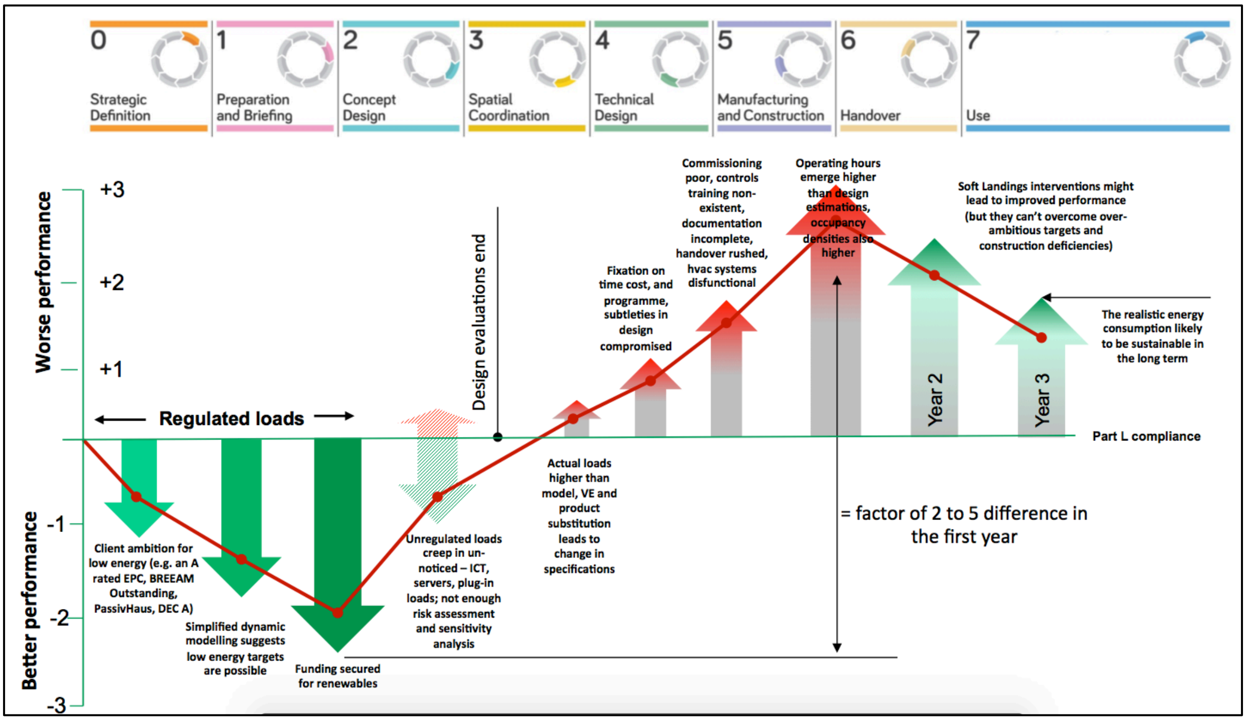
The energy S-curve concept

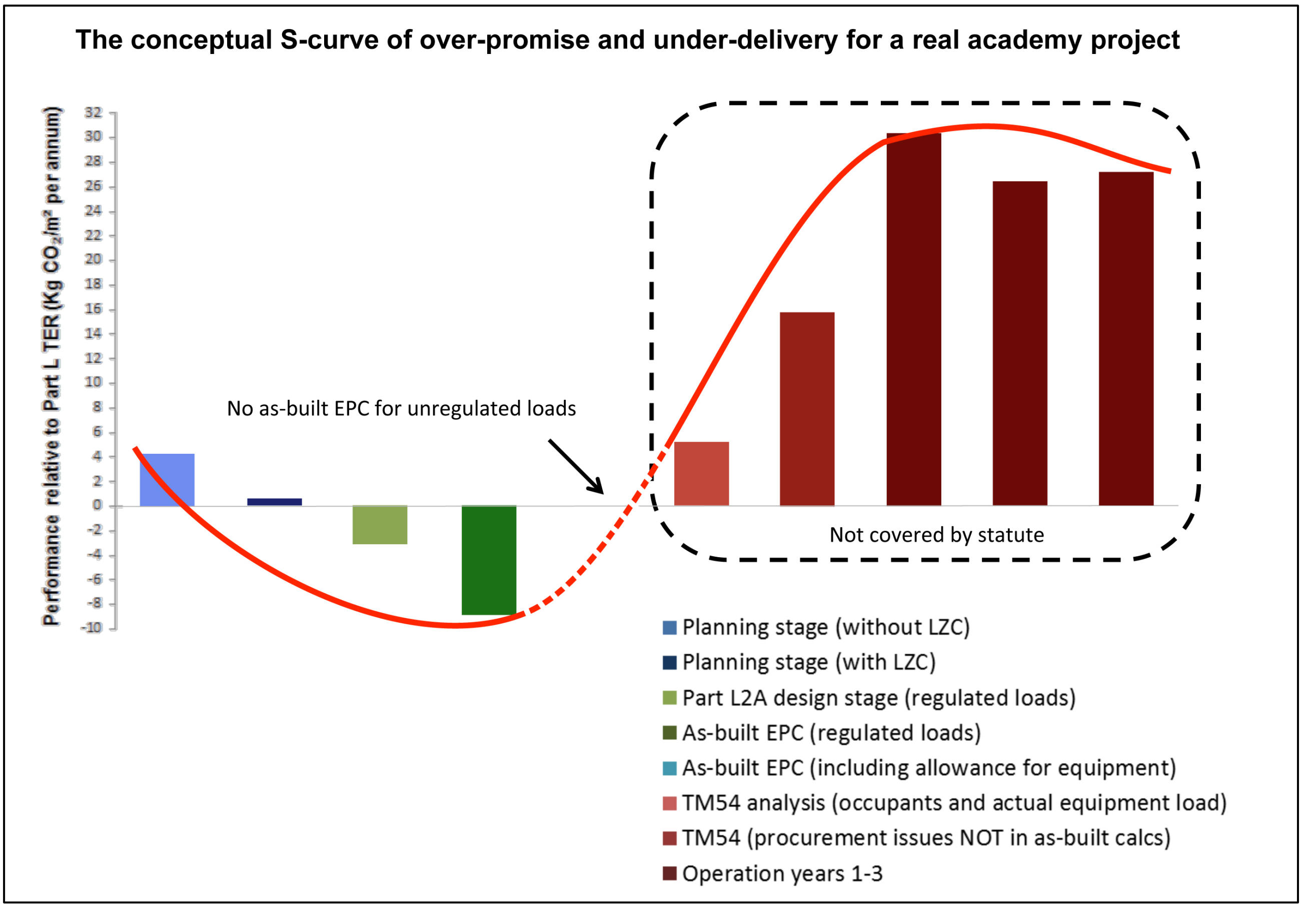
The S-curve concept describes the situation where a construction project team (inclusive of client advisors, designers and builders) over-estimates the theoretical energy performance of a new building and under-delivers in reality. This is the basis of the energy and emissions 'performance gap'. In building performance studies, performance factors between 3-10 are regularly found. Factors of 3 are typically found in the first full year after handover. Factors of 10 are sadly not uncommon. When such factors are found, a project team will characteristically express degrees of shock and disbelief, shortly followed by degrees of self-denial and elements of self-justification. In the absence of Soft Landings-type interventions by the project team the energy penalties tend to become chronic. Even with Soft Landings interventions, some aspects of poor performance cannot be corrected without new capital investment.

The diagram shows a theoretical S-curve and some of the classic causes of emissions penalties that typically occur during procurement and construction – even if the penalties are unknown at the point they occur. For simplicity, *Part L* planning requirements are shown as the baseline, and the 2020 RIBA *Plan of Work* as the project timeline. The vertical axis can be energy use or carbon emissions. In the chart, the design team has improved the calculated performance below the baseline through a variety of measures. During procurement, energy loads, increased hours of operation, and wastage starts to creep in. Many penalties occur due to decisions and actions that run counter to good outturn performance. The trajectory shows that some improvements are possible through fine-tuning, but intrinsic shortcomings are already bolted into the building and can't be overcome.

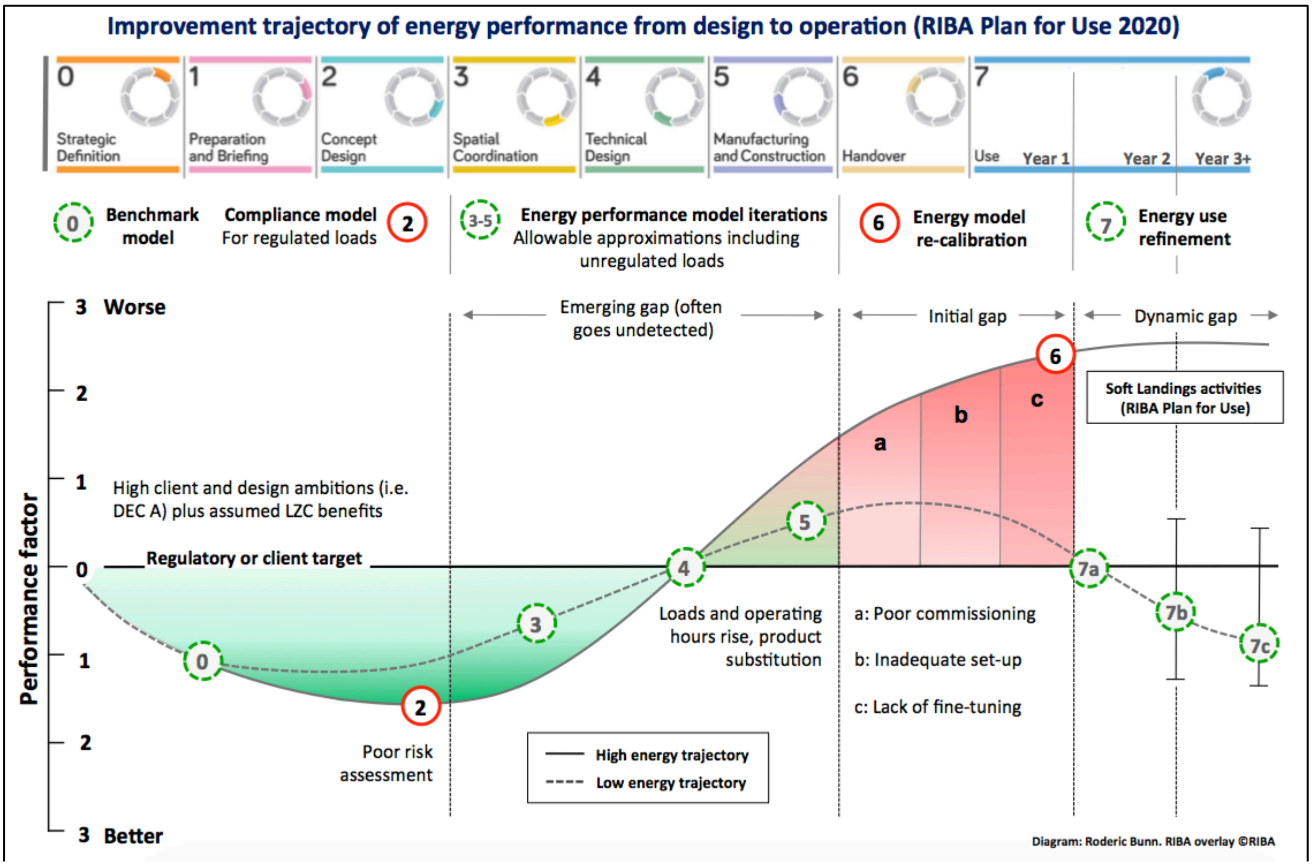


The S-Curve of over-promising and under-delivering in reality (A 14,600 m^2 academy built in 2010)
The S-curve has considerable basis in the evidence amassed from building performance evaluation (BPE) studies, particularly data obtained from the InnovateUK BPE programme (2011 – 2015).

The diagram below shows the S curve overlain on an actual academy building. In this real example, the vertical axis has normalised the energy penalties into kilograms of carbon dioxide against the TER baseline. This attempts to join the dots from the first diagram. However, as the energy data were only available at regulatory gateways (i.e. *Part L* submissions and EPC declarations), the tendency to over-promise at design and under-deliver at project completion neither subscribes a neat, smooth, nor even a linked trajectory. The main problem is a lack of visibility of any performance-damaging decisions and actions made during procurement, shown as the hashed portion of the overlain (notional) S-curve. In this particular case, there was no as-built EPC for unregulated loads. Also, the Display Energy Certificate was never updated.



The reliability of the S-curve trajectory has led to institutional support for the concept. The third diagram has been published in CIBSE TM61 (2020): *Operational Performance of Buildings.*



This diagram overlays two curves on a dimensionless 'performance factor' vertical scale: a default high-energy project trajectory (as shown in diagram 1), and a lower-energy trajectory which is the consequence of attempts to control or eliminate causes of energy waste. It incorporates aspects of Soft Landings now included in the 2020 RIBA *Plan of Work*. The lower energy curve assumes some defensible rises in energy use (such as extended hours of operation), and therefore ranges of energy use as shown by the error bars on the dotted trajectory for energy-use refinements in RIBA Stage 7.

The key question is whether the S-curve concept can be converted into a project management tool in a way that can make emerging performance visible during procurement. Such a tool would need to calculate the energy and emissions consequences in an accurate and believable way, to the extent that the causes of a high-energy trajectory can be acted upon and corrected before they become fixed characteristics of the building at project completion.

Project teams could use the tool by regularly computing the energy and carbon dioxide savings attributed to project team actions and inputs, and thereby demonstrate that they are not on the high energy default trajectory, for example by following the dotted trajectory or bettering it. A visualisation aspect of the tool would show the emerging project trajectory tracking against the high-energy (default) trajectory as data becomes progressively available.

Further information for SPACES Members

Bunn R and Burman E (2015) 'S-curves to model and visualize the energy performance gap between design and reality – first steps to a practical tool' Proc. CIBSE Technical Symposium 2015, London (available at https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I6yQ) (registration required) (accessed 8.07.20)