Deep Energy Retrofits - Over-Time, Phased Guidance

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Overview

Completing a deep green upgrade over-time may be an attractive alternative to an all-at-once approach, which can be seen as too costly, disruptive and simply overwhelming. Research in the United Kingdom has demonstrated that retrofits carried out over-time can achieve levels of home performance equal to those achieved by all-at-once DERs (Fawcett, 2013; Fawcett, Killip, & Janda, 2014), and select projects have been successful in the U.S. (Less & Walker, 2014). Over-time home energy upgrades can occur either with careful planning from the outset, or in a piece-meal fashion as time progresses. Both strategies have been shown to produce effective retrofits in the UK, and both paths have their own benefits and liabilities. The guidance we provide below is intended to capture the benefits (and limit the risks) of both approaches.

The following ***potential benefits*** may exist with an over-time approach:

1. Less perceived disruption, because it is spread out over-time.
2. More likely that occupants can continue to inhabit their home continuously, without any need for alternative accommodations.
3. Costs are spread over-time, allowing owners to build up savings between phases.
4. Introduce occupants to the benefits of energy upgrades, thus feeding their desire for further improvements and refinements.
5. More aligned with making incremental deep green improvements, as maintenance and equipment replacement require.
6. Over-time process can inform occupants of the effects of their behaviors, and the potential for behavior modification to reduce both energy use and project costs (through use of human effort rather than technology to achieve savings)

There are also some ***potential downsides*** to an over-time approach:

1. More numerous small disruptions.
2. Difficult to finance traditionally.
3. Costs may be higher, due to repeated fees and fixed costs, such as permitting, inspection and construction labor.
4. Possible need to reinvest in measures that are inadequately addressed, due to a lack of careful and detailed planning.
5. Lower aggregate energy savings and reduction in environmental footprint.
6. Difficult for occupants to delay the gratification of investing in glamorous efficiency measures (such as solar PV or windows), by first investing in the invisibles (insulation and airsealing).

We anticipate the following ***potential challenges*** in over-time projects:

1. Create rather than block future options and flexibility. Insulating an attic prior to air sealing it is the classic example of this. But a more deep retrofit example would be spending $3,000 on duct system repairs, which might later discourage the use of non-ducted space conditioning, or ducts might be brought into conditioned space later, making the initial investment wasteful.
2. Minimizing negative unintended consequences of the over-time approach. For example, aggressive air sealing could introduce substantial IAQ risks, if NOT pursued in parallel with upgrades to ventilation systems, as well as to combustion appliances.
3. Lack of tools to design and track progress on over-time DERs.
4. Project planning may be difficult over an extended time frame (e.g., substantially >5-years). An extended timeframe may mean that best practices in energy retrofit measures change, as might available equipment types/efficiencies, local codes and applicable standards (e.g., ASHRAE 62.2).
5. It will be challenging to implement a technical and complex project over an extended time period without a consistent and knowledgeable integrator, who can tie the phases and plans together, as well as help adjust plans according to changes in energy use, as well as in technology, materials and best practices.

It is important to note that some of the benefits and challenges are in tension with one another. For example, occupant needs (financial, social, etc.) may stipulate an over-time approach, but this might be more costly and has the potential to be technically sub-optimal. It is not always possible to have one's cake and eat it too. Here we provide guidance that hopefully helps to leverage the benefits and limit the downsides of over-time approaches, making such projects mostly 'win-wins'.

Guidance and strategies to address challenges and increase success

Use detailed and careful planning from the outset. To the extent possible, an over-time retrofit should be planned from the beginning with as much detail as an all-at-once project would be, even though all the work is not to be completed at that time. Project goals and performance metrics should be identified, and upgrade plans for each element of the project should be developed and carefully documented using a systems approach. Some additional effort is also required on: (1) anticipating future changing needs, such as aging-in-place, added floor area, new electronics, etc., (2) developing a timeline for required deferred maintenance, equipment replacement, and other upgrades, so as to be aligned with efficiency measures, and (3) developing contingency plans that anticipate some of the ways in which changes in codes/standards, technologies and best practices might affect upgrade plans.

Use iterative, post-occupancy evaluations at each stage of work, in order to inform changes or adjustments required in future stages. This is essentially equivalent to performing an energy audit between each stage of the over-time retrofit. In order to generate valuable feedback and to develop important new insights for an over-time upgrade, two things are required:

- An assessment of how installed efficiency measures compare with their intended performance and specifications (e.g., commissioning and potentially monitoring), as well as comparing measured energy use with predictions and objectives.
- An assessment of the home occupants' experience and needs in the upgraded home, likely by unstructured interview (e.g., issues or successes with comfort, controls, maintenance, etc.).

Actual over-time deep energy upgrade projects have shown that design and occupant experience in prior phases can usefully inform future decisions and plans, as well as to formulate new goals and objectives. For example, solar gain and afternoon overheating might prove to be an issue after the first phase of a retrofit, and this could spur inclusion in future phases of mechanical cooling or passive strategies, such as shading, thermal mass, or cross-ventilation.
Identify a home energy specialist who is willing to act as an over-time integrator for your project from start to finish, contributing when necessary and possibly providing services such as post-occupancy evaluation, utility bill analysis and feedback during interim periods.

Use transitionally appropriate technologies. These are those technologies that will be able to respond to future changes brought about by the retrofit. For example, variable capacity/multi-speed heat pumps have widely varying outputs and good efficiency at part-load, which means that if the home is insulated and air sealed in the future, the appliance can still provide perfectly adequate heating and cooling services.

Avoid sub-optimal investment and required re-work. It is best to fully address items when the fixed costs of design, permitting, disruption, on-site labor, and quality assurance (home performance specialist) are already engaged. Elements of the project that are addressed in any given retrofit stage should be done so fully, using current best practices for high performance homes, or explicit future plans to do so should be developed. This should help to limit the future obsolescence of any given measure. For example, if you install a variable capacity, ductless heat pump with SEER rating >20, it is unlikely that future changes in minimum federal standards will make that technology obsolete anytime soon. On the other hand, rework may be required if one insulates an attic, but only to a minimum level, such as R25, and not using best practices to avoid wind-washing along eaves and ensuring no compression at the roof perimeter and missing the access hatch. Of course, it is important to understand that with a long enough timeframe (and the associated changes in fuel prices and other associated costs), all projects will implement some upgrades that appear “suboptimal” in retrospect; following this guidance should help limit this.

Cluster upgrade projects by building trade, in order to limit transaction costs. For example, address all plumbing related measures at the same time, such as changes to distribution piping, pipe insulation, new piping for HVAC, low-flow fixtures and a new water heater. There may be some practical limitations on this, such as the need to use multiple trades persons for a given project/repair (e.g., needing to hire a carpenter or plasterer to make livable any damages caused by the primary plumbing work).

Whenever possible, address the building envelope and passive design elements (e.g., shading, cross-ventilation, daylighting) prior to making major HVAC and technology investments. The common argument for this approach is that it will allow you to properly select and size your HVAC system according to the loads of the upgraded home, which can save upfront costs and increase efficiency and performance. We argue further that in the over-time paradigm, innovation and change occur most dramatically in the realm of technology, so investments in the elements most subject to technological advances should be preferentially implemented later in the process, so as to capture as much of the innovative advantage as possible. Advances in heating and cooling technologies and household appliances are rapid, and they are driven by intense market competition, large R&D budgets and ever-increasing federal minimum efficiency standards. Other project elements, such as passive conditioning strategies, insulation and air sealing, experience much lower levels of innovation and change (i.e., we are still anxiously awaiting the cheap and effective 0.25” thick R30 wall sheathing).

Track and benchmark home performance over-time. Tracking performance from utility bills, or even better from Smart Meter data or other feedback devices, will help in assessing project performance over-time. This can greatly help any iterative post-occupancy evaluation that is engaged in. The use of real progress and data will help to calibrate expectations along the way. Always expect that energy consumption will vary year-to-year due to random factors, such as weather.

References

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