国土交通省 国土技術政策総合研究所
建築研究部・環境設備基準研究室

平成 26 年 12 月 16 日

「第２回建物性能シミュレーションに関するアジア地域の国際会議」に投稿した論文が最優秀論文賞を受賞しました

平成 26 年 11 月 28, 29 日に名古屋で開催された「第 2 回建物性能シミュレーションに関するアジア地域の国際会議」において、わが国における建築物の省エネルギーのためのシミュレーションツール開発に関する論文を投稿し、最優秀論文賞を受賞しました。

【 表彰内容 】

会議名称 ： The 2nd Asia Conference of
International Building Performance Simulation Association – ASim2014
（第２回建物性能シミュレーションに関するアジア地域の国際会議）

開催場所 ： 名古屋大学（名古屋市）

受賞日 ： 平成２６年１１月２９日

受賞名 ： Web-based Simulation Tool for the 2013 Energy Efficiency Standard for Commercial Buildings in Japan
（非住宅建築物の省エネルギー基準のための Web ベースシミュレーションの開発）

受賞者 ： 国土技術政策総合研究所 建築研究部環境･設備基準研究室主任研究官 宮田征門
住宅研究部長 澤地孝男、住宅研究部住環境計画研究室主任研究官 赤嶺嘉彦
(独)建築研究所 環境研究グループ上席研究員 桑沢保夫、主任研究員 三木保弘

受賞時の様子
（右から三人目が宮田主任研究官）


ASim2014
The 2nd Asia Conference of
International Building Performance Simulation Association
November 28-29, 2014, Nagoya, Japan
BEST PAPER AWARD
to
Masato Miyata, Takao Sawachi, Yasuo Kuwasawa,
Yasuhiro Miki, Yoshihiko Akamine
for the paper entitled
Web-based Simulation Tool for the 2013 Energy Efficiency Standard
for Commercial Buildings in Japan
奥宮 正哉
Masaya OKUMIYA
Conference Chair, ASim 2014
President, IBPSA - Japan

表彰状

【 会議の概要 】

「建物性能シミュレーションに関するアジア地域の国際会議」は、30 年の歴史を持ち 2 年に 1 度開催される「国際建物性能シミュレーション協会による国際会議」下に、アジア地域の発展に寄与するため中間年に開催される会議です。本年度は、11 月 28, 29 日に名古屋で開催され、150 名の参加と 107 の論文が寄せられました。

【 論文の概要 】

本論文は、国総研が（独）建築研究所とともに新たに開発した、設計時点において建築物のエネルギー消費量を精度良く推計する方法（シミュレーションツール）について解説をしたものです。この方法は、エネルギーの使用の合理化等に関する法律（省エネ法）などに基づいて建築確認手続きに付随して行われる届出のため、設計者等が建築物の省エネ達成状況を評価する際に使用されるものです。国総研・建築研究所は、この推計方法に基づく評価を Web 上で簡易に行うことができるシステムも開発し、2012 年 12 月より国土交通省のホームページなどを通じて無償で公開しています。このシステムは、新たな推計方法による届出が義務化された 2014 年 4 月以降の平均で 1 日あたり約 800 回利用されており、建築物の省エネルギー化の推進に寄与しています。

【 参考 】

- 国土交通省　改正省エネルギー法関連情報（住宅・建築物関係）
  http://www.mlit.go.jp/jutakukentiku/build/jutakukentiku_house_tk4_000005.html
- 住宅・建築物の省エネルギー基準及び低炭素建築物の認定基準に関する技術情報（国土交通省国土技術政策総合研究所、独立行政法人建築研究所）
  http://www.kenken.go.jp/becc/index.html
- 発表時に使用した資料（次頁以降参照）

以　上

Web-based Simulation Tool for the 2013 Energy Efficiency Standard for Commercial Buildings in Japan

Masato Miyata *1) , Takao Sawachi *1) ,
Yasuo Kuwasawa *2) , Yasuhiro Miki *2), Yoshihiko Akamine *1)

*1) National Institute for Land and Infrastructure Management
*2) Building Research Institute

Outline

1. Background
   - Present situation of Japanese Energy Efficiency Standard for commercial buildings
2. Energy Efficiency Standard revised in 2013
3. Web-based simulation tool
4. Calculation methodologies
   (air-conditioning system)

1. Background

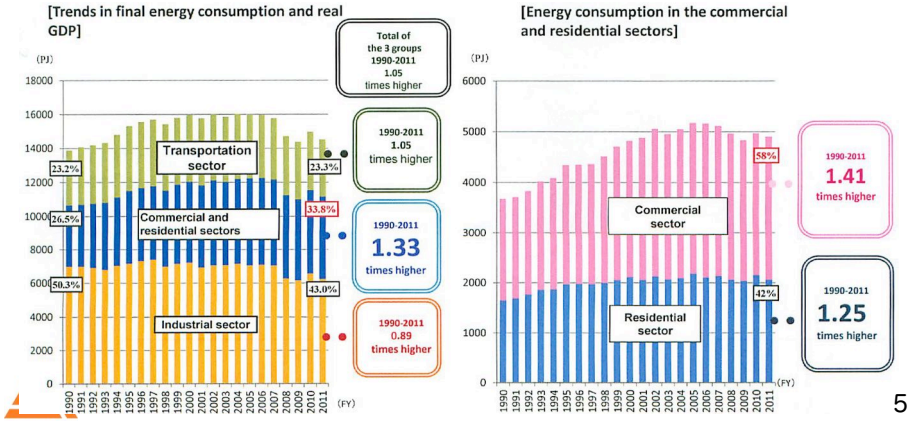
History of the Building Energy Efficiency Standard

1979	The Energy Conservation Law was established.
1980	The Building Energy Efficiency Standard was established according to the law. No obligation was taken on building owners. So the standard was similar to the recommendation.
1992	The standard for housing was revised owing to the Gulf War.
1993	The standard for buildings was revised as well as that for housing.
1999	The levels of the standard were enhanced because of the Kyoto Protocol.
2009	Reporting on the standards made mandatory except for small buildings and housing.

When building constructors build new commercial buildings with a floor area of more than 300 m^2, they must review their buildings' energy performance and report the review results to administrative agencies before they start building.

Transition of Final Energy Consumption and Energy Consumption in Housing and Building in Japan

When we consider transition of Final Energy Consumption, the commercial and residential sectors account for over 30% of final energy consumption in Japan.
The graph on the left shows that these sectors have seen a more significant increase than the transportation and industrial sectors. Therefore, strengthened energy efficiency measures are called for mostly in the commercial and residential sectors.



History and Future of the Building Energy Standard

1979	The Energy Conservation Law was established.
1980	The Building Energy Standard was established according to the law. No obligation was taken on building owners. So the standard was similar to the recommendation.
1992	The standard for housing was revised owing to the Gulf War.
1993	The standard for buildings was revised as well as that for housing.
1999	The levels of the standard were enhanced because of the Kyoto Protocol.
2009	Reporting on the standards made mandatory except for small buildings and housing.
2013	The whole standard was revised. Primary energy consumption is needed as a criterion index, in addition to envelope performance.
2020	Compliance with the standard will be mandatory for all newly built buildings and housing.

2. Revision of the 2013 Standards

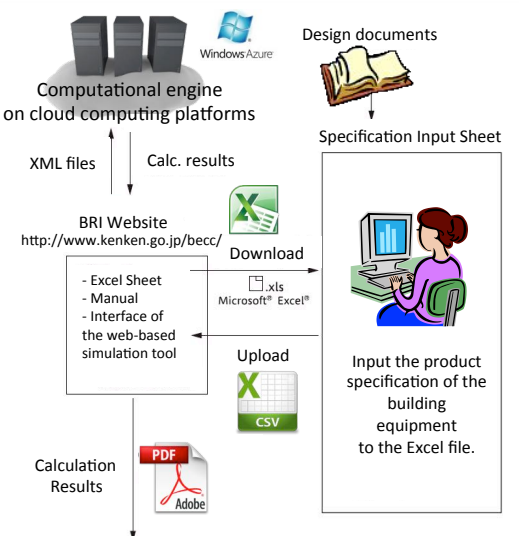
Revision of the 2013 Standards

- Primary energy consumption is needed as a criterion index, in addition to envelope performance.
- NILIM and BRI have developed new methodologies for evaluating the primary energy consumption.

- The methodologies are expected to be suitable for the mandatory standard.
  - Easy to understand evaluation logic (simplified and streamlined)
  - Easy to understand evaluation results
  - A fair, reliable, and transparent evaluation logic
  - Streamlined and efficient evaluation and review
    - Provision of evaluation-assistance simulation tools
  - Defined and unified evaluation rules
    - Same results regardless of who makes data entries
    - Same results regardless of who performs a review

3. Web-based simulation tool

Web-based Simulation Tool for Compliance with 2013 Energy Efficiency Standard



Flow for evaluation of a building's primary energy consumption in commercial buildings

Design/Reference Primary Energy Consumption

- BEI (*Building Energy Index*)
  = Design primary energy consumption Ed (design value)
  / Reference primary energy consumption Er (reference value)

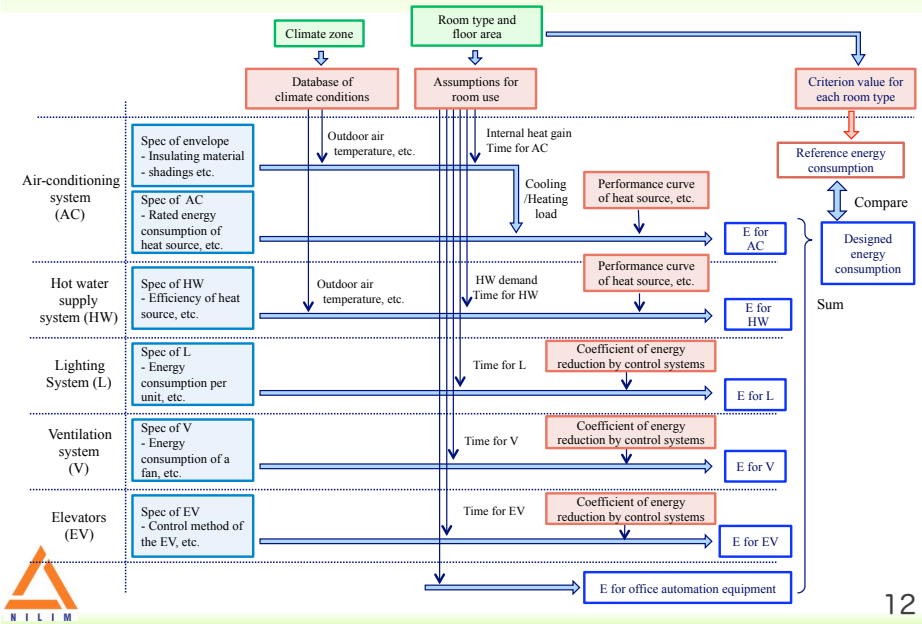
  Note: If BEI ≤ 1.00, the Energy Efficiency Standards are met.

$$E_d = E_{d,AC} + E_{d,V} + E_{d,L} + E_{d,HW} + E_{d,EV} + E_{OT} - E_{d,EF}$$

$$E_r = E_{r,AC} + E_{r,V} + E_{r,L} + E_{r,HW} + E_{r,EV} + E_{OT}$$

AC: air-conditioning system; V: ventilation system; L: lighting system;
HW: hot water supply system; EV: elevators;
OT: office automation equipment;
EF: photovoltaic power generation systems and cogeneration systems

Calculation Flow of Primary Energy Consumption



Reference Energy Consumption

$$\begin{cases} E_r = E_{r,AC} + E_{r,V} + E_{r,L} + E_{r,HW} + E_{r,EV} + E_{OT} \\ E_{r,*} = \sum_{j=1}^{N} \left(E_{r,per,*,j} \times A_j \right) \end{cases}$$

Aj : Floor area of room j [m²]

Er,per,j is defined in the standard for 8 climate areas and for 201 room types

- Reference values Er,per,*,j are defined for each room-use type
  - 201 types
  - Standardized room-use conditions are specified for each room-use type

Reference primary energy consumptions, Er,per,*,j described in the standard [MJ/m²/year]

Building type	Type of room	Air-conditioning			Ventilation	Lighting	Hot water supply			Others
		Area 1	Area 2	…	-	-	Area 1	Area 2	…	-
Office	Office	898	917	…	0	498	20	20	…	498
	Meeting room	1060	1071	…	0	231	51	50	…	42
	Central monitoring roo	2457	2508	…	0	1171	46	43	…	2565
	Locker room	787	797	…	138	202	995	975	…	0
	…									

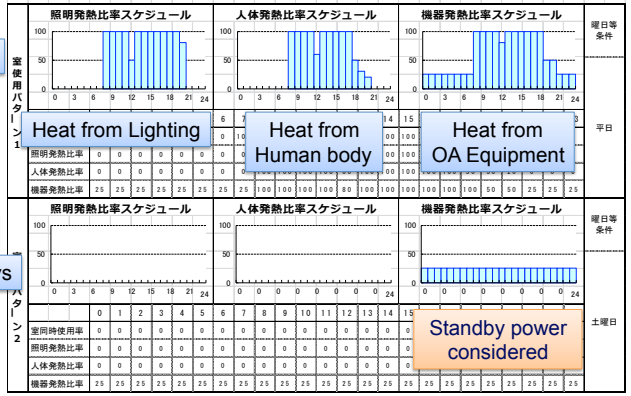
Example of Assumptions for the Room Usage

Building Type	Type of room	Operation Time for AC	Internal heat gain (lighting)	Internal heat gain (metabolism)	Internal heat gain (OA equipment)	Fresh air intake	Illuminance level	…
		[h/year]	[W/㎡]	[person/㎡]	[W/㎡]	[m³/m²h]	[lx]	
Office	OfficeRoom	3374	12	0.1	12	5.0	750	
	ComputerRoom	3374	12	0.1	30	5.0	750	
	MeetingRoom	2410	10	0.25	2	12.0	500	
	TeaRoom	2410	10	0.25	2	12.0	300	
	Canteen	723	30	0.5	0	15.0	500	
	CentralMonitoringRoom	8760	20	0.15	30	4.0	500	
	LockerRoom	3374	15	0.3	0	4.0	300	
	Corridor	3133	15	0.03	0	2.5	200	
	Lobby	3133	15	0.03	0	2.5	500	
	Toilet	3133	15	0.03	0	2.5	300	
	SmokingRoom	3133	15	0.03	0	2.5	300	
	Kitchen	0	0	0	0	0.0	750	
	IndoorParking	0	0	0	0	0.0	150	
	MechanicalRoom	0	0	0	0	0.0	200	
	ElectricalRoom	0	0	0	0	0.0	200	
	Kitchenette	0	0	0	0	0.0	300	
	StorageRoom	0	0	0	0	0.0	300	
	CopyRoom	0	0	0	0	0.0	500	
	GarbageStorage	0	0	0	0	0.0	150	

Standardized room-use conditions
(Office Buildings, Offices)

Reference value for heat-generation density
Lighting: Old Standards
25 W /m² → 12 W/m²
Human body: Old Standards
0.2 persons/m² → 0.1 persons/m²
Equipment: Old Standards
10 W/m² → 12 W/m²

共通		空調						空調以外の換気				照明						給湯
カレンダパターン		年間空調時間	照明発熱参照値	在室者数参照値	機器発熱参照値	新鮮外気導入量		年間換気時間	基準設定換気風量	基準設定換気回数		年間照明点灯時間	基準照明消費電力	基準設定照度	基準設定保守率			年間給湯日数
A		[h/年]	[W/㎡]	[人/㎡]	[W/㎡]	[m3/㎡・h]		[h/年]	[m3/m2h]	[回]		[h/年]	[W/㎡]	[lx]				[日]
室使用パターン別年間日数		3374	12.0	0.1	12.0	5.0		0	0.0	–		3133	16.3	750	0.69			241
		空調時刻（時間）		人体発熱参照値	機器発熱参照値	作業強度指数		換気時刻（時間）			基準設定全熱交換効率[P.u]	照明点灯時刻（時間）			基準設定器具形式	基準設定光源		基準設定湯使用量
1	241	1	7	21	(14)			1	–	–	0	1	8	21	(13)			
2	51	2	–	–	(0)	[W/㎡]	[W/㎡]	[-]	2	–	–	(0)	基準設定換気方式	2	–	–	(0)			L/人日
3	73	3	–	–	(0)	11.9	3.0	3	3	–	–	(0)	–	3	–	–	(0)	C	FHF32	3.8



Weekdays

Saturdays

Sundays/Holidays

Heat from Lighting

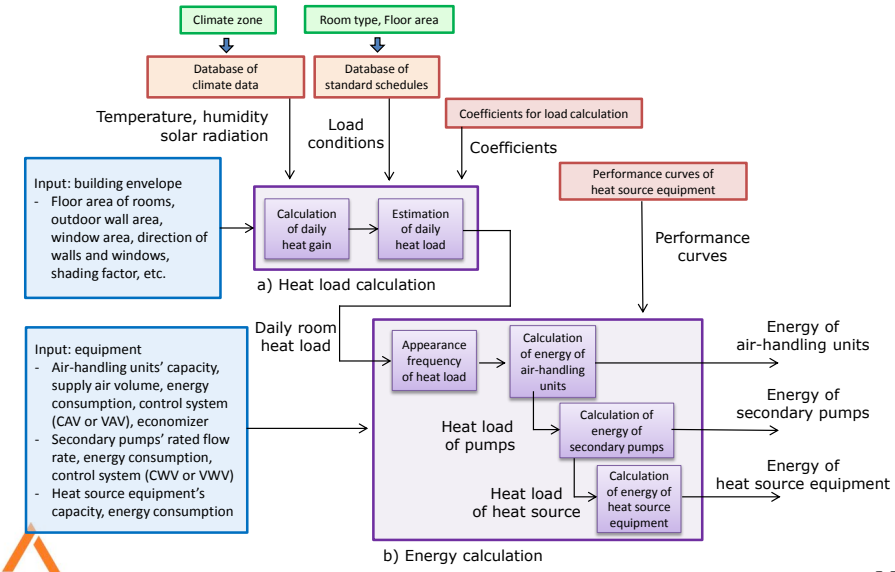
Heat from Human body

Heat from OA Equipment

Standby power considered

4. Calculation methodologies (air-conditioning system)

Calculation Flow of Primary Energy Consumption



Concept of Room Heat Load Calculation (1)

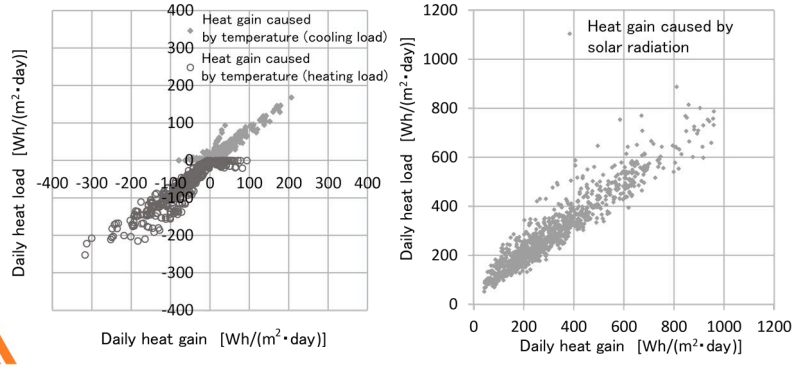
- Daily heat loads of each room $Q_{rL,j}$ are calculated using steady-state heat gain $Q_{rG,j}$.

$$Q_{rL,j}(t) = a_j\, Q_{rG,j}(t) + b_j$$

- Two kinds of heat gain $Q_{rG,j}$ are taken into account:
  - Heat gain through exterior walls and windows as a result of the temperature difference
    = Overall heat transfer coefficient of walls and windows x area x indoor-outdoor temperature difference
  - Heat gain through windows as a result of solar radiation
    = Solar heat gain coefficient x area x shading coefficient x solar radiation

Concept of Room Heat Load Calculation (2)

- Coefficients a_j and b_j are coefficients for converting static heat gain to dynamic heat load.
- These coefficients are determined by using the dynamic thermal load calculation program NewHASP.
- These coefficients are dependent on the zone, room use, and season and on the use of air-conditioning the previous day.

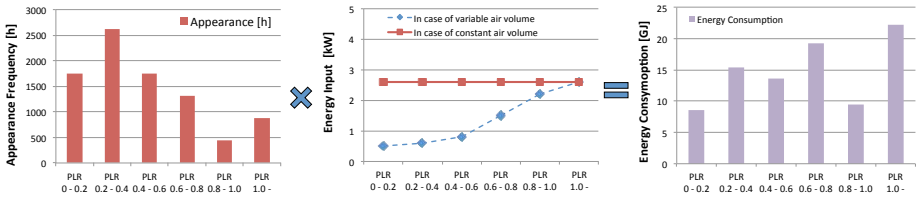


Concept of Energy Consumption Calculation

- Primary energy consumption of the air-conditioning system.

$$E_{d,AC} = E_{d,AC,AHU} + E_{d,AC,PUMP} + E_{d,AC,REF}$$

- The concept used to calculate these values are the same.
  - The appearance time of each part load ratio (PLR) band is calculated
  - The energy consumption of the equipment on each PLR band is calculated by multiplying the appearance of the load and the energy input, which differs depending on the control system introduced.



Appearance frequency of load (from load calculation results)

Energy input (from the equipment characteristics database)

Primary energy consumption (Load appearance hours x power consumption)

(Example 1) Primary Energy Calculation for Air-Handling Units

- Example: The rated cooling capacity is 110.9 kW, with a 15.0 kW air supply fan, a 1.5 kW exhaust fan, and VAV (variable air volume) control (minimum flow rate ratio 40%).

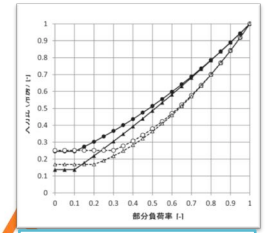
	Part load ratio	0–0.1	0.1–0.2	0.2–0.3	0.3–0.4	0.4–0.5	0.5–0.6	0.6–0.7	0.7–0.8	0.8–0.9	0.9–1.0	1.0–	Sum.
Cooling	Appearance of load [h]	400	300	310	230	140	230	20	0	0	0	0	1630
	Energy input [kW]	3.34	3.34	3.34	3.34	3.34	4.99	6.97	9.28	11.92	14.89	19.80	
	Energy consumption [MWh]	1.34	1.00	1.04	0.77	0.47	1.15	0.14	0	0	0	0	5.90

- In a part load ratio of 0.6 to 0.7, the Appearance of load (20 h) can be obtained from the results of the heat load calculation.
- Energy input = Rated power consumption (15 kW + 1.5 kW) x average load factor 0.65^2 = 6.97 kW
  - If a VAV control system is installed, the amount of power consumed is dependent on the load factor (the square of the average load factor).
- Amount of power consumed = 20h x 6.97 kW/1000 = 0.14 MWh

(Example 2) Primary Energy Calculation for Heat Source Equipment

- As with heat source equipment, the appearance frequency of the air-conditioning loads is generated according to not only the part load ratio but also the outdoor air temperature.

Outdoor temperature [°C]	Part load ratio	0–0.1	0.1–0.2	0.2–0.3	0.3–0.4	0.4–0.5	0.5–0.6	0.6–0.7	0.7–0.8	0.8–0.9	0.9–1.0	1.0–
	–10	28	14	0	0	0	0	0	0	0	0	0
	10–15	0	322	98	0	0	0	0	0	0	0	0
	15–20	0	14	350	98	0	0	0	0	0	0	0
	20–25	0	0	14	504	168	28	0	0	0	0	0
	25–30	0	0	0	0	210	280	70	0	0	0	0
	30–	0	0	0	0	0	70	14	0	0	0	0



Partial load characteristic curve

Energy consumption of a heat source
= Appearance of load
x number of units operated
x energy consumed by the heat source

Summary

- The building energy standard was revised in 2013.
  - Primary energy consumption is needed as a criterion index, in addition to envelope performance.
- Until 2020, compliance to the standard will be mandatory for all newly built buildings and housing.
- NILIM and BRI have developed the on-line calculation tools for the new energy standard.