

Crucial Building Parameters as a Novel Approach for the Design of Passive Solar Houses in a Mediterranean Climate

Ernst Müller

Building Research Institute, University of Kassel / Germany

(Forschungslabor für Experimentelles Bauen, Universität Kassel)

this investigation formed part of an international project on:

**” Earthquake Resistant Housing with Passive Climatisation,
built with Local Materials in Rural Zones of the Andes Region ”**

funding:

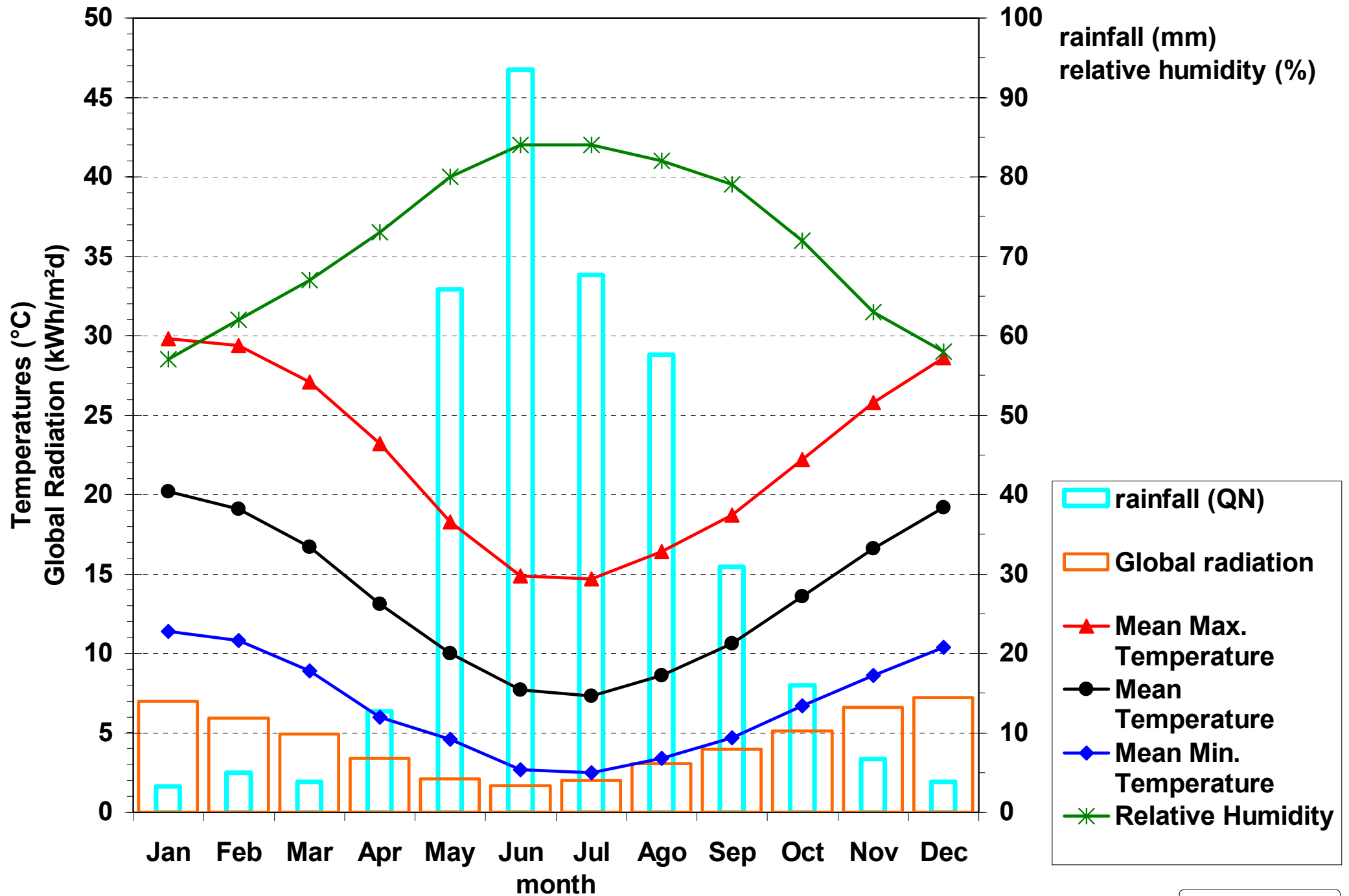
Deutsche Forschungsgemeinschaft DFG and German Technical Cooperation GTZ

Introduction

- **Passive design** is a promising strategy for **sustainable housing design** both in developing and rich countries:
it permits the improvement of thermal comfort
at low ecological and economical cost, making it accessible for all people.
- Thermostatically regulated central heating systems or air conditioning can rarely be found in residential houses and apartments in Chile.
- Here, **passive design** means the absence of mechanical heating and cooling systems, without promising always-perfect thermal comfort conditions

Climate Graph for Santiago de Chile (Pudahuel)

latitude: -33,4°; longitude: -70,8°; altitude: 475 m



Aims and Methods

- **Standard methods** and **calculation procedures** for thermal comfort, that assume constant interior temperatures and are oriented in energy needs, are not appropriate for the evaluation of thermal quality.
- **Thermal simulations** are **too complicate for the first stages** of the design process and their use is more justified for investigation.
- **Aims:**
 - 1) create **simple and efficient design tools**
 - 2) permit a better **understanding** and optimisation of the complex balance between the demands for the hot and cold period
 - 3) offer clear **design recommendations** and simple **design solutions**
- **Basic methods:**

large number of **thermal simulations** with a **test reference year** for central Chile, elaborated with an own methodology

Concept of Crucial Building Parameters and Design Tools

classical building code calculations

basic **primary thermal parameters**: size dependent

total heat loss coefficient H_t

thermal capacity C

total heat gains P_g

building codes:
energy needs
for heating
in winter

passive design characteristics included in
basic thermal parameters

crucial **secondary thermal parameters**:
size independent combinations of basic parameters
gains-to-loss ratio GL , time constant τ , utilisation factor η

thermal simulations → **correlation functions** :

effective gains-to-loss ratio GL_{eff}

excess gains-to-loss ratio GL_{exc}

not adequate for
passive design

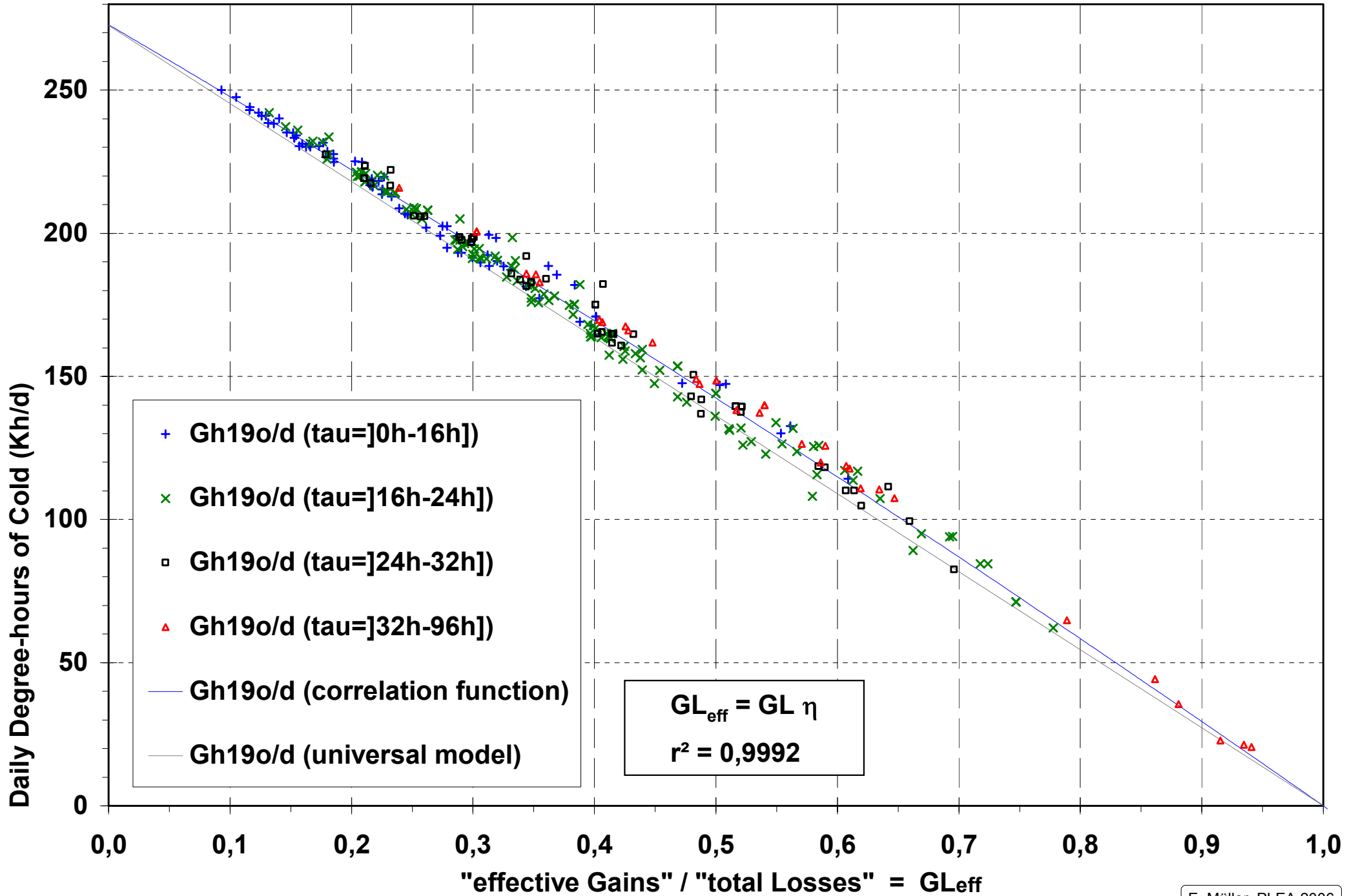
winter:
mean daily
degree-hours
of cold

summer:
mean daily
degree-hours
of heat

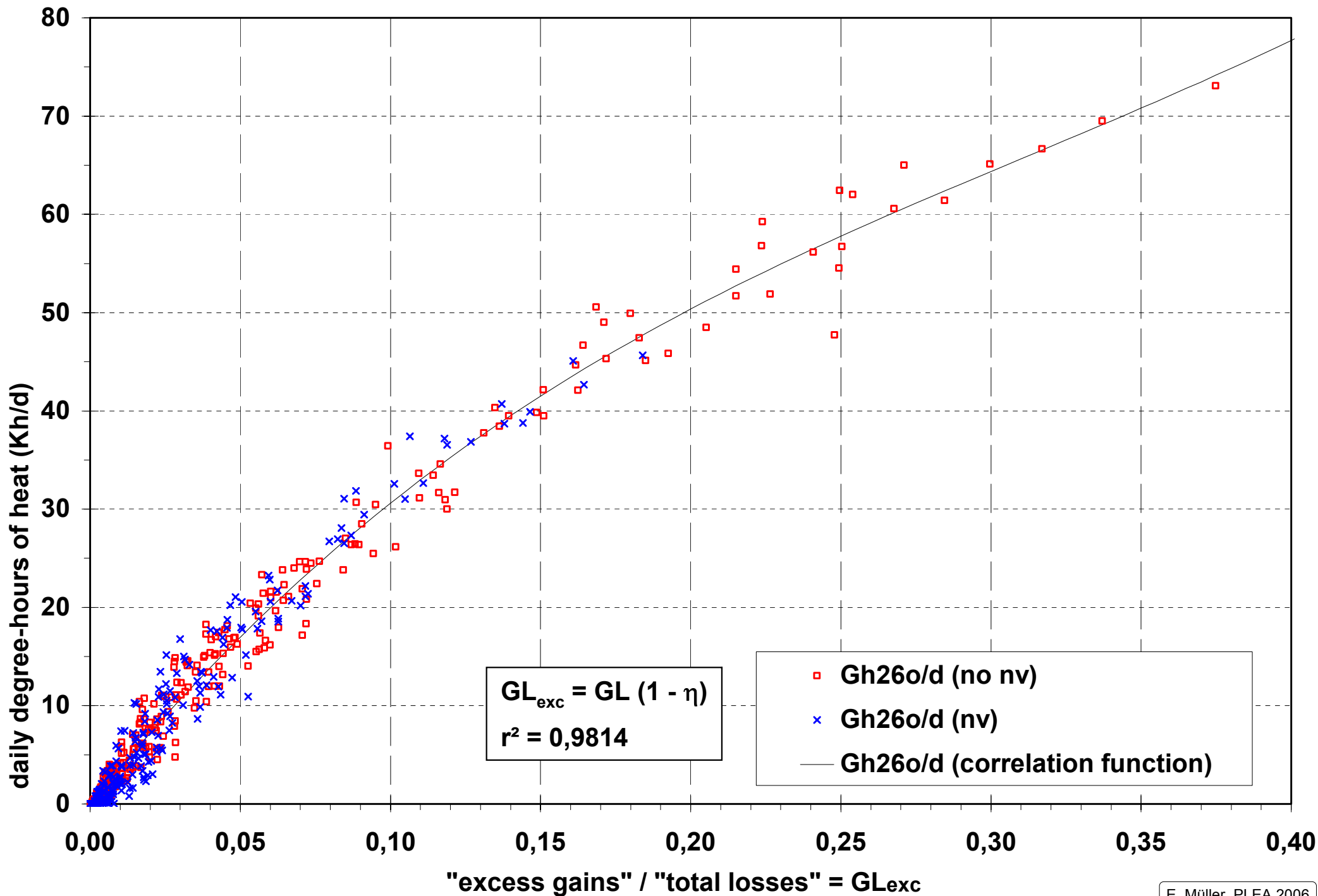
evaluation of passive design performance

Correlation for Daily Degree-hours of Cold of Operative Temperatures

indicating time constant for winter (July) in Santiago (Chile); base 19°C

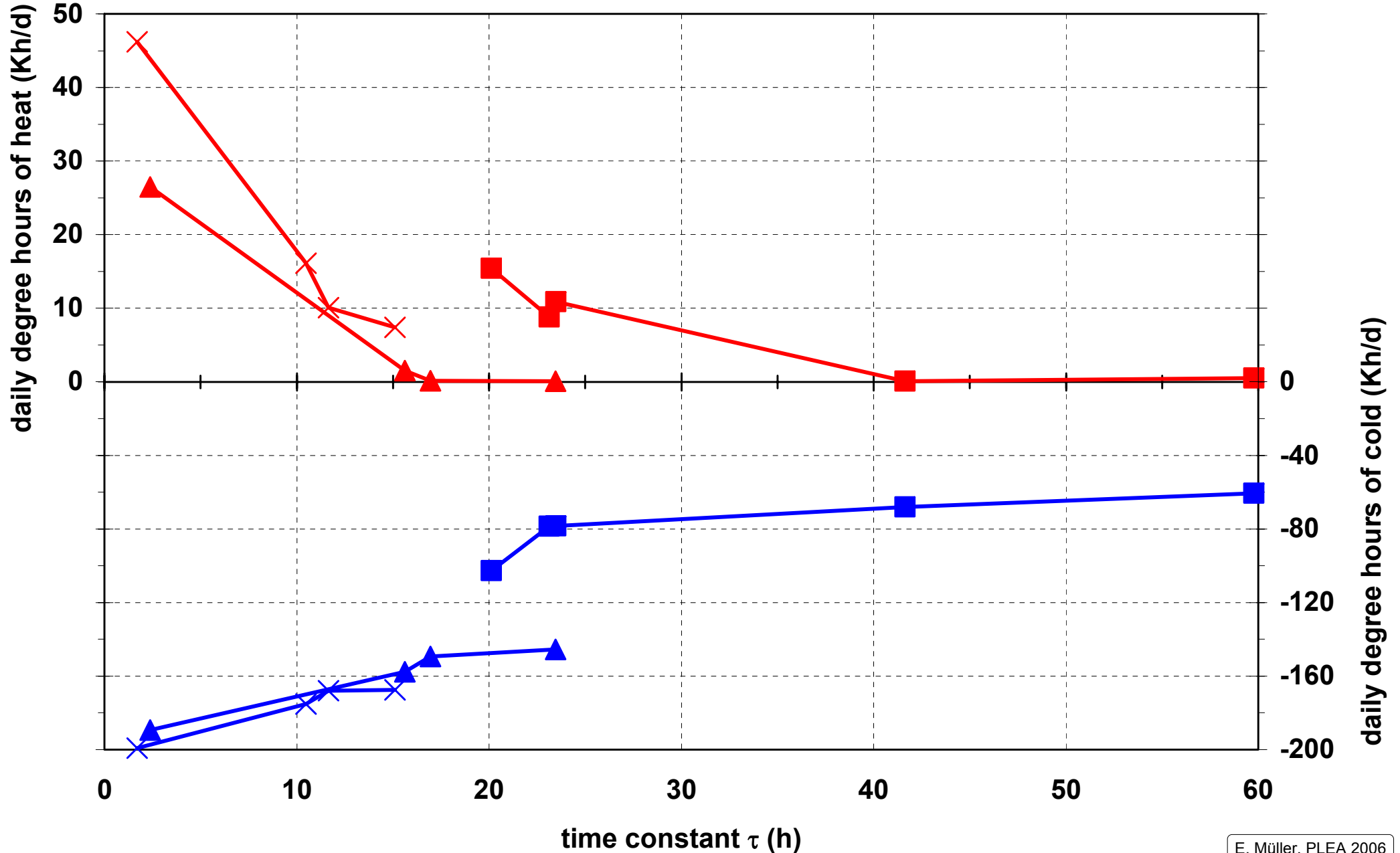


Correlation for Daily Degree-hours of Heat of Operative Temperatures indicating night ventilation for **summer** (Jan.) in Santiago (Chile); base 26°C



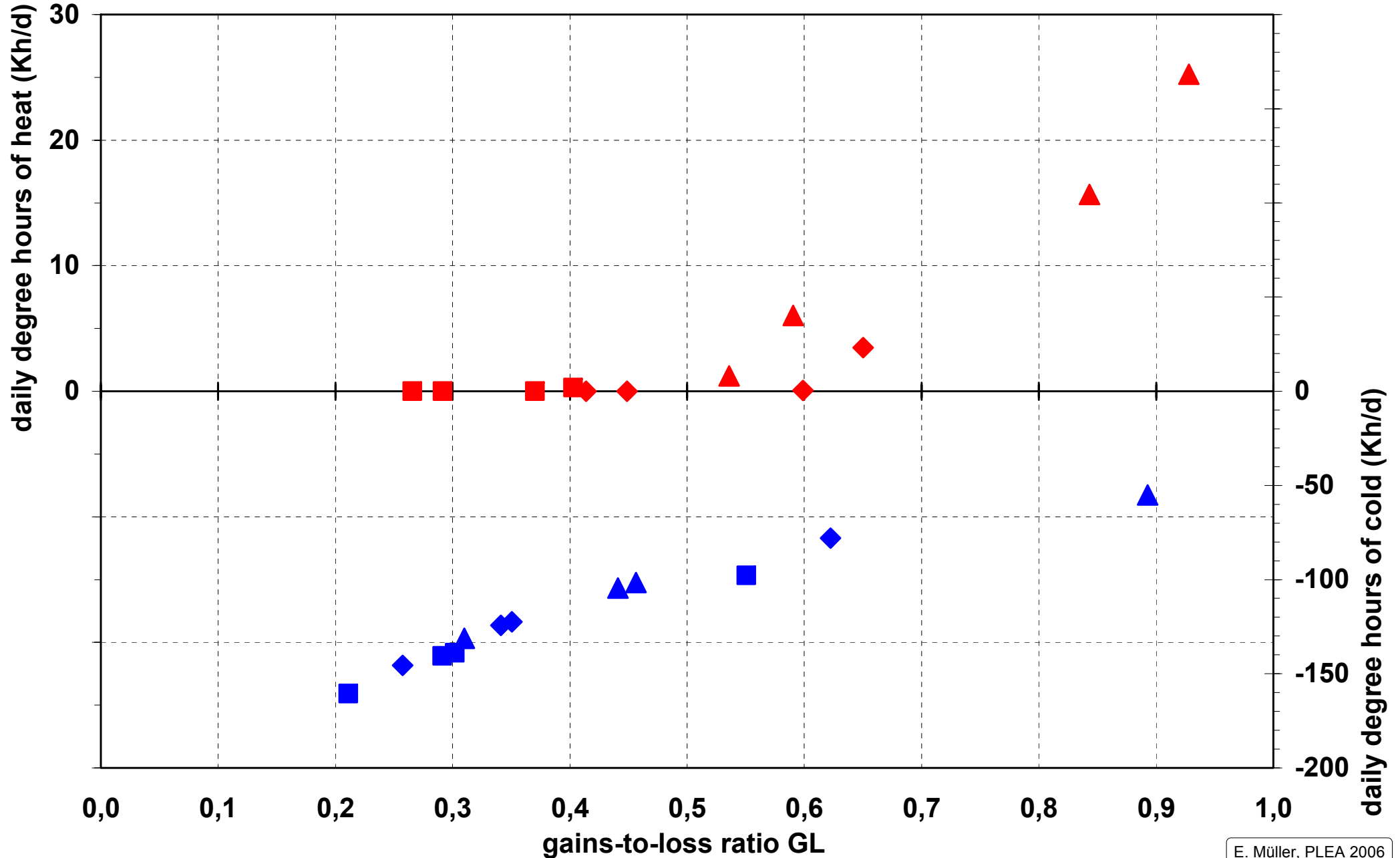
Systematic Design Recommendations: time constant and insulation level

hot period (12~2, base 26°C, >0) and cold period (5~9, base 19°C, <0)



Influence of gains-to-loss ratio - insulated walls of rammed earth (heavy floor)

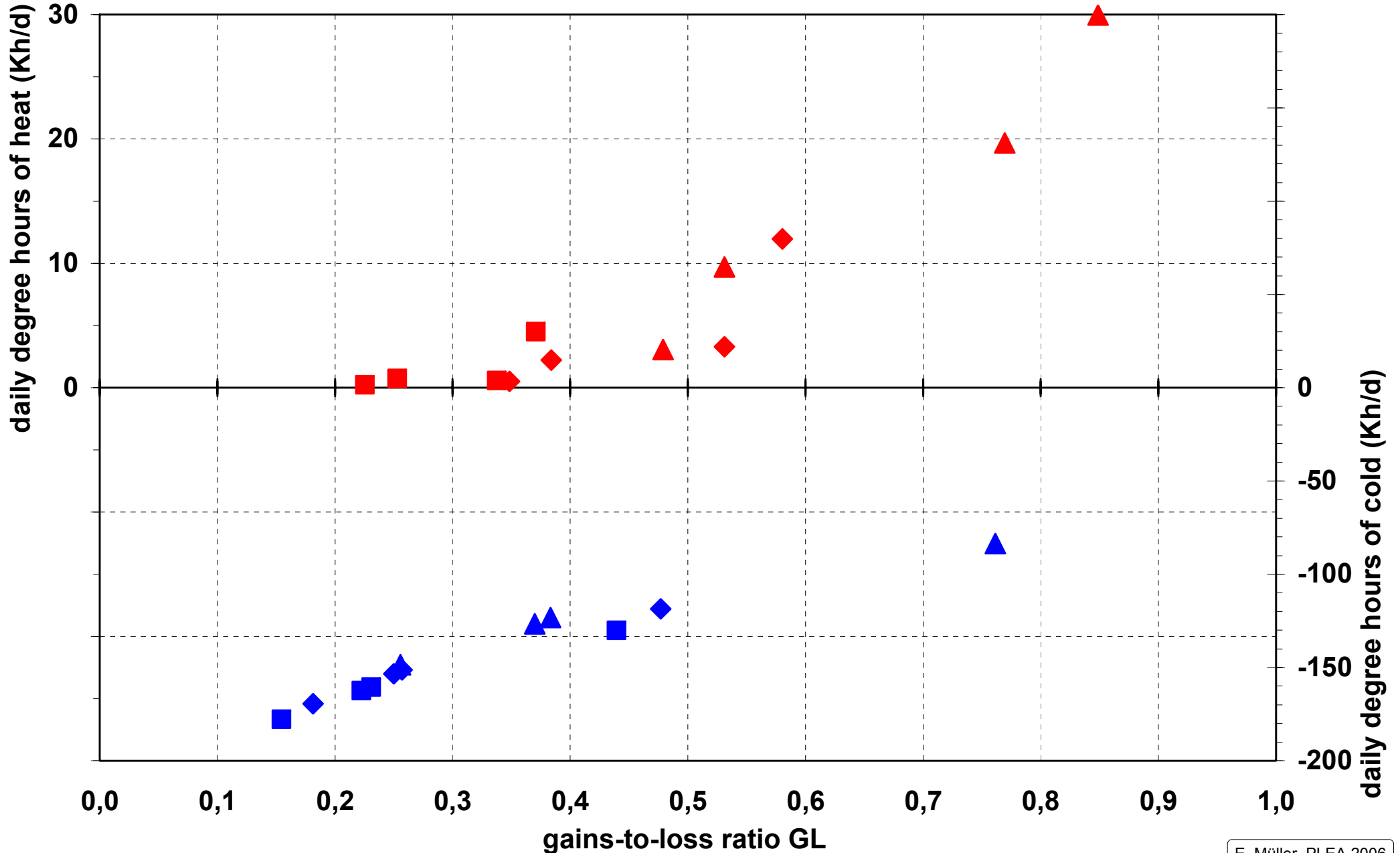
hot period (12~2, base 26°C, >0) and **cold period** (5~9, base 19°C, <0)



■ big simple win. (sum.; 26,3h)	◆ std. double win. (sum.; 31,6h)	▲ big double win. (sum.; 23,5h)
■ big simple win. (wint.; 26,3h)	◆ std. double win. (wint.; 31,6h)	▲ big double win. (wint.; 23,5h)

Influence of gains-to-loss ratio - wood panel house (heavy floor)

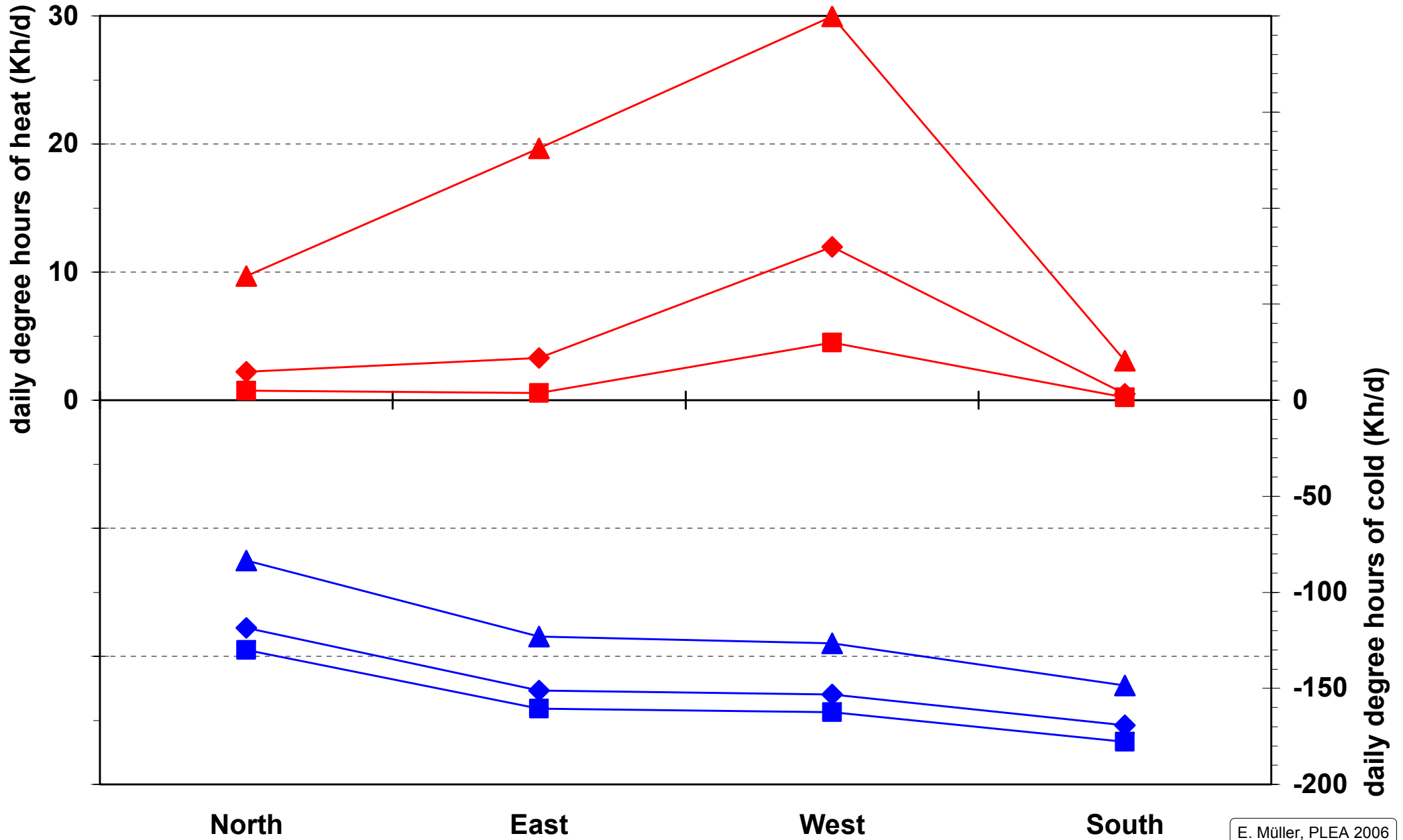
hot period (12~2, base 26°C, >0) and cold period (5~9, base 19°C, <0)



■ big simple win. (sum.; 15,6h)	◆ std. double win. (sum.; 18h)	▲ big double win. (sum.; 17,4h)
■ big simple win. (wint.; 15,6h)	◆ std. double win. (wint.; 18h)	▲ big double win. (wint.; 17,4h)

Influence of orientation (gains-to-loss ratio) - wood panel house (heavy floor)

hot period (12~2, base 26°C, >0) and **cold period** (5~9, base 19°C, <0)



E. Müller, PLEA 2006

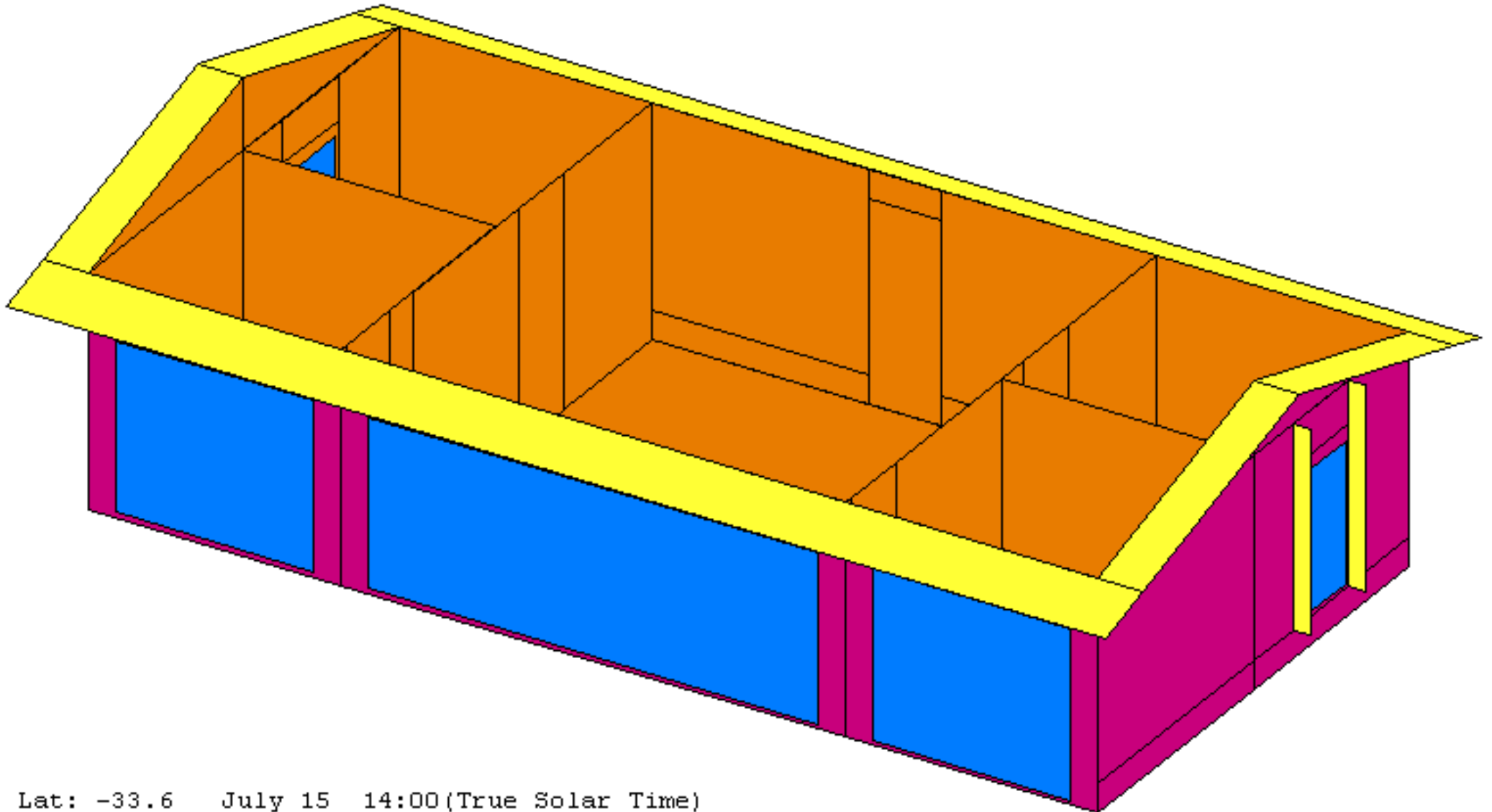
- big simple win. (sum.; 15,6h)
 ◆ std. double win. (sum.; 18h)
 ▲ big double win. (sum.; 17,4h)
- big simple win. (wint.; 15,6h)
 ◆ std. double win. (wint.; 18h)
 ▲ big double win. (wint.; 17,4h)

Application: Design Recommendations

- **during the whole year:**
 - maximise the **utilisation factor η**
with a large **time constant τ** and thermal capacity, depending on GL;
this permits good utilisation of passive gains and avoids overheating
 - time constants over 16h are necessary and over 32h are recommendable
- **in the cold period (winter):**
 - increase the **effective gains-to-loss ratio GL_{eff}**
reducing losses and increasing solar gains in an equilibrated way
 - effective gains-to-loss ratio: GL_{eff} values over 0.95 (at least 0.9)
- **in the hot period (summer):**
 - minimise the **excess gains-to-loss ratio GL_{exc}**
limiting solar gains and increasing heat losses,
 - selective and variable elements permit to
resolve seasonal conflicts of recommendations for hot and cold period:
orientation, shading, losses by ventilation
 - excess gains-to-loss ratio: GL_{exc} values up to 0.008 (max. 0.015)

Passive House - direct gain: 15.7. - 14:00

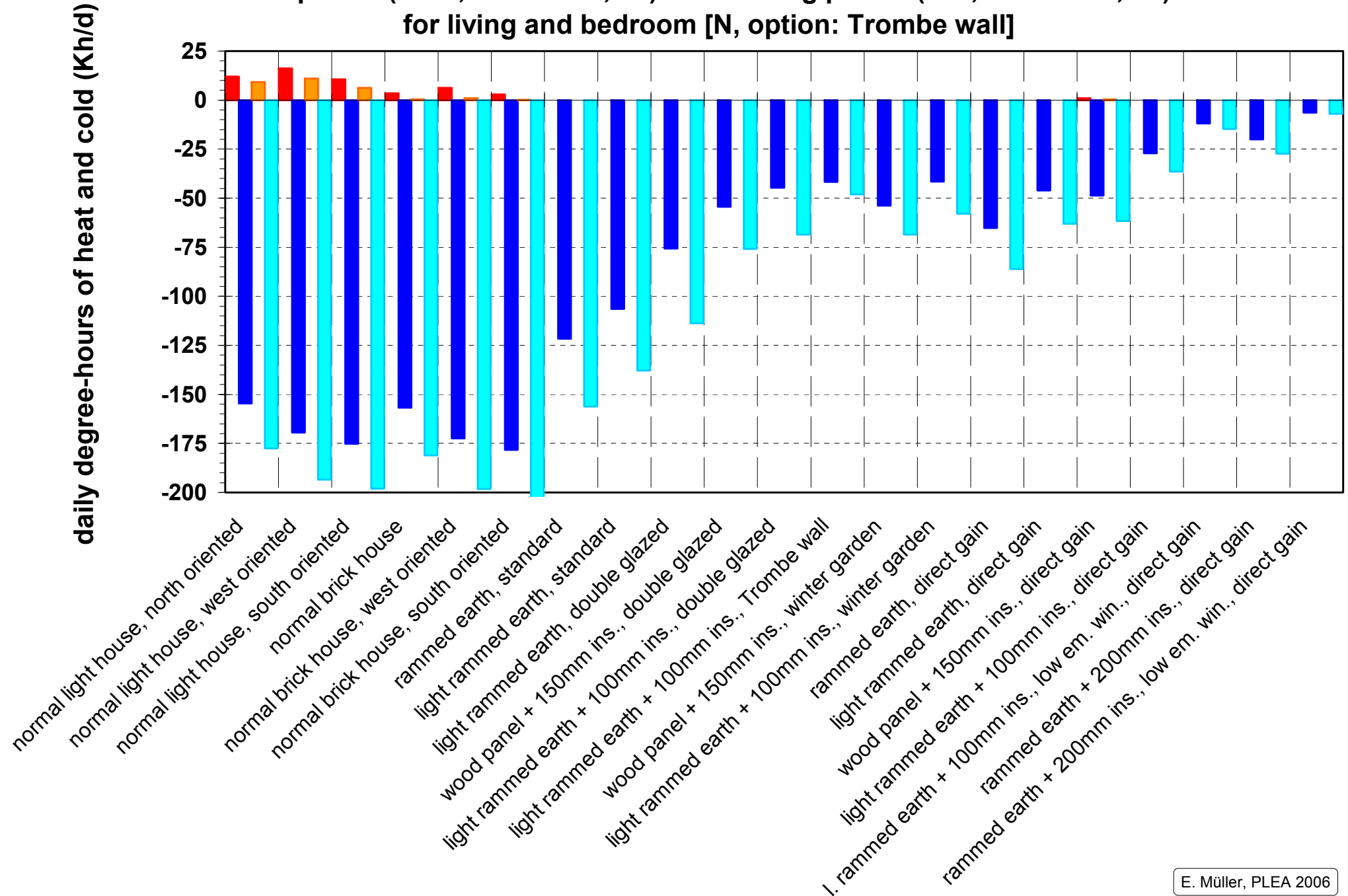
rammed earth, improved insulation, solar protection, night ventilation



Lat: -33.6 July 15 14:00 (True Solar Time)

Parameter Study - Santiago: daily degree hours of heat and cold

hot period (12~2, base 26°C, >0) and heating period (5~9, base 19°C, <0)
for living and bedroom [N, option: Trombe wall]



Ernst Müller

Manual de diseño para viviendas con climatización pasiva

**Forschungslabor für Experimentelles Bauen
Universidad de Kassel, Alemania**

Contenido:

Agradecimientos	iv	
Prefacio	v	
1	Introducción a la climatización pasiva	1
1.1	Climatización pasiva.....	1
1.2	Confort térmico	1
1.3	Estrategias de climatización pasiva y matriz de soluciones constructivas	3
2	Herramientas para el diseño pasivo	13
2.1	Herramientas tradicionales de diseño pasivo y comparación de métodos de diseño	13
2.2	Herramientas simples.....	15
2.2.1	Análisis del clima	15
2.2.2	Herramientas de cálculo para el dimensionamiento de sobretechos	17
2.3	Simulación térmica	23
2.4	Herramientas de cálculo para la estimación del confort térmico en verano e invierno	23
2.4.1	Desarrollo de las herramientas de cálculo.....	23
2.4.2	Características térmicas básicas de una casa	25
2.4.3	Elementos especiales: espacio ático	26
2.4.4	Determinación de los factores de corrección.....	27
2.4.5	Estimación del confort térmico en invierno	27
2.4.6	Estimación del confort térmico en verano.....	30
2.4.7	Calificación del diseño térmico por las condiciones de confort térmico	32
2.4.8	Resumen de las aplicaciones posibles de las herramientas de cálculo	33
3	Recomendaciones de diseño pasivo	35
3.1	Recomendaciones de diseño por aspecto constructivo para la zona central de Chile	35
3.2	Estrategias y recomendaciones sistemáticas de diseño pasivo	44
3.3	Comparación de propuestas de diseño pasivo con diseños convencionales.....	49
4	Anexos	60
4.1	Referencias bibliográficas	60
4.2	Instrucciones para el uso de las herramientas de cálculo para el confort térmico	60

Conclusions

The concept of **crucial building parameters** can facilitate a better understanding of the dynamic interaction of building design, climate and user behaviour.



In its essence **passive design** means the **intelligent control of variable natural energy flows**.



Simple design recommendations and proposals could be presented in a **manual on passive design**, published electronically in Spanish.



The application of complex computational methods in the investigation permitted the development of simple and economical **tools** and **design solutions** for **passive houses**.



The **concept of crucial building parameters** and the **methods** developed here are useful to simplify the design process, for the elaboration of simple design tools and for design recommendations in other climate zones.



This can facilitate the diffusion of **passive houses** as an important contribution to **sustainable development**.