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14:42 18.10.2018

Techno economic analysis of individual building renovation roadmaps as an instrument to achieve national energy performance targets

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ABSTRACT

In order to achieve the Paris COP21 agreement, retrofitting activities in the building stock have to be strongly enhanced, therefore individual building renovation roadmaps (IBRR) can be an instrument for guiding building owners through this process. The research question of this paper is: how ambitious should individual building renovation roadmaps be to achieve consistency with future scenarios of the building stock's energy performance? The methodology applied follows these steps: first, the bottom-up discrete choice building stock model Invert/EE-Lab (www.invert.at) is applied to develop a scenario of building stock related energy demand, CO_2-emissions and costs until the year 2050. The scenario is based on the assumption of current or only slightly strengthened policies and results in 77% CO_2-emission reductions of the building stock from 2012 to 2050. In the second step, we selected representative building types from the Invert/EE-Lab model scenarios. For these building types, we developed IBRR (individual building renovation roadmaps) based on previous experience and literature research. Further, we calculated the building's new energy performance after the renovation measures defined in the IBRR. Finally, we analysed to which extent the energy saving through IBRR measures are in line with the simulated scenario. We carried out this study for the case of Germany. Moreover, we restrict the analysis to single-family houses. The results showed that - based on the approach of the IBRR – it would be required that annually about 4-6% of the buildings apply at least one refurbishment measure (change windows or insulate the roof, change heating system, etc.) in order to achieve a scenario, such as the one simulated by the model Invert/EE-Lab.

KEYWORDS

Deep renovation, Individual Renovation Roadmap, Bottom-up modelling, Energy Performance for Buildings Directive (EPBD), Energy performance targets.

INTRODUCTION

The building sector has been identified as one of the key sectors for achieving the energy and climate policy targets of the EU, as buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions in the EU. In light of single family houses, they represent across the EU between 59,4% (in Slovakia) to 89% (in Italy) of the total building floor area (EU Buildings Datamapper, 2013). In this context, the recast of the Energy Performance of Buildings Directive 2010/31/EU (revised in 26.04.2018)(European Parliament, 2018) is an important legislative instrument at EU level, which supports deep renovation of existing buildings. Here, it is necessary to highlight the necessity of deep renovation (retrofitting), instead of esthetical or maintenance renovation. In a study on renovation rates of energy performance activities in the residential building stock in the Netherlands (Filippidou et al., 2017), the authors pointed out the need of packages for deep renovation measures, rather than single refurbishment measures. A study on the success for energy efficient renovation of dwellings in Norway emphasizes the importance of private homeowners to have access to

relevant and reliable advices, to make energy efficient choices in the process of renovation, as a role player in the process of increasing building renovation rates (Risholt and Berker, 2013). Fabbri et al., 2018 identified the lack of engagement and knowledge of the homeowners with energy efficiency issues as main barrier to increase energy performance of single-family houses, stressing the relevance of developing individual building renovation roadmaps (IBRR), which foresee the renovation measures over a period, according to building owner's desire. In Europe, there are already some demonstration projects, which focus on the key concept of IBRR, as an initiative to increase awareness about building`s energy performance, and to encourage homeowners to deep renovate their houses. One of these are: in Germany, the concept of renovation roadmap (*Sanierungsfahrplan – SFP*), and in France, the low energy roadmap *Passeport Efficacité Énergétique (P2E)*. In this context, the iBRoad EU-funded project works on eliminating the barriers between house owner and building energy performance, by developing an Individual Building Renovation Roadmap (iBRoad) tool for single-family houses. This study aims to understand the role of these IBRR in the German case as an instrument to achieve national decarbonisation targets until 2050 for the energy performance of single-family houses.

METHODS

To analyse on how ambitious IBRR (individual building renovation roadmaps) should be, in order to achieve national decarbonisation targets in the building stock, first, the dynamic bottom-up discrete choice building stock simulation model Invert/EE-Lab was used to simulate the a "current policy scenario" for the German building stock. Secondly, a norm based monthly energy balance calculation model was applied to calculate the energy savings resulting from the measures suggested in IBRR for reference buildings. As cooling energy demand in Germany's single family houses are low: 0.07 TWh (Olonscheck et al., 2011), the present study focused on space heating energy demand. Finally, we compared and aligned both results, by extrapolating the results of the selected reference buildings on Germany's single-family building stock.

1. Techno-economic bottom-up modelling of energy demand and CO_2 emissions for the building stock

Invert/EE-Lab is a dynamic bottom-up discrete choice building stock simulation tool. In particular, Invert/EE-Lab is designed to simulate the impact of policies and other side conditions in different techno-economic scenarios. These scenarios drawn with this tool build on much disaggregated representation of the national building stock by a large number of reference buildings. Based on several parameters such as the age distribution of the building components; heat supply; distribution technologies in the building stock; and the ratio between the total costs of purchase of new components and the energy-consumption related annual costs using the installed component, the share of buildings and components is determined, carrying out a renovation measure. For more information see www.invert.at (Müller, 2015), (Kranzl et al., 2013) and (Steinbach, 2016). By setting the model with the current policy instruments, a scenario study developed for the European Project SET-Nav showed that 77 % CO_2-Emission from the building stock during the analysed period 2012 to 2050 can be achieved (Hartner et al., 2018).

2. Choice of reference buildings and their individual building renovation roadmaps

In order to select representative reference buildings, Germany's single family house building stock was mainly classified according to building construction vintage, building geometry, gross and heated floor area, envelope quality and heating systems (Pfluger et al., 2017). For this, from the mentioned database of the German building stock, six reference buildings,

which together represent 33% of total energy demand of single-family houses, were chosen. Table 1 below shows the building characteristics and the relation between construction vintages and envelope's quality of the selected reference buildings B1-B6:

Table 1: Reference buildings characteristics selected from Invert/EE-Lab building stock typology database

Reference building	Construction vintage	Heated area [m²]	U-value Exterior walls [W/m²K]	U-value windows [W/m²K]	U-value roof [W/m²K]	U-value floor [W/m²K]	Heating system
B1	1949 - 1957	139	0.93	2.57	1.11	1.01	Oil boiler
B2	1958 - 1968	140	1.44	2.90	0.92	0.97	Oil boiler
B3	1969 - 1978	147	1.21	2.57	0.63	0.85	Oil boiler
B4	1979 - 1983	148	0.80	4.30	0.43	0.81	Oil boiler
B5	1984 - 1994	146.	0.68	2.57	0.30	0.55	Oil boiler
B6	1995 - 2001	142	0.50	1.60	0.22	0.34	Oil boiler

The renovation roadmap measures for the reference buildings listed above were defined based on literature (Hoier et al., 2013) and considering the achievement of national building code standards (EnEV,2014). Table 2 shows the stepwise renovation measures:

Table 2: Individual building renovation roadmap

Renovation step	Renovation measures
1	Roof insulation
2	Walls, floor insulation and air tighness increase
3	Window replacement
4	Insulation heat distribution system
5	Heating system replacement

A survey within the iBRoad Project scope, which aimed understanding potential users, showed that a time horizon of individual building renovation roadmaps between 5 and 10 years is most favorable for building owners (Fabbri et al., 2018). Because of that, in the present study assumes a total of 10 years renovation period with two years renovation time-step (period between renovation measures are made). Building elements present different renovation cycles, opaque envelope elements have renovation cycle of 50 years, while window's renovation cycle are about 36 years and heating systems 30 years (Hoier et al., 2013). In the assumed 10 years renovation period, only one renovation cycle was considered.

3. Building Energy Performance Calculation Model and Extrapolation

The energy performance of the reference buildings due IBBR was assessed using a norm based monthly energy balance calculation model. This multi-zone model was developed in Matlab and calculates the monthly balance of energy performance of buildings. Energy need, delivered energy and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting are assessed based on the calculation methodology specified on the DIN V 18599, which is a an aggregation of the norms (DIN V 4108-6/ DIN V 4701-10 und -12, EN 832, ISO 13790) (Garcia, 2017). After assessing building's new energy performance for the IBBR, a linear extrapolation method was applied, where the calculated energy demand [kWh/m²a] was multiplied by the number of existing buildings of each reference building according to the building stock typology database from Invert/EE-Lab, also into consideration, the percentage of reference building on the total single-family houses construction vintages, as showed in **Fehler! Ungültiger Eigenverweis auf Textmarke.** below.

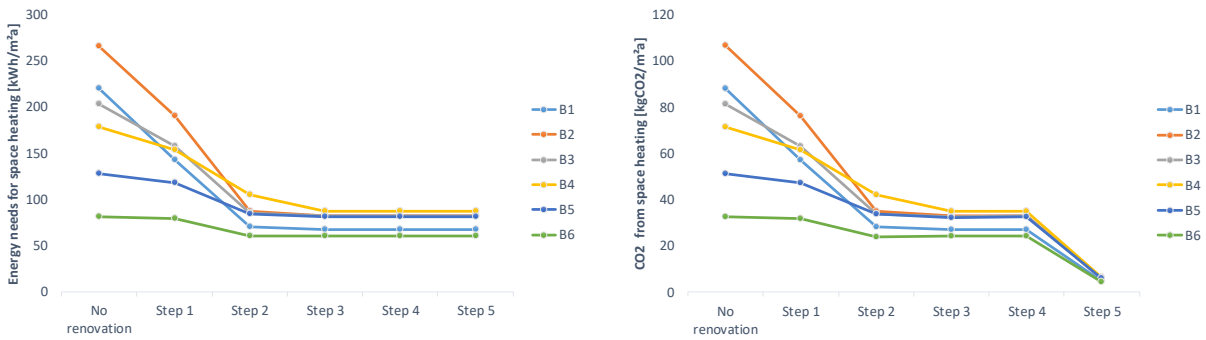
Table 3: Reference Buildings and its representativeness in the building stock for the base year 2012

Construction vintage	Number of buildings per Construction vintage [Tds]	Reference building for the Construction Vintage	Percentage of Reference building's on the Building Vintage	Percentage of Reference building's on Reference building the SFH building stock
1949 -1957	162	B1	26%	2%
1958 -1968	407	B2	36%	7%
1969 -1978	451	B3	39%	6%
1979 -1983	518	B4	80%	7%
1984 -1994	743	B5	79%	7%
1995 -2001	962	B6	94%	5%

This method allowed obtaining an estimation of the total energy needs for space heating, aligning them with the scenario estimated by the techno-economic bottom-up modelling with Invert/EE-Lab.

RESULTS

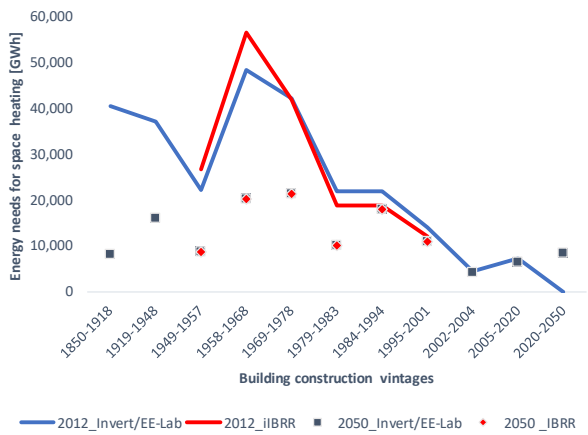
The graph 2 illustrates the energy needs and CO_2-emissions caused by space heating of each reference building (B1 until B6) and their effects due to the five steps IBBR, according to the renovation steps and measures described in Table 2 above.



a) b)

Graph 1: Effects on the a) energy needs, on the b) CO_2 emissions, for space heating due to the individual renovation roadmap (IBRR)

The results show a wide range on energy needs for space heating between the reference buildings in the status quo (base year 2012). Reference building B2 has the highest energy need (266 kWh/m²a) while reference building B6 the lowest (81 kWh/m²a), which can be expected since envelope quality differs according to the building construction vintages. Renovation measures on the envelope quality (renovation steps 1 until 3) lead to 25% until 70% energy needs reduction, in reference buildings B6 and B2 respectively. The effects of the renovation measures "insulation of the heat distribution system" and "heating system change" are better observed on the final energy and on primary energy. In step 5, we considered a roadmap, where the oil boiler is substituted by a biomass boiler, which has a lower thermal efficiency, but has significantly lower CO_2 emission factors. As a result from the individual renovation roadmaps, CO_2 emissions are reduced to 5 until 6 $kgCO_2/m^2$ depending on the building. The current policy scenario calculated with Invert/EE-Lab, which only considers single-step major renovation of buildings, resulted a reduction from 260 TWh to 132 TWh on the total energy needs for single-family houses space heating. The extrapolation of the IBRR results indicates that such a scenario is also achievable with the approach of stepwise renovation, guided through IBRR. **Fehler! Verweisquelle konnte nicht gefunden werden.** depicts the comparison of energy needs for space heating between Invert/EE-Lab model and the IBRR extrapolation, for each building construction vintage:



Graph 2: Comparison between Invert/EE-Lab and the individual renovation roadmap (IBRR) extrapolation

The graph shows the energy needs for space heating according to the building construction vintages in both years, 2012 (base year) and 2050, for both approaches (Invert-EE/Lab and IBRR). For the base year (2012), Invert/EE-Lab and IBRR present similar energy needs for space heating, exceptionally for the construction vintage 1958-1968, where a difference of 8.140 GWh can be seen. Regarding the trend of the energy needs, between 2012 and 2050 occurs a significant decrease on the energy needs in all building construction vintages, especially on the buildings constructed in 1850-1918, 1958-1968 and 1969-1978. In the Invert-EE/Lab model, buildings constructed after 2012 did not carry out any renovation measures, as the model prioritizes building renovation in buildings with higher specific energy need (kWh/m²), which is the case of older building construction vintage. Finally, the graph shows that for the analysed building construction vintages represented by the reference buildings B1 until B6, Invert/EE-Lab current scenario's can be achieved, as the points representing scenario for 2050 Invert/EE-Lab (in blue) and IBBR (in red) are overlapped.

DISCUSSIONS

The results showed that - based on the approach of the IBRR – it would be required that annually about 4-6% of the single-family building stock, according to the building construction vintage, need to apply at least one retrofitting measure (change windows or insulate the roof, change heating system, etc.), in order to achieve the scenario simulated by the model Invert/EE-Lab. This annual building stock renovation rate results deliver from a static calculation, as the extrapolation considers the same number of buildings from 2012 until 2050, meaning no demolition of old buildings. The definition of a 10-years IBBR period is a significant parameter for the obtained results, rather than the time step between the measures. Concerning the IBRR concept, it should consider national, regional and cultural particularities, political incentives and available technology and therefore it is specific for each country. Especially by the renovation measure "change of heating system", the analysis should be extended and study a mix of different measures as connecting to district heating net or installing a heat pump. In the present study, only one possibility by changing the oil boiler to biomass oiler was considered. Also, when developing IBRR to buildings situated in hotter climate zones as Germany, measures related to the cooling energy demand should also be considered, as well as cooling energy demand scenario analysis. In regard to the ambitiousness of IBRR, this paper considers renovation standards according to the national building codes. However, if ambitious CO_2-reductions were aimed (>90% CO_2-Emission) not only more energy efficient IBRR would be needed, but also higher annual percentage of at least one retrofitting measure.

CONCLUSIONS

Results show that for the analysed construction vintage (1949-2001), annually about 4-6% of the single-family building stock need to apply at least one retrofitting measure, in order to achieve CO_2-Emission reduction according to the current policy scenario. Uncertainties are related to the calibration of the base year (2012) between both approaches Invert-EE/Lab and IBBR. More accuracy on the results can be assured by extending the reference buildings to all

construction vintages provided by the single-family houses building stock of Invert-EE/Lab, in a way that each building construction vintage from 1850 until 2012 has at least one reference building. Also, the chosen reference buildings for the vintages 1949-1958, 1959-1968 and 1969-1978 represent less than 50% of percentage of energy needs on the building construction vintage. This means, choosing more than one reference buildings for these groups can increase accuracy. In all, IBRR can become an important instrument to achieve national targets, as it reduces some barriers for renovation activities in single-family houses, by increasing the application of annual deep renovation measures in the existing single-family houses.

ACKNOWLEDGEMENT

This work was supported by the European Union's Horizon 2020 Framework Programme (iBRoad project –http://ibroad-project.eu/).

REFERENCES

EU Buildings Datamapper, 2013. EU Buildings Datamapper - Energy - European Commission [WWW Document]. Energy. URL /energy/en/eu-buildings-datamapper (accessed 6.21.18).

European Parliament, 2018. Directive of the European Parliament and of the Council - amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficienc [WWW Document]. URL http://data.consilium.europa.eu/doc/document/PE-4-2018-INIT/en/pdf (accessed 6.12.18).

Fabbri, M., Volt, J., de Groote, M., 2018. iBRoad _D.2.2 The Concept of the Individual Building Renovation Roadmap.pdf.

Filippidou, F., Nieboer, N., Visscher, H., 2017. Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database. Energy Policy 109, 488–498. https://doi.org/10.1016/j.enpol.2017.07.025

Garcia, J., 2017. Nearly Zero Energy Buildings (nZEB): definition and comparative analysis in selected EU countries. Master Thesis.

Hartner, M., Forthuber, S., Kranzl, L., Fritz, S., Müller, A., Bernath, C., Sensfuß, F., Maranon-Ledesma, H., 2018. D5.3 SET-Nav: Summary report on case study - Energy demand and supply in buildings and the role for RES market integration.

Hoier, A., Erhorn, H., Hauser, G., Sedlbauer, K., 2013. Energetische Gebäudesanierung in Deutschland, Studie Teil 1: Entwicklung und energetische Bewertung alternativer Sanierungsfahrpläne.

Kranzl, L., Hummel, M., Müller, A., Steinbach, J., 2013. Renewable heating: Perspectives and the impact of policy instruments. Energy Policy. https://doi.org/10.1016/j.enpol.2013.03.050

Müller, A., 2015. Energy Demand Assessment for Space Conditioning and Domestic Hot Water: A Case Study for the Austrian Building Stock 285.

Olonscheck, M., Holsten, A., Kropp, J.P., 2011. Heating and cooling energy demand and related emissions of the German residential building stock under climate change. Energy Policy 39, 4795–4806. https://doi.org/10.1016/j.enpol.2011.06.041

Pfluger, B., Bernath, C., Bosmann, T., Elsland, R., 2017. Langfristszenarien für die Transformation des Energiesystems in Deutschland [WWW Document]. URL https://www.bmwi.de/Redaktion/DE/Downloads/B/berichtsmodul-0-zentrale-ergebnisse-und-schlussfolgerungen.pdf?__blob=publicationFile&v=6 (accessed 6.12.18).

Risholt, B., Berker, T., 2013. Success for energy efficient renovation of dwellings—Learning from private homeowners. Energy Policy 61, 1022–1030. https://doi.org/10.1016/j.enpol.2013.06.011

Steinbach, J., 2016. Modellbasierte Untersuchung von Politikinstrumenten zur Förderung erneuerbarer Energien und Energieeffizienz im Gebäudebereich. FRAUNHOFER VERLAG, Stuttgart.