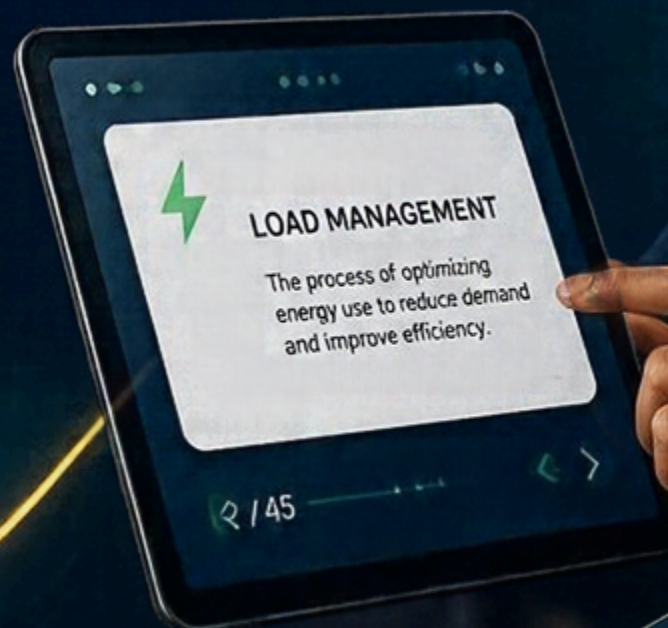


Energy Management Professional **EMP**

EMA EMP Key Terminologies Flash Cards



EMA EMP

Key Terminology Flashcards

Energy Management Professional (EMP) Exam Question Bank
EMA Guideline · EMP Handbook · ASHRAE/IES 90.1-2022 · ACG Guideline Part I

Final Exam Review

Domain A: Planning Effective Energy Management (29%) — 97 terms
Domain B: Managing Energy Information (11%) — 23 terms
Domain C: Implementing the Energy Management Program (20%) — 28 terms
Domain D: Managing Budgets and Finance (13%) — 49 terms
Domain E: Implementing Energy Efficient Projects (22%) — 49 terms
Domain F: Managing Energy Communications (5%) — 13 terms

259 terms · Beyond Smart Cities

Domain A - Planning Effective Energy Management: Process & Scope**Energy Management Professional (EMP)**

Practitioner certified to lead a building's energy management program: assessing use, finding and analyzing measures, overseeing implementation, commissioning and M&V, and sustaining results (EMA)

EMA Energy Management Process

Seven-phase process: 1 Project Assessment, 2 Energy Use Exploration, 3 Site Investigation, 4 ECM/FIM and EBCx Analysis, 5 Implementation, 6 Final Acceptance, 7 Continuous Energy Management

Phase 1 - Project Assessment

Client consultation and initial review: motivations, goals, site information, preliminary scope; ends with a proposal including a preliminary EBCx Scope

Phase 2 - Energy Use Exploration

Analysis of utility history (ideally at least three years), benchmarking and end-use breakdown; results may revise the evolving project plan and EBCx Scope

Phase 3 - Site Investigation

Further site visits, data collection and measurement to screen and develop measures; ends with the Energy Plan Outline and Investment Proposal

Phase 4 - ECM/FIM and EBCx Analysis

Detailed engineering and financial analysis of approved measures and EBCx; produces savings estimates, costs and the plans used for implementation

Domain A - Planning Effective Energy Management: Process & Scope**Phase 5 -
Implementation**

Final planning, installation, commissioning of new equipment and EBCx activities, with EMP oversight to deliver the design intent of each measure

**Phase 6 - Final
Acceptance**

Final testing, commissioning/EBCx reports, as-builts, System and O&M Manuals, O&M changes, staff training and the M&V reporting strategy

**Phase 7 - Continuous
Energy Management**

Ongoing tracking, ongoing commissioning, training and new measures so savings persist and the program keeps improving

**Energy Conservation
Measure (ECM)**

A change to equipment, systems or operation that reduces energy use or cost, e.g. a VFD, lighting retrofit or control sequence change

**Facility Improvement
Measure (FIM)**

A measure improving the facility (comfort, reliability, maintenance, safety, water) that may or may not save energy; evaluated alongside ECMs

**Owner's Project
Requirements (OPR)**

Document of the owner's goals, criteria and expectations for a project; the benchmark against which commissioning and final testing are judged (ACG)

Domain A - Planning Effective Energy Management: Process & Scope**Current Facility Requirements (CFR)**

Existing-building counterpart of the OPR, recording the owner's present operating requirements; developed for EBCx (ACG)

Basis of Design (BoD)

Designer's record of the concepts, assumptions, calculations and product decisions used to meet the OPR and codes (ACG)

Project scope

Defined buildings, systems, services and deliverables the EMP will cover; set with the client in Phase 1 and refined as findings emerge

Energy policy

Top-management statement of commitment, goals and responsibilities for energy; gives the program authority and continuity

Energy objective / target

Measurable result to be achieved by a date, e.g. "reduce site EUI 15% vs 2025 baseline by 2028"; should be specific and weather-normalized

SMART goals

Goals that are Specific, Measurable, Achievable, Relevant and Time-bound; a common test for energy targets

Domain A - Planning Effective Energy Management: Process & Scope**Strategic Energy Plan (SEP)**

Long-range plan setting goals, priorities, measures, schedule, budget and responsibilities; may grow from the Energy Plan Outline

Energy Plan Outline

Phase 3 summary to the client: energy use findings, an ordered list of potential ECMs/FIMs and EBCx, and proposed further development

Investment Proposal

Phase 3 companion to the Energy Plan Outline covering financial aspects: proposed costs to analyze and develop each ECM/FIM and the EBCx Scope

EBCx Scope

Preliminary description of existing-building commissioning work in the proposal: systems, activities and timeline; treated as an evolving document

Energy team

Cross-functional group (management, operations, finance, occupants' representatives, EMP) that plans and sustains the energy program

Energy champion

Respected staff member who promotes the program, removes barriers and keeps energy on management's agenda

Domain A - Planning Effective Energy Management: Process & Scope

**Capital (non-energy)
project consulting**

EMP input to planned renovations or replacements so efficiency is built in at low incremental cost, rather than retrofitted later

Domain A - Planning Effective Energy Management: Energy Use & Benchmarking**Energy Use Intensity (EUI)**

Annual energy per unit floor area.
Formula: $EUI = \text{annual energy} \div \text{gross floor area}$ (kBtu/ft²·yr or kWh/m²·yr);
state site or source basis

Site energy

Energy consumed at the building as metered (electricity, gas, fuel, steam), converted to common units

Source (primary) energy

Site energy plus generation, transmission and delivery losses; source = site × source-site ratio. Used by Energy Star for fair fuel comparison

Benchmarking

Comparing a building's energy performance with its own history, similar buildings or a reference data set, to judge potential and track progress

ENERGY STAR Portfolio Manager

Free EPA online tool for tracking energy, water and emissions and for generating 1-100 scores and benchmarking reports

ENERGY STAR score

1-100 percentile ranking of a building's source energy vs similar US buildings, normalized for weather and activity; 50 = median; 75+ may qualify for certification

Domain A - Planning Effective Energy Management: Energy Use & Benchmarking**CBECS**

Commercial Buildings Energy Consumption Survey (US EIA); national sample used for peer medians. Tip: data lag years and may contain few outliers like supertall towers

Energy baseline

Reference period energy use (usually 12+ months) and its relationship to drivers, against which savings or targets are measured

Baseline adjustment

Routine (weather, production) or non-routine (floor area, schedule, new loads) change applied so baseline and reporting periods are comparable

Energy performance indicator (EnPI)

Metric used to track performance, e.g. kWh per bed-night, kWh/m³ of product water, GJ per tonne; chosen to fit the facility's drivers

Normalization

Adjusting energy data for factors such as weather, occupancy or production so comparisons reflect efficiency rather than activity

Energy end-use breakdown

Allocation of total use to heating, cooling, fans, pumps, lighting, plug loads, process, etc.; guides where to look for savings

Domain A - Planning Effective Energy Management: Energy Use & Benchmarking**Load profile**

Demand vs time (daily, weekly, seasonal) from interval data; reveals base load, after-hours use and peak drivers

Load factor

Average demand ÷ peak demand for a period. Formula: $LF = kWh \div (peak\ kW \times hours)$. Low LF means peaky use and high demand cost per kWh

Equivalent full-load hours (EFLH)

Annual energy ÷ rated input (or capacity); e.g. $450,000\ kWh \div 300\ kW = 1,500\ h$. Used to scale savings and compare equipment use

Heating degree days (HDD)

Sum over days of (base temperature – mean daily temperature) when positive; base often 18°C/65°F. Drives heating energy normalization

Cooling degree days (CDD)

Sum over days of (mean daily temperature – base) when positive; used to normalize cooling energy

Balance point temperature

Outdoor temperature at which internal and solar gains just offset losses, so no heating is needed; the correct base for degree days

Domain A - Planning Effective Energy Management: Energy Use & Benchmarking**Weather normalization**

Regression of energy on degree days
(or temperature) so years with
different weather can be compared
fairly

Domain A - Planning Effective Energy Management: Audits & Opportunities**ASHRAE Level 1 audit**

Walk-through analysis: utility review, benchmarking, brief site visit; identifies low-cost/no-cost measures and potential capital measures

ASHRAE Level 2 audit

Energy survey and engineering analysis: end-use breakdown, measure savings and cost estimates with financial analysis

ASHRAE Level 3 audit

Detailed analysis of capital-intensive measures: extended data collection, often modeling; investment-grade cost and savings accuracy

Preliminary energy use analysis (PEA)

Utility bill and benchmarking analysis done before or at the start of a Level 1 audit (ASHRAE audit procedures)

Investment-grade audit (IGA)

Audit detailed enough for financing or a performance contract guarantee; similar to ASHRAE Level 3

Site investigation plan

Plan for visits listing systems, data to collect, loggers, staff access and safety needs; coordinated with operations before arrival

Domain A - Planning Effective Energy Management: Audits & Opportunities**Data logger**

Portable recorder of temperature, current, light, status etc. Tip: duration = $\text{memory} \div (\text{channels} \times \text{samples per hour} \times \text{bytes per sample})$

Low-cost/no-cost measure

Operational fix such as schedules, setpoints, resets or repairs; often found in EBCx with rapid payback

Measure interaction (interactive effects)

Savings of one measure change another's, e.g. lighting retrofit cuts cooling but raises heating; combined savings $\neq$ sum of individual

Measure ordering

Apply load-reducing measures (envelope, lighting) before sizing equipment measures, so plant is not oversized and savings not double-counted

ECM/FIM matrix

Table listing each measure with savings, cost, payback and non-energy factors (maintenance, comfort, risk) for client prioritization

Prioritization

Ranking measures by economics, risk, client goals, disruption and interactions; bundling quick paybacks with long ones to meet a portfolio target

Domain A - Planning Effective Energy Management: Audits & Opportunities**Non-energy benefits**

Value beyond energy cost: comfort, productivity, maintenance savings, reliability, safety, public relations; often decisive for approval

Heat recovery

Capturing waste heat (exhaust, condensate, flue gas, process) for another use; often needs calculations beyond standard simulation tools

Flash steam

Steam formed when high-pressure condensate drops to lower pressure.
Fraction = $(h_{f,high} - h_{f,low}) \div h_{fg,low}$

Fuel switching

Replacing one energy source with another (e.g. gas to heat pump); compare on cost, source energy and emissions, not site energy alone

Domain A - Planning Effective Energy Management: ASHRAE 90.1-2022**ANSI/ASHRAE/IES
Standard 90.1**

Energy standard for buildings except low-rise residential; sets minimum requirements for envelope, HVAC, service water heating, power, lighting and other equipment

Mandatory provisions

90.1 requirements that apply under every compliance path, whether prescriptive, ECB or Appendix G

Prescriptive path

Compliance by meeting each listed requirement of Sections 5–10 plus Section 11 Additional Efficiency Requirements (90.1-2022)

**Energy Cost Budget
(ECB) method**

Section 12 performance path: proposed design's annual energy cost must not exceed a budget building's cost (90.1-2022)

**Appendix G -
Performance Rating
Method**

Modeling method comparing proposed design with a stable baseline; used for code compliance ($PCI \leq PCI_t$) and beyond-code rating programs

**Performance Cost Index
(PCI)**

Appendix G ratio: $PCI = \text{proposed building performance} \div \text{baseline building performance (annual energy cost)}$

Domain A - Planning Effective Energy Management: ASHRAE 90.1-2022**PCI target (PCIt)**

$$PCIt = (BBUEC + BPF \times BBREC) \div BBP$$

where BBUEC/BBREC = baseline unregulated/regulated energy cost, BBP = baseline performance, BPF from Table 4.2.1.1

Building performance factor (BPF)

Factor by building type and climate zone used in PCIt; area-weighted for mixed-use buildings ("All others" if type not listed)

Regulated vs unregulated energy

Regulated: loads governed by 90.1 (HVAC, lighting, SWH). Unregulated: plug and process loads not covered; modeled the same in proposed and baseline

Unmet load hours

Hours when a zone's temperature is outside its thermostat band; Appendix G reports them for both proposed and baseline; excess indicates undersized or mis-modeled systems

Additional Efficiency Requirements (energy credits)

90.1-2022 Section 11: projects earn a required number of energy credits by building use type and climate zone, choosing from listed measures

Alteration (90.1)

Replacing or adding to systems, equipment, structures or assemblies; routine maintenance, repair and service, or a change of use classification, is not an alteration

Domain A - Planning Effective Energy Management: ASHRAE 90.1-2022**Verification and testing
(V&T)**

90.1-2022 requirement to verify or test listed systems; providers must not have designed or installed the systems tested

Climate zone

Zone (0-8, with A/B/C moisture subtypes) assigned by location; sets envelope, economizer and other 90.1 requirements

U-factor

Heat transmission through an assembly per unit area and temperature difference ($\text{W/m}^2\cdot\text{K}$); lower is better insulating. $R = 1/U$ for a homogeneous layer

**Solar heat gain
coefficient (SHGC)**

Fraction of incident solar radiation admitted through fenestration, directly or absorbed and re-radiated; 0-1, lower means less solar gain

Fenestration

Windows, glazed doors, skylights and other light-transmitting openings in the envelope; limited by window-to-wall ratio in the prescriptive path

**Lighting power density
(LPD)**

Installed lighting power per unit floor area (W/m^2); 90.1 sets allowances by building area or space-by-space method

Domain A - Planning Effective Energy Management: ASHRAE 90.1-2022

Daylight zone / daylight area

Floor area near vertical glazing (sidelighted) or under skylights (toplighted) where daylight-responsive controls are required

Occupant sensor control

Automatic lighting (or HVAC) shutoff when spaces are vacant; vacancy sensors require manual-on, occupancy sensors switch on automatically

Automatic receptacle control

90.1 requires at least 50% of 125 V, 15/20 A receptacles in private offices, conference, copy, break rooms, classrooms and workstations to be automatically switched off

Electrical energy monitoring

90.1 requires new buildings (above a size threshold) to separately monitor total, HVAC, interior and exterior lighting, receptacle and refrigeration electricity

Voltage drop limit

90.1: feeders plus branch circuits sized for a maximum 5% total voltage drop

Domain A - Planning Effective Energy Management: HVAC Controls in 90.1**Air economizer**

Dampers and controls that use outdoor air for cooling when it is cool/dry enough, reducing mechanical cooling; required by climate zone and capacity

Economizer high-limit shutoff

Control that returns outdoor air to design minimum when outdoor air no longer reduces cooling energy (dry-bulb, enthalpy or combination type)

Integrated economizer

Economizer able to operate together with mechanical cooling (partial economizing), not locking out when compressors start

Economizer fault detection & diagnostics (FDD)

90.1 requires FDD on listed air-cooled DX units with economizers, detecting sensor faults and economizing when it should or should not

Demand control ventilation (DCV)

Varies outdoor air with actual occupancy (CO₂, occupancy counts); 90.1 requires it in high-occupancy spaces above a size threshold

Ventilation optimization (VAV)

Multiple-zone VAV systems with zone DDC must automatically reset outdoor air intake below design as system ventilation efficiency changes (Std 62.1 basis)

Domain A - Planning Effective Energy Management: HVAC Controls in 90.1**Exhaust air energy recovery**

Transfer of heat (and moisture) between exhaust and outdoor air streams; required by 90.1 above airflow and outdoor-air fraction thresholds

Simultaneous heating and cooling limits

90.1 limits reheat, recooling and mixing; VAV zones must reduce airflow before reheating

Dehumidification reheat limits

90.1 restricts using new energy to reheat air for humidity control; site-recovered heat or limited airflow approaches are allowed

VAV static pressure reset

DDC resets duct static setpoint from zone damper positions so the most-open damper is nearly open; 90.1 limits sensor setpoint to 300 Pa

Chilled/hot water temperature reset

Resetting water supply temperature with load or outdoor temperature to save plant energy; balance against pump energy

Setback / setup

Lower heating and higher cooling setpoints during unoccupied periods; required controls capability in 90.1

Domain A - Planning Effective Energy Management: HVAC Controls in 90.1**Deadband**

Range between heating and cooling setpoints with no active conditioning; 90.1 requires a deadband (typically $\geq 3^{\circ}\text{C}/5^{\circ}\text{F}$) for zone thermostats

Isolation areas

90.1: zones operated non-simultaneously divided into areas ($\leq 2,300 \text{ m}^2$ and one story) each with automatic shutoff devices

Domain B - Managing Energy Information: Data & Metering**Interval data**

Utility or submeter readings at short intervals (15-min or hourly); shows load profiles, peaks and after-hours use

Submetering

Meters on systems, tenants or buildings below the utility meter; allows measure-level verification and faster fault detection

Meter multiplier

Factor (CT and PT ratios) converting dial or register readings to actual kWh/kW; a wrong multiplier causes step changes in recorded use

Building automation system (BAS)

Network of controllers, sensors and software controlling HVAC and other systems; source of trend data for diagnosis and M&V

Trend log

Time series of BAS points (temperatures, positions, speeds, status) recorded for analysis; set intervals and storage before testing

Energy information system (EIS)

Software that collects, stores and visualizes meter and BAS data, with dashboards, alarms and analytics

Domain B - Managing Energy Information: Data & Metering**Fault detection and diagnostics (FDD)**

Analytics that compare operating data with rules or models to flag faults such as simultaneous heating/cooling or stuck dampers

Data validation

Checking data for gaps, spikes, flat lines, units and time-zone errors before analysis; bad data produce bad conclusions

Calibration

Comparing an instrument with a reference and adjusting it; M&V meters must be installed and calibrated properly to produce useful data

Utility bill history

At least three years of bills (EMA) to see trends, seasonality and anomalies; request early since it takes time to gather

Domain B - Managing Energy Information: Analysis & Reporting**Linear regression
baseline**

Model of energy vs independent variables, e.g. kWh = $a + b \times \text{CDD}$; coefficients from least squares on baseline data

**Coefficient of
determination (R^2)**

Fraction of variance in energy explained by the model, 0–1. Tip: ASHRAE Guideline 14 suggests $R^2 > 0.75$ as a screening level for whole-building models

CV(RMSE)

Coefficient of variation of root mean square error = $\text{RMSE} \div \text{mean of measured values}$; measures model scatter. Guideline 14 calibration: $\leq 15\%$ monthly, $\leq 30\%$ hourly

NMBE

Normalized mean bias error = $\Sigma(\text{measured} - \text{predicted}) \div [(n - p) \times \text{mean}]$; shows systematic over/under prediction. Guideline 14: $\pm 5\%$ monthly, $\pm 10\%$ hourly

Change-point model

Regression with a break at a balance-point temperature (e.g. 3-parameter heating or cooling, 5-parameter heating and cooling); fits HVAC-driven loads

CUSUM

Cumulative sum of differences (actual – expected) over time; a falling line shows savings, a change in slope shows when performance changed

Domain B - Managing Energy Information: Analysis & Reporting**Calibrated simulation**

Energy model adjusted until it matches measured data within tolerances; used for complex interactive measures and IPMVP Option D

Sensitivity analysis

Varying uncertain inputs to see effect on results; 90.1 ECB requires varying each estimated input from half to double the assumed value

Specific energy consumption (SEC)

Energy per unit of output, e.g. kWh/m³ for desalination, GJ/tonne for paper; the key EnPI for process plants

Energy report

Internal (management) or external (regulator, public, certification) report of use, savings and progress; state basis, period and normalization

Emissions factor

Mass of CO₂e per unit of energy (kg CO₂e/kWh or per GJ); grid factors vary by region and year, so separate efficiency from grid changes

Global warming potential (GWP)

Warming effect of a gas relative to CO₂ over a period (usually 100 years); refrigerant CO₂e = kg leaked × GWP ÷ 1,000 (t)

Domain B - Managing Energy Information: Analysis & Reporting

**Energy disclosure
(benchmarking
ordinance)**

Local law requiring owners to report
annual energy (often via Portfolio
Manager); floor areas and space uses
must be defined correctly

Domain C - Implementing the Program: Management & Teams**Energy management program**

Organized, continuing effort (policy, people, data, projects, training, review) to reduce energy use and cost; not a one-time project

Plan-Do-Check-Act (PDCA)

Continual improvement cycle: plan targets and actions, implement, measure results, act on findings; basis of ISO 50001

ISO 50001

International standard for energy management systems: policy, energy review, baseline, EnPIs, objectives, operational control, monitoring, management review

Energy review

ISO 50001 analysis of energy use and consumption to identify significant energy uses (SEUs) and improvement opportunities

Roles and responsibilities

Defined duties among owner, operators, tenants, contractors and EMP; unclear ownership is a common reason savings fade

Energy awareness campaign

Communication and engagement activities (posters, competitions, feedback) to change occupant behavior; evaluate with metered results

Domain C - Implementing the Program: Management & Teams**Operations and maintenance (O&M) practices**

Routine operation, inspection and maintenance affecting energy: filter changes, coil cleaning, calibration, schedules, steam trap checks

Preventive maintenance (PM)

Scheduled maintenance to prevent failure and efficiency loss; CMMS work orders document it and can reveal performance trends

CMMS

Computerized maintenance management system: tracks assets, work orders, PM schedules and history

Integrated project team

EMP, owner, operators, designers, contractors and specialists working together from early stages so requirements are clear

Design-build

Delivery method where one entity designs and builds; EMP should verify OPR, energy targets and commissioning are written into the contract

Domain C - Implementing the Program: Commissioning**Commissioning (Cx)**

Quality-focused process verifying and documenting that systems are planned, designed, installed, tested, operated and maintained to meet the OPR (ACG)

Existing building commissioning (EBCx)

Systematic process to investigate, analyze and optimize existing systems so they meet the current facility requirements; umbrella for retro-, re- and ongoing Cx (ACG)

Retro-commissioning (RCx)

Commissioning of an existing building that was never commissioned; finds operational deficiencies and low-cost measures

Re-commissioning

Repeating commissioning on a previously commissioned building, e.g. after use changes or at intervals, to restore performance

Ongoing commissioning (OGCx)

Continuous or periodic monitoring and testing to keep systems optimized and catch drift; often supported by trend analysis and FDD

EBCx Plan

Document setting EBCx scope, team, schedule, tests, documentation and communication; must give clear sequences, not "optimize" statements

Domain C - Implementing the Program: Commissioning

**Commissioning
provider / authority
(CxP/CxA)**

Party leading the commissioning process; the EMP may act as CxA or coordinate a third-party provider

**Pre-functional checklist
(PFC)**

Installation verification checklist completed before start-up and functional testing (also called construction checklist)

**Functional performance
test (FPT)**

Test proving systems operate as intended through all modes and sequences, using defined procedures and acceptance criteria

Sampling

Testing a representative portion of identical units; failures trigger testing of a larger sample or all units

Issues (deficiencies) log

Record of problems found during Cx/EBCx, responsible party, resolution and retest status; part of the final report

**Testing, adjusting and
balancing (TAB)**

Measuring and adjusting air and water flows to design; findings may allow fans or pumps to run slower

Domain C - Implementing the Program: Commissioning**Sequence of operation**

Written description of how a system is controlled in each mode, with setpoints, sensor locations and limits

Commissioning Report

Final report on new systems: summary, checklists, test results, issues and corrective actions (ACG; EMA Phase 6)

EBCx Report

Final report on existing systems: revised as-builts, activities and measurements, tests, recommended O&M practices, training opportunities (EMA)

**Systems Manual
(System Manual)**

Living document for operators: system descriptions, sequences, setpoints, benchmarks, test data; update responsibility should be in a job description

Persistence of savings

Degree to which savings last over time; protected by training, OGCx, monitoring and clear O&M responsibilities

Domain D - Budgets & Finance: Utility Bills & Tariffs**Energy charge**

Cost per unit energy (kWh, therm, GJ);
may vary by block, season or time of
use

Demand (kW)

Rate of energy use; billing demand is
usually the highest integrated average
over a 15- or 30-minute interval in the
billing period

**Integrated vs
instantaneous demand**

Billing demand averages kW over the
demand interval; a short spike counts
only for its share of that interval

Demand charge

Cost per kW of billing demand
(\$/kW-month); can be a large share of
commercial electric bills

Demand ratchet

Tariff clause setting billing demand to
at least a percentage (e.g. 80%) of the
highest demand in prior months (often
11); one peak can raise bills for a year

Time-of-use (TOU) rate

Prices vary by period (on-peak,
mid-peak, off-peak) and season;
shifting load to cheaper periods saves
cost without saving energy

Domain D - Budgets & Finance: Utility Bills & Tariffs**Real-time pricing (RTP)**

Tariff with hourly prices linked to wholesale market; rewards flexible loads and storage

Power factor (PF)

Real power ÷ apparent power = kW ÷ kVA = $\cos \theta$. Low PF means more current for the same kW

kVAR (reactive power)

Power that sustains magnetic fields without doing work; $kVA^2 = kW^2 + kVAR^2$. Capacitor kVAR needed = $kW \times (\tan \theta_1 - \tan \theta_2)$

Power factor penalty

Tariff charge or demand adjustment when PF falls below a threshold (often 0.90 or 0.95); corrected by capacitors

Rate schedule (tariff)

Utility's approved pricing document for a customer class: charges, riders, demand definitions, ratchets and terms

Rate class review

Checking whether the customer is on the most economical eligible tariff given its load profile; a no-cost saving opportunity

Domain D - Budgets & Finance: Utility Bills & Tariffs**Bill audit**

Checking invoices for errors: meter multipliers, rate class, estimated reads, taxes, demand values, duplicate or late charges

Marginal (avoided) cost

Cost saved by the last unit of energy or demand reduced; use it, not average cost ($\$ \div \text{kWh}$), to value savings

Delivery vs supply charges

In deregulated markets the utility bills delivery (wires) while a retail supplier bills energy supply; both are needed to audit total cost

Natural gas units

1 therm = 100,000 Btu $\approx$ 105.5 MJ; 1 Dth (dekatherm) = 10 therms = 1 MMBtu; 1 kWh = 3,412 Btu = 3.6 MJ

Domain D - Budgets & Finance: Procurement & Supply**Energy procurement**

Buying energy supply through utility tariffs or competitive contracts; consider price, risk, term, load shape and green attributes

Fixed-price contract

Supply price locked for a term; budget certainty but no benefit if market prices fall

Hedging (block and index)

Buying part of expected load at a fixed price and the rest at index, to balance cost and risk

Demand response (DR)

Reducing or shifting load when requested by a utility or grid operator, in return for payments or lower rates; baseline rules define credited reductions

Peak shaving

Lowering peak demand by load control, storage or on-site generation to reduce demand charges

Battery storage economics

Net savings = demand savings + arbitrage – losses. Energy charged = discharge ÷ round-trip efficiency; losses = charged – discharged

Domain D - Budgets & Finance: Procurement & Supply**Combined heat and power (CHP)**

On-site generation using recovered heat; economic when spark spread is favorable and thermal output is used

Spark spread

Difference between value of electricity produced and cost of fuel to make it:
 $\$/\text{MWh electricity} - (\text{heat rate} \times \text{fuel price})$

Heat rate

Fuel input per unit of electric output (Btu/kWh or MJ/kWh); efficiency = $3,412 \text{ Btu/kWh} \div \text{heat rate}$

Renewable energy certificate (REC)

Tradable certificate for 1 MWh of renewable generation and its attributes; renewable claims require owning and retiring RECs

Power purchase agreement (PPA)

Long-term contract to buy electricity from a generator (on-site or off-site, physical or virtual) at agreed prices

Domain D - Budgets & Finance: Economics & Financing**Simple payback**

Initial cost $\div$ annual savings (years).
Ignores time value of money and savings after payback

Return on investment (ROI)

Annual net savings $\div$ investment (as %); simple ROI is the reciprocal of simple payback

Time value of money

A dollar today is worth more than one later; future values are discounted at the discount rate

Present value (PV) factor

Single sum: $P = F \div (1 + i)^n$. Uniform series: $P = A \times [(1 + i)^n - 1] \div [i(1 + i)^n]$

Net present value (NPV)

Sum of discounted savings minus initial cost; $NPV > 0$ means the project beats the discount rate

Internal rate of return (IRR)

Discount rate at which $NPV = 0$; accept if IRR exceeds the hurdle rate (minimum attractive rate of return)

Domain D - Budgets & Finance: Economics & Financing**Discounted payback**

Years until cumulative discounted savings equal the investment; longer than simple payback

Savings-to-investment ratio (SIR)

PV of savings ÷ PV of investment; SIR > 1 is cost-effective (used in FEMP life cycle costing)

Life cycle cost (LCC)

PV of all costs over study period: first cost + energy + maintenance + replacements – residual value; lowest LCC is preferred

Capital recovery factor (CRF)

Converts a present cost to equal annual payments: $CRF = i(1 + i)^n \div [(1 + i)^n - 1]$

Cost of conserved energy (CCE)

Annualized cost per unit saved: $CCE = (\text{investment} \times CRF) \div \text{annual energy saved}$; compare with energy price

Marginal abatement cost

Net cost per tonne CO₂e avoided = $(\text{annualized cost} - \text{annual savings}) \div \text{annual tonnes avoided}$; negative means it saves money

Domain D - Budgets & Finance: Economics & Financing**Discount rate (nominal vs real)**

Nominal includes inflation; real excludes it: $(1 + \text{nominal}) = (1 + \text{real})(1 + \text{inflation})$. Use nominal with escalated cash flows

Energy price escalation

Expected change in energy prices over time; escalated savings use $[(1 + e)^n]$ factors in cash flows

Depreciation tax shield

Tax saved because depreciation is deductible: $\text{shield} = \text{depreciation} \times \text{tax rate}$. After-tax cash flow = $(\text{savings} - \text{depreciation})(1 - t) + \text{depreciation}$

Energy savings performance contract (ESPC)

ESCO designs, installs and often finances measures; payments come from guaranteed savings verified by M&V

Guaranteed savings contract

ESCO guarantees a savings level; owner usually carries financing; shortfalls paid by the ESCO

Shared savings contract

ESCO finances and receives an agreed share of measured savings for the term; ESCO carries more performance risk

Domain D - Budgets & Finance: Economics & Financing**Energy service company (ESCO)**

Firm providing energy projects under performance contracts, with design, installation, financing and M&V

PACE financing

Property Assessed Clean Energy: loan repaid via property tax assessment, transferable with the property where enabled

Tax increment financing (TIF)

Local financing tool using future increases in property tax revenue in a district to fund improvements; EMA advises owners to learn about TIF, rebates and tax benefits

Incentives and rebates

Utility or government payments (prescriptive or custom) that reduce project cost; usually need pre-approval before purchase

Domain E - Implementing Energy Projects: Systems & Calculations**Coefficient of performance (COP)**

Useful heating or cooling output ÷ energy input in the same units; COP = $3.517 \div (\text{kW/ton})$

Energy efficiency ratio (EER)

Cooling output (Btu/h) ÷ electric input (W) at rated conditions; EER = $3.412 \times \text{COP}$

kW/ton

Chiller (or plant) input kW per ton of cooling; 1 ton = 12,000 Btu/h = 3.517 kW. kW/ton = $12 \div \text{EER}$

IPLV / NPLV

Integrated (rated) or non-standard part-load value: weighted part-load efficiency of chillers per AHRI 550/590

Sensible heat (air)

$Q = \rho \times c_p \times V \times \Delta T$; SI: $Q(\text{kW}) \approx 1.2 \times 1.006 \times \text{m}^3/\text{s} \times \text{K}$. IP: $\text{Btu/h} \approx 1.08 \times \text{cfm} \times ^\circ\text{F}$

Latent heat (air)

Moisture removal load; IP: $\text{Btu/h} \approx 4,840 \times \text{cfm} \times \Delta\omega (\text{lb/lb})$

Domain E - Implementing Energy Projects: Systems & Calculations**Water heat transfer**

$$Q = m \times c_p \times \Delta T; \text{ IP: Btu/h} \approx 500 \times \text{gpm} \times ^\circ\text{F}; \text{ SI: kW} \approx 4.19 \times \text{kg/s} \times \text{K}$$

Fan affinity laws

Flow $\propto$ speed; pressure $\propto$ speed²; power $\propto$ speed³. Real savings are lower due to static head, minimum speed and drive losses

Pump power

$$\text{Hydraulic kW} = \rho \, g \, Q \, H \div 1,000 \, (Q \text{ in m}^3/\text{s}, H \text{ in m}) = Q \times \Delta p \div 1,000 \, (\Delta p \text{ in Pa}); \text{ electric input} = \text{hydraulic kW} \div (\text{pump} \times \text{motor} \times \text{drive efficiency})$$

Delta T (chilled water)

Supply-return temperature difference; flow = load $\div$ ($c_p \times \Delta T$), so low delta T raises pump flow and chiller staging

Variable frequency drive (VFD)

Adjusts motor speed to load; large savings on variable-torque loads (fans, pumps) per the affinity laws

Motor efficiency and load

$$\text{Input kW} = \text{hp} \times 0.746 \times \text{load factor} \div \text{efficiency}; \text{ premium-efficiency motors save most at high run hours}$$

Domain E - Implementing Energy Projects: Systems & Calculations**Lighting savings**

kWh saved = (W before – W after) ×
hours ÷ 1,000; add HVAC interaction
(less cooling, more heating)

**Boiler combustion
efficiency**

Fuel heat converted to useful heat,
determined from flue gas O₂/CO₂ and
stack temperature; excess air and
stack temperature are the main losses

Radiant heat loss

$Q = \varepsilon \sigma A (T_1^4 - T_2^4)$, temperatures in
kelvin; $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4$

Infiltration heat loss

$Q = \rho c_p \times (\text{air leakage m}^3/\text{s}) \times \Delta T$; IP:
 $1.08 \times \text{cfm} \times \Delta T$; opening large doors
can dominate hangar or dock heating
loads

**Simultaneous heating
and cooling penalty**

Reheat energy plus the cooling energy
that removed the same heat earlier:
penalty = reheat × (1 + 1/COP) for
electric reheat

Heat pump

Moves heat from a low- to a
high-temperature reservoir; heating
 $\text{COP} = 1 + \text{cooling COP}$ (ideal energy
balance)

Domain E - Implementing Energy Projects: Systems & Calculations

Cooling tower cycles of concentration

Makeup = evaporation $\times$ C $\div$ (C - 1);
blowdown = evaporation $\div$ (C - 1);
higher cycles save water

Domain E - Implementing Energy Projects: Implementation & Close-Out**Implementation plan**

Detailed plan of tasks, sequence, schedule, responsibilities, access, outages and testing for each measure (EMA Phase 5)

Measure specification

Document stating equipment, performance, controls sequence, submittals, testing and training requirements for a measure

Submittal

Contractor documentation (product data, drawings) for approval before purchase or installation; verifies compliance with design intent

Installation verification

EMP checks that equipment and controls are installed as specified before functional testing

Start-up

First operation of new equipment per manufacturer procedures; precedes functional performance testing

Outage and access coordination

Scheduling shutdowns and entry to occupied or tenant spaces to avoid disrupting operations; confirm tenant presence first

Domain E - Implementing Energy Projects: Implementation & Close-Out**Final testing**

Phase 6 testing confirming systems operate in agreement with the OPR, building on Phase 5 tests; consult industry standards for unfamiliar systems

As-built documentation

Record drawings and descriptions of what was actually installed, including changes, points and locations; delivered in paper and electronic form

O&M Manual

Manufacturer and contractor information for operating and maintaining equipment: procedures, parts, schedules, warranties

Training

Instruction for operators (and occupants where needed) on new systems, sequences and practices; key to persistence of savings

Project close-out

Completion activities: punch list, final tests, documentation, training, warranty start, M&V setup and client acceptance

Complaint matrix

O&M rule setting the minimum number of complaints and areas before facility-wide setpoint changes (EMA)

Domain E - Implementing Energy Projects: M&V**Measurement and verification (M&V)**

Process of using measurement to reliably determine actual savings, since savings cannot be measured directly (they are the absence of use)

IPMVP

International Performance Measurement and Verification Protocol (EVO); defines M&V framework and Options A-D

Savings equation

$$\text{Savings} = (\text{Baseline energy} - \text{Reporting period energy}) \pm \text{Routine adjustments} \pm \text{Non-routine adjustments}$$

IPMVP Option A

Retrofit isolation: key parameter measurement; some parameters (e.g. hours) stipulated. Example: lighting with measured watts, estimated hours

IPMVP Option B

Retrofit isolation: all parameter measurement of the affected system, short-term or continuous, e.g. VFD with kWh metering

IPMVP Option C

Whole facility: utility or main meter data with regression for weather and other variables; needs savings large relative to noise (often > 10%)

Domain E - Implementing Energy Projects: M&V**IPMVP Option D**

Calibrated simulation of facility or system; used when baseline data are missing or measures interact strongly

Measurement boundary

Notional boundary around equipment or facility within which savings are determined; interactive effects outside it must be estimated

**Baseline period /
reporting period**

Baseline: time before implementation used to model use; reporting (post-installation) period: time when savings are determined

Routine adjustments

Adjustments for expected changing variables (weather, production) through the baseline model

**Non-routine
adjustments**

Adjustments for unexpected static-factor changes (area, occupancy type, equipment added) not in the model

Stipulated value

Agreed estimate used in place of measurement (Option A); its uncertainty and risk should be acknowledged

Domain E - Implementing Energy Projects: M&V**Avoided energy use**

Savings expressed as reporting period use adjusted to reporting conditions vs baseline under the same conditions

Normalized savings

Savings expressed under fixed (e.g. typical weather) conditions, comparing baseline and reporting models

M&V Plan

Document defining option, boundary, baseline, adjustments, metering, analysis, reporting, responsibilities and budget; outline it with the client first

Realization rate

$\text{Verified savings} \div \text{predicted (estimated) savings}$; < 1.0 means savings were overestimated or measures underperform

Measure life (EUL)

Effective useful life: expected years a measure delivers savings; used in lifetime savings and LCC

Energy model refinement

Updating the energy model with as-built and measured data in Phase 6 so it supports ongoing M&V (EMA)

Domain F - Managing Energy Communications**Advocacy**

Promoting energy conservation to management, staff and occupants by showing benefits in terms each audience values

Executive summary

One-page summary for senior management: results, cost, savings, risk, decision needed; avoid jargon

Business case

Argument linking a project to the organization's goals with financial metrics (NPV, IRR, payback), risk and non-energy benefits

Communication plan

Plan of audiences, messages, channels, frequency and responsibility for energy program communication

Progress report

Periodic (e.g. monthly) report on measures, savings vs plan, issues and next steps; format agreed with the client

**Greenhouse gas (GHG)
Scope 1**

Direct emissions from owned or controlled sources: on-site combustion, fleet, refrigerant leaks (GHG Protocol)

Domain F - Managing Energy Communications**GHG Scope 2**

Indirect emissions from purchased electricity, steam, heat or cooling; reported location-based and market-based (GHG Protocol)

GHG Scope 3

Other indirect value-chain emissions: purchased goods, commuting, travel, waste, tenants' use (GHG Protocol)

Location- vs market-based Scope 2

Location-based uses average grid factors; market-based uses contractual instruments (RECs, PPAs, supplier factors)

Carbon neutrality claim

Claim requires measured emissions, reductions and retired offsets/RECs for the remainder; avoid claims not supported by evidence

External parties

Utilities, regulators, government agencies, ESCOs, certification bodies, vendors, professional organizations; coordinate early and document agreements

Professional organizations

Groups (e.g. AEE, ASHRAE, BOMA, local chapters) offering O&M training and peer support; EMA suggests staff join them

Domain F - Managing Energy Communications

Utility program coordination

Working with utility incentive staff and third-party verifiers on pre-approval, documentation and M&V requirements

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