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End of previous Forum article

Angela Köppl and Stefan Schleicher*

Material Use: The Next Challenge to Climate Policy

New challenges for climate policy are emerging from potentially disruptive technologies: a new wave of automatisation and highly advanced machines; new production processes like additive manufacturing, also known as 3D printing; and new materials like sophisticated polymers that might substitute steel and aluminium. The potential impact of these technologies ranges from the local organisation of work to global supply chains. Investigating the potential impact of these evolving transformations might reveal substantial opportunities for enforcing deep decarbonisation. Examples are an active role of buildings in integrated local energy systems, advanced communication technologies for substituting transport needs, or a deliberate re-localisation of production processes. The built infrastructure (and thus construction materials) plays a tremendous role in the context of transformation and stock flow interactions. We put these challenges into the context of EU energy and climate policy with the proposition that without a new understanding of materials, it will not be possible to meet with the emerging long-term climate targets.

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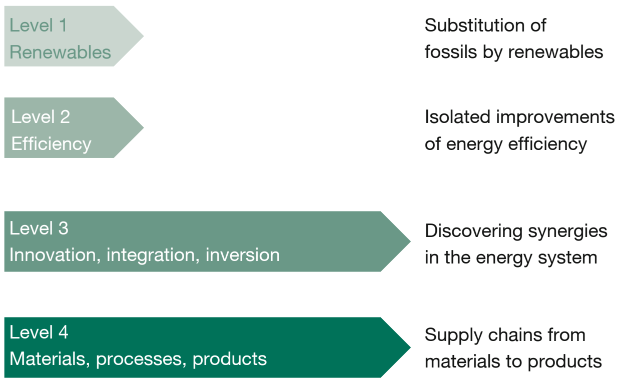
Angela Köppl, Austrian Institute of Economic Research, Vienna, Austria.

Stefan Schleicher, Wegener Center at the University of Graz, Austria.

Transition policies from renewables to materials

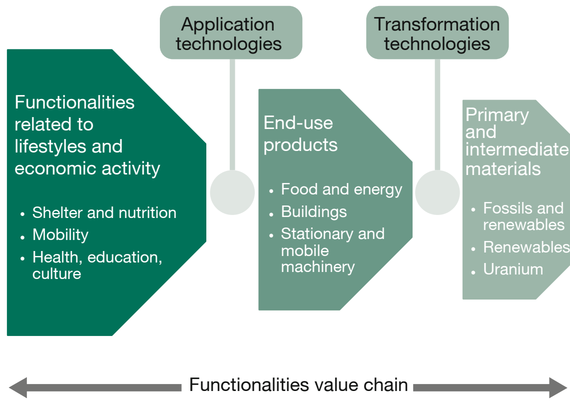
Our understanding of the transitions needed for shifting to an energy system that exhibits low-energy and low-carbon qualities can be explained as a four-step evolution that is depicted in Figure 1. At the outset, we encouraged ambitious efforts to substitute fossil energies with

Figure 1
Steps in the evolution of energy systems



Source: Authors' own illustration.

Figure 2
The functionality perspective



Source: Authors' illustration.

renewables (level 1 policies). Then we realised the limits of this strategy both with respect to availability and costs but discovered opportunities for improving the efficiency of energy use (level 2 policies). Only recently did we come to the vast potential for harvesting synergies by integrating all components of an energy system (level 3 policies). Ultimately, we are hitting the final frontier for transformations: the use of energy in materials (level 4 policies).

The design of the European Union's climate policy has undergone a similar evolution over the past two decades. The current three targets for 2030 echo level 1 and 2 policies, the shift to renewables and the improvement of energy efficiency. Both targets imply emissions reduction. Policymakers, however, have become aware only recently of the fact that the current three target design only allows for a choice of two targets since the third is just an implication of the other two targets.

With the proposed 2050 long-term strategy by the European Commission in November 2018, EU energy and climate policy design is moving to levels 3 and 4. The defining keywords are innovation and competitiveness together with a new view on the circular economy. The target of becoming carbon neutral by mid-century thus emerges quasi in the shadow of the less disputable targets of innovation and a deepened understanding of a circular economy. This is a very deliberate and constructive shift for making energy and climate policy less controversial among member states.

Materials in the supply chain for functionalities

For analysing radical transformations towards a low emission society, a deepened perspective on innovation, disruptive technologies and the related supply chains is required. New in this approach is the focus on functionalities, the ultimate purpose of supply chains. Functionalities serve (basic) human needs such as shelter,[1] e.g. the thermal experience in buildings results from the quality of the building stock and the related energy flows. Another example would be mobility, which from a functionality perspective is the access to persons, goods and services, and that can be provided by different spatial allocations of industrial and settlement locations, transport technologies, transport modes or in some cases by communication technologies. Figure 2 indicates this new perspective of the full value chain that enables functionality. End-use products, such as buildings and stationary or mobile machinery, coupled with chosen application technologies provide the required functionality for shelter or mobility. Transformation technologies, in turn, convert primary and intermediate materials into end-use products.

Learning from the supply chain of construction materials

For a deepened understanding of the role of materials in the design of energy and climate policies, we need to discover the interdependence between the stock of (material) resources and the flow of (material) goods and services needed for a specific functionality. In the context of the functionality shelter, e.g. for a specific room temperature, a higher flow of energy is required in the case of a low quality of building stock or vice versa. In the case of mobility, we need to consider the range of infrastructure from highways to high-speed internet connections. Thus, a specific functionality is always the result of resource flows and capital stocks.

1 A. Köppl, C. Kettner-Marx, S. Schleicher, C. Hofer, K. Köberl, J. Schneider, I. Schindler, T. Krutzler, T. Gallauner, G. Bachner, T. Schinko, K.W. Steininger, M. Jonas, P. Zebrowski: ClimTrans2050 – Modelling Low Energy and Low Carbon Transformations, The ClimTrans2050 Research Plan, WIFO, 2016.

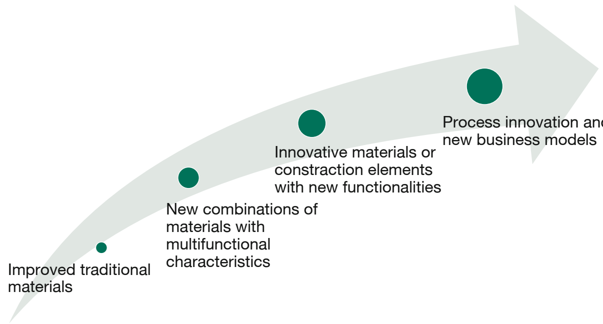
The currently available built infrastructure and the construction materials industry play a key role for low carbon structures over the service life of buildings and other infrastructure. This, however, requires a broader perspective on supply chains and the construction materials industry. The conventional view on the supply chain in the construction material industry does not take account of the specific characteristics of this industry cluster from a functionality-oriented approach. It also omits the emission relevance that arises from climate policy in the supply of building materials and subsequently the emissions over the entire service life of the built infrastructure. The specific characteristics of this industry cluster include a high resource demand and high emissions during the production of construction materials. Construction materials are characterised by a long service life and the built infrastructure remains in the economic system for many years. The conventional perspective on supply chains, however, neglects the aspect of a long service life.

This calls for structures in the construction materials industry that go beyond sub-sectors and sectors and allow for a widened perspective on supply chains and innovation processes.[2] Such a broadened perspective could open new opportunities for innovation that encompasses materials, processes, services and new business models. These elements build on active co-operation along the whole value chain and go beyond incremental innovation strategies. Such innovation could also address the changes in demand and support the competitiveness of the industry cluster. The goal in this case is the supply of sustainable functionalities over the entire service life. The development from incremental to radical innovation processes is illustrated in Figure 3 and highlights the integrated approach to innovation. A functionality-oriented innovation process where the construction materials industry plays a central role, however, has to deal with the complex structure of a cluster of heterogeneous companies and interests: from the final user, investors, architects, engineering, suppliers of construction machines to building material suppliers. A strongly shared objective, expressed by functionalities over the whole service life, facilitates integrated innovation processes. The range of an integrated view on innovation processes can be illustrated for multifunctional buildings.[3] On the one hand, these buildings show the highest energy efficiency and thus most advanced building materials; on the other hand, they are integrated in the energy system by providing and storing electricity and heat. The example of multifunctional buildings reveals that current sectoral boundaries in innovation strategies might miss these opportunities for innovation.

2 See also World Economic Forum: Shaping the future of construction. A breakthrough in mindset and technology, May 2016.

3 S. Schleicher, A. Köppl, M. Sommer, S. Lienin, M. Treberspurg, D. Österreicher, R. Grünner, R. Lang, M. Mühlberger, K.W. Steininger, C. Hofer: Welche Zukunft für Energie und Klima? Folgenabschätzungen für Energie- und Klimastrategien – Zusammenfassende Projektaussagen, Vienna 2018.

Figure 3
From incremental to radical innovation



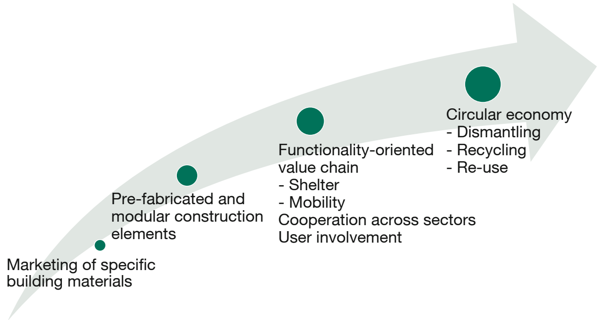
Source: Authors' illustration.

Functionality-oriented supply chains

An integrated innovation process as described above facilitates a re-orientation from product-oriented to functionality-oriented value chains. This results in a higher range of innovation options than in product-oriented value chains. Furthermore, new opportunities for revenues and business models may be the result of more integrated processes. The construction materials and construction industry have a broad impact over long time periods. The corresponding cluster highlights the importance of taking account of stock flow interactions over the whole operating period of the built infrastructure: construction materials used in the construction phase determine – to a large extent – the operating costs, the demand for energy and the amount of greenhouse gas emissions over the entire service life. Options for synergies between sub-sectors of the industry cluster may result from the functionality-oriented value chains. These synergies may be coupled with new revenue options like innovative concrete constructions that depict new material characteristics with less cement input. Thermo active building systems illustrate synergies across conventional sector boundaries providing for heating and air conditioning during the operating phase. A circular-oriented perspective of supply chains (illustrated in Figure 4) includes the phase after the service life of the built infrastructure.

Pre-fabricated construction elements could, for example, boost refurbishment of the European building stock ac-

Figure 4
From product-oriented to functionality-oriented value chains including circular economy aspects



Source: Authors' illustration.

cording to research results,[4] especially through cost and time savings. Integrating energy components in prefabricated construction elements as well as thermo active building systems in refurbishment and new construction adds to the functionality-oriented approach as proposed here.

Implications for implementing climate policies

This deepened understanding of energy systems that considers not only synergies by integrating all elements of an energy system (level 3 policies) but also the role of materials (level 4 policies) has major implications for the upcoming redesign of EU climate policies.

First, climate policies need to be intimately linked to all industrial policies that focus particularly on energy intensive industries like steel, cement, basic chemicals and aluminium. Process innovation, such as considering green hydrogen, or product innovation, such as using less clinker for cement, are important, but the full supply chain for functionalities also needs to be given much more attention.

Second, the concept of a circular economy is being acknowledged as the key driver for a radical reduction in materials related emissions. Steel and aluminium already rely to a large extent on recycled materials. Next steps might involve capturing carbon from steel production that is used for producing high-grade polymers.

Third, we need to reconsider the conventional sector targets for climate policy. Just imposing reduction paths on emission-intensive industries, as is currently done in the EU Emissions Trading System, might even be counterproductive both in terms of reductions achieved and the related costs.

Thus, our hitherto experience with materials in the transition to low-emissions structures point to a systemic approach that considers the full value chain for providing the relevant functionalities. This requires a substantial shift from current practices, in particular, in the business models. Further discussions and adequate governance procedures are necessary to produce policy incentive adjustments.

4 See, e.g. Buildings Performance Institute Europe: Innovation brief – Deep renovation using prefabricated components, September 2019, available at http://bpie.eu/publication/innovation-brief-deep-renovation-using-prefabricated-components/.