

ENERGY PLANNING IN LONG PERIOD WITH THE INSERT OF THE HEAT PUMP AS TECHNOLOGY FOR THE WATER HEATING IN THE RESIDENTIAL SECTOR IN MINAS GERAIS.

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Abstract. *The present work presents a summary of the developed activities of the partnership between CEMIG and UFMG and it is inserted in the project "P&D-16", sub-project 3, which its title is "Approach of the Energy Efficiency and Renewable Energies". The objective of this work is an energy planning study in long period with the heat pump insertion as technology for the water heating in the residential sector in Minas Gerais. It was used for the energy planning study the module Balances of the ENPEP 2.20 program and the used data were obtained from market research, Belo Horizonte metropolitan area, and from 20°BEEMG. The results showed that the heat pump is a clean technology, because it doesn't emit pollutant in its operation and it reduces it the electricity consumption about 20%. It also promotes the load modulation by moving the electricity consumption out of top time. It is verified at the end of the study horizon that the heat pump participation in the ideal market is about 30% what would take a reduction of the electricity consumption of 41 for 24%. It was confirmed that the electric heaters by Joule effect are not suitable for the water heating.*

Keywords: *Water heating, Heat pump, Energy Planning, Residential Sector.*

1. INTRODUCTION

The energy planning is an extremely important task. It is a strategic politics, because with base in the study of the results obtained at the end of the planning horizon, the agents, who take the decision, can determine the plan to be executed. The extrapolation of this analysis show us that "the plan is not anything, the planning is everything", because the planning is a dynamic procedure, adjusting with the changes that are going happening along the planning period and already the plan is only the execution for which way must follow with the results analysis. Then a government, industry or specific company can generate the plan to be drawn.

It is known that a planning study is an extremely complex and arduous task that requests a specialized team demanding time and high resources.

This work objective is an energy planning study in long period with the heat pump insertion the technology goes the water heating in the residential sector in Minas Gerais. Tends a sketch of the energy fraction of the energy residential section at the end of the study horizon being visualized the insert of the bomb of heat as alternative for the heating of water.

2. METHODOLOGY

In a simplified way, we can consider a study of energy planning as to proceed. It begins with the collection of data contained in four different classes being the economical, energy demand, energy resources and converters.

With the database it is made the swinging between the offer and demand of energy for the section along the study horizon looking for the balance among the two. Several models exist for the search of this balance. The module BALANCE of the program ENPEP 2.20 was used for the accomplishment of this procedure. With the program ENPEP 2.20 is possible to do an analysis of environmental impacts; however this stage was not accomplished in this work.

After having accomplished the swinging between the offer and demand, it is had, or no, the validation of the results. If approved it takes place the results analysis and the planning study report. These stages are schematized in the Illustration 1 proceed.

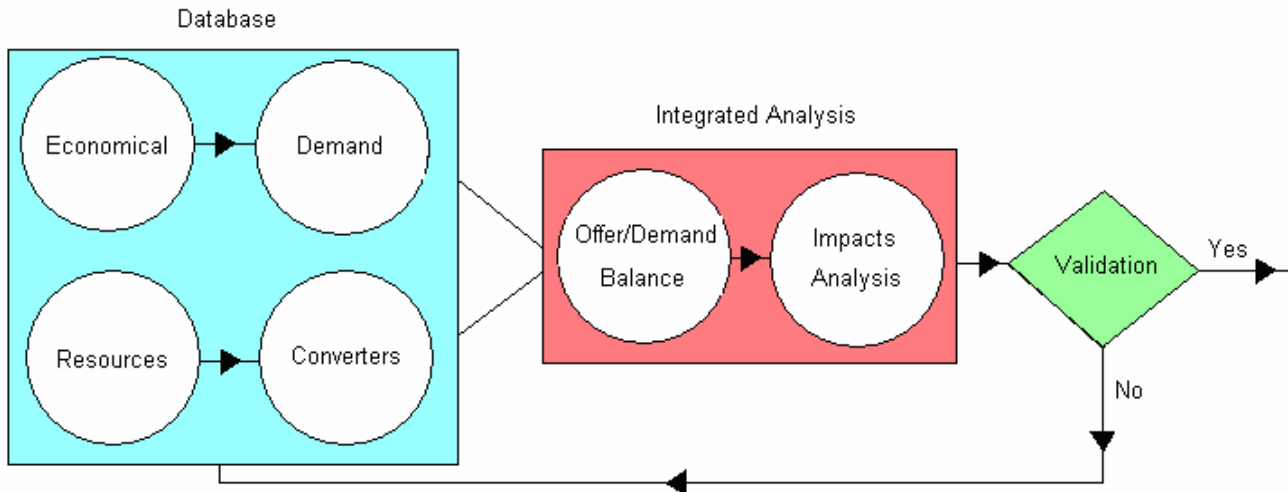


Figure 1: Planning Study outline.

3. STUDY PARAMETRERS

3.1 Base year

It was chosen the year 2000. The choice of this year is due to the fact that it is the most recent year previous to 2001, it is facilitated to find the largest number of information, without influence of the electric power rationing happened.

The data of the year base and, above all, the precedent historical data, are important for the construction of the projections of future growth. Therefore, the choice of solid data, that a lot of times it is of difficult obtaining, is fundamental in the planning study. Such data was obtained through 20° BEEMG accomplished officially by CEMIG. The year of 2001 is an atypical one for the fact of the rationing problem and it takes the difficulties in the analyses of the subsequent years to the rationing.

3.2 The planning horizon

The planning horizon can be, of short, medium or long periods. The long period is the time, superior to 10 years, enough so that all of the forecasts as for new technologies, politics or inputs pass to penetrate at the market. The defined period was it of long period, of the year base 2000 to the year of 2025.

3.3 Scenery

The definition of sceneries is another important step for the Analysis of alternatives for strategies and/or politics in the long period. To establish the sceneries, several aspects are considered, from growth of the economy to politics of incentives to energy sources or sections of the economy.

It was established a reference scenery on which the study will be based. This scenery possesses a tax of moderate economical growth, the politics adapts and as for the use maintainable of the inputs it will be the same applied now, regarding PROCEL. There is no subsidy the any technology in study.

3.4 Data bank

3.4.1 Converters data

Table 1: Prices and efficiencies of the heaters.

Water Heater	Price [R\$]	Efficiency (η)
Gas passage	1800,00	80%
Gas accumulation	2300,00	70%
Electric passage	150,00	95%
Electric accumulation	2300,00	85%
Solar	2300,00	55%
Heat pump	2800,00	430%

Font: "Programa Brasileiro de Etiquetagem".

3.4.2 Economic data

In the base year of the study the State grew around 5%. However, we cannot affirm that this is a growth tendency. In fact, it is big complexity to establish a tendency for the tax of growth of GDP. It was adopted the following definition of the projections of the taxes of economical growth then for the scenery. The medium growth, through the method of temporary series the medium tax of the verified growth from 1994 to 2000, was of 3,7% a.a. in agreement with the values of growth of GDP of Minas Gerais in DATAGERAIS (FJP) since 1994 and also with reference to the data of CEMIG 1997.

It is attributed 1,5 above and 1,5 below the value of medium and they are had the indexes then Loud for Analysis of the Sceneries (5,2%a.a.) and Low (2.2%a.a.). through conversations with economists, teachers and other friends is that the that conclusion was arrived, in agreement with MELO'S work (2006).

3.4.3 Energetic data

The GLP and electricity prices were from the table 7.10 page 96 from Brazilian Energetic Balance (BEN 2004). The demand and source data for GLP and electricity used were from the tables 3.1.16 e 3.1.20 pages 51 and 55 from 20°BEEMG.

The market share for demand by SOUZA, 2001 used were 26% for water heating; 32% for cooling; 24% for illumination; 6% TV and 12% for other services. Taken the hypothesis that market share will not change on the study horizon.

3.5 Energetic network

The energy supply/demand net for the residential sector. In the construction of the net the different patterns of use of the energy were considered, the devices of energy consumption the energy supply systems and the net for the base year was used in every study horizon.

In that way the module BALANCE can do the balance between offer and demand of energy and to compare the several energy alternatives.

The Figure 2 is the schematic representation of the energy net that ties the demand for energy useful (hot water) for the residential sector in Minas Gerais to the offers of final energy going by the allocation knots and converters (heaters).

In the base to be seen the elements that indicate the resources, in other words, the amounts of final energy (electricity, solar, GLP etc.). in the cases of electricity and GLP the allocation knots exist, because these resources assist more than a converter.

The converters are presented to the center. These elements make the separation among the energy useful (above) and final energy (below). The different among the two flows, what enters in the converter and the one that leaves is function of his/her efficiency.

There is a separate representation for the bomb of heat, for reason of his/her superior efficiency to 100%. Para to solve this problem, the bomb of heat it was represented by their components. One is the electric compressor and the other the evaporator. Being added the flows of energy useful, to a fixed reason, of each one the bomb of heat is had.

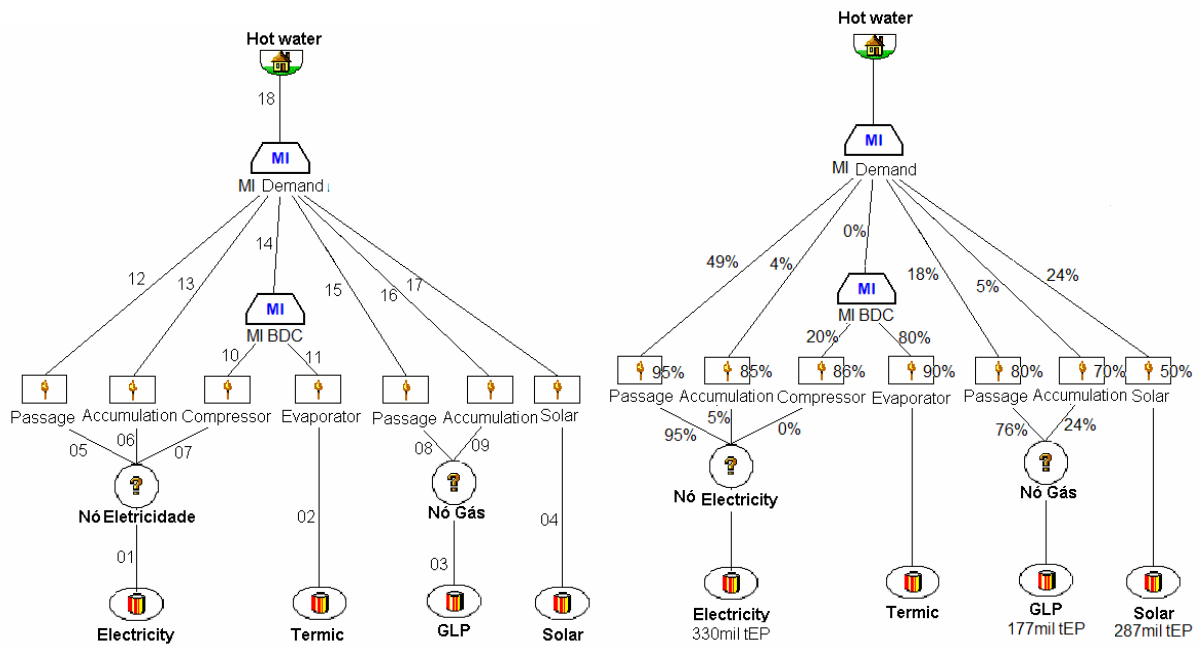


Figure 2: The energy net representation

The energy net presents the flows of energy then between the final energy and the useful. However their amounts that it passes in each road are the important for the program is carried for the planning.

These flows were then determined initially, with base in the market research accomplished in the metropolitan area of Belo Horizonte, it was determined which was the market division (knot disputes) for the converters in the Base year. This market share is shown in the Figure 2 below the Knot Disputes.

With this information and with Souza (2000) data it was obtained the value of the demand useful through the multiplication of the value of the total offer of electricity for the sector. This value is then multiplied by the fraction of electricity for the electric heater of passage (0,95). The new flow is then multiplied by the efficiency of the converter (0,95), the value of energy useful corresponding to 49% of the demand is had.

In this way with the values of the total demand and the market share, can be calculated all of the flows of the net in the Base year.

4. RESULTS

It comes the evolution of the flows of energy useful (Figure 3) along the study horizon.

Soon afterwards, the evolution of the flows of final energy is shown that assists the converters (heaters) (Figure 4) of the Year Base at the end of the study horizon. Then the electricity market share is presented (Figure 5) and for GLP (Figure 6), because these inputs assist more than an alternative.

This way, the graph with the evolution of the energy useful along the study horizon is shown to proceed.

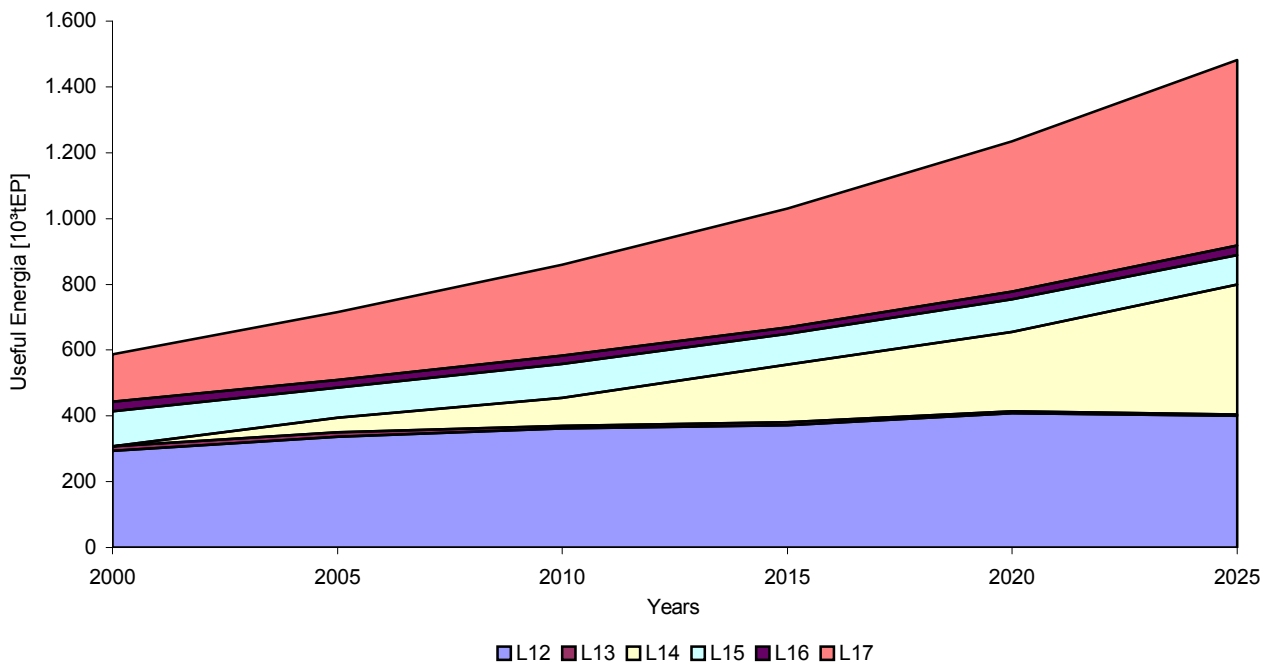


Figure 3: Useful energy evolution.

Tabela 2: Useful energy data.

Useful energy		2000	2005	2010	2015	2020	2025
Gas passage	L12	49%	47%	42%	36%	33%	27%
Gas accumulation	L13	4%	2%	1%	1%	1%	0%
Electric passage	L14	0%	6%	10%	17%	20%	27%
Electric accumulation	L15	18%	13%	12%	9%	8%	6%
Solar	L16	5%	3%	3%	2%	2%	2%
Heat pump	L17	24%	29%	32%	35%	37%	38%

The heat pump will get a 27% of penetration in the market. The participation of the electric heater of passage will reduce from 49% to 27%. The same happens with the accumulation tramway, however, this no more gatecrasher in the market at the end of the study horizon.

It is observed that the participations of the gas heaters reduced from 23% to 8% in 2025.

For the solar heaters the tendency was inverted, tends a growth in the 24% of participation in the market in the base year Base to about 40% at the end of the study horizon. However this was a result tax, because this penetration was limited for the solar heaters, because otherwise the program would take him a market penetration exaggeratedly big, in the greater them 95%.

To proceed comes the evolution of the final energy along the study horizon. This evolution is function of the evolution of the useful energy for the water heating.

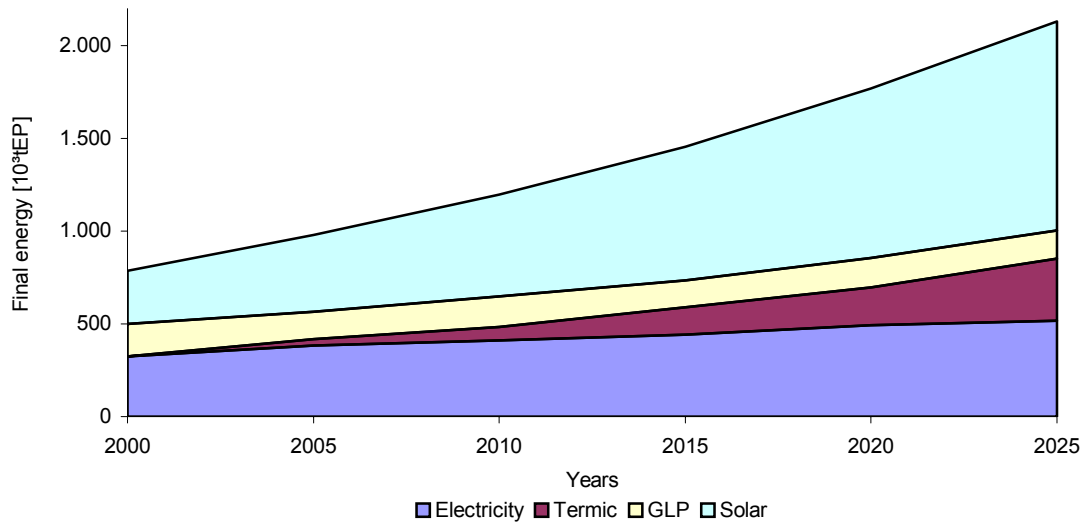


Figure 4: Final energy offer evolution.

Tabela 3: Final energy data.

Final energy		2000	2005	2010	2015	2020	2025
Electricity	L01	41%	39%	34%	30%	28%	24%
Termic	L02	0%	4%	6%	10%	11%	16%
GLP	L03	22%	15%	14%	10%	9%	7%
Solar	L04	36%	42%	46%	49%	52%	53%

It is verified with the data shown above for the evolution of the four sources of energy end that the participation of the electricity in the demand for hot water reduced of 41% of the total in the base year Base, for 24% at the end of the study horizon. This happens due to penetration of the heat pump as alternative.

The possible to also verify the reduction of the participation 22% GLP for 7%. These two variations in the participations of the electricity and of GLP they are take a reduction in the costs to assist the demand for hot water.

The solar final energy goes up it participation of 36% in the base year for 53% at final of the planning horizon. The thermal energy of atmosphere enters in the market getting to reach 16% of the market at the end of the study horizon. These two facts are in agreement with the previous analysis for the reduction of the participations of the electricity and of GLP.

The flows of final energy for electricity and GLP supply several converters. This way, the evolution is visualized of these of these flows in the graph of Figure 4.

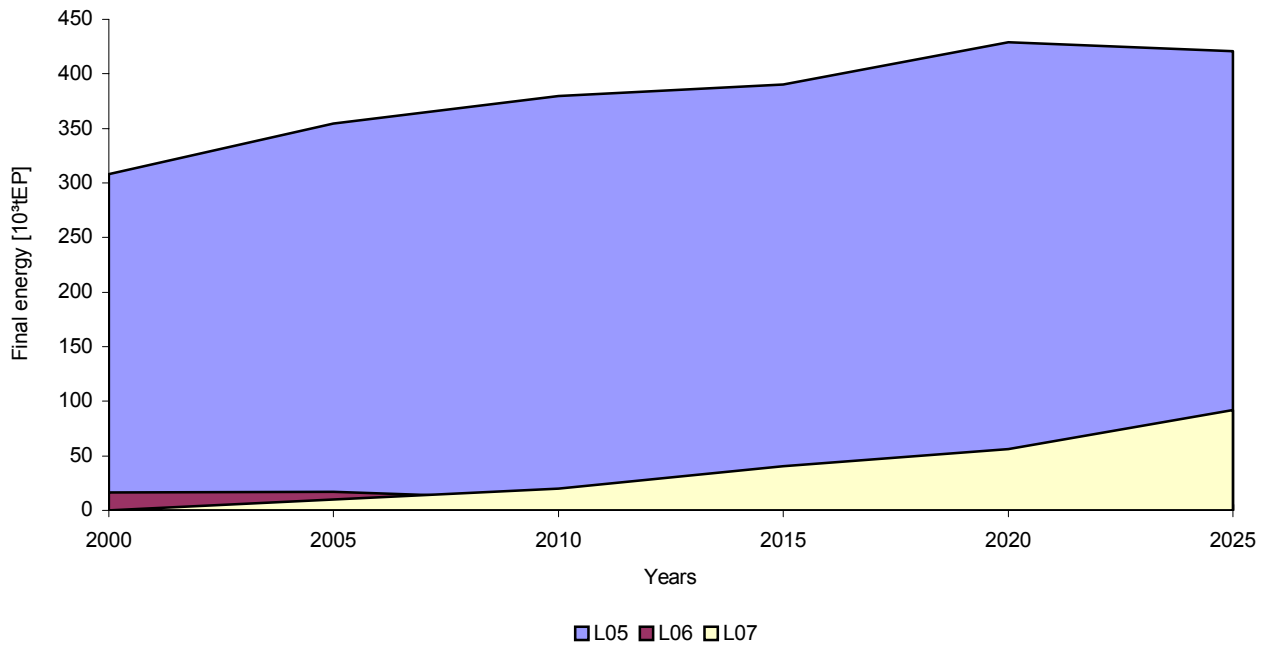


Figure 5: Electricity offer evolution.

Tabela 4: Electricity data.

Final energy		2000	2005	2010	2015	2020	2025
Electric passage	L05	95%	93%	93%	88%	87%	81%
Electric accumulation	L06	5%	4%	2%	3%	1%	1%
Heat pump	L07	0%	3%	5%	9%	11%	18%

To be seen that the participation in the base year of the electric heaters of passage in the electricity was of 95% of the total offer. Their participation, however it continues being the largest at the end of the study horizon, however it reduces for 81%.

The heat pump, acted by the electric consumption of it compressor, it arrives to 18% of the final consumption of electricity at the end of the study horizon.

The electric heater of accumulation reduces their participation in the consumption of electricity of 5 for 1%.

The heat pump uses in their conversion always the relationship of 20% of electric power and 80% of energy of the atmosphere.

The evolutions of the participation of the gas converters of passage and accumulation are seen in the graph of the Figure 5.

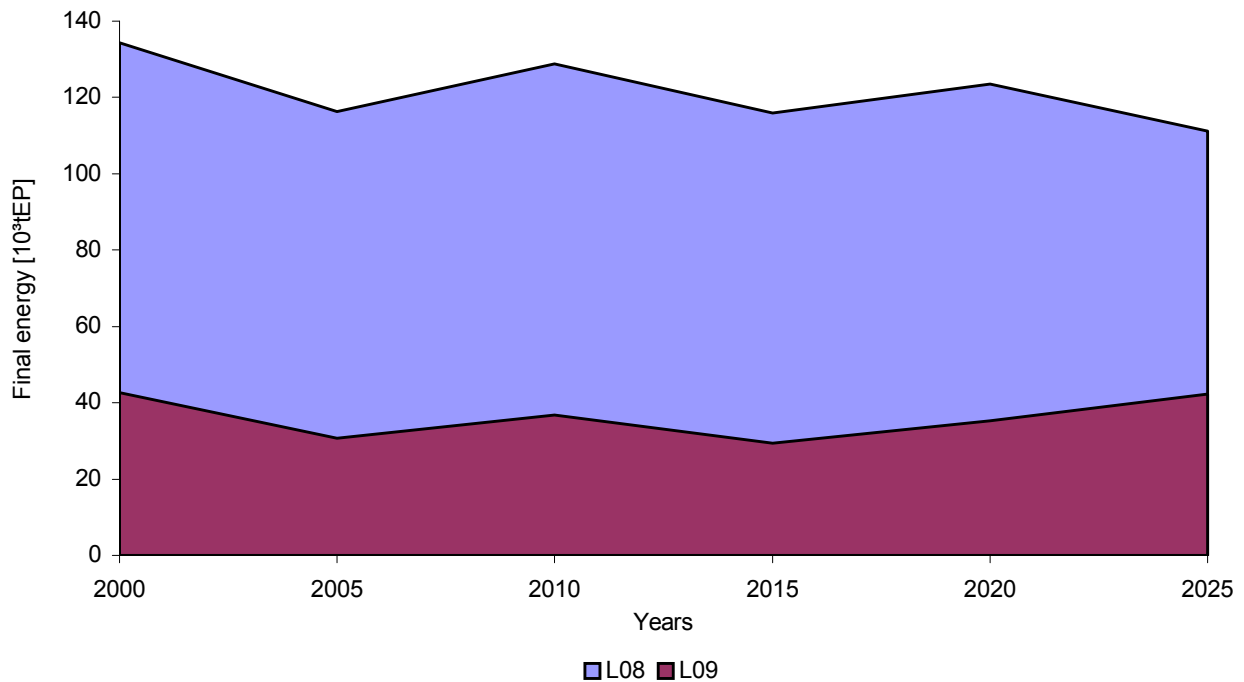


Figure 6: GLP offer evolution.

Tabela 5: GLP data.

Final energy		2000	2005	2010	2015	2020	2025
Gas passage	L08	76%	79%	78%	80%	78%	72%
Gas accumulation	L09	24%	21%	22%	20%	22%	28%

The participation in the consumption of GLP for the gas heaters of passage reduces from 76 to 72% at the end of the study horizon. The profiles of consumptions of the two types of gas heaters oscillate for more and for minus, but maintaining a relationship of 75% and 25% on average.

5. CONCLUSION

The objective was reached with the results of the energy planning, for the Reference Scenery is verified that the heat pump was also shown viable. Its penetration in the market was from 27% to the end of the study horizon.

To stand out that the solar heating had maximum its market penetration limited in 40%. The 60% of the remaining market were of free choice of the program among the other technologies including the heat pump.

Once again the non indication of the electric heaters was confirmed as alternatives for the water heating. The electric heater of passage had its market participation reduced of 49% for 27% at the end of the study horizon. The electric heater of accumulation left the market also at the end of the study horizon.

New solutions for the water heating are researched their all the moment and everywhere of the world. These researches generate gain in quality of the energy services.

Whole to research it is made step by step and continually. One more step was given with this work for the demonstration of the viability of the insert of the heat pump as technology for heating of water in the residential section in Minas Gerais.

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