

OPPORTUNITY

How much energy is used for heating, ventilation and air conditioning (HVAC) in U.S. office buildings?

34% OF ENERGY goes to HVAC<sup>1</sup>

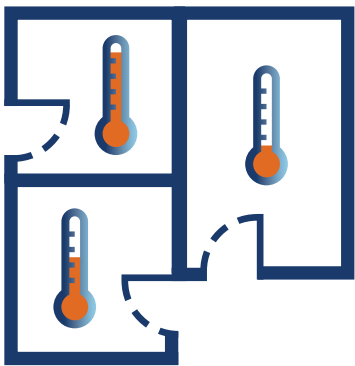
3% OF U.S. OFFICE BUILDINGS RELY ON VRF<sup>2</sup> primary HVAC system in Europe, Japan and China<sup>3</sup>

TECHNOLOGY

How does VRF work?

PROVIDES INDEPENDENT TEMPERATURE CONTROL to rooms throughout building

USES REFRIGERANT as cooling/heating medium; substituting thin pipes for ductwork



M&V

Where did Measurement and Verification occur?

PACIFIC NORTHWEST NATIONAL LABORATORY drew from a wide variety of sources to evaluate the performance of VRF for GSA buildings

RESULTS

How did VRF perform in M&V?

34% ENERGY SAVINGS projected Relative to code-compliant HVAC<sup>4</sup>

THIN PROFILE advantageous in historic buildings with limited room for ductwork<sup>5</sup>

COST-EFFECTIVE When the premium is < \$4/SQ.ft. compared to code-compliant HVAC<sup>6</sup>

Projected Payback for VRF vs VAV

Reasonable paybacks achievable (shown in white)

		Energy Cost Savings, \$/ft²							
		\$ .10	\$ .14	*\$ .18	\$ .22	\$ .26	\$ .30	\$ .34	\$ .38
Added Cost \$/ft²	\$1	10	7	6	5	4	3	3	3
	\$2	20	14	11	9	8	7	6	5
	\$3	30	21	17	14	12	10	9	8
	**\$4	40	29	22	18	15	13	12	11
	\$5	50	36	28	23	19	17	15	13
	\$6	60	43	33	27	23	20	18	16

		Energy Cost Savings, \$/ft²							
		\$ .13	\$ .19	*\$ .24	\$ .29	\$ .34	\$ .40	\$ .45	\$ .50
Added Cost \$/ft²	\$1	8	5	4	3	3	3	2	2
	\$2	15	11	8	7	6	5	4	4
	\$3	23	16	13	10	9	8	7	6
	**\$4	30	22	17	14	12	10	9	8
	\$5	38	27	21	17	15	13	11	10
	\$6	45	32	25	21	17	15	13	12

\* Average GSA Portfolio Energy Cost Savings (based on GSA average usage of 60.7 kBtu/ft², GSA average cost of \$0.89/therm, and EIA average cost of \$0.10/kWh)

\*\* Average Added Cost

DEPLOYMENT

Where does M&V recommend deploying VRF?

PILOT PROJECTS Research on field performance is limited

<sup>1</sup>Variable Refrigerant Flow Systems. Brian Thornton, Anne Wagner (PNNL), December 2012, p.4   <sup>2</sup>Ibid, p.11   <sup>3</sup>Ibid, p.4   <sup>4</sup>Ibid, p.13   <sup>5</sup>Ibid, p.24   <sup>6</sup>Ibid, p.46