Pathways to 80%

Analysis of Different Scenarios for Achieving 80% Energy Saving in EU's Building Sector

Introduction

The Renovate Europe Campaign has, as its headline objective, the achievement of an 80% reduction in the energy demand of the EU building stock by 2050. This is an ambitious, yet achievable goal that nevertheless requires all Member States to transform the policy landscape and market dynamics of their building renovation sectors. It is noteworthy that the European Parliament own-initiative report of 14th March 2013 on the Energy Roadmap 2050[1] also calls for an 80% reduction by 2050.

In this paper, we examine various pathways or scenarios for achieving the 80% goal. All scenarios require a very significant scaling up of renovation activity compared to the current position. This is evident from the fact that most renovations undertaken today typically achieve energy savings of around 20-30%, and only around 1% of the building stock is renovated each year[2], yet in order to achieve the Renovate Europe Campaign objectives, both rates as well as depths of renovation need to be increased significantly. Clearly, not every renovation undertaken between now and 2050 will achieve this figure, perhaps due to architectural or locational limitations or the need to preserve heritage buildings. The implication is that some buildings will need to achieve savings in excess of 80% in order for the overall average to be attained.

The importance of a strategic approach to building renovation can be seen in the Energy Efficiency Directive 2012/27/EU[3], adopted in October 2012, which includes a requirement for Member States to develop long term renovation strategies for their national building stocks.

Figure 1 below provides a schematic illustration of three possible pathways to achieve the desired goal of raising the renovation activity from the current "low rate & shallow" (bottom left quadrant) to "high rate & deep" (top right). For the green path, the focus in the early years is on increasing renovation depth before increasing rates. Conversely, the red path focuses initially on increasing renovation rates before depths are increased. This paper presents a set of scenarios that take a broadly central approach (blue path), whereby in each case, rates and depths are increased simultaneously, albeit at different speeds.

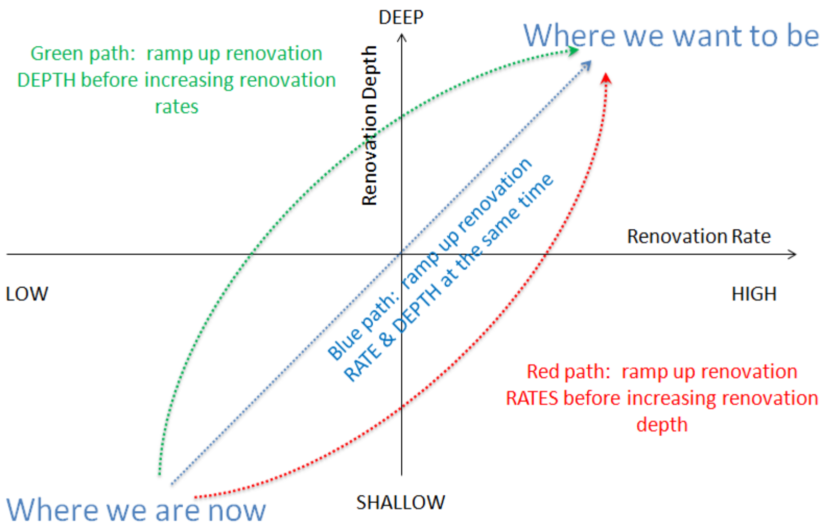

Figure 1 – Schematic illustrating possible pathways towards scaling up renovation activity

[1] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A7-2013-0035+0+DOC+PDF+V0//EN
[2] Estimates by BPIE in "*Europe's Buildings Under The Microscope*" http://bpie.eu/eu_buildings_under_microscope.html
[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF

Modelling Assumptions

This paper considers only the energy use associated with the fabric and structure of existing buildings in order to provide required comfort levels (through heating, cooling and ventilation), sanitary hot water, and fixed lighting – these are typically referred to as the "regulated loads" as they are addressed by the Energy Performance of Buildings Directive (EPBD – 2010/31/EU). Process energy, and energy used in appliances and equipment (internal plug loads) are excluded from the calculations.

The starting position for all scenarios is the set of assumptions contained in "*Europe's Buildings Under The Microscope*" published by the Buildings Performance Institute Europe (BPIE) in 2011. Based on a survey of experts in all 27 EU Member States plus Norway and Switzerland, BPIE concluded that the average renovation rate across Europe is equivalent to approximately 1% of aggregate floor area per annum. BPIE stressed that this is a best estimate, since comprehensive information on renovation activity is not systematically collected in any country. Indeed, the absence of such market intelligence remains a significant shortcoming to this day. Likewise, information on the actual level of savings achieved in renovations undertaken at present is sparse, though BPIE concluded that energy reductions of 20-30% would be typical of today's renovation activity.

In order to categorise renovations according to the level of savings achieved, BPIE developed the following four descriptors:

- MINOR renovations, achieving up to 30% energy saving
- MODERATE renovations, achieving 30-60% energy saving
- DEEP renovations, achieving 60-90% energy saving[4]
- NEARLY ZERO ENERGY (nZEB) renovations, achieving over 90% energy saving

By varying the proportion of savings achieved in each of the depth categories in a given year, and also the percentage of aggregate floor area renovated each year, different pathways or scenarios can be described.

The renovations discussed in this paper are technology neutral. Savings can be achieved through any combination of fabric improvements, replacement of technical systems (e.g. heating, ventilation, air conditioning or lighting), installation of intelligent controls, as well as the installation of renewable energy systems. Indeed, it is to be expected that combinations of measures and "whole building" solutions will be required to achieve the higher savings rates.

Depending on the particular circumstances, deep renovations can be undertaken as a single project at a single point in time, or over a period of time, perhaps reflecting the replacement cycle of different building components. In the latter case - known as a "staged deep renovation" - it is important to have a clear plan of the ultimate goal of a high energy performance building, and to ensure that each stage delivers the maximum long-term potential savings for the building elements or components upgraded, without impeding or unduly increasing the cost for implementing subsequent stages. In terms of the model used in this paper, all savings from a staged deep renovation are allocated to the initial phase of the renovation.

Technology development will have an increasingly important part to play in all scenarios. Research, development and demonstration of new ways to achieve energy savings, and, through the learning and upskilling process, to deliver savings at volume and at lower costs than can be achieved today are all considered to be essential components of a strategy to achieve 80% energy savings in the building sector. In this context, it is noteworthy that the drive towards nearly zero energy new buildings from the end of 2020 (2018 for public

[4] In some recent studies and guidance documents on the new Energy Efficiency Directive, the definition of "deep renovation" may vary somewhat. Instead of 60%-90% energy savings, the range has sometimes been set at 65% -95%.
There are also several different definitions of nZEB in use today.

buildings), as required by EPBD, will stimulate the development of technological solutions that can also be applied to existing buildings. Accordingly, the costs of renovating to nearly zero energy standards are likely to come down considerably, while experience of building to these levels will also benefit the renovation market.

THE ROLE OF NEW BUILD & DEMOLITION

Based on the assumptions from the BPIE "*Europe's Buildings Under The Microscope*" study, the rate for construction of new buildings is estimated to be around 0.5%/year and the demolition rate around 0.2%/year. As a result, over the period between now and 2050, the EU building stock will increase by over 10% net, compared to today's floor area.

New buildings are typically much more energy efficient than older ones, and this difference will be enhanced after 2020 when the Energy Performance of Buildings Directive (EPBD) nearly-zero energy building (nZEB) requirements come into force. Indeed, it is likely that more demanding requirements will be introduced in future, requiring true net zero energy buildings, or even "energy positive" buildings. For this reason, the contribution of new buildings to the total building stock energy consumption will be very small, and in time may be negative as the stock of energy positive[5] buildings grows.

Demolition of typically older buildings with poor energy performance has the effect of reducing energy use of the building stock. Though the rate of demolition is much lower than the new build rate, the much higher energy use of demolished buildings largely offsets the net increase in building stock, with its much lower energy consumption. Due to the fact that demolition and new build effectively cancel each other out in terms of energy use, they have not been specifically modelled in the scenarios presented in this paper.

In the context of changing demographics and employment patterns, there is a case for replacing a higher proportion of existing buildings with new ones better suited to our future requirements. Higher rates of demolition and new build could make a valuable contribution to cutting building sector energy use, as it is easier to achieve a very high energy performance level in a new building than when retrofitting an old one.

The following boundary conditions were applied to all scenarios:

- The target is a reduction in energy use for regulated loads of 80% in 2050 compared to 2005 levels.
- All existing buildings within EU 27 are renovated between now and 2050, less an allowance for buildings that will be demolished over the period. It is assumed that heating, ventilation and air conditioning (HVAC) plant (including standalone boilers) will be replaced with higher efficiency products at least once in every building over the period, which will generate savings (i.e. achieving a MINOR renovation) even if no further measures are undertaken.
- The starting renovation rate in 2012 is 1% p.a.
- A practical limit in terms of peak renovation rate in any given year is assumed to be 3.5% p.a. Whilst higher rates may technically be possible, perhaps as much as 5% p.a., there is a risk of developing macro-economic bottlenecks as supply capacity struggles to meet high levels of demand.
- The final renovation rate in 2050 is 2% p.a. While the period post-2050 is not modelled, it is assumed that the higher renovation rate of 2% should be maintained thereafter, as buildings renovated in the early years become candidates for further improvements 30 years later[6].
- The weighted average energy saving achieved in each renovation increases annually in all scenarios until it achieves a plateau for the period 2040-2050 of between 85% and 90%, depending on scenario.

[5] An energy positive building is one that, over a year, produces more energy than it consumes

[6] Whilst it is impossible to predict technological developments into the second half of the century, savings achieved in subsequent renovations are unlikely to be of the same order of magnitude as in the first renovation, since the major effort of bringing the historical backlog of inefficient buildings up to high energy performance levels will have been achieved by 2050

The Scenarios

Three scenarios have been considered. The main difference between them is the speed at which renovation rates and depths are ramped up. Accordingly, they are named "**Low Acceleration**", "**Medium Acceleration**" and "**Fast Acceleration**". It should be noted that all scenarios represent significant departures from prevailing renovation practice. Accordingly, it is important that Member States' renovation strategies, as required by the Energy Efficiency Directive, are ambitious and transformational in order to effect the necessary change.

The **Low Acceleration** scenario is characterised by a gradual increase in renovation activity, such that it takes 10 years to achieve renovation rates of 2% p.a. and a further 10 years to achieve 3% p.a. In order to achieve the renovation of the entire building stock, rates need to peak at 3.5% p.a. in the late 2030s, before scaling back to 2% p.a. in 2050. Equally, the speed at which average renovation depths increase is more modest than in the other two scenarios. This scenario requires 83% of all renovations to achieve nZEB levels (saving 90% or more) from 2040 onwards. The profile of renovation depths for the Low Acceleration scenario is depicted in figure 2 below.

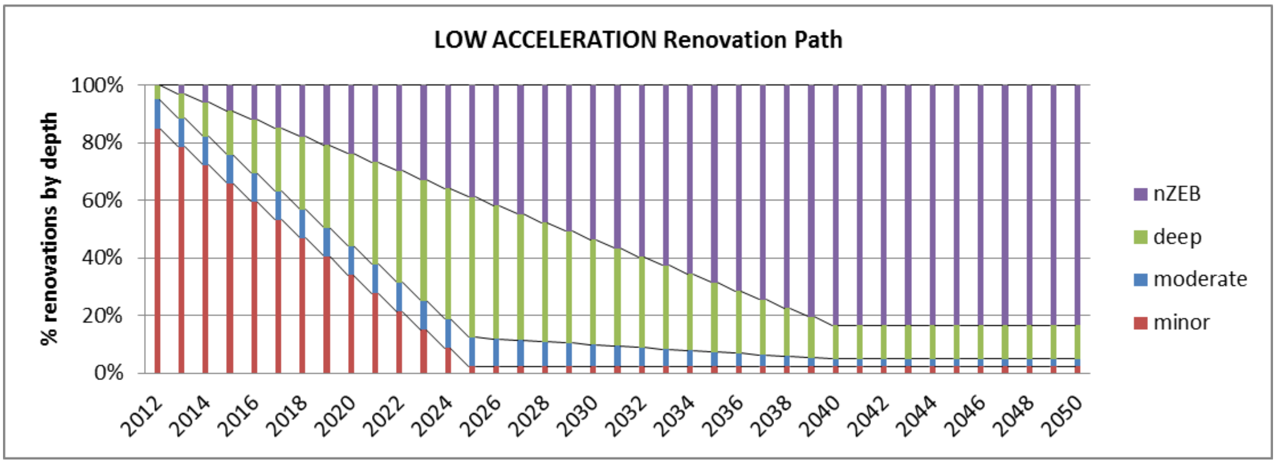

Figure 2 – Profile of renovation depth on the Low Acceleration scenario

In the **Medium Acceleration** scenario, renovation rates increase steadily in order to achieve 3% within a decade, i.e. by 2022. That rate is maintained for most of the period, until 2040, before scaling back to 2% in 2050. Minor renovations are largely phased out (i.e. down to just 2.5% p.a.) by 2022, some three years sooner than in the Low Acceleration scenario. Because of the more rapid increase in renovation rates than in the Low Acceleration scenario, the Medium Acceleration scenario results in a greater number of minor and moderate renovations being undertaken. To compensate for this, the required penetration of nZEB renovation is slightly higher than in the Low Acceleration scenario, at 88% of the total from 2040 onwards.

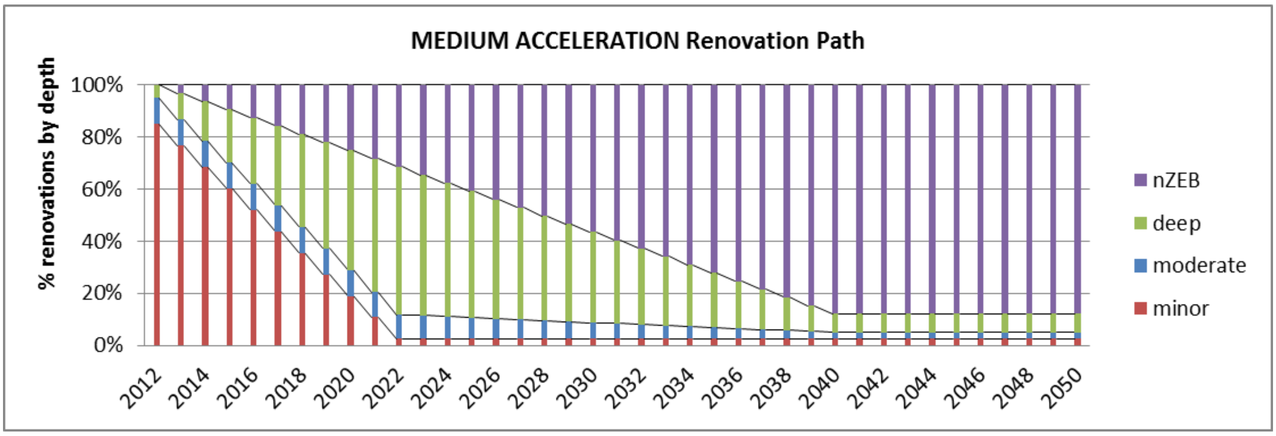

Figure 3 – Profile of renovation depth on the Medium Acceleration scenario

The **Fast Acceleration** scenario requires an accelerated phasing out of minor renovations, by 2018 and the achievement of a renovation rate of a little over 3% p.a. by 2020. That rate is maintained for a decade and then gradually reduced to 2% p.a. over the following 20 years.

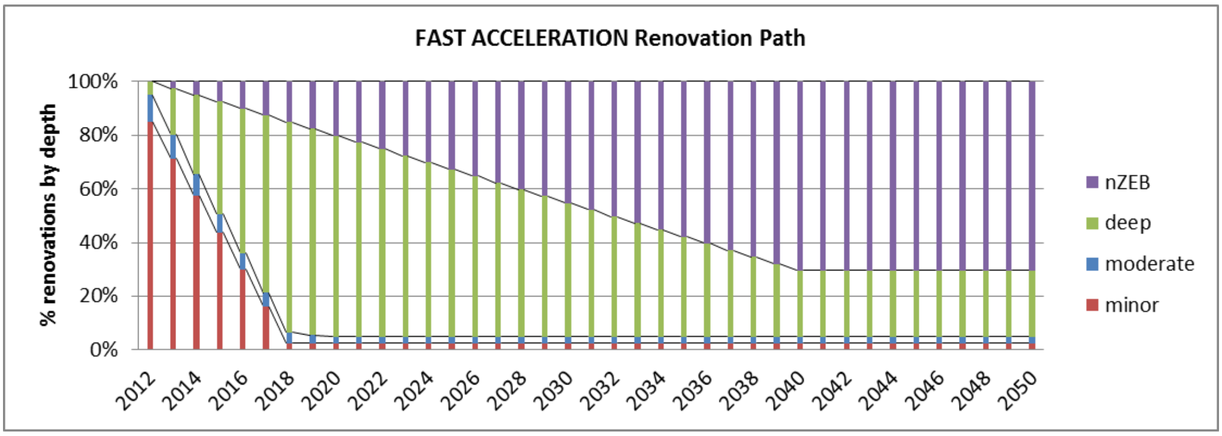

Figure 4 – Profile of renovation depth on the Fast Acceleration scenario

The renovation rates and weighted average renovation depths for the scenarios are compared in figures 5 and 6.

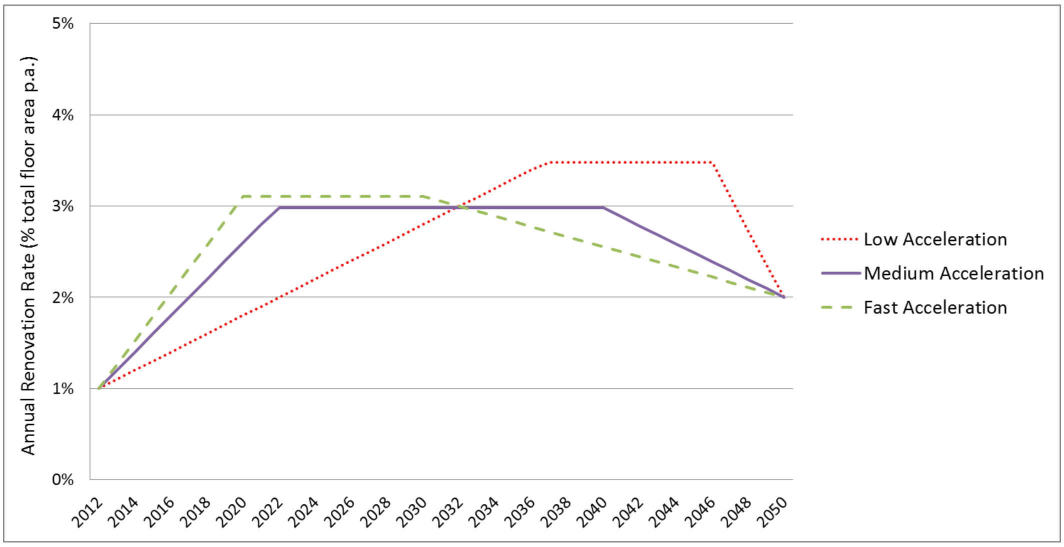

Figure 5 – Renovation profiles for the three scenarios

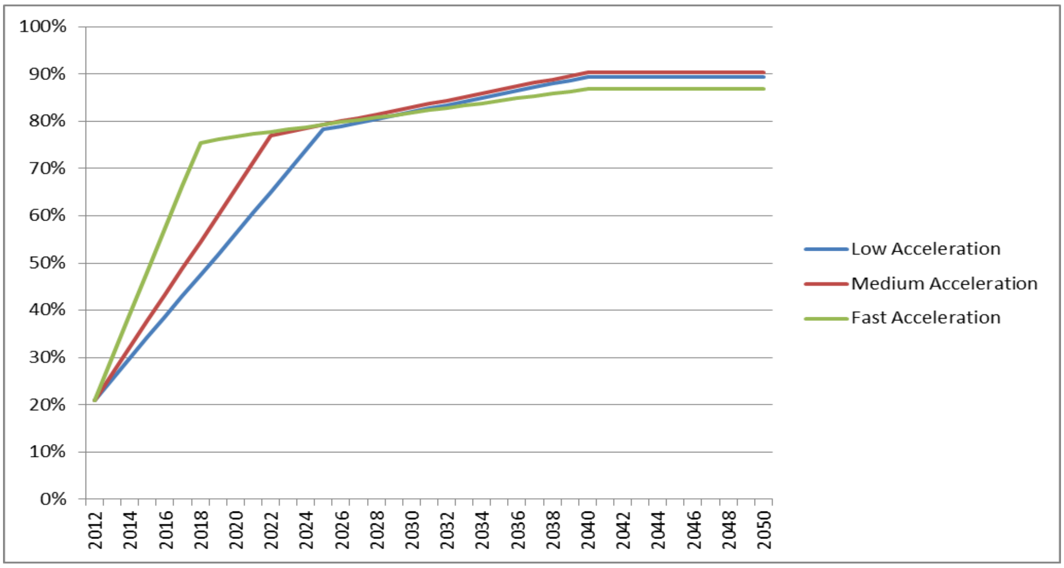

Figure 6 – Comparison of weighted average renovation depths under the three scenarios

Results

As per the modelling assumptions discussed earlier, all three scenarios achieve an 80% energy saving by 2050, illustrated in figure 7. The figure includes a baseline curve, which assumes that current rates and depths of renovation continue unchanged throughout the period. The baseline assumptions are:

- Renovation rate of 1% of floor area each year. Accordingly, under this scenario only around 38% of the building stock is renovated by 2050;
- Prevailing renovation depths continue throughout the period, namely a preponderance of minor renovations with savings under 30%.

It should be noted that the baseline curve represents a highly conservative set of assumptions which does not seek to quantify the impact of existing or possible new Directives at EU level or additional policies at Member State level.

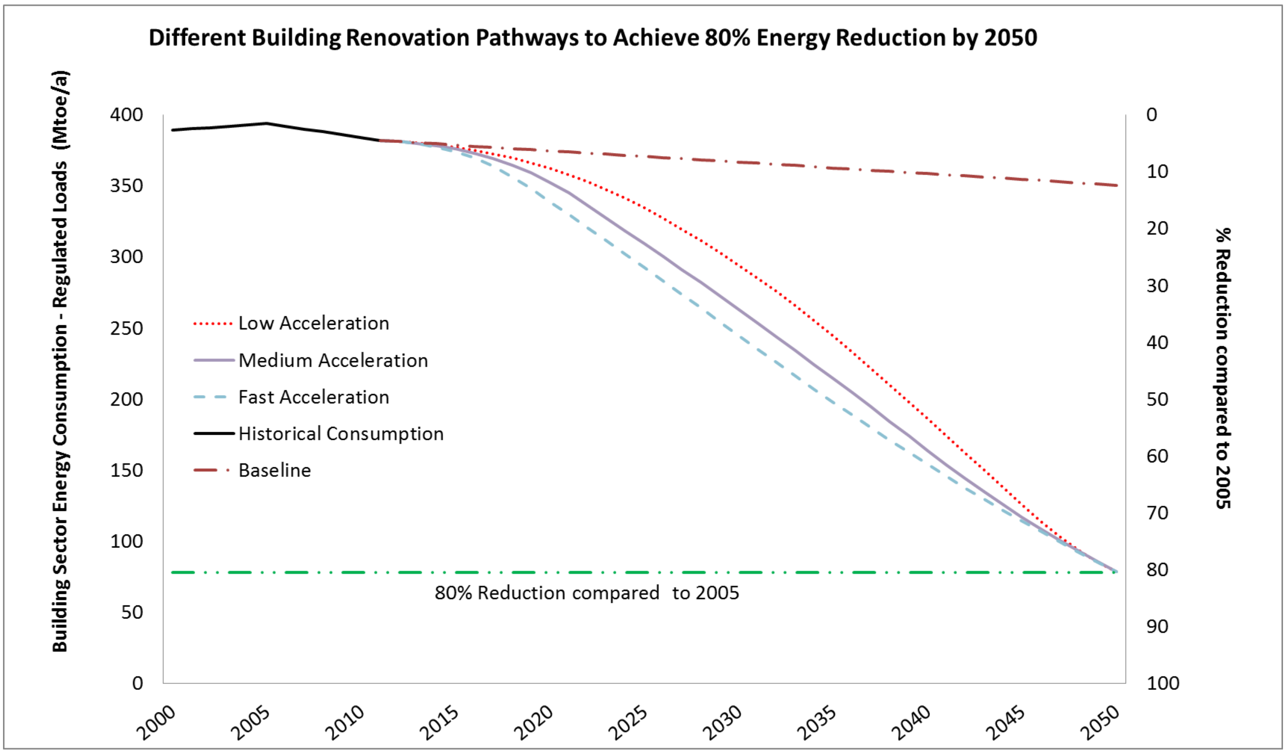

Figure 7 – Energy saving profiles

Figure 8 sets out the savings achieved during each decade. Because of the shorter time frame (7 years) and the fact that the current decade is a ramping up phase, the savings in the period 2013-2020 are considerably lower than in the other periods, accounting for just 6-14% of the total.

As would be expected, the Fast Acceleration scenario achieves the highest proportion of savings (31%) in the period 2021-2030. The peak period for the Medium Acceleration scenario, at 33% of the total, is the following decade, the 2030s, while for the Low Acceleration scenario the last two decades each deliver36% of the total.

A significant difference can be seen if the savings to 2030 are considered. The Low Acceleration path only achieves 28% of the total savings by 2030, whereas the Fast Acceleration scenario achieves nearly half (45%) of the total savings by the same date.

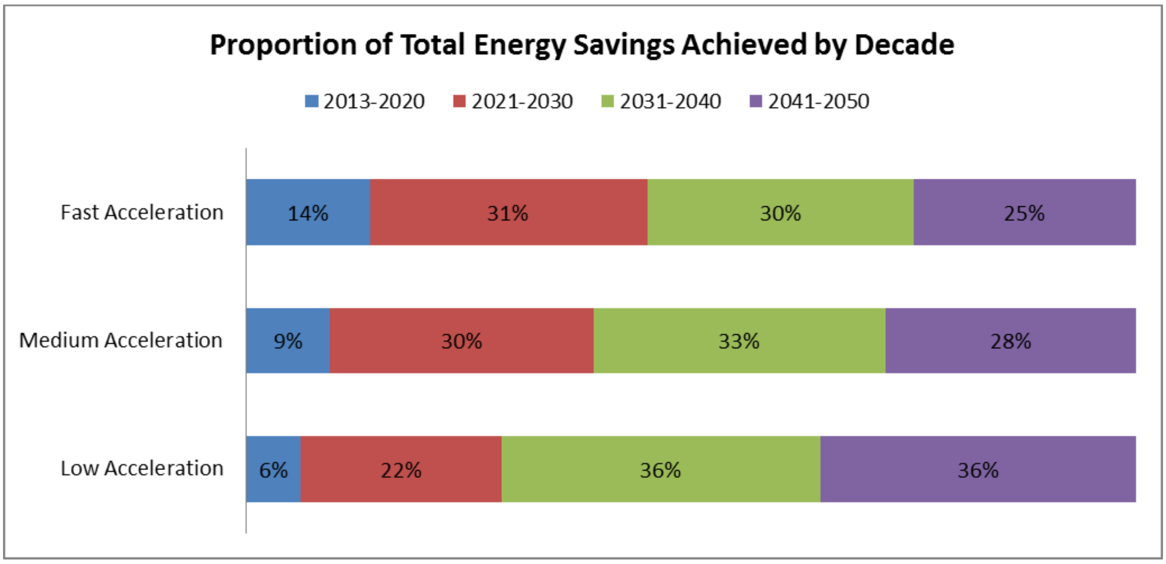

Figure 8 – Breakdown of energy savings achieved by period

Table 1 presents the same data expressed in terms of energy savings achieved by each scenario in each period.

Pathway	2013-2020	2021-2030	2031-2040	2041-2050
Low Acceleration	19	68	108	107
Medium Acceleration	29	90	99	85
Fast Acceleration	42	94	90	75

Table 1 – Breakdown of total annual energy savings achieved by period for each scenario (Mtoe/a)[7]

The different savings profiles are of particular interest when considering future demand reduction targets. In the context of the ongoing debate on EU's 2030 targets, the building sector could contribute between 87 Mtoe and 136 Mtoe delivered energy saving by 2030 on the basis of these pathways, as presented in Table 2. The corresponding range for 2040 is 195-227 Mtoe.

The total potential for savings from regulated energy use in the existing building stock is just over 300 Mtoe in 2050.

Pathway	Cumulative Annual Savings To ...			
	2020	2030	2040	2050
Low Acceleration	19	87	195	302
Medium Acceleration	29	118	217	302
Fast Acceleration	42	136	227	302

Table 2 – Cumulative annual energy savings in given year (Mtoe/a)

[7] Mtoe/a = million tonnes of oil equivalent per annum

Whilst all scenarios achieve the same annual saving in 2050, the total energy saving (and hence carbon emission reduction) over the period varies by virtue of the different pathways. This is demonstrated in Figure 9. Compared to the baseline, the three scenarios deliver 8-9 times the cumulative level of savings.

The Fast Acceleration scenario achieves 8% - 22% more total energy savings (and correspondingly high carbon reductions) compared to the Medium and Low Acceleration scenarios respectively, and may therefore be considered preferable. However, there is a trade-off in terms of costs, since the learning effects – i.e. continually improving technology and installation techniques – mean that the cost of achieving a given level of savings will come down over time. While costs have not been explicitly modelled, the effect of the learning curve are such that the Low Acceleration curve is likely to have the lowest cost per unit of energy saving of the three scenarios.

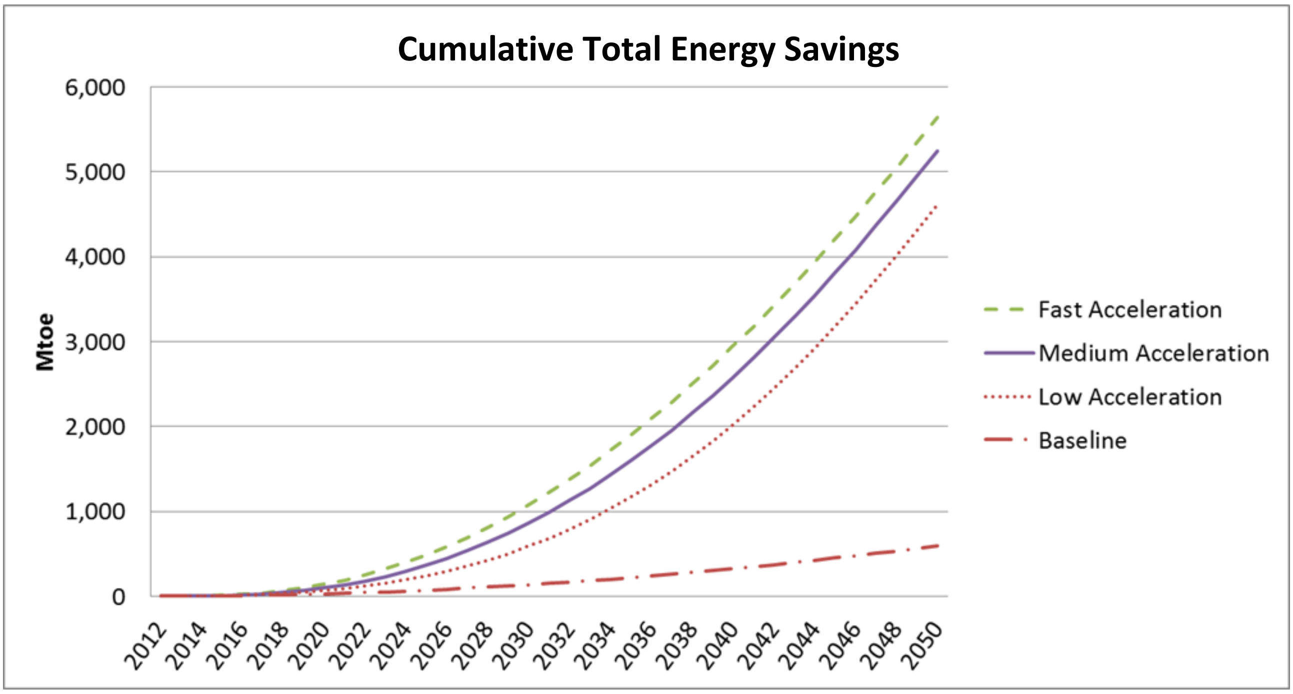

Figure 9 – Cumulative total energy savings (Mtoe)

Discussion

The long life of buildings, the absence until relatively recently of energy performance standards in their construction, and historically cheap energy mean that a backlog of energy profligacy has been generated in Europe's homes, workplaces and public buildings. With the requirement in EPBD for all new buildings to achieve nearly zero energy targets from the end of 2020 onwards (2018 for public buildings), Europe is leading the agenda in terms of preparing to rectify the issue in future buildings. Yet in the absence of ambitious policies, programmes and measures to cut energy use in the existing stock, the majority of the building sector's energy use will continue to be consumed, for decades to come, in buildings that are standing today. A concerted programme of renovation is required to address this historic backlog.

Evidence of the potential for significant economic, environmental and societal benefits that can be achieved through bringing the existing European building stock up to a high energy performance standard has been growing in recent years. The Intergovernmental Panel on Climate Change has identified the buildings sector as the one with the highest potential for carbon mitigation, at the lowest overall cost. Energy security, health, employment rates, air quality, indoor climate, and indeed citizens' prosperity and well-being will all be improved as a result of increased building renovation.

This paper illustrates three pathways whereby, through a combination of addressing historical underinvestment and technology development to find better and cheaper ways of saving energy in and on buildings, an 80% reduction in energy requirements is technically achievable. However, in order to deliver the potential, each pathway requires changes in renovation practices that are truly transformational in nature, as not only do we need to increase the number of buildings renovated each year by a factor of three or more, but the average energy saving achieved in each renovation needs also to increase by a similar amount. At peak rates, this represents around a 10-fold increase in the annual energy savings achieved from building renovation compared to today's rate.

While none of the three scenarios can be considered complacent, the Low Acceleration path is least ambitious in the speed at which renovation rates and depths are ramped up. Yet even this scenario requires a wholesale transformation in terms of the prevailing depth of renovation, which needs to be up-scaled from 20-30% to around 80% on average within little more than a decade - even sooner in the Medium Acceleration and Fast Acceleration scenarios.

Whichever pathway is considered, scaling up renovation depths within a relatively short time period, and no later than 2030, is essential if the 80% goal is to remain within reach. In terms of peak renovation rates, these are in the range 3-3.5% in all cases and as such, the practical implications for peak manufacturing and installation capacity are not greatly different between the alternative routes, other than the timing. What is materially different is the speed at which capacity needs to be ramped up, particularly in the Medium Acceleration and Fast Acceleration scenarios.

All scenarios assume today's demolition rate continues to 2050. However, in the context of demographic and other societal changes over the next 30-40 years, one may witness increased demolition in the future, with new buildings erected that better meet users' needs. The implications for the building sector of higher demolition rates is that fewer renovations in total will be required, and also that it should be easier to achieve very low or zero energy consumption in new buildings than through retrofitting of energy saving measures to existing structures.

The issue of total accumulated energy and carbon savings also needs to be considered. While all three scenarios achieve the same end result in terms of savings in the year 2050, the Fast Acceleration scenario achieves most energy and carbon saving in total over the period by virtue of the earlier investment and longer duration of the savings measures being installed. That said, the cost per unit of energy saved will be lowest under the Low Acceleration scenario, since the relatively later renovations undertaken under this scenario will benefit from the learning effect of technical and technological progress. Conversely, the Medium Acceleration path will strike a balance between total costs and total savings.

In conclusion, this discussion paper sets out the technical feasibility of delivering an 80% energy demand reduction in the existing building stock by 2050. This challenging yet achievable objective will require Member State governments across the EU to develop renovation strategies that are truly transformational in nature, enacting policies that unlock barriers to renovation and creating a climate whereby high rates of deep renovation becomes the norm within a matter of years.