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Regional evaluation of the positive feedback between climate change and energy consumption

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Abstract

It is assumed that climate change induced by anthropogenic actions will manage to a new kind of human behaviour. In particular, since the economy is sensitive to climatic variations, including leisure activities like tourism, health and energy consumption, some aspects of the "possible" climate change will be able to cause a positive feedback from an economic point of view. An example of this feedback is located in heating consumption for domestic and industrial sectors. The modifications in the heating practice will be a reality. In the winter season, corresponding to local climate, households and industries consume more or less natural resources in function of air temperature. Hence, considering one of the standard scenarios of global change, we find more than 50% of reduction in vapor consumption to heat a mean industry at the year 2080 in our regional area.

1 Introduction

Energy consumption in the industrialised regions has increased almost exponentially with the growth of population and economies. Notwithstanding efficiency improvements and environmental measures, the

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growth of levels of activities in industry, transport, households, services and agriculture has, in general, led to increasing environmental pressures with an unequal geographical distribution.

A particularly uncertain factor is to what extent the development and implementation of clean technologies, methods and processes in industrialised countries will spill over or be transferred to developing economies.

The Fifth Environment Action Program of the European Community (5EAP) looks for the integration of environmental considerations into other policy areas, focusing on five sectors (EEA[1]). For the environmental theme of climate change, energy and transport are the two most important targets sectors.

Forecasts suggest a near doubling of freight road transport and about a 50% increase of passenger road transport between 1990 and 2010. Hence, energy consumption continues to increase, because improvements in energy efficiency in industry and the domestic sector are counterbalanced by the increased consumption in the transport sector.

2 Climate change

Climate change impacts assessments are diverse in nature, both in the areas studied and in their spatial and temporal scales. The primary aim of such impact studies is the assessment of the response of complex global and regional systems to climate change. To assess the impacts of climate change there is a clear need for consistent representations of future changes in climate, so-called 'climate change scenarios'.

The latest Second Assessment Report of Intergovernmental Panel on Climate Change (IPCC[2]) concluded *inter alia* that "for the mid-range IPCC scenarios of future emissions, and assuming the best estimate value of climate sensitivity, models project an increase in global mean temperature, relative to 1990, of about 2°C by the year 2100 (the uncertainty range is 1-3.5°C)".

In this study, we use to calculate energy savings one of the most solve built climate change scenario (Hadley Centre, UK). Particularly, it considers: (a) climatic data base of the University of East Anglia (UK) for the period 1961-90; (b) CO_2 concentration according to the IPCC scenario "business as usual"; (c) population growth as the World Bank estimated for 1994/95, and (d) the economic growth established by the Energy Modelling Forum 14. Table 1 resumes foresights for three periods of 30 years centring in year 2020, 2050 and 2080.

Table 1 Assumptions of climate change

	Today	2020	2050	2080
CO_2 concentration (ppm)	365	441	565	731
Temperature change (°C)	0	+ 1.2	+ 2.1	+ 3.2
sulphate & aerosols included	0	+ 1.0	+ 1.6	+ 2.6
Rainfall change (%)	0	+ 1.6	+ 2.9	+ 4.5
Rise sea level (cm)	0	10	26	44
Population (milions)	5,266	8,121	9,759	10,672

3 Energy consumption

Energy consumption is not only influenced by driving forces like economic growth, low energy prices or demand for transport services, it depends also by environmental issues. In the households and the tertiary sector, as in industrial sector, energy consumption varies with climatic conditions and fluctuations.

The study "Economic Impacts of the Hot Summer and Unusually Warm Year of 1995" edited by the Department of the Environment of UK (Palutikof *et al.*[3]), shows that there are both positive and negative impacts from a warm year. Besides positive impacts on health and in the natural environment, the most obvious impact was seen in the energy sector, with net savings to the consumer.

4 Local correlation between climate and energy consumption

Considering the above conclusions, we have analyzed the relation between gas consumption for a typical domestic heating and the local temperatures. The same correlation is studied for vapor needed to heat a mean local industry. Figures 1 and 2 show the scatterplots corresponding to the energy consumption *versus* the number of degree-day for winter time, period 1989-1997 for domestic consumption and 1982-1993 for heating industry.

We can observe a better linear correlation in the industry case ($r=0.907$) than in domestic one ($r=0.799$). The reason is the optimized control of the heating process in industry.

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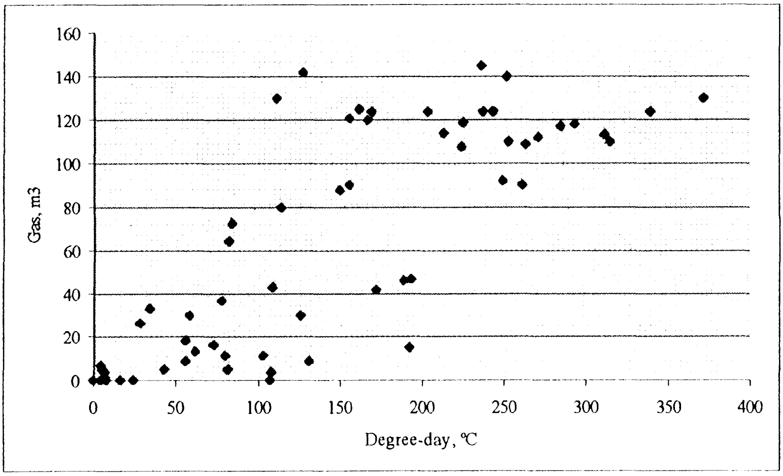

Figure 1. Gas consumption vs Degree-day for domestic heating.

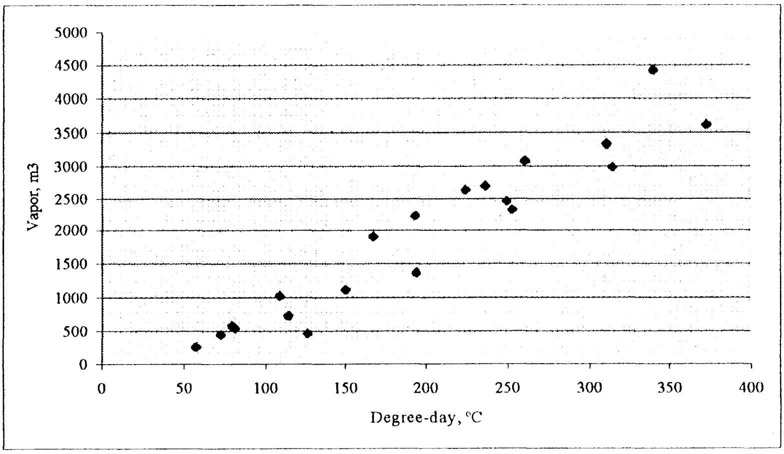

Figure 2. Vapor consumption vs Degree-day in industry.

Is the number of degree-day better than air temperature to correlate energy consumption and climate? If we compare the average monthly values of air temperature, number of degree-day, vapor consumption and number of heating hours for industry case, and their linear correlation (see Tables 2 and 3), we can observe a better correlation with degree-day, but the difference is few significant.

Table 2. Average monthly data.

	Temperature (°C)	Degree-day (°C)	Vapor (m^3)	Heating time (h)
October	15,4	32,5	480	99,6
November	10	155,9	1748	324,1
December	5,9	282,5	3611	568,6
January	4,5	324,1	4413	595,5
February	6,8	231	3087	465,3
March	9,9	157,8	1799	314,9
April	12,2	90,7	620	139,1

Table 3. Linear correlations, f(x) = A*x+B.

	A	B	R
Vapor = f(Degree-day)	14,27	-347,30	0,988
Vapor = f(Temperature)	-380,86	5771,36	0,969
Heating time = f(Temperature)	-50,23	-822,42	0,978
Heating time = f(Degree-day)	1,87	18,17	0,990

Figures 3 and 4 show correlation between monthly vapor consumption and monthly heating time *versus* air temperature, respectively, for heating seasons (October-April).

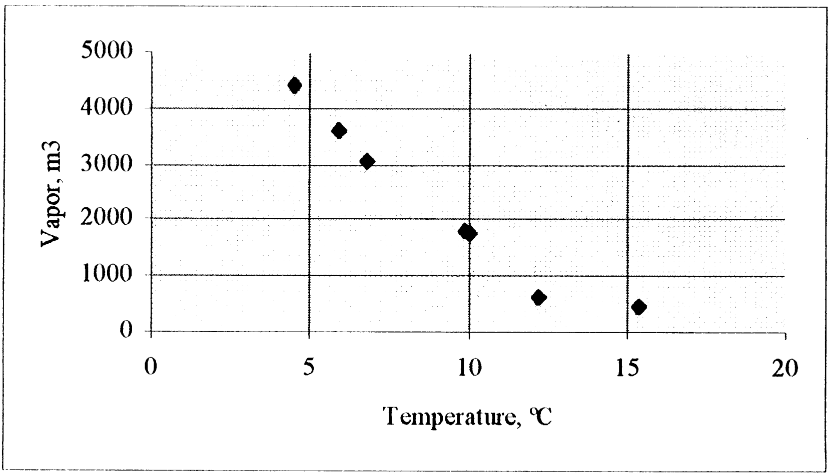

Figure 3. Monthly Vapor consumption vs Temperature.

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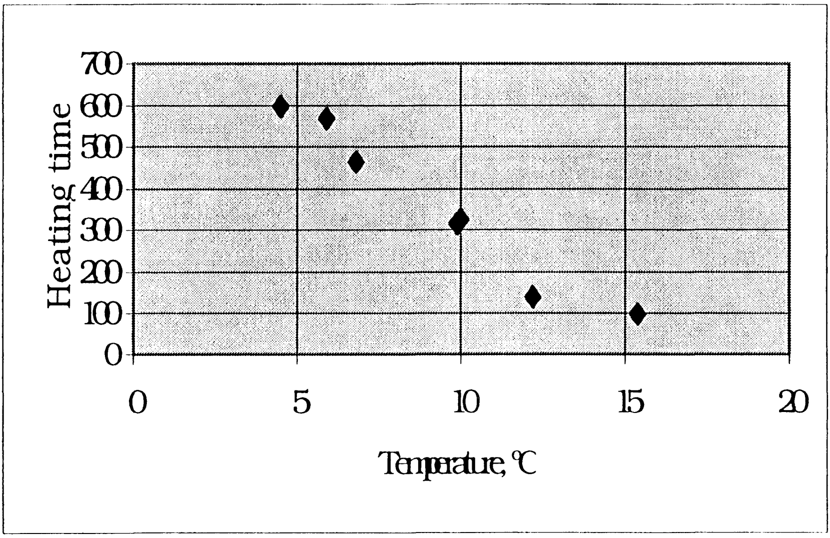

Figure 4. Monthly heating time vs Temperature.

If we consider the hypothesis for temperature change showed in Table 1 ($\Delta T=+1.2°C$, $+2.1°C$ and $3.2°C$ for year 2020, 2050 and 2080, respectively) and the correlation of Table 3, we can estimate the energy savings for heating in local industry as is reflected in table 4 (yearly vapor consumption) and table 5 (percentage of reduction):

Table 4. Evolution of heating consumption (absolute values) for climate scenario of table 3.

	Today	2020	2050	2080
Vapor (m^3)	15758,0	12558,6	10159,2	7226,6
Heating time (h)	2507,1	2085,1	1768,7	1381,9

Table 5. Evolution of heating consumption (percentage values) for climate scenario of table 3.

	Today	2020	2050	2080
Vapor (m^3)	-	-20,3	-35,5	-54,1
Heating time (h)	-	-16,8	-29,5	-44,9

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Figure 5 and 6 show estimated values for the climate scenario considered.

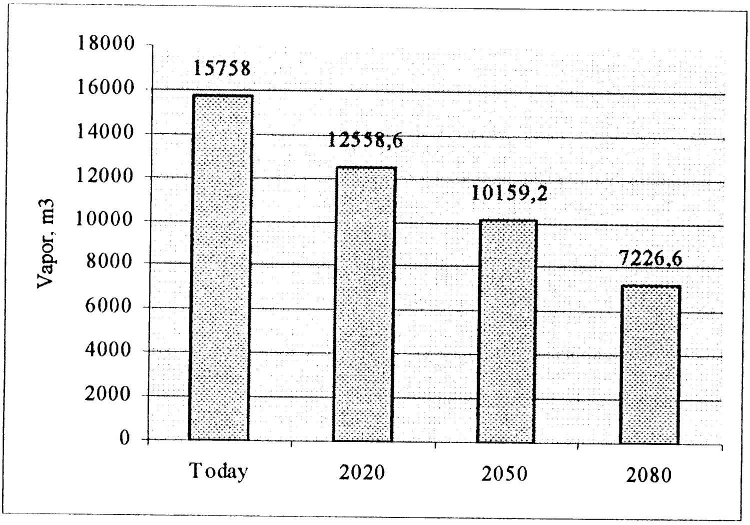

Figure 5. Yearly vapor consumption to heating local industry.

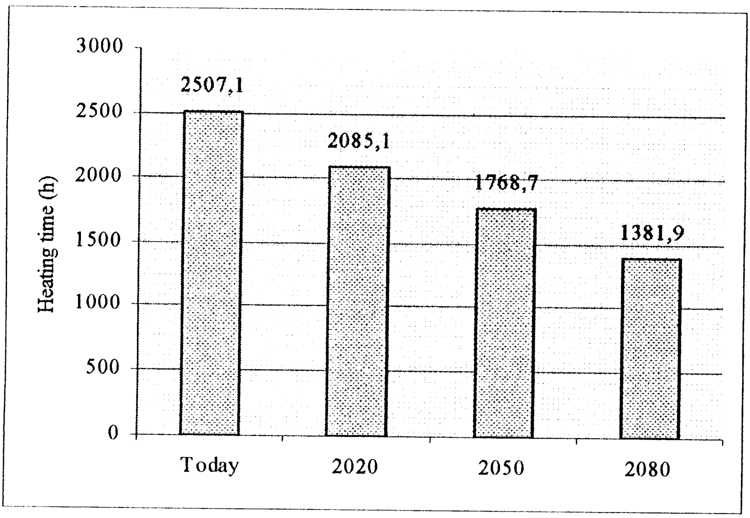

Figure 6. Yearly vapor consumption to heating local industry.

5 Conclusions

To increase the level of competitiveness is actually one of the main goals for an enterprise. For this objective a correct management of actual technical and human resources is basic, but a future point of view is also required. The size of machinery must be designed thinking in temporary process and maintenance. For instance, a heating system for public or private installations (e.g. schools, households, factories,...) must take into account external forcing factors, like climate variability or the numbers of users, for next times.

After correlating heating consumption for a mean local industry and air temperature, and considering a standard climate scenario, we have estimated savings in heating consumption about 20%, 35% and 50% for year 2020, 2050 and 2080, respectively. So, it suggests to go into details of more specific regional climate scenarios, in order to consider the feedback between climate change and energy management.

References

[1] EEA. *Climate Change in the European Union*. European Environment Agency, Copenhagen (1996).

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[3] Palutikof, J.P.; S. Subak and M.D. Agnew (eds.). *Economic Impacts of the Hot Summer and Unusually Warm Year of 1995*. University of East Anglia and Department of the Environment of the United Kingdom (1997).