

QUESTIONNAIRE REPORT SHEET

iPQ5CMVP.V2.1



B E Y O N D
S M A R T C I T I E S

**AEE'S CERTIFIED MEASUREMENT & VERIFICATION PROFESSIONAL
CMVP EXAM QUESTION BANK**

iPQ.No	Correct Answer	Points	Explanation
5CMVP001	4	8	Answer = 4 All of the above Explanation : Certified Measurement & Verification Professionals® (CMVPs) manage or perform internationally recognized methods of quantifying energy usage impacts of energy management activities. They apply performance and savings verification principles to energy savings performance contracts and utility/government incentive programs. Clear communication with project partners can help a CMVP® confidently and cost-effectively implement cost-saving activities.
5CMVP002	4	8	Answer = 4 All of the above Explanation : This program teaches the fundamentals of all modern "M&V" standards, guidelines, and protocols. The CMVP® Certification shows that the individual understands the critical issues surrounding M&V theory implementation. The program raises technical and ethical standards for energy efficiency and performance measurement and verification professionals.
5CMVP003	1	8	Answer = 1 2001 Explanation : 2001: The Association of Energy Engineers and the Efficiency Valuation Organization (EVO) launch the Certified Measurement and Verification Professional (CMVP®) program as a global standard to meet energy industry needs.
5CMVP004	4	8	Answer = 4 All off the above Explanation : M&V is necessary to accurately determine the return on investment and other benefits generated from an energy efficiency project. Verification of the potential to achieve savings is referred to as "operational verification," which may involve inspection, commissioning of equipment, functional performance testing, and/or data trending. IPMVP-adherent M&V includes both operational verification and an accounting of savings based on site energy measurements before and after implementation of a project, as well as adjustments.

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5CMVP005	4	18	Answer = 4 All of the above Explanation : increase energy savings. Document financial transactions. Enhance financing for efficiency projects. Improve engineering design and facility operations and maintenance. Manage energy budgets. Enhance the value of emission reduction credits. Support the evaluation of regional efficiency programs. Increase public understanding of energy management as a public policy tool.
5CMVP006	1	8	Answer = 1 True Explanation : The Certified Measurement and Verification Professional® program was established by the Association of Energy Engineers for the dual purpose of recognizing the most qualified professionals in this expanding sector of the energy industry and raising the overall professional standards within the measurement and verification field.
5CMVP007	4	8	Answer = 4 All of the above Explanation : Determining baselines and estimated savings Developing the M&V plan Developing the post-installation M&V report, which is part of conducting post-installation M&V activities, Performing annual M&V, which is part of conducting annual M&V activities.

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5CMVP008	4	8	Answer = 4 All of the above Explanation : Savings can't be measured. They are estimated from the pre- and post-retrofit energy measurements. The measurement boundary for an ECM or a group of ECMs has to be defined. Understanding the differences between pre-retrofit, baseyear, installation, post-retrofit, and performance periods The baseline energy in the post-retrofit period is the baseline energy adjusted to the post-retrofit conditions. The "savings" are the difference between the estimated baseline energy and the actual post-retrofit energy, both in the post-retrofit period. M&V protocols and guidelines have been developed to provide a consistent and verifiable approach for determining savings for all types of energy savings projects. There are inherent errors and risks that contribute to savings uncertainty. A balance has to be found between the M&V cost and the savings uncertainty, consistent with the project objectives and constraints. The fundamental importance of preparing, documenting, and following an M&V plan The basic approach to planning, designing, and implementing project-specific M&V and to reporting and verifying the savings

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5CMVP009	4	18	Answer = 4 All off the above Explanation : An M&V Option describes an M&V method that can be used to determine savings for a specified common type of ECM. There are four generic approaches for energy savings determination, which provide a range of approaches for determining savings with varying levels of uncertainty, cost and methodology. Options A and B are used if your ECM is about improving the efficiency or operation of end-use equipment. Option C should be used when you have more than one ECM and you can't separate out their individual savings contribution and ECM interactions. Option D should be used when no measurement data is available. It is not used very often for M&V as it requires the services of an energy simulation specialist Each project and each ECM is different. Each situation should be analysed including costs relative to estimated savings and desired accuracy.
5CMVP010	4	8	Answer = 4 All of the above Explanation : The Efficiency Valuation Organization (EVO) is a non-profit organization whose products and services help people engineer and invest in energy efficiency projects worldwide. EVO is the only global organization solely dedicated to M&V. EVO's vision is to create a world that has confidence in energy efficiency as a reliable and sustainable energy resource. EVO's mission is to ensure that the savings and impact of energy efficiency and sustainability projects are accurately measured and verified. EVO owns and disseminates the International Performance Measurement and Verification Protocol® (IPMVP®).

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5CMVP011	3	8	Answer = 3 Both Explanation : Option A—partial retrofit isolation with stipulation—is best used when: the magnitude of savings is relatively low for the entire project or the portion of the project to which this M&V Option is applied; the risk of not achieving projected savings is low, or ESCO payments are not directly tied to the actual savings.
5CMVP012	1	8	Answer = 1 True Explanation : Operational verification involves inspection, commissioning, functional performance testing, and/or data trending to determine savings potential. Operational verification and savings accounting are part of the IPMVP-adherent M&V.
5CMVP013	4	8	Answer = 4 All of the above Explanation : Option B—retrofit isolation—is typically used when: • Energy savings from equipment replacement projects are less than 20% of the total facility energy use; • Energy savings arising from individual measures must be determined; • Interactive effects of multiple measures are deemed unimportant; • The independent variables that affect energy use—for example, operating schedule— are neither complex nor difficult to monitor; • sub-meters already exist to measure the energy use of the systems being considered for retrofit.
5CMVP014	2	8	Answer = 2 Predicted energy savings are relatively small (greater than 5% to 10% of total facility energy use); Explanation : Option B—retrofit isolation—is typically used when: • Energy savings from equipment replacement projects are less than 20% of the total facility energy use; • Energy savings arising from individual measures must be determined; • Interactive effects of multiple measures are deemed unimportant; • The independent variables that affect energy use—for example, operating schedule— are neither complex nor difficult to monitor; • sub-meters already exist to measure the energy use of the systems being considered for retrofit.

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5CMVP015	4	8	Answer = 4 All of the above Explanation : Option D—calibrated simulation—is used in situations similar to Option C, or when: • new construction projects are involved (i.e. there is no historical data for baseline determination); • energy savings per measure are required; • Option C tools cannot assess particular measures or their interactions when complex baseline adjustments are anticipated.
5CMVP016	2	8	Answer = 2 False Explanation : In collaboration with the Efficiency Valuation Organization (EVO), the Association of Energy Engineers establishes the Certified Measurement and Verification Professional (CMVP®) program as a global standard to meet the growing needs of the energy industry.
5CMVP017	4	8	Answer = 4 All of the above Explanation : The following are examples of baseline adjustments: Changes in weather or occupancy: adjustments might include recalculating the baseline consumption rates using post-installation period weather data (HDD or CDD) or occupancy data based on a mathematical expression of how energy consumption depends on these factors; • Changes in operating schedule or tenant improvements: the real impact of the retrofit project is independent of decreases or increases in operating hours of the facility or system and, therefore, the baseline consumption needs to be scaled up or down to correspond to such changes if any occur; similarly, tenant improvements—new plug loads, improved lighting levels unrelated to the retrofit itself, etc.—that may increase energy consumption in the post-installation period must be separated from the post-installation period performance. • Changes in the actual function of the facility—office space being converted to storage, for example—and their impact on energy performance separate and apart from the retrofit, need to be quantified as adjustments to baseline performance. The following are examples of baseline adjustments:

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5CMVP018	3	8	Answer = 3 BOTH Explanation : M&V: An Essential Tool to Enable the Use of Energy Performance Contracting . Energy efficiency projects in general, and EPC projects more specifically, usually rely on which of the main elements? • a performance component that is directly related to the efficiency of the equipment installed. • the operation of this equipment, essentially reflecting how the facility owner uses such equipment.
5CMVP019	4	8	Answer = 4 All of the above Explanation : M&V activities are at the core of EPC projects realized by ESCOs. They are based on business transactions between parties that includes i) an owner where the project is implemented; ii) an ESCO taking care of the project design and implementation; and iii) sometimes, a third-party financier.
5CMVP020	1	8	Answer = 1 ISO 50015:2014 Explanation : ISO 50015:2014 establishes general principles and guidelines for the process of measurement and verification (M&V) of energy performance of an organization or its components. ISO 50015:2014 can be used independently, or in conjunction with other standards or protocols, and can be applied to all types of energy.

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5CMVP021	3	8	Answer = 3 Both Explanation : Energy quantities and independent variables are often measured as part of a M&V program using metering and measurement equipment. No measurement equipment is 100% accurate or precise. The precision of meters and measurement equipment is published by the manufacturer based on laboratory tests. Proper sizing of metering and measurement equipment is important to ensure the range of possible quantities to be measured falls within the acceptable limits of the equipment being used.
5CMVP022	4	8	Answer = 4 All of the above Explanation : Where uncertainty is unacceptable, consider taking the following actions: Use more precise measurement equipment. Look for more independent variables that have an influence on energy consumption. Increase the measurement sample size. Review the measurement boundary to minimize unknowns. Use an alternative M&V option that is less affected by unknown variables.
5CMVP023	1	8	Answer = 1 True Explanation : AEE hosted its first World Energy Engineering Congress (WEEC), an energy conference and expo, at the Royal Coach Inn in Atlanta, Georgia, in 1978.
5CMVP024	4	8	Answer = 4 64%

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5CMVP025	3	8	Answer = 3 Both (i) and (ii) are correct.
5CMVP026	1	8	Answer = 1 True Explanation : Many of the technologies that offer advanced M&V capability are not exclusively tools for energy savings estimation but rather multi-featured tools used to support various data-driven approaches to operational efficiency in buildings.
5CMVP027	3	8	Answer = 3 Explanation : By modifying both the baseline and reporting period to align with a reference data set
5CMVP028	2	8	Answer = 2 43,800 kWh Explanation : From the air leak losses table $(21900/2) * 4 = 43800$ kWh
5CMVP029	4	8	Answer = 4 For optimal project results, M&V procedures should function Effectively. Explanation : For best project results, the two procedures should work together. M&V should verify energy goals by commissioning systems throughout design and construction. Commissioning helps M&V by verifying that systems work properly after construction and will continue to work efficiently. Formal M&V methods can also aid commissioning during construction project verification testing. Recommissioning might use M&V to ensure system performance. M&V concludes.
5CMVP030	2	8	Answer = 2 Continuous or real time commissioning Explanation : Continuous or real-time commissioning is the commissioning activity that frequently monitors the system or facility over time to determine when additional maintenance is required.

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5CMVP031	4	8	Answer = 4 Reduce the temperature of fresh air. Explanation : The heat transfer in an enthalpy wheel between fresh and exit air reduces the temperature of fresh air.
5CMVP032	1	8	Answer = 1 True Explanation : One of the most basic goals of an energy audit is to determine the cost of energy that a facility uses.
5CMVP033	2	8	Answer = 2 Ammeter Explanation : Ammeters are utilized to measure the amount of electric current in an electrical circuit.
5CMVP034	2	8	Answer = 2 \$13.30/GJ. Explanation : $(\$0.06/\text{kWh}) \times (277.8 \text{ kWh/GJ}) = (\$16.67/\text{GJ})$ $= (\$ X/\text{GJ}) \times (1/0.8)$ $X = \$13.30/\text{GJ}.$
5CMVP035	2	18	Answer = 2 Choose fuel oil Explanation : For natural gas $(\$4.00/\text{GJ})(1.0/0.92) = \$4.35/\text{GJ}$ For fuel oil $(\$123/\text{ton})(1 \text{ ton}/1000 \text{ kg})(1 \text{ kg}/42,000 \text{ kJ})(1/0.8) (1,000,000 \text{ kJ/GJ}) = \$3.33/\text{GJ}$ Choose fuel oil

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5CMVP036	1	18	Answer = 1 716 MJ/ m2 /yr Explanation : Gas (500 GJ/yr)(1000 MJ/GJ) = 500,000 MJ/yr Elect (60,000 kWh/yr)(3.6 MJ/kWh) = 216,000 MJ/yr EUI = (716,000 MJ/yr)/1000 m2 = 716 MJ/ m2 yr
5CMVP037	1	18	Answer = 1 Explanation : $P = A \times [P/A, I, N]$ $P = 25,000 \times [P/A, 15\%, 8]$ $= 25,000 \times [4.4873] = \\$112,182$ (round off) or \$112,175 (depending on tables)
5CMVP038	2	18	Answer = 2 20% Explanation : $P = A \times [P/A, IRR, 8]$ $34,500 = 9000 \times [P/A, IRR, 8]$ $[P/A, IRR, 8] = 34500/9000 = 3.833$ From the Interest Tables – Look for P/A and 8 years For I = 20% table; P/A = 3.83 so IRR = 20%
5CMVP039	3	18	Answer = 3 \$7970 Explanation : $P = A \times [P/A, I, N]$ $40,000 = A \times [P/A, 15\%, 10]$ $A = 40,000/[5.0188] = \\$7970$

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5CMVP040	1	18	Answer = 1 \$3,240/yr Explanation : Explanation : $P = A \times [P/A, I, N] \quad 40,000 = A \times [P/A, 15\%, 10]$ $A = 40,000/[5.0188] = \$7970$ kW saved = 196 fix x (0.285 kW/fix) - 140 fix x (0.185 kW/fix) = 30 kW Heating effect (30 kW) x (24 h/day) x (1/0.8) x (200 days/yr) x (3.6MJ/kWh) = 648,000 MJ/yr = 648 GJ/yr Added cost = (648 GJ/yr)(\$5/GJ) = \$3,240/yr
5CMVP041	4	8	Answer = 4 20.67 W/m² Explanation : $W = [(30 \times 192) + (10 \times 10) + (20 \times 75)]$ $= 8260 \text{ watts}$ $W/m^2 = 8260 \text{ W}/400 \text{ m}^2 = 20.67 \text{ W/m}^2$
5CMVP042	4	8	Answer = 4 All of the above
5CMVP043	2	8	Answer = 2 16.13 W/m² Explanation : $W = [(40 \times 162) + (10 \times 10) + (20 \times 75)]$ $= 9682 \text{ watts}$ $W/m^2 = 9682 \text{ W}/600 \text{ m}^2 = 16.13 \text{ W/m}^2$

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5CMVP044	1	8	Answer = 1 \$29,490/yr Explanation : kW saved = (45) x 1/0.9 = 50 kW kWh saved = 50 kW x 8,760 hours/yr = 438,000 kWh \$ saved = 50 kW x \$ 9/kW/mo x 12 mo/yr + 438,000 kWh x \$0.055/kWh = \$29,490/yr
5CMVP045	3	8	Answer = 3 44.3 kW Explanation : $q = \text{LPS} \times 1.2 \times \text{DT} = (3185)(1.2)(32.2-20.6)$ = 44.3 kW
5CMVP046	1	8	Answer = 1 680.4 GJ/yr Explanation : $q = \text{UA DT};$ $\text{UA} = 105 \text{ kW}/30 \text{ C} = 3.5 \text{ kW/C}$ Also, $Q = \text{UA} \times 24 \times \text{DD}$ = (3,500) W/C x 24 h/day x 1,800 C-day/yr x 1/0.8 = 189,000 kWh/yr = 680.4 GJ/yr
5CMVP047	3	8	Answer = 3 94.44 kW Explanation : $\text{kW} = (340,000 \text{ kJ/h})/(3600 \text{ kJ/kWh})$ = 94.44 kW

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5CMVP048	3	8	Answer = 3 2.65% Explanation : From combustion chart $\text{EffOLD} = 80.5\%$ $\text{EffNEW} = 82.7\%$ $\% \text{ savings} = (\text{EffNEW} - \text{EffOLD})/\text{EffNEW}$ $= (82.7 - 80.5)/82.7 = 2.65\%$
5CMVP049	4	8	Answer = 4 All of the above
5CMVP050	3	8	Answer = 3 \$ 1620
5CMVP051	1	18	Answer = 1 0.1 L/s Explanation : $\text{L/s} = \text{CwPD} = 0.01\sqrt{100} = 0.1 \text{ L/s}$
5CMVP052	1	8	Answer = 1 Efficiency Valuation Organization Explanation :
5CMVP053	4	8	Answer = 4 All of the above Explanation : Efficiency evaluation, measurement, and verification can have which of the following objectives: • Document the benefits and costs of a program and determine whether the program met its goals. • Understand why program-induced effects occurred and identify ways to improve current and future programs, including supporting continuous improvement. • Support energy demand forecasting and resource planning by understanding the historical and future resource contributions of efficiency as compared to other energy resources.

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5CMVP054	4	8	Answer = 4 All of the above Explanation : • Energy volume-based charges • demand charges • fixed and non-energy-related charges
5CMVP055	3	8	Answer = 3 Both Explanation : • Energy commodity charges and network charges • Metering charges, regulated and environmental charges
5CMVP056	1	8	Answer = 1 True Explanation : One of the most important aspects of the M&V process is to take into account any necessary adjustments.
5CMVP057	3	8	Answer = 3 Both Explanation : The standard equation cost avoidance is $\text{Cost avoidance (\$)} = \text{pricing structure} \times (\text{energy use adjusted baseline} - \text{energy use actual})$ In essence, this equation determines that amount of money saved through implementation of the ECM against the business as usual forecast had the ECM not been implemented. In the equation above it is important to note; A baseline energy model has been adjusted for post-retrofit conditions (i.e. the adjusted baseline and the actuals span the same time period. The same energy pricing structure is applied to the adjusted baseline as well as the actual usage
5CMVP058	3	8	Answer = 3 Both Explanation : • Cost avoidance should not be confused with cost savings. The term 'cost savings' infers that energy costs post-retrofit will be lower than those within the baseline period. This simplistic view does not take into account: • § Changes in factors that determine energy use (e.g. changes in site activities, effects of independent variables such as production or weather, etc) • § Price risks such as changes to energy contracts, structures or tariff rates

iPQ.No	Correct Answer	Points	Explanation
5CMVP059	4	18	Answer = 4 All of the above Explanation : • For energy-related ECMs, greenhouse gas emission savings arise from: • Reduced energy use • Switching from a fuel to an alternative with lower greenhouse emissions • Harnessing renewable energy sources that are emission free
5CMVP060	4	18	Answer = 4 All of the above Explanation : • Calculation based on default emission factors • Determination of greenhouse content of fuels using laboratory testing combined with fuel use • Direct measurement through continuous or periodic monitoring
5CMVP061	4	8	Answer = 4 All of the above Explanation : Consider the ECM where a Variable Speed Drive is fitted to a condenser water pump to control water flow based on demand. Using Option B we may simply measure the baseline and post- retrofit periods, with actual savings claimable for the measurement period. Extrapolating beyond this to create a 12 month savings estimate, may involve the following additional effort: 1. Develop an energy model between energy and demand for condenser water (or a proxy) 2. Forecast an annual demand profile for condenser water, which may incorporate factors such as seasonality, public holidays, vacancy and site usage patterns 3. Extrapolate the actual savings across 12 months by applying the annual demand profile to the energy model we developed. In this scenario, the 12 months savings figure is an estimate. In order to claim actual savings for this period, we would need to conduct continuous measurement for 12 months.

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5CMVP062	3	8	Answer = 3 Both Explanation : Poor precision: Achieved savings are 100,000kWh $\pm 100\%$ with 90% confidence Low confidence: Achieved savings are 100,000kWh $\pm 7\%$ with 10% confidence
5CMVP063	3	8	Answer = 3 Both Explanation : Sampling involves conducting measurements on a subset of a population to estimate the characteristics of the entire population. In a M&V context, this can be either: 1. periodic measurements of the same equipment to represent continuous measurement (e.g. multiple readings of the same circuit in different conditions) 2. sampling of a subset of devices, systems or components within a larger population
5CMVP064	3	8	Answer = 3 Both Explanation : Defining a population, sampling approach, and sample size Collecting and analyzing sample data
5CMVP065	4	8	Answer = 4 All of the above Explanation : • It is highly recommended that data is reviewed to ensure completeness and integrity prior to being used for developing energy models or calculating savings. • It is good practice to document within your M&V plan, your data quality control procedures and review techniques. • Another good reason to document the approach is in preparation for audit and verification. Auditors pay close attention to underlying data processing quality controls as well as the calculations and final outcome.

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5CMVP066	4	8	Answer = 4 All of the above Explanation : 1. Change the measurement period by one day to use a full day of data. Check that the period is still representative and that all other data sources are adjusted. 2. Use data from another source to estimate minor data gaps (e.g., a missing utility bill can be "gap filled" with interval meter data or meter readings from adjacent bills). 3. Interpolate best-estimates to fill minor data gaps. Consider data predictability. 4. Remove the measurement from the analysis (e.g., if multiple samples are taken, we can ignore those with obvious measurement errors if the remaining sample size is representati
5CMVP067	3	8	Answer = 3 Both 1 and 2 Explanation : Power factor is a measure of how efficiently a facility uses electricity. Power factor is the ratio of your demand for 'real' electric power (kW), divided by demand for 'apparent' power, (kVA). Power factor is represented by a figure between 0 and 1, with 1 being ideal.
5CMVP068	4	8	Answer = 4 All of the above Explanation : Demand is simply the current instantaneous power draw, which can be: - Continuous measurement using an rms power meter during the measurement period - Calculated from instantaneous, periodic, or continuous power draw measurements - Estimated (in cases where the key parameter is not known) using equipment specifications or manufacturer's data

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5CMVP069	3	8	Answer = 3 Both Explanation : - Degree-days are an indicator of how far the average temperature departs from a human comfort level called the base. - Degree days can be added over time to evaluate the cumulative effects over months or a year.																																																												
5CMVP070	1	18	Answer = 1 The following example illustrates the concept: <table><tr><th>Day</th><th>Daily Minimum Temp (°C)</th><th>Daily Maximum Temp (°C)</th><th>Max Average Temp (°C)</th><th>CDDs (balance point = 15 °C)</th><th>HDDs (balance point = 18 °C)</th></tr><tr><td>1</td><td>14.6</td><td>22.4</td><td>18.5</td><td>3.5</td><td>0</td></tr><tr><td>2</td><td>13.9</td><td>19.5</td><td>16.7</td><td>1.7</td><td>1.3</td></tr><tr><td>3</td><td>11.7</td><td>20.1</td><td>15.9</td><td>0.9</td><td>2.1</td></tr><tr><td>4</td><td>12.2</td><td>17.6</td><td>14.9</td><td>0</td><td>3.1</td></tr><tr><td>5</td><td>9.2</td><td>15.0</td><td>12.1</td><td>0</td><td>5.9</td></tr><tr><td>6</td><td>7.5</td><td>14.3</td><td>10.9</td><td>0</td><td>7.1</td></tr><tr><td>7</td><td>5.0</td><td>9.8</td><td>7.4</td><td>0</td><td>10.6</td></tr><tr><td>7 day total</td><td>-</td><td>-</td><td>-</td><td>6.1</td><td>30.1</td></tr><tr><td colspan="4">Combined CDD + HDD 7 day total</td><td colspan="2">36.2</td></tr></table> Explanation : Average daily temp = $(13.9 + 19.5) / 2 = 16.7$ CDDs. = average daily temp – CDD balance point = $16.7 - 15.0 = 1.7$	Day	Daily Minimum Temp (°C)	Daily Maximum Temp (°C)	Max Average Temp (°C)	CDDs (balance point = 15 °C)	HDDs (balance point = 18 °C)	1	14.6	22.4	18.5	3.5	0	2	13.9	19.5	16.7	1.7	1.3	3	11.7	20.1	15.9	0.9	2.1	4	12.2	17.6	14.9	0	3.1	5	9.2	15.0	12.1	0	5.9	6	7.5	14.3	10.9	0	7.1	7	5.0	9.8	7.4	0	10.6	7 day total	-	-	-	6.1	30.1	Combined CDD + HDD 7 day total				36.2	
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Explanation :																																																															
Average daily temp = $(13.9 + 19.5) / 2 = 16.7$																																																															
HDDs = HDD balance point – average daily temp = $18.0 - 16.7 = 1.3$.																																																															

iPQ.No	Correct Answer	Points	Explanation
5CMVP072	1	18	Answer = 1 The figure consists of two side-by-side graphs. The left graph plots 'Electrical Demand (kWe)' on the y-axis (0 to 500) against 'Load (kW)' on the x-axis (0 to 3,000). It shows two data series with quadratic regression lines. The top series (black squares) has the equation $y = 0.00001x^2 + 0.14411x + 51.20601$ and $R^2 = 0.99888$. The bottom series (orange diamonds) has the equation $y = 0.000056x^2 + 0.020062x + 93.647250$ and $R^2 = 0.997883$. The right graph plots 'Coefficient of Performance (COP)' on the y-axis (0 to 7) against 'Load (kW)' on the x-axis (0 to 3,000). It shows two data series with quadratic regression lines. The top series (black squares) peaks at a COP of approximately 6.2 at a load of about 1,500 kW. The bottom series (orange diamonds) peaks at a COP of approximately 5.2 at a load of about 2,000 kW. Explanation : The electrical demand can be estimated for each chiller using the equations shown based on the corresponding cooling load. Using 1,800 kW as an example the demands for two chillers are: Old chiller demand (kW) = $0.00001 \times \text{load}^2 + 0.14411 \times \text{load} + 51.20601 = 343 \text{ kW}$ New chiller demand (kW) = $0.000056 \times \text{load}^2 + 0.020062 \times \text{load} + 93.647250 = 311 \text{ kW}$ And the demand saving is: $343 - 311 = 32 \text{ kW}$ By applying this process to a chilled water load profile, we can estimate the electrical profile, and compare them to determine the demand savings for a given load, time of day, or season. It is important to note that in this case the savings will vary depending on the load of the chiller (i.e. the savings at low loads are different to those at peak COP or even full load. This variation will occur due to changing ambient conditions (day/night, summer/winter, etc) as well as control strategies, particularly if multi-chiller staging occurs

iPQ.No	Correct Answer	Points	Explanation
5CMVP073	3	8	Answer = 3 Both Explanation : • Input energy use for the heating and cooling systems • New heating and cooling requirements within the conditioned space
5CMVP074	4	8	Answer = 4 All of the above Explanation : • Equipment technical lifetime • Installation and commissioning • Maintenance and part replacement practices
5CMVP075	3	8	Answer = 3 Both 1 and 2 Explanation : • Digits from 1–9 are always significant (e.g., 134.6, 56,000). • Zeros between two other significant digits are always significant (e.g., 2,049).
5CMVP076	4	8	Answer = 4 All of the above Explanation : The IPMVP framework has adopted standard engineering practice for rounding figures in savings calculations so that reported figures reflect the accuracy of their underlying data. This involves rounding measurements and calculating values according to an appropriate number of significant digits. Rules for significant digits (significant digits are bolded in examples): Digits from 1–9 are always significant (e.g., 134.6, 56,000). Zeros between two other significant digits are always significant (e.g., 2,049). One or more additional zeros to the right of both the decimal place and another significant digit are significant (e.g., 0.290). Zeros used solely for spacing the decimal point (placeholders) are not significant (e.g., 24,560 or 0.00654).

iPQ.No	Correct Answer	Points	Explanation
5CMVP077	4	8	Answer = 4 All of the above Explanation : A M&V report is a document that summarizes the M&V project and the outcomes achieved. M&V savings reports typically include: Overview of the site and the ECMs List of installed equipment and/or technology A summary of the approach as per the M&V Plan the M&V option that has been used, with reference to the IPMVP edition list of project team members performance measurements process for calculating savings expected savings for the first year savings uncertainty
5CMVP078	4	8	Answer = 4 All of the above Explanation : • The M&V option that has been used, with reference to the IPMVP edition list of project team members • Expected savings for the first year savings uncertainty • Performance measurements and process for calculating savings

iPQ.No	Correct Answer	Points	Explanation
5CMVP079	4	8	Answer = 4 All of the above Explanation : Which of the following tips may assist when preparing M&V savings reports: Consider the audience of the report. Use appropriate language and provide background details to put findings into context. Use the details within your M&V plan to shape your report, including goals, expected outcomes and measures for success Use both words and diagrams to demonstrate the savings Add pictures which demonstrate the ECM in-situ and the process for conducting measurements Describe step-by-step the data analysis and savings calculations. Add equations with explanations if they are unfamiliar to the audience. Report savings figures using an appropriate number of significant digits Note that 'actual' savings can only be stated for the post-retrofit measurement period. Any extrapolation beyond this is considered an estimate. Acknowledge key stakeholders and project champions.
5CMVP080	4	8	Answer = 4 All of the above Explanation • Describe step-by-step the data analysis and savings calculations. Add equations with explanations if they are unfamiliar to the audience. • Report savings figures using an appropriate number of significant digits • Add pictures which demonstrate the ECM in-situ and the process for conducting measurements
5CMVP081	3	8	Answer = 3 Both 1 and 2 Explanation Note that 'actual' savings can only be stated for the post-retrofit measurement period. Any extrapolation beyond this is considered an estimate. Acknowledge key stakeholders and project champions.

iPQ.No	Correct Answer	Points	Explanation
5CMVP082	4	8	Answer = 4 All of the above Explanation : Consider the ECM, where a variable speed drive is fitted to a condenser water pump to control water flow based on demand. Using Option B, we may simply measure the baseline and post-retrofit periods, with actual savings claimable for the measurement period. Extrapolating beyond this to create a 12-month savings estimate may involve which of the following additional efforts? 1. Develop an energy model between energy and demand for condenser water (or a proxy). 2. Forecast an annual demand profile for condenser water, which may incorporate factors such as seasonality, public holidays, vacancy, and site usage patterns. 3. Extrapolate the actual savings across 12 months by applying the annual demand profile to the energy model we developed.

iPQ.No	Correct Answer	Points	Explanation																																																		
5CMVP083	3	8	Answer = 3 Both 1 and 2 <table><tr><th></th><th colspan="2">Old conditions: 50 hours per week</th><th colspan="2">New conditions: 60 hours per week</th></tr><tr><th></th><th>Annual Energy Use (kWh)</th><th>Annual Cost (@16c/kWh)</th><th>Annual Energy Use (kWh)</th><th>Annual Cost (@16c/kWh)</th></tr><tr><td>Old Lighting System</td><td>150,000</td><td>\$24,000</td><td>180,000</td><td>\$28,800</td></tr><tr><td>New Lighting System</td><td>127,500</td><td>\$20,400</td><td>153,000</td><td>\$24,480</td></tr><tr><td>Difference</td><td>22,500</td><td>\$3,600</td><td>27,000</td><td>\$4,320</td></tr></table> Explanation : A bank branch implements a lighting retrofit and is told by the lighting contractor that project will reduce site energy use by 15% and they will recoup their investment within three years. The Branch Manager reviews the first three months of energy bills and cannot see any reduction in cost. In frustration she asks the lighting contractor to explain. After some initial investigations, the lighting contractor confirmed that the new lighting was performing as expected. Following further discussion with the Branch Manager it was discovered that the bank branch has begun opening on Saturdays. This has increased the weekly hours of operation by 16%. The lighting contractor used cost avoidance to justify the initial claim as follows: <table><tr><th></th><th colspan="2">Old conditions: 50 hours per week</th><th colspan="2">New conditions: 60 hours per week</th></tr><tr><th></th><th>Annual Energy Use (kWh)</th><th>Annual Cost (@16c/kWh)</th><th>Annual Energy Use (kWh)</th><th>Annual Cost (@16c/kWh)</th></tr><tr><td>Old Lighting System</td><td>150,000</td><td>\$24,000</td><td>180,000</td><td>\$28,800</td></tr><tr><td>New Lighting System</td><td>127,500</td><td>\$20,400</td><td>153,000</td><td>\$24,480</td></tr><tr><td>Difference</td><td>22,500</td><td>\$3,600</td><td>27,000</td><td>\$4,320</td></tr></table> Although the Branch Manager could not see any 'cost savings', the cost avoidance actually increased from \$3,600 to \$4,320 per annum. In addition the payback dropped from 3 years to 2.5 years.		Old conditions: 50 hours per week		New conditions: 60 hours per week			Annual Energy Use (kWh)	Annual Cost (@16c/kWh)	Annual Energy Use (kWh)	Annual Cost (@16c/kWh)	Old Lighting System	150,000	\$24,000	180,000	\$28,800	New Lighting System	127,500	\$20,400	153,000	\$24,480	Difference	22,500	\$3,600	27,000	\$4,320		Old conditions: 50 hours per week		New conditions: 60 hours per week			Annual Energy Use (kWh)	Annual Cost (@16c/kWh)	Annual Energy Use (kWh)	Annual Cost (@16c/kWh)	Old Lighting System	150,000	\$24,000	180,000	\$28,800	New Lighting System	127,500	\$20,400	153,000	\$24,480	Difference	22,500	\$3,600	27,000	\$4,320
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5CMVP084	3	8	Answer = 3 Both 1 and 2 Explanation : In this example, each additional widget manufactured will consume 45 kWh. If 20,000 widgets are produced in one month, the electricity use associated with widget production will equal 900,000 kWh. Also, irrespective of how many widgets are manufactured, the plant will consume 96,000 kWh per month, which may be due to static (non-variable) loads such as plant lighting, standby equipment power, standby hot water energy consumption, and the like.																																																		

iPQ.No	Correct Answer	Points	Explanation
5CMVP085	1	8	Answer = 1 293 kWh Explanation : Baseline energy use (kWh) = $50 \times 90 \times 65 / 1000 = 293 \text{ kWh}$
5CMVP086	4	8	Answer = 4 263 kWh Explanation : Adjusted baseline energy use (kWh) = $45 \times 90 \times 65 / 1000 = 263 \text{ kWh}$
5CMVP087	1	8	Answer = 1 194 kWh Explanation : Post-retrofit energy use (kWh) = $45 \times 90 \times 48 / 1000 = 194 \text{ kWh}$
5CMVP088	4	8	Answer = 4 All of the above Explanation : In this situation, the inefficient incandescent lights have been replaced with higher-efficiency lights that produce more light per watt and hence less heat. In addition to the energy savings from the reduction in lighting load, the air conditioning will also benefit from a reduced cooling load, yielding further savings. This reduction in heat will affect the energy use of the air conditioning system, reducing cooling loads but potentially increasing heating requirements. Due to the choice of measurement boundary, the energy savings associated with the air conditioning are considered to be an interactive effect. Should these savings be significant, there is the option of creating a second M&V project for the air conditioning system or expanding the original measurement boundary to incorporate both.
5CMVP089	3	8	Answer = 3 Both 1 and 2 Explanation : Within a commercial building, interior lighting produces heat as well as light, which the air conditioning system may be required to remove or augment. Similarly, both the lighting and air conditioning systems are dependent on the size and positioning of windows, affecting the amount of available natural light and solar heat gain. Within a manufacturing site, the output from one production line may be an input to another.

iPQ.No	Correct Answer	Points	Explanation
5CMVP090	3	18	Answer = 3 Both 1 and 2 Explanation : Key parameters refer to the data types that are measured or estimated in relation to a defined measurement boundary for measuring and verifying the impact of an ECM and calculating savings. Key parameters are the data types that will be measured or estimated to: 1. Calculate baseline and post-retrofit energy use. 2. determine the size of adjustments, and 3. calculate energy savings.
5CMVP091	2	18	Answer = 2 24.9 °C degree-days
5CMVP092	3	8	Answer = 3 680.4 GJ/year Explanation : 680.4 GJ/year $q = (UA \cdot DD \cdot 24) = (3500 \cdot 1800 \cdot 24) / .8 = 189000 \text{ kWh/year}$ $189000 \cdot .0036 = 680.4 \text{ GJ/year}$
5CMVP093	4	8	Answer = 4 All the above
5CMVP094	1	8	Answer = 1 Spot measurement (option A)
5CMVP095	2	8	Answer = 2 Combustion analyzer: Explanation : This instrument has in-built chemical cells which measure various gases such as O₂, CO, NO_x and SO_x.
5CMVP096	3	8	Answer = 3 Financing information about the project
5CMVP097	1	8	Answer = 1 True. Explanation : The principle of exercising caution is one of the guiding principles for M&V (ACCERT). An M&V analyst should always make choices and apply assumptions that tend to underestimate the amount of energy saved. Nevertheless, when putting this principle into practice, it is essential not to make any analysis choices or assumptions that lead to reported energy savings that are excessively pessimistic and unrealistic.

iPQ.No	Correct Answer	Points	Explanation
5CMVP098	3	18	Answer = 3 55kW Explanation : 55kW $940 \times 0.75 = 705\text{kW}$ $705 - 650 = 55\text{kW}$
5CMVP099	3	8	Answer = 3 Both options 1 and 2 Explanation : Explanation : • M&V is the process of using measurement to reliably determine actual savings for energy, demand, cost, and greenhouse gases within a site through an Energy Conservation Measure (ECM). • Measurements are used to verify savings rather than applying deemed savings or theoretical engineering calculations, which are based on previous studies, manufacturer-provided information, or other indirect data. Savings are determined by comparing post-retrofit performance against a "business as usual" forecast.
5CMVP100	1	8	Answer = 1 1977 Explanation : AEE was founded:1977 The National Energy Policy & Conservation Act (1978) defines what an "energy manager" should be. AEE, a nonprofit professional society, is founded by Albert Thumann. In the same year, the US Department of Energy (DOE) and governments grapple with the 1970's Oil Crisis. Presiding President Al Thumann.