ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

2011-26

LESO-PB

Towards a minergie standard for tropical climates

Kriesi R.
Aabid F.
Roulet C.-A.
Vigliotti F.
Scartezzini J.-L.

CISBAT 2011
195-200

2011

INFOSCIENCE

Publication soumise

Merci d'avoir pris le temps de soumettre votre publication.

Votre soumission a été ajoutée à la file d'attente d'Infoscience. Il y a en ce moment 9 tâches en attente. Temps d'attente estimé: 54mn.

Votre publication sera accessible à cette adresse: **http://infoscience.epfl.ch/record/174466**

INFOSCIENCE

Confirmation

Veuillez vérifier les informations avant de terminer la soumission

Publication telle qu'Infoscience l'affichera

CONFERENCE PAPER

TOWARDS A MINERGIE STANDARD FOR TROPICAL CLIMATES

Kriesi, Ruedi ; Aabid, Fouad ; Roulet, Claude-Alain ; Vigliotti, Franco ; Scartezzini, Jean-Louis

- **Presented at:** CISBAT 2011, Lausanne, September 14-16
- **Published in:** Proceedings of CISBAT 2011 - CleanTech for Sustainable Buildings, p. 195-200. Scartezzini, Jean-Louis (ed.)
- Lausanne: EPFL, 2011

The Swiss Minergie®-standard is, by the number of labelled buildings (> 20'000) one of the most successful building energy labels in the world. It is obviously a strong incentive for designing comfortable, low energy buildings. This standard is now valid for temperate - cold climates only. There is therefore a need for a similar standard for buildings dominated by cooling loads, as it is common in the tropical and sub-tropical climates of the world. Since the new EPFL campus planned in Ras al Kaimah (United Arab Emirates) should be exemplary, a project was launched by the Dean of EPFL Middle East, together with Minergie®-Association and the Solar Energy and Building Physics Laboratory of EPFL, aiming to set-up such a standard. In order to initiate this project, two buildings (a single family dwelling and an office building) were chosen. The single-family dwelling was simulated at an hourly time step using a detailed dynamic thermal model based on the computer simulation programme Energy plus issued from LBNL. The monthly energy consumption of the dwelling shows a good correlation with the monitored data. In addition to that, both energy consumptions, calculated with the dynamic and the simplified models are close to each other, giving confidence to the predictions of the latter. Therefore, both buildings were assessed using a simplified monthly energy balance method. Starting from the current buildings configurations, several variants implementing various improvements towards energy efficiency were considered. These simulations show that considerable energy saving (up to a factor 5) can be achieved by implementing together several improvements to these buildings. In addition, the building reaches a higher level of users comfort.

Reference

Laboratoires

LESO-PB - Solar Energy and Building Physics Laboratory

LSU - Laboratory of Ultrafast Spectroscopy

Documents

Documents principaux

Vous n'avez pas joint de document

Documents additionnels

Vous n'avez pas joint de document

Annuler | < Retour | Suivant > | Terminer

TOWARDS A MINERGIE®-STANDARD FOR TROPICAL CLIMATES

Ruedi Kriesi[1] ; Fouad Aabid[2]; Claude-Alain Roulet[2]; Franco Vigliotti[3], Jean-Louis Scartezzini[2];

1: Kriesi Energie GmbH, Meierhofrain 42, CH-8820 Wädenswil, Consultant, Vice-President of Minergie®-Association

2: Solar Energy and Building Physics Laboratory (LESO-PB), Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne

3: EPFL Midlle East, Ras al Kaimah, United Arab Emirates (UAE)

ABSTRACT

The Swiss Minergie®-standard is, by the number of labelled buildings (> 20'000) one of the most successful building energy labels in the world. It is obviously a strong incentive for designing comfortable, low energy buildings. This standard is now valid for temperate - cold climates only. There is therefore a need for a similar standard for buildings dominated by cooling loads, as it is common in the tropical and sub-tropical climates of the world. Since the new EPFL campus planned in Ras al Kaimah (United Arab Emirates) should be exemplary, a project was launched by the Dean of EPFL Middle East, together with Minergie®-Association and the Solar Energy and Building Physics Laboratory of EPFL, aiming to set-up such a standard. In order to initiate this project, two buildings (a single family dwelling and an office building) were chosen. The single-family dwelling was simulated at an hourly time step using a detailed dynamic thermal model based on the computer simulation programme *Energy plus* issued from LBNL. The monthly energy consumption of the dwelling shows a good correlation with the monitored data. In addition to that, both energy consumptions, calculated with the dynamic and the simplified models are close to each other, giving confidence to the predictions of the latter. Therefore, both buildings were assessed using a simplified monthly energy balance method. Starting from the current buildings configurations, several variants implementing various improvements towards energy efficiency were considered. These simulations show that considerable energy saving (up to a factor 5) can be achieved by implementing together several improvements to these buildings. In addition, the building reaches a higher level of users comfort.

INTRODUCTION

The Minergie®-standard [1] is among the most applied building energy label in the world (about 20'000 labelled buildings in Switzerland by the end of 2010). It is obviously a strong incentive for designing low energy buildings in a perspective of climate change, as the standard not only asks for low energy consumption, but for above average comfort and competitive cost. It has even been extended by "Minergie®-Eco" (low environmental impact buildings) and "Minergie®-P" (optimized for passive solar gain). However, the methodology applied to evaluate the building energy performance and the conditions for getting the label are yet valid for temperate - cold climates only, where buildings are dominated by space heating and domestic hot water production and where cooling is only a minor issue. For hot and humid areas, a Minergie®-standard exists for villas in southern Japan only, where heating, cooling and dehumidification are equally required. There is therefore a need for a similar standard that can be applied to different types of buildings in areas dominated by cooling loads, as it is common in the tropical and sub-tropical climates of the world.

The new EPFL campus planned in Ras al Kaimah (United Arab Emirates) should be exemplary and gather buildings with high user comfort and top energy performance. Therefore, a project was launched by the Dean of EPFL Middle East, together with Minergie®-Association and the Solar Energy and Building Physics Laboratory of EPFL, in order to set-up a new Minergie®-standard for tropical climates.

METHOD

The Minergie® label is awarded to buildings that achieve the largestpossible energy performance with an optimal comfort at a competitive cost. These limits depend on local climate, building habits, available materials, etc. Therefore, we intended to simulate buildings in the climate of Ras-al-Khaimah for exploring various ways for reaching the goals. Passive ways such as thermal insulation, sun shadings, free cooling, as well as improvement of active ways such as artificial cooling, dehumidification or solar water heating should be explored.

Starting from typical local buildings, computer simulations using acknowledged and validated models allow estimating the effect of any energy saving measure applied to these buildings. Impacts on cost and comfort can be also assessed this way. A series of simulations of different types of buildings should provide the precise criteria for labelling buildings.

In order to initiate this project, a single-family dwelling was simulated both at an hourly time step using a detailed dynamic thermal model based on the computer simulation programme *Energy plus* issued from LBNL [2], as well as by a simplified model using monthly mean values [3]. The monthly energy consumption of the dwelling shows an excellentcorrelation with the actual energy use of the single family home, carefully monitored (Figure 1). In addition to that, both annual energy consumptions, calculated with the dynamic and the simplified models are close to each other (divergences lower than 10%), giving confidence to the predictions of the building models used in the simulation.

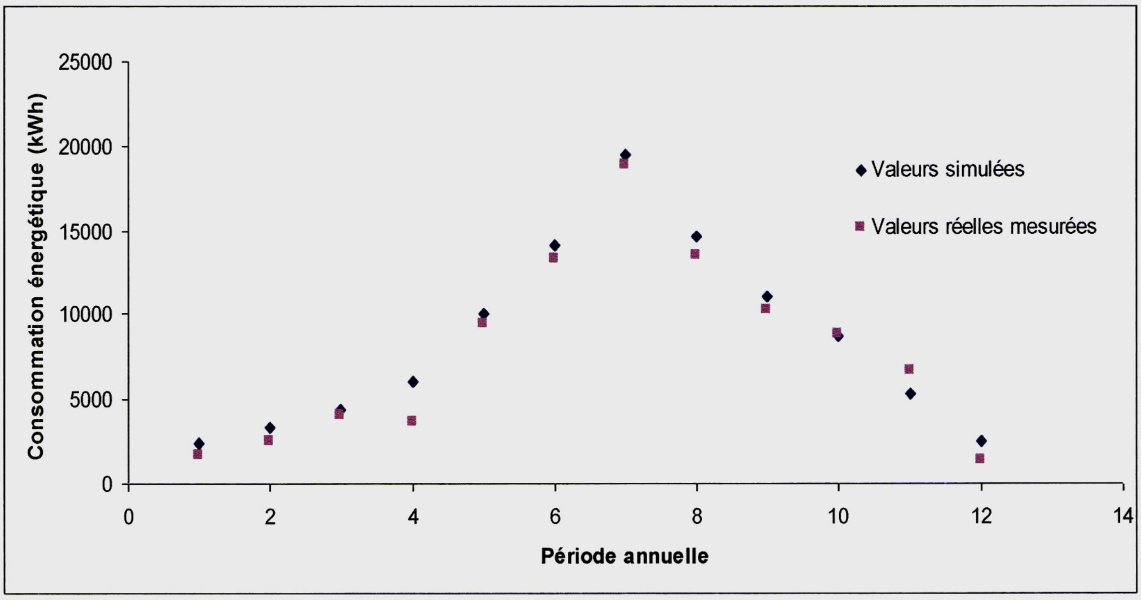

Figure 1: Measured monthly energy use and results of dynamic simulation of the family house.

The same technical improvements towards comfort and energy efficiency were considered for the calculation of an office building, assessed by the simplified monthly energy balance method, again starting from the current buildings configurations [4]. Only the results for the single family building are presented here.

RESULTS

Energy savings

The simulated home is an existing building for which annual energy use is known. Its actual view and model are shown on Figure 2. Its basic thermal characteristics are given in Table 1.

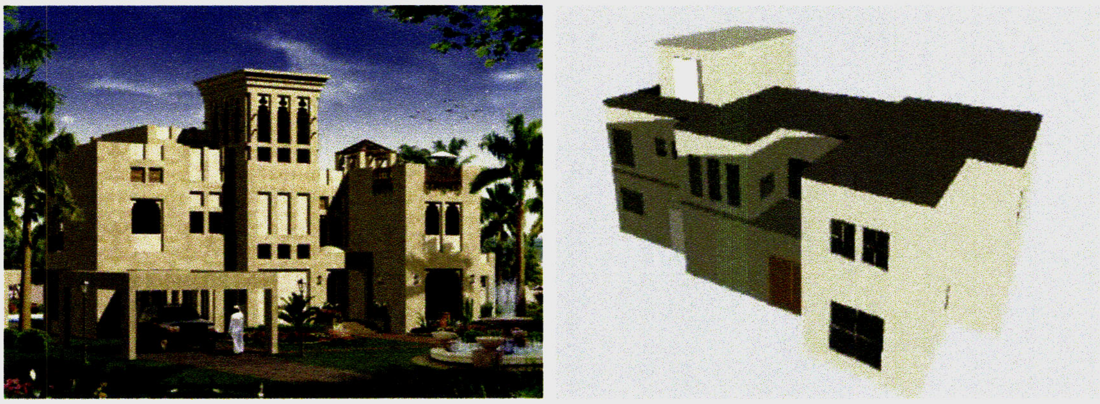

Figure 2: The modelled single family home in Raz al Khaimah. To the right is the 3-D model used for calculations.

Table 1: Characteristics of the reference building.

- Heated/cooled gross floor area:	437	m^2
- Surface of envelope to cooled floor area ratio:	2.1	-
- Cooled floor area per number of inhabitants:	73	m^2/p
- Set point room temperature winter:	22	°C
- Set point room temperature summer:	25	°C
- Window area:	103	m^2
- Window ratio per cooled floor area: $103m^2/498m^2$ =	0.24	
- Windows ratio of total walls area:	17	%
- Glass ratio of total window area:	80	%

The simulated improvement measures include, namely:

- Thermal insulation of the building envelope (walls, roof and windows)
- Efficient adjustable solar shadings
- Airtight envelope and enthalpy recovery through efficient HVAC systems
- Efficient appliances and lighting
- Improvement of the cooling quipment
- Solar hot water heater.

Typical values for these improvements are listed in Table 2, resulting energy use is given in Table 3 and illustrated in Figure 3, showing a dramatic reduction of electrical energy use.

Table 2: Reference characteristics and Minergie® improvements.

		Existing	Minergie®	
1.	U-Value roof	1.8	0.2	W/m^2K
2.	U-values walls	1.3	0.2	W/m^2K
3.	U-value windows:	2.8	1.0	W/m^2K
4.	g-value windows:	0.6	0.5	
	shading factor	0.3	0.8	
5.	air infiltration through cracks, open windows	0.6	0.1	h^{-1}
	air exchange by HRV/ERV:	-	0.46	m^3/m^2h
	efficiency of heat recovery:	-	0.85	
	efficiency of enthalpy recovery:	-	0.6	
	annual electricity use for ventilation	-	1.4	kWh/m^2
6.	annual electricity use for lights, appliances:	34	14	kWh/m^2
7.	domestic hot water, 300 l/day, 60°C	electric	solar	
8.	EER of cooling machine	3	4	

Table 3: Energy use for all purposes in the existing home and in the optimised one.

	Existing		Optimised	
Energy user	Load	Electricity use	Load	Electricity use
Transmission through envelope	195.0	65.0	27.6	6.9
Solar radiation through windows	61.5	20.5	17.6	4.4
Air infiltration	131.2	43.7	24.8	6.2
Enthalpy losses through heat recovery			19.3	4.8
Appliances		34.0		14.0
Load from appliances	34.0	11.3	14.0	3.5
Domestic hot water	13.0	13.0	13.0	0
Fan for ventilation			1.5	1.5
Total	**434.7**	**187.5**	**117.8**	**41.3**

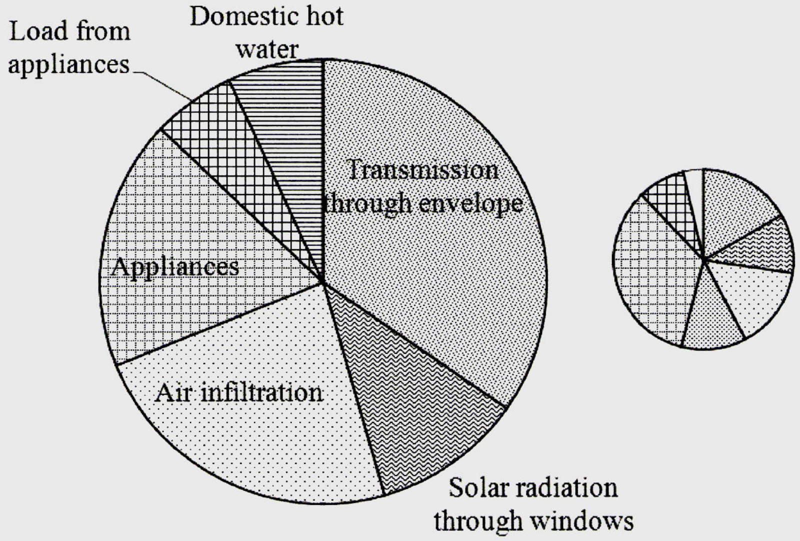

Figure 3: Representation of the energy use of the existing building (left) and the optimised one (right). Energy amounts are proportional to areas.

Cost

An important requirement of the Minergie® standard is that improvements shall be obtained at a reasonable cost. The estimated costs of recommended measures are listed in Table 4.

Table 4: Estimated cost of measure to reduce the energy use.

	Measure, description	Cost
1.	Roof insulation, $226m^2$	100 CHF/m^2; (equal to wall); 23'000.-
2.	Wall insulation, $494m^2$	140-170 CHF/m^2; 70'000.-
3.	Window insulation, triple heat mirror glazing instead of ordinary double glazing, $103m^2$	double glazing: 350 CHF/m^2; triple glazing heat mirror: 400 CHF/m^2
4.	Shading between window panes, approx. $90m^2$	Cost difference of internal to inter-glazing shading: 300 CHF/m^2;
5.	Air tight envelope, Enthalpy recovery ventilation in all rooms, type ComfoAir 550, ComfoFresh	5000 CHF for air tightness 20'000 CHF for Comfort Ventilation
6.	Optimized appliances and lights	5000 CHF (rough estimation),
7.	Hot water by unglazed solar collector	5000 CHF (rough estimation),
8.	Highly efficient cooling machine, oversized for exclusively night time use, distribution of cooling water in radiant ceiling	15000 CHF (rough estimation),

At electricity cost of 0.20 CHF/kWh, a life span of 20 years and an interest rate of 6%, investments of up to 2.50 CHF/kWh are economically interesting, if energy savings are the only one gain. With this point of view, wall insulation, insulating glazing and solar protection, which costs are between 3 and 4 CHF/kWh are not cost-effective. However, a well-insulated and air tight building envelope has many additional advantages related to comfort and hence building-value: avoid sand infiltration, better thermal comfort, lower cooling power, hence less draft and smaller cooling system, better acoustic insulation, less noise, no mould growth risk. Moreover, such investments fall below the short time economic limit if the life span is expanded to 40 years.

DISCUSSION

The energy consumption in this climate is mainly determined by space cooling. If the domestic hot water is heated by solar thermal collectors (preferably unglazed to avoid overheating), the demand is reduced to cooling and ventilation only. The load can be reduced to low values by :

- thermal insulation of roof and walls to U-values of 0.2 - 0.3 W/m^2K
- air-tight envelope (leakage rate at 50 Pa less than1/h) to reduce uncontrolled infiltration of hot, humid ambient air
- high efficiency enthalpy recovery ventilation to reduce the cooling needs for the required fresh air and to improve dramatically indoor comfort (no mould, no sand, no bad odours, no humid air)
- adjustable shading to reduce radiation through windows, while allowing for day-light on windows not hit by the sun (systems mounted between window panes exist)
- double or triple heat mirror inner glazing to reduce heat transmission

- highly efficient cooling machine, thanks to radiant cooling with water loop, over-sizing and enlarging heat exchangers. Oversizing allows using the cooling machine at night only, when outdoor air is cooler, thus improving its COP.

Photovoltaic system could provide electricity at reasonable cost, thanks to the 2100 sunshine hours of peak power per year. It is also a perfect means to reduce electricity demand, since the sun is available every month. However, according to users of the dwelling, PV absorbers have to be cleaned weekly from sand, to maintain a good efficiency. It must be assumed that this would not be done by average local users. It therefore makes less sense to include PV as a mandatory means of the standard.

A first draft of the definition of a Minergie® standard for the tropics is as follows

Maximum annual use of electricity 30 kWh/m^2 for space cooling and heating, domestic hot water and ventilation. This is close to twice the value in Switzerland, as a result of the difficult climate conditions.

Primary requirements:
- Air tightness of building envelope: $n_{L50} < 0.6h^{-1}$
- Automatic ventilation with heat recovery
- Minimal level of thermal insulation: U_{walls} and $U_{roof} < 0.3$ W/m^{2}K, $U_{windows} < 1.5$ W/m^{2}K
- Shading of windows with g < 0.15, for all windows receiving direct sun-light
- water consumption:
  - dishwasher < 7 l/use for 12 standard covers
  - washing machine < 45 l/use per 7 kg of laundry
  - shower heads < 12 l/min
  - water heads on sinks < 9 l/min
  - toilet flush < 6/3 l/use with choice of flush amount
  - only traditional plants in garden, to avoid or strongly reduce watering

ACKNOWLEDGEMENTS

The authors cheerfully thank the Ras Al Khaimah Investment Authority and Al Hambra Construction who provided the drawings, characteristics and data of the buildings.

REFERENCES

1. Minergie: T*he MINERGIE®-Standard for Buildings- Information for architects.* http://www.minergie.ch/publications.478.html
2. Aabid Fouad: *Standards Minergie® dans les pays à climat tropical humide.*Projet de semestre – Master en Mécanique, LESO-PB/EPFL, Juin, 2011.
3. Ruedi Kriesi: *Minergie® standard for single family home in the climate of Ras Al Khaimah.* Personal communication, 2011.
4. Ruedi Kriesi: *Minergie® standard for office building in the climate of Ras Al Khaimah.* Personal communication, 2011.