Life cycle environmental and cost evaluation of heating and hot water supply in social housing nZEBs

Patxi Hernandez[1], Julen Hernandez[1], Iñigo Urra[1], David Grisaleña[2]

[1] *TECNALIA Research & Innovation, Astondo Bidea, Edificio 700, Derio, 48160 Spain*

[2] *VISESA, Basque Country Public Housing Body, Portal de Gamarra 1A, 01013, Vitoria-Gasteiz, Spain*

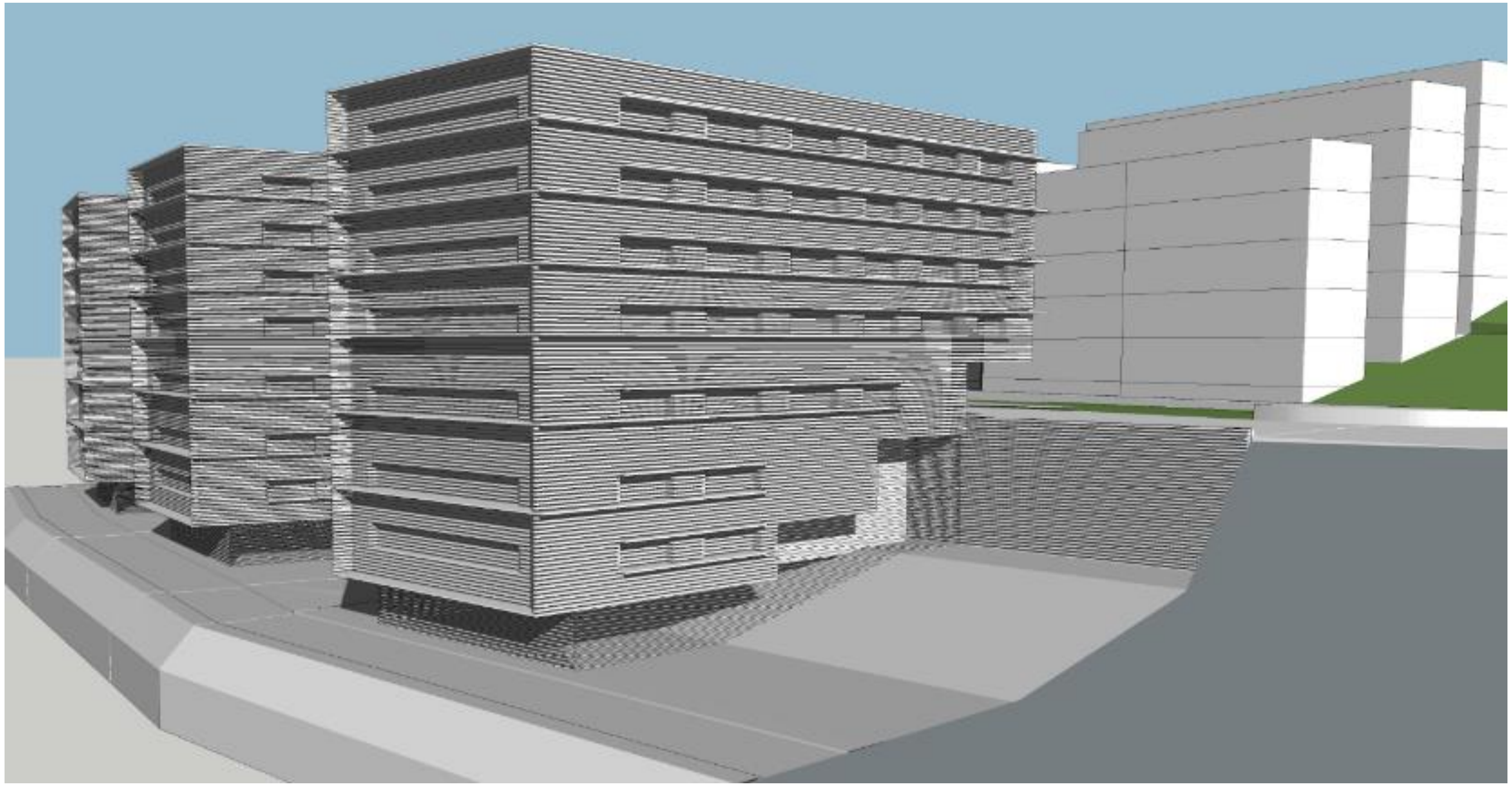
AZEB Affordable Zero Energy Buildings

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754174

Case Study presentation

Santurtzi, B-87, 96 social housing dwellings (3 x 32)

Developer: VISESA – Basque Country Public Housing Body



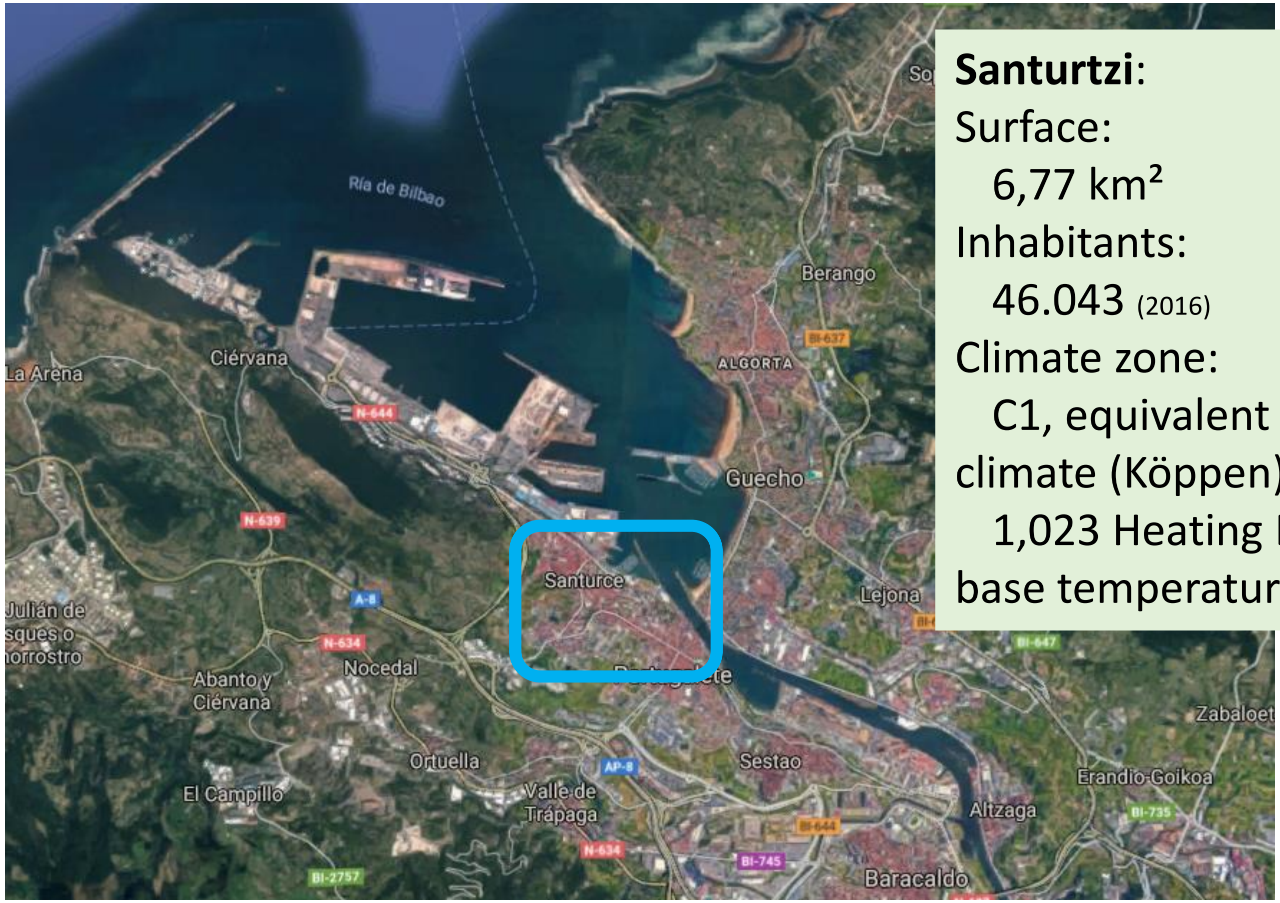
Santurtzi


La Coruña
Gijón
Oviedo
Santander
Bilbao
San Sebastián
Toulouse
Nimes
Montpellier
Santiago de Compostela
León
Vitoria
Andorra
Pontevedra
Orense
Vigo
Gerona
Valladolid
Zaragoza
Barcelona
Oporto
Tarragona
Salamanca
Madrid
Coimbra
Castellón de la Plana
Toledo
Mar Balear
Portugal
Valencia
España
Palma de Mallorca
Lisboa
Badajoz
Benidorm
Alicante
Córdoba
Murcia
Sevilla
Huelva
Granada
Albufeira
Faro
Málaga
Almería
Argel
مدينة الجزائر
Gibraltar
Mar de Alborán

Santurtzi


N-634
Castro Urdiales
Guecho
Baracaldo
Bilbao
Urdaibai
Reserva de
la Biosfera
Lequeitio
Guernica-Luno
San Se
Zarauz
AP-8
Durango
Éibar
AP-68
N-636
Vergara
Tolosa
Arceniega
Amurrio
N-240
Mondragón
Beasain
Gorbeiako
Parke Naturala
Aizkorri-Aratz
AP-68
Vitoria
A-1
E-80
Urbasa
y Andía
Salinas
de Añana
A-1
Parque Natural
Montes
Obarenes-San
Zadornil
AP-68
Miranda
de Ebro
Corres
Estella

Santurtzi



Santurtzi:

Surface:

6,77 km²

Inhabitants:

46.043 (2016)

Climate zone:

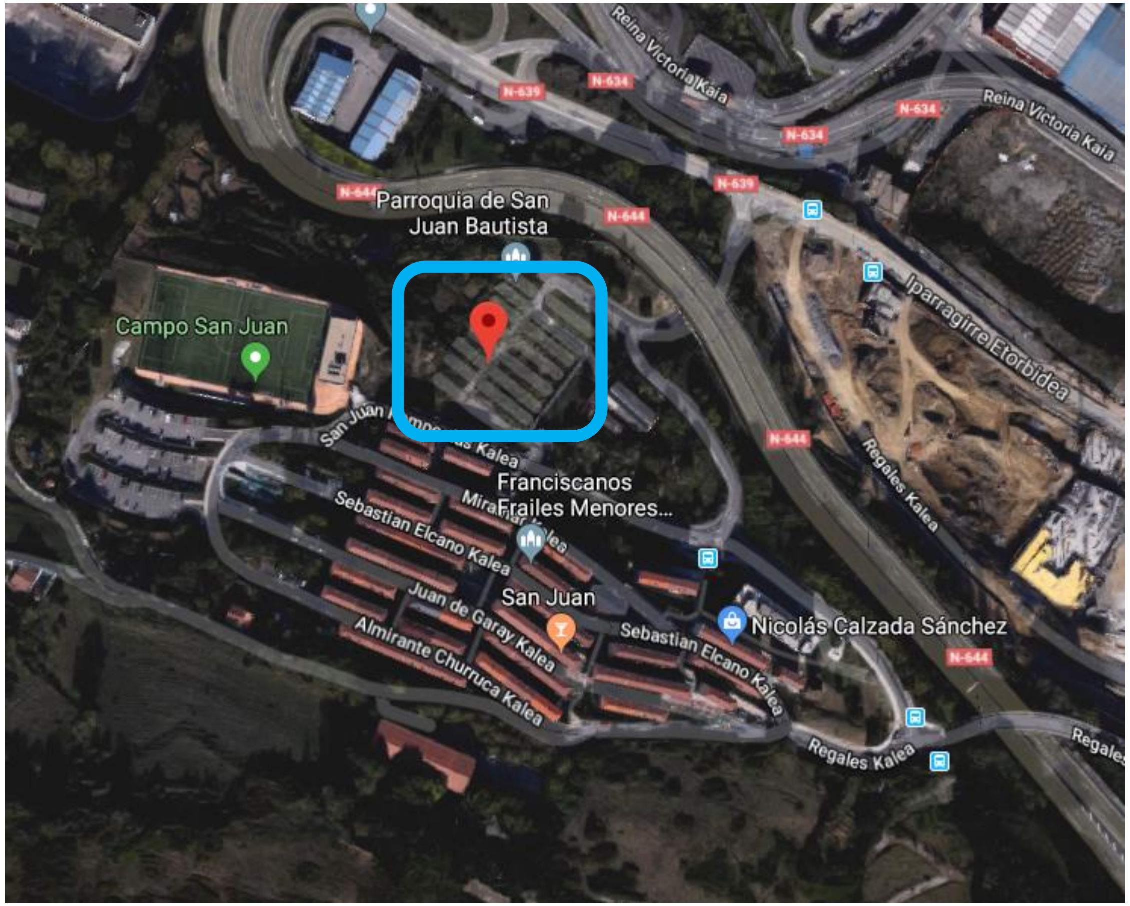
C1, equivalent to Cfb = Temperate oceanic climate (Köppen)

1,023 Heating Degree Days (15 degree base temperature).

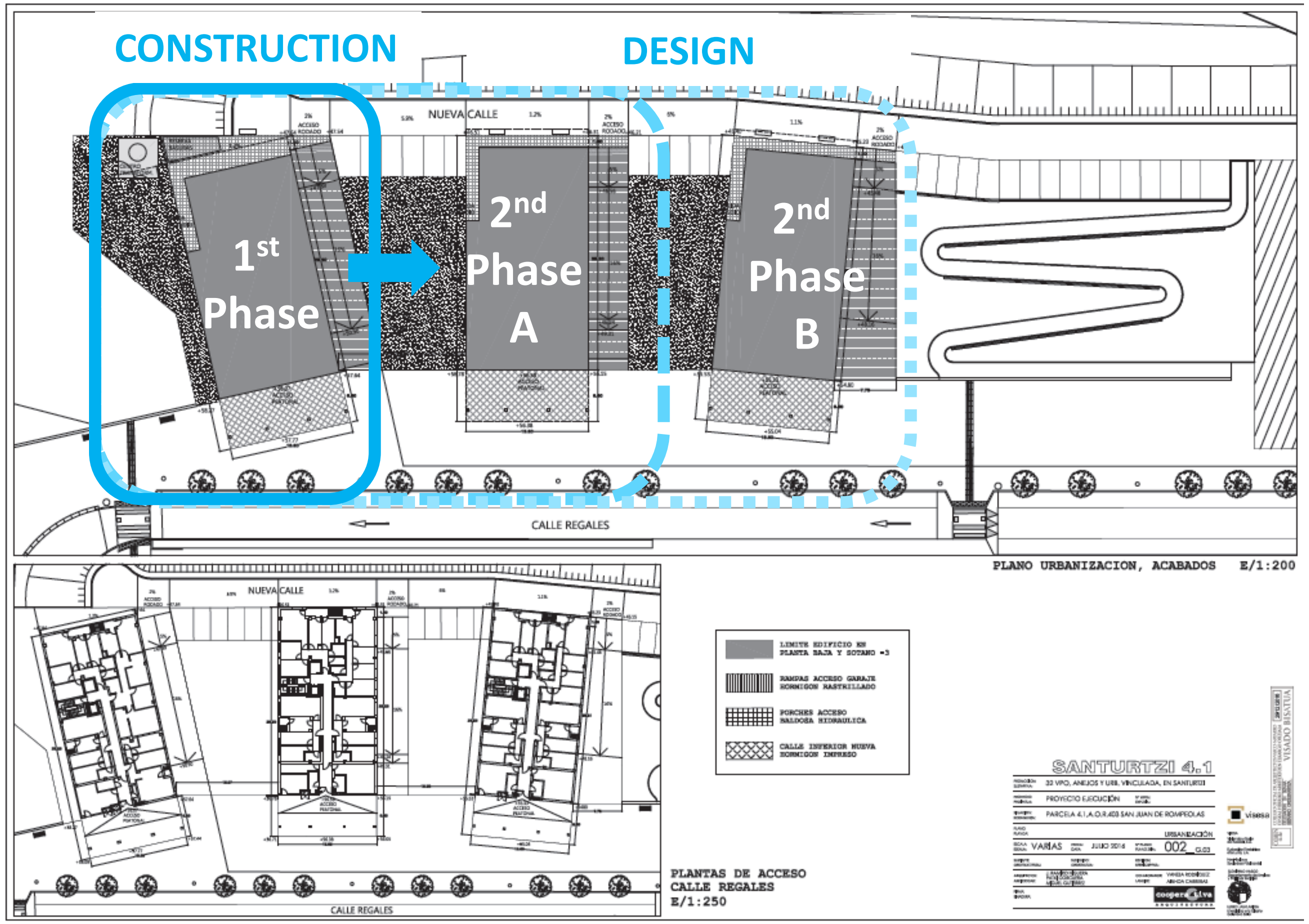
Santurtzi

N-639
N-644
Santurce
CUETO AUZOA
LAS ARENAS
Zugatzarte Etorbidea
Bizkaiko Zubia
BI-3791
El Villar
CAMPANZAR AUZOA
Calle Gral. Castaños Kalea
BARRAL AUZOA

Santurtzi


Reina Victoria Kaia
N-639
N-634
N-644
Parroquia de San Juan Bautista
Campo San Juan
Iparragirre Etorbidea
Regales Kalea
Franciscanos Frailes Menores...
Sebastian Elcano Kalea
San Juan
Juan de Garay Kalea
Almirante Churruca Kalea
Nicolás Calzada Sánchez
Sebastian Elcano Kalea
Regales Kalea

The case study overview



The case study overview

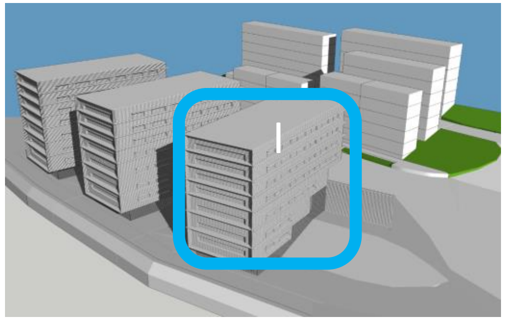
ESTIMATED SCHEDULE:

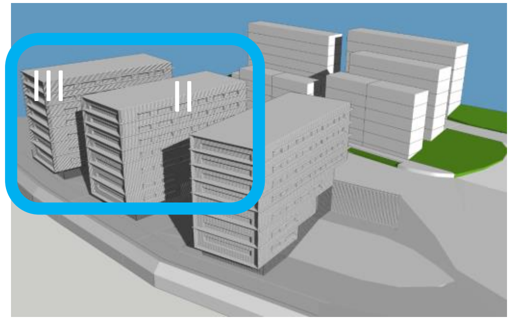
1ST PHASE: BUILDING I

- Construction works: On-going
- Estimated end of construction works: November 2019

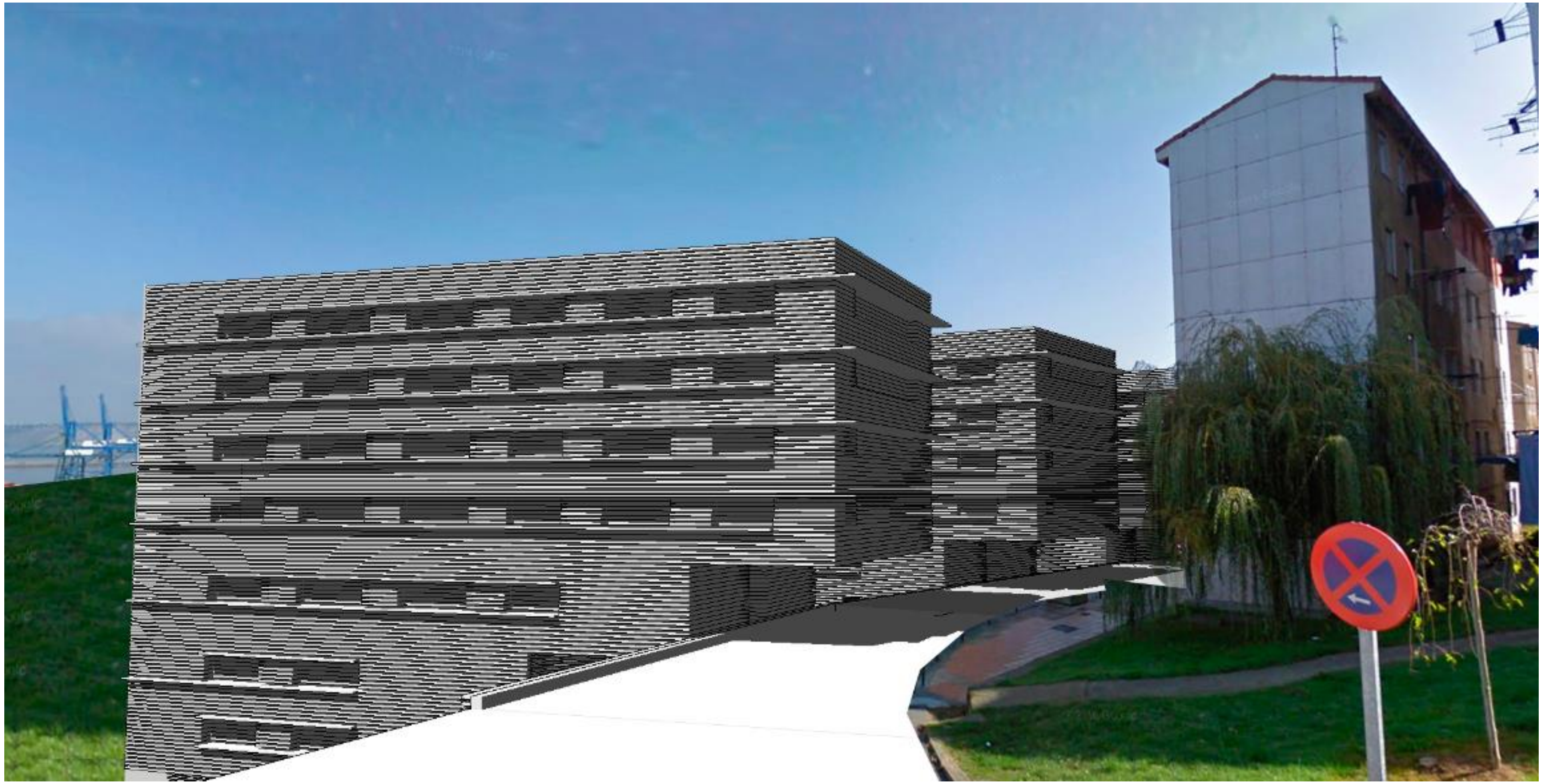
2ND PHASE: BUILDINGS II & III

- Designing works: On-going
- Public tender construction: 2020





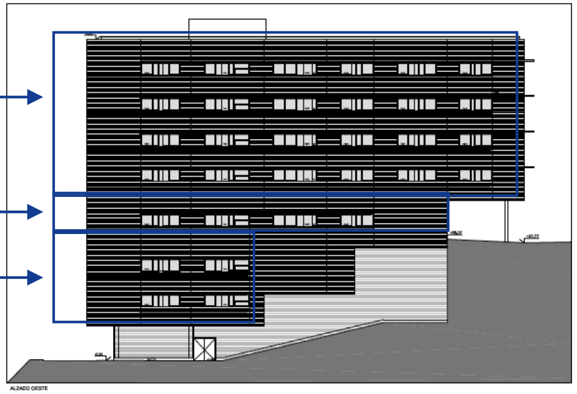
Building I “B-87” – 1st phase

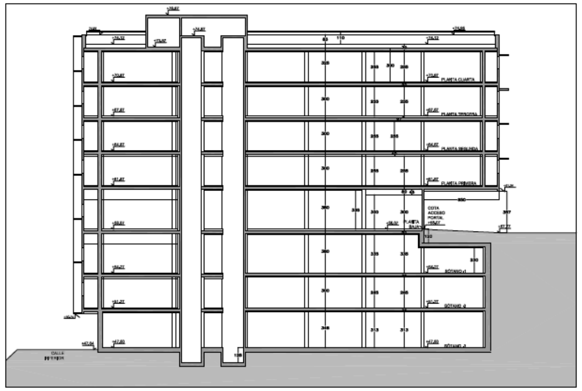


Building I "B-87" – 1st phase

Case study characteristics:

- Use: residential (social renting)
- Ownership: public (ALOKABIDE Basque Gov. Renting Company)
- Nº of dwellings: 32 flats (total dwelling surface: around 3.000 m^2)
- Profile: 6 flats x4 floors
  4 flats x 1 ground floor
  2 flats x 2 semi-basements
  32 storage rooms in basement -1
  14 + 18 parking spots in basements -2 and -3





- Building geometry: 36.2 x 15´6 m
- Orientation: North - South
- Programme: 22 flats x 3 bedrooms (2 handicapped accessible)
  10 flats x 2 bedrooms
- Current status: under construction
- Works ending estimated date: November 2019

Building I "B-87" – 1st phase

Case study ENERGY characteristics:

Highly efficient building envelope

Transmittance U-values:

- Windows: 1,20 $W/m^2 \cdot K$ (Low emissivity, Argon filled, 4/16/3+3)
- Façade: 0,23 $W/m^2 \cdot K$
- Wall to dwelling: 0,30 $W/m^2 \cdot K$
- Wall to stairs: 0,39 $W/m^2 \cdot K$
- Floor to dwelling: 0,58 $W/m^2 \cdot K$
- Ceiling to dwelling: 0,62 $W/m^2 \cdot K$
- Roof: 0,21 $W/m^2 \cdot K$

Reduced infiltration levels (n50≈1,5ach)

Centralized heat recovery mechanical ventilation system

Calculated demand:

Heating: 6 kWh/m^2 DHW: 12 kWh/m^2

LCC & LCA of alternative energy systems

GAS + SOLAR - CENTRAL

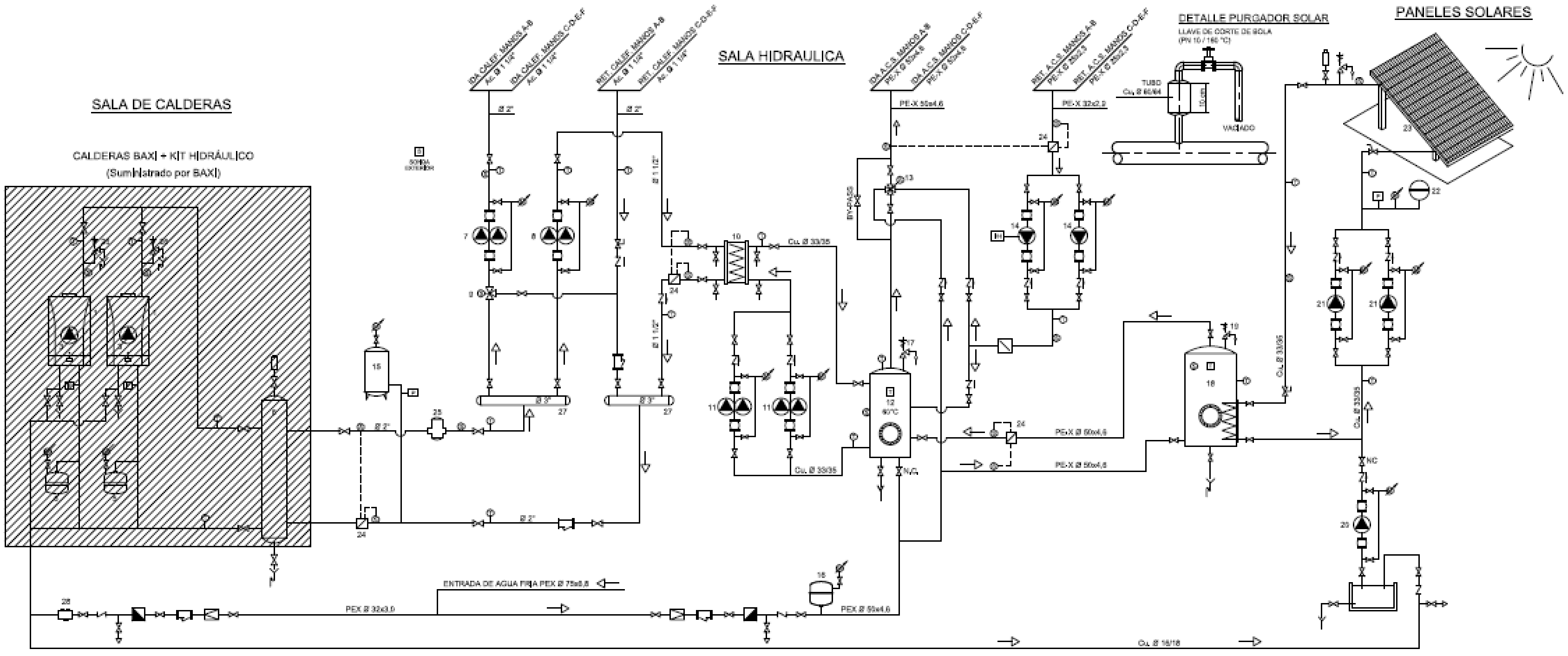
AIR-TO-WATER HEAT PUMP - CENTRAL

AIR TO WATER + GEOTHERMAL HEAT PUMPS - CENTRAL

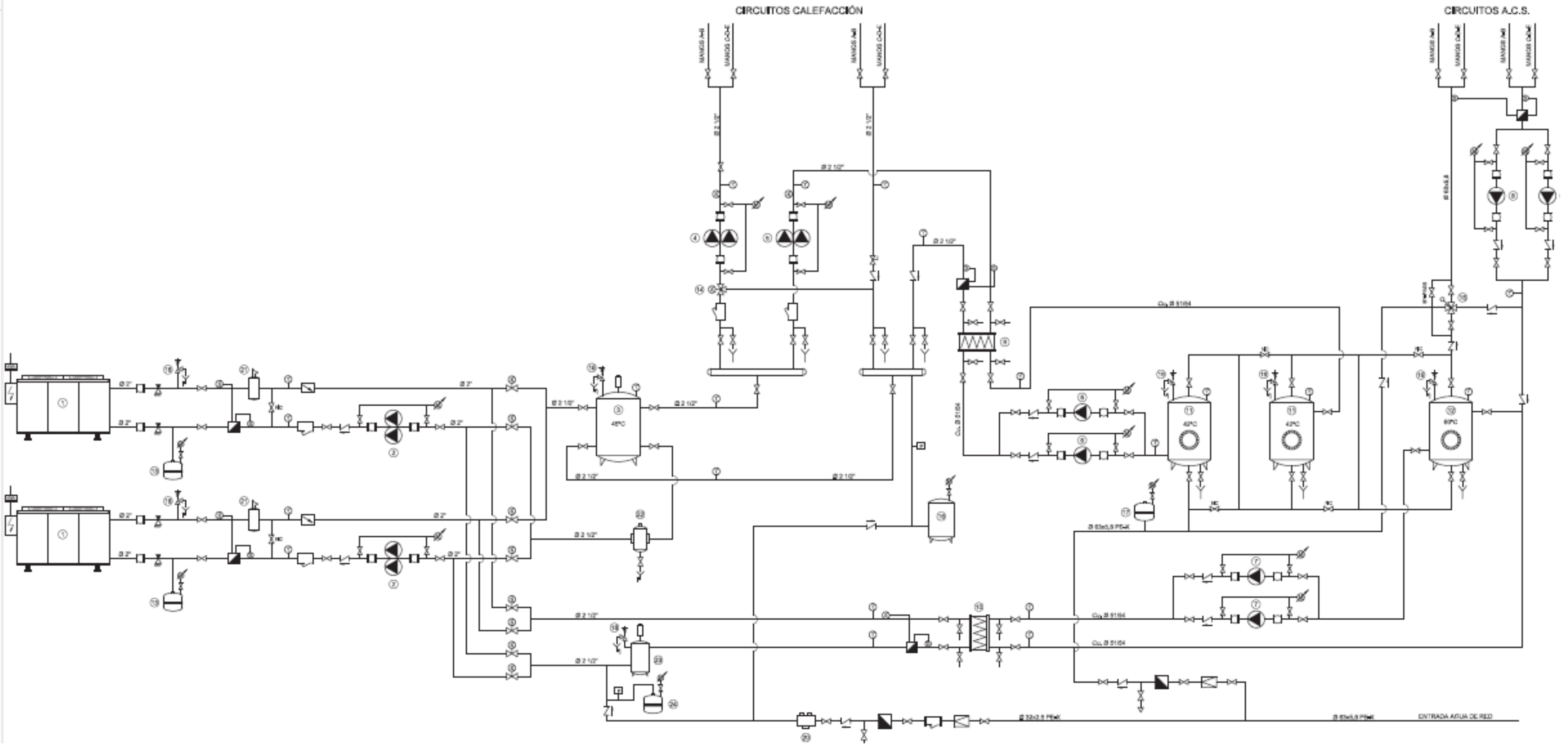
GEOTHERMAL HEAT PUMPS - CENTRAL

AIR-TO-WATER HEAT PUMPS - INDIVIDUAL

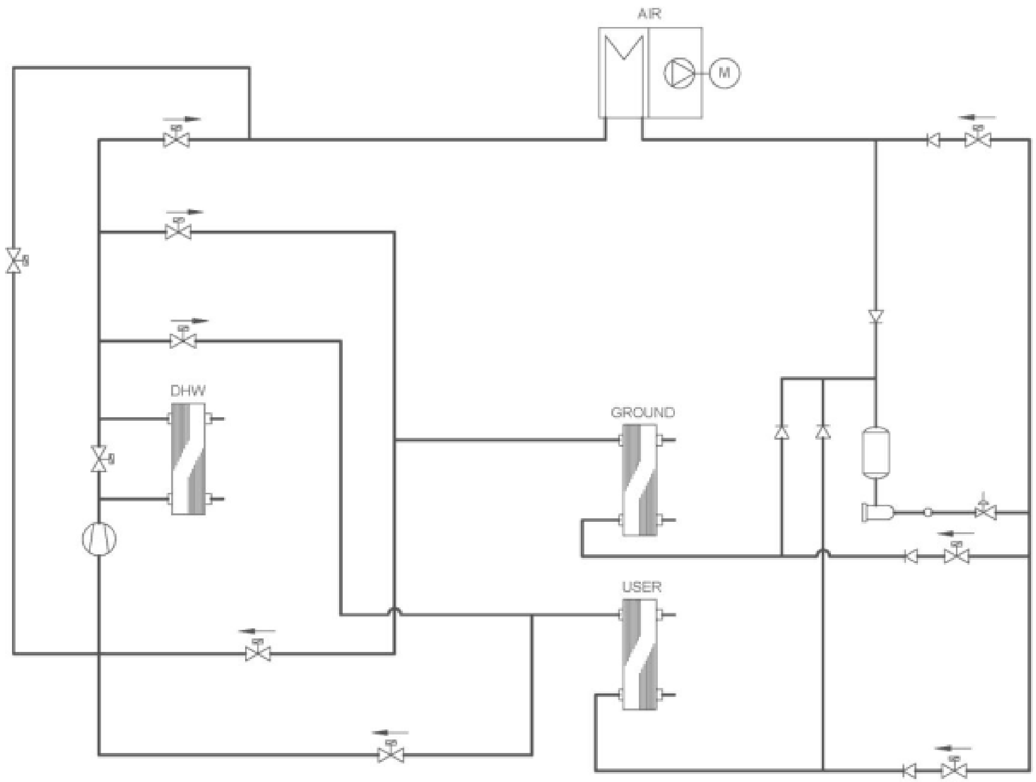
GAS BOILERS + SOLAR THERMAL



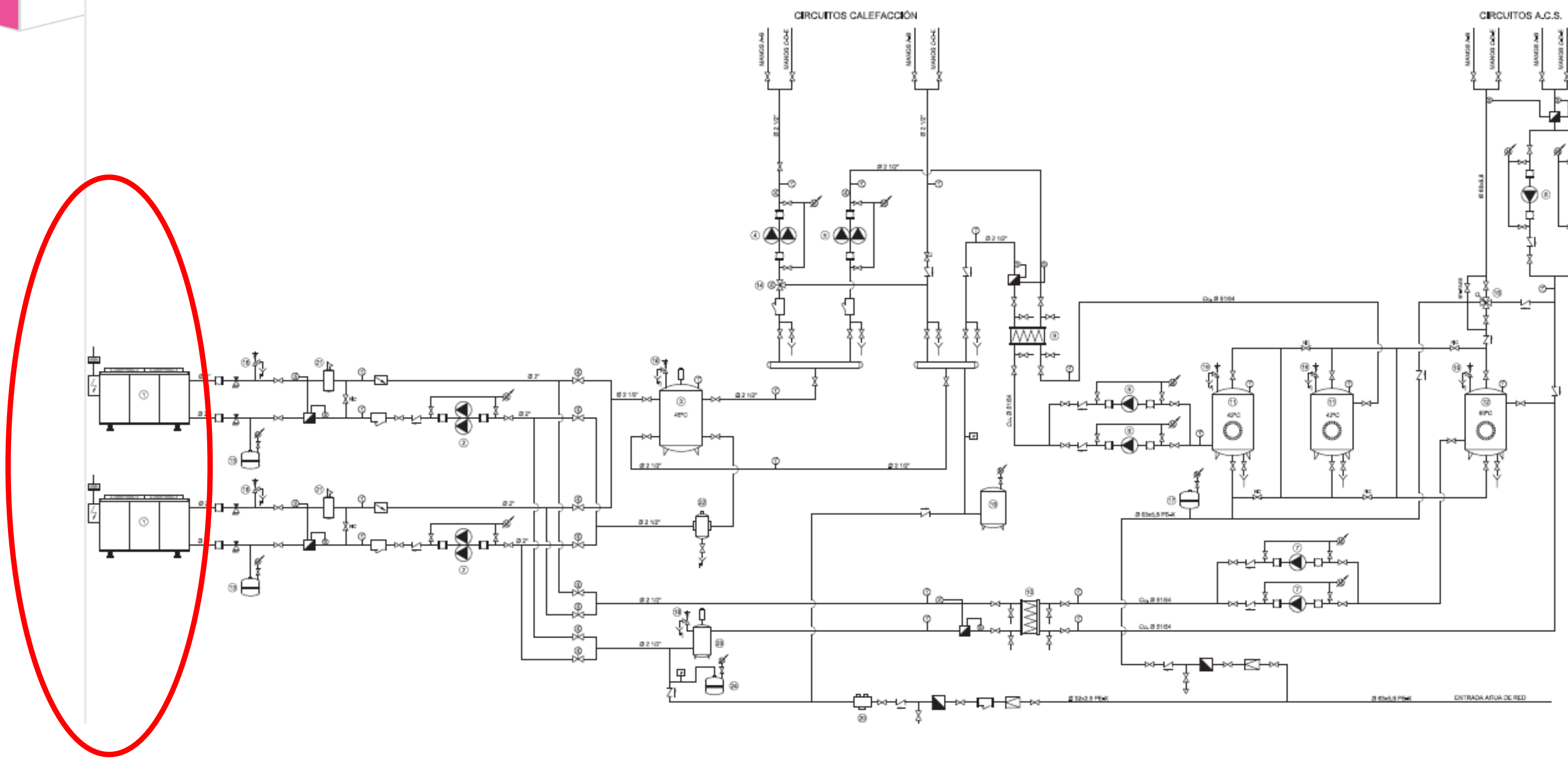
AIR-TO-WATER HEAT PUMP – CENTRALIZED



MIXED AERO/GEOTHERMAL INSTALLATION - CENTRALIZED

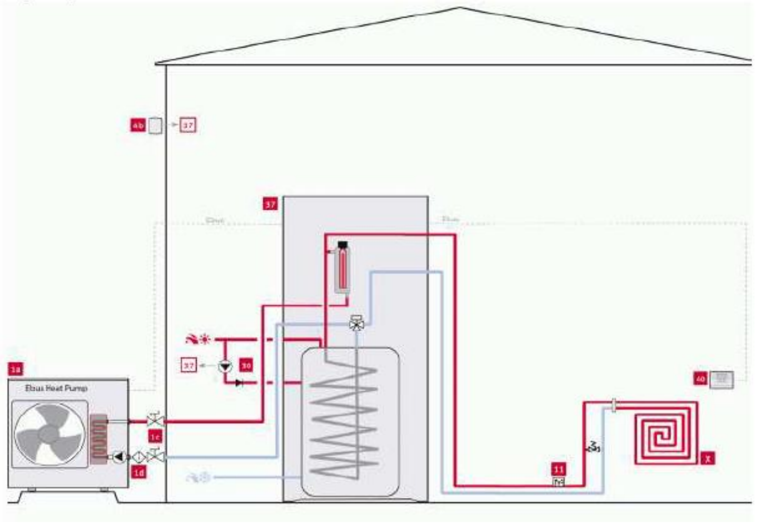


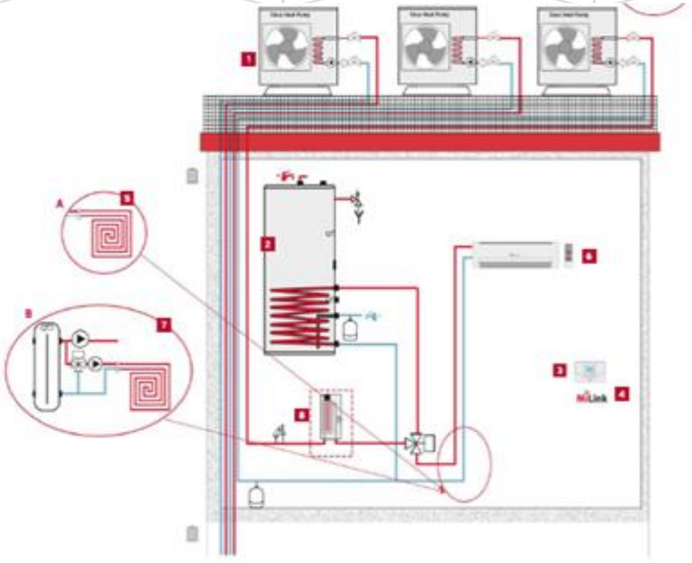
GEOTHERMAL INSTALLATION - CENTRALIZED



INDIVIDUAL HEAT PUMP INSTALLATIONS

Esquema de principio





UNCERTAINTY ON HEAT PUMP EFFICIENCY

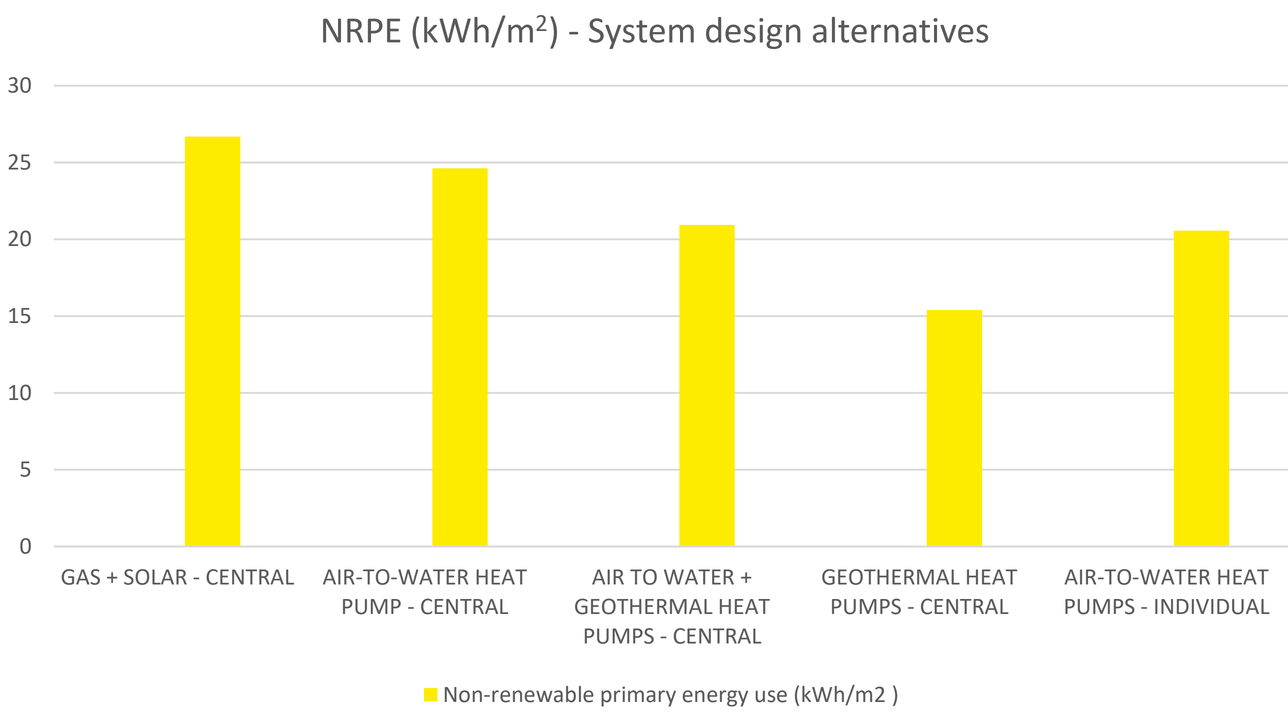
HEATING & DWH PRE-HEAT	SCOP	COPnom	Air Tª	Water Tº
			ºC	ºC
HULC heating (with correction values)	1,22		variable	45
Manufacturer (EN 14825)	3,89		2	45
IDAE (Fórmula SPF)	2,28		variable	45
HULC heating (COP directl input)		2,57	-	45
Manufacturer (EN 14511)		2,86	7	45
DHW	**SCOP**	**COPnom**	**Air Tª**	**Water Tº**
			ºC	ºC
HULC heating (with correction values)	2,86		variable	65
Manufacturer (EN 14825)	2,82		2	65
IDAE (Fórmula SPF)	1,72		variable	65
HULC heating (COP directl input)		2,57	-	60
Manufacturer (EN 14511)		2,15	7	65

SUMMARY OF TECHNICAL CHARACTERISTICS

GAS + SOLAR - CENTRAL	2 * 50 kW	EFFICIENCY 102%, 32% DHW DEMAND COVERED BY SOLAR WATER HEATING SYSTEM
AIR-TO-WATER HEAT PUMP - CENTRAL	2 * 47 kW	SCOP = 2,5
AIR TO WATER + GEOTHERMAL HEAT PUMPS - CENTRAL	2 * 47 kW	SCOP = 3
GEOTHERMAL HEAT PUMPS - CENTRAL	2 * 47 kW	SCOP = 4
AIR-TO-WATER HEAT PUMPS - INDIVIDUAL	2 * 47 kW	SCOP = 2,5

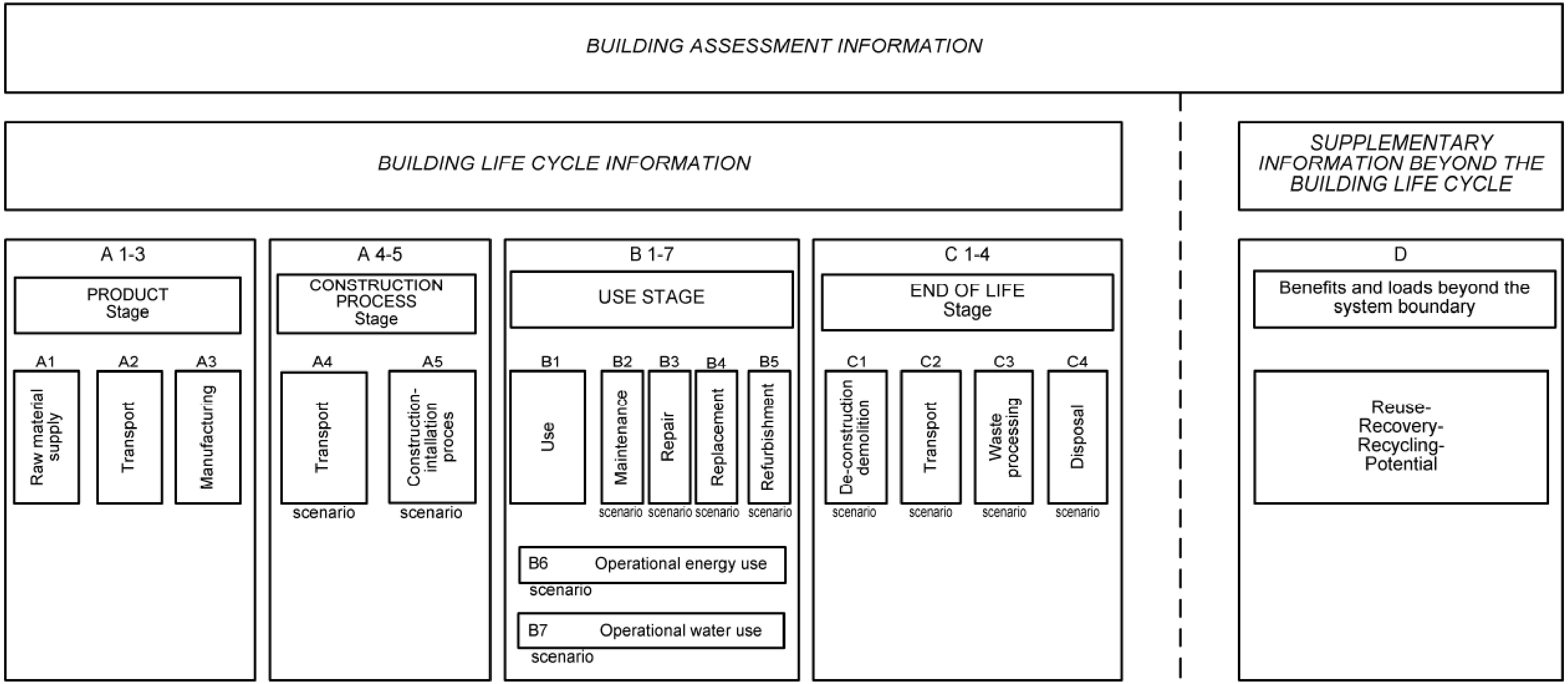
SUMMARY ENERGY PERFORMANCE FOR THE ALTERNATIVES

	GAS (kWh)	ELECTRICITY (kWh)	NRPE (kWh)
GAS + SOLAR - CENTRAL	64701	0	76994,19
AIR-TO-WATER HEAT PUMP - CENTRAL	0	36355	71037,67
AIR TO WATER + GEOTHERMAL HEAT PUMPS - CENTRAL	0	30926	60429,404
GEOTHERMAL HEAT PUMPS - CENTRAL	0	22722	44398,788
AIR-TO-WATER HEAT PUMPS - INDIVIDUAL	0	30355	59313,67



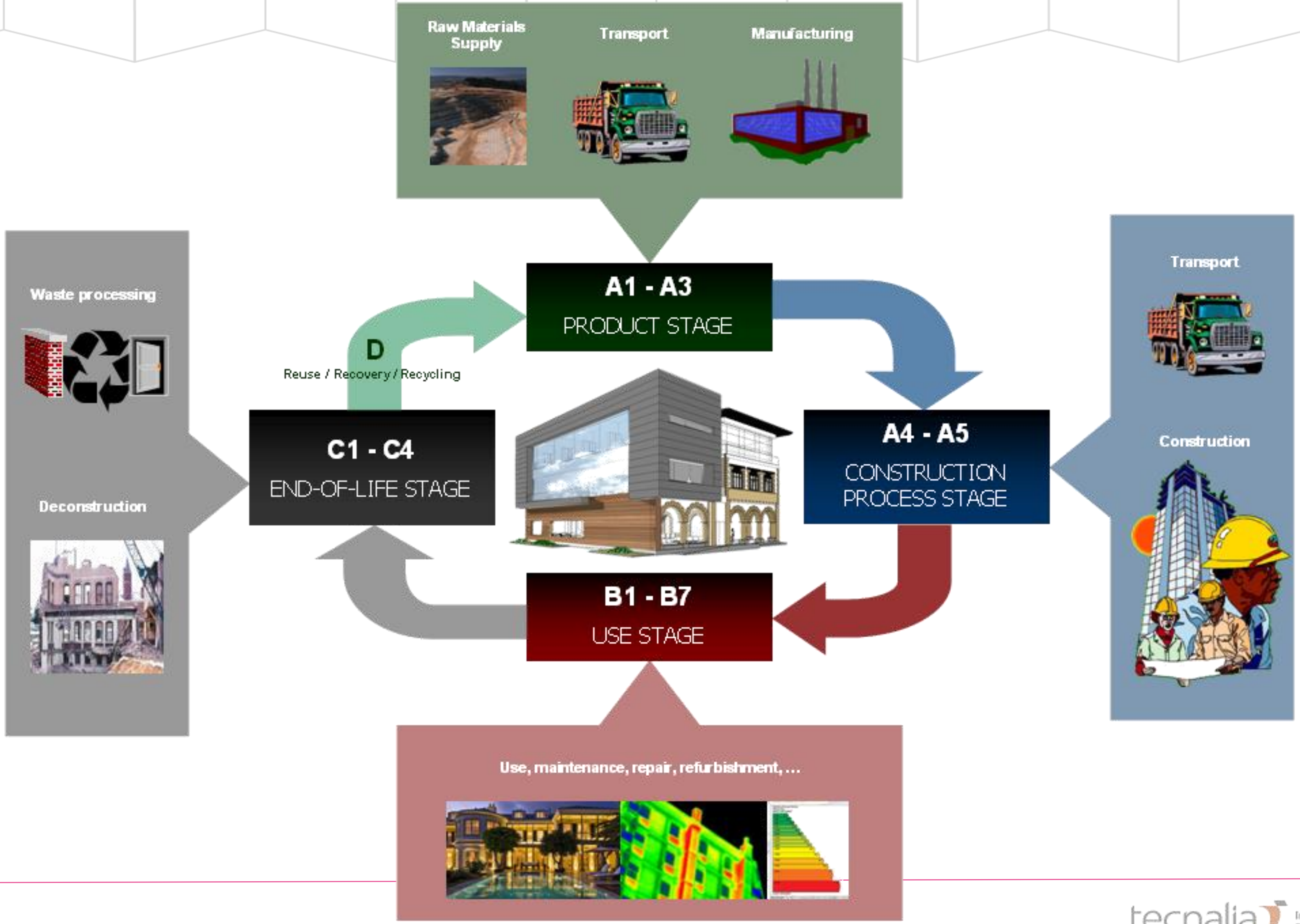
New CTE 2018 (draft): NRPE < 32 kWh/m^2

CEN-TC 350 Standards – Sustainability assessement of construction works



EN 15978 – Buildings - environmental
EN 16627- Buildings - economic

CEN-TC 350 Standards – Sustainability assessement of construction works



LCC of Energy Systems Design Alternatives

PERIOD OF STUDY - 15 YEARS

- Construction cost (€/m^2)   (A1-A5)
- Operational energy and energy related maintenance costs (€/m2) (B2+B6)
- Life cycle cost (€/m2)

- **Discount rate : 3%**
- **Annual increase electricity price: 0,5%**
- **Annual increase gas price: 1%**

CONSTRUCTION COSTS (A1-A5)

	GAS + SOLAR	AEROT - CENTRAL	GEOT+AEROT - CENTRAL	GEOT - CENTRAL	AEROT - INDIVIDUAL
Total Generation + Distribución: Heating & DHW Calefacción y ACS	**72.504,25 €**	**111.757,47 €**	**155.190,39 €**	**165.446,00 €**	**247.898,59 €**
Legal procedures	1.171,88 €	1.115,53 €	1.115,00 €	1.115,00 €	1.143,71 €
Generationand boiler room	27.453,93 €	69.347,62 €	71.866,81 €	70.089,00 €	237.920,00 €
Regulation and control	14.311,96 €	33.175,48 €	25.870,74 €	20.765,00 €	8.834,88 €
General distribution (not including internal for each apartment)	8.832,44 €	8.118,84 €	8.118,84 €	8.118,00 €	
Isolar installation	20.734,04 €				
Bore holes			39.533,00 €	56.400,00 €	
Thermal Response Testing (TRT) & commissioning			8.686,00 €	8.959,00 €	

MAINTENANCE COSTS (B2)

GAS + SOLAR - CENTRAL	1,700 €/year
AIR-TO-WATER HEAT PUMP - CENTRAL	1,700 €/year
AIR TO WATER + GEOTHERMAL HEAT PUMPS - CENTRAL	1,500 €/year
GEOTHERMAL HEAT PUMPS - CENTRAL	1,000 €/year
AIR-TO-WATER HEAT PUMPS - INDIVIDUAL	2,560 €/year

OPERATIONAL ENERGY COSTS (B6)

Electricity tariff- 3.0A

CONTRACTED POWER – GEOT. CENTRAL

	P1	P2	P3
Fixed rate – contracted power (kW)	12,5	25	12,5
Energy use in each period	30%	40%	30%

CONTRACTED POWER – AEROT. CENTRAL.

	P1	P2	P3
Fixed rate – contracted power (kW)	20	45	20
Energy use in each period	30%	40%	30%

CONTRACTED POWER- GEOTTHERMAL + AEROTHERMAL

	P1	P2	P3
Fixed rate – contracted power (kW)	20	40	20
Energy use in each period	30%	40%	30%

Cost contracted power P1	40,72	€/kW*year
Cost contracted power P2	24,43	€/kW* year
Cost contracted power P3	16,29	€/kW* year

Energy costs	0,12	€/kWh
Energy costs	0,068	€/kWh
Energy costs	0,045	€/kWh

Electricity tariff- 2.0A

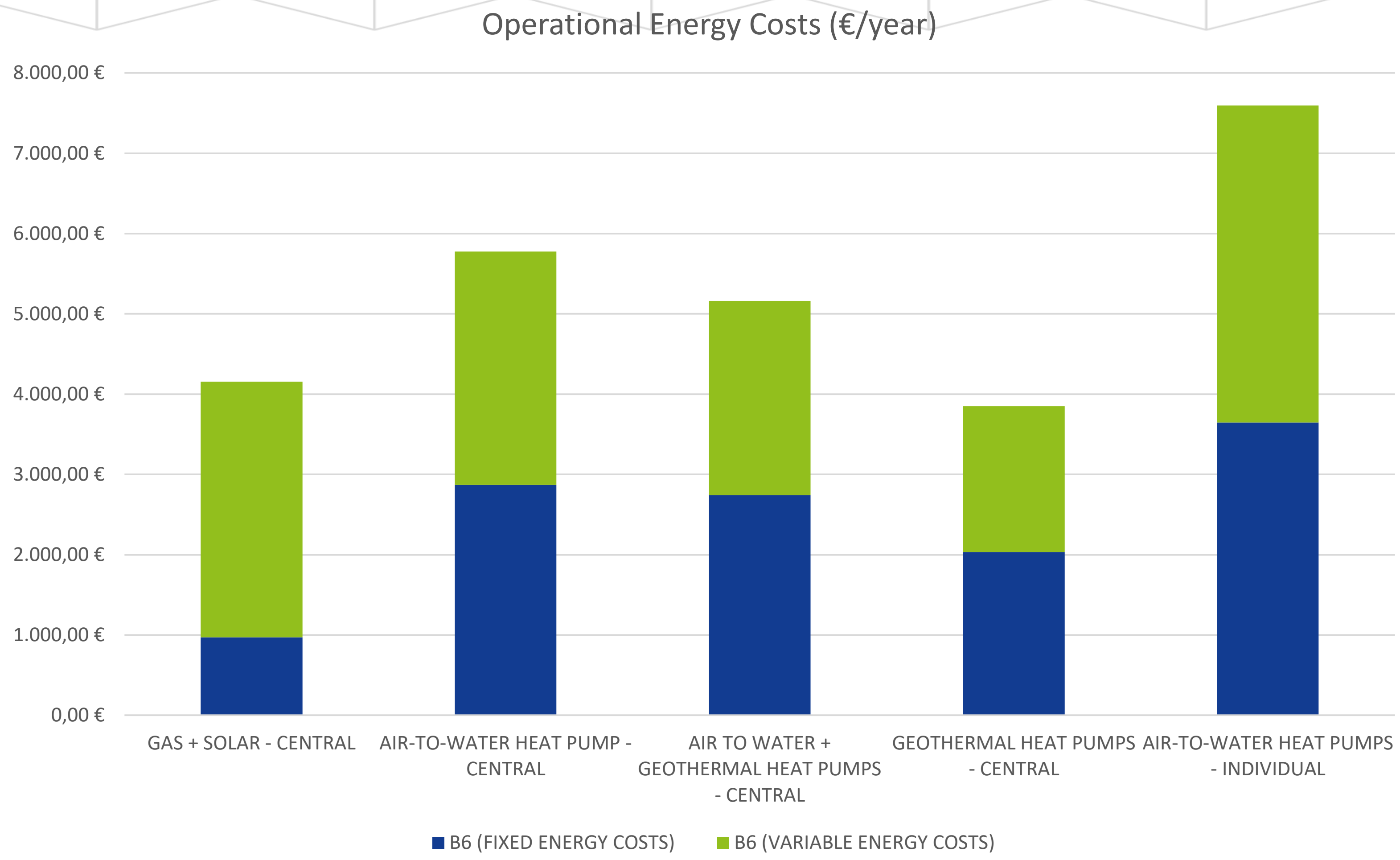
CONTRACTED POWER AEROT. INDIVIDUAL

ADDITIONAL POWER REQUIRED IN EACH APARTMENT	3	kW
FIXED COSTS (POWER)	38	€/kW* year
Electricity costs	0,13	€/kWh

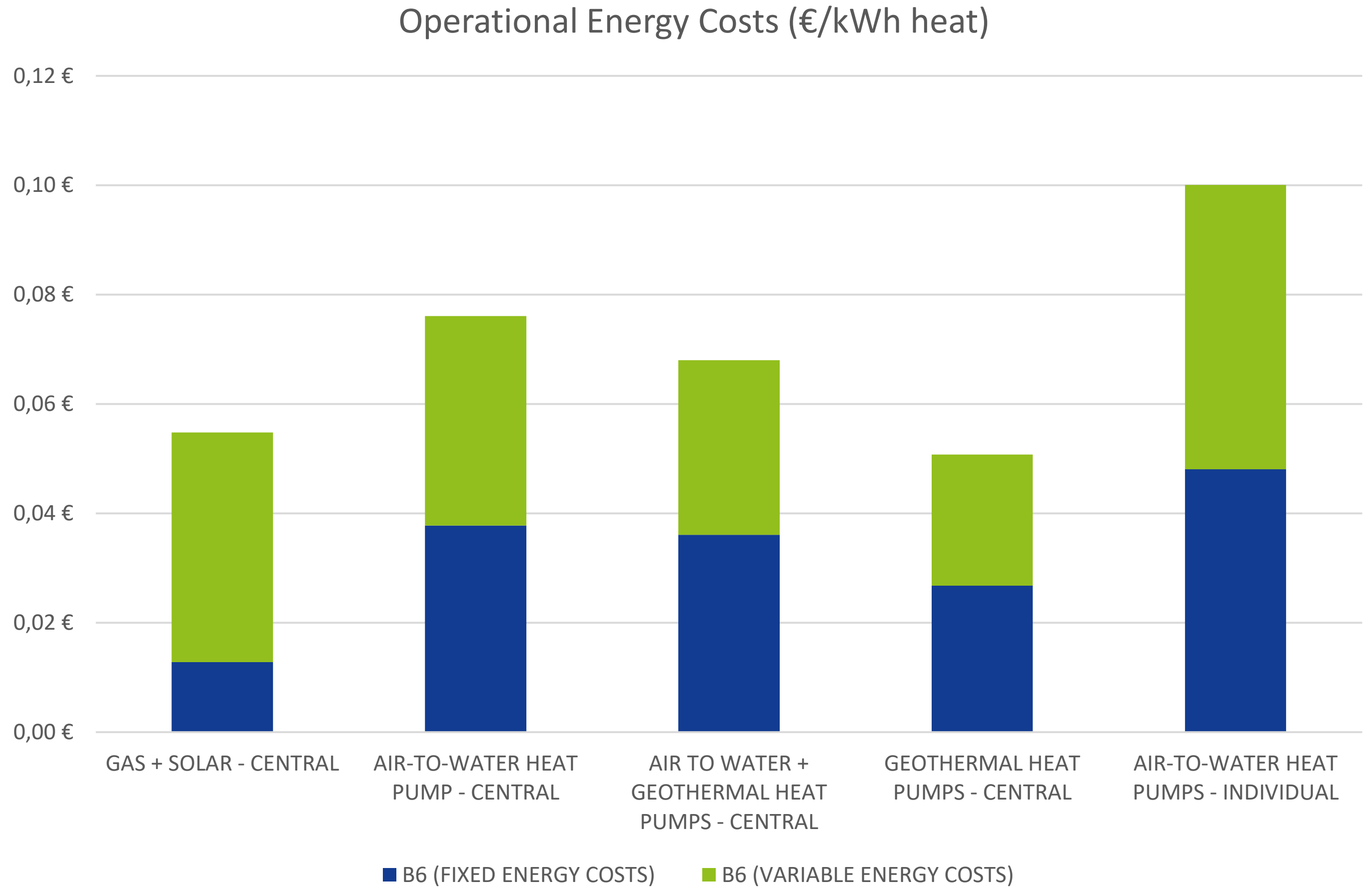
Gas tariff-3.4A

VARIABLE	0,04923 €/kWh
Fixed costs	80,97 €/month

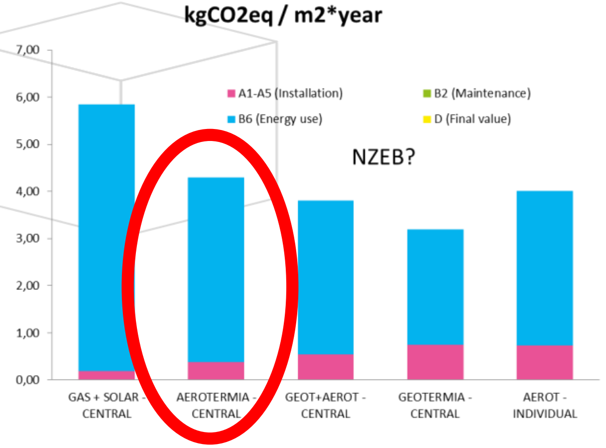
OPERATIONAL ENERGY COSTS (B6)



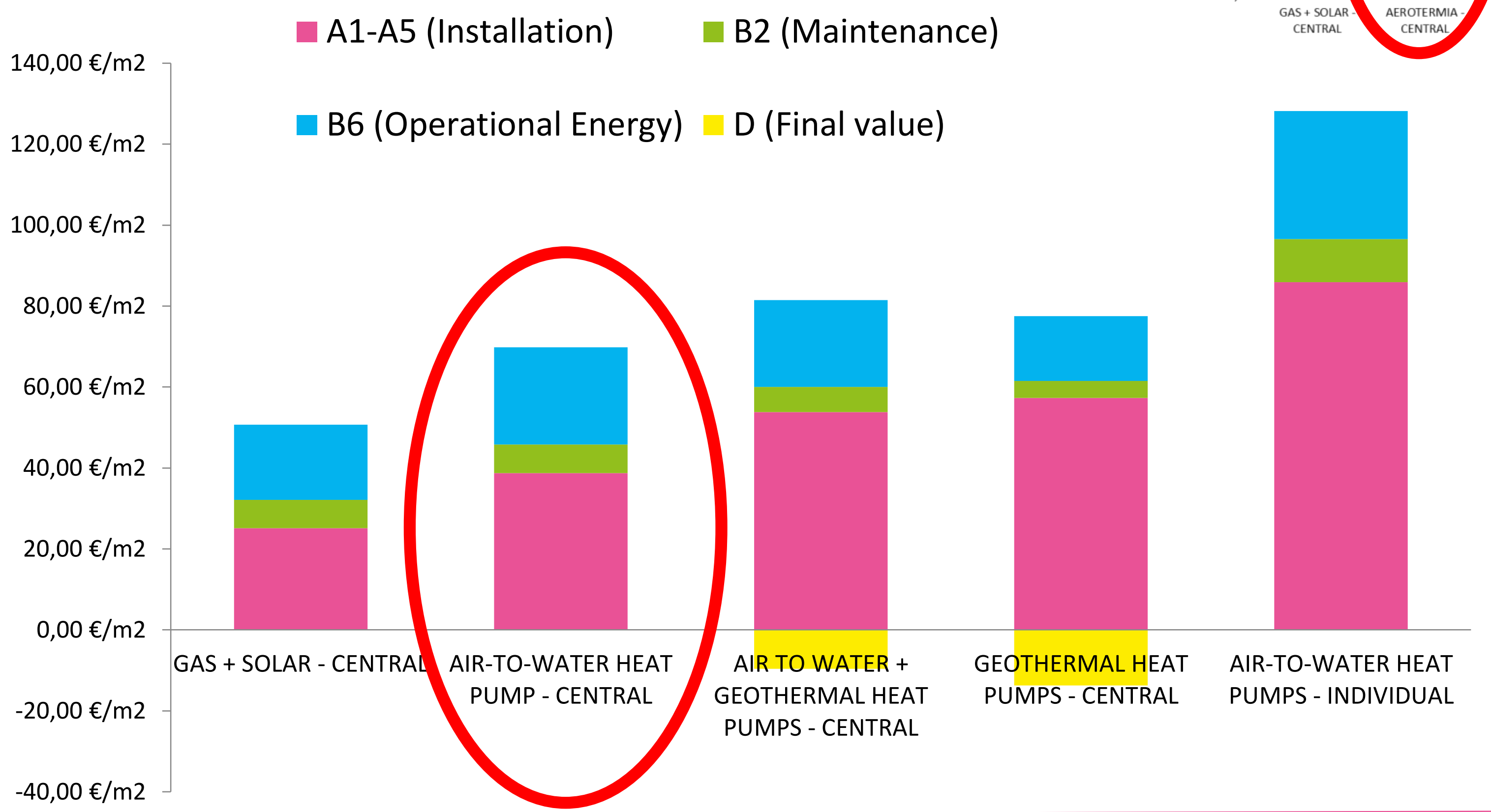
OPERATIONAL ENERGY COSTS (B6)



LIFE CYCLE COSTS



LCC - (€/m2) 15 years



Building I "B-87" – 1st & 2nd phase
Lessons learnt

- **1st Phase:** Energy installations 2 heat pumps (47kW) + 3 buffer deposits + 2 expansion vessels
  - First "full electric" building developed by VISESA
  - LCA & LCC useful to select low environmental impact solutions and evaluate and reduce life cycle costs (developer, owner, user)

- **2nd Phase**: Application of all the lessons learned during 1st phase. Use LCC to explore options to reduce costs (eg. reduce installation for distribution of heat?).
  - Add Commissioning + M&V plans as standard protocol in VISESA – reduce uncertainty on the operation of the heat pumps.
  - Add Energy Performance Guarantee clauses in Public Tendering processes

Thank you!

AFORDABLE ZERO ENERGY BUILDINGS:

A European project to achieve cost reduction for new nearly zero energy buildings

May 2017- Abril 2020

www.azeb.eu

Affordable Zero Energy Buildings

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754174

tecnalia Inspiring Business

Patxi Hernández
patxi.hernandez@tecnalia.com

AZEB what and why

What

- AZEB will create a common methodology for cost effective NZEB
- 36-month EU-project until April 2020
- 8 partners from Bulgaria, France, Germany, Italy, Spain and The Netherlands

Why

- The largest potential in lifecycle cost reduction for new (N)ZEB is in optimizing design and construction processes to fully integrate available solutions in the areas of process, technology and contracting.

8 AZEB partners

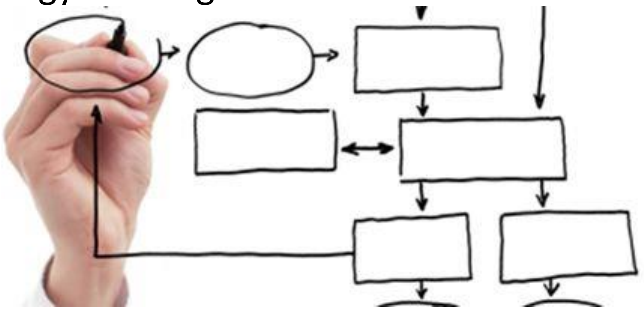
- Armines (Association Pour La Recherche Et Le Developpement Des Methodes Et Processus Industriels) – France
- DNA in de Bouw – The Netherlands (projectleader)
- Oberon Konzeptbau – Bulgaria
- OHL (Obrascon Huarte Lain) - Spain
- Passive House Institute – Germany
- Politechnico di Milano (eERG-PoliMI) – Italy
- Tecnalia (Fundacion Tecnalia Research & Innovation) – Spain
- Visesa (Vivienda y Suelo de Euskadi) – Spain

Methodology for cost effective (N)ZEB

- The AZEB project will develop a general methodology for reducing the lifecycle cost of new (Nearly) Zero Energy Buildings.

- Existing solutions in the areas of technology, process and contracting will be integrated into a common methodology to facilitate building professionals and clients on their journey to affordable and high quality zero energy buildings.

- This methodology will be applicable in different European cultures and climate zones and will be tested and improved during the AZEB project.



Thank you!

Project leader **Partners**

Working together in

Affordable Zero Energy Buildings

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 754174

The information in this presentation reflects only the author's view, the European Agency and Commission are not responsible for any use that may be made of the information it contains.