SUSTAINABLE SYSTEMS

Fields of Expertise TU Graz

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Urs Leonhard Hirschberg, Sustainable Systems

Source: Lunghammer – TU Graz

In the 18th round of the initial funding program, a total of four proposals were submitted in the Sustainable Systems category. Usually, our field of expertise receives many more proposals than we can fund, but this time we were happy to be able to fund them all.

Eva Sollgruber from the Institute of Building Typologies proposes a Sustainable refurbishment Assessment Tool (SAT), an FFG BRIDGE project to develop a method to assess the potential for refurbishment of postwar architecture. Buildings from this era tend not to have the best reputation, and because they are also not easily adapted to fulfill today's standards, they are often demolished without much further thought. Given how much there is to gain in terms of sustainability if we preserve more of our existing building stock, the research aims to change this practice by developing a holistic evaluation method in cooperation with the Institute of Design in Existing Structures and Architectural Heritage Preservation and the Sustainable Building Group of TU Graz as well as BIG (Bundesimmobiliengesellschaft).

Dirk Schlicke, newly appointed head of the Institute of Structural Concrete, proposes CrackInvest, an FWF project that promises to gain a deeper understanding of the conditions that lead concrete to crack. While the building industry is currently called upon to reduce the amount of concrete it uses to reduce its carbon footprint, it is equally timely to make the structures we continue to build with this material even more durable. That's where this research, which builds on extensive expertise of the institute and will use distributed fiberoptical measurements along reinforcements in its analysis, promises to make a contribution. The institute partners with the Laboratory for Structural Engineering (LKI) and Institute of Engineering Geodesy and Measurement Systems (IGMS).

Thomas Rumpf from the Institute of Structural Design applied for the funding with an ambitious Horizon Europe project, which in fact builds on work he developed in his master thesis. The project is titled Non-planar functional formwork systems for floor slabs in lightweight reinforced concrete. With a large consortium, which includes five TU Graz Institutes as well as partners from industry, the project proposes to significantly reduce the amount of concrete used in standard construction by way of a novel flat vaulting system. The research builds on significant expertise at the institute including a track-record of built projects that successfully demonstrate the reduction of concrete in standard construction.

Radostina Radulova-Stahmer from the Institute of Urbanism received funding to apply for an FFG/EU project that develops New Work Spaces (NWS) in urban peripheral zones as a way to reduce commuter traffic and carbon emissions. The project is part of a larger European project consortium with university partners in Brussels and Kent as well as international industry partners. The idea of the 15-minute city, the concentration of uses that allows people from the periphery to reach all of their daily necessities within 15 minutes, is meant to counteract many of the tendencies that are currently leading to a downturn at the outskirts of cities as well as a high dependency on the automobile.

We wish all successful applicants the best of luck with their proposals and hope that the resulting projects can one day be presented on these pages.

Matthias Landgraf

Sustainable Railway Infrastructure

In our research, we focus on environmental impacts of production, provision and maintenance of railway infrastructure by using the methodology of life cycle assessment (LCA). The goal is to identify main drivers for environmental impacts in order to enhance mitigation and implementation of circular economy. Moreover, we implement these findings within the planning and public procurement processes in the railway system.

Mitigating environmental impacts is one of the main challenges faced by society. In past decades, the regulatory focus in regards to mobility was largely on tailpipe emissions only, and neglected the environmental impacts of manufacturing, construction, maintenance and disposal of the infrastructure components as well as the vehicles[1]. Hence, we focus on environmental impacts of production, provision and maintenance of railway infrastructure by using the methodology of life cycle assessment (LCA).

Our calculation of network-wide environmental impacts is the first which is specific to local conditions and representative of the entire railway network[2]. Previous studies have referred to railway track with a generic service life while neglecting a variation in maintenance demands and service lives due to different boundary conditions such as alignment, types of components and traffic load. Carrying out a top-down approach for the whole railway infrastructure shows that track is the main contributor of greenhouse gas emissions and energy demand within the Austrian network (Figure 1). There is a high potential of implementing innovations as there is a continuous renewal rate of around 3% of Austria's track network length each year. This means any innovation can be implemented promptly whereas construction of tunnels is carried out less frequently. >

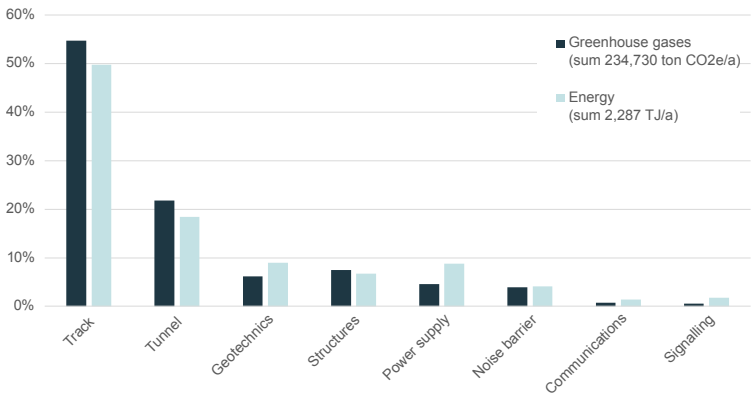

Figure 1: Contribution to energy demand and GHG emissions of relevant railway infrastructure component production and construction in the Austrian network (cradle-to-gate emissions per year from network-wide top-down approach).

Source: Matthias Landgraf

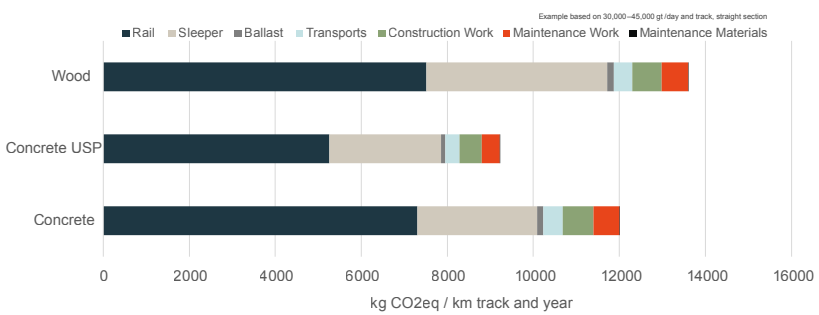

Figure 2: GHG emissions per km of track and year for straight sections, traffic load between 30,000–45,000 gt/day and track.

Source: Matthias Landgraf

1 Chester M V, Horvath A. Environmental assessment of passenger transportation should include infrastructure and supply chains. Environ Res Lett. 2009;4(2):24008.

2 Landgraf M., Horvath A. Embodied greenhouse gas assessment of railway infrastructure: the case of Austria Environmental Research: Infrastructure and Sustainability, IOP Publishing, 2021, https://doi.org/10.1088/2634-4505/ac1242

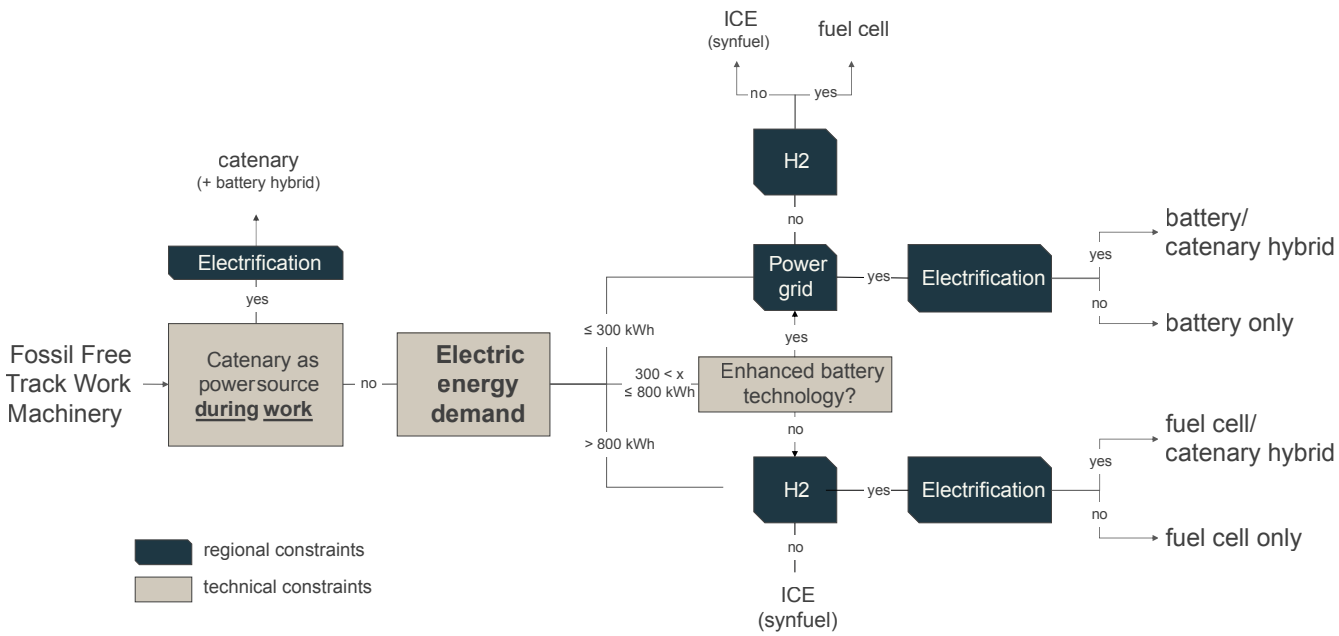

Figure 3: Decision tree for future fossil-free track work machinery.

Source: Matthias Landgraf

The sum of annual cradle-to-gate emissions (based on infrastructure network, asset distribution, and renewal rates of 2015-2019) of railway infrastructure amounts to 234,730 tonnes CO2eq. In 2018, greenhouse gas emissions for passenger operations amounted to 165,600 tonnes CO2eq[3,4]. Thus, for Austrian boundary conditions, railway infrastructure contributes an additional 141% of GHG emissions over emissions associated with passenger operations. This underlines the necessity to include embodied carbon emissions of infrastructure for long-term decision making in regards to sustainability goals.

An in-depth bottom-up approach is carried out for the main contributor of GHG emissions within the Austrian railway network – railway track. For a straight track with a medium traffic density, wooden sleepers show the highest GHG emissions per km track and year (Figure 2). This is mainly caused by the sleeper preservation process in manufacturing, lower service life and a lower potential for reuse compared to concrete sleepers. The lowest GHG emissions per km track and year derive from concrete sleepers with under-sleeper pads. The material of under-sleeper pads causes higher emissions in the production process, but can be easily balanced out due to a significantly higher service life of railway track compared to conventional concrete sleepers.

A relevant potential for mitigation is the track (re-)construction and maintenance process itself. Studies carried out with

3 Austrian Environmental Agency. Austrian Emission factors for transport [Internet]. Vienna; 2019. Available from: https://www.umweltbundesamt.at/umweltsituation/verkehr/verkehrsdaten/emissionsfaktoren_verkehrsmittel/

4 Austrian Federal Railways. OeBB Facts & Figures 2019 [Internet]. Vienna; 2019. Available from: https://presse.oebb.at/en/publications

5 Zeiner M, Landgraf M, Knabl D, Antony B, Barrena Cardenas V, Koczwara C. Assessment and Recommendations for a Fossil Free Future for Track Work Machinery. Sustainability, mdpi Publishing, 2021, https://doi.org/10.3390/su132011444

6 Landgraf M, Zeiner M, Knabl D, Corman F. Environmental impacts and associated costs of railway turnouts based on Austrian data. Transp Res Part D Transp Environ. 2022, Feb 103:103168., Elsevier https://doi.org/10.1016/j.trd.2021.103168

the Austrian Federal Railway, the German Federal Railway Authority and manufacturer Plasser & Theurer focus on track work vehicles and their potential for fossil-free operation in the mid- and long-term future[5]. At the moment, single machine groups burn up to 1000 litres of fossil fuel per 1 km of track renewal. This is the reason why we analysed machines based on their electrical energy demand per working shift. Then, we formulated migration strategies on the path to fossil-free track work following the basic concepts of the established decision tree in Figure 3.

In general, main potentials for mitigation of environmental impacts within railway infrastructure can be identified in steel production, circular economy, use of alternative propulsion systems for heavy maintenance machinery and transport as well as prolongation of service life components and materials by innovative technology. A major point for future research is also the harmonization of environmental pricing schemes[6]. Quantification, monetization and inclusion of environmental impacts within the procurement process may help suppliers to justify investments in environmentally efficient production processes and services.

Matthias Landgraf

is a private lecturer at TU Graz as well as CEO and founder of evias. From 2011 to 2023, he was responsible for project lead, research and teaching at TU Graz's Institute of Railway Engineering and Transport Economics. In 2016, he received his doctorate in the field of condition monitoring of railway infrastructure. He established the research area of Environmental Aspects in the Railway System and after research stays at UC Berkeley (California, US) and ETH Zurich (Switzerland, CH), he completed his habilitation (venia docendi) at TU Graz in 2022.

Source: Sabine Hoffmann