bibm Congress 2017

PROMOTING SUSTAINABLE MARKETS

Reducing the need of installations whilst improving energy labelling

Reducción de la necesidad de instalaciones al mismo tiempo que se mejora la calificación energética

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Contents

1. CSIC and Torroja Institute for Construction Science.
2. European context. Regulation. Efficiency and energy savings. Certification.
3. Technologies and boundaries.
4. Thermal mass and concrete. Inertia.
5. Case studies and research projects.
6. Innovative solutions.
7. Conclusion and some ideas.

Torroja Institute for Construction Sciences
CSIC. Spain.

Introduction CSIC. Research Council

Main Spanish research institution (3rd in Europe): 20% research production

Goal: to develope and promote research in benefit of scientific and technologic progress

Comprises from basic research to knowledgement transfer to the productive sector

135 institutes: 15.000 workers: 6.000 researchers: 8 research areas: Humanities and social science, biology and biomedicine, natural resources, agricultural science, physics, **materials**, food and chemical science and technology.

http://www.csic.es/web/guest/presentacion

Eduardo Torroja Institute for construction science (IETcc)

Scientific-technical research, assistance and knowledge transfer in the construction field

» 1934

» 2014: 80th anniversary

» > 200 people staff

- 3 research departments: Cement and materials recycling, Estructural safety and durability and Construction
- 4 technical support departments: Physical and chemical analysis, Scientific and technical support, **Quality in construction** and Innovative products assesment (DIT)

http://www.ietcc.csic.es/index.php/en/

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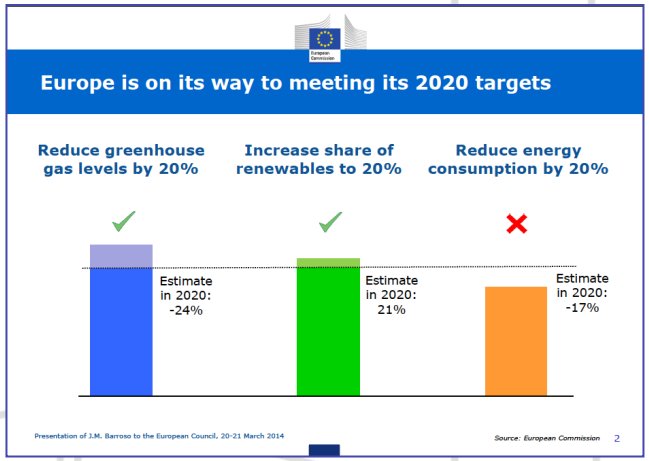
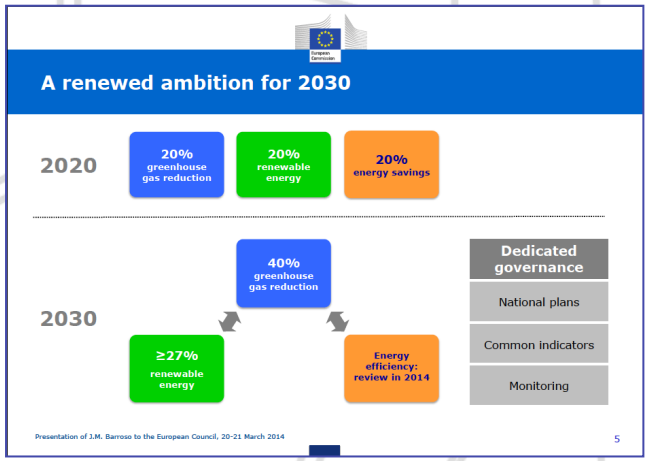
European context

- EPDB 2002 required all EU countries to enhance their energy regulations and to introduce energy certification schemes for new and existing buildings.
- EPBD recast 2010 established new challenges towards nearly-zero energy buildings nZEB by 2020 (2018 in the case of Public buildings).
- In Spain,Technical Building Code 2006 has been updated in 2013 with a remarkable increase in the level of energy efficiency.
- Nearly zero-energy concept requires increasing the level of performance of the building envelope and systems, and additionally a higher contribution of renewable energy.



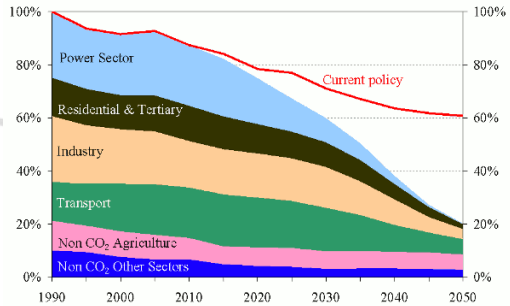


Meeting the "20-20-20" targets for reduction of CO2 emissions necessarily involves a drastic reduction of energy consumption in buildings.

Climate action

2020 European strategy	**2020**	**20% Reduce Greenhouse gas**	**20% Increase renewal energy**	**20% Reduce energy**
2030 Climate and energy framework	**2030**	**40% Reduce Greenhouse gas**	**27% Increase renewal energy**	**27% Reduce energy**
2050 Competitive Low-carbon economy	**2040**	**60% Reduce Greenhouse gas**		
	2050	**80% Reduce Greenhouse gas**		

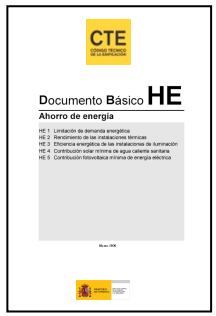
Reduction over 90% in buildings

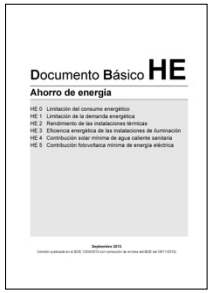


Paris Agreement (2015): Greenhouse gas (GHG) emissions neutrality in the second half of the century

Greenhouse gas (GHG) emissions neutrality should be interpreted to mean net zero anthropogenic GHG emissions from all sectors. It is achieved first and foremost by reducing total GHG emissions to as close to zero as possible. Any remaining GHGs would be balanced with an equivalent amount of removals (such as enhanced sequestration in the land sector) or negative emissions (possibly using future technologies like bioenergy combined with carbon capture and sequestration, although these remain unproven at scale).

Regulation





1979 2006-2007 2010 2013 2020

- **NBE- CT 1979**
- **RITE (M&E services. Thermal installations)**

  CTE 2006: HE1: Energy and saving- Energy efficiency certificates)
- **EPBD Recast**
- **CTE 2013: Code revision HE1: Energy. Energy efficiency cert.**

2020 Objectives

CTE
CÓDIGO TÉCNICO
DE LA EDIFICACIÓN

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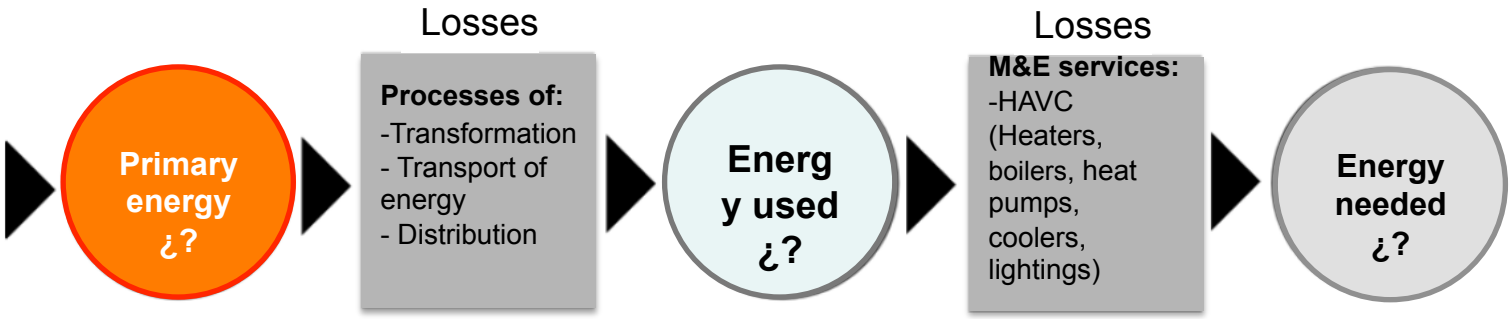
Nearly zero Energy Buildings

- ‘Nearly zero-energy building’ means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.
- **‘Energy performance of a building’ means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting.**



DIRECTIVE 2010/31/EU. Recast

- "Nearly zero-energy building' means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby"
- Member States shall ensure that:

  (a) by 31 December 2020, all new buildings are nearly zero- energy buildings; and

  (b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings

nZEB

Spanish regulation

- The Spanish Building Code is the Spanish regulation which establishes the security and habitability requirements buildings must fulfil and was approved in 2006. Renewed in 2013 in energy matters.

Types of regulations

- Prescriptive approach: Establish rules about what to do. Accepted solutions and alternative solutions
- Performance approach: based on the "Performance System Model" PSM.

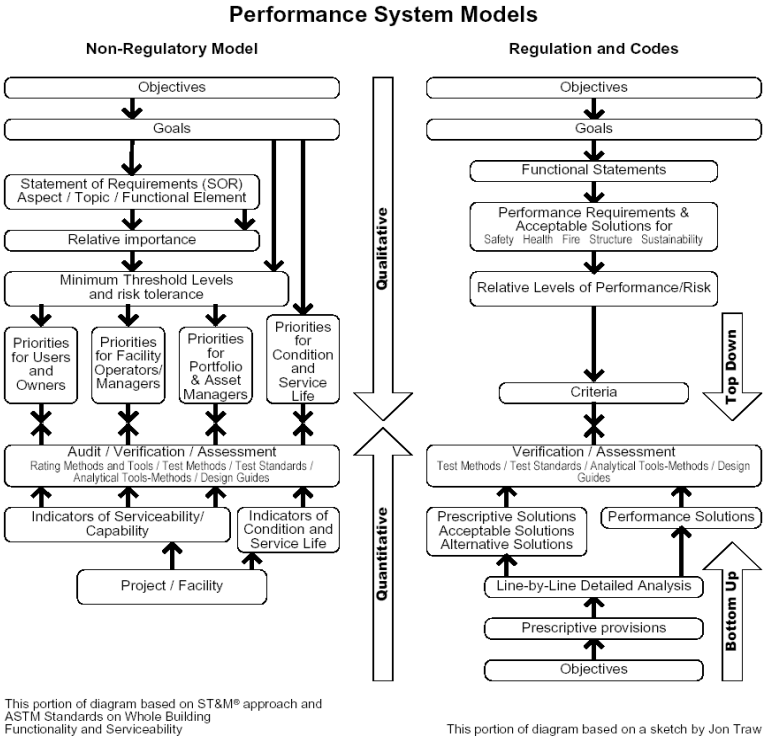


Figure 1 – The Performance System Models showing both Non-Regulatory and Regulatory Requirements

Building Regulations: Performance

- Setting energy efficiency requirements for each building part and for each part of the equipment
- Trading off: some values could be better and some are worse than the requirements (set values)
- Simple model. Method that calculates a reference building with the same shape as the object building and with set values. The model compares the energy demand or consumption between the object and reference buildings
- Setting the building's maximum energy loss with a model of reference
- Establishing the maximum consumption of energy or emissions

Building Regulations. Levels

- Ways of expressing energy performance requirements

LEVEL1	LEVEL 2	LEVEL 3	LEVEL 4
Global consumption	Heating consumption	Heating needs	U-values
		Average C.O.P	Efficiency of heating systems
	Cooling consumption	Cooling needs	U-values Solar factors
		Average E.E.R	Efficiency of cooling systems
	Hot water production	Solar Contribution	Hot water production using solar energy
		Average Efficiency	Efficiency of hot water production systems Technical specifications of the thermal solar installation
	Lighting	Average Efficiency Solar contribution	Efficiency of lighting systems

Building Regulations 1979-2006

Parameters (Spain)	Regulation 1979	TBC 2006
Requirement for heating	Building envelope	Building envelope
Requirement for cooling	No	Yes
Climate	Winter	Winter and summer Climate severity
Building envelope Quality	Global Value K_G	U-values Solar factors for windows, roof lights, etc
Air permeability (infiltration)	No	Windows and doors
Compacity, form factor, volume, size	Global Value	No
Heat bridges	No	Yes
Urban planning regulations	No	No
Limitations of existing building	No	No
Solar factor	No	Yes, General option
Thermal mass. Inertia	No	Yes, General option
Use of the building	No	Yes

Building Regulations 2013 and future.

2013 | **2017-18**

Limitation on Non renewable primary energy consumption

Non renewable primary energy consumption

Energy efficiency
Non renewable primary energy consumption

Limitation on energy demand

Energy demand
Heating + cooling

Global energy consumption
(renewable + non renewable)

Building quality
Quality of the building envelope + Solar control

Efficiency in M&E services

Heating and cooling services.
RITE regulation

Heating and cooling. RITE

lighting

Lightings

Renewables

Solar energy for Hot water

Photovoltaic energy production

Implicit

+ Additional conditions

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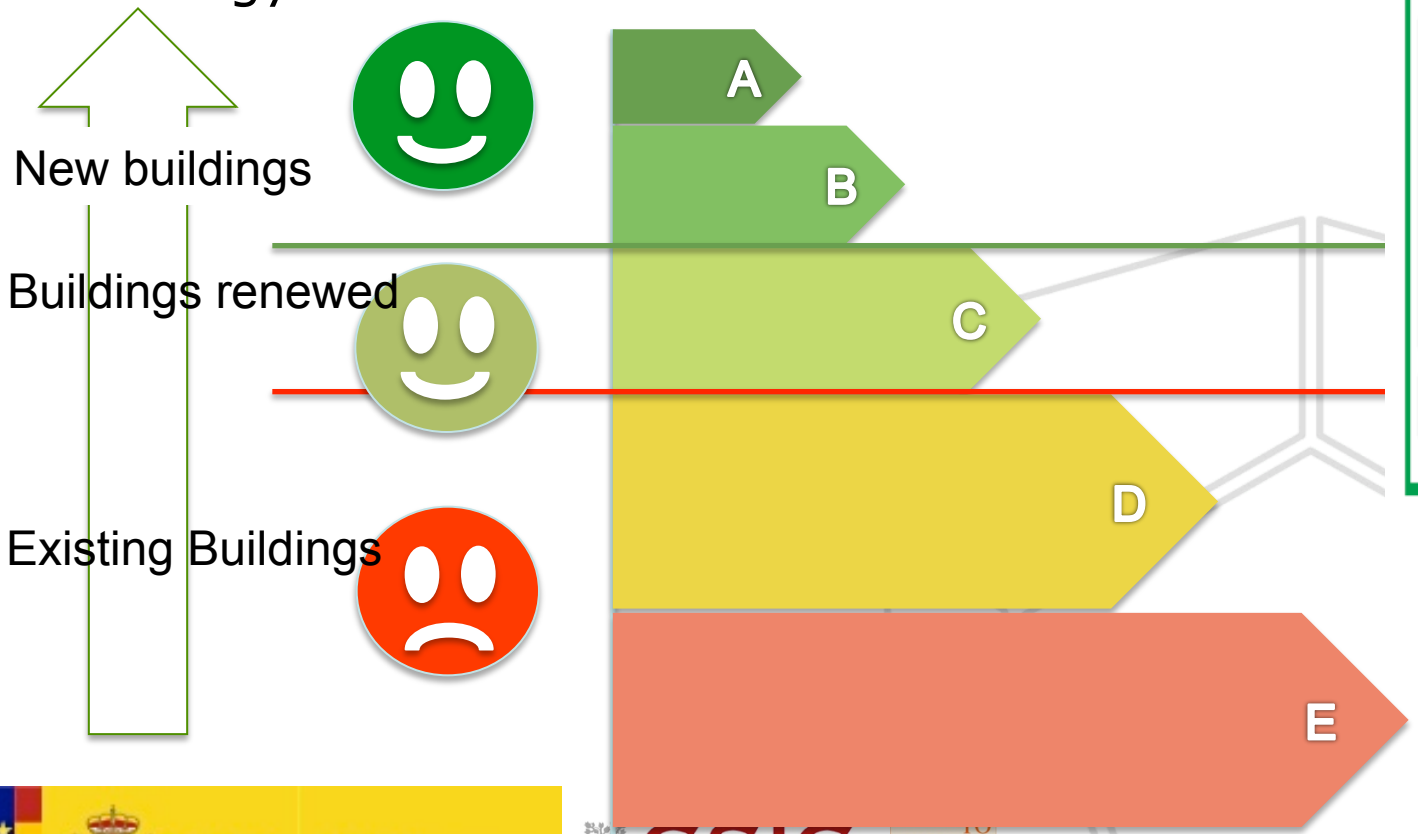
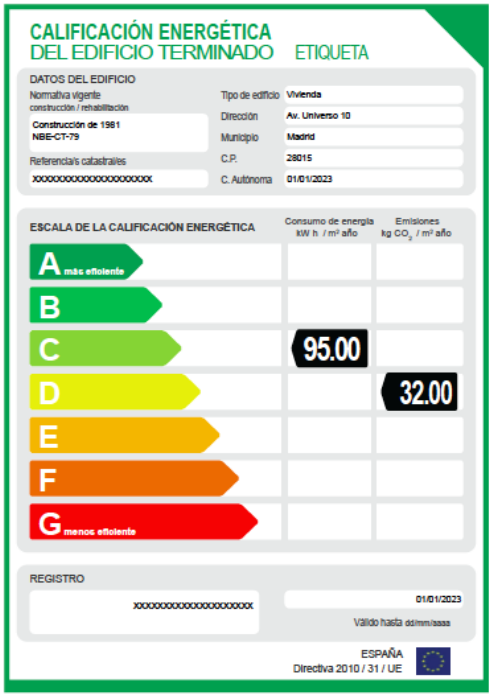
Certification. Energy labelling

- CO2 Emissions
- Non renewal energy consumption
- Energy demand





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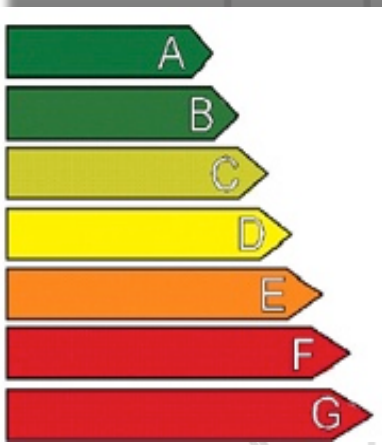
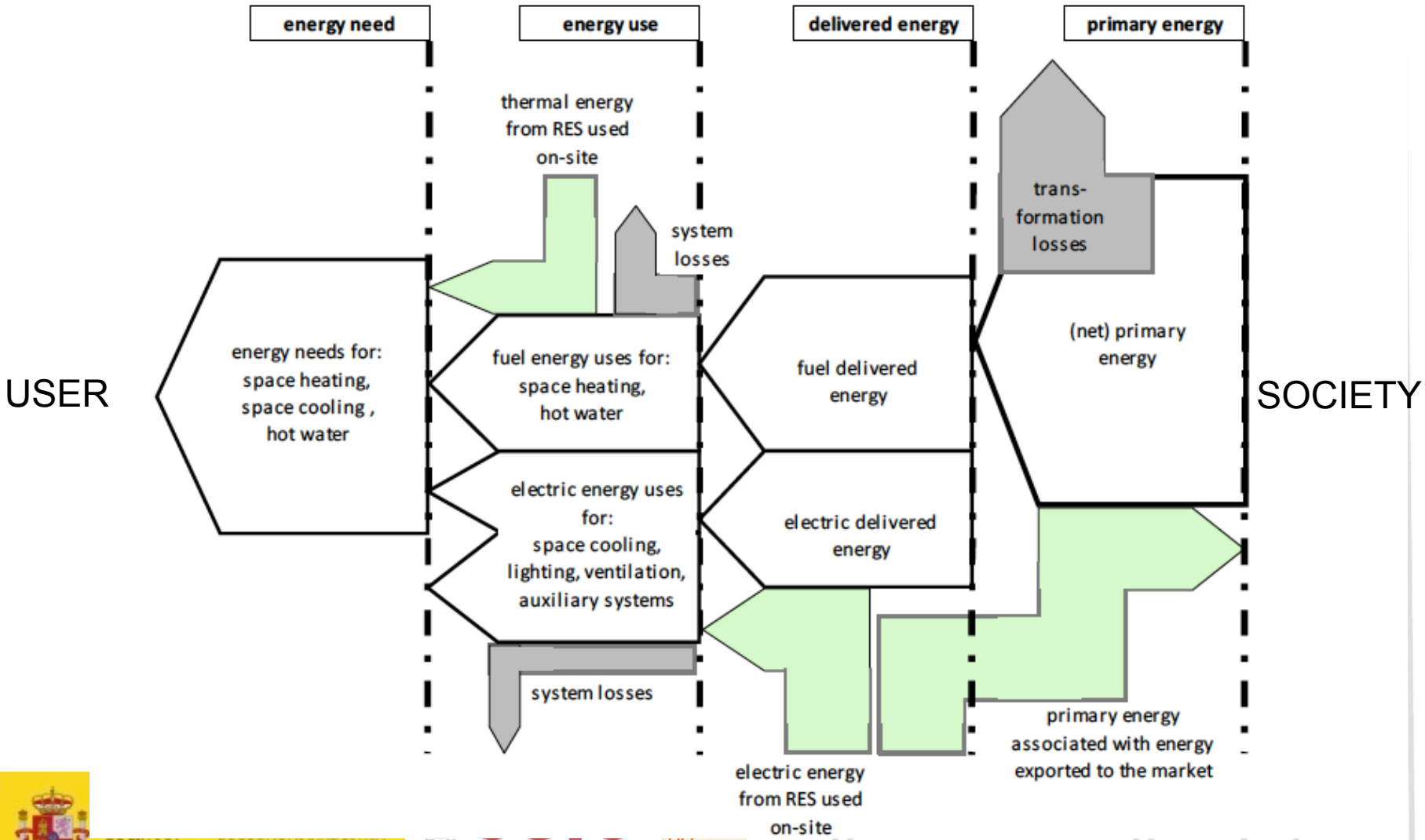
Building Certification

- US, Canada, Australia: Energy Star
  - insulation upgrades
  - higher-performance windows
  - better draft proofing
  - more efficient heating, hot water and air conditioning systems…
- Europe: Building certification
  - Measured or calculated energy performance ratings
  - Mandatory in member states



Also in products.

Building regulation. Schema



Design and technologies

Winter cold ⟷ Hot summer

- Isolation: U values
- Thermal bridges control
- Ventilation (Energy looses in ventilation, moisture problems or air-infiltration)
- Passive solar systems
- Furnaces
- HVAC (Heaters, boilers, heat pumps)

Condensing Units (dehumidifier)

- Solar factor (or g-value)
- Ventilation and passive ventilation
- Solar protection and control
- Night cooling
- Fans
- Swamp coolers and evaporative coolers
- HVAC (Coolers)

Renewable technology…
Innovative technology…

Strategy

Energy in buildings

$$\text{Consumption} = \frac{\text{Energy Demand}}{\text{Energy efficiency installations}}$$

in

Heating
Cooling
Hot water
lighting

- Reducing energy demand of buildings
- Increasing energy efficiency in installations
- Using more renewables energies

New & existing buildings

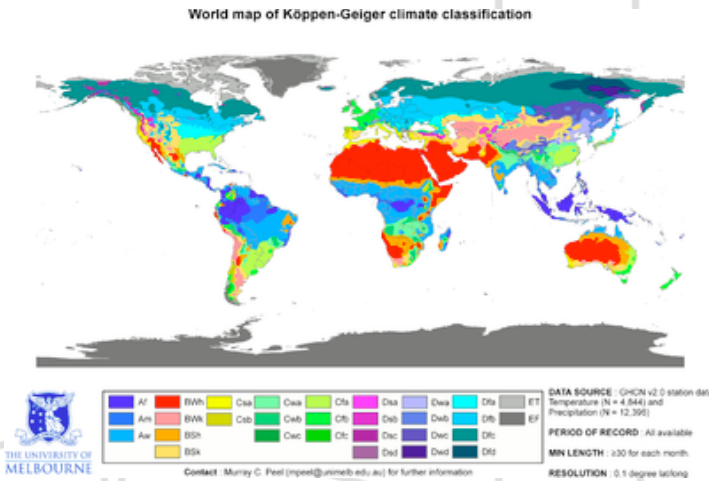
Boundaries: Building building type and location

New Buildings		Existing Buildings	
New	New Building in consolidated urban area	Refurbishment in existing Building	Heritage Building

Boundaries: Climatology

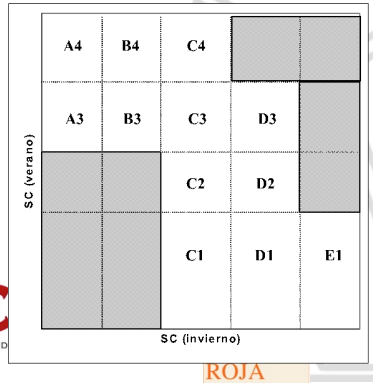
Climatology:

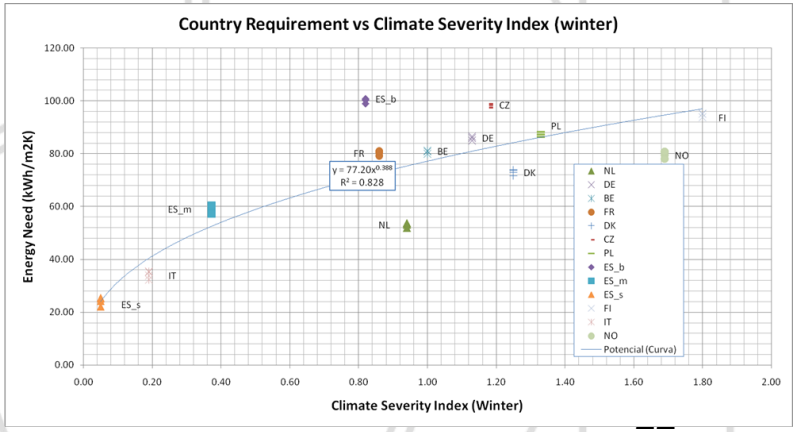
- Köppen Climate Classification system, which proposes six general climate types: A) tropical, B) dry, C) mild latitude, D) serves latitude, E) polar and H) for highland. Each of these classes is divided into sub categories according to the type of winter or summer
- ASHRAE standard for commercial and large complex buildings uses 8 zones and 17 sub zones (A, B, C) alone for the US
- International Energy Conservation Code, IECC: 10-12 zones
- Spanish code: 12 zones (new zones 2013)



Source: Peel, M. C., Finlayson, B. L., and McMahon, T. A. (University of Melbourne)

Heating
Cooling
Humidity control





Source: Pr. Alvarez. Seville University

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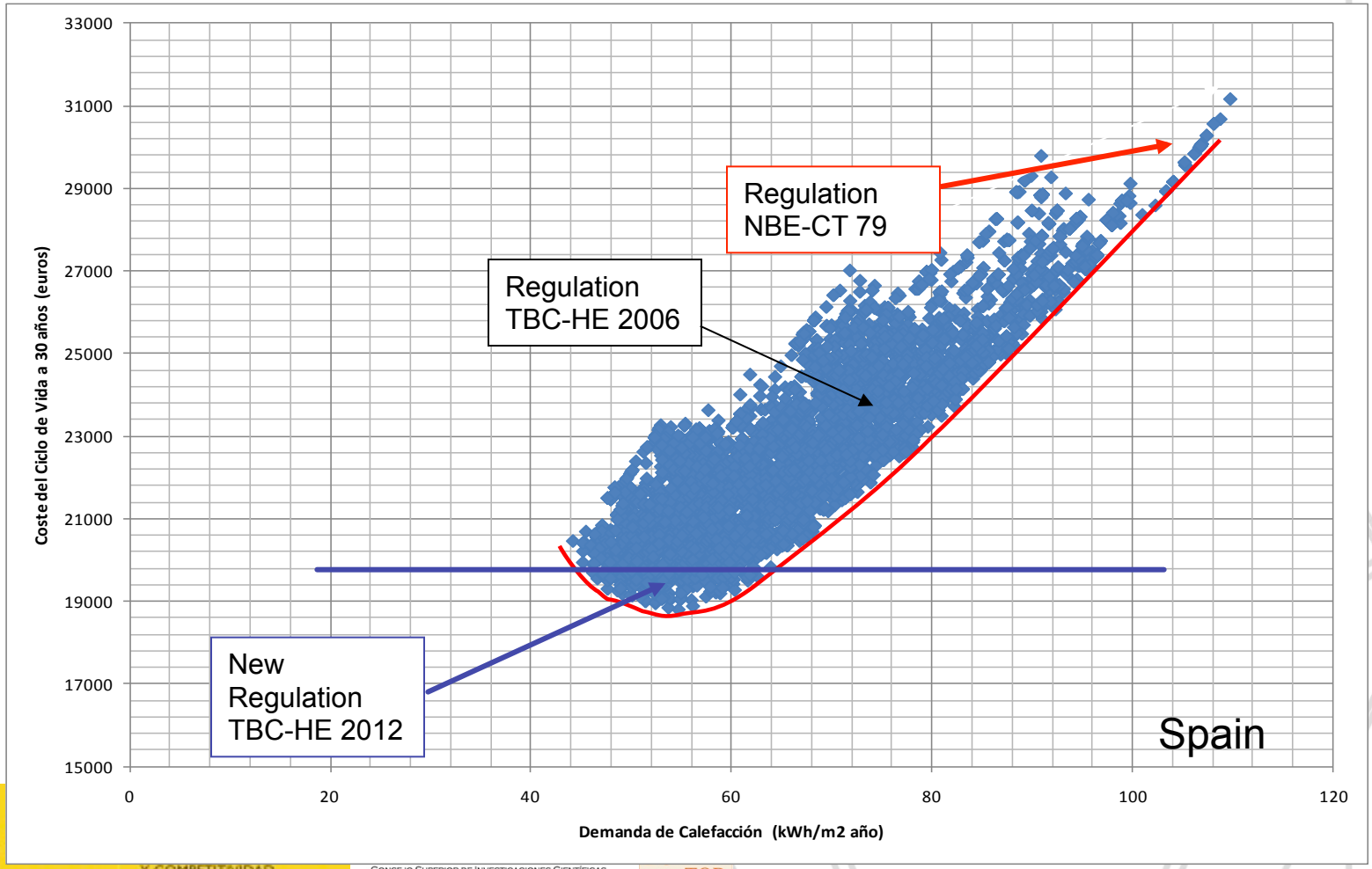
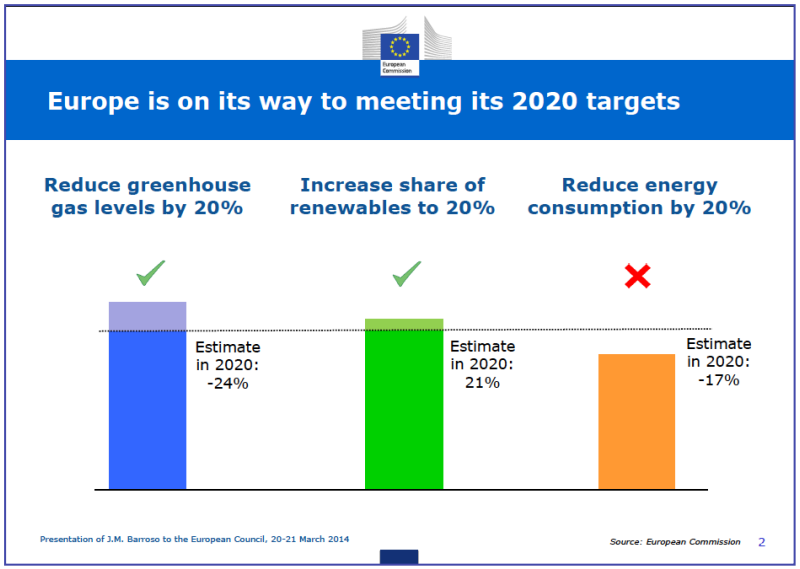
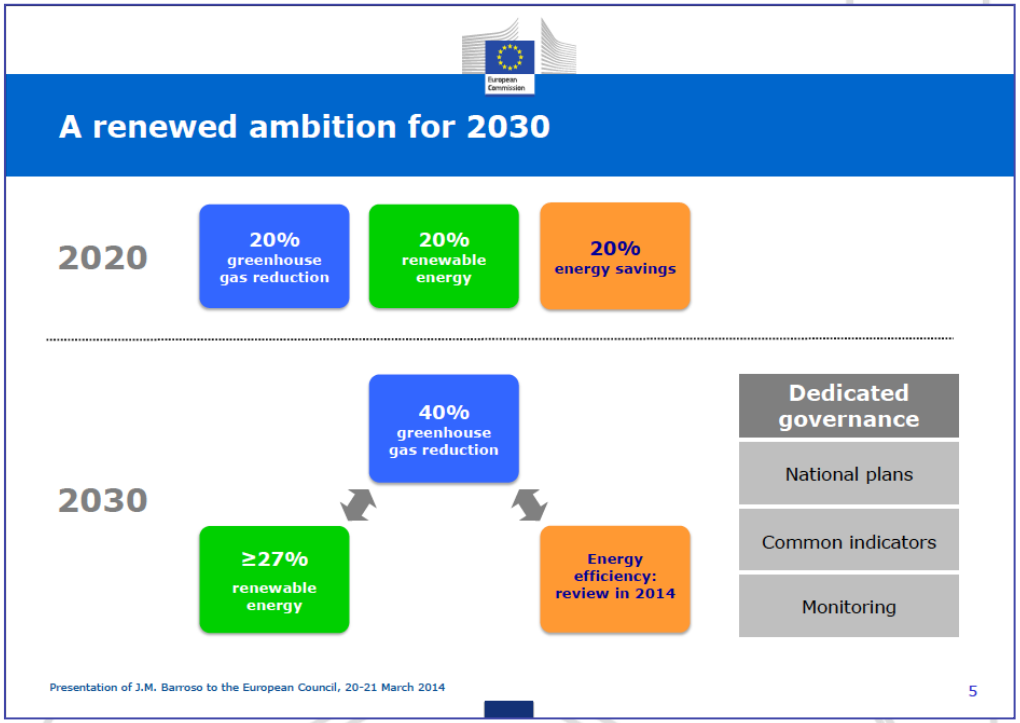
Boundaries: Cost-optimal

- Cost-optimal analysis for new minimum requirements



2020 Objectives





Efficiency:

- Insulation, thermal bridges…
- Renewables
- Effective ventilation, innovative solutions…

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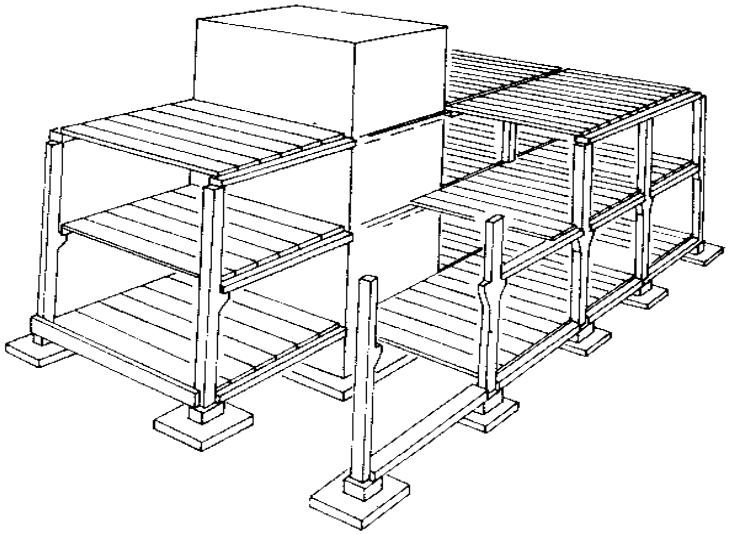
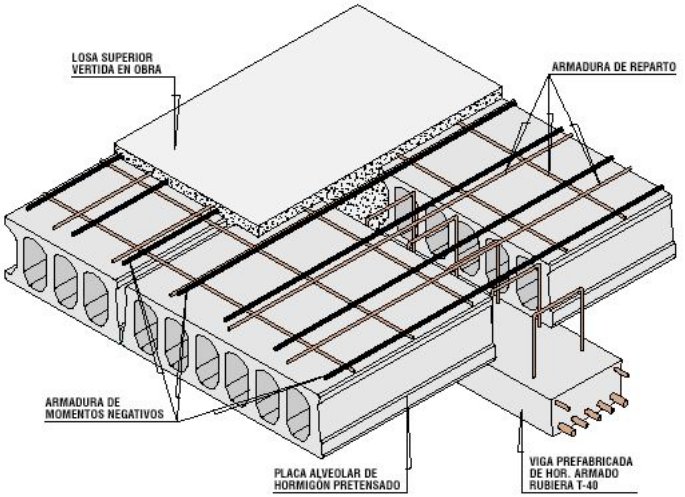
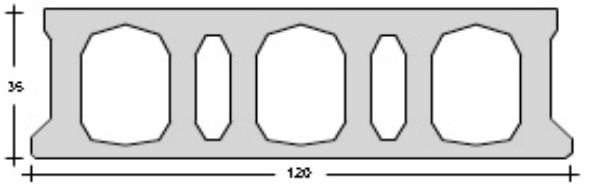
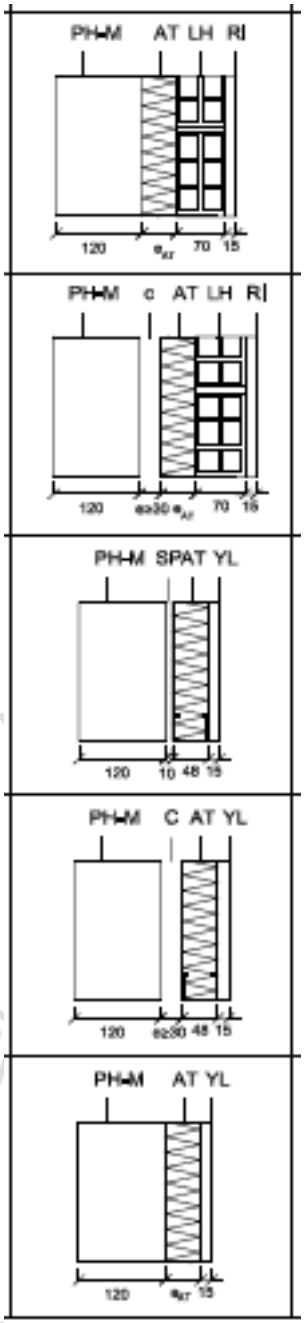
Precast concrete. Energy potential.







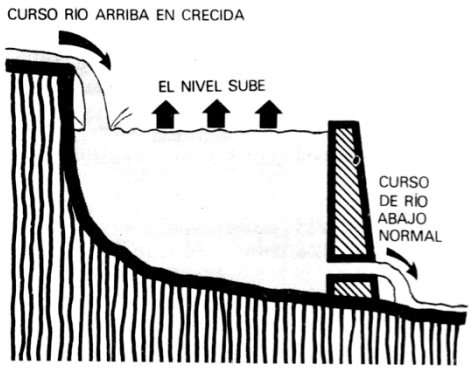


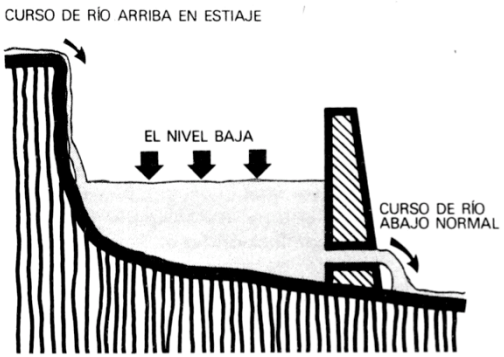
Concrete + Energy = Inertia

Thermal mass is a property of the mass of a building which enables it to store heat, providing "inertia" against temperature fluctuations.

- Capacity to absorb, store & release heat is proportional to the amount of material and the specific heat capacity.
- Using thermal mass effectively.:
  - **Delay heat flow through the building envelope** (indoor temperatures delays swings from outdoor conditions)
  - **Moderates internal temperatures by averaging out diurnal (day−night) extremes**.

The main energy benefit of using concrete in buildings is its high thermal mass that leads to thermal stability.



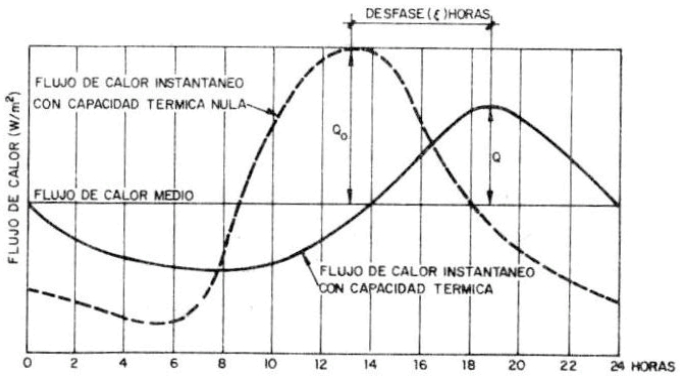


Analogía hidráulica de la influencia de la capacidad.

But, thermal mass needs to be activated

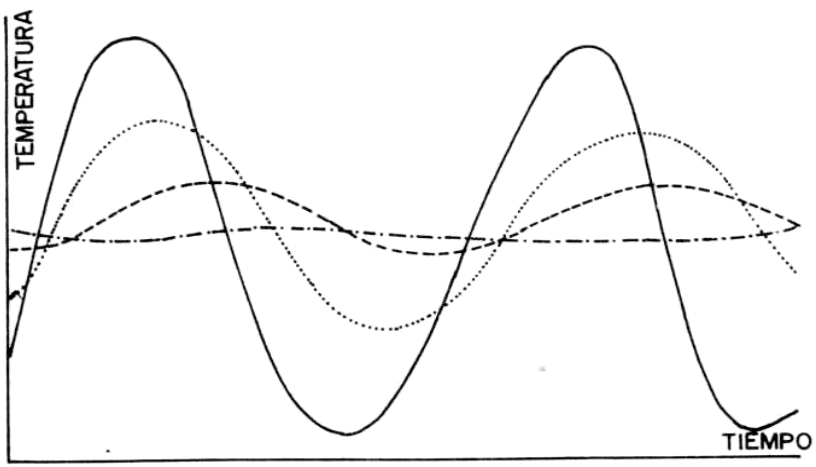
Thermal mass

- Indoor thermal comfort
- Climate potential
  - Renewable energy
- Storage capacity:
  - k-values (kJ/m^{2}K)
  - Thermal conductivity
- Energy Storage and Release
  - Distribution of incoming solar radiation
  - Heat transfer coefficient or film coefficient
  - Night freecooling
  - Passive or active (enhanced) strategy required



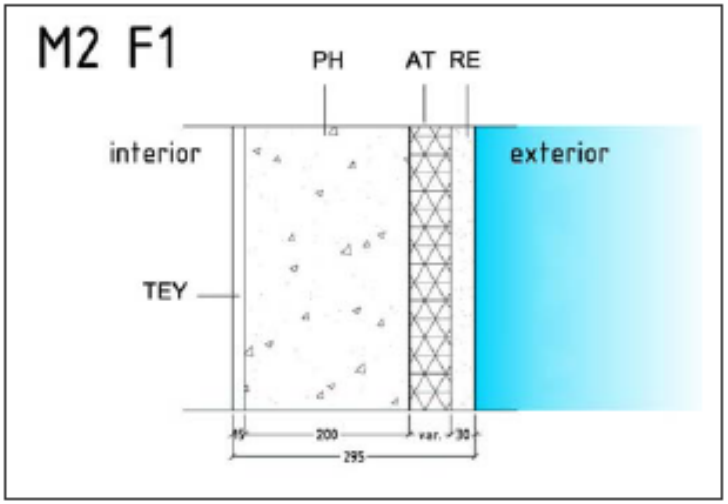
Innovative solution are not totally covered by thermal mass regulation models.

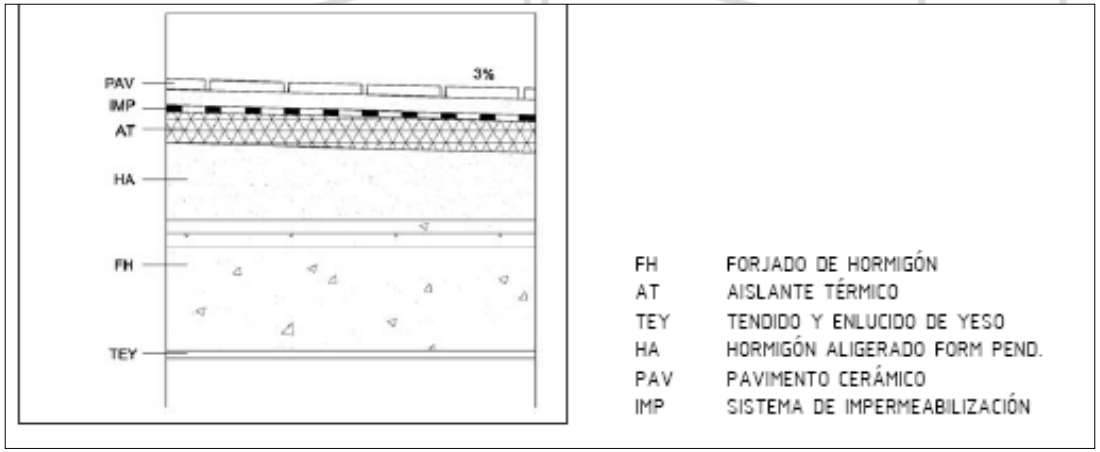
Inertia



aire exterior
aire interior : cerramiento ligero
aire interior : cerramiento pesado, aislamiento en el exterior.
aire interior : cerramiento pesado. edificio semienterrado.

Thermal mass of concrete delays and reduces peak loads.





PH MURO DE HORMIGÓN ARMADO
AT AISLANTE TÉRMICO
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TEY TENDIDO Y ENLUCIDO DE YESO

Inertia

Is thermal mass good or bad, from the point of view of energy comsumption?

This depends on how you use it.

- Climate
- Use of the building

• In general is good on an equal basis on insulation condition.

• Always is good if heat sources and sinks are from renewables sources. Indoor Thermal mass have to receive sun in winter and use free night cooling in summer.

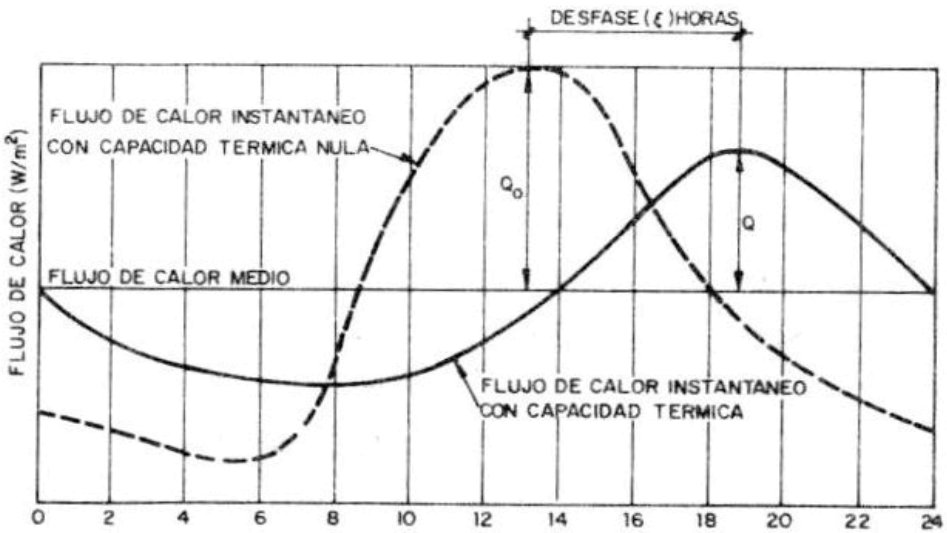
• Increase comfort.

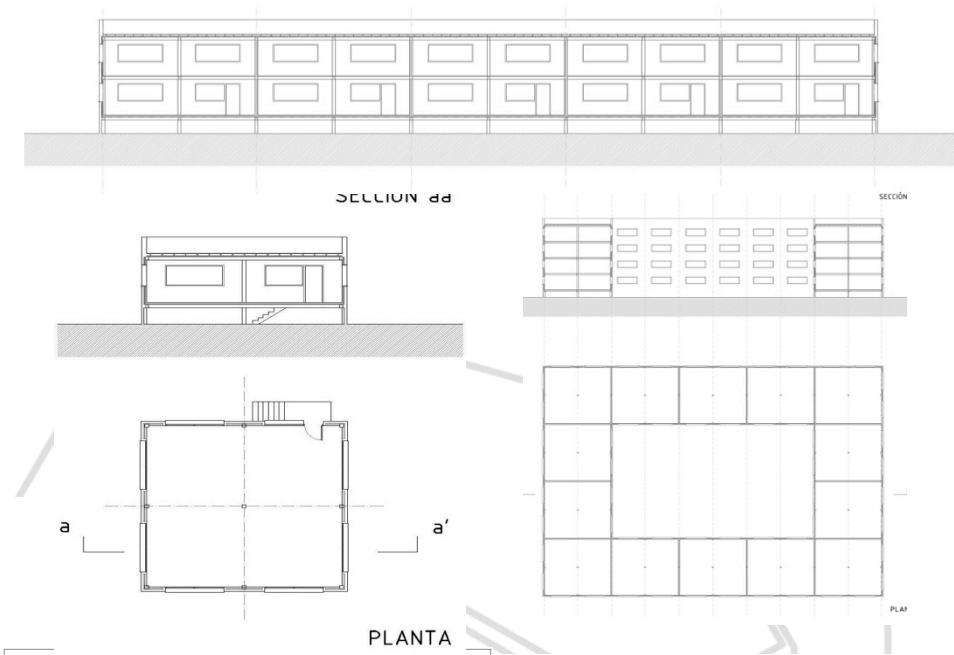
In any case thermal mass a is technology that will contribute strongly to save energy in buildings.

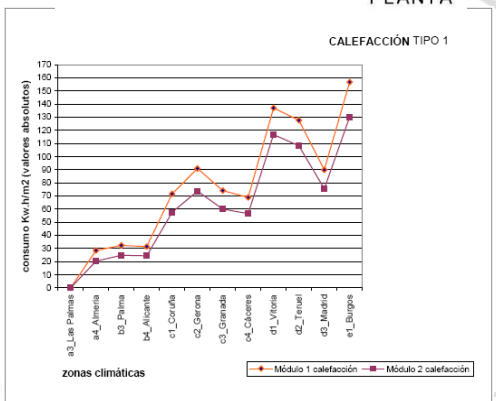
Solar design

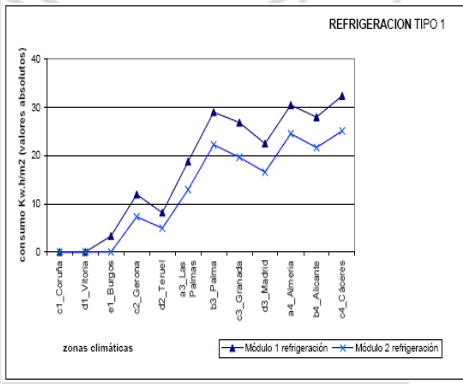
Passive solar heating:

- Capture the sun's heat
- Store
- Release energy



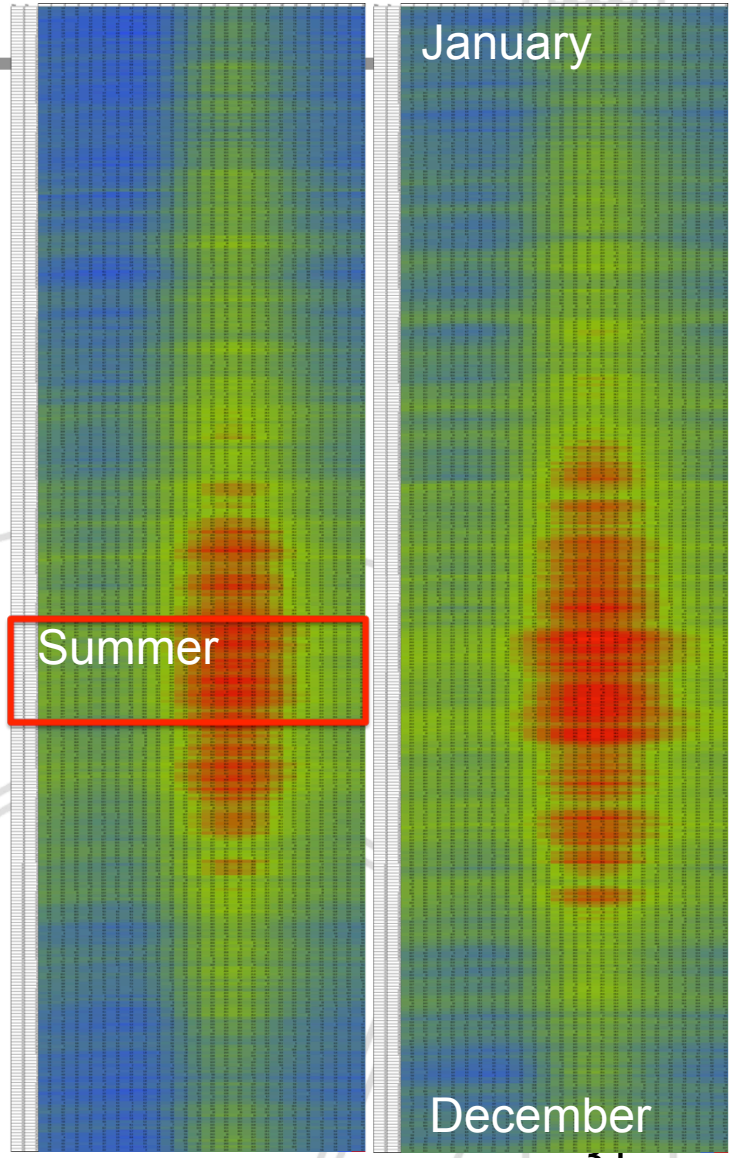






Environmental heat sources and sinks in Mediterranean climates

- In most Mediterranean locations the availability of solar radiation in winter and the low temperatures during night-time in summer could potentially eliminate the heating and cooling loads of a significant percentage of the buildings.



Inertia reduce M & E services

Building as a thermal battery → less loads and peaks →Lower power systems

→ Improve energy efficiency in boilers and conditioning systems… → Sustainability (LCA)

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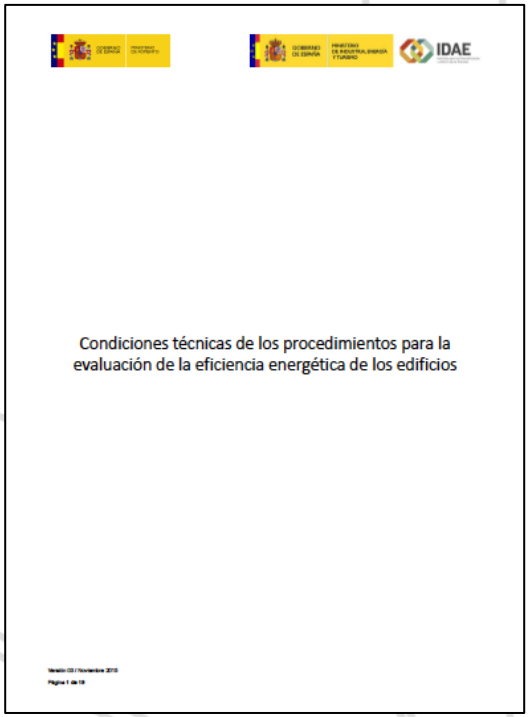
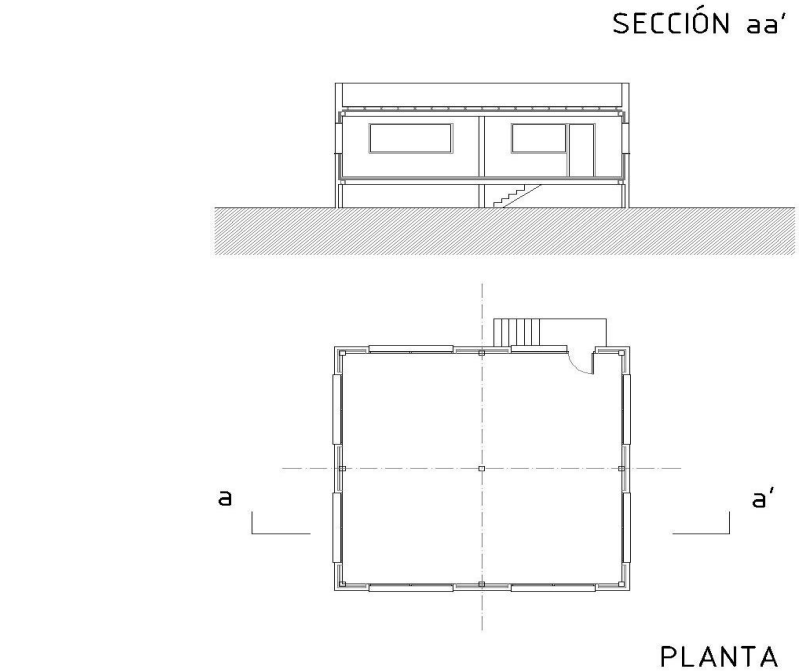
Thermal mass and regulation

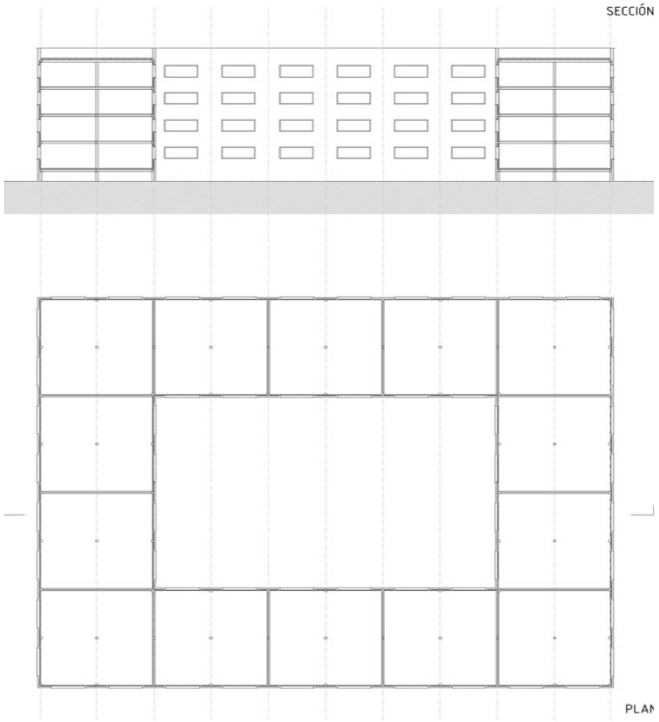
- In verification method since 2006
- Document: Technical conditions of procedures for evaluating the energy efficiency of buildings

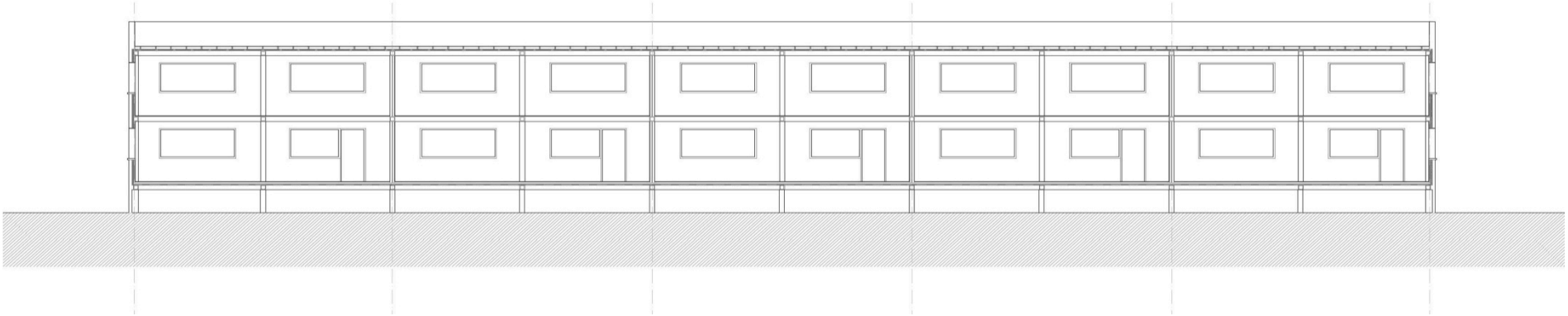


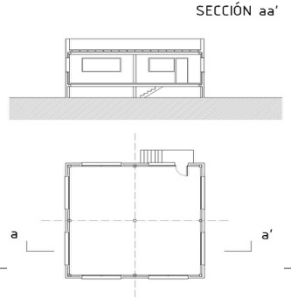
http://www.minetur.gob.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/DocumentosReconocidos/Paginas/Normativaymodelosdeutilizaci%C3%B3n.aspx

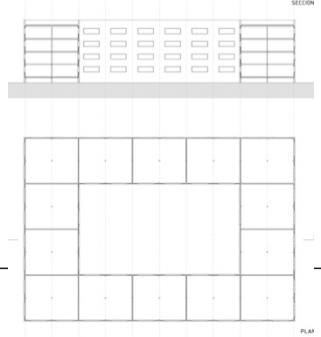
Case study. Thermal performance of the concrete as high thermal inertia material



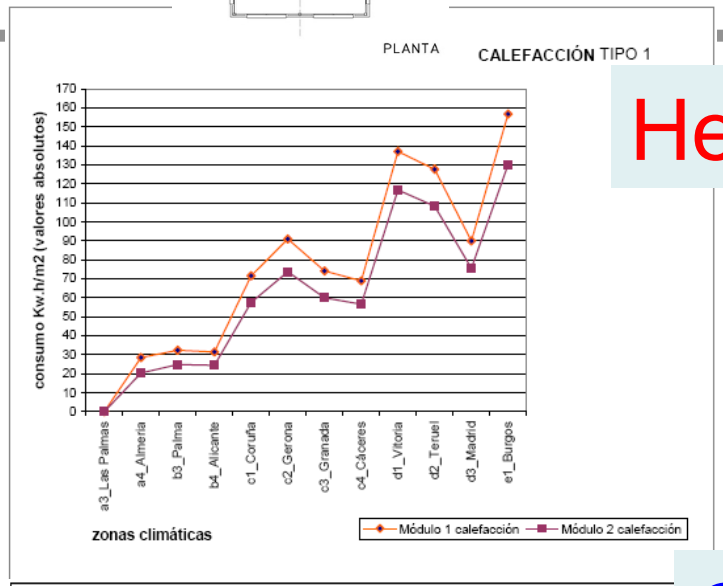


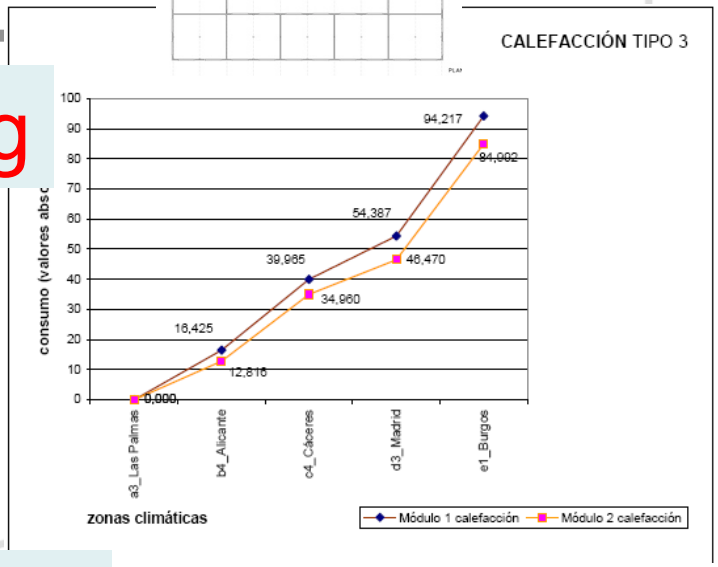




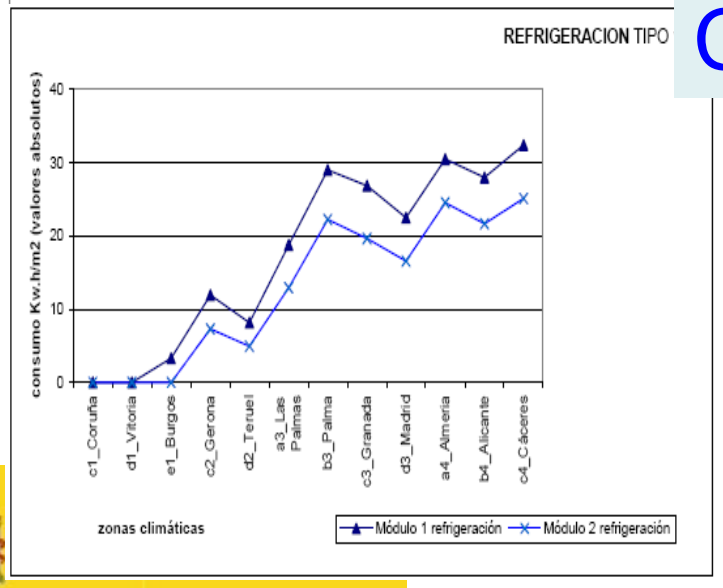


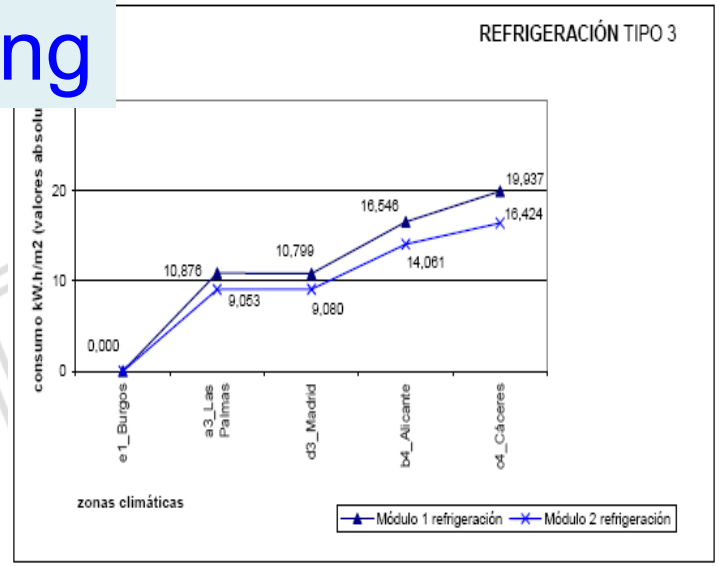
Heating





Cooling





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Sinhor

Analysis of the thermal behavior of concrete façades based on the maximization of its thermal inertia

Prof. Servando Álvarez

Análisis del comportamiento energético de los cerramientos de hormigón en base a la maximización de las ventajas derivadas de su inercia térmica

Grupo de Termotecnia de la Universidad de Sevilla

Instituto Español del Cemento y sus Aplicaciones

Estudio de Arquitectura Samler

Agencia de Obra Pública de la Junta de Andalucía
CONSEJERÍA DE FOMENTO Y VIVIENDA

Unión Europea

GRUPOTERMOTECNIA

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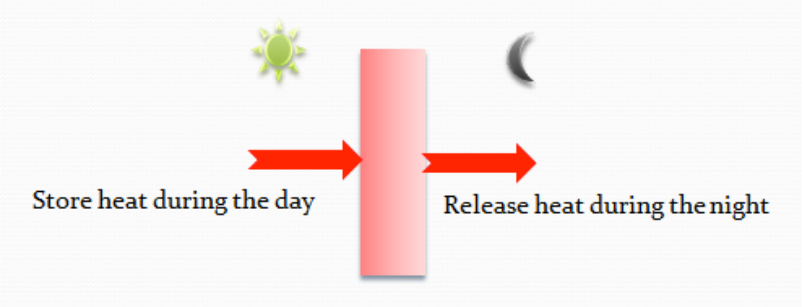
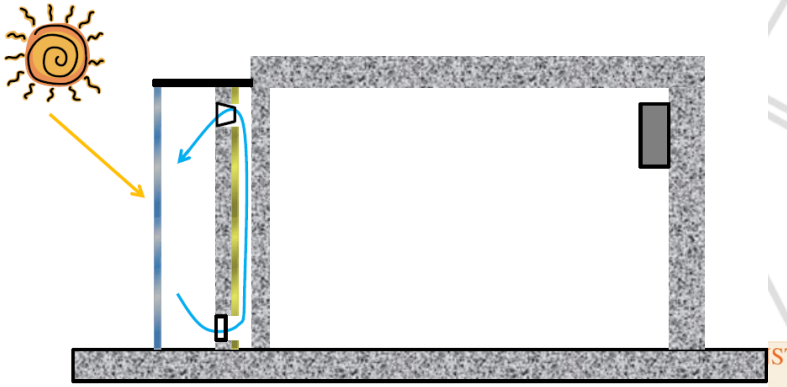
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

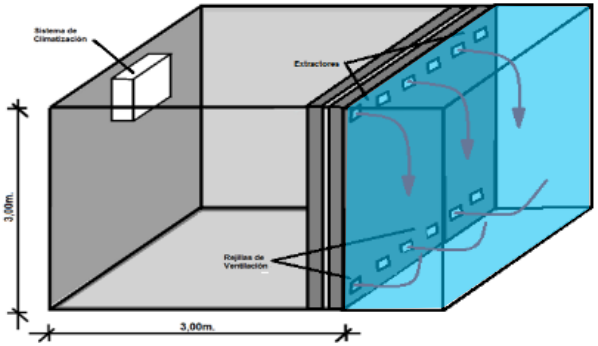
TOR ROJA

Winter solution



- Glazed Spaces: Act as greenhouses and in principle have no connection to the building. The space between the exterior cladding and glazed element is heated, the heat stored inside wall, it will go after giving the interior space throughout the day.





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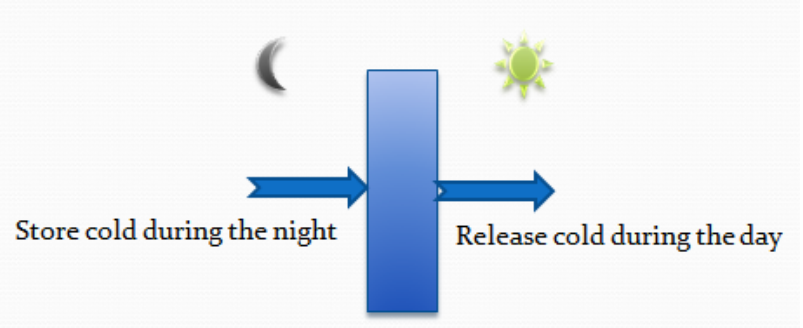
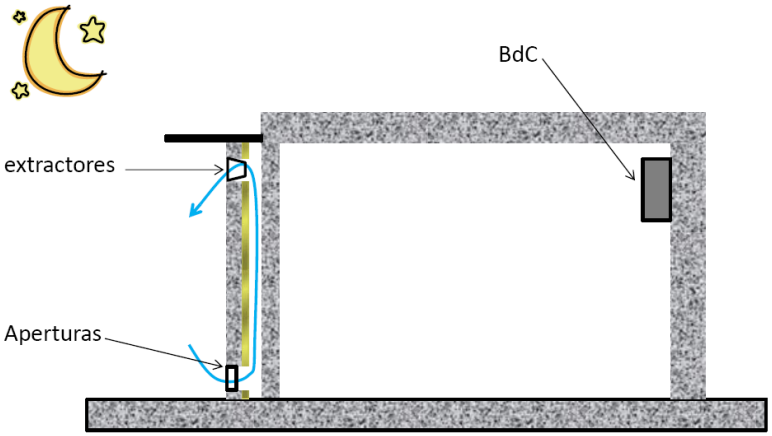
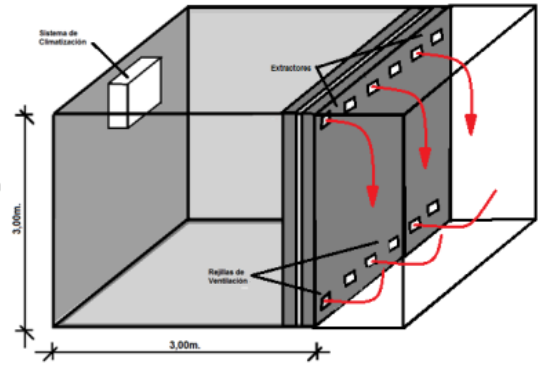
Summer solution



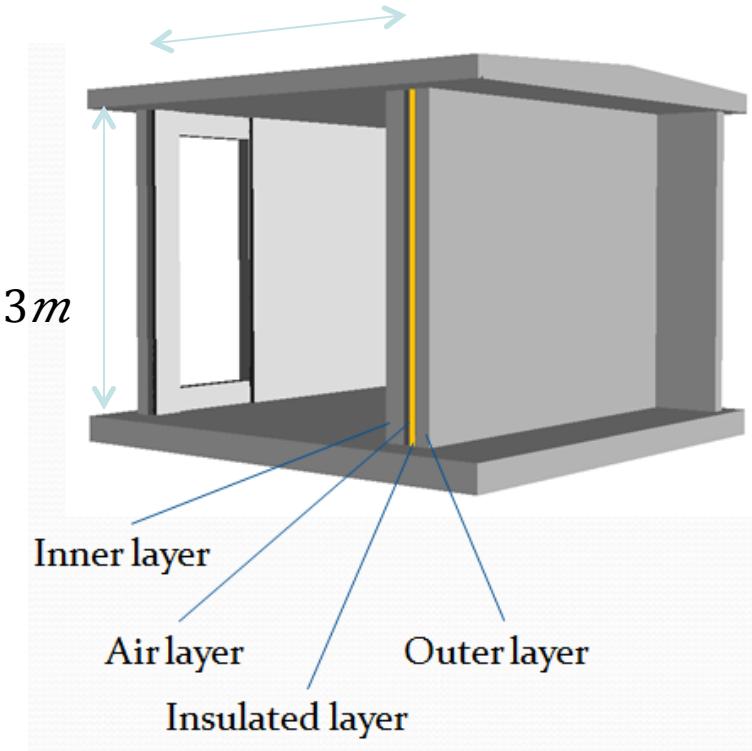
- Thermally active walls. The enclosure is cooled using low outside air temperatures overnight. The inner leaf of the wall is cooled and then go into space yielding along the next day.

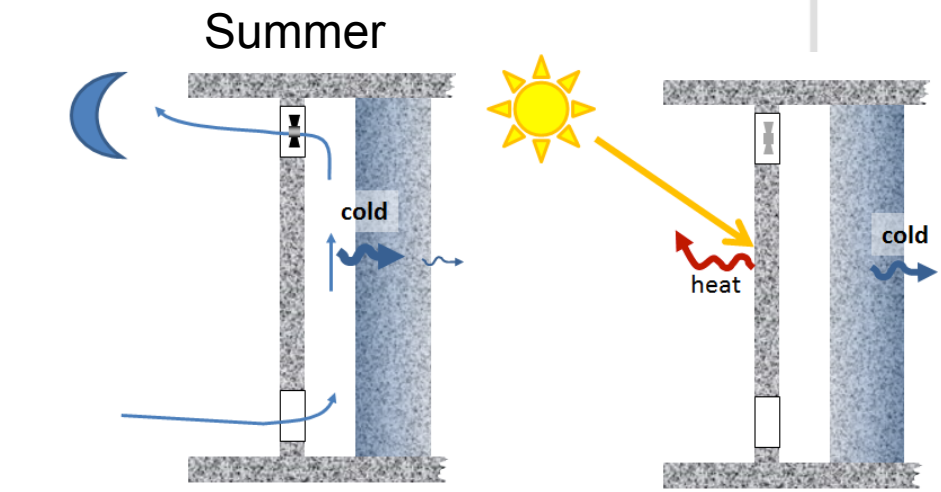


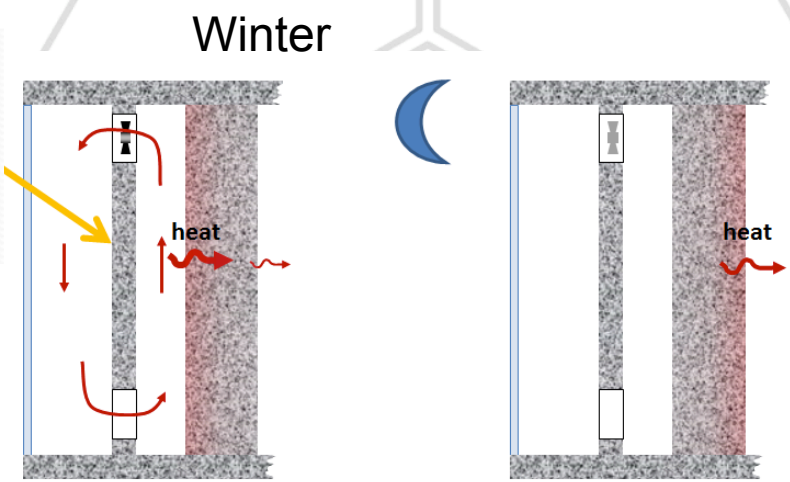


- This innovative element is a combination of the mechanisms of Trombe-Mitchell and Constantine walls. It can be classified as an opaque solar facade .

Experimental cell







Inner layer: Concrete with high thermal inertia

Outer +insulating layer: low thermal transmittance

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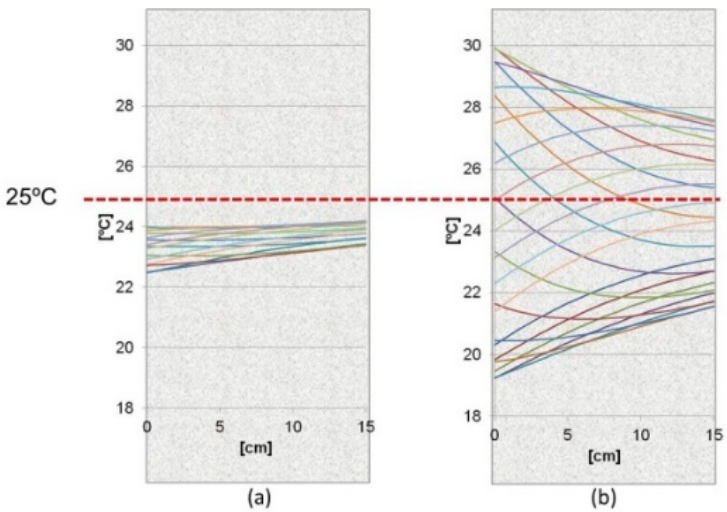
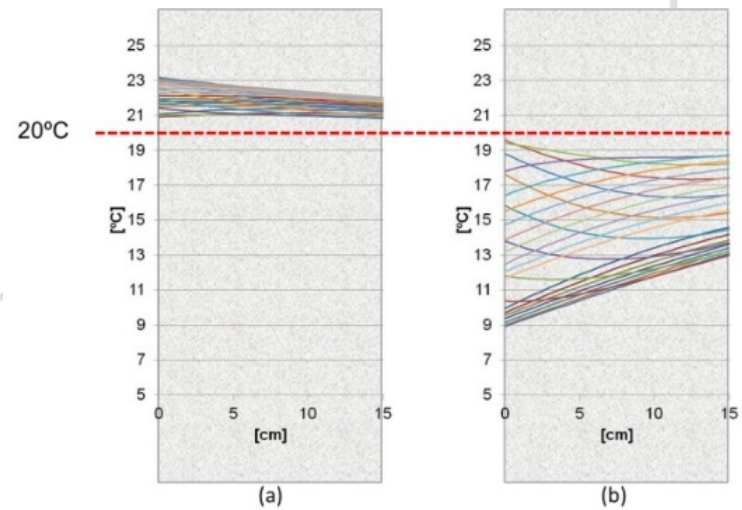
Innovative element vs. conventional

- One typical day





Cooling season *Heating season*

- *(a) Interior layer of the innovative element (b) Conventional wall*

Results

	Summer			Winter		
	Innovative element Heat gains	*conventional wall heat gains*	*difference (savings)*	*Innovative element Heat gains*	*conventional wall heat gains*	*difference (savings)*
	kWh/ m²	*kWh/ m²*	*kWh/ m²*	*kWh/ m²*	*kWh/ m²*	*kWh/ m²*
Seville	*-13.1*	*12.6*	*-25.8*	*37.1*	*-17.9*	*54.9*
Cadiz	*-36.1*	*4.2*	*-40.3*	*52.0*	*-10.4*	*62.4*
Granada	*-72.9*	*3.4*	*-76.3*	*26.4*	*-45.0*	*71.4*

Granada (the coldest locality) savings in both, heating and cooling, are higher than in the other two localities.

This is because in summer, is in Granada where a larger value of cooling is provided by the innovative element while the conventional wall is almost neutral. By contrast, in winter, is Granada where innovative element provides the least amount of heat input, however, as the conventional wall shows high losses, the difference between the heat input of the innovative element and the heat losses of the conventional wall, is greater than in the other two locations

iNPHASE

RETOS_COLABORACIÓN 2015

INNOVATIVE SOLUTIONS OF PREFABRICATED CONCRETE FACADES WITH PCMS FOR NEARLY ZERO ENERGY BUILDINGS.

INDAGSA
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Universitat de Lleida

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INSTITUTO ESPAÑOL DEL CEMENTO Y SUS APLICACIONES

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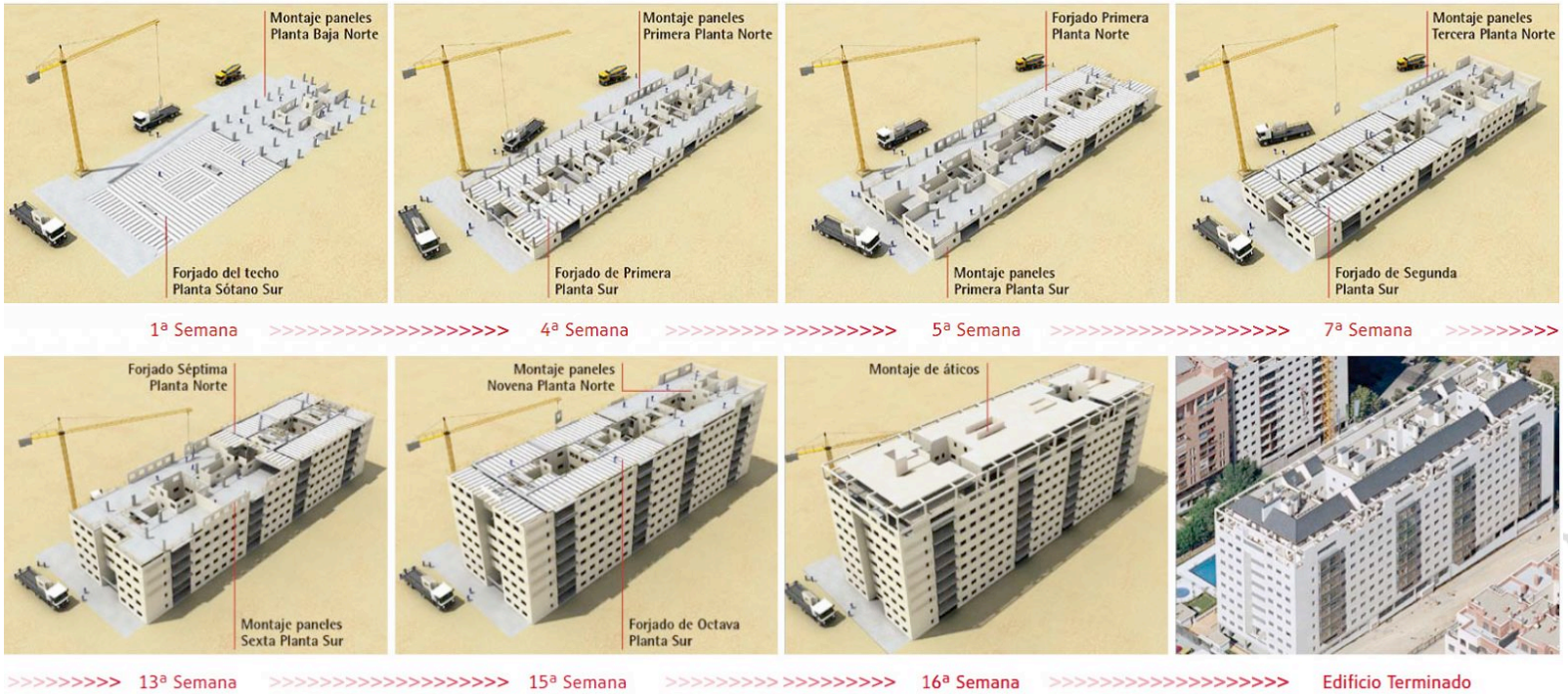
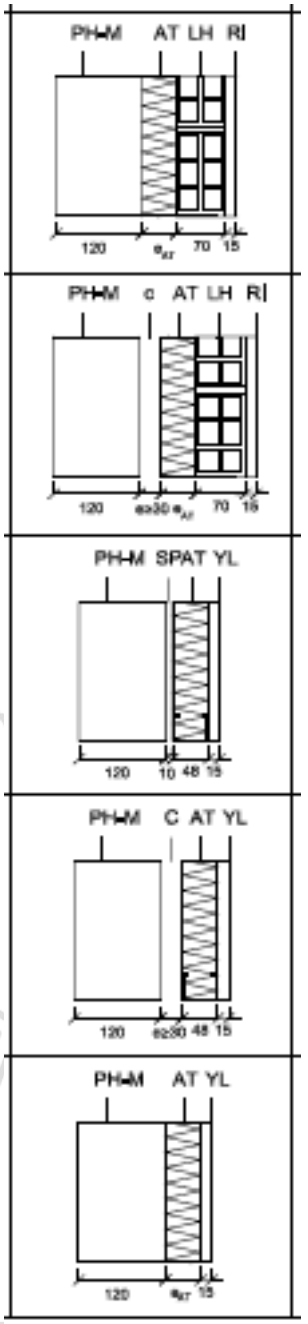
UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL
"Una manera de hacer Europa"

El proyecto INPHASE ha sido financiado por el Ministerio de Economía y Competitividad, dentro del Programa Estatal de Inve a Soci y Técr n FONDOS FEDER, con el objetivo de promover el desarrollo tecnológico, la innovación y una investigación de calidad. Referencia del proyecto: RTC-2015-3583-5

The INPHASE project has been funded by the Spanish Ministry of Economy and Competitiveness.

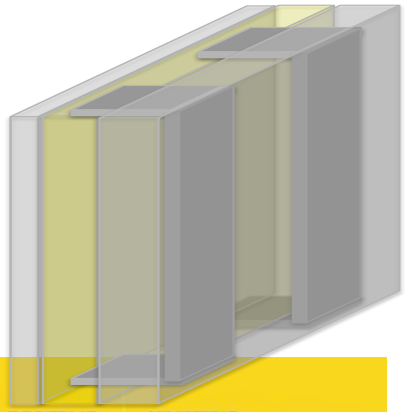
Precast concrete solution

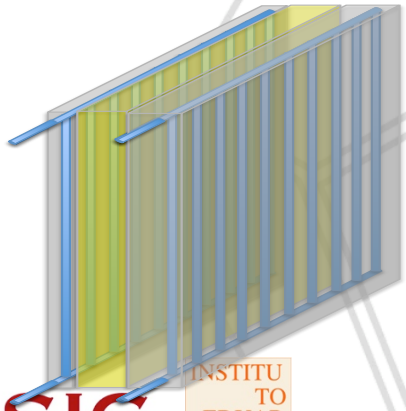


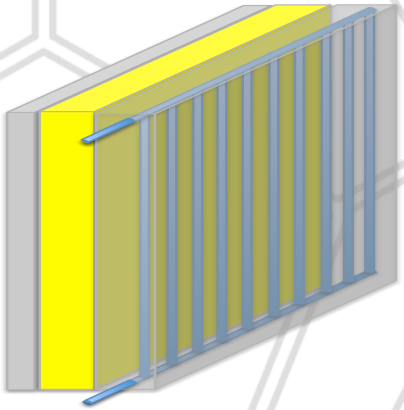


Innovative solutions

- Phase change material (enhancing inertia). PCMs
- New concrete materials
- Development of thermal models
- Assesment of innovative solutions
- Development of demonstrators







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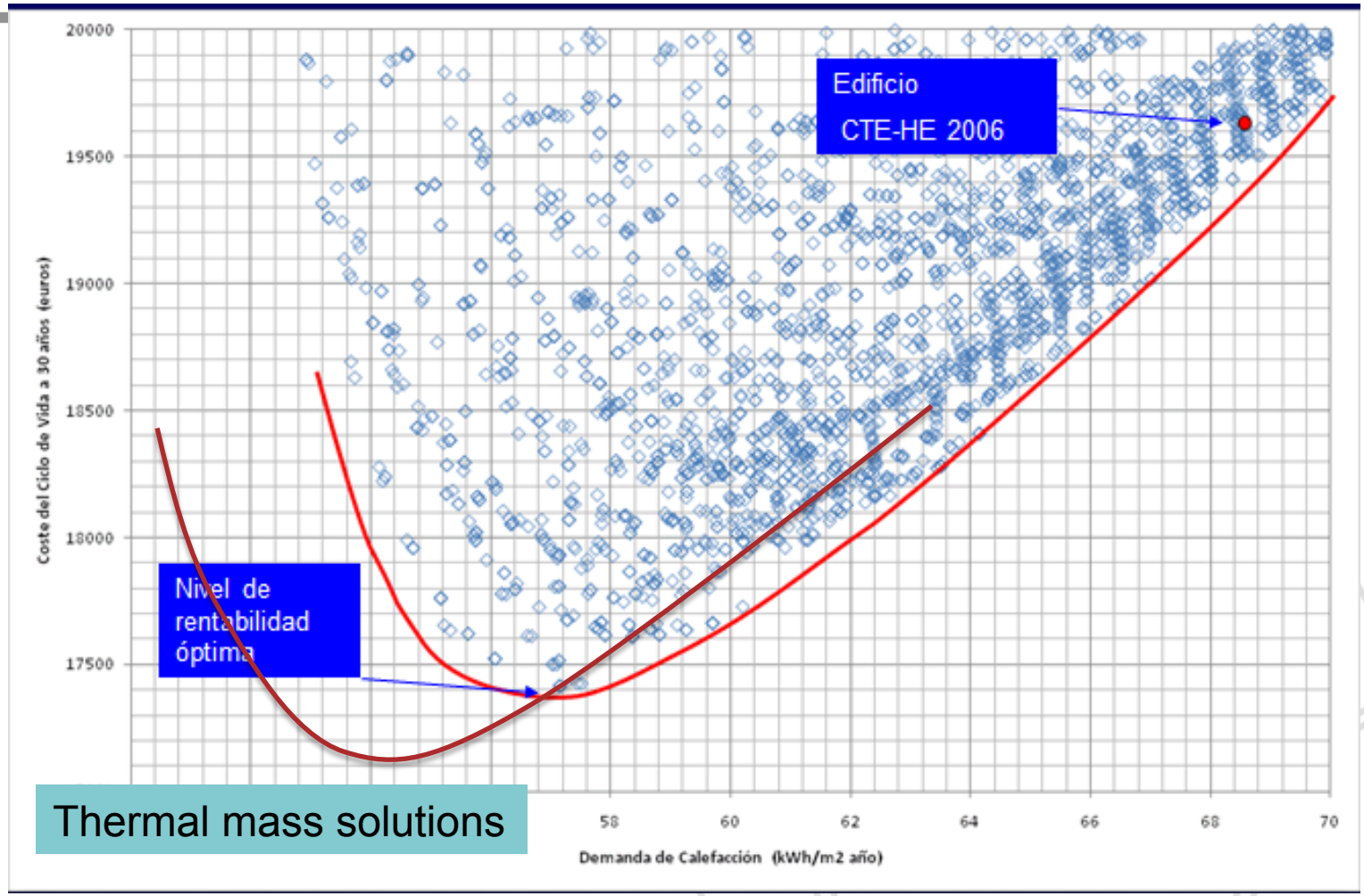
Cost-optimal



Thermal mass solutions

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Fuente: Pr. Servando Álvarez

Conclusions

- The physical characteristics of the concrete gives it a high thermal inertia, which allows to predict optimum energy performance of the building.
  - Reduce the energy consumption of heating.
  - Softens variations in internal temperature.
  - Delay maximum temperatures in offices and commercial buildings to the exit of the occupants.
  - Reduces peak temperatures (maximum and minimum) and can make the air conditioning unnecessary.
  - Maybe employed with nocturnal ventilation to eliminate the need for cooling during the day.
  - Makes better use of sources of low temperature heating such as heat pumps for underfloor heating.

Conclusions

- The results show that the innovative element provides cooling in summer and heating in winter.
- The levels of expected savings in both, heating and cooling show a promising performance in energy savings.
- Thermal mass reduce the need of installations whilst improving energy labelling.

Acknowledgements: TMT. Seville University and GREA Lleida University.

Thanks for your attention