APIS GUIDE 05 · ENERGY

The building energy *audit playbook.*

How to commission an audit that survives contact with a finance director — baselines, measurement, measure selection and verified savings, for building owners and energy managers.

APIS · ESCO & ENERGY PERFORMANCE

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ABOUT THIS GUIDE

An audit is worth exactly *what gets built.*

Most energy audits are technically competent and commercially inert. They identify real measures, calculate real savings, and are then filed — because the baseline could not be defended, the payback rested on an assumption nobody tested, or the report arrived after the capital budget had closed.

An audit is not an end in itself. It is a document whose purpose is to get work approved and then to prove that the work delivered. Everything in this playbook is arranged around those two jobs.

It covers how to choose the depth of audit you actually need, what to assemble before an auditor arrives, how to build a baseline that will survive scrutiny, what to measure and for how long, how to sequence measures that interact, how to convert findings into a case a finance director will approve, and how to verify afterwards that the savings were real. It ends with a forty-point checklist you can attach to the instruction.

> A WORD ABOUT SAVINGS PERCENTAGES
>
> You will have seen figures — that an audit typically identifies twenty, thirty or forty per cent. **This guide states no such figure, and you should be sceptical of anyone who does before they have seen your building.**
>
> What an audit identifies depends on the building's age, its condition, its climate, its hours of use, what has already been done and what the energy price is. Two identical buildings on the same street can have entirely different potential because one has been maintained and the other has not. A percentage quoted without a measured baseline for your specific building is a marketing number, and it is the first thing an experienced finance director will ask you to justify.
>
> The honest sequence is the reverse: **establish the baseline first, then the percentage means something.** Section 03 is about doing exactly that.

Who this is written for

- Building owners and energy managers commissioning their first audit, or their fifth after four that went nowhere
- Public bodies and municipalities preparing an audit tender, or spending grant funding on one
- Industrial and commercial operators with a sizeable energy bill and no internal specialist
- Finance directors and boards evaluating an audit report and the proposal that follows it
- Consultants and contractors preparing or reviewing an audit scope

What this guide is not

It is not a substitute for a qualified energy auditor, and it does not teach you to perform an audit. It covers **buildings and their systems**; industrial process energy and transport fleets are separate disciplines with their own methods. It states no tariffs, no costs and no payback periods, and it recommends no equipment or manufacturer.

How to use it

If you are commissioning: work through Sections 01 to 03 before instructing anyone, and attach the checklist in Section 09. If an audit has already been delivered and you are deciding what to do with it, start at Section 06 and read forward. Sections 04 and 05 describe what a thorough audit actually does, and are the sections to use when judging whether the one you received was thorough.

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SECTION 01

What an audit is for, and *how deep to go.*

Three depths of audit, three different costs, three different decisions they can support. Buying the wrong depth wastes either money or the opportunity.

An energy audit is a systematic examination of how a building uses energy, producing a ranked list of measures with their savings, costs and implementation requirements. EN 16247 sets out the process requirements for energy audits in Europe, with a dedicated part for buildings; ISO 50002 provides a parallel international framework. Both describe the same arc: agree the scope, collect data, survey, analyse, report, and hold a closing meeting.

What neither standard decides for you is **how deep to go**. That is a commercial decision, and it should be taken deliberately rather than inherited from whatever the cheapest quotation covered.

The three depths, in practice

Depth	What it involves	What decision it can support
Screening or walk-through	Bill analysis, a short site visit, benchmarking against comparable buildings, an indicative list of opportunities. Days rather than weeks. Little or no measurement	Whether to investigate further, and roughly where the opportunity sits. **Not an investment decision** — the numbers are indicative and should be labelled as such
Detailed audit	Full survey of systems, interval data analysis, targeted measurement, calculated savings for each measure with costs and interactions considered	Prioritisation and budgeting. Sufficient for most self-funded programmes and for deciding which measures deserve deeper work
Investment-grade audit	Everything above, plus metered baseline data over a full cycle, calibrated modelling where appropriate, firm costs from suppliers, risk analysis and a defined measurement and verification plan	Financing. Required where a lender, an energy performance contract or a guarantee depends on the numbers, because somebody else is taking risk on them

The names vary between markets and frameworks — some use numbered levels — but the distinction that matters is constant: **how much of the result is measured, and how much is estimated**. Ask that question of any audit proposal and the depth becomes obvious regardless of what it is called.

> THE MISMATCH THAT WASTES THE MOST MONEY
>
> A screening audit commissioned to support an investment decision. The report identifies genuine measures with indicative savings, the organisation tries to build a capital case on them, finance asks how the numbers were derived, and the answer is “benchmark and experience”. The project stalls, and the audit is blamed for being wrong when it was simply the wrong depth for the job it was given.
>
> The reverse mismatch — an investment-grade audit on a building where nobody has yet decided whether to invest — wastes less but is still avoidable. Screen first. Then go deep where the screening said it was worth it.

What a good audit produces

Regardless of depth, the deliverable should contain all of the following. If any is missing, the report cannot do its job.

1. **A stated baseline**, with the period, the data source, the normalisation method and the assumptions — see Section 03
2. **Energy use broken down by end use** — heating, cooling, ventilation, lighting, hot water, plug and process loads — with the basis for the split stated
3. **A ranked measure list**, each with savings in energy and in cost, capital cost, and the confidence attached to both
4. **The interactions between measures** made explicit, so that savings are not double-counted — see Section 06
5. **Non-energy benefits and consequences**, which frequently carry more weight with a board than the energy saving itself
6. **A measurement and verification plan** for whatever is implemented
7. **What was not investigated**, specifically, and what the exposure is

Why audits fail commercially

Five reasons, in rough order of frequency. All are avoidable at the instruction stage.

- **No defensible baseline.** The savings cannot be proved because there is nothing credible to prove them against. Section 03.
- **Arrived at the wrong time.** An excellent report delivered a month after the capital budget closed will wait a year, and by then its costs are stale.
- **Measures presented as a flat list.** Twenty-eight items ranked by payback, with no sequencing, no grouping and no view on which are quick wins and which are a programme. Nobody can act on a list like that, so nobody does.
- **The costs were indicative.** Finance approves against firm costs. An approximate cost is a reason to defer.
- **No owner.** The report was commissioned by facilities, needs capital from finance, requires downtime from operations, and belongs to nobody.

> FIX FOUR OF THE FIVE BEFORE YOU INSTRUCT
>
> Set the delivery date against your capital budget cycle, not against the auditor’s convenience. Require firm costs on the top measures rather than indicative ones. Require the measure list to be grouped and sequenced rather than merely ranked. And name the person who will own the outcome before the work starts, not after the report lands.
>
> The baseline is the fifth, and it is the one this guide spends the most time on.

SECTION 02

What to assemble *before the auditor arrives.*

The quality of an audit is capped by the quality of the data it starts from, and most of that data is yours.

An auditor arriving to a building with three years of clean interval data, a complete asset register and an accurate occupancy schedule will produce a fundamentally better result than one arriving to twelve paper invoices. Assembling it is unglamorous and it is the highest-return hour anyone spends on the project.

The data pack

Item	Why it matters, and what to ask for
Energy invoices, all fuels, three years	Every line, not the totals. Standing charges, capacity charges, reactive power penalties and tariff structure all affect which measures pay
Interval consumption data	At the metering interval, for as long as it exists. This is the single most valuable dataset and it is frequently held by the supplier and never requested
Sub-meter readings	Whatever exists, however patchy. Even partial sub-metering constrains the end-use breakdown usefully
Occupancy and operating schedule	Hours of use by area, headcount, shift patterns, holidays and shutdowns. The most common cause of a wrong baseline is an assumed schedule
Production or activity data	Where energy use tracks output, visits, occupancy or bed-days, this is what the baseline must be normalised against alongside weather
Floor areas and zoning	By area and by function, on a consistent measurement basis. State which basis, because benchmarks differ
Asset register with ages and ratings	Plant, its capacity, its year of installation. If this does not exist, creating it is itself a worthwhile output of the audit
Controls documentation and set points	The BMS strategy as designed, and the set points as they actually are. These diverge, and the divergence is often the finding
Maintenance records and the reactive call log	Reveals which plant actually fails and which complaints recur. Chronic complaints usually indicate a control or balancing fault that is also wasting energy
Drawings and any previous studies	Including audits that were never implemented — knowing what was recommended before, and why nothing happened, saves repeating it
Planned changes	Refurbishment, new plant, expansion, occupancy change. An audit of a building about to change is an audit of a building that will not exist

IF YOU HAVE NO INTERVAL DATA, START THERE

Monthly totals cannot tell you when energy is used, and when is where most of the opportunity hides — plant running overnight, weekend baseload that should not exist, a peak that costs more than the energy behind it. Two routes: request the interval data your supplier or distribution operator already holds, which is often available and rarely asked for; or install logging at the main incomer and run it for a year.

A year of monitoring feels like a delay. It is cheaper than acting on assumptions, and the monitoring is permanently useful, because it is also how you will verify savings afterwards.

Four questions to answer internally first

1. **What is the decision this audit must support?** A budget submission, a grant application, an ISO 50001 requirement, a lender's condition, or a genuine open question about where to start. The answer sets the depth.
2. **What is the capital envelope, realistically?** An auditor who knows the envelope will shape the measure list around it. One who does not will produce a list where the best measures are unaffordable and the affordable ones were not prioritised.
3. **What is off limits?** Processes that cannot be interrupted, tenant areas that cannot be altered, plant with remaining warranty, works already committed. Constraints stated up front produce a usable list; constraints discovered afterwards produce a rewrite.
4. **Who owns the outcome?** Named, before the work starts.

Choosing the auditor

- **Competence and independence.** EN 16247 includes a part addressing the competence of energy auditors, and many markets operate a register or licensing regime. Establish which applies where your building is, and confirm the individual — not only the firm — holds it.
- **Building-type experience.** A hospital, a cold store and an office are different energy problems. Ask for comparable work.
- **Whether the auditor also wants to implement.** This is common, it is not inherently wrong, and it must be disclosed. An auditor who will deliver the works tends to cost measures realistically — and also has an interest in the list being long. Decide in advance whether you want that, and if the audit is intended to procure the works competitively, say so at the outset.
- **Measurement capability.** Ask what instruments they will bring and what they will log. An audit with no measurement is a walk-through, whatever it is called.
- **The report format,** agreed in advance — including the measure schedule as a working spreadsheet rather than a PDF table, so that the assumptions can be tested.

SECTION 03

The baseline — *everything rests on this.*

A saving is a comparison against something. If that something is not defensible, nothing downstream is either.

A baseline is a model of how the building consumed energy before any intervention, expressed as a relationship between consumption and the things that drive it. It is not a number. A single annual figure is not a baseline, because it cannot answer the question that will eventually be asked: would that year have been different anyway?

The three components

1. **A period.** Normally twelve consecutive months, covering a full heating and cooling cycle and a full operating cycle. Longer where operations vary between years.
2. **Driving variables.** The things consumption genuinely depends on — outdoor temperature above all, and then occupancy, operating hours, and production or activity where relevant.
3. **A stated relationship** between the two, so that consumption can be predicted for any conditions and compared against what actually happened.

Weather normalisation

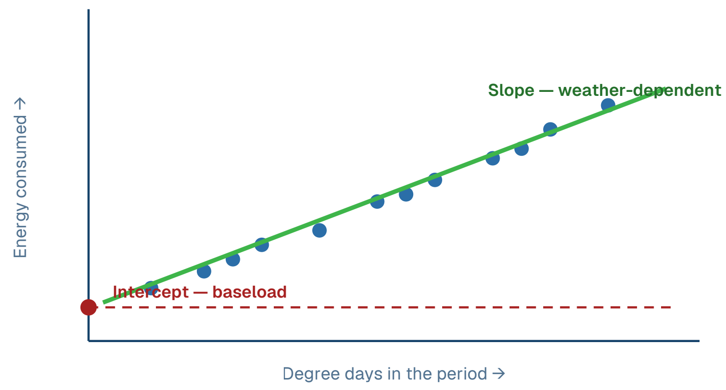
Heating and cooling consumption varies with weather, and a mild winter will produce a “saving” that no measure caused. Degree days are the standard instrument: a measure of how far and for how long outdoor temperature fell below, or rose above, a stated base temperature.

Two things must be stated for a degree-day analysis to be meaningful, and both are commonly omitted:

- **The base temperature used**, and why. It is a property of the building — the outdoor temperature below which heating is required, given the building’s internal gains and fabric. Using a conventional default without testing it against your building’s own data is a frequent source of a poor fit.
- **The weather data source and station**, with its distance from the site. A station in a different microclimate introduces error that will later be mistaken for performance.

> HOW THE RELATIONSHIP IS ACTUALLY ESTABLISHED
>
> Plot consumption for each period — monthly, weekly or daily, depending on data — against degree days for the same period. A well-behaved heating system produces a recognisable straight-line relationship: a slope, which is the weather-dependent consumption, and an intercept, which is the baseload that occurs regardless of weather.
>
> Both numbers are diagnostic before any measure is considered. **A high intercept means substantial consumption unrelated to heating** — plant running when it should not, hot water losses, or a control fault. A poor fit means something other than weather is driving consumption, and finding out what is usually more valuable than any measure on the list.

THE BASELINE RELATIONSHIP, AND WHAT IT REVEALS



Read it before you read the measures

A **high intercept** means consumption that has nothing to do with the weather — plant running out of hours, hot water losses, or a control fault.

A **poor fit** means something other than weather is driving consumption. Finding out what is usually worth more than any measure on the list.

A **steep slope** points at the fabric and at heating system efficiency.

ILLUSTRATIVE — NOT DATA FROM ANY BUILDING

Figure 3.1 — The baseline relationship. Both the slope and the intercept are diagnostic in their own right, before any measure is evaluated. Points shown are illustrative of the method only.

Beyond weather

Weather is the dominant driver in most buildings but rarely the only one. Where consumption also tracks occupancy, operating hours, production volume or another activity measure, the baseline must include it — otherwise a busy year will erase a real saving and a quiet year will manufacture one that did not happen.

Whatever variables are used, three rules apply:

- **They must be independently measurable** for the whole reporting period, not only for the baseline period. A driving variable you will not be able to measure next year is useless.
- **They must not be affected by the measures themselves**, or the baseline adjusts away the very saving it is meant to detect.
- **They must be agreed in writing before implementation**, particularly where a guarantee or a performance contract depends on the result. Renegotiating a baseline after the works is the most common cause of dispute in performance contracting.

THE BASELINE IS A CONTRACTUAL OBJECT, NOT A TECHNICAL ONE

If any part of the project involves a savings guarantee, an energy performance contract, a grant condition or a lender's covenant, the baseline is the term the whole arrangement turns on. It must specify the period, the data source, the driving variables, the normalisation method, the treatment of missing data, and — critically — **what constitutes a non-routine adjustment**: a change to the building that is nobody's fault but that alters consumption, such as an occupancy change, an extension, or new equipment.

Agree the adjustment mechanism before signing. Section 08 returns to this.

Common baseline errors

- **Using a single year with no normalisation.** The saving is then whatever the weather did.
- **Choosing an unrepresentative baseline year** — one with a long shutdown, a partial occupancy, or a major fault. Convenient, and indefensible.
- **Ignoring a tariff change.** A cost saving that came from renegotiating a contract is real, but it is not an energy saving and it must be reported separately.

- **Mixing metered and estimated readings** without saying which is which.
- **Not stating the base temperature** used for degree days.
- **Building the baseline after the works have started.** At that point it is a reconstruction, and it will be treated as one.

SECTION 04

The site *survey.*

What a thorough survey covers — and what to look for yourself, because the most revealing evidence is usually behaviour rather than plant.

The survey converts data into explanation. The interval record shows that something consumes energy at three in the morning; the survey establishes what, and why nobody noticed.

Start with the times nobody looks at

Before examining any system, look at consumption when the building is empty — nights, weekends, the shutdown period. Whatever is running then is running without producing anything, and it is almost always the cheapest opportunity in the building.

A survey conducted only during working hours will miss it entirely. Ask for at least one out-of-hours visit, and treat it as a required part of the scope rather than an extra.

> THE OUT-OF-HOURS WALK FINDS WHAT THE DAYTIME WALK CANNOT
>
> - Air handling plant running on a schedule nobody has revisited since handover
> - Lighting on in unoccupied areas, or controls overridden and never restored
> - Circulation pumps running continuously because a bypass was opened years ago
> - Process and IT equipment left energised out of habit
> - Heating and cooling operating simultaneously in the same zone — see below

Systems, and what to establish for each

Building fabric and envelope

- Construction, insulation and glazing type by elevation, with any previous upgrade recorded
- Evidence of air leakage — draughts at junctions, doors that do not close, unsealed service penetrations, open loading doors
- Thermal imaging where conditions permit it, which requires a temperature difference across the envelope and therefore a season
- Shading, orientation and solar gain, which drive cooling load as much as fabric drives heating

Heating, cooling and ventilation

- Plant type, age, rated capacity and — separately — the load it actually serves. Oversizing is endemic and it costs efficiency at every hour of part load
- Distribution: insulation condition, leakage, whether the system was ever balanced
- Control strategy as designed and as operating — weather compensation, optimum start, setback, zoning
- **Simultaneous heating and cooling**, which is the single most wasteful fault a building can have and is remarkably common in mixed systems. Look for it explicitly
- Heat recovery: whether it exists, whether it works, and whether it has been disabled
- Fresh air rates against actual occupancy, and whether any demand control exists

Lighting

- Lamp and luminaire type by area, and installed load per unit area
- Controls — presence detection, daylight linking, time control, and whether any of it is functioning as intended
- Measured illuminance against the level actually required for the task, since over-illumination is common and is a pure loss
- External and car park lighting, which frequently runs on a time clock nobody has adjusted for the season

Hot water

- Generation type, storage volume against actual demand, and standing losses
- Circulation regime and its hours — a circulation pump running continuously in a building with intermittent demand is a steady, invisible cost
- Insulation of vessels, pipework and valves, which is inexpensive and frequently missing
- Temperature regime, which is constrained by hygiene requirements that take precedence over any energy consideration

Electrical, controls and everything else

- Power factor and any reactive charge on the bill, which is sometimes correctable cheaply
- Motors and drives — whether variable speed control is fitted where the load varies, and whether fitted drives are actually modulating
- Compressed air, where present: leakage is the classic industrial loss, and it is audible
- Refrigeration and cold storage — door discipline, seals, defrost strategy, condenser cleanliness
- IT and plug loads, and out-of-hours policy
- The BMS: what it monitors, what it controls, whether anyone reads it, and whether alarms have been standing for months

> ASK THE PEOPLE WHO WORK THERE
>
> Occupants know which rooms are too cold, which are too hot, and what they do about it. A zone where people run portable heaters while the cooling operates is a control fault the data may not resolve on its own. Taped-over grilles, propped doors, blocked radiators and permanently open windows are all evidence, and they are free to collect.
>
> They also carry a second finding: a building generating chronic complaints is not only wasting energy, it is failing the people in it — which is frequently the argument that gets the work approved when the energy saving alone does not.

SECTION 05

Measurement — what, where *and for how long.*

The difference between an audit you can finance and one you can only file is usually the amount of the result that was measured rather than assumed.

Every audit contains estimates; the question is which numbers are load-bearing. A measure worth a large capital sum should not rest on an assumed running hour or a nameplate rating. Measure the inputs to the biggest numbers, and estimate the rest.

What to measure, in priority order

Measurement	Typical duration	What it settles
Main incomer, interval data	A full year, or as long as exists	The baseline, the out-of-hours load, the peak, and the shape of everything
Sub-metering of major end uses	Two to four weeks per circuit, covering a weekend	The end-use breakdown, which is otherwise estimated and therefore contestable
Plant run hours	Two to four weeks, covering typical and atypical operation	The most common single error in savings calculations — assumed hours
Temperature logging, internal and flow/return	Two to four weeks	Overheating, control performance, simultaneous heating and cooling, and whether set points are what anyone believes
Motor and drive loading	One to two weeks	Whether variable speed control would pay, and whether existing drives are modulating
Illuminance	Spot measurements	Over-illumination, and the achievable reduction
Thermal imaging	Single survey, seasonal	Insulation defects, air leakage paths, missing pipe insulation, electrical hot spots
Air-tightness test	Single test	Infiltration losses — worth it where fabric measures are being considered seriously
Power quality and power factor	One to two weeks	Reactive charges, harmonics, and any correctable billing penalty
Compressed air leakage	Off-load test plus survey	Frequently the largest single industrial loss, and among the cheapest to fix

TWO WEEKS INCLUDING A WEEKEND, OR IT DOES NOT COUNT

A logging period that covers only working days cannot show what happens when the building is empty — which is the finding you are most likely to be looking for. Any logging campaign should span at least one full weekend, and ideally a period containing both a typical week and an atypical one.

Equally: a two-week campaign in October tells you nothing about August. Where a measure depends on seasonal behaviour, either log across seasons or state clearly that the result was extrapolated, and from what.

Permanent metering — the decision to take now

Temporary logging answers the audit's questions. Permanent sub-metering answers next year's, and the year after that. It is the difference between knowing what the building did once and managing it continuously.

The argument for installing permanent metering as part of the programme rather than as a separate project:

- **It is the verification mechanism.** Section 08 depends on being able to measure after the works, and retrofitting metering afterwards means there is no "before".
- **Installation is far cheaper when switchboards are already open** for other work in the programme.
- **It is normally a prerequisite for any formal energy management system**, and for most reporting obligations a lender or a group parent will impose.
- **Without it, savings decay unnoticed.** Settings drift, plant is overridden, and the saving quietly disappears. Nobody finds out until the next audit.

What to meter permanently, at minimum: the main incomer for each fuel; the major plant items — heating, cooling, ventilation; lighting where it is separately distributed; hot water; and any single load large enough to matter on its own. Where a building has tenants or distinct cost centres, meter to that boundary as well.

METERING WITHOUT A READER IS DECORATION

Sub-metering that nobody looks at achieves nothing. Specify, alongside the meters: where the data goes, at what interval, who reviews it, how often, and what triggers an investigation. A monthly half-hour with a consumption chart and a named person will find more than most subsequent audits.

SECTION 06

Building and sequencing *the measure list.*

A ranked list of twenty-eight items is not a plan. Grouping, sequencing and interaction are what turn findings into work that gets done.

Categorise before you rank

Ranking by payback alone buries the measures that should happen first. Group them instead:

Category	What it is	How to treat it
Operational — no or low cost	Schedules, set points, control strategy, switching off, correcting overrides, tuning the BMS	**Do these first, always.** They cost little, deliver quickly, and they also establish whether the building responds as expected — which de-risks everything that follows
Maintenance and restoration	Restoring plant and controls to designed performance — cleaning, balancing, recommissioning, repairing failed sensors and valves, replacing missing insulation	Cheap, often overlooked, and it must precede any capital measure that assumes the system works properly
Capital replacement	Plant, lighting, controls, fabric	Sequence against the asset replacement cycle. Replacing plant early costs the residual life; replacing it at end of life costs only the increment over a like-for-like replacement, which transforms the case
Generation and storage	Solar PV, heat pumps, storage, CHP	**Last, not first.** Reducing demand before sizing generation produces a smaller, cheaper system. Sizing generation to an unreduced load means paying twice

THE SEQUENCING RULE THAT SAVES THE MOST MONEY

Reduce, then restore, then replace, then generate.

Installing solar PV before addressing an oversized, badly controlled system means sizing the array to a demand that should not exist. Replacing a chiller before recommissioning the controls means buying capacity to serve a fault. Every step out of order is paid for twice — once in the oversized asset, and again in the saving that was available and was not taken.

Interactions — where savings get double-counted

Measures affect each other, and a list that adds up individual savings will overstate the total. The auditor should quantify the interactions; the reader should check that they did.

- **Lighting and thermal load.** Efficient lighting produces less waste heat, which reduces cooling and increases heating. In a cooling-dominated building this adds to the saving; in a heating-dominated one it subtracts from it.
- **Fabric and plant sizing.** Improving the envelope reduces the load, which means any plant replacement that follows should be smaller — a capital saving that is only captured if the two are sequenced together.

- **Controls and everything.** Correcting a control fault may deliver much of the saving a capital measure was claiming, which changes that measure's case substantially.
- **Demand reduction and generation.** As above — the array or the storage should be sized to the reduced load.
- **Heat recovery and demand-controlled ventilation.** Both save on the same air; installing both does not save twice.

The three things every measure needs

1. **A savings figure with its basis and confidence.** Measured, calculated, modelled or estimated — stated, not implied. A measure whose saving is "estimated" and whose cost is large is the one to investigate before committing.
2. **A cost that includes everything.** Not the equipment price: design, installation, access, out-of-hours working, temporary provision, making good, commissioning, disruption and any consequential works. This is where measure lists most often fail, in exactly the way capital forecasts do.
3. **Its implementation requirements.** Downtime, access, permits, lead times, and what else must happen first. A measure with a nine-month lead time and a measure that can be done next week belong in different phases.

> BE HONEST ABOUT PERSISTENCE
>
> Some savings persist without attention; others decay. A fabric measure keeps saving for decades. A control set point can be overridden by one person in one afternoon, and frequently is — usually by someone responding to a genuine complaint the change caused.
>
> Where a saving depends on behaviour or on a setting remaining as commissioned, say so in the measure list, and attach the mechanism that will hold it: monitoring, an alarm on deviation, a locked parameter, a named owner, or a periodic review. A saving with no persistence mechanism should be discounted, not assumed.

Presenting the list so it can be acted on

Three phases, each of which can be approved separately:

- **Phase 1 — now.** Operational and maintenance measures. Little or no capital, quick delivery, and they prove the building responds.
- **Phase 2 — this budget cycle.** Capital measures with strong cases and no dependency on anything unresolved.
- **Phase 3 — planned.** Measures tied to the asset replacement cycle, to a refurbishment, or to a decision not yet taken. Dated against the cycle rather than left open.

A board can approve Phase 1 in a meeting. It cannot approve twenty-eight items ranked by payback, and it will not try.

SECTION 07

From measures to *a business case.*

Payback is the weakest instrument in the toolbox and the one most audits stop at. Here is what to use instead, and what else belongs in the paper.

Simple payback — capital cost divided by annual saving — is easy to calculate, easy to explain, and systematically biased against exactly the measures with the longest lives. It ignores everything that happens after the payback point, ignores the cost of capital, and ignores residual value. A fabric measure with a twenty-five-year life and a lighting control with an eight-year life are not comparable on payback, and treating them as though they are will produce the wrong programme.

What to use instead

Instrument	What it captures	When to use it
Simple payback	How quickly the outlay returns, ignoring everything else	Screening only. Useful for sorting the obvious from the marginal, never for deciding between measures with different lives
Net present value	Total value created over the measure's life, discounted	The primary instrument. Compares measures with different lives on the same footing
Internal rate of return	The return the measure earns, comparable to other uses of capital	Where the measure competes against other investments for the same money — which it always does
Life-cycle cost	Capital plus operating plus maintenance plus replacement over a defined period	Where the choice is between alternatives — this system or that one — rather than whether to act
Marginal cost of the upgrade	The additional cost of the efficient option over the like-for-like replacement	**Where plant is being replaced anyway.** Transforms the case, and is the single most under-used argument in energy investment

THE MARGINAL-COST ARGUMENT

A boiler at end of life will be replaced regardless. The relevant question is not “what does an efficient system cost” but "what does it cost more than the replacement we were going to buy anyway".

Measured that way, the efficient option frequently has a case that the full-cost comparison completely obscures — and the moment to make it is when the replacement is already in the plan, not two years later when the like-for-like has been installed and the opportunity is gone for another twenty years.

This is why Section 06 insists on sequencing capital measures against the asset replacement cycle. The cycle is where the cheap wins are.

What else belongs in the case

Energy saving is often not the largest benefit, and in front of a board it is frequently not the most persuasive. State the rest explicitly rather than leaving them to be inferred.

- **Maintenance and reliability.** New plant needs less attention and fails less. Reduced reactive maintenance and avoided downtime are real money and belong in the model.
- **Avoided replacement.** Where the measure defers or removes a capital item already in the forecast.
- **Comfort, productivity and complaints.** Harder to quantify, and often the reason approval is actually granted. A building generating chronic complaints has a cost that does not appear on the energy bill.
- **Compliance and reporting.** Where a requirement is arriving during the holding period, the measure is not discretionary and should not be evaluated as though it is.
- **Asset value and lettability.** Increasingly material for institutional owners and for anything that will eventually be sold or refinanced.
- **Resilience.** Reduced exposure to price volatility and to supply interruption.
- **Emissions.** Where the organisation has a commitment, a target or a reporting obligation, the measure's contribution belongs in the paper.

Assumptions to state, and to test

Every case rests on assumptions. The credible ones are the cases that name them and show what happens when they move.

- **Energy price and its trajectory.** The most influential single assumption and the least knowable. Present a range rather than a forecast, and show the result at the bottom of the range as well as the middle.
- **Discount rate**, and whether it is your organisation's standard.
- **Measure life**, and whether it assumes the maintenance that will actually be performed.
- **Operating hours and occupancy** — if these change, the saving changes with them.
- **Persistence** — see Section 06. Savings that depend on a setting should be discounted unless a mechanism holds them.
- **Take-back.** Where a building was under-heated because it was expensive to heat, an efficiency measure may deliver comfort rather than saving. That is a legitimate and valuable outcome — but it must be stated as such, not booked as energy saving that will not appear.

How the work gets paid for

Route	How it works	Trade-offs
Self-funded	Own capital, own risk, all savings retained	Cheapest overall and the simplest. Competes with every other use of capital, which is usually why the work does not happen
Energy performance contract	A provider designs, installs and guarantees a level of savings, verified against an agreed baseline. Payment linked to performance	Transfers performance risk and can be structured off the capital budget. Requires an investment-grade baseline, a rigorous M&V regime, and a long contract that must be read carefully
Energy as a service	The provider owns and operates the plant; the client buys the output — heat, cooling, light — on a service charge	No capital, and the equipment risk sits with the provider. Long commitment, and the cost over the full term must be compared honestly against ownership
Grant, subsidy or concessional finance	Public, EU or development-bank programmes supporting efficiency investment	Can be decisive. Carries conditions, reporting obligations and deadlines that shape the programme, and application windows that rarely align with your budget cycle

IF A GUARANTEE IS INVOLVED, THE BASELINE IS THE CONTRACT

An energy performance contract is a commercial arrangement built on a technical object: the baseline from Section 03. Before signing, establish exactly how savings will be measured, what happens when the building changes, who bears the risk of an energy price move, what happens if savings exceed or fall short of the guarantee, and how disputes are resolved.

These are legal and commercial questions on which this guide expresses no view, and they should be taken with advisers. What the guide does say is that they are decided by the baseline and the M&V plan — so those are not technical annexes to be settled later. They are the deal.

SECTION 08

Verifying that the savings *were real.*

The step that turns a claim into a fact — and the one that is dropped first when the programme runs late.

Measurement and verification establishes what actually happened after the works. It matters for three reasons: it is how a guarantee is settled, it is how the next investment gets approved, and it is how you find out when a saving quietly stops.

The International Performance Measurement and Verification Protocol — IPMVP — is the framework in general international use, and it defines four options. Choosing between them is the first decision in any M&V plan.

Option	Approach	Suits
Option A	Isolate the affected system. Measure the parameters that matter most; estimate the rest from stipulated values	Measures where one variable dominates and can be measured cheaply — a lighting replacement where the load is measured and the hours stipulated
Option B	Isolate the affected system and measure all relevant parameters continuously	Single systems with variable operation — a motor and drive, a pump, a chiller — where the saving is worth the metering
Option C	Whole-facility. Compare metered consumption against the baseline model, adjusted for weather and other drivers	Programmes of many measures, and anywhere the saving is large enough to be visible against total consumption. The natural fit for a whole-building retrofit
Option D	Calibrated simulation. Model the building, calibrate the model against measured data, and use it to determine savings	New build with no baseline, deep retrofits where the building changes fundamentally, or where individual measures cannot be isolated

CHOOSING BETWEEN THEM

Two questions decide it. **Is the saving large enough to be seen in the whole building's consumption?** If yes, Option C is usually simplest and cheapest, because the meter already exists. If no — the measure is real but small relative to total use — it must be isolated, which means A or B.

Then: **how much of the result do you need measured rather than stipulated?** The more that rides on the number — a guarantee, a lender, a grant condition — the more must be measured. The cost of M&V should be proportionate to the value at risk, and it is reasonable for it to be a meaningful line in the project rather than an afterthought.

What the M&V plan must contain

1. **The option selected, and why.**
2. **The baseline** — period, data, driving variables, normalisation method, as Section 03.
3. **The measurement boundary** — what is inside the assessment and what is outside.
4. **The reporting period** and its frequency.
5. **Routine adjustments** — the normalisation applied every period for weather, occupancy and activity.

6. **Non-routine adjustments** — the mechanism for handling changes nobody planned: an extension, an occupancy change, new equipment, a change of use. **This is the clause that prevents disputes**, and it must define who may propose an adjustment, on what evidence, and how disagreement is resolved.
7. **Stipulated values**, where used, with their source and the agreement to them.
8. **Data handling** — who collects, who calculates, what happens to missing data, and who verifies.
9. **Accuracy expectations** — an honest statement of the uncertainty in the result, because every measurement has some.

> AGREE THE NON-ROUTINE ADJUSTMENT MECHANISM BEFORE THE WORKS
>
> Buildings change. An extension is built, a floor is sublet, a production line is added, a department moves out. Each alters consumption for reasons unrelated to the measures, and each will otherwise be argued about after the fact by two parties with opposite incentives.
>
> Define the mechanism in advance and it is an administrative step. Leave it undefined and it is the dispute that consumes the relationship — and it always arrives, because no building stays the same for the length of a performance contract.

Beyond verification — keeping the saving

Savings decay. Set points drift, overrides accumulate, plant is replaced with something configured differently, the person who understood the system leaves. A programme that verifies once and then stops will find, some years later, that much of the saving has gone and nobody can say when.

Four things hold it:

- **Continuous monitoring against the baseline**, reviewed on a stated frequency by a named person. A cumulative-deviation chart — plotting the running total of actual against expected consumption — makes drift visible long before an annual comparison would.
- **Alarms on the things that matter** — out-of-hours consumption above a threshold, set points outside a range, plant running when the schedule says it should not.
- **A formal energy management system.** ISO 50001 exists precisely to make this a process rather than a person's habit, and ISO 50006 addresses baselines and performance indicators specifically.
- **A change-control step.** Any alteration to a commissioned control parameter should be recorded, with who changed it and why. Most decay is a series of individually reasonable adjustments that nobody wrote down.

> THE AUDIT THAT PAYS FOR THE NEXT ONE
>
> An organisation that can demonstrate, with verified numbers, that its last energy investment delivered what it promised will get the next one approved without argument. One that cannot will be asked the same sceptical questions every time.
>
> That, rather than compliance, is the real reason to do M&V properly the first time.

SECTION 09

The forty-point *checklist.*

Attach it to the instruction. If every box can be ticked when the report is delivered, you have something you can finance.

A · BEFORE INSTRUCTING

- [ ] The decision the audit must support is stated in one sentence
- [ ] Audit depth chosen deliberately — screening, detailed or investment-grade
- [ ] Delivery date set against the capital budget cycle, not the auditor's convenience
- [ ] Realistic capital envelope disclosed to the auditor
- [ ] Constraints stated — uninterruptible processes, tenant areas, plant under warranty, committed works
- [ ] Named owner of the outcome appointed before work starts
- [ ] Auditor competence confirmed for the individual, not only the firm
- [ ] Any auditor interest in implementing the works disclosed and accepted
- [ ] Measurement scope agreed — what will be logged, where, and for how long
- [ ] Measure schedule required as a working spreadsheet, not a PDF table

B · DATA

- [ ] Three years of invoices obtained, every line
- [ ] Interval consumption data obtained for all available history
- [ ] Occupancy and operating schedule documented by area
- [ ] Production or activity data assembled where consumption tracks it
- [ ] Asset register with ages and ratings provided, or its creation added to scope
- [ ] Control set points as operating — not as designed — obtained
- [ ] Reactive maintenance call log for two years provided
- [ ] Planned changes within the measures' life registered

C · BASELINE

- [ ] Baseline period stated, covering a full heating, cooling and operating cycle
- [ ] Driving variables identified and independently measurable in future periods
- [ ] Weather data source and station stated, with distance from site
- [ ] Base temperature for degree days stated and justified against the building's own data
- [ ] Relationship between consumption and drivers shown, with the quality of fit stated
- [ ] Baseload and weather-dependent consumption separated and both interrogated
- [ ] Estimated readings identified separately from metered ones
- [ ] Baseline agreed in writing before any implementation begins

D · SURVEY, MEASURES AND CASE

- [ ] At least one out-of-hours survey performed
- [ ] Logging campaigns span at least one full weekend
- [ ] Simultaneous heating and cooling checked for explicitly
- [ ] Occupants consulted, and workarounds recorded as evidence
- [ ] End-use breakdown produced with the basis for each split stated
- [ ] Measures grouped — operational, maintenance, capital, generation — before ranking
- [ ] Interactions between measures quantified, with no double counting
- [ ] Capital measures sequenced against the asset replacement cycle
- [ ] Generation sized to the reduced load, not the current one
- [ ] Every measure carries savings basis, confidence, full cost and implementation requirements
- [ ] Persistence mechanism attached to any saving that depends on a setting or behaviour
- [ ] Case presented on NPV or life-cycle cost, with marginal cost used where plant is replaced anyway

E · VERIFICATION

- [ ] M&V plan delivered with the report — option, boundary, adjustments, reporting frequency
- [ ] Non-routine adjustment mechanism defined and agreed before implementation

Audit instruction sign-off

Complete and retain with the audit file.

ENERGY AUDIT READINESS SIGN-OFF

Item	Name and role	Date and signature
Building and address		
Decision the audit must support		
Audit depth and auditor appointed		
Baseline agreed by		
Owner of the outcome		
Checklist points 1–40 confirmed		
Outstanding items listed and owned		
Released for implementation by		

> IF YOU CAN ONLY DO THREE THINGS
>
> **One.** Get interval data and build a defensible baseline before anyone calculates a saving. Everything downstream depends on it.
> **Two.** Do the operational and maintenance measures first, and sequence capital measures against the replacement cycle so you pay only the marginal cost.
> **Three.** Install permanent metering as part of the works, not afterwards — it is the only way to prove the saving and the only way to notice when it stops.

REFERENCE

Standards referred to *in this guide.*

Listed by number and subject so that you can obtain and read them. Confirm the current edition and the applicable national adoption before citing any of them.

STANDARDS REGISTER

Reference	Subject
EN 16247 series	Energy audits — general requirements, and dedicated parts for buildings, processes, transport and the competence of energy auditors
ISO 50002	Energy audits — requirements with guidance for use
ISO 50001	Energy management systems — requirements with guidance for use
ISO 50006	Measuring energy performance using energy baselines and energy performance indicators
ISO 50015	Measurement and verification of energy performance of organizations
IPMVP	International Performance Measurement and Verification Protocol — the four options described in Section 08
EN ISO 52000 series	Energy performance of buildings — overarching assessment framework
EN ISO 52120 series	Energy performance of buildings — contribution of building automation, controls and building management, superseding the former EN 15232
EN 16798 series	Energy performance of buildings — ventilation, and indoor environmental input parameters
EN 15378 series	Energy performance of buildings — inspection of heating systems and hot water systems
EN 16247-5	Energy audits — competence of energy auditors
ISO 41011	Facility management — vocabulary

HOW TO USE THIS REGISTER — AND WHAT GOVERNS ABOVE IT

Standards are revised, withdrawn and superseded. Verify the current edition with the national standards body applicable to your project, confirm whether a national adoption exists, and confirm that the clause you intend to rely on still says what you think it says. Nothing in this guide should be relied upon as a statement of the content of any standard.

Where an audit is performed to satisfy a legal obligation, a grant condition or a lender's requirement, that requirement governs above all of the above — including the audit depth, the auditor's qualification, the report format and the verification regime. Establish it in writing before the audit is scoped.

About APIS

APIS is an integrated engineering group founded in Kosovo, operating across the Western Balkans and into the European Union. The Group delivers mechanical, electrical, energy and infrastructure works through twenty-one delivery divisions across two strategic business units — Building Systems & Technologies, and Energy, Industry & Infrastructure — supported by four engineering excellence centres. APIS operates management systems certified to ISO 9001, ISO 14001, ISO 45001 and ISO 50001.

The **ESCO & Energy Performance Division** delivers energy audits to EN 16247 and ISO 50002, energy performance contracts with guaranteed savings, measurement and verification to IPMVP, and ISO 50001 and ISO 50006 implementation. Work is delivered under the Group's DBOM lifecycle model — design, build, operate and maintain — so that the party which calculates the saving is accountable for delivering it.

Prepared by the APIS ESCO & Energy Performance Division · **Document** APS-GD-05 issue v1.0 of 20 August 2026 · **Contact** apisgroup.net/contact

Have an audit report that never *became anything?*

Most do. Usually the baseline could not be defended, the costs were indicative, or the measure list was a flat ranking nobody could act on. Our engineers will read the report you already have and tell you what is financeable in it — or start where it should have started, with twelve months of your own data.

SPEAK TO THE ESCO & ENERGY PERFORMANCE DIVISION

Energy audits to EN 16247 and ISO 50002 · baseline development · metering and monitoring · measure sequencing and business case · energy performance contracts with guaranteed savings · measurement and verification to IPMVP · ISO 50001 implementation

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