BETWEEN BUILDINGS

TEMPERATURA MODERADA

USERS MULTIPLE



INTEGRACIÓN RENOVABLES



RECURSOS LOCALES

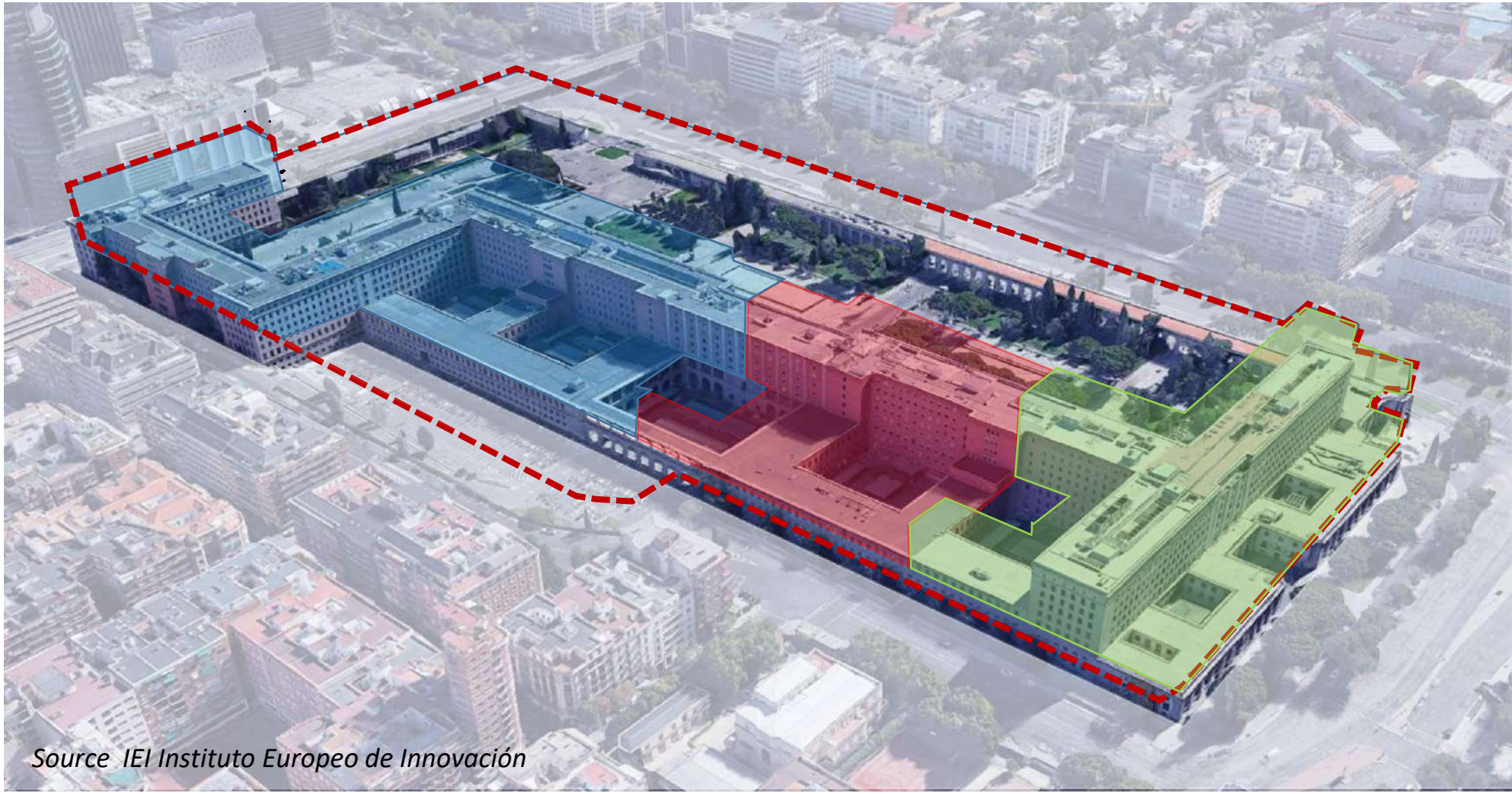
-86%e

86% reduction in primary energy consumption in the production of heat and cold.

Source IEI Instituto Europeo de Innovación

Integration of buildings and geothermal resources under 5GDHC

New Ministries Complex NNMM . Madrid 2022.



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Integration of buildings and geothermal resources under 5GDHC

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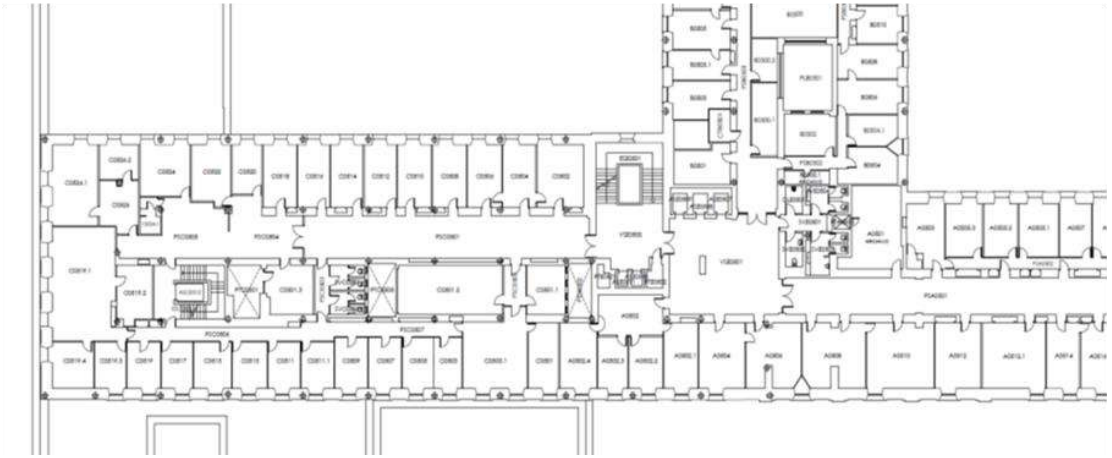
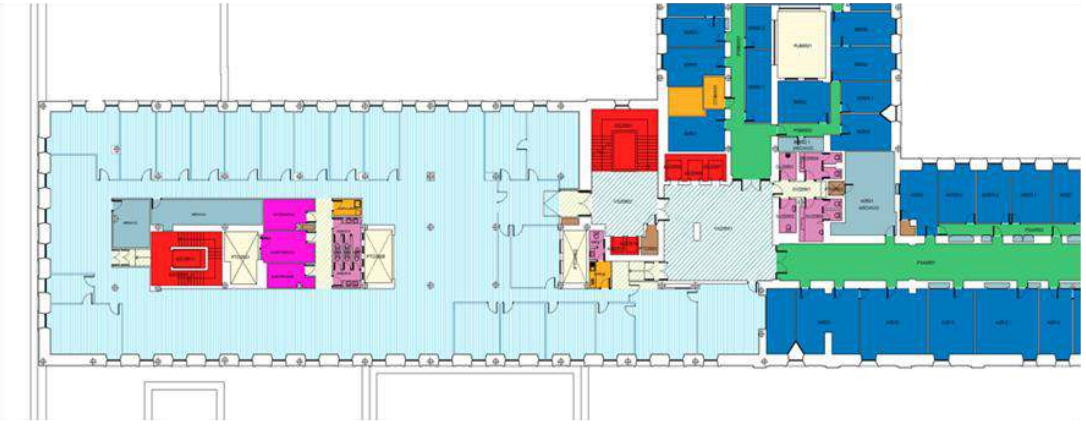


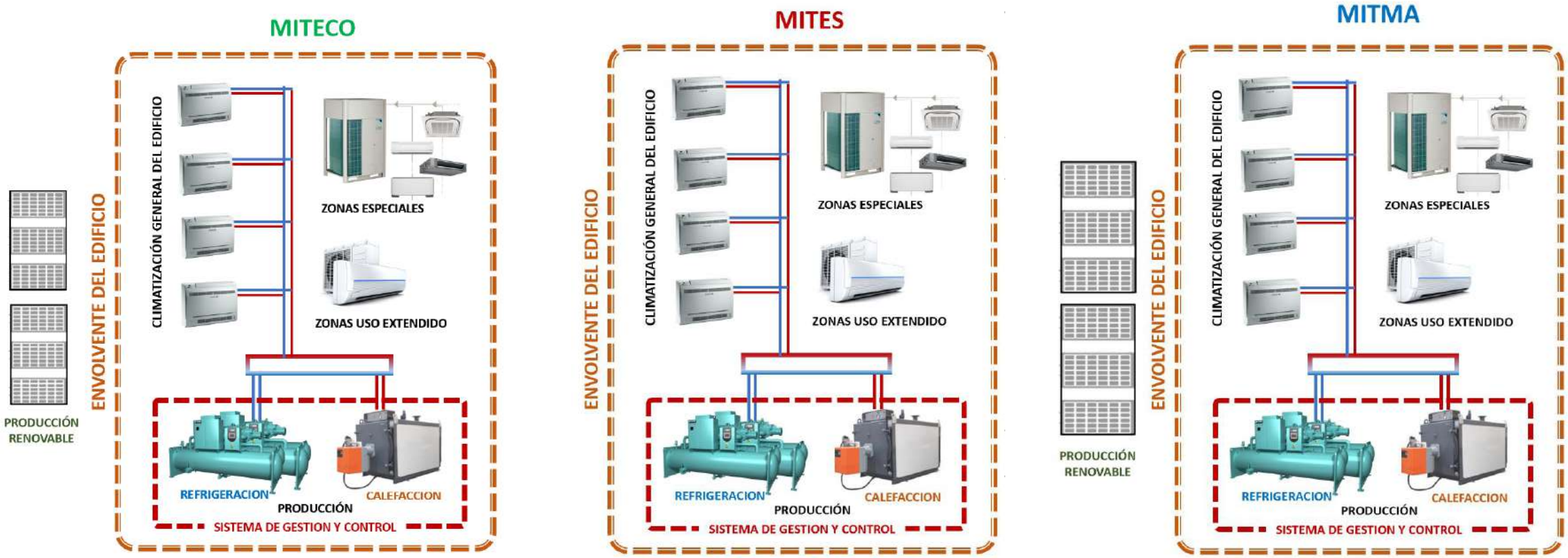


Source IEI Instituto Europeo de Innovación

New Ministries Complex NNMM . Madrid 2022. Collective scale of the NNMM Complex Current status

Despite having similar structures and strategies, each of the 3 Ministries is an independent management, benefits and consumption unit that has acted over decades independently and punctually in the transformation of its components and systems and common elements.

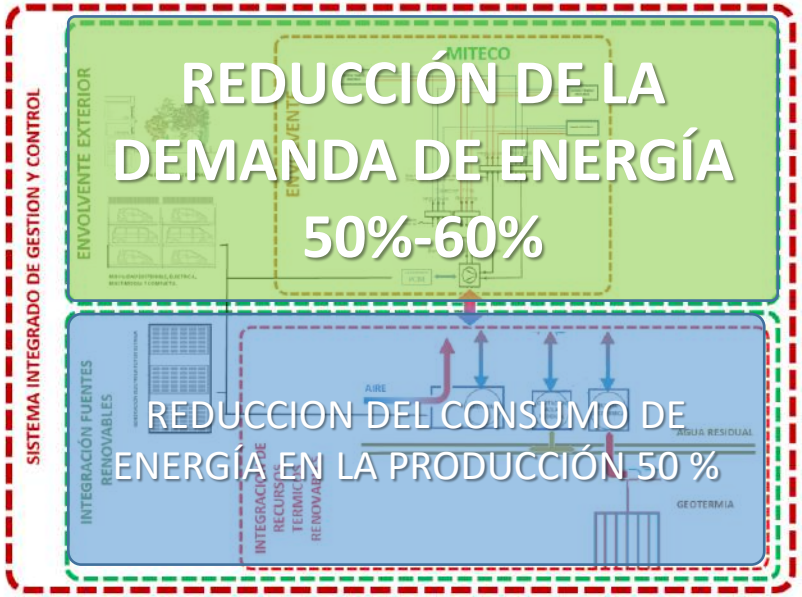
The efficiency potential of integrated, coordinated and community-managed action is not exploited.



Source IEI Instituto Europeo de Innovación

New Ministries Complex. Collective scale of the NNMM Complex. The importance of integration.

The aggregation of individual efficiency models raises the levels of environmental quality in all areas, reduces demand and reduces the consumption of primary resources, but does not take advantage of the enormous potential for resource transfer between the three Ministries and the implementation of management strategies associated with the use of moderate temperature systems. the integration of all renewable resources in the environment and the management of recovered energy through staggered transfer and storage systems.



That is why a model is proposed that preserves the independence of each Ministry in Management and that integrates common resources in an area of concerted management in which MITECO, MITES and MITMA converge.

Source IEI Instituto Europeo de Innovación

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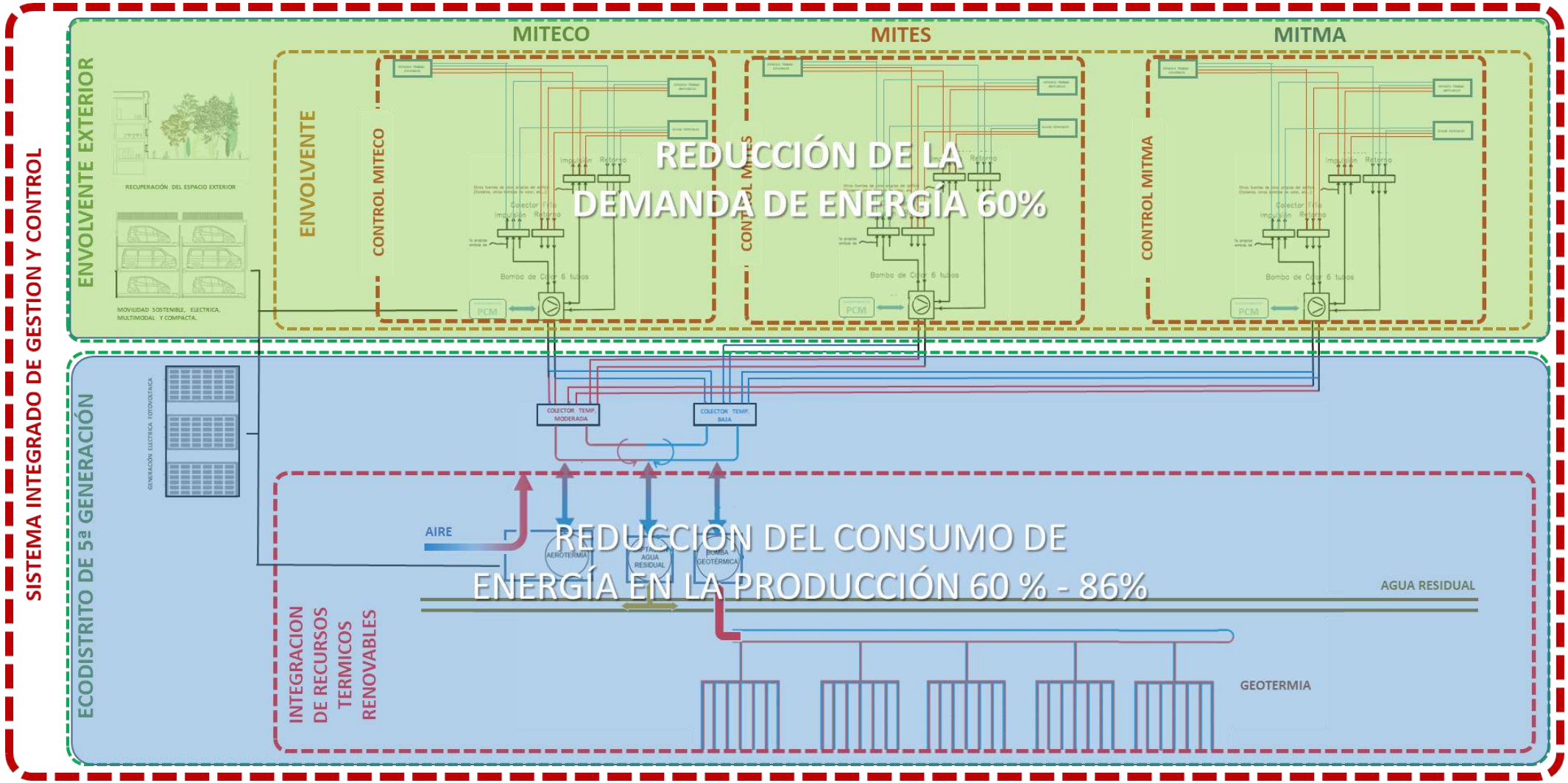
New Ministries Complex NNMM . Madrid 2022.



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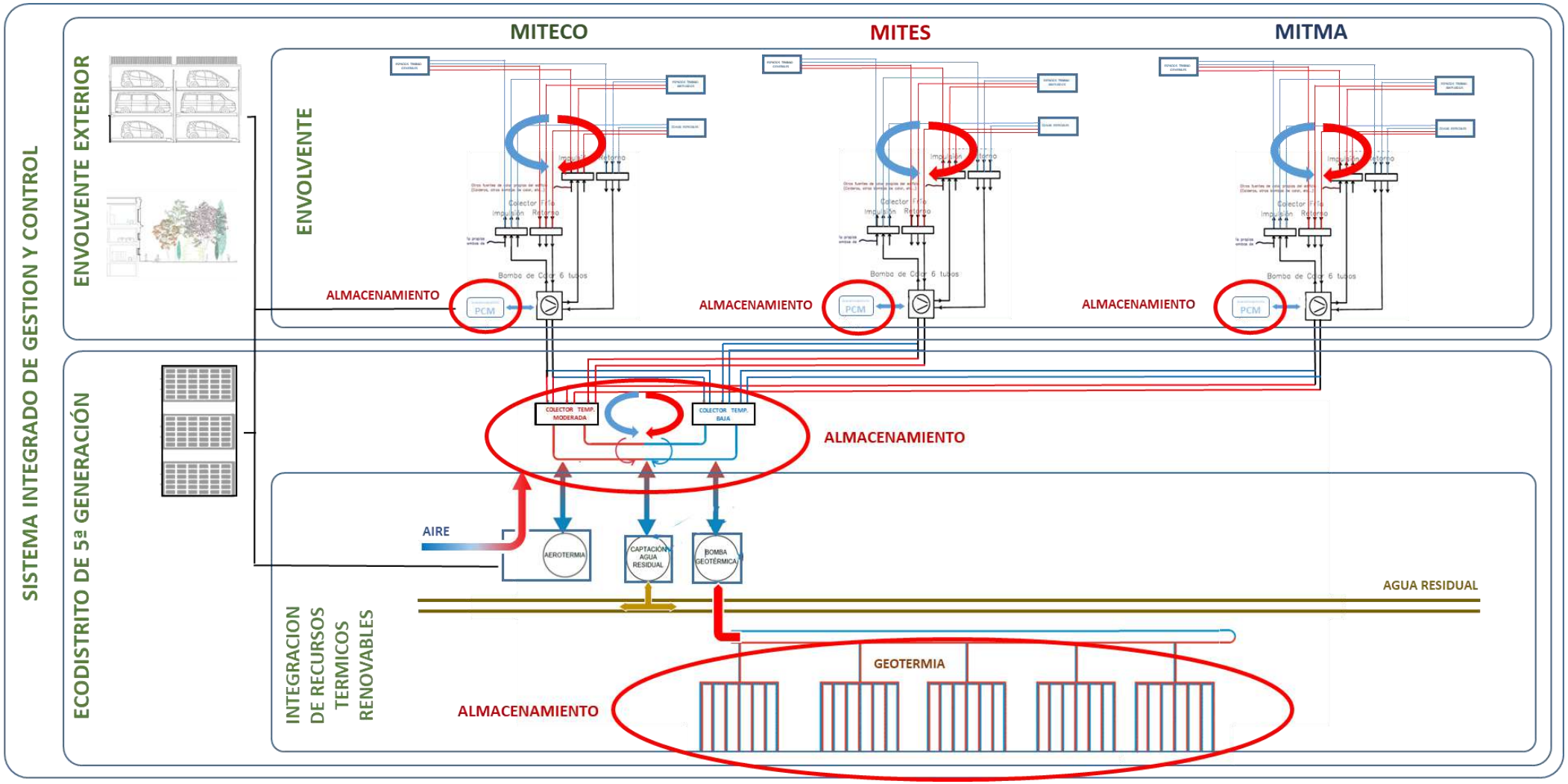
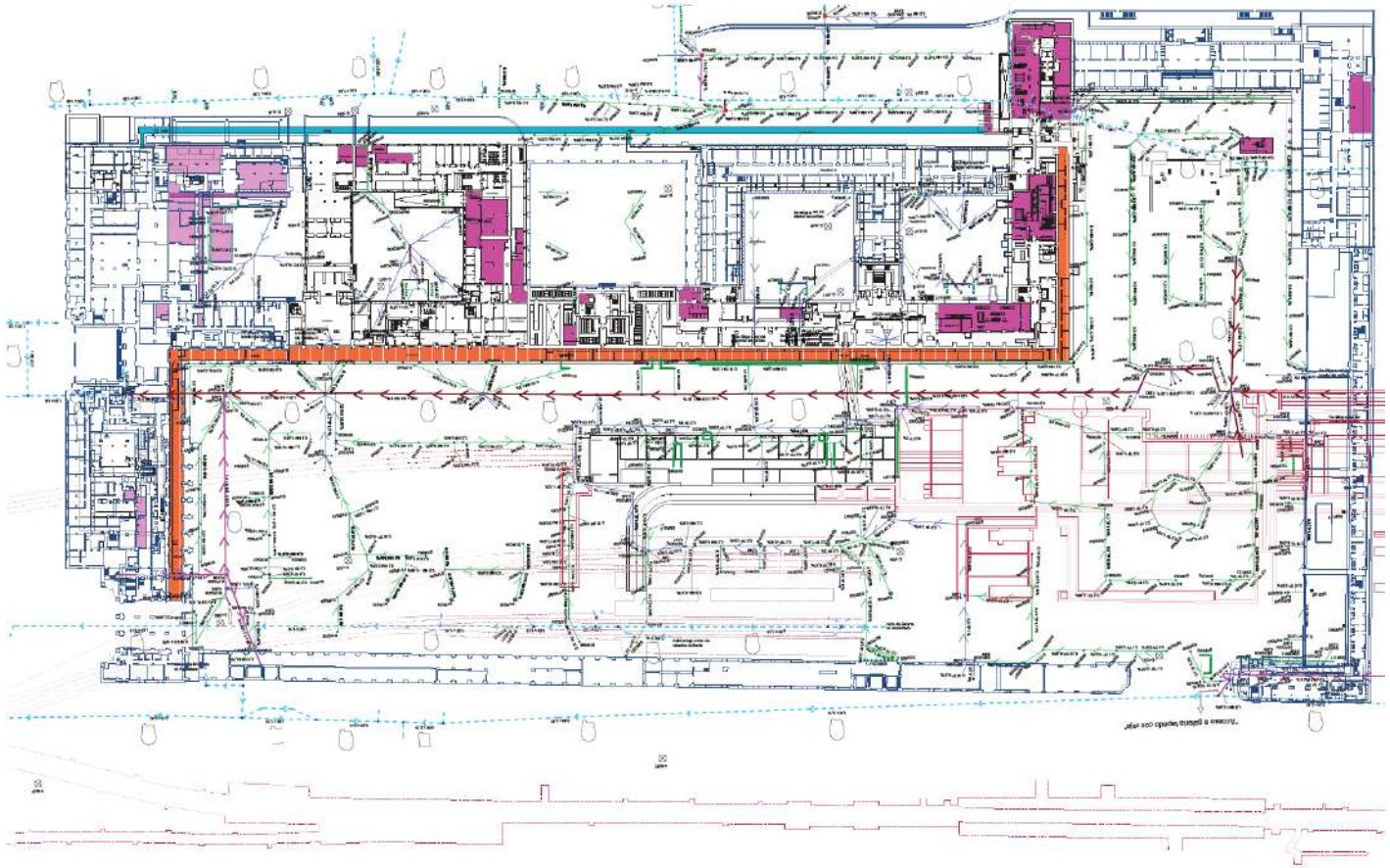


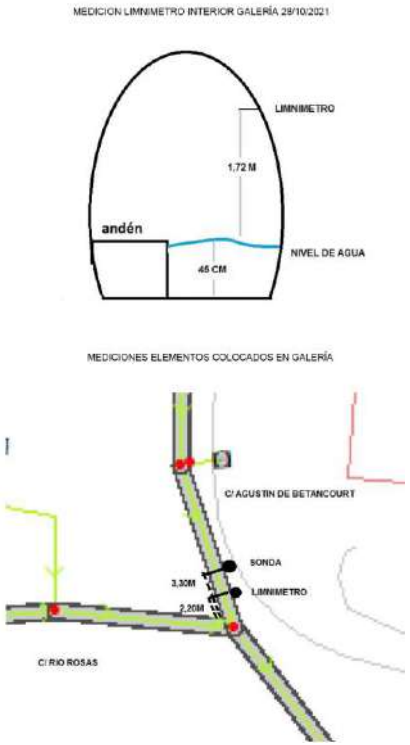
Source IEI Instituto Europeo de Innovación

New Ministries Complex NNMM . Madrid 2022.

Source IEI Instituto Europeo de Innovación

New Ministries Complex NNMM . Madrid 2022.



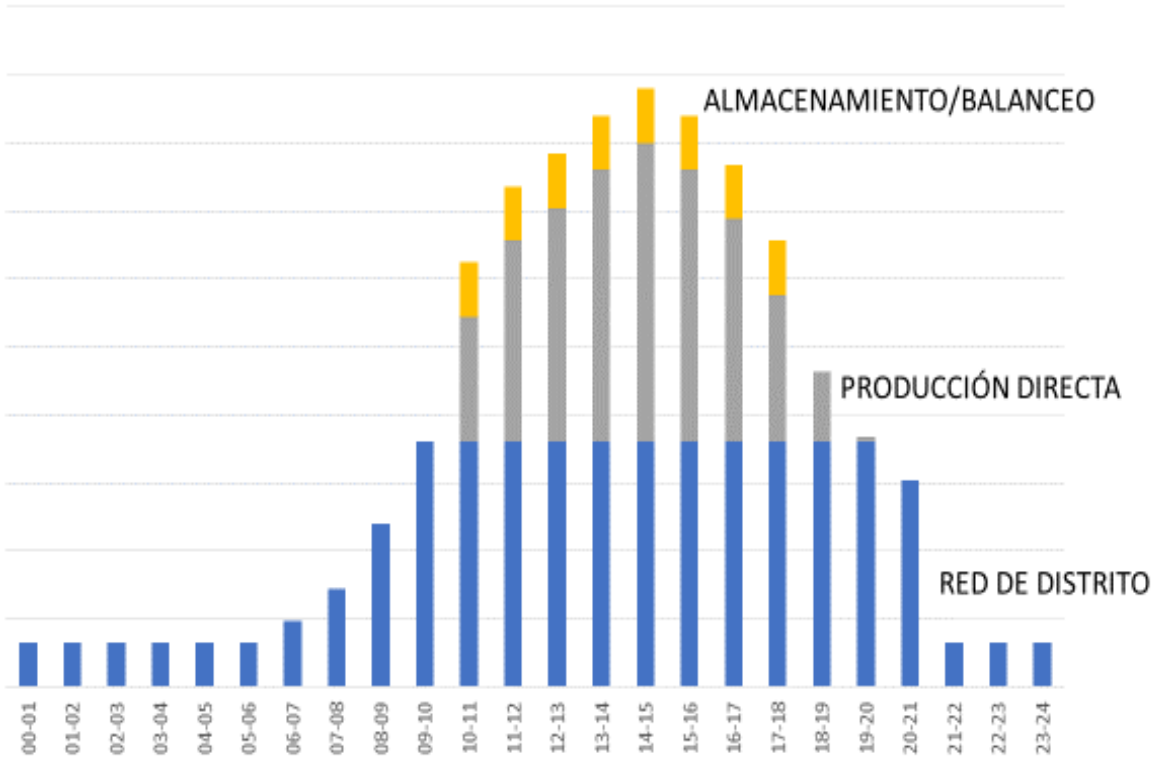


Source IEI Instituto Europeo de Innovación

New Ministries Complex NNMM . Madrid 2022.

Reduction of demand and reduction of emissions by actions in the 5th generation ecodistrict network under the integrated control system.

	DEMANDA RESULTANTE POR MEJORAS DE LA ENVOLVENTE kWh	CONSUMO ACTUAL kWh	CONSUMO PROPUESTA kWh	AHORRO kWh	%	KG CO2	%
TOTALES SISTEMA 5ªG	**5,108,964.92**	**4,425,778.04**	**611,176.79**	**3,814,601.25**	**86%**	**1,123,579.36**	**84.7%**
COMPONENTES DEL SISTEMA DE 5ª G.							
Control (15% consumo evitado por recuperación y almacenamiento). COP actual ponderado 1,15	766,344.74			666,386.73			
Produccion Directa (40% cobertura de la demanda total) COP 6	2,043,585.97			1,436,433.62			
Red De Distrito (45% cobertura de la demanda total). COP 8	2,299,034.21			1,711,780.91			



Source IEI Instituto Europeo de Innovación

GEOTERMIA SUPERFICIAL **Aplicações de sistemas geotérmicos** Aveiro . Lisboa

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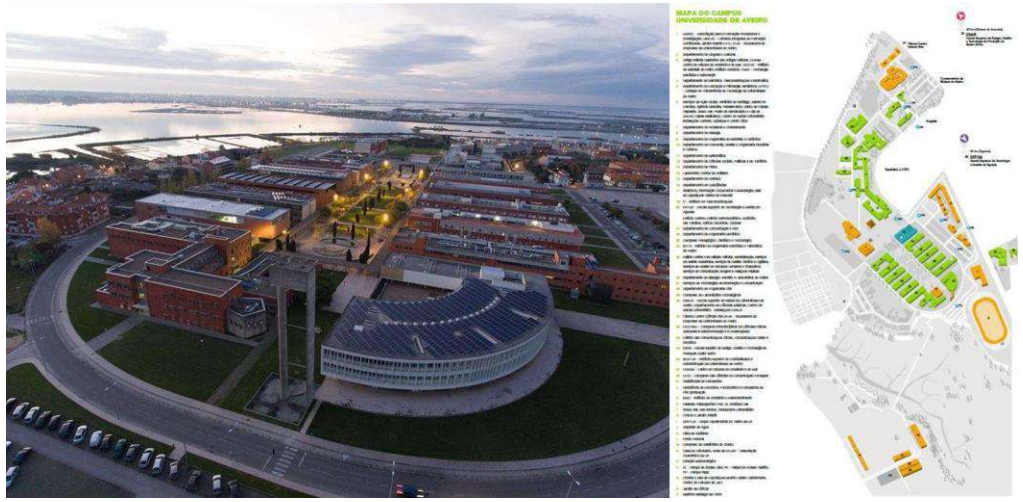

PARCEIROS

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Basic Ecologic Fundamentals and Cases.

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ENERES Sistemas Energéticos Eficientes

29 SETEMBRO 2023