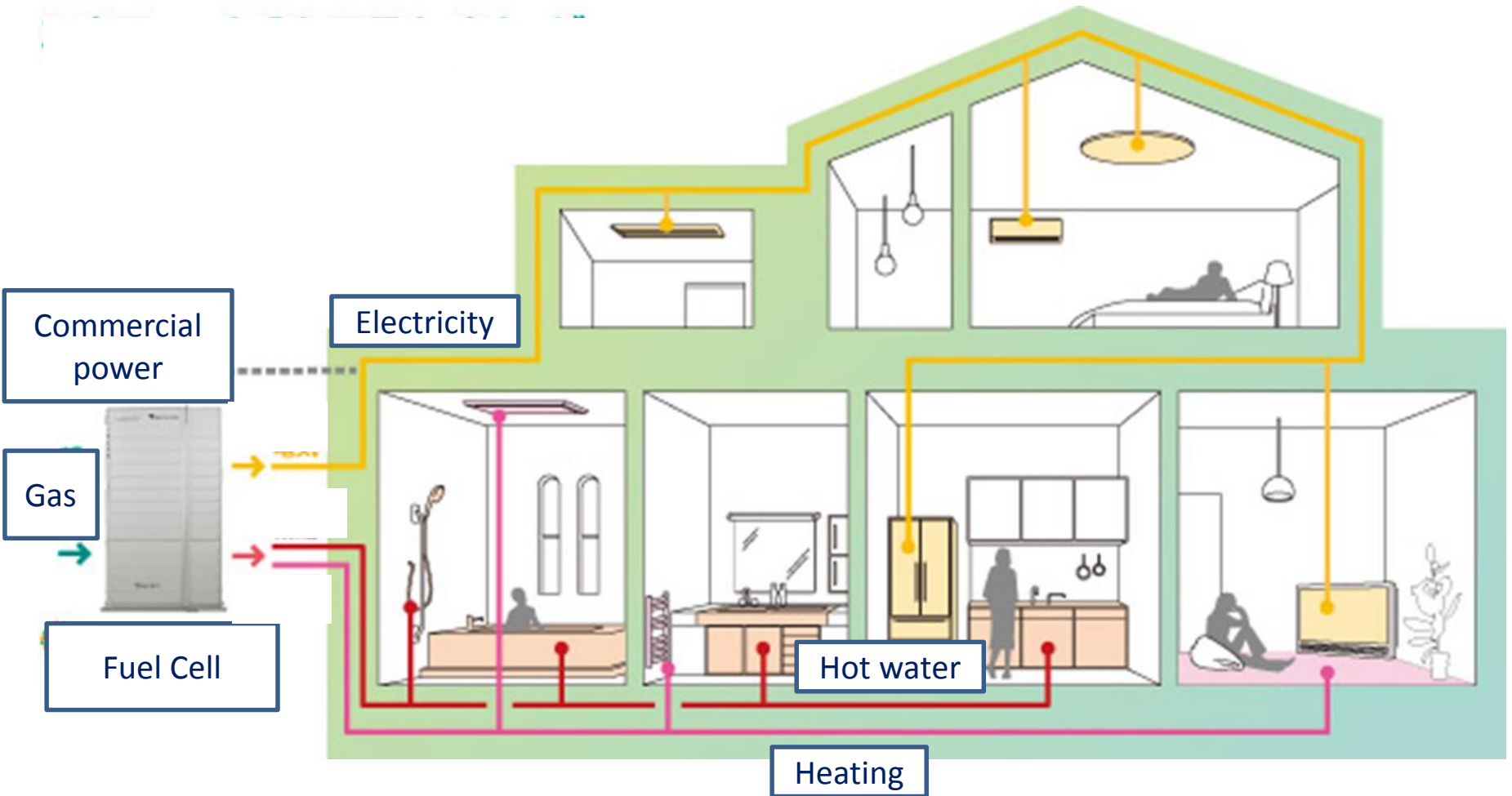


# **EVALUATION OF SAVING ENERGY OF SOFC (Solid Oxide Fuel Cell) AND STORAGE BATTERY COMBINED SYSTEM**

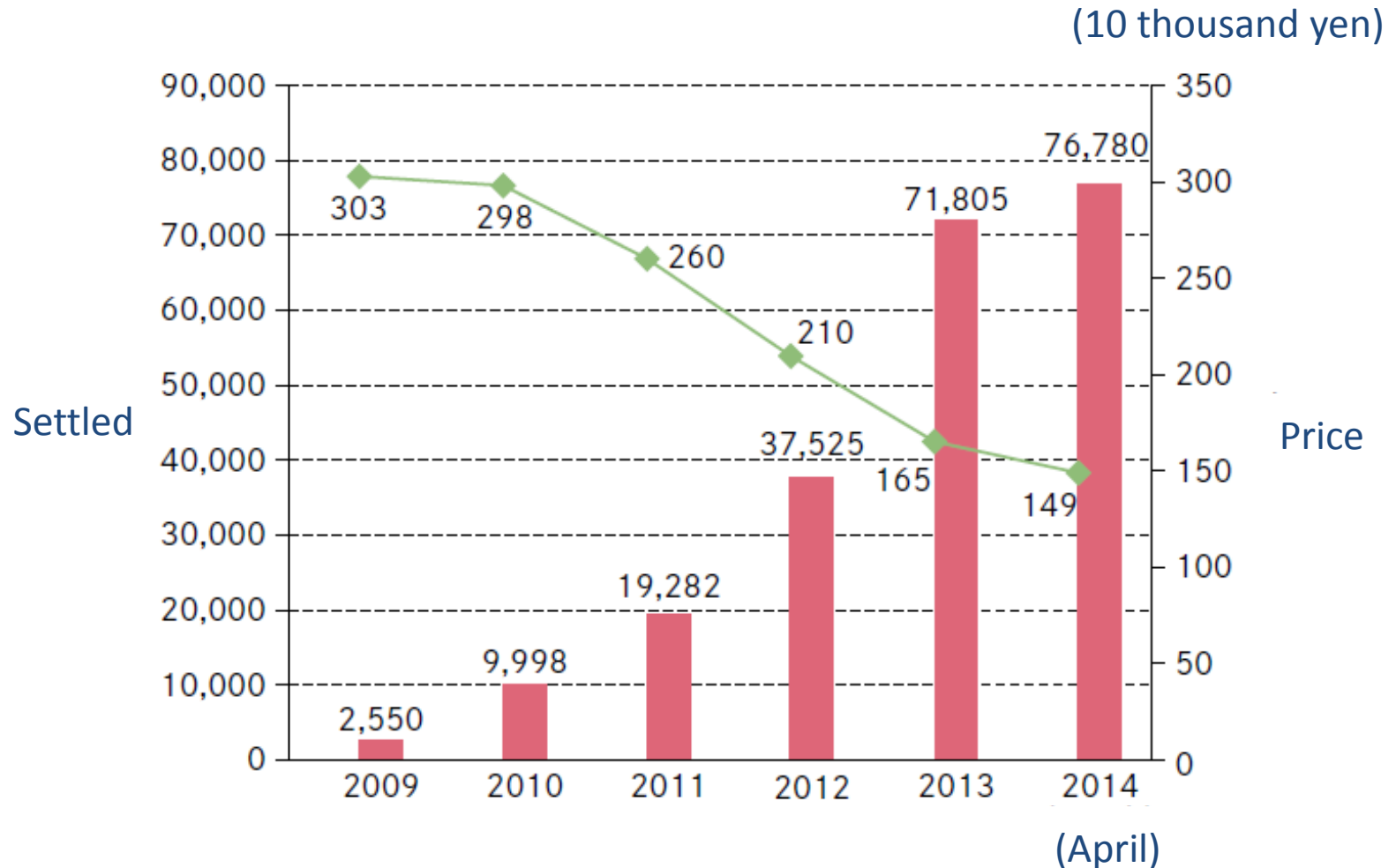
Building Research Institute  
Environmental Technology Group  
Takeshi Sase  
2017/06

# Fuel Cell in a Household



Fuel Cell : Co-generating system produces both electricity and heat

# Fuel Cells for household in Japan

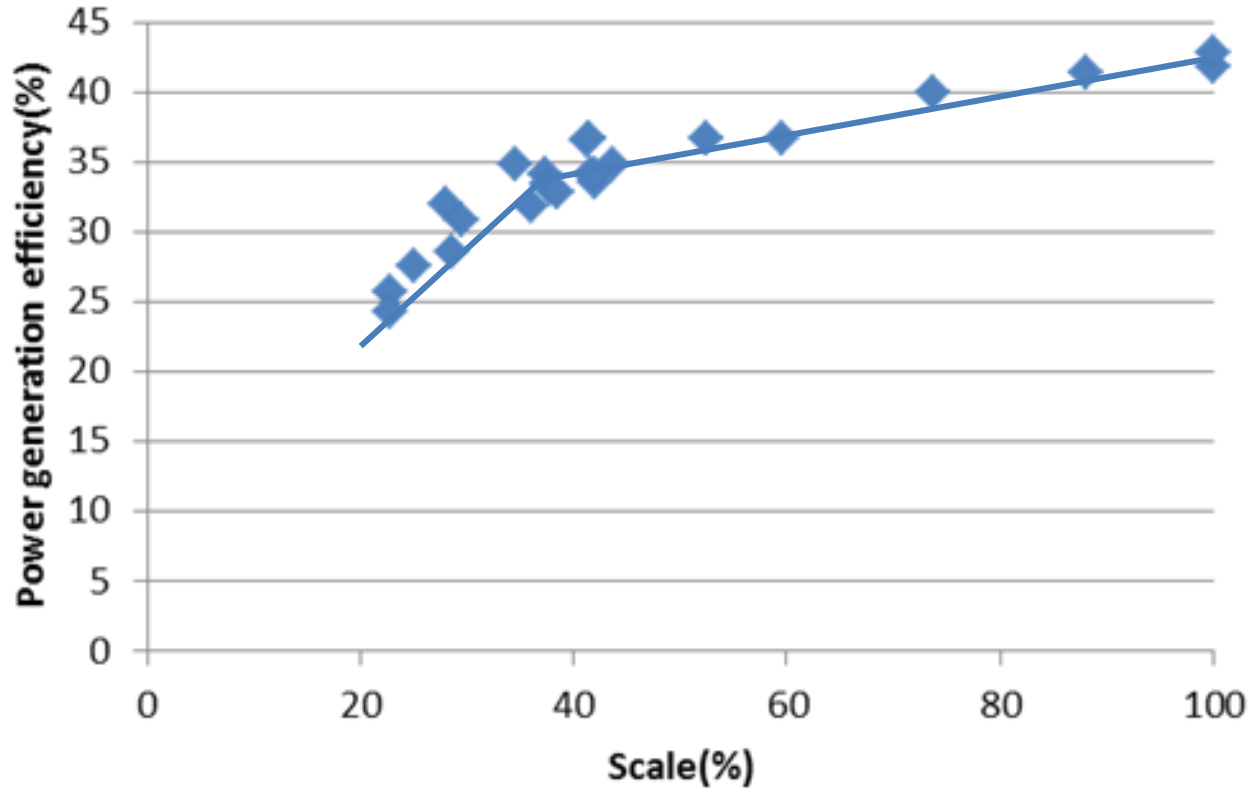


# Types of Fuel Cells

	PEFC(Polymer Electrolyte Fuel Cell)	SOFC(Solid Oxide Fuel Cell)
Electrolytes	Polymer Electrolyte	Ceramic
Operating temperature	70 – 90 °C	700 –1000 °C
Power generation efficiency	35 – 45 %	45 -60 %
Output	1W – 10kW	1kW – 100 MW
Main Usage	Residential, car use	Commercial, industrial use

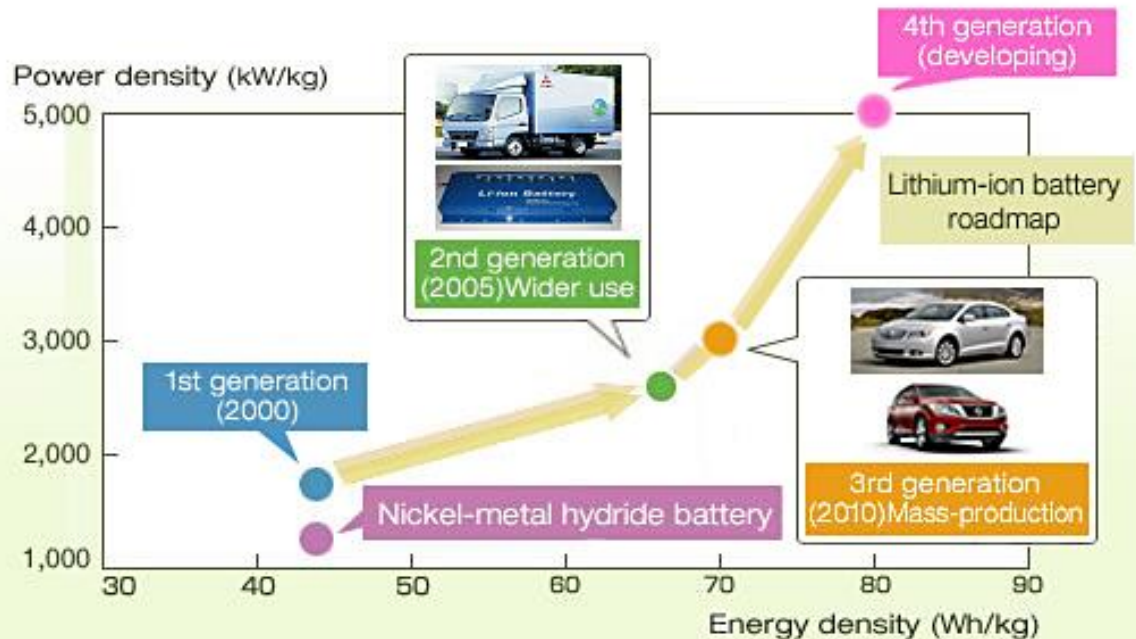
SOFC has higher power generation efficiency. So recently, they have been introduced into households.

# SOFC traits on the power generation efficiency



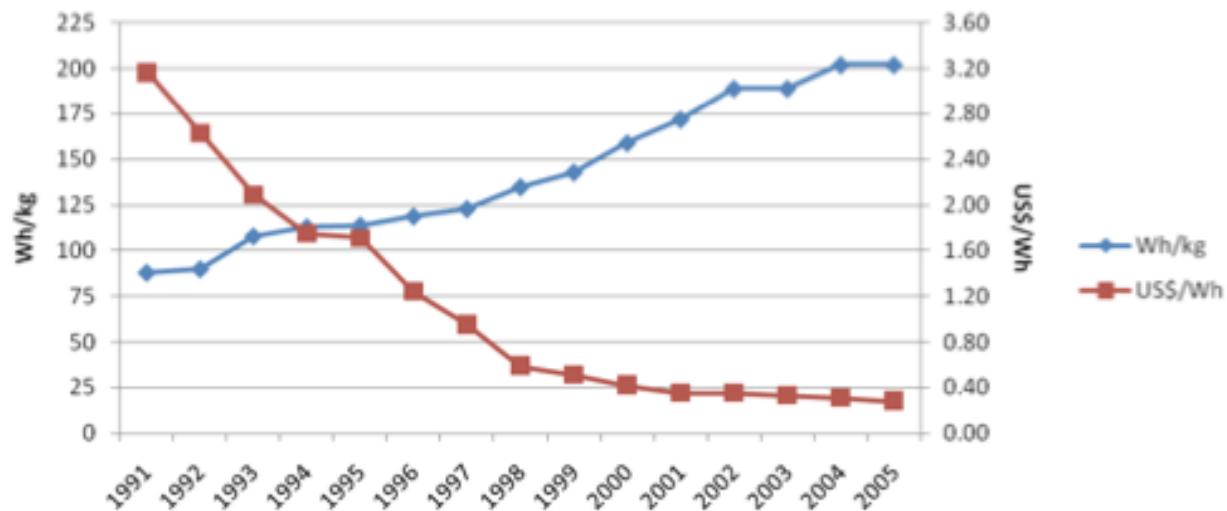
Its efficiency is high at near the full scale load. But it decreases at low scale load.

# Advances in Lithium-ion Battery Technology



## Li-Ion Pricing and Energy Density, 1991-2005

Adapted from Buchman (2005)

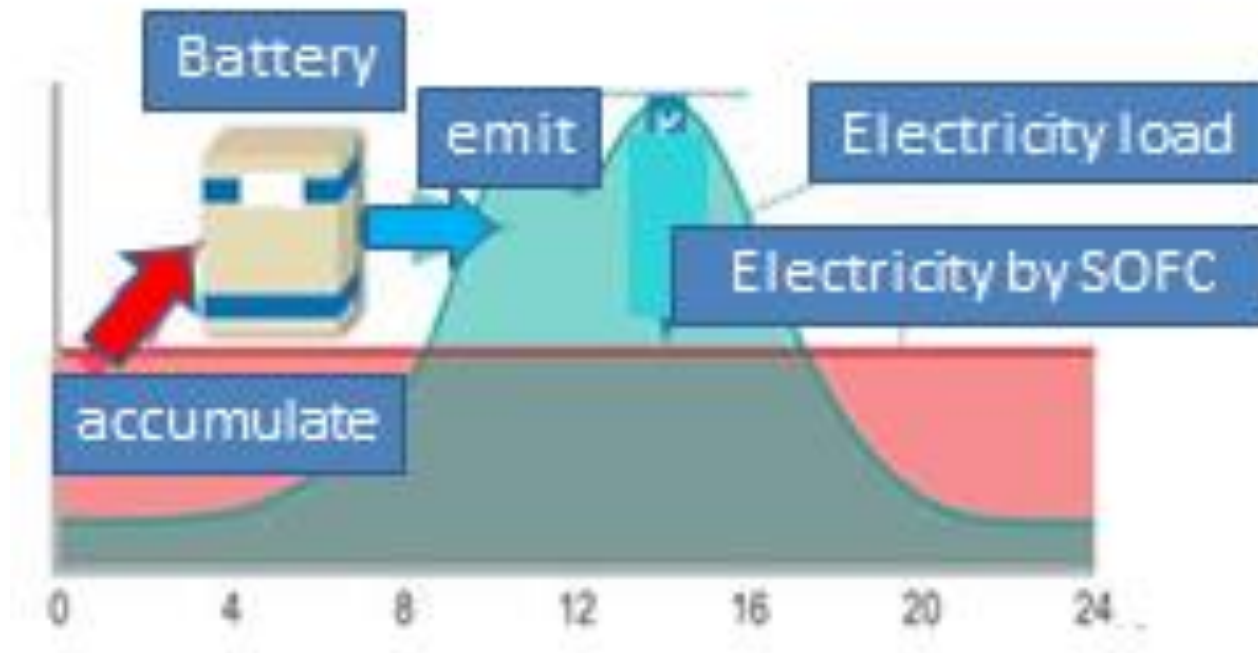


# Operation of SOFC and Storage Battery System

SOFC is always operated at the full load scale.

The overloaded power is accumulated into the storage battery.

When SOFC generating power is short, the battery emits power.



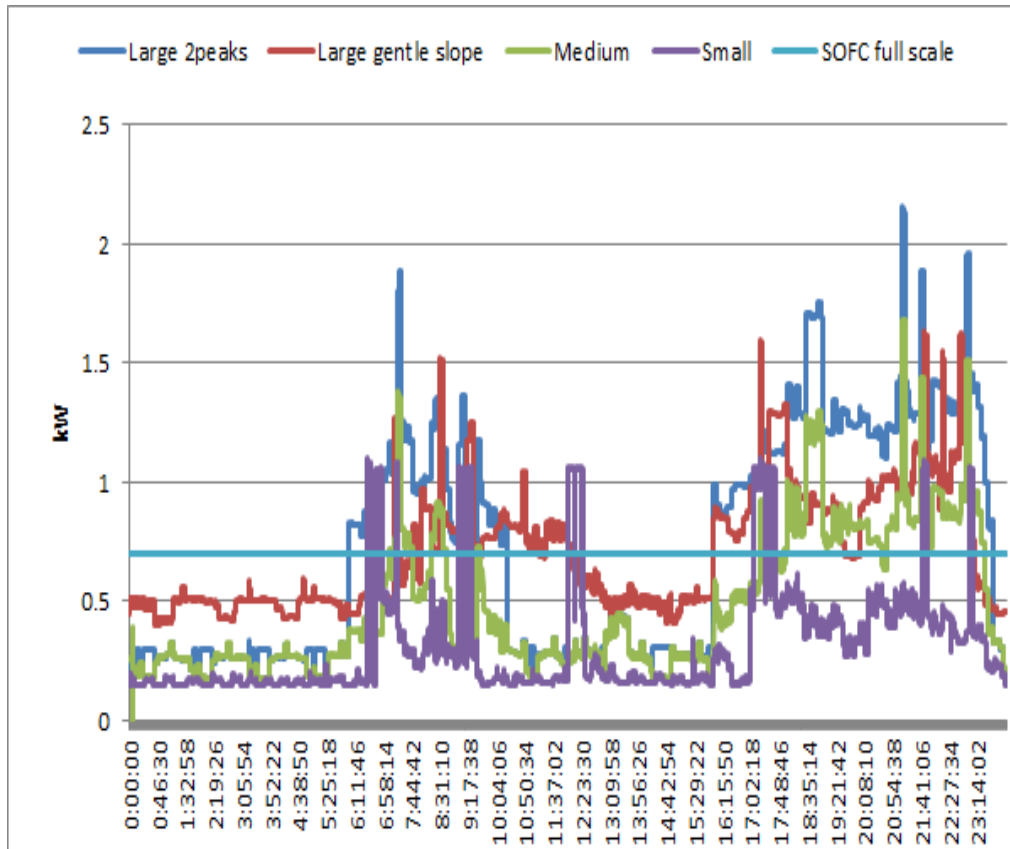


# LCCM(Life Cycle Carbon Minus)Household



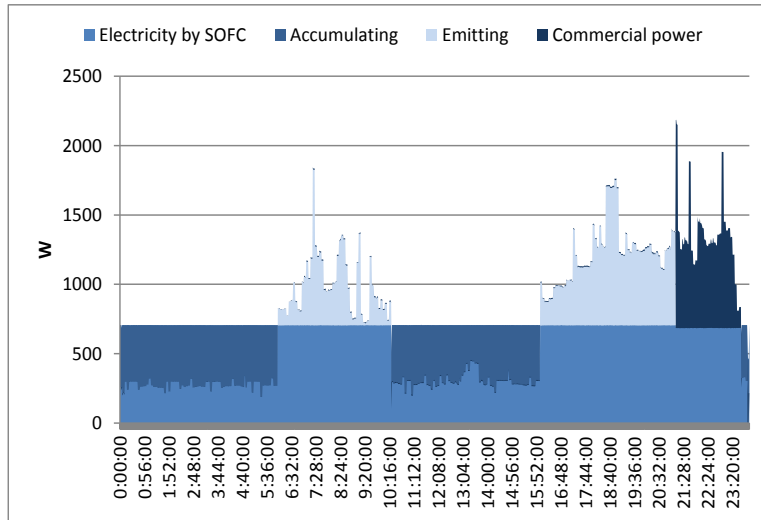


# Test Loads of Electricity(4 types),Hot water

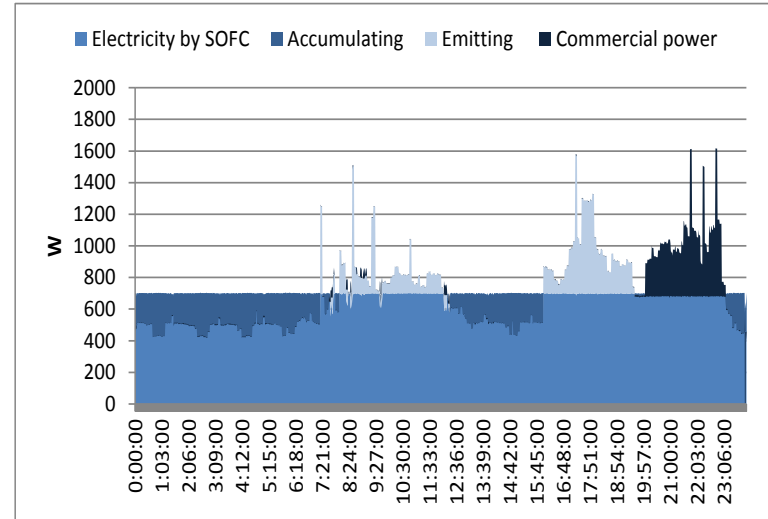


Hot water loads(L/day)	
Modified M1 mode	Modified M1 mode (Saving type)
650	522
550	454
470	387
380	324
380	306
240	166

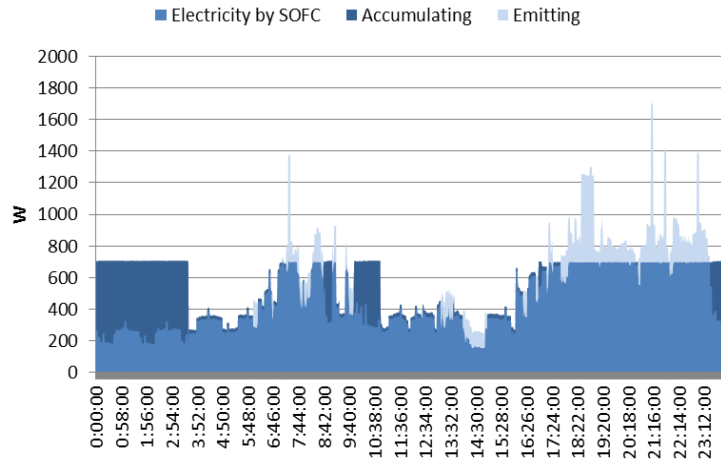
# Supply of Electric Power



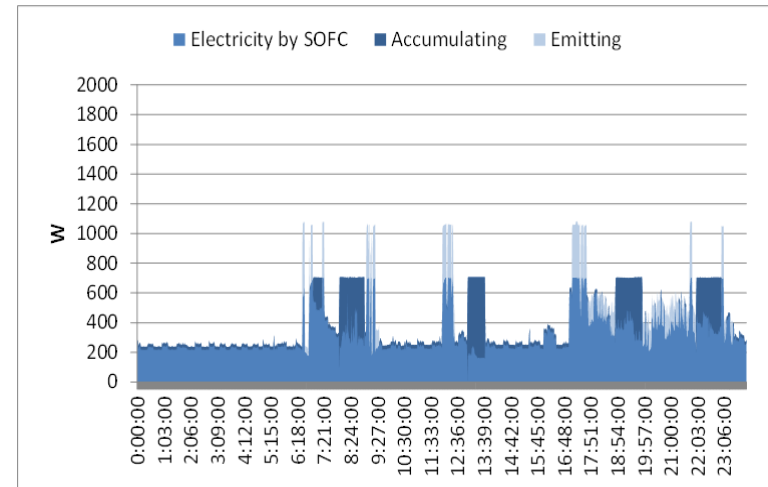
Large 2 peaks



Large gentle slope

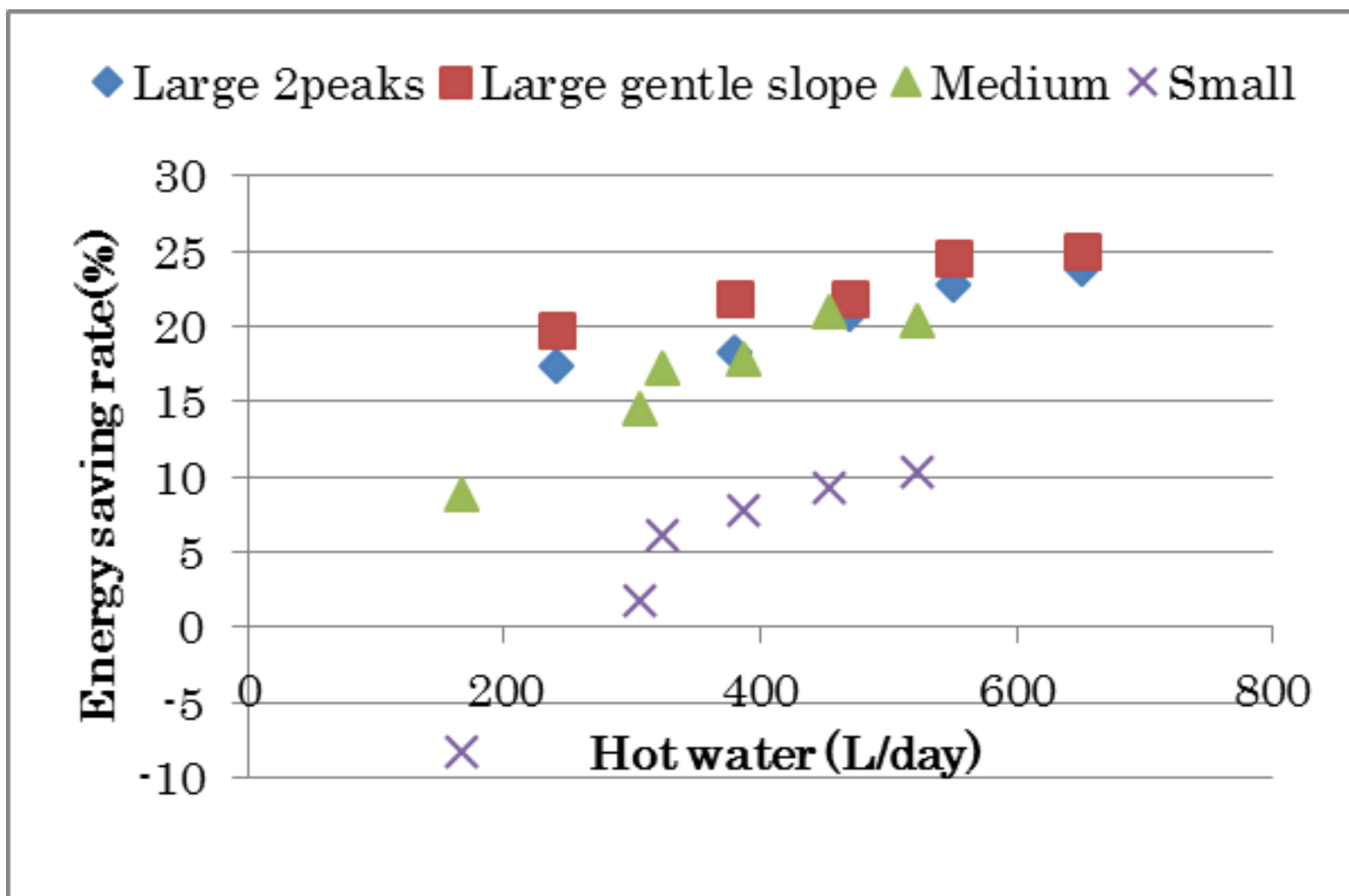


Medium



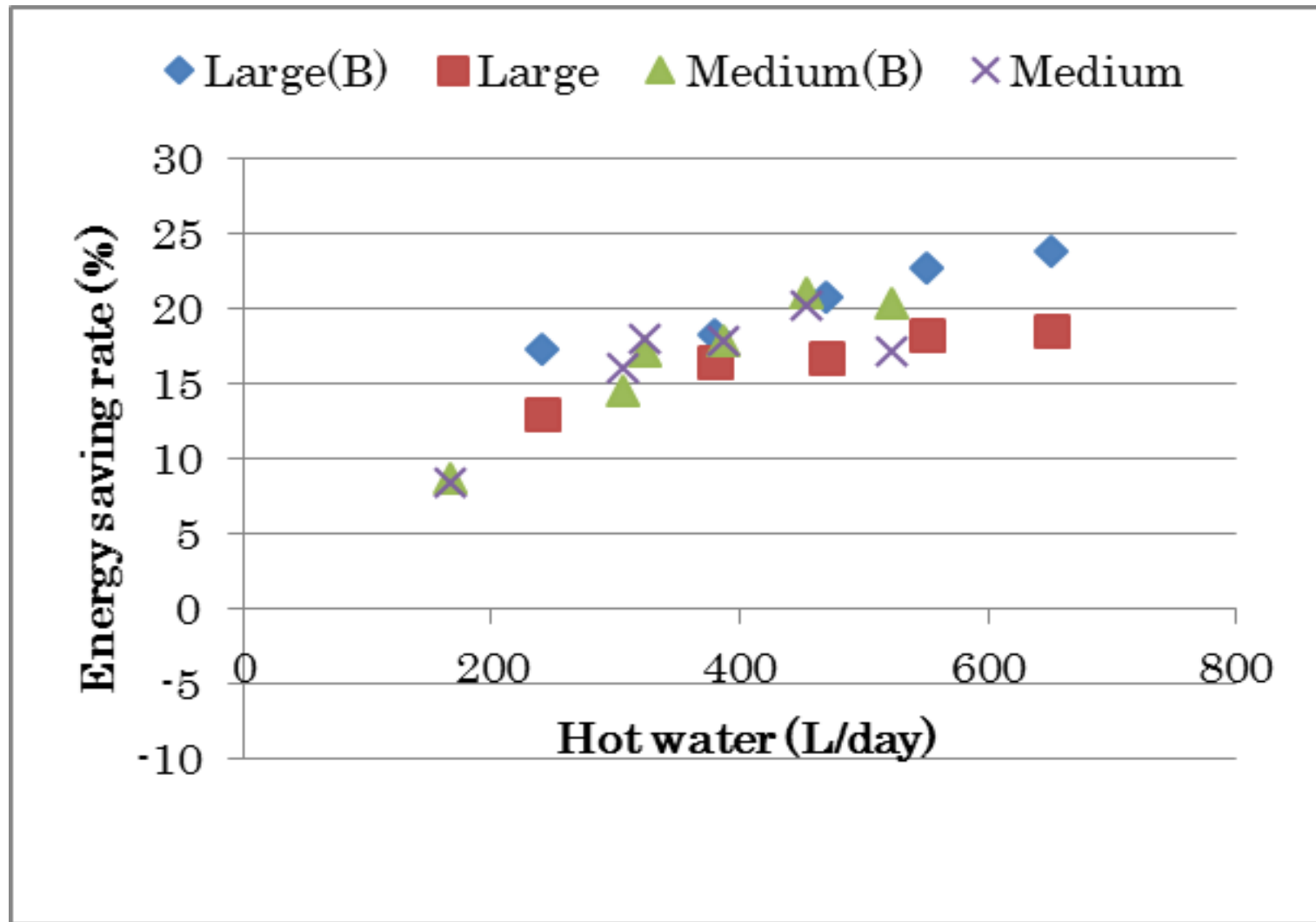
Small

# Energy-saving rates with various loads



Energy-saving rate are calculated , compared with commercial power and traditional gas boiler.

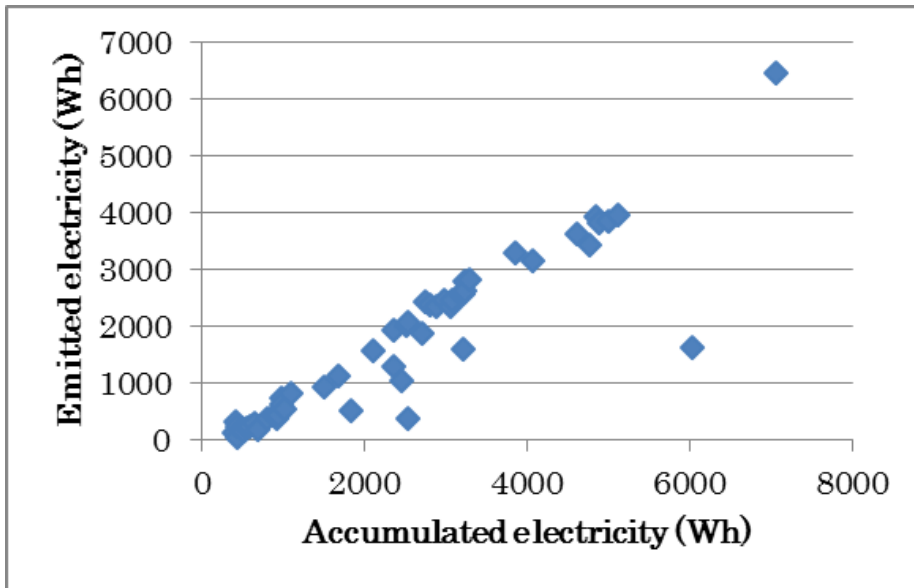
# Energy-saving rates (SOFC + Battery vs SOFC)



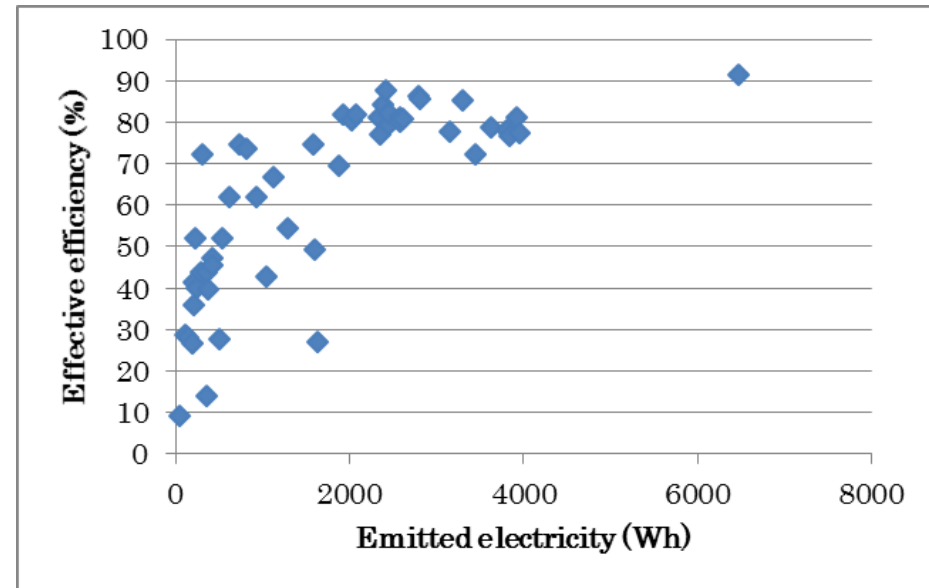
Energy-saving rate are calculated , compared with commercial power and traditional gas boiler.

# Storage Battery traits

accumulated vs emitted electricity

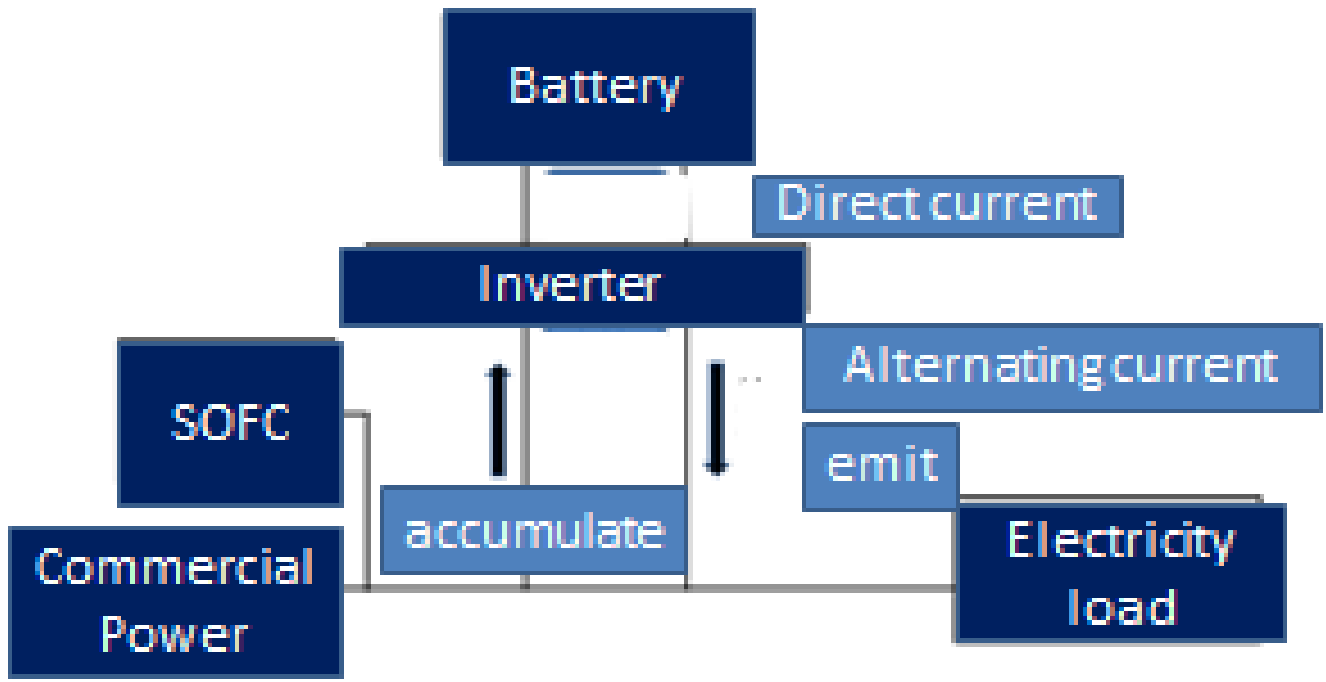


effective efficiency vs emitted electricity



# Conversion of electric power (direct $\Leftrightarrow$ alternating)

Electric power is lost in the process of converting indirect to direct, direct to indirect. This loss should be evaluated.





# Conclusion

1. SOFC + Battery system is more effective than SOFC with larger electric load, but not more effective with smaller one.
2. More than 20% electricity is lost during accumulating, emitting and converting process, especially at small scale.
3. It is suggested its efficiency and effectiveness could be improved by reducing this electric loss.

# Solar power generation with storage battery

