RockiG - Factors and assumptions for scenarios A, B and C

| **Category** | **Key factor** | **2022** | **2030** | **2045** | **Modeling Perspective** |
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| **Category 1:** Energy-efficient building refurbishment as a core component of the energy transition | **Serial rehabilitation**  In particular, the influence of serial renovation to increase the renovation rate - where are the limits? | It has not yet been demonstrated how and that serial renovation in Germany is more cost-efficient than conventional renovation. An increased speed of implementation has also not yet been demonstrated.  However, pilot projects, projects in other countries and many theoretical studies demonstrate cost efficiency, higher speed and scalability. | **Assumption A**  Serial renovation has already been adopted in practice in many places and the renovation rate can be increased as a result.  The negative effects of labour shortages are greater than the positive effects of serial renovation.  **Assumption B**  There is not yet any widespread application, but the path towards this is clearly beginning to take shape.  **Assumption C**  Serial renovation does not prove to be cost-efficient and does not lead to a higher renovation rate. | **Assumption A**  Through serial renovation, a great many German buildings have already been insulated quickly and cost-effectively. The approach has become widespread and is only being improved in a few places where necessary.  **Assumption B**  Serial renovation has already been adopted in practice in many places and the renovation rate can be increased as a result.  **Assumption C**  There is not yet any widespread application, but the path towards this is clearly beginning to take shape. | How is renovation triggered?   1. Natural renovation: triggered by lifetime being reached. Sync renovation could happen. 2. Forced renovation: triggered by efficiency or RE requirement (policy scenario). However, this can create another problem: if a large number of buildings are triggered by this in a specific year, it can create an unreasonable shock to the renovation activities and energy consumption.   How is renovation done?   1. Conventional renovation: building components are replaced individually with longer time and lower cost. 2. Serial renovation: building components are replaced individually or jointly, with shorter time and higher cost.   Modeling feasibility assessment   * Logic: clear, the three scenarios are distinguished by the cost of conventional and serial renovation, as well as the demand of craftsman and material. * Data: to be developed * Overall: feasible |
| **Lower flow and district heating temperature**  Where do problems arise with existing buildings? | Flow temperatures in existing buildings and district heating networks are high. This makes the use of low-temperature systems challenging.  Flow temperatures: Insulation, replacement of the heat transfer system and use of hybrid systems are available as options for reducing flow temperatures, but have not yet been investigated in detail.  District heating temperatures: Reduction of temperatures through 4th and 5th generation grids possible, but so far only isolated projects. Municipal utilities as a centrally important actor.  The use of heat pumps is rising sharply as a result. | **Assumption A**  Clear design rules on how to reduce flow temperatures have been established and are gradually being implemented.  Municipal utilities have also been able to establish procedures for lowering district heating temperatures.  **Assumption B**  Unlike assumption A, where all potentials are used, here the potentials are only partially used, e.g. only in the denser area.  **Assumption C**  The challenges of the low temperature system will continue to be an obstacle - business as usual. | **Assumption A**  The reduction of flow temperatures and district heating temperatures are no longer an obstacle and are passed through as standard during the refurbishment of buildings and networks.  **Assumption B**  Clear design rules on how to reduce flow temperatures have been established and are gradually being implemented.  Municipal utilities have also been able to establish procedures for lowering district heating temperatures.  **Assumption C**  Unlike assumption B, where all potentials are used, here the potentials are only partially used, e.g. only in the denser area. | For each representative building, according to its efficiency class (hwb in the unit of kWh/m2), we will assign the feasibilities to use (1) HP, and (2) low-temperature district heating.  When possible, HP will be included in the list of heating technologies for choosing. However, since we don’t model the heat supply (i.e., district heating systems), we cannot model if these buildings really switch to low-temperature district heating.  Besides, radiator replacement can be added. There is empirical study on it.  In summary, what the model can provide is: the potential (percentage of heating demand) that can be covered by low-temperature district heating for a given “location” in the model.  Modeling feasibility assessment   * Logic: to be confirmed, because the “low-temperature DH potential” is a result of other renovation related policies. We don’t have a specific policy (scenario setting) on “promoting the low-temperature DH”. In reality, this is usually done at the municipal level, for example, through specific plans to promote renovation so that a local low-temperature DH system could be feasible. * Data: to be developed, e.g., the relation between hwb and the feasibility of using HP and low-temperature DH * Overall: feasible, if we only provide “low-temperature DH potential” as results of other renovation related policies. |
| **Refurbishment roadmaps**  In particular, influence of renovation roadmaps and their follow-up by the offices. | Renovation roadmaps are encouraged (higher funding for residential buildings).  Data availability and access often poor or not possible.  Current estimate of renovation rate at 1-1.5%, with regional differences.  The current target, loosely formulated by the federal government, has been in place for a long time.  Insufficient understanding of the multiple benefits of building retrofits (beyond reduced energy costs).  Limited craft capacities to implement the many necessary measures in the existing building stock.  For modelling:  A. High rate and depth of remediation;  B. high rate of renovation, but low depth of renovation;  C. Low rate and depth of remediation. | **Assumption A**  Digitisation of timetables for the whole building. Determination of the CO2 footprint of a building (not only energy-related, but also e.g. materials).  Very high depth of remediation as a result  **Assumption B**  Digitisation of timetables.  Focus on specific components (façade & basement ceiling, heat supply system).  **Assumption C**  Not digitised, no improvement.  Reduction of competences: In terms of personnel, a lot has been reduced in the offices, including competences (not only quantitatively, but also qualitatively). | **Assumption A**  Offices are digitalised and processes run faster and better.  There have been significant improvements in the efficiency of renewable energy technologies (PV, solar thermal, heat pump).  **Assumption B**  Digitisation of timetables for the whole building. Determining the carbon footprint of a building (not only energy-related, but also e.g. materials).  **Assumption C**  Digitalisation of the timetables  Focus on specific components (façade & basement ceiling, heat supply system). | The three assumptions can be reflected by introducing the “forced renovation” logic:   * Assumption A: with forced renovation and the minimum efficiency is higher. * Assumption B: with forced renovation and the minimum efficiency is lower. * Assumption C: without forced renovation.   Modeling feasibility assessment   * Logic: to be confirmed. As mentioned, the “roadmap” can be reflected by the “minimum building efficiency requirement” that triggers the buildings’ renovation. But there is nothing about digitalization. * Data: to be developed, e.g., reasonable efficiency requirements for the buildings, especially considering the characteristics of the specific buildings and owners * Overall: feasible. |
| **Choice of the optimal energy system**  In existing buildings, incl. electrification in the building sector: i.a. influence of energy prices | Immediate conceptual development of neighbourhoods: Municipal heat management planning.  Planning and optimisation tool e.g. DGNB (German Sustainable Building Council) system for the refurbishment of buildings.  District heating: low share of heat supply, few climate-neutral producers.  Fossil fuels are made unattractive. | **Assumption A**  Ensure attractive electricity prices (e.g. by reducing levies/taxes or modernising the electricity market). Buildings as prosumers.  Process for automated determination of the best system is available to energy consultants, planners, etc. and (through update of standardisation) dynamic effects that have increased due to renewable energies are better taken into account.  Cooling and electricity demand in buildings have increased compared to 2022 due to more necessary comfort and digitalisation as well as e-cars and heat pumps. Cities and grid operators are well prepared for this.  **Assumption B**  Ensuring attractive electricity prices, but not good management.  Cooling and electricity demand in buildings have increased compared to 2022 due to more necessary comfort and digitalisation as well as e-cars and heat pumps. This is only partially taken into account in modernisation concepts.  **Assumption C**  Due to high electricity prices, fossil fuels are still more attractive. No financial support or obligation to change the heating system in existing buildings. | **Assumption A**  Building as flexumer: goes beyond prosumer: in addition, it can be flexibly controlled / one does not always just react but can also proactively flexibly influence it.  In the meantime, planners can precisely predict the demand.  **Assumption B**  Ensure attractive electricity prices (e.g. by reducing levies/taxes or modernising the electricity market). Buildings as prosumers.  Process for automated determination of the best system is in place for energy consultants, planners, etc.  **Assumption C**  Ensuring attractive electricity prices, but not good management. | To model these aspects, following details should be included in the model:   * Buildings electricity demand profiles are simulated at hourly resolution, including appliance, cooling, ventilation and also HP-based space and water heating. * Buildings are triggered to consider adopting PV based on two reasons:   + Exogenous penetration curve, independent from impacting factors such as electricity price. So, the buildings will not “consider” adopting PV but are forced to install PV. The energy saving of PV adoption is endogenously calculated based on hourly modeling, as well as the energy saving   + Sync action of heating technology replacement: buildings can consider “best energy system” by considering PV adoption when considering replacing gas boiler with HP, i.e., adopting a PV together with HP so the combination is more profitable than gas boiler. The impact of electricity price is also included.   Besides, apart from PV, battery and EV could also be relevant.   * Battery could be included in the hourly simulation. For households that already have PV installed, they could be triggered to consider battery adoption. However, this will be modeled depending on exogenous penetration curve (within the buildings with PV adopted). * The interaction of EV with such energy system is complicated, because it also depends the driving behavior, i.e., how much it is driven and when it is parked at home.   In brief, the hourly simulation logic with PV could be added, even with battery. But, EV is difficult to be added in such a building stock model.  Modeling feasibility assessment   * Logic: to be confirmed.   + If we only model PV adoption based on “exogenous penetration curve”, it would be the easiest. We can also calculate the impact of PV penetration on demand profiles.   + If we consider “sync action”, the “best energy system” idea of the scenario aspect is better captured, but this is more complicated.   + If we consider battery also, the adoption logic is similar with data to be developed. However, we will not be able to include EV, as meaningful modeling of EV charging depends on the driving behavior as well as charging behavior with other infrastructure, which are difficult to consider in this model. * Data: to be developed, e.g., the exogenous penetration curve, or trigger probability, and the adoption probability as function of cost saving. * Overall: exogenous PV penetration curve can be included in the basic package for RokiG, but such curve needs to be developed first. The sync adoption logic could be possible. |
| **Category 2:** Integration of the individual building into the overall system | **Flexibility potentials on the end consumer side (buildings)**  Among other things, decrease in flexibility on the power generation side | Flexibility is not (sufficiently) rewarded.  At the moment, tariff structures are not built on this.  It is not taken into account (no specifications in residential buildings, load dependency for large consumers).  Flexibility is seen as an additional expense.  Problem: slow changeover, e.g. to remotely readable metering systems. | **Assumption A**  Mature DSM business models for most large electricity consumers.  Automated control -> hardly any additional work for users.  Mature DSM business models for most large electricity consumers.  Behaviour of the users: Individual responsibility instead of external control by producers.  **Assumption B**  No flexibility through buildings. Flexibility is created by integrating large central storage facilities (electricity & heat).  **Assumption C**  No flexibility. | **Assumption A**  Holistic, central interconnection of electricity, heat, mobility (related to municipality or supply area).  Wide use of AI for central control: for example, intelligent charging of e-cars.  Grid stability will also be ensured by consumers and not only by producers.  **Assumption B**  End users receive suggestions from the grid operators on how to use electricity, e.g. on the following day.  The end users (building owners) decide for themselves whether to adapt their own electricity use behaviour and thus offer decentralised flexibility for the electricity grid.  Flexibility is thus ensured partly by consumers and partly by producers/grid operators.  **Assumption C**  No flexibility through buildings. Flexibility is achieved through the integration of large central storage facilities (electricity & heat) and intelligent dispatch and control by the generators/grid operators. | In brief, this is to model the reaction of building stock electricity demand profiles to different electricity price (8760h values), which needs to include SEMS and optimization.  Technically, RENDER can export building stock in each year to FLEX-Operation. The latter can modify the buildings’ electricity load profiles in that year by using SEMS. Comparing the two set of demand profiles, we can see how much “flexibility” is supported by the SEMS and energy storages. The penetration rate of SEMS and storages can be used to distinguish the assumptions.  Modeling feasibility assessment   * Logic: clear. * Data: to be developed, e.g., penetration of PV, battery, and SEMS, as exogenous input in the model. * Overall: more budget needed for such a model interaction. |
| **Digitisation progress in the building sector**  In particular, influence on the demand side management potentials | Digital infrastructure for demand-side management does not yet exist.  Smart meters, as one of the most important building blocks, are not yet widely used in new buildings and hardly ever in existing buildings.  Control algorithms still need to be researched.  Uniform communication standards among the devices/systems are still to be developed. | **Assumption A**  Previously planned smart meter rollout can probably be completed by 2030 despite interruptions in the pandemic. The infrastructural basis for DSM is thus in place.  **Assumption B**  Previously planned smart meter rollout can probably be partially completed by 2030, or only in the area of new buildings with high electricity consumption.  **Assumption C**  Previously planned smart meter rollout can probably not be achieved by 2030 either in the area of new buildings or in existing buildings. | **Assumption A**  Digital business models, control algorithms at grid operator level are being developed.  Uniform communication standards are developed and applied. A functioning digital infrastructure for DSM is thus established.  **Assumption B**  Smart meter rollout successfully completed. The infrastructural basis for DSM is thus in place.  **Assumption C**  Smart meters cannot be installed nationwide.  Main challenges are the retrofitting of existing buildings and actors with data protection concerns. Digitisation progress remains slow. | Same as above. |
| **Category 3:** New construction as a driver of innovation | **Efficiency increase through research work/technology advancement** | Research promotes progress in the field of plant and building technologies, e.g. efficiency improvements.  Innovations are often first used in new buildings and then transferred to existing ones. | **Assumption A**  High increase in efficiency due to technological progress and high transferability to or implementation in existing buildings  **Assumption B**  Medium increase in efficiency due to technological progress and medium transferability to or implementation in existing buildings.  **Assumption C**  No increase in efficiency due to technological progress and low transferability to or implementation in existing buildings. | **Assumption A**  High increase in efficiency due to technological progress both in new buildings and in existing buildings  **Assumption B**  High increase in efficiency due to technological progress and high transferability to or implementation in existing buildings  **Assumption C**  Medium increase in efficiency due to technological progress and medium transferability to or implementation in existing buildings. | This is included in the “efficiency improvement” of building components and technologies in the model:   * When a new building is constructed, all the building components and technologies are installed with the current available options in the market. * To reflect the differences between the scenarios, we have two options:   + Open higher efficiency class options (only building components, not heating technologies) earlier or later.   + Requirements are specified for new construction:     - R1 – For all new buildings, it is forced to choose the most efficient option that is available, instead of drawing from the available ones based on utility and distribution.     - R2 – The building must be efficient enough and with PV, so that it can operate as “climate-neutral”.     - R3 – solar obligation.   Modeling feasibility assessment   * Logic: clear. * Data: mostly ready. * Overall: R1 is feasible. R2 requires extension and more budget. R3 is feasible. |
| **Mandatory climate-neutral (or plus-energy?) building operation for new buildings** | Climate-neutral operation (or operation with energy plus) not mandatory for new buildings. | **Assumption A**  Climate-neutral operation (or operation with an energy plus) is obligatory for new buildings and is partly being implemented in existing buildings.  **Assumption B**  Climate-neutral operation (or operation with energy plus) is mandatory for new buildings.  **Assumption C**  Climate-neutral operation (or operation with energy plus) is not mandatory for new buildings; climate-neutral or energy-plus operation is limited to buildings with a pioneering function (e.g. city-owned buildings). | **Assumption A**  Climate-neutral operation (or operation with energy plus) is obligatory for new buildings and existing buildings  **Assumption B**  Climate-neutral operation (or operation with an energy plus) is obligatory for new buildings and is partly being implemented in existing buildings.  **Assumption C**  Climate-neutral operation (or operation with energy plus) is mandatory for new buildings | As mentioned above in R2. |
| **Solar obligation (PV) for new buildings** | Currently, there is no solar obligation for new buildings, except in BW (60 % of suitable roof surfaces must be occupied, also applies to basic roof renovations from 2023). | **Assumption A**  Solar obligation for all new buildings is enforced (e.g. 80 % of suitable roof areas).  **Assumption B**  Solar obligation for all new buildings is enforced (e.g. 60 % of suitable roof areas).  **Assumption C**  Compulsory solar energy is not enforced, but continues to be limited to individual federal states or cities. | **Assumption A**  Solar obligation for all new buildings is enforced (e.g. 90 % of suitable roof areas).  **Assumption B**  Solar obligation for all new buildings is enforced (e.g. 70 % of suitable roof areas).  **Assumption C**  Solar obligation for all new buildings is enforced (e.g. 40 % of suitable roof areas). | As mentioned above in R3. |
| **Category 4:** Regulatory framework | **Support programmes**  Influence of the changed funding programmes, including Efficiency House 55/40 before and after 2022 | Focus on existing buildings by discontinuing Promotion 55 for new buildings  Support programme for the skilled trades is missing: At the moment it is mainly the owners of buildings who receive support  Existing buildings: funding programmes still diverse -> jungle; often not used due to the requirements / complex application process, sometimes not feasible without advice  New construction: funding applications for Efficiency House Level 40 with Sustainability Class / Efficiency Building Level 40 with Sustainability Class possible again.  In 2020, there were 29, 174 and 2,458 funding programmes for energy-efficient building refurbishment at the federal, state and local levels - funding jungle.  If possible in the modelling:  Flexible increase or reduction of funding volumes possible.  Alternative funding rates (e.g. one focus on insulation, one on regenerative systems technology). | **Assumption A**  Process for funding has been simplified - debureaucratisation, digitalisation if necessary.  Resource efficiency is "rewarded" (cradle to cradle).  Promotion of climate-neutral construction (wood, insulation materials, etc.) and increased promotion of climate-neutral heat generators.  Conversion to EH classes according to CO2 emissions.  For existing buildings: federal promotion of efficient heat grids; audit mechanisms to protect against misuse; reinvestment of the CO2 tax from the existing building stock into the existing building stock; promotion of stocking up (coupled with refurbishment).  **Assumption B**  Complicated procedure for applying for financial support and support only available for very specific objectives.  There is funding, but it is not well distributed - eventisation of funding measures and lack of long-term orientation.  **Assumption C**  Complicated procedure for applying for financial support and support only available for very specific objectives.  There is less funding. | **Assumption A**  Process for funding has been simplified - debureaucratisation, digitalisation if necessary.  Targeted promotion of measures is possible - efficient implementation of measures.  Overcoming the social imbalance between new and existing buildings - fair distribution of funding.  In addition, overall concepts for the energy supply for neighbourhoods are available.  **Assumption B**  The funding process has been simplified - less bureaucracy, possibly digitisation or merging of funding programmes at the differentiation levels reduced the amount of information required.  **Assumption C**  Complicated procedure for applying for financial support and support only available for very specific objectives  There is funding, but it is not well distributed. | Funding can be designed for specific type of renovation or technology replacement. It may also depend on the income of owners, but the income group is a feature not implemented.  The total amount of funding can be flexible. Besides, we can calculate (1) total funding demand per year, or (2) funding constraint.  Modeling feasibility assessment   * Logic: clear. Possible packages can be filtered according to the income constraint. * Data: to be defined. From Eurostat, we have income distribution for regions. The funding can target on different income groups specifically. * Overall: feasible. |
| **Regulatory restrictions for new construction and conversion**  a.o. additional costs, possible savings | Amendment of the BEG promotion  Promotion of individual measures and efficiency house standards according to the BEG (reduction of funding rates compared to the old BEG as well as cancellation of funding for gas hybrid systems) | **Assumption A**  Minimum requirement of 65% RE in every newly installed heating system, planned in the coalition agreement + discussion paper BMWK, was exceeded - 80% RE.  Ban on the use of fossil fuels in buildings for new installations.  **Assumption B**  Technology bans on the installation of new monovalent gas heating systems in new buildings and, if reasonable, in refurbishments (case-by-case verification, e.g. via assumptions on the flow temperature in existing buildings).  Minimum requirement of 65 % RE in every newly installed heating system was implemented as planned (coalition agreement + discussion paper BMWK) from 2024 without further progress.  **Assumption C**  No tightening of the current requirements | **Assumption A (2030 update)**  Minimum requirement of 100% RE in every newly installed heating system is implemented.  New gas and oil heating systems in Germany no longer possible due to the legal framework.  Ban on the use of fossil fuels in buildings.  **Assumption B**  Obligation to replace old gas and oil boilers (e.g. older than 20 years)  Minimum requirements 80 % EE also in case of change of ownership  **Assumption C**  Technology bans on the installation of new monovalent gas heating systems in new buildings and, if reasonable, in refurbishments (case-by-case verification, e.g. via assumptions on the flow temperature in the existing building stock). | Regarding the restrictions on heating system replacement, we can have the following:   * R1 – Banning specific technologies starting from a specific year. * R2 – Filtering the possible system options according to the RE share. However, there can be some unclarified problems:   + What are the acceptable options for the heating system? Only HP or DH? How about a combined system? Hybrid HP?   + For inefficient buildings, HP may not be feasible, while DH may also be not available. What will happen?   Modeling feasibility assessment   * Logic: R1 is clear. R2 is to be confirmed. * Data: to be developed. * Overall: R1 is feasible. R2 is hopefully solvable after researching relevant questions. |
| **Redevelopment constraints**  Among other things, stricter minimum requirements for building renovation | Requirement of a minimum thermal insulation of the top floor ceiling in existing buildings according to §47 BEG, in case of occupancy since before 2002 only in case of change of ownership. | **Assumption A**  Requirements for energy efficiency classes for existing buildings (e.g. KfW EH 100)  Possibly compulsory preparation of renovation roadmaps for buildings (also the relevant energy demand, building age, etc.)  **Assumption B**  Requirements to comply with energy efficiency classes when changing ownership (e.g. KfW EH 75).  **Assumption C**  Business as usual. | **Assumption A**  Compulsory renovation of existing fossil fuel plants.  **Assumption B**  Further tightening of requirements to comply with energy efficiency classes when changing ownership (e.g. EH 100)  **Assumption C**  Requirements to comply with energy efficiency classes when changing ownership (e.g. KfW EH 75) | * This can be modeled by “forced renovation – triggered by efficiency requirement”. * The trading of buildings cannot be modeled. |
| **Category 5:** Society and Economy | **Craft capacities / economic efficiency of the enterprises**  Bottleneck of craft enterprises; lack of skilled workers/ craftsmen for implementation; profitability of enterprises - prices and investments | 2022, the number of skilled workers in the construction industry has increased. Nevertheless, the shortage of skilled workers continues to make itself felt. There is little spare capacity.  Significantly more companies want to hire new employees (31%) than reduce the number of employees (6%). And a third of the companies want to increase the number of their trainees in the coming year, but many positions will probably remain unfilled.  2021: In the construction sector, 60% of apprenticeships remain open.  Current areas of tension - from inflation to energy prices, material availability and interest rates to the gas issue - ensure that the coming development is difficult to calculate for businesses. The economy is unsettled.  The companies are also concerned about the price increases for building materials (96% of the construction companies. 82% percent assume that purchase prices will continue to rise significantly. This applies above all to reinforcing steel and petroleum-based building materials - but not only: prices for wood and mineral insulation materials are also rising significantly.  To avoid being in the red, many companies no longer bid for new contracts - over 30% of construction companies no longer submit new bids. | **Assumption A**  Through further training and advertising, the craft sector is beginning to gain a better reputation. Funding programmes are made available for training and further education in the skilled crafts sector.  The capacities are at the target level.  **Assumption B**  The typically used career guidance instruments (online portals, regional fairs, etc.) have shown their effect in some regions to partly counteract the shortage of skilled labour.  However, capacities are still behind the target level.  However, due to limited time and organisational resources or a lack of professional experience, the activities of the companies are often individual actions and not designed for the long term.  **Assumption C**  There is a clear shortage of skilled workers. The declining number of people in employment and the working-age population has further increased the pressure on the skilled labour situation in the skilled crafts sector.  Shifts in manufacturing occupations pose additional challenges, especially for the skilled trades for commercial needs, the finishing trades and, in parts, the main construction trades. The trend towards academic qualifications has a similar effect.  The willingness to invest in the skilled crafts sector has decreased. The order situation has deteriorated - at the same time, many companies still have few free capacities. | **Assumption A**  By offering various vocational training opportunities and facilitating the recruitment of skilled workers from abroad, there is no shortage of skilled workers.  The attractiveness of the skilled crafts has increased further.  **nnahme B**  Craft capacities do not yet meet the necessary values, but they have increased significantly because they are better paid and have a better image.  **Assumption C**  The medium-term development of the supply/demand ratio of  craft services shows a worsening of the excess demand. This means that the shortage of craft services has increased. The main construction and finishing trades are particularly affected. | We can model the craftsman demand or constraint. Data needs to be developed for the specific demand of craftsman by different actions, including building renovation, heating system replacement, building construction and demolition, as well as the adoption of other technologies, including air-conditioner, ventilation, PV, and battery.  Modeling feasibility assessment   * Logic: clear. * Data: to be exchanged with partners. * Overall: feasible. |
| **Supply chain development**  Value creation process from order to production to delivery; availability of resources | 2021: the biggest challenge facing the construction industry is delays and problems in the supply chain and raw material availability. There are increasing material shortages in the construction industry.  Increasing globalisation and global consumer behaviour mean that supply chains can become long and complex.  However, supply chain management is facing a fundamental paradigm shift. The supply chain is so closely interlinked with one's own production system and the entire business model that it can no longer be seen separately. It is increasingly becoming an extension of one's own company.  In general, the entire construction industry is complaining about a shortage of materials. Most of the steel used in Germany comes from Russia or Ukraine, and most of these suppliers are now no longer available. But there are also shortages of asphalt, concrete and oil. The danger of a shortage of building materials exists wherever Russia, Ukraine and Belarus are involved in the process chain. | **Assumption A**  Based on the lessons learned from the Corona period, the companies have managed supply risks better and more closely, e.g. through more warehousing, the establishment of alternative suppliers and supply routes, or even with more regional purchasing.  **Assumption B**  Based on the lessons learned from the Corona period, companies have managed supply risks better - planning has partially started regionally/locally.  **Assumption C**  There are a number of risks that interrupt or disrupt global supply chains.  These include natural disasters that can significantly disrupt production in the domestic economy or disasters in a third country that affect the international supply of inputs.  There are also intentional interruptions, such as terrorist attacks, sabotage or activist actions. | **Assumption A**  Supply chains have become more stable as the focus has shifted to regional or national supply altogether.  The problems could be solved, not in the abolition of just-in-time, but in selective hedging against specifically identified default risks.  **Assumption B**  Based on the lessons learned from the Corona period, the companies have managed supply risks better and more closely, e.g. through more warehousing, the establishment of alternative suppliers and supply routes, or even with more regional purchasing.  The problems could be solved not by doing away with just-in-time, but by selectively hedging against specifically identified default risks.  **Assumption C**  Based on the lessons learned from the Corona period, companies have managed supply risks better - planning has partially started regionally/locally. | We can model the material demand or constraint. Data needs to be developed for the specific demand of material by building renovation and construction. Besides, the recycling of material by building demolishing can also be calculated.  Modeling feasibility assessment   * Logic: clear. * Data: to be developed. * Overall: feasible with extension and further budget. |
| **Income development**  Social inequality / property | Incomes are more unequally distributed in 2021 than they were two to three decades ago, and wealth is more concentrated than in almost all other euro countries.  The share of housing costs in disposable household income has increased in recent years.  The wage share - the share of the economic output of a national economy that is generated by the factor labour - has steadily declined in Germany in recent decades.  Since 2021, there has been a clear discrepancy between the decrease in real wages and the increase in the consumer price index.  According to their own data, about half of the residents in Germany live in their own home. Moreover, the rate of home and flat ownership rises significantly with increasing net household income. | **Assumption A**  Inequality has been reduced by allocating subsidies and grants to the right target groups.  Number of renovation and modernisation works has increased.  **Assumption B**  Social mobility is relatively low: the social status of children depends strongly on the parental home. Inequality has not decreased.  Share of housing costs in disposable household income has increased.  The number of people in Germany who want to renovate a rented flat (or individual rooms in it) has fallen somewhat.  **Assumption C**  The inequality is clearly greater.  Share of housing costs in disposable household income has risen sharply.  As a result, there are significantly fewer renovation and modernisation plans. | **Assumption A**  By allocating subsidies and grants to the right target groups, inequality has been significantly reduced.  Number of renovation and modernisation works has increased significantly.  **Assumption B**  Inequality has been reduced by allocating subsidies and grants to the right target groups.  Number of renovation and modernisation works has increased.  **Assumption C**  Social mobility is relatively low: the social status of children depends strongly on the parental home. Inequality has not decreased.  Share of housing costs in disposable household income has increased.  The number of people in Germany who want to renovate a rented flat (or individual rooms in it) has fallen somewhat. | We can have financial constraint in the investment decision modeling (only for SFH), and we can also model subsidy targeting on specific income group.   * Ideal setting: specific to each building type and role (owner/tenant). But we don’t know how to link owner/tenet and the income group with the buildings. But, we can have at least * Basic setting: ignore such relations and randomly assign the income group of buildings based on the income distribution.   Modeling feasibility assessment   * Logic: clear. * Data: to be developed and see to which extent we can develop the relation between role (owner/tenant), building type, and income group. * Overall: the basic setting is feasible, but more detailed relations modeling needs with extension and further budget. |
| **Household structure and size**  Lifestyles / living concepts / living space | On average, the living space per person increases by one square metre every five years. In rural regions, it increases significantly faster than in cities.  In 2020, the demand for living space among tenants declined, but the ownership rate is rising steadily.  Up to now, neighbourhood concepts have mainly been implemented through an inefficient bundling of individual subsidies. | **Assumption A**  Alongside single forms of living, the idea of communal living lives across age boundaries.  The neighbourhood idea combines the need for communal living, such as multi-family and multi-generation houses.  In the course of the energy transition, neighbourhoods are assuming a more important role - more experience Planning and coordination of neighbourhood projects.  The cohort effect nevertheless comes into play: from generation to generation, more living space is in demand. The reasons for this are rising prosperity and the singularisation of society.  **Assumption B**  The number of older households (60 years and older) has increased. At the same time, the number of larger households (more than two persons) decreased.  The number of single households has remained stable.  **Assumption C**  The number of older households (60 years and older) has increased. At the same time, the number of larger households (more than two persons) decreased.  While the number of single households continues to rise, the proportion of partnerships with separate households is growing and more and more older people over 60 live alone.  This is where the age structure effect comes into play: the older a person is, the greater the demand for living space. | **Assumption A**  In addition to single forms of housing, the idea of communal living lives across age boundaries. The neighbourhood idea combines the need for communal living, such as multi-family and multi-generation houses.  In the course of the energy transition, neighbourhoods are assuming a more important role - more experience Planning and coordination of neighbourhood projects.  The cohort effect could be cancelled out - there is less demand for living space per person.  **Assumption B**  In addition to single forms of housing, the idea of communal living lives across age boundaries. The neighbourhood idea combines the need for communal living, such as multi-family and multi-generation houses.  In the course of the energy transition, neighbourhoods are assuming a more important role - more experience Planning and coordination of neighbourhood projects.  The cohort effect nevertheless comes into play: from generation to generation, more living space is in demand. The reasons for this are rising prosperity and the singularisation of society.  **Assumption C**  The number of older households (60 years and older) has increased. At the same time, the number of larger households (more than two persons) decreased.  The number of single households has remained stable. | This can be reflected in the building construction logic:  Q1 – What type of new buildings are built?  Q2 – How is the number of new buildings decided? Is it just to hold the population from the demolished buildings plus the population growth? Or, if there are more buildings, it means the average person number per dwelling is going down. This needs to be added as another input.  Modeling feasibility assessment   * Logic: to be discussed, as well as the logic of building demolishing. * Data: to be developed. * Overall: feasible, but living area change only captured in new constructions. |

For the year 2030, scenarios A and C represent two rather extreme development possibilities: (A) The potential for increasing building efficiency has been fully exploited. This includes technological implementation as well as regulation and economic-social aspects such as craft capacities. (C) The potentials were hardly exhausted. The scenario describes a continuation of the status quo.

Scenario B represents a mixed variant between the two extreme scenarios.

For the year 2045, there is a development push in the direction of increasing building efficiency for all factors and assumptions (in all scenarios), so that the extreme negative variant in terms of efficiency (Scenario C from the year 2030) is no longer justified.