SPANISH BUILDING REGULATIONS AS A BUSINESS AND INNOVATION OPPORTUNITY FOR THE MANUFACTURERS OF BOILERS, EQUIPMENT AND ANCILLARY UNITS IN THE GLOBAL KNOWLEDGE ECONOMY

JUANA DOMÉNECH-SUBIRÁN[1*], LUIS M. LÓPEZ-OCHOA[1], JESÚS LAS HERAS-CASAS[1], CÉSAR GARCÍA-LOZANO[1]

[1] *University of La Rioja. Higher Industrial Engineering School. Department of Mechanical Engineering. C/ Luis de Ulloa 20, 26004 Logroño, La Rioja, Spain.*

Abstract: The traditional working methods of companies making boilers, equipment and ancillary units are of no use in the world of the global economy and the knowledge society. Industrial processes and their optimising effectively form part of a mesh that goes far beyond economic, technical and other aspects. The goal is the integrated management of companies from a global innovative perspective, taking advantage of emerging markets and innovative, intelligent and profitable solutions and attaining sustainability. The case of Spain is unique. Despite the current economic situation, it offers very good opportunities with great possibilities for business in the next 10 years, in this case in the sector of the manufacture of boilers, equipment and ancillary units. Those who are not innovating must begin to do so. Those who are already innovating must have a global perspective of business and management.

Keywords: manufacturers, boilers, equipment, ancillary units, innovation, future challenges, sustainability

1. INTRODUCTION

In the last few decades, prior to the current complicated situation, the building sector has developed quickly. Housing developments boomed for many years, becoming one of the most important economic activities in Spain [1].

Although this urbanisation process has generated building environments, which reasonably satisfy the basic needs of most of the Spanish population, much of this new building – and most of that from earlier times – is not of sufficient quality to meet the current demands of the public. Spaniards, like the societies around us, increasingly demand quality in buildings and urban spaces, so new housing must match current needs and existing buildings require an adaptation process [2].

In the times that we now face there will be more renovations and fewer new-build homes, although the sustainability parameters of the sector will improve overall. Further, renovations must be made with higher standards of quality than the original buildings involved. This falls without doubt within our research interests [3].

* Corresponding author, email juana.domenech@unirioja.es

This demand for greater higher building quality comes in response to a more demanding concept of quality of life for everyone with regard to the use of the buildings constructed. It is also a response to new requirements for sustainability in building and town planning processes in three aspects – environmental, social and economic [4, 5].

Because of its direct effect on the configuration of inhabited spaces, the building process implies a compromise between functionality, economy, harmony and environmental balance which is clearly relevant from the general interest point of view.

The building sector is, as mentioned, one of the main sectors of the economy. It has important effects on society as a whole and on the cultural and environmental values of the architectural heritage.

The Technical Building Code (TBC) and other public works legislation are designed to promote innovation and sustainability in order to improve the quality of building.

The code is a regulatory instrument that sets the basic quality requirements for buildings and their installations. It ensures that certain basic building requirements are met, relating to the safety and well-being of persons, in terms of structural safety and fire protection, as salubriousness, protection against noise, energy saving and accessibility for the disabled. Specific legislation for public works has the same purposes as the TBC although with its own nuances.

Currently there are numerous tensions and difficulties which will gradually diminish as the new balance leaves things in their proper terms.

The thorough renovation of homes will offer many opportunities in building although it must be adapted to future demands. The part of the sector dedicated to civil engineering work will continue to work on major social problems: transport of persons and goods, energy etc.

Regardless of this, innovation and the search for environmental and economic sustainability will be determining factors, generally, for the building sector. Companies that do not innovate will not be competitive and will not be profitable. Likewise, companies that do not base their operations on sustainability will have few economic opportunities.

The future of the building sector lies in sustainability and innovation with a permanent search for excellence [3].

2. SPANISH BUILDING REGULATIONS

The main regulations covering housing in Spain are those in the Technical Building Code (TBC) and in Building Energy Certification (BEC) requirements.

2.1. The TBC

The TBC is a set of regulations based on provisions or objectives rather than mere prescription. This means that the optimum method for reaching its goal is sought through the regulations themselves. That is, it provides calculating tools and design methods that must be used but is not limited to their application - it also attempts to overcome the constraints on innovation and technical development found in traditional regulatory codes, in which the application of the method is given priority over the achievement of the objectives.

2.2. BEC

Building Energy Certification is a legal requirement for all new buildings, and will also apply to existing ones in future [6].

Almost 30% of primary energy consumption is due to buildings, so European regulations have tried to curtail energy consumption in buildings, in this case by creating a tool similar to that used for domestic appliances.

The Decree approving the BEC makes it compulsory for new buildings to be classified with a label that informs purchasers of their degree of efficiency. The idea is that each building will have a label with its energy qualification (from A for the most efficient buildings to G for the least efficient) that includes its estimated energy consumption and associated CO_2 emissions.

Buildings are complex systems whose functioning cannot be estimated or tested as simply as that of domestic appliances, as they are subject to much more variable conditions and usage habits. Thus, a system of this type cannot be implemented without major simplifications.

Furthermore, the method set for certification has various controversial points, as explained below, and there is still a high degree of confusion and uncertainty in the sector, which goes some way towards explaining why the BEC has not been implemented more widely in spite of its compulsory nature.

The purpose of building certification is to encourage promoters to build more efficient buildings and to encourage the renovation of buildings so that they consume less energy. The idea is that a development with a higher efficiency qualification will have a better image – another sales argument – and the existence of labelling will make energy consumption into another purchasing criterion for the consumer.

These objectives require very strong support, especially in the economic crisis that is currently affecting Spain, and hitting the building sector particularly hard.

The Decree covering energy certification is very general. It makes certification obligatory and sets requirements for the IT programs that must be used but leaves the development of procedures for its implementation and, very importantly, the monitoring of certification in the hands of the regional authorities. Therefore, it is the regions that must establish the necessary administrative procedures on the basis of this decree or directly from the Directive if they have authority to do so, together with the scope and properties of the building controls to guarantee the accuracy of the certificate and other matters such as the procedure for renewing the certificate.

2.3. European antecedents

European Directive 2002/91/CE aims to encourage energy efficiency in buildings and to oblige all Member States, among other things, to ensure that all buildings sold and rented have an Energy Efficiency Certificate. This certificate must be handed over to the owner or tenant concerned. In Spain, this Directive was not transposed until 2007 through the approval of the Technical Building Code (TBC), the amendment of Building Heating Installations Regulations (BHIR) and Royal Decree 47/2007, 19 January, which defines the application of energy certificates.

3. THE CURRENT PER (PRESSURE EQUIPMENT REGULATIONS)

A boiler is defined as a pressure vessel in which produced by any form of energy is made usable through a liquid or steam phase as a means of transport. It is a device in which heat is passed from a fuel to a fluid. The main components of boilers are the combustion chamber, the burner, the heat exchanger and the casing [7].

The efficiency requirements for new hot water boilers fired by liquid or gas fuels are described in Royal Decree 275/1995, 24 February, which lays down rules for the application of Council Directive 92/42/EEC, modified by Article 12 of Directive 93/68/EEC, as one of the actions within the framework of the SAVE programme relating to the promotion of energy efficiency in the European Union.

The following UNE standards are also applicable:

- UNE 9100:1986 Steam boilers. Safety valves. Steam boiler safety valves must meet these specifications;
- UNE 60601:1993 Installation of gas boilers for heating and/or hot water, with a useful output of over 70 kW (60,200 kCal/h);

- UNE 60601/1M:1996 Installation of gas boilers for heating and/or hot water, with a useful output of over 70 kW (60,200 kCal/h).

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Heat generating equipment must comply with Royal Decree 275/1995, 24 February, which lays down rules for the application of Council Directive 92/42/BEC relating to the minimum efficiency requirements for new hot water boilers fired by liquid or gas fuels, valid for boilers with a rated power of between 4 and 400 kW. Boilers rated at over 400 kW must have an efficiency equal to or greater than that required for boilers of up to 400 kW.

Boilers fired by solid, liquid or gas fuels whose properties or specifications differ from standard commercial fuels and that come from the recovery of effluents, by-products or waste whose combustion is not affected by limits on environmental impact (for example, waste gases, biogas, biomass, etc) are excluded from this requirement.

Gas boilers must in all cases comply with current regulations as established in this complementary technical instruction and especially in Royal Decree 1428/1992, 27 November, approving the rules for the application of Directive 90/396/BEC on gas devices.

The boiler manufacturer must supply the documentation required by other applicable regulations and at least the following data:

a) Information on power and output required by Royal Decree 275/1995, 24 February, approving the rules for the application of Council Directive 92/42/EEC.
b) The conditions for using the boiler and nominal outlet conditions for the carrier fluid.
c) Properties of the carrier fluid.
d) Optimum capacity for fuels in the hearth of coal boilers.
e) Content of carrier fluid in the boiler.
f) Minimum flow-rate of carrier fluid through the boiler.
g) Maximum external dimensions of the boiler and locations of elements that must be connected to other parts of the installation (chimney, inlet and outlet of carrier fluid etc).
h) Dimensions of the bed.
i) Weights during transport and in operation.
j) Instructions for installation, cleaning and maintenance.
k) Power/draft curves needed in the smoke box for the conditions given in Royal Decree 275/1995, approving the rules for the application of Council Directive 92/42/EEC.

4. TECHNOLOGICAL STAGES

One of the main objectives of Community policy is energy saving. The Hot Water Boilers Directive (Directive 92/42/EEC) defines types of boilers and sets the minimum requirements for energy use (minimum combustion output) for boilers of up to 400 kW. Standard boilers, low temperature boilers and condensation boilers are defined as follows [8].

- Standard heating boilers: those in which the working temperature may be limited by their design. This type of boiler need comply only with the minimum requirements for energy use.
- Low temperature heating boilers: those that may operate continuously with return temperatures of between 35 and 40 °C and in which the steam in the combustion smoke may be condensed in some circumstances.
- Gas-condensation boilers: those designed so that most of the steam in the combustion fumes is permanently condensed.

Appendix III of Directive 92/42/EEC describes the minimum efficiency for the various types of boilers. These output requirements are given for the rated output and for a part load of 30%, with part load being defined as the ratio between the useful output of a boiler operating intermittently or at an output lower than the rated useful output, and this rated useful output, as shown in Table 1.

Table 1. Types of boilers and minimum outputs according to nominal power and work load.

TYPE OF BOILER	POWER OUTPUT (kW)	EFFICIENCY AT RATED OUTPUT (%) AT 70 ºC AVERAGE TEMPERATURE	EFFICIENCY AT PART LOAD (0.3 P_n)	
			AVERAGE TEMPERATURE (ºC)	EFFICIENCY (%)
Standard	4 to 400	$\geq 84 + 2 \cdot \log P_n$	≥ 50	$\geq 80 + 3 \cdot \log P_n$
Low temperature*	4 to 400	$\geq 87.5 + 1.5 \cdot \log P_n$	40	$\geq 87.5 + 1.5 \cdot \log P_n$
Gas-condensation	4 to 400	$\geq 90 + \log P_n$	30 (**)	$\geq 97 + \log P_n$

For part loads, average boiler temperatures are set at 30 °C for gas-condensation boilers, 40 °C for low temperature boilers and 50 °C for standard boilers. From this table, it is deduced that the part load in gas-condensation and low temperature boilers must be associated with working at lower than rated temperature conditions, otherwise these boilers would behave as high quality standard boilers.

Appendix V of the Directive also gives efficiency requirements for obtaining CE label for energy performance, which can be one, two, three or four stars. The efficiency levels shown in Table 2 must be met.

Table 2. Labels and minimum efficiency per rated power output and work load.

LABEL	EFFICIENCY AT NOMINAL OUTPUT (%) AND AVERAGE TEMPERATURE OF 70 ºC	EFFICIENCY AT PART LOAD (%) $0.3 \cdot P_n$ AND AVERAGE TEMPERATURE ≥ 50 ºC
*	$\geq 84 + 2 \cdot \log P_n$	$\geq 80 + 3 \cdot \log P_n$
**	$\geq 87 + 2 \cdot \log P_n$	$\geq 83 + 3 \cdot \log P_n$
***	$\geq 90 + 2 \cdot \log P_n$	$\geq 86 + 3 \cdot \log P_n$
****	$\geq 93 + 2 \cdot \log P_n$	$\geq 89 + 3 \cdot \log P_n$

Applying the equations given in the Directive gives the minimum efficiency levels required for the various types of boiler and various power outputs. The limits for applying the Directive are 4 to 400 kW. The following table shows the efficiency for nominal output and part load at 30% of nominal output and includes the efficiency levels required by the previous heating regulations. As can be seen, these requirements were much lower than the current ones.

Figure 1 shows the case of boilers working at 30% of nominal output while Figure 2 shows boilers working at full power (100%).

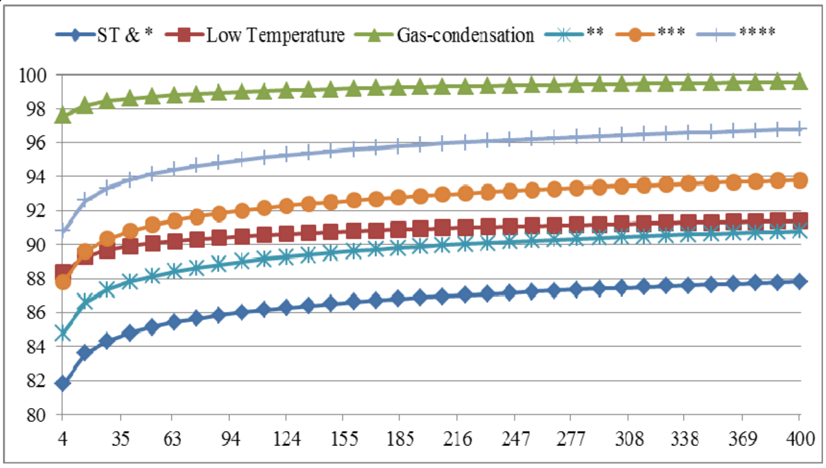

Fig. 1. Efficiency by type of boilers and label at 30% power output.

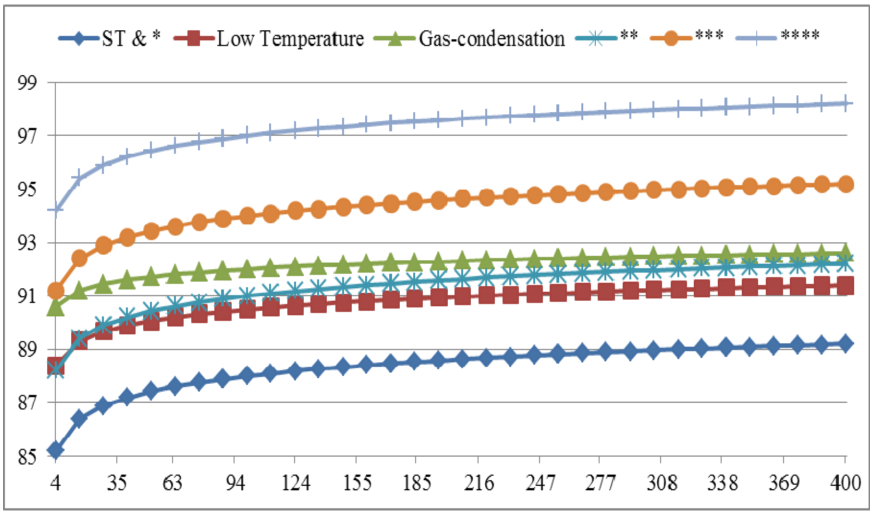

Fig. 2. Efficiency by type of boilers and label at 100% power output.

5. BOILERS AND THEIR EFFICIENCY

To obtain maximum profitability, the design of a new installation must ensure first and foremost that the efficiency of the equipment installed is acceptable and as high as possible, otherwise the real consumption obtained will be higher than expected from the calculation. This shows the importance of knowing the efficiency of the boilers to be installed.

Something apparently as simple as determining the output of a boiler to be acquired is however far from easy given that, generally, most boiler manufacturers use the combustion efficiency or instantaneous efficiency to determine the behaviour of their products. The following shows what these data comprise.

5.1. Combustion efficiency

This is the percentage of energy actually used once losses for heat in fumes and unburned materials are deducted from the total energy generated by the burner. This datum is an indicator used for maintenance work to determine the correct adjustment of the burner and the state of cleanliness of the boiler's exchanger. It is clear that the datum is not significant for the purposes of evaluating the boiler's energy performance as we have calculated since it does not take into account such important data as, for example, radiation and convection losses.

5.2. Instantaneous efficiency

This is the percentage of energy actually used once losses for heat in fumes, unburned materials, radiation and convection are deducted with the burner functioning and with the boiler at an operating temperature of at least 70 °C. This output is expressed with functioning loads for the burner of 100% and 30%.

An examination of the behaviour of heating and hot water installations in Spain shows that of the total hours for which the boilers are available for service in an installation of this type, burners only operate to provide useful heat for 20-30% and are on standby for the rest of the time.

It is easy to understand that the instantaneous efficiency calculated as described with the burner operating is not an effective indicator of the energy performance of a boiler since it does not include losses during the 70 or 80% of the time for which the burner is on standby. In these conditions, the burner will start up throughout the time frame considered to offset these losses and not because there is actually any demand in the installation. Thus, to determine an efficiency reading that enables a real calculation of the annual consumption of a boiler to be made, the amount of energy consumed during the standby period must be included. Such losses are referred to as "standby or maintenance losses".

The results of these analyses provide the seasonal or annual average efficiency which, unlike combustion or instantaneous efficiency, is directly proportional to consumption.

5.3. Seasonal efficiency

This is the percentage of heat used (useful heat) in relation to the total amount of heat generated annually.

This is the percentage of energy actually used once losses for heat in fumes, unburned materials, radiation and convection and standby losses are deducted, both in the periods of demand for useful heat (burner operating) and when the burner is off. This value is therefore the only parameter that considers all the losses in a boiler throughout a season and, therefore, the only valid efficiency value for the purposes of comparing the energy efficiency of two boilers.

The seasonal output of the various types of boiler available on the market can only be determined if the manufacturers publish the date, something which is not currently usual practice in Spain. However, countries in central and northern Europe have this value standardised (DIN 4702-8) so that the official seasonal efficiency figures for each type of boiler can be known at all times.

There are manufacturers that incorporate technological elements into boilers to eliminate "standby losses" and thus obtain seasonal efficiency levels that are even higher than instantaneous ones.

Fig. 3. Economy and the knowledge society.

As stated above, a boiler’s seasonal efficiency is directly proportional to consumption and can vary radically as a function of its average working temperature and of the insulation used on the boiler’s body, doors and dry parts. It is higher the lower the average temperature is and the greater the thicknesses and quality of the insulation used is. These properties are more important than any other parameter in high-quality low temperature boilers.

6. THE KNOWLEDGE SOCIETY

Economic relationships over history have combined in an extraordinary way, following the rhythm of special circumstances in each case.

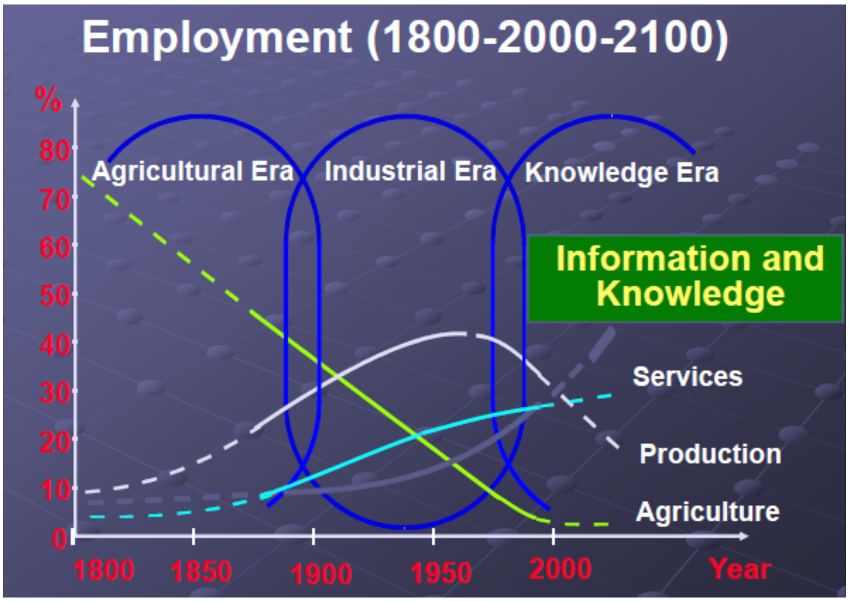

Fig. 4. The relationship between the knowledge society and employment.

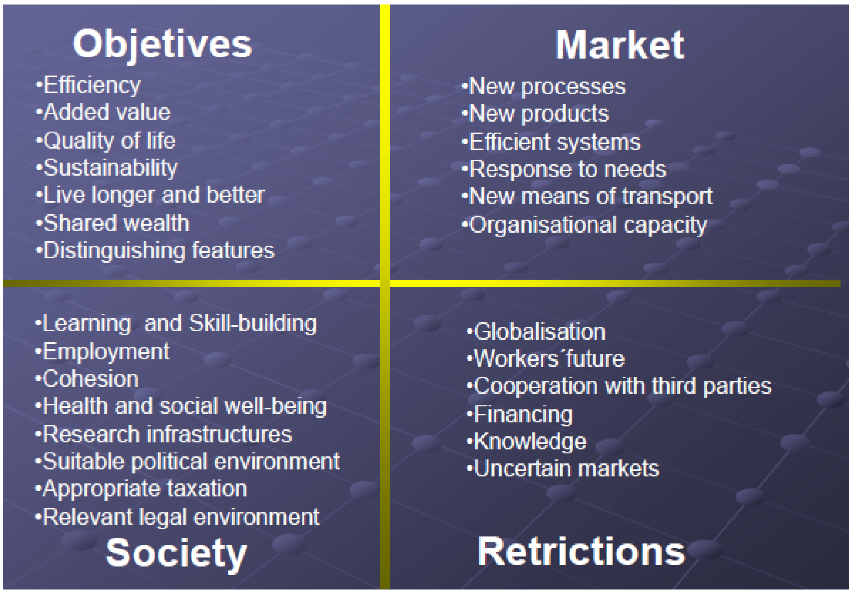

Fig. 5. The conditioning factors of the knowledge society.

Thus, since the so-called agricultural age in which the soil predominated as an essential part of these relationships to the knowledge era in which knowledge itself predominates, there have always been a number of fundamental ideas. Each era has an essential form of identification. Figure 3 shows this evolution.

Figure 4 shows the creation of employment in various eras. It is clear that we are moving towards a society with an economy with jobs in what we could call the information and knowledge sector.

Figure 5 shows the conditioning factors implied by the knowledge society. Effectively, the objectives that it defines are clear and very coherent. The market approaches are very clear and most of them are suitable. Problems arise and are solved with social needs when the real needs of society arise and the need for the right political system at all levels: laws, law courts, governments etc.

The existing restrictions must be resolved, especially with regard to employment, given the current economic panorama.

In any case, the future lies in knowledge and innovation and there are no other viable routes, especially in matters relating to the building sector.

7. POSSIBILITIES OF INNOVATION IN DOMESTIC BOILERS

The possibilities for innovation in domestic boilers are innumerable, ranging over aspects of calculation, design, manufacture, installation, use, maintenance and upkeep with the variations involved in the various nominal power outputs and fuel possibilities.

To summarise, boilers occupy a very important field because they must meet the requirements of the knowledge society and innovate permanently. Anything that is well done is valid if it meets the requirements of the knowledge society.

The manufacturer also plays a leading role and must rise to the challenge.

8. CONCLUSIONS

This paper is a initial approach to part of the research that we are undertaking in the building sector in the region of La Rioja (Spain), which will be completed at the end of 2012.

The building sector accounts on average for around 40% of the primary energy demand in Spain, so it is a major emitter of CO_2 and is highly conditioned by the need to reduce its emissions of greenhouse gases. Furthermore, installations in homes, especially heating installations, have a large social sensitivity component since they are deeply rooted in the culture of building, and require permanent innovation due to the obligations described in the current Technical Building Code (TBC).

The TBC is based, as far as this work is concerned, on permanent innovation and on the improvement of the quality of life.

The most important heating installations include natural gas boilers, the purpose of which is to produce domestic hot water and heating. There are various types of boilers and fuels to choose from.

Thus, manufacturers compete in a single European market to supply boilers for energy purposes with a great variety of ancillary equipment, a wide range of power outputs and fuel possibilities, etc.

The first challenge for manufacturers, within the specialist field of each one, is to reduce costs and pollution while improving boiler efficiency, reducing noise, improving aesthetics and prolonging the useful life of boilers and equipment.

The scope for research, development and innovation in these fields is very wide. Computational fluid dynamics (CFD) enables better boilers to be designed, making it possible to build prototypes and design new products that will comply with all the improvements required at a suitable price. This work affects the entire process of the design and building of boilers and their components, tougher requirements for ancillary equipment, etc.

Manufacturers must improve their manufacturing processes and pursue objectives that the market has assumed as its own, given the demands of users and the European needs for improvements in environmental aspects and competitiveness.

But manufacturers must go a step further and search for alternative energy solutions. Thus, boilers must adapt to the needs for other fuels, giving rise to new products to meet the needs of new markets. The sector must prepare itself for biomass, biofuels, etc, even in complicated design situations.
Manufacturers must also think streetwise: that they must not think just of boilers and the fuels that they need but of the ancillary equipment that makes the whole thing competitive, so that users and end customers – i.e. the public – can choose an innovative, aesthetic, practical solution similar to that provided by, for example, electricity.

Thus, boiler manufacturers must collaborate closely with the manufacturers of biomass tanks and various biofuels, with feeder systems and with the needs of the knowledge society.

Manufacturers should no longer be preoccupied by their industrial processes, production lines, distribution, etc, as required by production management, but should become suppliers of innovative solutions. This requires a system that functions correctly, into which the boiler and its circumstances, its tanks and ancillary equipment can fit.

Manufacturers must take a positive step in their traditional market and seek to enter another, larger, more complex and competitive market with immense business possibilities, where manufacture is one part of the complex system required.

The second challenge is the need for integrated management where innovation, with the need to manage innovation in the company, quality, safety, the environment and energy coexist harmoniously, suitably, permanently and continuously, in search of excellence. They will then cease to be merely manufacturers of boilers for the building sector and become businessmen on the road to excellence with permanent innovative solutions, without forgetting tomorrow’s great challenges.

Individual energy systems are often not as efficient as are collective installations. In apartment buildings, collective solutions are much more efficient but a conceptual change is needed in the solutions that must be supplied. Not only among manufacturers of boilers and auxiliaries but among all the stakeholders in the building sector and among consumers and users themselves. Thus there must be space for boiler rooms and ancillary equipment according to needs.

What initially seems to be a complication for boiler manufacturers who work traditionally in the residential market with individual systems thus becomes a new market for them and for traditional industrial manufacturers who can also enter a sector which in Spain has hitherto shown little interest in collective solutions.

This new situation encourages the provision of professional, scheduled, effectively managed maintenance covering the entire cycle from design to the end of the useful lifetime. This maintenance and upkeep is an improvement that can bring innovative manufacturers rewards in the form of integrated management and provide a new market for new companies or others that switch their business from the industrial sector.

This paper seeks to provide manufacturers of boilers and ancillary equipment and the trades associated with them with a new business concept with great possibilities and improved added value for their products.

Collective solutions require more competitive products and all the things mentioned above, including effective, suitable maintenance and upkeep.

If sustainable fuels such as, for example, biomass, are added to the equation then this is a sure step towards environmental and economic sustainability.

The vision of the energy solutions required by the knowledge society must serve to show manufacturers of boilers, tanks, ancillary equipment, etc., from a global perspective with viable, efficient local solutions.

The famous European slogan 20-20-20 for 2020 is a good reason to seek businesses that provide efficient and innovative solutions.

Renewables are of increasing importance in Spain. The European 20-20-20 objective (20% energy saving, 20% use of renewables, 20% reduction of CO_2) by 2020 is gradually becoming consolidated, albeit with difficulties.

Once the current economic crisis has ended, Spain will undertake actions of the types proposed here.

The authorities must lead all these processes, especially in regard to renewables such as biomass, which involves so many difficulties because of its operational peculiarities and its social and technical conditioning factors, which must be tackled effectively, giving sustainable and innovative solutions.

The great advantage of biomass is that it can be managed broadly.

Another aspect to be taken into account is the incorporation of boilers, as a fundamental part in the heating and hot water installation, into intelligent control systems that can regulate the installation's functions to favour user comfort and energy saving, taking into account the continuous development of these control systems from a simple on/off control to the integration of systems based on environmental intelligence.

This trend is developing into a new field of work which is a major advance in home automation. The objective of environmental intelligence is to guarantee the well-being of persons and to set up more efficient, stable connections between users and their surroundings. The development of this technology allows the parallel increase of energy efficiency and the regulation of consumption in buildings. The key is that it is embedded in the environment and can be customised to specific needs and adapted to the current ambience, with the possibility of predicting future situations. The European Commission has described environmental intelligence as the main future scenario for the 21st century.

It has also been proven that if users' habits are known and learned from, then greater comfort and energy saving can be provided.

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