

CIBELES PROJECT: HOW TO REACH A HIGH SOLAR FRACTION IN AN INDEPENDENT BUILDING

Presentation of the Cibeles project

Ajuntament  de Barcelona

Patronat Municipal de
l'Habitatge



AIGUASOL

BACKGROUND

THE HIGH-COMBI PROJECT

DESIGN PHASE

THE CIBELES PROJECT IN BARCELONA

CONCLUSIONS



AIGUASOL in few words

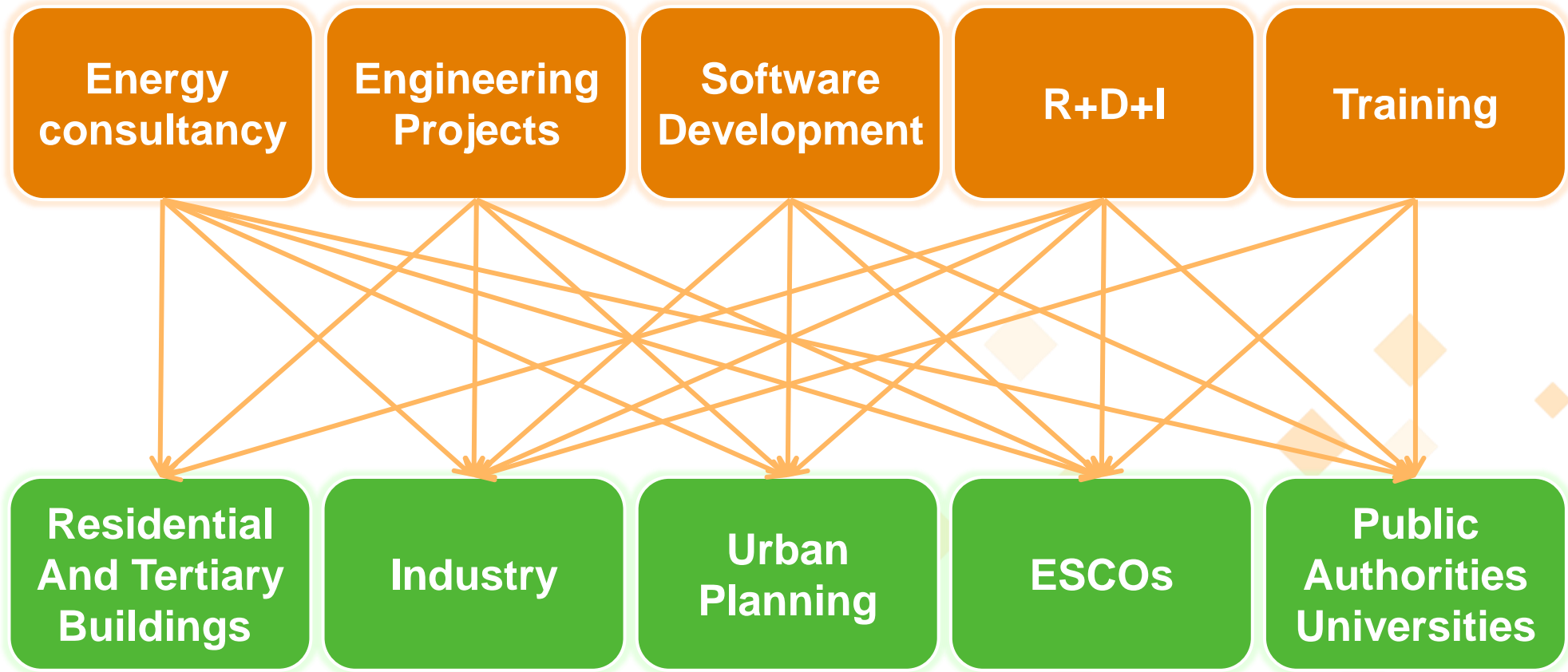
- Independent engineering and consultancy company
- Team of 20 highly qualified professionals (*PHDs, Physicists, Engineers and Architects*) dedicated to consultancy tasks, R&D and energy engineering
- Organised under the legal framework of a cooperative, with a participative and horizontal work structure
- Founded in 1999 by two PhDs of the Universitat Politècnica de Catalunya, with a wide experience in R&D (tasks 25,33,44,45 of the International Energy Agency, more than 15 EC projects)
- A step before the market in energy engineering (or at least trying!)

Mainly focused in:

- Energy optimisation of buildings and urban areas
- Renewable energies for buildings and industry
- Advanced simulation and calculation tools



Services and markets





AIGUASOL

BACKGROUND

THE HIGH-COMBI PROJECT

DESIGN PHASE

THE CIBELES PROJECT IN BARCELONA

CONCLUSIONS

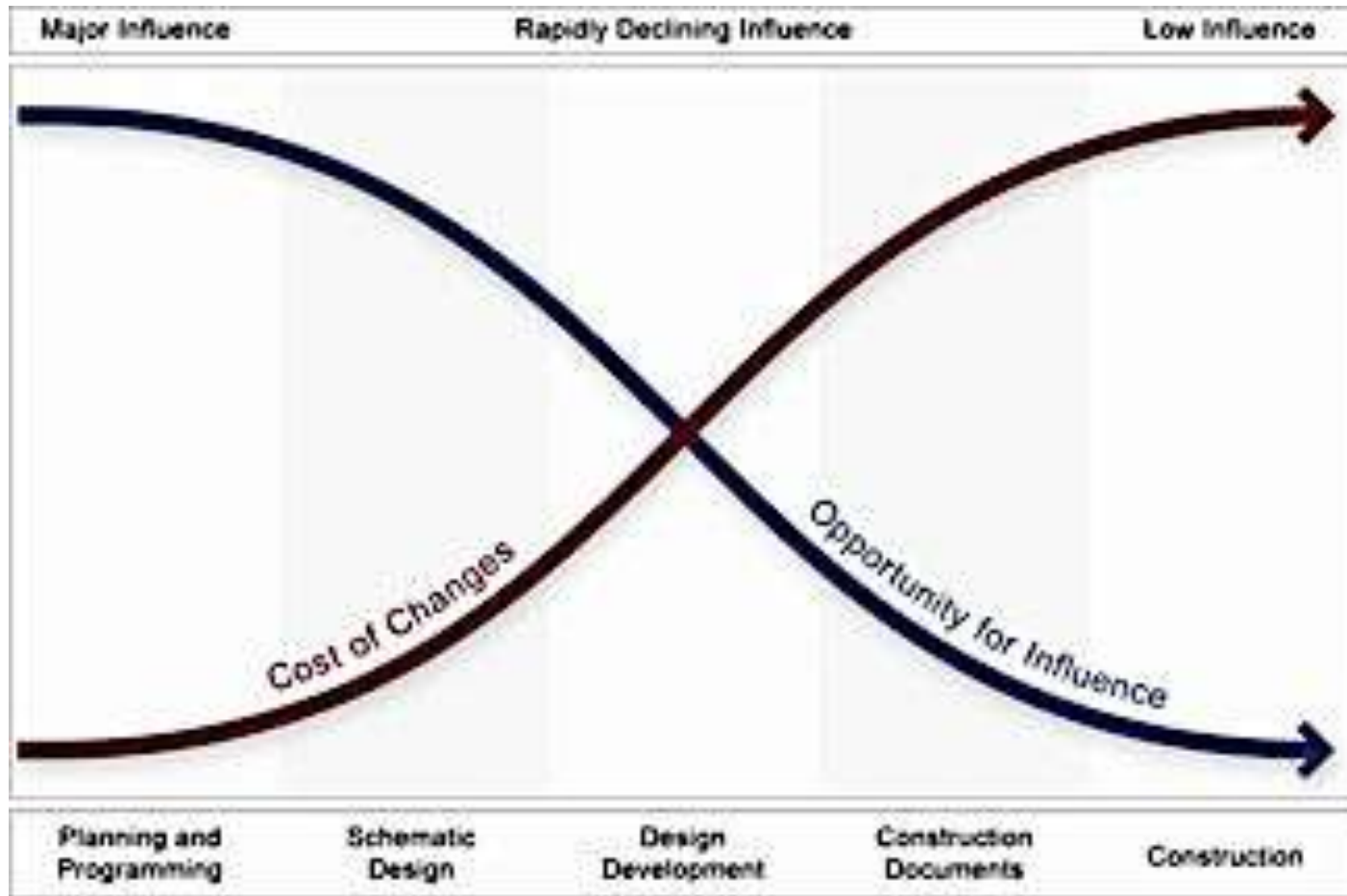


background

- The reduction of energy consumption in residential and diffuse sectors has become one of the key objectives of all countries when trying to avoid climate change (building and operation).
 - New energy Performance Building Directive EPBD 2010
 - Published in OJEU 18th June 2010
 - Looking to minimize **buildings life cycle cost**. Cost efficiency.
 - All new EU buildings must be near zero energy by December 2020 (public buildings December 2018). More renewables and centralization
- Current efforts from the national governments have to go this way. **COST AND EFFICIENCY**

background

Cost efficiency vs. ZEB or NZEB building design

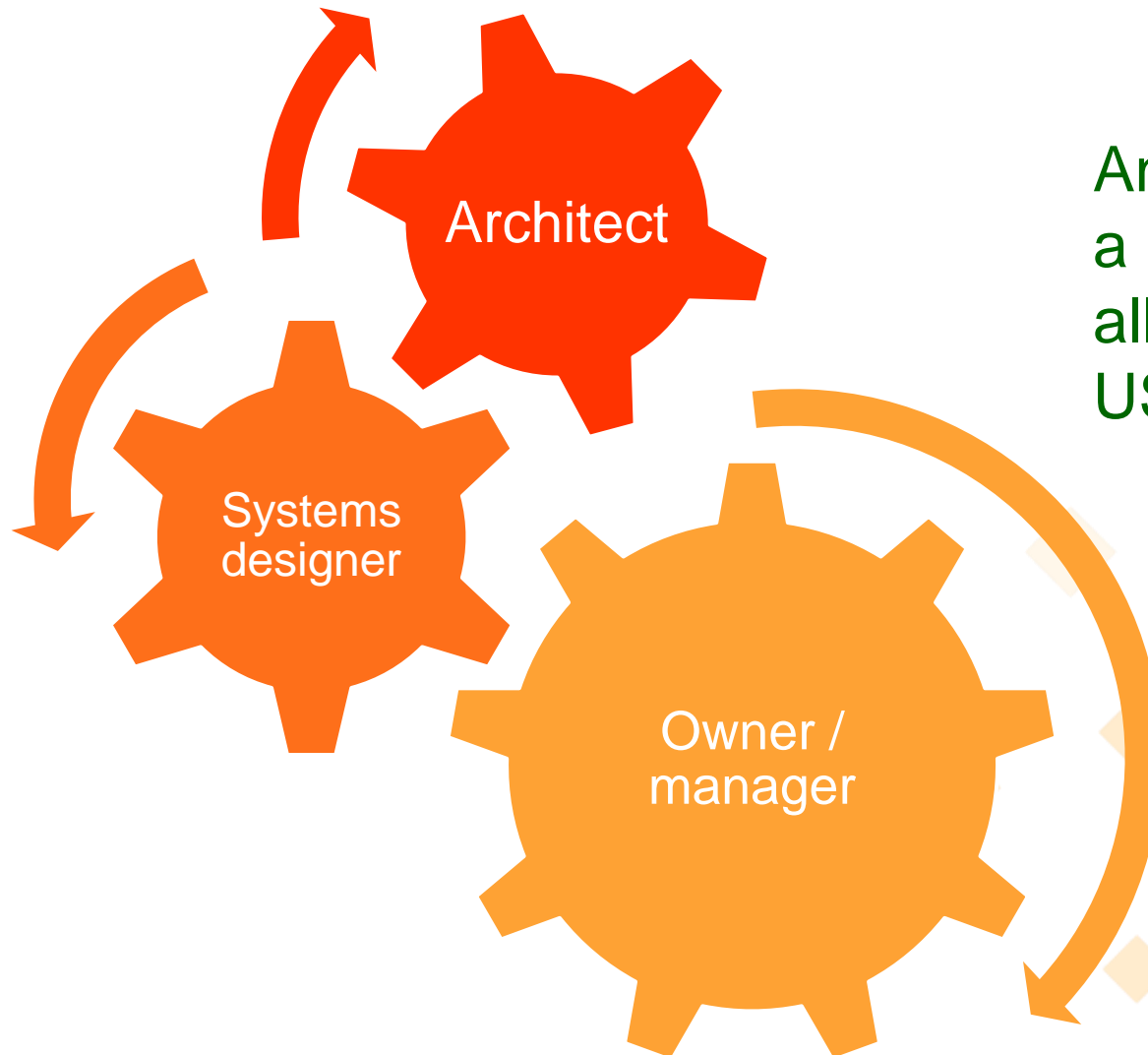


Early stages involvement
and throughout the process

background

- Important to focus on LOGIC and good simulation tools .Dynamic simulation is the best option:
 - Cost
 - speed
 - Results accuracy
- Important to help clean technologies break the market barriers and develop strongly, so as to be able to help fulfil new EPBD goals!
- Important to focus on on-site technologies!!

background



And, of course, and in a relevant position in all actions, the **USER!!!**

Three main actors in the process to make a NZEB building



AIGUASOL

BACKGROUND

THE HIGH-COMBI PROJECT

DESIGN PHASE

THE CIBELES PROJECT IN BARCELONA

CONCLUSIONS

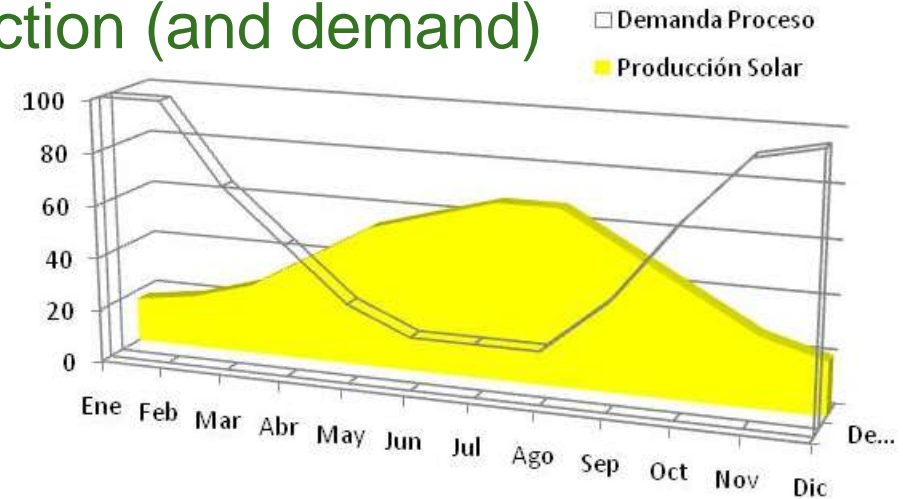
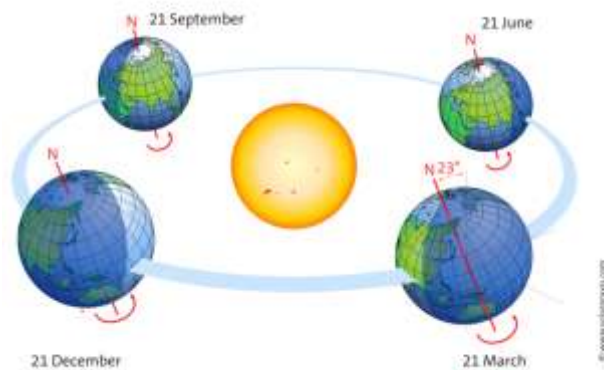


High-combi project

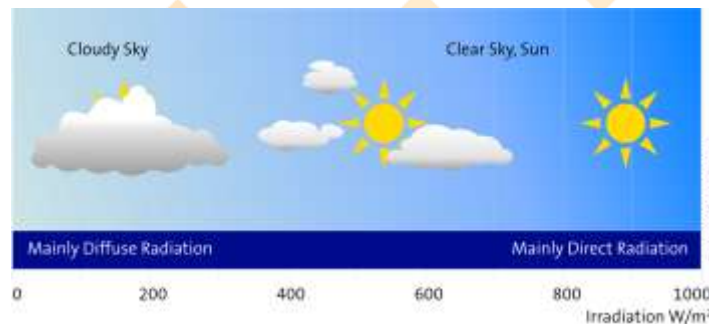
- The Cibeles project is born from the coincidence between these three actors, and an EC FP7 project that was ongoing, and where one of the partners (Habitatge Terrassa) had to quit the project
- The Patronat offered the Cibeles building
- The Cibeles building is not strictly a NZEB, but it is a very LEB, which has tried to reduce the demands and the consumption at a very low levels...with the goal to overcome the difficulties of one renewable energy technology to become an essential actor in a building
- SO... WHICH WAS THE IDEA BEHIND HIGH-COMBI?

Solar thermal technology

- Main limitations to high-solar (thermal) fractions:
 - Seasonality of production (and demand)

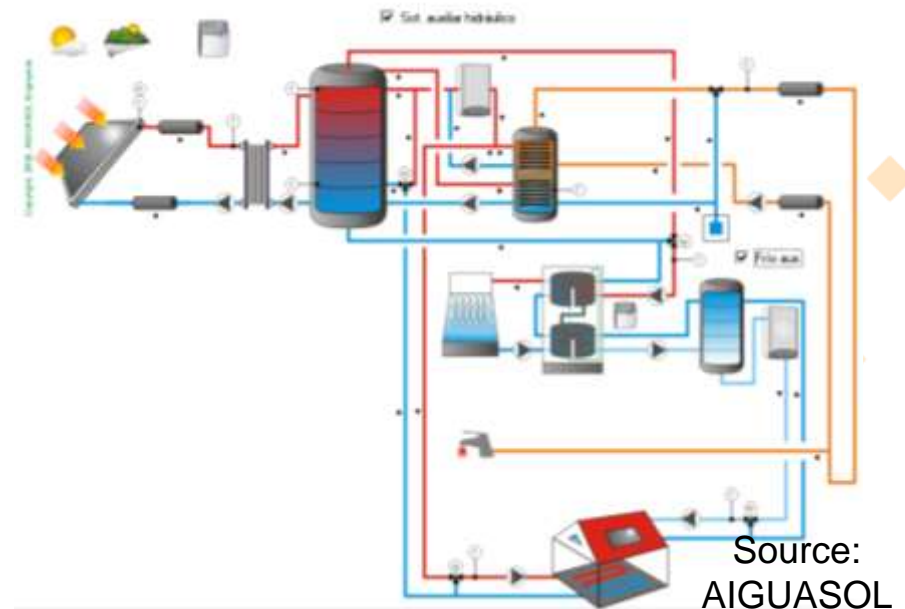
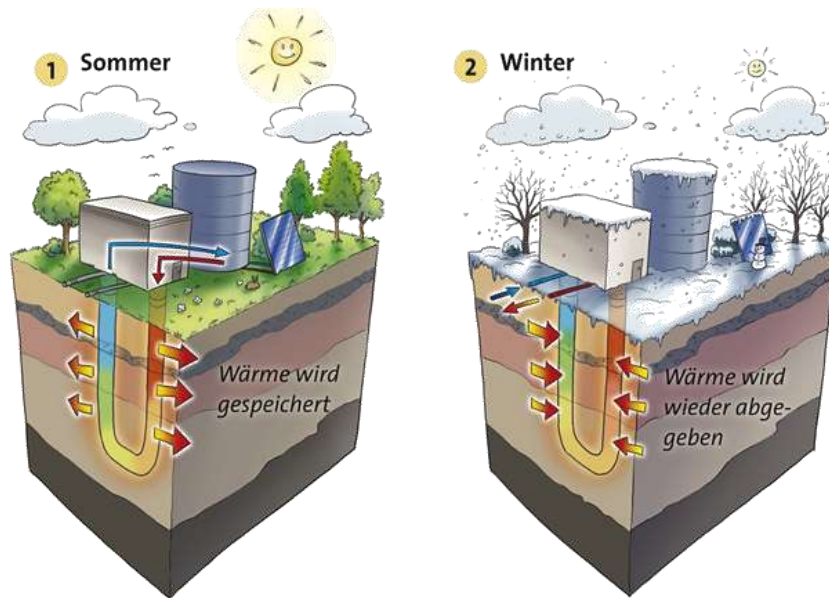


- Production unstability



MAIN IDEA BEHIND HIGH-COMBI

- Combination of two state-of-the-art technologies
 - Solar cooling
 - Seasonal storage
- With the objective to reach a 60% of the total demand of heat, cold and domestic hot water



Source:
AIGUASOL

- Greece
- Austria :
 - 1 office
 - 1 office
- Italy : To
with build
- SPAIN:
Changed to building in Barcelona, field of 200 m2.
 - ONLY BUILDING FROM THE INITIAL DESIGN PHASE



AIGUASOL

BACKGROUND

THE HIGH-COMBI PROJECT

DESIGN PHASE

THE CIBELES PROJECT IN BARCELONA

CONCLUSIONS



design phase

Design concept involves consideration (evaluation) of:

- Functionality
- Architectural design → Energy considerations
- Maximum comfort → Air quality
psychosocial
visual
thermal
acoustics
- Minimum energy impact → deconstruction
renovation
construction
transport
use
Manufacturing
- Economical optimum → deconstruct.
maintenance
operation
investment

Considering

- Regulation (current and future)
 - Comfort
 - Energy demand in use and implementing RES
 - Waste management
 - Cost efficiency

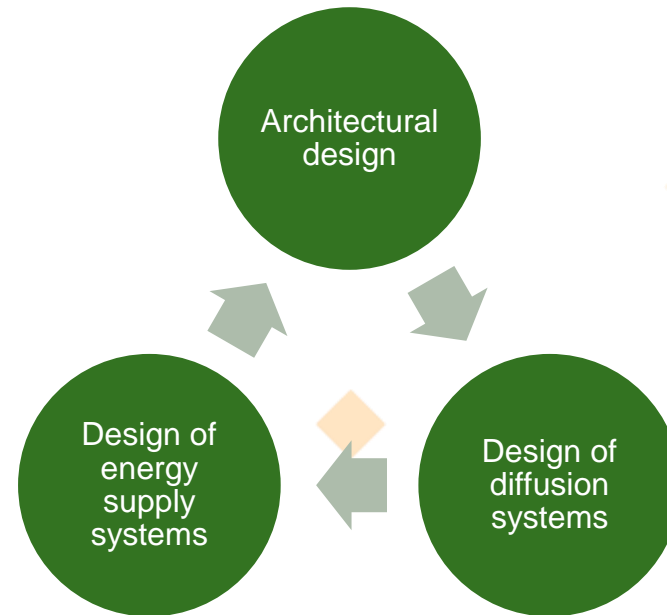
Air quality
psychosocial
visual
thermal
acoustics
comfort

demolition
maintenance
operation
investment
costs

demolition
retrofitting
use
construction
transport
manufacture
energy

Design phase

In the design phase, it is important to focus on the three main aspects of the building, which have feedback on each other



- **Climate**
- **Building use**



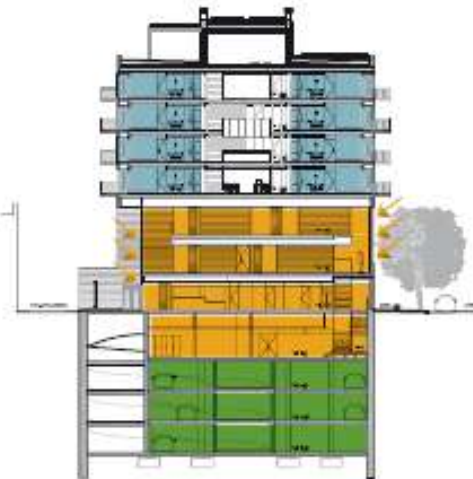
Design phase-architectural design

Architectural design / Bioclimatic design

The three uses of the building have to be integrated : small healthcare center, elderly social housing, parking.

A strong effort has been put in natural daylighting to common spaces.

HABITATGE PER GENT GRAN 2.245,42 M2 / 4 PLANTES 32 HABITATGES
CENTRE ASSISTÈNCIA PRIMÀRIA 1.647,38 M2 / 4 PLANTES
APARCAMENT 2.215,31 M2 / 3 PLANTES 44 PLACES APARCAMENT
ZONES COMUNS 247,96 M2
TOTAL 6.356,07 M2



Design phase-architectural design

Ajuntament de Barcelona

Patronat Municipal de l'Habitatge



Edifici situat en una zona de transició entre diferents trames urbanes, just als límits de Gràcia i l'Eixample.



INTEGRACIÓ DE LA FAÇANA INTERIOR AMB L'ENTORN. La dimensió dels forats així com la textura i color de la façana que dona al passadís interior, s'adaptaven a la trama urbana.



Domòtica

A banda del control domòtic del propi edifici, la planta baixa disposa d'un smart Point d'accés públic que comunica en temps real totes les dades d'estats i en consumeix amb les emissions de CO2 del propi edifici.



Calefacció / refrigeració amb 'Llosa Solar'

Un innovador sistema de radiació solar combinat amb un sistema de llosa radiant, utilitza l'energia solar per refrigerar els habitatges a l'estiu i escalfar-les els dies freds d'hivern.



Escalfament de l'aigua

L'aigua s'escalfa mitjançant la instal·lació solar comunitària que absorbeix el calor del sol per suministrar aigua calenta. Tant per a la demanda d'AACS com per a la demanda de calefacció de l'edifici.



Ventilació d'alt rendiment energètic

Construït un edifici hermètic implica disposar d'una bona ventilació en espais interiors. En aquest sentit comptem un intercambiador de calor aire-aire altament eficient.



Tubs de buit HighPerf.

El sistema d'alta eficiència solar amb tubs de buit dissenyat en aquest Projecte Pilot permet aproximar-se a l'Autosuficiència Energètica amb independència de les fonts d'energia externes.



Baix Consum / Classe A+

Per il·luminar els habitatges en hores que no hi ha llum natural, hem inclòs lluminàries eficients. Al mateix temps, els electrodomèstics integrats en el disseny són d'alt rendiment energètic, A+.



Relació dels habitatges tutelats amb l'exterior. L'espai de balcons forma un col·li internig entre interior i exterior, que queda "flotant" entre les còpies dels arbres del C/ Còrsega. Aquest espai internig ajuda a la privacitat dels habitatges, i al distanciament del soroll i moviment d'aquest carrer. Es pot també la visió frontal des dels habitatges, augmentant la dimensió visual.



Els espais comuns dels habitatges compten amb diferents estances i espais de relació. Un joc de dobles espais fan que es pugui percebre la totalitat dels espais des d'alguns punts, sense perdre la dimensió humana necessària en els habitatges per gent gran. Un pou de llum al mig de la mitgera permet fer arribar llum natural als espais comuns de totes les plantes.



Hores de llum

Hem aplicat estratègies per a l'aprofitament de la llum solar, a fi de optimitzar la il·luminació natural i mantenir la llum elèctrica apagada durant el dia.



Filtre Solar

Els voladus de les terrasses juntament amb el retranqueig dels tancament exteriors orientats a sud ajuden a obtenir un control tèrmic primari per a regular el sobreescalfament de l'habitatge a l'estiu i l'aprofitament de l'aportació natural solar tèrmica a l'hivern.



Inèrcia estructural

Els terres i sostres dels habitatges actuen com elements captadors inercials aportant confort als usuaris i una baixa demanda energètica als sistemes.



Façana ventilada

Les façanes dels edificis han estat conceptualitzades amb una camera ventilada especialment dissenyada per a millorar el comportament tèrmic de l'edifici.



Espai acondicionat reduït

Mitjançant la creació d'un espai exterior -no condicional- treballant les terrasses com prolongació de la sala d'estar, combinat amb la façana verda del propi carrer, es genera un fresc microclima a l'estiu.



Coberta Ventilada

La gran coberta solar instal·lada a manera de pèrgola de diferents alçades, crea un col·li tèrmic o espai ventilat que protegeix la propra coberta de les fortes radiacions solars directes.



Gestió de residus

Tots els habitatges incorporen el seu propi sistema de classificació de residus, facilitant així la tasca de reciclatge als seus ocupants.



Finestres

La transmissió i l'envidrament de les finestres permeten un rendiment energètic eficient, per a reduir dràsticament la transmissió de calor entre l'interior i l'exterior.



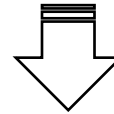
Evitar fugues d'aire

L'ús d'una construcció més hermètica millora el nostre benestar i estalvia energia per aquest motiu s'hi ha treballat amb especial cura en tot el procés constructiu.

Design phase- diffusion systems design

Research phase

So, we analyse different diffusion technologies, which depend on the demand profile obtained from the building design phase and the use:



Hypotheses:

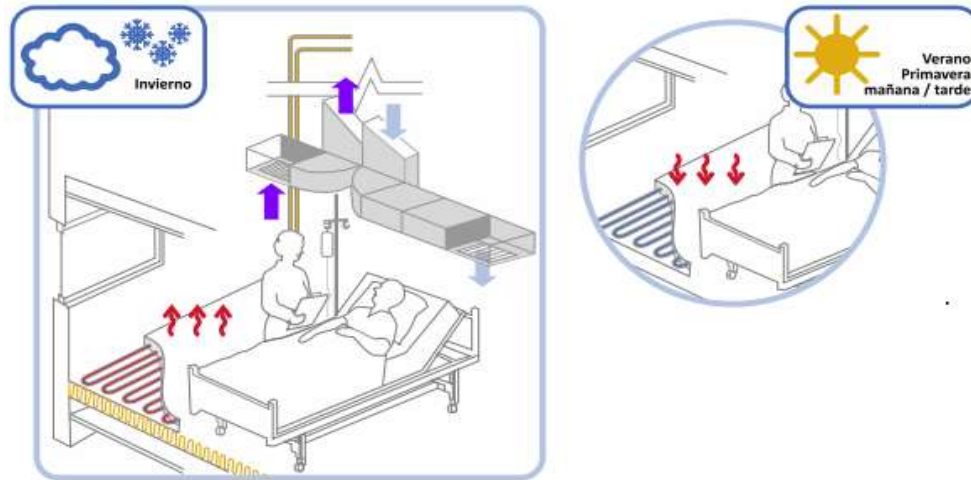
- Elderly people social housing : Building with continuous occupancy in the housing part, with low changes, and an equilibrate demand between heat and cold. Important DHW demand per m2. **Comfort is important.**
- Healthcare center : daily occupancy, high peaks, mainly cooling demand.



Design phase- diffusion systems design

Decision

For the elderly people, we opt for a very inertial system (radiant floor), for heat and cold, with hygienic air renovation (continuous, because of constant loads). Operative temperature more important to comfort than air temperature.

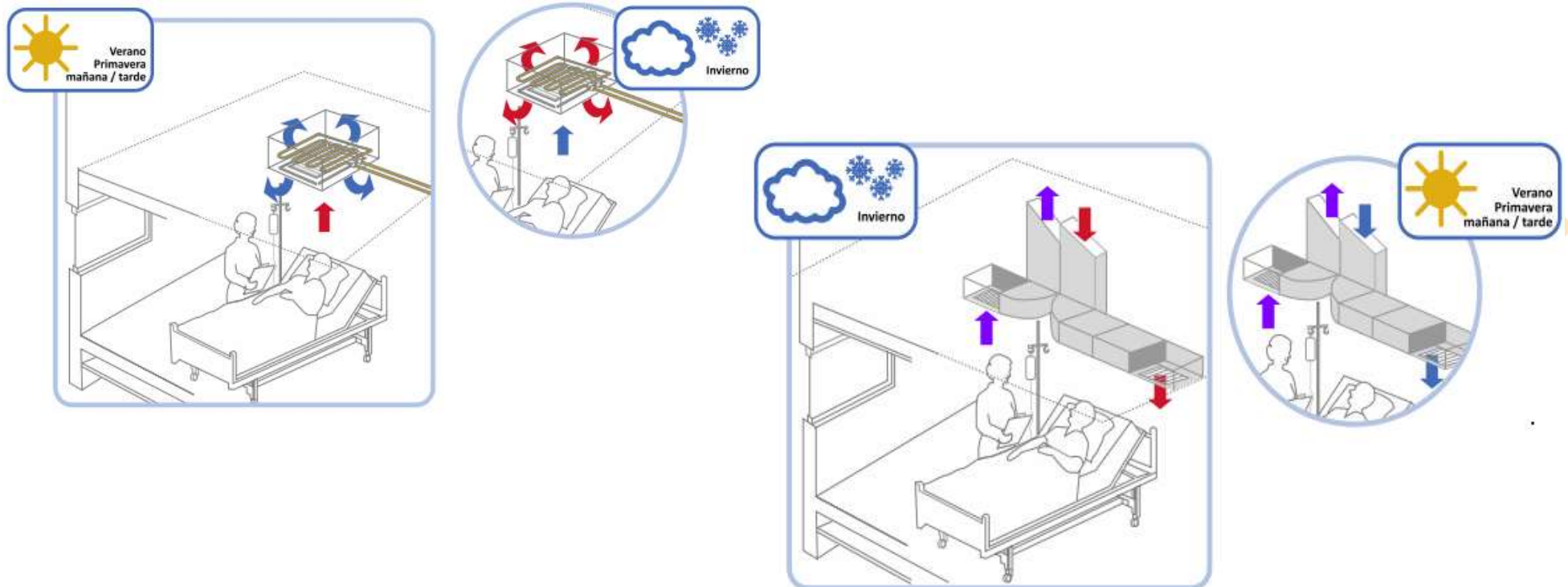


- In summer, to be able to avoid condensation and increase power, renovation air (1 ach) is dehumidified air. A humidity sensor is incorporated, to close the valve when high humidities are detected

Design phase- diffusion systems design

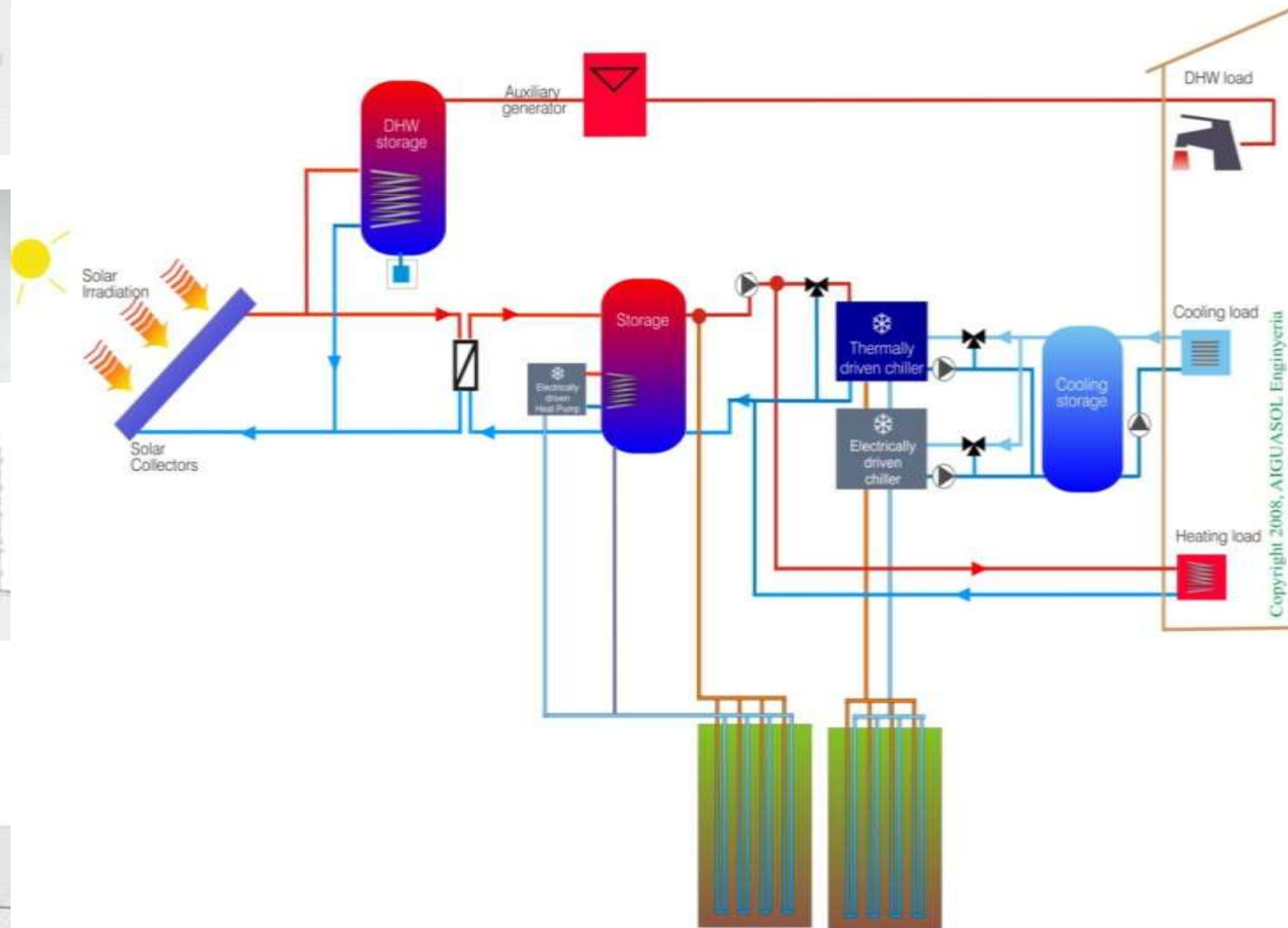
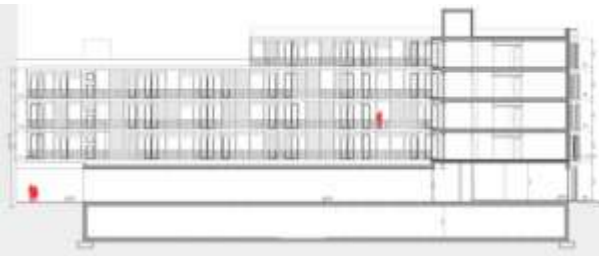
Decision

For the small healthcare center, because of the different behaviour and the different occupancies, two systems are foreseen :
VAV for central spaces and fan-coils for the boxes



Design phase- generation systems design

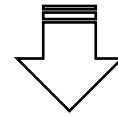
SCH 1



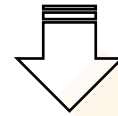
Design phase- generation systems design



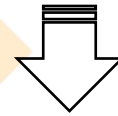
Administrative problems



~~Terrassa building not built~~



New building to find

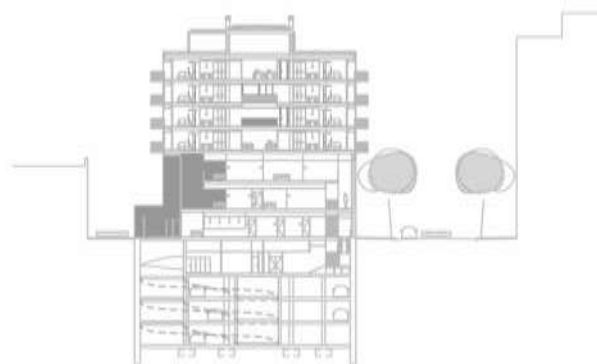
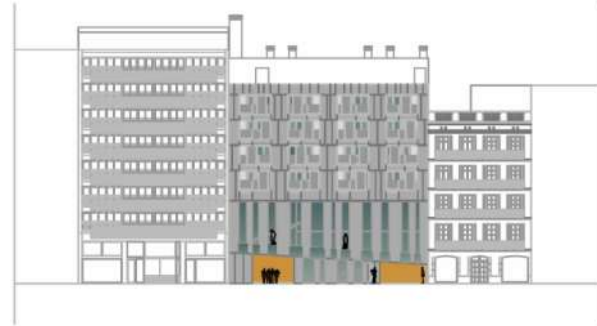


Cibeles building, PMHB



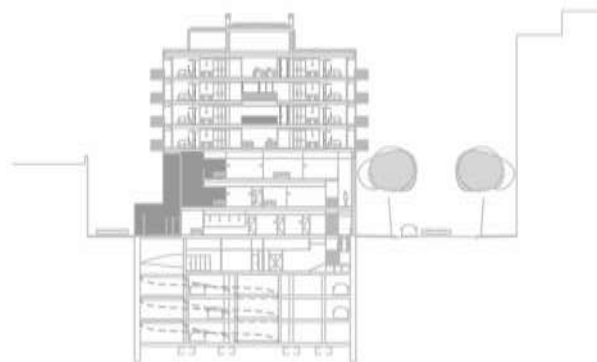
Design phase- generation systems design

Terrassa is dryer and colder. Different usages

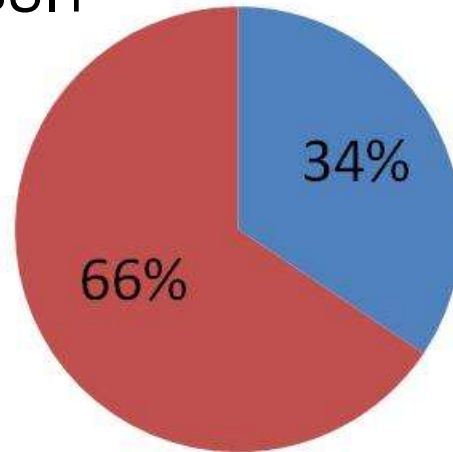


Demand kWh/m ²	Cold	Heat	DHW
BUI 1	22	12	30
BUI 2	28,4	9,6	14,1
Difference	+ 29,1%	-20,0%	-53,0%

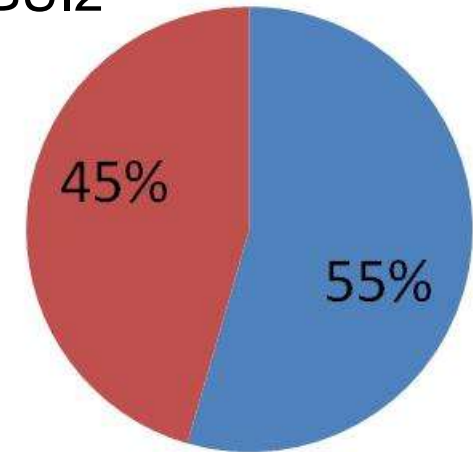
Design phase- generation systems design



BUI1



BUI2



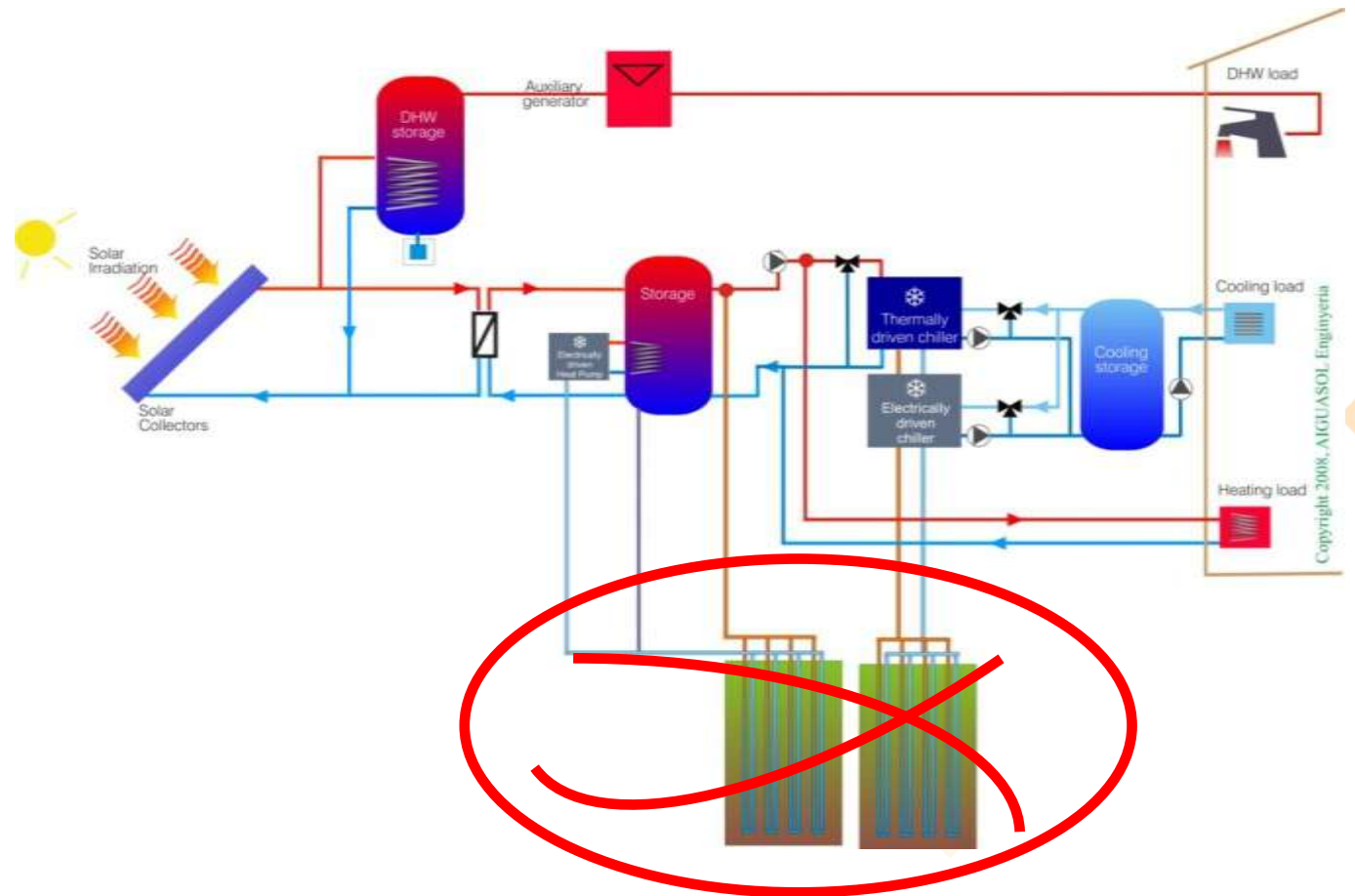
■ Cooling

■ Heating + DHW

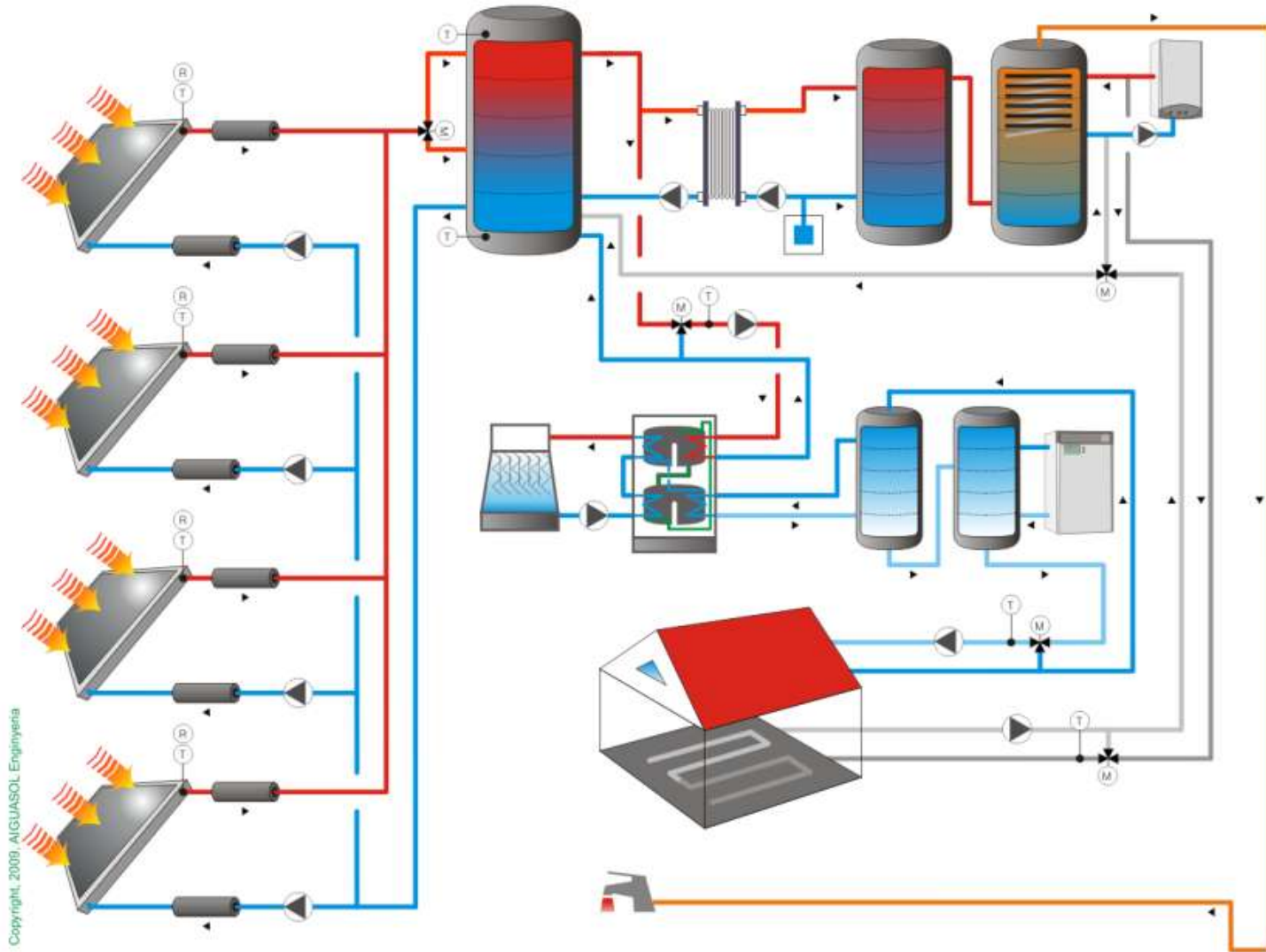
	Ratio (Heat+DHW)/Cold	
BUI 1	1,9	Heat+DHW>> Cold
BUI 2	0,8	Heat+DHW< Cold

Design phase- generation systems design

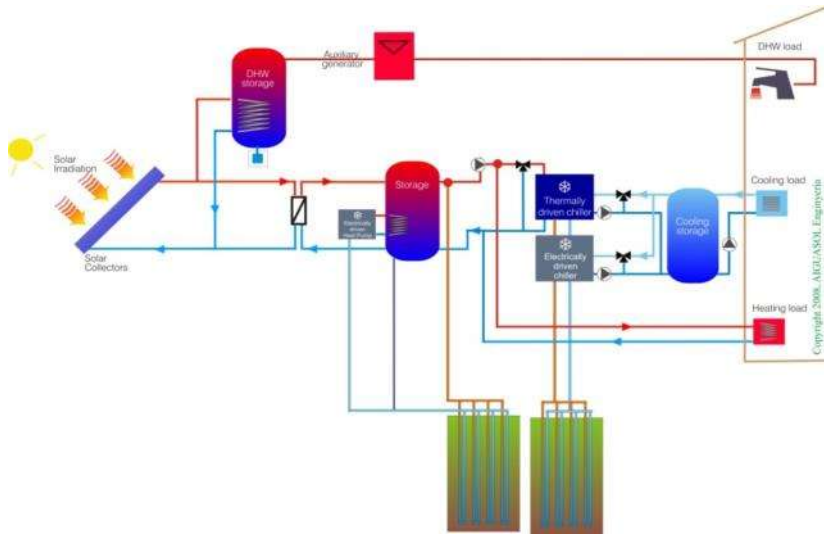
New building, new scheme



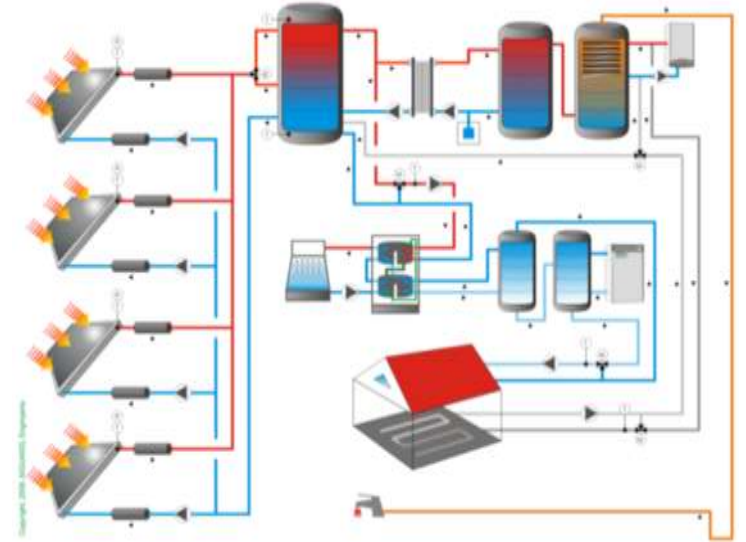
Design phase- generation systems design



Design phase- generation systems design



LOADS BUI2



VS

SCH 1

		SCH1	TOTAL	73,1%	SCH2	TOTAL	72,5%	
Winter								
			Demand DHW 9,1 Cooling 0,0 Heating 9,6 Total 18,7				Demand DHW 9,1 Cooling 0,0 Heating 9,6 Total 18,7	
			f 83,3% - 100,0% 83,9%				f 99,5% - 33,6% 65,8%	
			Consumption Electricity 1,5 Gas 1,5				Consumption Electricity 0,0 Gas 6,2	
Summer								
			Demand DHW 4,9 Cooling 28,4 Heating 0 Total 33,4				Demand DHW 4,9 Cooling 28,4 Heating 0 Total 33,4	
			f 89,8% 63,2% 0 67,1%				f 95,4% 73,0% 0 76,3%	
			Consumption Electricity 3,9 Gas 0,5				Consumption Electricity 3,7 Gas 0,2	

SCH 2

Design phase- generation systems design



BUI2		SCH 1	SCH 2	Dif.
Electricity	kWh/m ²	5,4	3,7	- 32 %
Gas	kWh/m ²	2,0	6,4	218 %
Primary energy	kWh/m ²	15,7	15,9	2 %
Solar fraction	%	73,1	72,5	- 1%
Investment cost	€/m ²	210	162	- 23 %

Costs

Solar fraction

Energy consumption



LIFE
+ CYCLE
ANALYSIS

Design phase- generation systems design



Innovations

Overheating problems

- Huge expansion vessels!
- Primary fluid water
- Antifreezing detailed control

Design phase- generation systems design

Final design

200 m² evacuated tube solar collectors
(4 fields), heat pipe, min inclination.

9 m³ accumulation

70 kW absorption machine

300 kW boilers

250 kW compression chiller





AIGUASOL

BACKGROUND

THE HIGH-COMBI PROJECT

DESIGN PHASE

THE CIBELES PROJECT IN BARCELONA

CONCLUSIONS





Ajuntament  de Barcelona

Patronat Municipal de
l'Habitatge



PREMIOS endesa
A LA PROMOCIÓN
INMOBILIARIA
MÁS SOSTENIBLE
2011













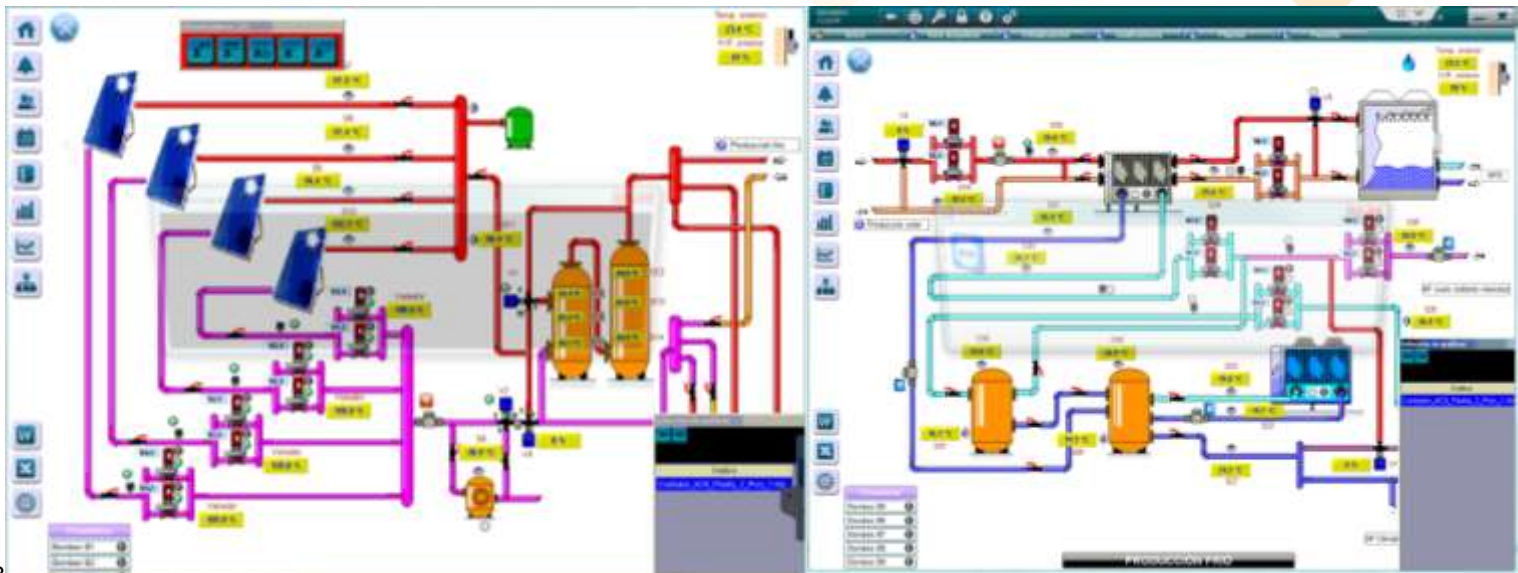






Project monitoring

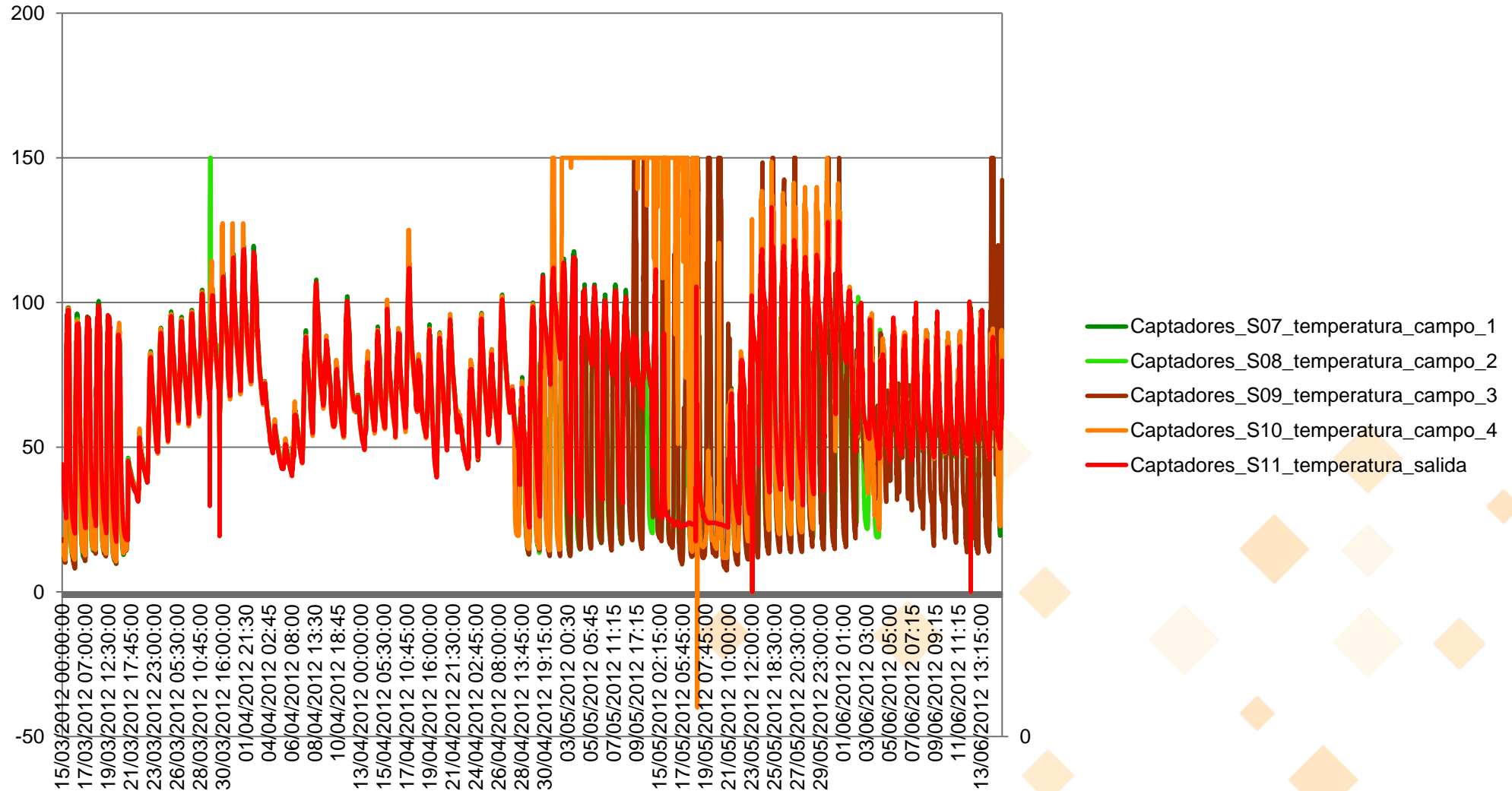
- A detailed monitoring of the system was installed, according to Task 38 from the IEA, to account well for the primary energy saved by the project
- We know the detailed operation of the project via SCADA, which is governed by an external energy service company



monitoring

- The EC project included a monitoring period
- However, due to the changes in the project, the building finished late (one month to the end of the project)
- Current R&D funds, either from the Catalan or Spanish project dedicate little effort in monitoring and evaluation
- Monitoring has been partially done, own funds from Aiguasol

reality (first six months)



reality (first six months)

expected

DHW Dem.	HEAT Dem.	COO Dem.
18,068	15,778	35,886
DHW solar contribution	Heating solar contribution	Solar cooling production
17,165	6,826	19,090
95%	43%	53%

reality

DHW Dem.	HEAT Dem.	COO Dem.
↑ 22,440	↑↑ 26,030	↑↑↑ 76,544
DHW solar contribution	Heating solar contribution	Solar cooling production
12,500	20,824	18,320
56%	80%	24%

reality

- Although the project has followed all correct steps, two lessons learnt:
 - Commissioning of this type of systems takes a loooooong time, if we want to tune perfectly the systems
 - Reality is stubborn.....
- According to real figures (we have to take into account that they are first months of partial operation of the building)
 - BUILDING
 - Higher heating consumption than expected (late entry of users and some problem with the control of the AHU)
 - High cooling demand (small change in initial project because of cost matters – solar protection façades-), freedom in regulation temperature between 22 and 25°C.

- BUILDING
- Some training has lately been done to users
- Problems with people switching on and off mains, thermostat is going crazy!
- DIFFUSION SYSTEMS
- Initial difficulties with radiant floor (not perceived as real cooling as there was no air involved), explanation was given and people is feeling each time more comfortable
- Hardly any condensation problem (2 apartments, before the temperature was correctly adjusted)

- GENERAL HVAC SYSTEM
- Good field production (higher than expected)
- Good behaviour of absorption machine, although late
- Control problems (strong difficulties with the control contractor, solving them now)
- Good solar fraction, although low in cooling and dhw
 - The absorption machine was turned on later than the rest of the system, commissioning problems
 - The control of the hysteresis temperature of boilers for DHW loop is being controlled
- **IMPORTANT TO WAIT FOR A FULL YEAR MONITORING, TO EVALUATE CORRECTLY**



AIGUASOL

BACKGROUND

THE HIGH-COMBI PROJECT

DESIGN PHASE

THE CIBELES PROJECT IN BARCELONA

CONCLUSIONS



Conclusions low energy building



- A lot of costs can be saved working together with the property and the architect (exe and the Patronat very collaborative from minute zero!!!!)
- Different heat and cold profiles imply different system solutions!!!
 - Avoid preconceived schemes
 - A very good initial choice of the scheme, design and basic project will reduce time of maintenance and operation.
- COST IS A BASIC ELEMENT IN DECISION CHOICE.

Conclusions low energy building



- The cost of a building like these (including parking) is lower than 900 €/m². The healthcare center has to be finished...
- For a low energy building, it is a very small cost, considering that we have a R&D demonstration project in it.
- With respect to the BAU scenario, we save around 3100 €/year in energy!!!
- So, it implies that if we decide to make a good building starting from scratch we can have a good behaviour for a cost that is not excessive



Conclusions low energy building

- However, it is important to point out that low energy buildings are not EASY buildings.
- People have to get used to them, they have to be trained (no immediate satisfaction of comfort in this case)
- Architects have to work thoroughly together with energy engineers and the owner.
- A good BEMS/BEPS system is necessary to be able to deal with all the details involved, as much as it is important to keep it as simple as possible.
- There are always problems in the beginning, it is our job to overcome them!!



Conclusions low energy building

- It is essential to have funds to monitor these buildings, otherwise a lot of experiences will be lost!!!
- Although inaugurating “monitoring data” is not as appealing as inaugurating “new premises”, it is basic and not so costly!!!!
- It is also important to disseminate the knowledge : congratulations to the AIDA project, it looks at things from the right point of view!!

GRÀCIES PER LA SEVA ATENCIÓ

E-mail:

oriol.gavalda@aiguasol.coop

<http://www.aiguasol.coop>

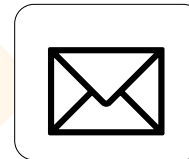


Dirección postal:

AIGUASOL ENGINYERIA

C/ Roger de Llúria 29, 3º 2ª

E-08009 BARCELONA



Tel: + 34 93 342 47 55

Fax: + 34 93 342 47 56

