

Analysis of Energy Saving Potential in High-Performance Building Technologies under Korean Climatic Conditions

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Supplementary Materials

Table S1. Breakdown of the primary energy consumptions and saving rate (Passive systems)

Energy Conservation Systems	Incheon			Jeju		
		Primary Energy Consumptions	Energy Saving Rate		Primary Energy Consumptions	Energy Saving Rate
Base	Total	464.1 kWh/m ²		Total	485.1 kWh/m ²	
	Heating	126.5 kWh/m ²		Heating	104.6 kWh/m ²	
	Cooling	198.7 kWh/m ²		Cooling	238.4 kWh/m ²	
	Fan	76.8 kWh/m ²		Fan	74.1 kWh/m ²	
C 1. High Performance Envelope	Total	439.8 kWh/m ²	5.2%	Total	455.7 kWh/m ²	6.1%
	Heating	115.9 kWh/m ²	8.4%	Heating	92.9 kWh/m ²	11.1%
	Cooling	196.3 kWh/m ²	1.5%	Cooling	238.4 kWh/m ²	3.4%
	Fan	71.7 kWh/m ²	6.4%	Fan	67.5 kWh/m ²	8.4%
C 2. High Performance Infiltration	Total	430.5 kWh/m ²	7.2%	Total	454.3 kWh/m ²	6.5%
	Heating	111.3 kWh/m ²	10.9%	Heating	93.9 kWh/m ²	9.4%
	Cooling	188.3 kWh/m ²	5.2%	Cooling	230.9 kWh/m ²	6.4%
	Fan	76.8 kWh/m ²	1.4%	Fan	73.2 kWh/m ²	1.1%
C 3. High Efficiency U-Value Low-E	Total	429.8 kWh/m ²	7.4%	Total	452.1 kWh/m ²	6.8%
	Heating	116.6 kWh/m ²	7.8%	Heating	99.2 kWh/m ²	5.1%
	Cooling	186.1 kWh/m ²	6.3%	Cooling	237.0 kWh/m ²	4.4%
	Fan	68.6 kWh/m ²	10.4%	Fan	66.5 kWh/m ²	10.1%
C 4. High Efficiency SHGC Low-E	Total	418.4 kWh/m ²	9.8%	Total	430.6 kWh/m ²	11.2%
	Heating	119.8 kWh/m ²	5.3%	Heating	204.8 kWh/m ²	2.9%
	Cooling	171.8 kWh/m ²	13.4%	Cooling	198.7 kWh/m ²	17.3%
	Fan	67.5 kWh/m ²	12.0%	Fan	63.3 kWh/m ²	14.4%
C 5. External Venetian Blind	Total	329.5 kWh/m ²	15.4%	Total	395.0 kWh/m ²	18.6%
	Heating	112.0 kWh/m ²	11.4%	Heating	96.0 kWh/m ²	8.2%
	Cooling	159.7 kWh/m ²	19.3%	Cooling	186.2 kWh/m ²	24.9%
	Fan	63.7 kWh/m ²	17.0%	Fan	60.6 kWh/m ²	18.1%

Table S2. Breakdown of the primary energy consumptions and saving rate (Active and Renewable systems)

Energy Conservation Systems	Incheon			Jeju		
	Primary Energy Consumptions		Energy Saving Rate	Primary Energy Consumptions		Energy Saving Rate
Base	Total	464.1 kWh/m ²	-	Total	485.1 kWh/m ²	-
	Heating	126.5 kWh/m ²		Heating	104.6 kWh/m ²	
	Cooling	198.7 kWh/m ²		Cooling	238.4 kWh/m ²	
	Fan	76.8 kWh/m ²		Fan	74.1 kWh/m ²	
C 6. VAV System	Total	330.4 kWh/m ²	28.8%	Total	335.2 kWh/m ²	30.8%
	Heating	106.1 kWh/m ²	16.1%	Heating	92.9 kWh/m ²	12.1%
	Cooling	148.8 kWh/m ²	25.1%	Cooling	173.1 kWh/m ²	30.2%
	Fan	26.6 kWh/m ²	65.4%	Fan	23.5 kWh/m ²	67.3%
C 7. Combined VAV -Economizer	Total	297.9 kWh/m ²	35.8%	Total	318.9 kWh/m ²	34.2%
	Heating	102.1 kWh/m ²	19.3%	Heating	88.9 kWh/m ²	14.9%
	Cooling	132.3 kWh/m ²	33.4%	Cooling	160.6 kWh/m ²	35.2%
	Fan	24.1 kWh/m ²	68.4%	Fan	22.5 kWh/m ²	69.4%
C 8. Combined VAV -Rotary ERV	Total	281.7 kWh/m ²	39.3%	Total	300.5 kWh/m ²	38.1%
	Heating	70.7 kWh/m ²	44.1%	Heating	62.3 kWh/m ²	40.4%
	Cooling	128.8 kWh/m ²	35.2%	Cooling	155.3 kWh/m ²	37.4%
	Fan	42.7 kWh/m ²	48.4%	Fan	40.2 kWh/m ²	45.6%
C 9. Combined VAV-UFAD	Total	280.2 kWh/m ²	39.6%	Total	287.5 kWh/m ²	40.7%
	Heating	89.7 kWh/m ²	29.1%	Heating	81.6 kWh/m ²	21.9%
	Cooling	119.7 kWh/m ²	39.4%	Cooling	136.4 kWh/m ²	44.9%
	Fan	23.8 kWh/m ²	69.0%	Fan	76.8 kWh/m ²	70.4%
C 10. Active Chilled Beam with DOAS	Total	244.2 kWh/m ²	47.3%	Total	247.8 kWh/m ²	48.9%
	Heating	79.5 kWh/m ²	37.1%	Heating	75.9 kWh/m ²	27.3%
	Cooling	92.4 kWh/m ²	53.5%	Cooling	95.8 kWh/m ²	61.3%
	Fan	21.6 kWh/m ²	70.8%	Fan	20.2 kWh/m ²	72.4%
C 11. HW Boiler (95%) + Centrifugal Chiller(4.0)	Total	342.3 kWh/m ²	26.2%	Total	362.3 kWh/m ²	25.3%
	Heating	80.3 kWh/m ²	36.5%	Heating	69.9 kWh/m ²	33.1%
	Cooling	157.0 kWh/m ²	20.9%	Cooling	187.7 kWh/m ²	24.2%
	Fan	60.7 kWh/m ²	23.5%	Fan	56.3 kWh/m ²	20.9%
C 12. HW Boiler (80%) + Centrifugal Chiller(6.5)	Total	313.1 kWh/m ²	32.5%	Total	314.9 kWh/m ²	35.0%
	Heating	100.3 kWh/m ²	20.4%	Heating	86.2 kWh/m ²	17.4%
	Cooling	115.7 kWh/m ²	41.7%	Cooling	130.7 kWh/m ²	47.2%
	Fan	56.7 kWh/m ²	26.2%	Fan	51.8 kWh/m ²	29.9%
C 13. HW Boiler (95%) + Centrifugal Chiller(6.5)	Total	292.4 kWh/m ²	37.0%	Total	292.2 kWh/m ²	39.1%
	Heating	83.5 kWh/m ²	33.9%	Heating	72.6 kWh/m ²	29.4%
	Cooling	123.7 kWh/m ²	37.7%	Cooling	138.7 kWh/m ²	43.4%
	Fan	46.7 kWh/m ²	38.2%	Fan	42.7 kWh/m ²	40.2%
C 14. Combined CAV-GSHP	Total	312.3 kWh/m ²	32.7%	Total	333.4 kWh/m ²	31.3%
	Heating	70.2 kWh/m ²	42.4%	Heating	66.1 kWh/m ²	36.8%
	Cooling	133.0 kWh/m ²	33.1%	Cooling	164.7 kWh/m ²	33.5%
	Fan	62.6 kWh/m ²	18.4%	Fan	60.3 kWh/m ²	15.4%
C 15. Active Chilled Beam with DOAS + GSHP	Total	189.4 kWh/m ²	59.2%	Total	206.2 kWh/m ²	57.4%
	Heating	43.0 kWh/m ²	64.9%	Heating	43.3 kWh/m ²	58.4%
	Cooling	33.1 kWh/m ²	54.2%	Cooling	108.5 kWh/m ²	56.2%
	Fan	21.3 kWh/m ²	72.2%	Fan	21.2 kWh/m ²	71.3%

Table S3. Breakdown of the CO₂ emissions and reduction rate (Passive systems)

Energy Conservation Systems	Incheon			Jeju		
		CO ₂ Emissions	Emission Reduction Rate		CO ₂ Emissions	Emission Reduction Rate
Base	Total	83.4 kgCO ₂ /m ²		Total	87.4 kgCO ₂ /m ²	
	Heating	23.1 kgCO ₂ /m ²		Heating	19.1 kgCO ₂ /m ²	
	Cooling	36.7 kgCO ₂ /m ²	-	Cooling	45.8 kgCO ₂ /m ²	-
	Fan	13.0 kgCO ₂ /m ²		Fan	12.6 kgCO ₂ /m ²	
C 1. High Performance Envelope	Total	79.1 kgCO ₂ /m ²	5.2%	Total	82.1 kgCO ₂ /m ²	6.0%
	Heating	21.2 kgCO ₂ /m ²	8.4%	Heating	17.0 kgCO ₂ /m ²	11.2%
	Cooling	36.2 kgCO ₂ /m ²	1.2%	Cooling	44.0 kgCO ₂ /m ²	3.9%
	Fan	12.2 kgCO ₂ /m ²	6.6%	Fan	11.5 kgCO ₂ /m ²	8.8%
C 2. High Performance Infiltration	Total	77.3 kgCO ₂ /m ²	7.3%	Total	81.7 kgCO ₂ /m ²	6.6%
	Heating	20.4 kgCO ₂ /m ²	12.0%	Heating	17.2 kgCO ₂ /m ²	10.2%
	Cooling	34.8 kgCO ₂ /m ²	5.2%	Cooling	42.6 kgCO ₂ /m ²	6.9%
	Fan	12.9 kgCO ₂ /m ²	1.3%	Fan	12.4 kgCO ₂ /m ²	11.4%
C 3. High Efficiency U-Value Low-E	Total	77.1 kgCO ₂ /m ²	7.5%	Total	81.5 kgCO ₂ /m ²	6.7%
	Heating	21.3 kgCO ₂ /m ²	7.8%	Heating	18.1 kgCO ₂ /m ²	5.1%
	Cooling	34.4 kgCO ₂ /m ²	6.3%	Cooling	43.8 kgCO ₂ /m ²	4.4%
	Fan	11.6 kgCO ₂ /m ²	10.7%	Fan	11.3 kgCO ₂ /m ²	10.1%
C 4. High Efficiency SHGC Low-E	Total	75.1 kgCO ₂ /m ²	9.9%	Total	77.5 kgCO ₂ /m ²	11.4%
	Heating	21.9 kgCO ₂ /m ²	5.3%	Heating	18.6 kgCO ₂ /m ²	2.9%
	Cooling	31.7 kgCO ₂ /m ²	13.6%	Cooling	37.8 kgCO ₂ /m ²	17.4%
	Fan	11.5 kgCO ₂ /m ²	12.1%	Fan	10.7 kgCO ₂ /m ²	14.5%
C 5. External Venetian Blind	Total	70.5 kgCO ₂ /m ²	15.5%	Total	71.1 kgCO ₂ /m ²	18.7%
	Heating	20.5 kgCO ₂ /m ²	11.5%	Heating	17.6 kgCO ₂ /m ²	8.1%
	Cooling	29.5 kgCO ₂ /m ²	19.6%	Cooling	34.4 kgCO ₂ /m ²	24.9%
	Fan	10.8 kgCO ₂ /m ²	17.0%	Fan	10.3 kgCO ₂ /m ²	18.1%

Table S4. Breakdown of the CO₂ emissions and reduction rate (Active and Renewable energy systems)

Energy Conservation Systems	Incheon			Jeju		
	CO ₂ Emissions		Emission Reduction Rate	CO ₂ Emissions		Emission Reduction Rate
Base	Total	83.4 kgCO ₂ /m ²	-	Total	87.4 kgCO ₂ /m ²	-
	Heating	23.1 kgCO ₂ /m ²		Heating	19.1 kgCO ₂ /m ²	
	Cooling	36.7 kgCO ₂ /m ²		Cooling	45.8 kgCO ₂ /m ²	
	Fan	13.0 kgCO ₂ /m ²		Fan	12.6 kgCO ₂ /m ²	
C 6. VAV System	Total	57.4 kgCO ₂ /m ²	31.1%	Total	58.1 kgCO ₂ /m ²	33.5%
	Heating	19.4 kgCO ₂ /m ²	16.1%	Heating	17.0 kgCO ₂ /m ²	11.1%
	Cooling	25.2 kgCO ₂ /m ²	31.2%	Cooling	29.4 kgCO ₂ /m ²	35.9%
	Fan	4.5 kgCO ₂ /m ²	65.4%	Fan	4.0 kgCO ₂ /m ²	68.3%
C 7. Combined VAV -Economizer	Total	51.9 kgCO ₂ /m ²	35.8%	Total	55.3 kgCO ₂ /m ²	34.2%
	Heating	18.7 kgCO ₂ /m ²	19.3%	Heating	16.3 kgCO ₂ /m ²	14.9%
	Cooling	20.6 kgCO ₂ /m ²	33.4%	Cooling	27.2 kgCO ₂ /m ²	35.2%
	Fan	4.1 kgCO ₂ /m ²	68.7%	Fan	3.8 kgCO ₂ /m ²	69.5%
C 8. Combined VAV -Rotary ERV	Total	48.7 kgCO ₂ /m ²	39.3%	Total	51.8 kgCO ₂ /m ²	38.1%
	Heating	12.9 kgCO ₂ /m ²	44.1%	Heating	12.0 kgCO ₂ /m ²	40.4%
	Cooling	20.6 kgCO ₂ /m ²	35.2%	Cooling	24.5 kgCO ₂ /m ²	37.3%
	Fan	6.7 kgCO ₂ /m ²	48.5%	Fan	6.2 kgCO ₂ /m ²	50.9%
C 9. Combined VAV-UFAD	Total	48.2 kgCO ₂ /m ²	41.8%	Total	49.9 kgCO ₂ /m ²	43.0%
	Heating	16.4 kgCO ₂ /m ²	29.1%	Heating	14.9 kgCO ₂ /m ²	21.9%
	Cooling	20.3 kgCO ₂ /m ²	44.7%	Cooling	23.1 kgCO ₂ /m ²	49.5%
	Fan	4.0 kgCO ₂ /m ²	69.0%	Fan	3.5 kgCO ₂ /m ²	71.8%
C 10. Active Chilled Beam with DOAS	Total	42.5 kgCO ₂ /m ²	49.1%	Total	43.0 kgCO ₂ /m ²	50.8%
	Heating	14.6 kgCO ₂ /m ²	37.1%	Heating	13.9 kgCO ₂ /m ²	27.3%
	Cooling	15.7 kgCO ₂ /m ²	57.3%	Cooling	16.3 kgCO ₂ /m ²	64.5%
	Fan	3.7 kgCO ₂ /m ²	71.9%	Fan	3.4 kgCO ₂ /m ²	72.7%
C 11. HW Boiler (95%) + Centrifugal Chiller(4.0)	Total	59.1 kgCO ₂ /m ²	29.1%	Total	62.4 kgCO ₂ /m ²	28.6%
	Heating	14.7 kgCO ₂ /m ²	36.5%	Heating	12.8 kgCO ₂ /m ²	33.1%
	Cooling	26.6 kgCO ₂ /m ²	27.4%	Cooling	31.8 kgCO ₂ /m ²	30.5%
	Fan	10.3 kgCO ₂ /m ²	21.0%	Fan	9.5 kgCO ₂ /m ²	23.9%
C 12. HW Boiler (80%) + Centrifugal Chiller(6.5)	Total	54.4 kgCO ₂ /m ²	34.7%	Total	54.6 kgCO ₂ /m ²	37.6%
	Heating	18.4 kgCO ₂ /m ²	20.7%	Heating	15.8 kgCO ₂ /m ²	17.5%
	Cooling	19.6 kgCO ₂ /m ²	46.5%	Cooling	22.2 kgCO ₂ /m ²	51.6%
	Fan	9.6 kgCO ₂ /m ²	26.2%	Fan	8.8 kgCO ₂ /m ²	30.0%
C 13. HW Boiler (95%) + Centrifugal Chiller(6.5)	Total	50.7 kgCO ₂ /m ²	39.2%	Total	50.5 kgCO ₂ /m ²	42.2%
	Heating	15.3 kgCO ₂ /m ²	33.9%	Heating	13.3 kgCO ₂ /m ²	30.6%
	Cooling	20.9 kgCO ₂ /m ²	42.8%	Cooling	23.5 kgCO ₂ /m ²	48.6%
	Fan	7.9 kgCO ₂ /m ²	39.3%	Fan	7.2 kgCO ₂ /m ²	42.3%
C 14. Combined CAV-GSHP	Total	53.4 kgCO ₂ /m ²	36.0%	Total	57.4 kgCO ₂ /m ²	34.3%
	Heating	12.9 kgCO ₂ /m ²	44.5%	Heating	12.5 kgCO ₂ /m ²	37.9%
	Cooling	22.2 kgCO ₂ /m ²	39.5%	Cooling	28.4 kgCO ₂ /m ²	34.9%
	Fan	10.3 kgCO ₂ /m ²	20.8%	Fan	10.2 kgCO ₂ /m ²	18.6%
C 15. Active Chilled Beam with DOAS + GSHP	Total	32.7 kgCO ₂ /m ²	60.8%	Total	35.6 kgCO ₂ /m ²	59.3%
	Heating	7.9 kgCO ₂ /m ²	65.9%	Heating	7.9 kgCO ₂ /m ²	59.8%
	Cooling	15.4 kgCO ₂ /m ²	57.9%	Cooling	18.4 kgCO ₂ /m ²	56.8%
	Fan	3.6 kgCO ₂ /m ²	72.2%	Fan	3.6 kgCO ₂ /m ²	71.3%