

Energy certification process in Chile: steps to dynamic simulation of buildings' energy performance.

Massimo Palme, PhD

Catholic University of the North

Email mpalme@ucn.cl

ABSTRACT

This paper presents comparative studies among dynamic simulation and steady-state evaluation (degrees – day) for residential building certification in Chile. Energy certification is still young in the country, but its impact in reduction of thermal demand could be very high. The main problem seems to be the use of simplified methods, which have not been tested for all the country's climates. Chile has a lot of very different scenarios, from the Atacama Desert to the extreme south Patagonia, which are not always well represented by daily average temperatures. The Chilean National Energy Certification System started in 2013 to qualify residential buildings, most of them by using steady-state evaluation. However, in the northern deserts of the country, dynamic simulation is needed to permit a quality work of certification. This paper presents 21 dwellings located in the city of Antofagasta, simulated by using normative software CCTE and also evaluated by using the simplified normative method developed by the Government. Results shows important differences in the final results, both in terms of estimated thermal demand and final etiquette obtained. Steady-state evaluation definitively seems to be not very useful for the desert climate, even in the coast region, where thermal oscillation is relatively low because of the Ocean's effect.

INTRODUCTION

In 2013, The Chilean Government introduced the National Energy Certification System for Dwellings. The system is voluntary but the Ministry of Housing has the intention to make it mandatory by 2015. The system assigns two different energy classes: one relates to architectural parameters (envelope, form, orientation) and the other relates to systems efficiency (heating system, solar energy use for hot water, and photovoltaic panels for electric generation to be used in electricity). The first group of accredited evaluators started to certify social and private projects in order to test the results of system implementation. Two options are managed to estimate heating energy demand: simplified steady state option that uses degree-day concept and fully dynamic simulation by using CCTE software (MINVU, 2012).

Chile is a country that extends from a latitude of 18 South (Arica) to 56 South (extreme south Patagonia). For this reason, in Chile all kind of climates can be detected, from arid to cold, from mountain to tropical. However, the national certification system only considers heating needs of the central and southern zones. The climate classification developed to use the degree-day concept divides the country in seven zones, plus two sub-zones (extreme south and north), not considering day-night thermal oscillations to distinguish locations with the same average temperature but very different maximum and minimum temperatures (MINVU, 2008b).

Massimo Palme is a professor in the School of Architecture, Catholic University of the North, Av. Angamos 610, 1240000 Antofagasta, Chile.

Thermal zones defined by Ministry of Housing are different with respect to climate zones defined by norm NCh 1079 (2008) that consider longitude and altitude as well as latitude defining Chile's climates. This contradiction has been mentioned in the country as one of the most important limitations of the National Energy Certification System; see for example Bustamante (2009).

In northern regions of the Country, the system does not appear to be completely useful, because of a lack of consideration in regards to cooling demand and because of the simplified options, which don't consider thermal inertia of construction. To reach a good energy class (starting from "D"), in the north zones dwellings have to have less than 75% of the thermal demand and less than 80% of total energy consumption in respect to the reference building. The reference building has the same size and form of the analyzed building, but mandatory compliance in materials and average orientation.

In addition, low heating demand in the North leads to poor energy labeling, because of the limitation in reference building demand (if reference building has an estimated heating demand lower than 30 kWh/m², thermal performance is not calculated and only hot water and electricity are considered to assign the energy class). To investigate discrepancies between the simplified method and dynamic full simulation, a social dwelling project was selected as a case study.

METHODOLOGY

In this research, 21 dwellings are evaluated by using steady-state method and also simulated by using dynamical software CCTE. Then, a comparison of results is done, searching for differences in heating demand and in the final energy class assigned to each dwelling.

Case study "Tres Mariás"

Dwellings located in the city of Antofagasta, 23° south and 70° west, at Sea level. Figure 1 shows project emplacement and dwelling orientation (courtesy of SERVIU). Site has a little slope, resulting in shadows on the east side and solar access on the west. Moreover, on the east the first line of mountains protects houses from solar access in the morning. On the south and north other buildings generate shadows at specific hours of the day in summer and winter, respectively.

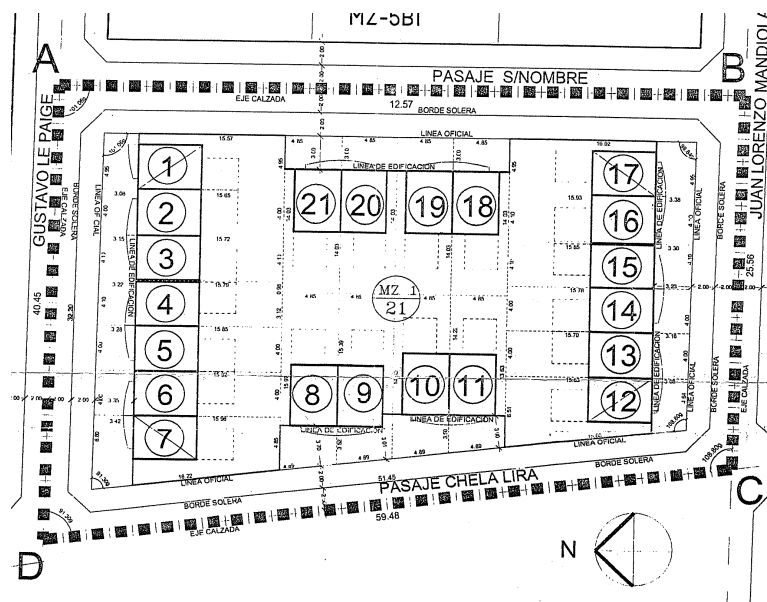


Figure 1 House's emplacement and orientation

Figure 2 shows architectural distribution on two floors. Houses have a floor surface of 45 m² (22 m² on each floor). Figure 3 shows the facade.

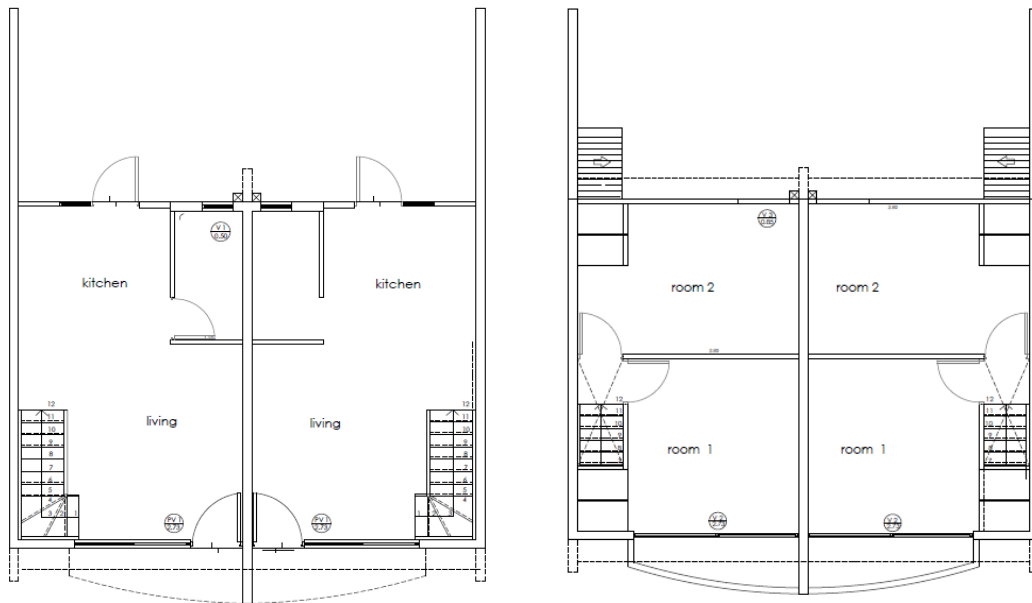


Figure 2 Ground and first floor plan

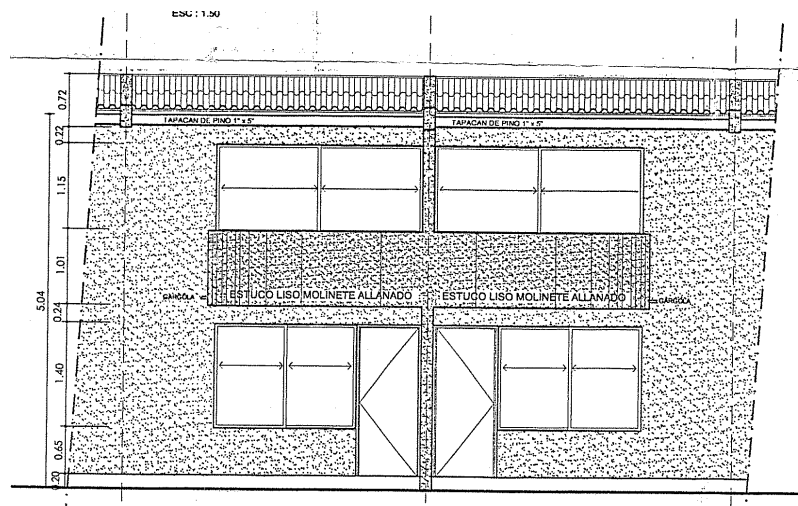


Figure 3 Facade of the dwelling

Materials and equipment

Construction uses two kind of vertical walls: block walls and external board walls. Block walls are composed by 150 mm of concrete plus 20 mm of insulation (polystyrene) and 10 mm of ceramic finishes. Thermal transmittance is $1.32 \text{ W/m}^2\text{K}$. External board walls are composed by OSB (11 mm) plus 40 mm of insulation (rock wool) between steel profiles, plus another 20 mm of insulation (polystyrene) and 10 mm of ceramic finishes. Thermal transmittance is $0.88 \text{ W/m}^2\text{K}$. Roof is made of block work (130 mm) plus 100 mm of insulation (rock wool). Thermal transmittance is $0.38 \text{ W/m}^2\text{K}$. Floor is composed by blockwork. Door is made of pressed wood, thermal transmittance $3.7 \text{ W/m}^2\text{K}$. Windows are single glazed, with thermal transmittance of $5.3 \text{ W/m}^2\text{K}$ and solar factor 0.87. Table 1 resumes transmittance values of construction elements. Transmittances have been calculated as indicated in Chilean norm NCh 851 (2008), NCh 853 (2008) and Thermal Norm of MINVU (2008a).

Table 1. Walls and windows properties

Wall	Transmittance (W/m ² K)	Thickness (mm)	Solar factor (%)
Blockwork wall	1.32	180	0
Board wall	0.88	81	0
Roof	0.38	230	0
Floor	3	230	0
Door	3.7	50	0
Window	5.3	6	87

Dwellings do not have heating systems. Hot water system is electric boiler with 150 dm³ deposit. No solar panels are considered for hot water or electricity production. Electricity is considered in certification as standard system. No other appliances are considered.

RESULTS AND DISCUSSION

Steady state evaluation

21 dwellings were evaluated, first by steady state method. The system considers a reference building that has the same form of the project, compliance materials and average orientation. Reference building has in most cases a heating demand of less than 30 kWh/m² year. As a result, most dwellings facing south or north are not evaluated in terms of heating demand. Only the dwelling numbers 1, 7, 12 and 17 are evaluated. East and west dwellings are also evaluated, because of the higher exposed surface. All dwellings are evaluated in terms of hot water production (electric system).

In the Chilean system, the architectural energy class assigned to a dwelling depends on the thermal zone where the dwelling is placed. In northern deserts, to attain an “E” label, the dwelling must have a thermal demand between 75 and 110% of the reference dwelling. Reference dwelling has the same form, average orientation and minimum standard compliance for materials. To reach a “D” class, the dwelling must have a thermal demand between 55 and 75% of the reference. To obtain a “C”, thermal demand has to be between 40 and 55%; to obtain a “B”, between 30 and 40% and to earn an “A”, between 0 and 30%.

System energy class depends on the primary energy consumption; therefore electrical systems for hot water are normally evaluated as “G”. To obtain an “E” label, primary energy consumption has to be between 80 and 110% of the reference; to obtain a “D” has to be between 60 and 80%; to obtain a “C” 45 to 60%; “B” 30 to 45% and “A” less than 30%. This indicator is not dependent on the thermal zone as the heating demand. Table 2 resumes the label correspondence for thermal zone 1 (northern coast deserts of Chile).

Table 2.
Energy percentage respect to reference building

	Label A	Label B	Label C	Label D	Label E
Demand	0-30	30-40	40-55	55-75	75-110
Consumption	0-30	30-45	45-60	60-80	80-110

Results are resumed in table 3: most of the dwellings have class energy “G” or “F”. The main reason of this result is the impossibility of evaluating dwellings if reference has less than 30 kWh/m² year heating demand. However, the result is illogical, because the dwelling has better values of transmittances than reference building, then a better class is expected (if dwelling has the same demand of the reference, class “E” is assigned).

Table 3. Steady state evaluation results

Dwelling	Orientation	Architecture	Systems	Heating demand (kWh/m ² year)	Heating reduction (%)
1	N	D	E	22.0	42
2	N	/	G	/	/
3	N	/	G	/	/
4	N	/	G	/	/
5	N	/	G	/	/
6	N	/	G	/	/
7	N	D	E	22.2	40
8	W	E	F	39.4	15
9	W	E	F	40.2	12
10	W	E	F	38.2	19
11	W	E	F	41.1	10
12	S	E	F	41.7	2
13	S	/	G	/	/
14	S	/	G	/	/
15	S	/	G	/	/
16	S	/	G	/	/
17	S	E	F	39.7	5
18	E	E	F	40.1	8
19	E	E	F	36.4	17
20	E	E	F	30.1	21
21	E	E	F	32.6	19

CCTE simulation

CCTE evaluation uses dynamical simulation of the real and the reference buildings. Because in this case the reference building has the same orientation of the analyzed one, four simulations have been done and reference building results are the average of the four orientations considered (N, S, E and W). Figure 4 shows the CCTE model of East/West dwellings.

All dwellings are analyzed because in this case the reference building has a heating demand higher than 30 kWh/m² per year. In general, analyzed dwellings are better than the reference in terms of heating demand (between 20% and 30%) and very close to the reference in terms of energy consumption, because of the low efficiency of the electric boiler.

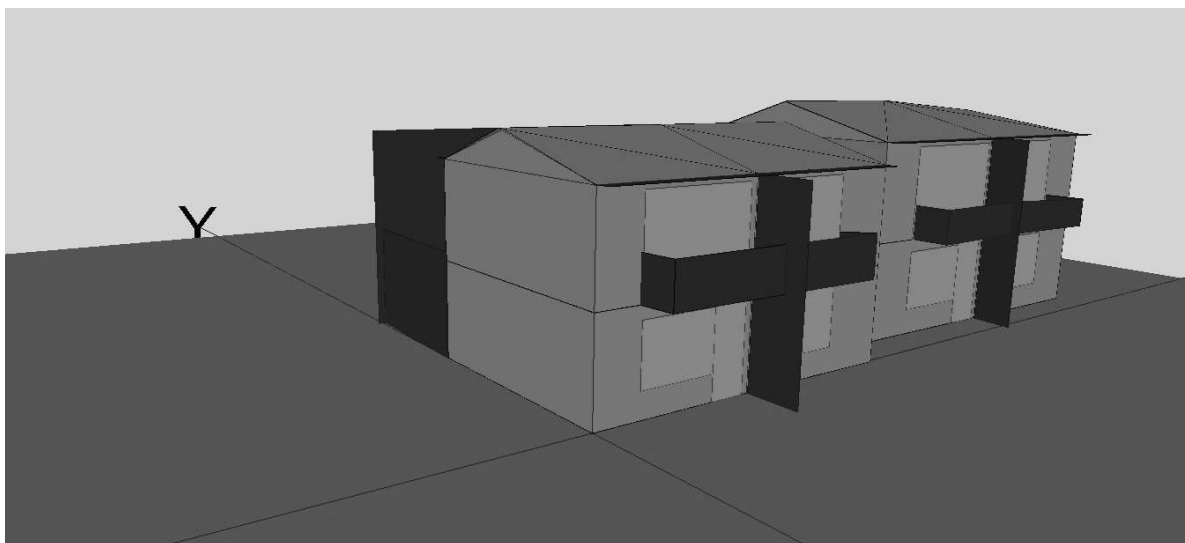


Figure 4 CCTE model used in simulations

Results in this case are more consistent, because all dwellings have a better or at least the same energy class of the reference building. The reason is that dynamic simulation leads to more than 30 kWh/m² year of heating demand, which permits the obtainment of the architecture class. Table 4 summarizes the results.

Table 4. CCTE evaluation results

Dwelling	Orientation	Architecture	Systems	Heating demand (kWh/m ² year)	Heating reduction (%)
1	N	D	E	34.1	37
2	N	D	E	25.4	31
3	N	D	E	24.8	33
4	N	D	E	23.6	37
5	N	D	E	25.8	34
6	N	E	E	32.2	26
7	N	E	E	36.1	22
8	W	D	E	35.3	36
9	W	E	E	36.1	24
10	W	E	E	34.9	19
11	W	E	E	34.2	27
12	S	E	E	35.9	19
13	S	E	E	27.9	19
14	S	D	E	26.3	28
15	S	E	E	26.3	20
16	S	D	E	25.5	30
17	S	E	E	31.9	23
18	E	E	E	40.1	26
19	E	D	E	32.2	34
20	E	D	E	30.1	32
21	E	E	E	35.5	26

North-facing dwellings have “D” class assigned (most of them), because of better solar access in winter. Some south-facing dwellings also have “D” class because they reach 25% of demand reduction.

Steady-state evaluation leads to unreliable results in most considered cases: because of low heating demand of the climate zone, architecture is not evaluated and only electrical system for hot water production is considered. Dwellings that have better performance than the reference building (between 20% and 30% considering heating demand) are classified as “G” or “F” because of the low efficiency of electric boilers for hot water production. Only two of the north-oriented dwellings are evaluated and classified as “D” in architecture and “E” in energy consumption. On the other hand, CCTE dynamic simulation lead to more realistic results and all the 21 dwellings are evaluated, obtaining architectural class “D” or “E” (depending on energy saving: to obtain “D” class energy saving has to be more than 30%). In this case, all consumption classes are “E”.

CONCLUSION

The energy certification process in Chile is focused on heating demand reduction, the most important problem in southern regions of the country. Northern regions are considered to be temperate, and building overheating is nowadays resolved by natural ventilation. However, some considerations have to be made. First, the energy certification system has two options, simplified evaluation and dynamic simulation. In the South of Chile, both methods lead to the same energy class in most cases, but in the North many cases have different classes, as discussed in this paper. Thermal mass effect and especially 30 kWh/m² limitations in reference building to evaluate architecture thermal demand are problems in the current system.

Second, natural ventilation is supposed to be sufficient to cool buildings, but in the future some urban climate changes could modify this situation. Global warming in northern Chile will probably be very high (up to 5 degree increase of temperature in the middle of the century), heat island effect will be present in cities of middle size, tall buildings construction in the first coast line will act as a blockage to sea wind. All these factors are clearly indicated as a danger for overheating in built environment; see works of Chilean Government (2013), Palme (2014), Valenzuela (2013).

Finally, economic development of the country, especially of the northern mining zones, will have the consequence that people will search for better comfort standards, and install air conditioners to avoid overheating in residences. This could be very dangerous, because it will add to an increase in global warming. In this conclusion, it appears very important to recommend the introduction of a dynamic system of energy certification, taking into account heating and cooling demand, as well as the removal of the 30 kWh/m² limitation in reference building heating demand.

REFERENCES

- Bustamante, W. 2009. Guia de diseño para la eficiencia energética en la vivienda social. Ministerio de Vivienda y Urbanismo, Santiago de Chile.
- GOBIERNO DE CHILE. 2013 Plan nacional de adaptación al cambio climático. Santiago: Chilean Government
- MINVU 2012. National Energy Certification System for Dwellings. Santiago de Chile: Ministry of Housing.
- MINVU 2008a Thermal Norm. Santiago de Chile: Ministry of Housing.
- MINVU 2008b Thermal Zoning. Santiago de Chile: Ministry of Housing
- NCh 1079. 2008. Standard Climate Zone Definition. Santiago: National Normalization Institute.
- NCh 851. 2008. Standard Materials and Construction Elements. Santiago: National Normalization Institute.
- NCh 853. 2008. Standard Materials and Construction Elements. Santiago: National Normalization Institute.
- Palme, M., Albano, L., Isalgué, A., Coch, H., Guerra, J. 2013. Latin-American Building's Energy Efficiency Policy. Sustainability in Energy and Buildings, Springer-Verlag Berlin, Cap. 31: 337-346
- Palme, M. 2014 Thermal demand and related CO₂ emissions of buildings under climate change conditions in arid climates: a simulation experiment in Antofagasta, Chile. Environmental Pollution Conference, Toronto, Canada, 12-15 June 2014
- SERVIU 2014. Tres Marías, Antofagasta: Social Dwelling Service of Antofagasta Region.
- Valenzuela, G. 2013. Efecto isla de calor en Santiago de Chile. ENCAC Conference, Brasilia, Brazil, September 2013