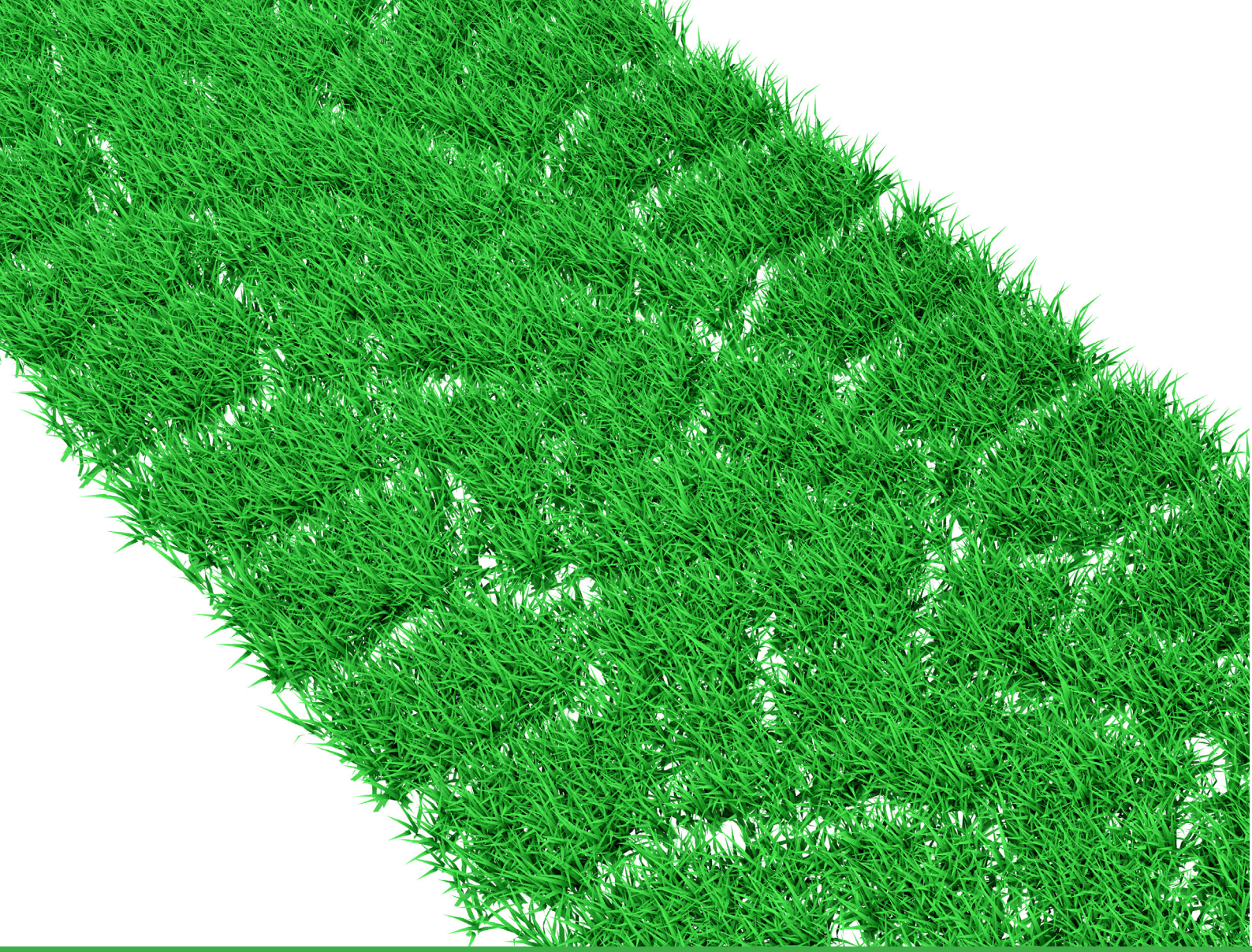

Greening of Infrastructure Assets

vol. 23 I n°1 I 2021

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networkindustries
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Network Industries Quarterly, Vol. 23, issue 1, 2021 (March)

"Greening of Infrastructure Assets"

This special issue of Network Industries Quarterly is dedicated to the greening of infrastructure assets. Despite the unprecedented challenges brought about by the COVID-19 pandemic, the European Commission has reaffirmed its commitment to the objectives of the European Green Deal and to transforming Europe into the first climate neutral continent by 2050. Delivering this ambition will necessitate the revision of regulatory and taxation frameworks, as well as the deployment of clean and innovative technologies. These, in turn, will have to be supported by massive public investments and increased efforts to direct private capital towards climate and environmental action while avoiding lock-in into unsustainable practices and infrastructures. Though the specific approaches to 'greening' of infrastructure assets may vary across the network industries, a set of questions pertaining to technology, regulation and funding will have to be addressed in all of them.

In this issue of the Network Industries Quarterly, our invited contributing authors critically examine these questions by drawing on the specific challenges and opportunities faced by the transport sector, as illustrated by the specific cases of airports, railways and ports.

The first contribution by **Serafimova** frames the renewed interest in infrastructure spending in the aftermath of COVID-19 as an opportunity to accelerate Europe's transition towards climate neutrality. Taking a broader perspective on transport infrastructure assets, this article illustrates the multiple angles greening can take throughout the different, though interrelated, phases of an infrastructure's lifespan, from planning to construction, operation and decommissioning. The article argues that the ability of infrastructures to serve as enablers for wider sectoral, but also cross-sectoral, greening, can and should be amplified by means of a conducive and coherent EU regulatory, financing and taxation framework, which engrains sustainability at its core.

Schneider demonstrates the importance of infrastructures in the fight against climate change by taking a closer look at the concrete case of airports. In particular, he argues that the impact of infrastructures does not limit itself to infrastructures' own operations but extends to their capacity to influence and shape their users' behaviours.

Quinet shares his analysis on the greening of trains and railway infrastructure assets in view of their enormous associated societal benefits. This article underlines, in particular, the need for infrastructure managers to follow a progressive approach, whereby actions are to be deployed over time in the most cost-effective way, depending on the portfolio of clean technologies available and the life cycle of assets.

Birindelli, **Radice**, **Bert** and **Guglielmi** reflect on the Italian experience in shifting towards intermodal hubs as a means to green railway stations. Drawing on experiences from Italy, where major railway stations are currently undergoing a profound transformation, this article illustrates that stations are no longer single-purpose places where trains stop to load or unload passengers but are increasingly becoming complex people-centred hubs where visitors can do much more than merely catching a train.

Sauri, **Sys** and **Vanelslander** discuss the greening of maritime shipping and ports, which are critical gateways for the European economy and global trade but also important contributors to air emissions. Their article argues that while legislation is available at various policy levels, more solutions are needed that are in a further stage of development, taking into account also the economics of the various involved actors.

Matthias Finger

Teodora Serafimova

dossier

Network Industries Quarterly | Published four times a year, contains information about postal, telecommunications, energy, water, transportation and network industries in general. It provides original analysis, information and opinions on current issues. Opinions are the sole responsibility of the author(s).

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Greening Transport Infrastructure: The Role of EU Regulation, Financing and Taxation

Teodora Serafimova*

The renewed interest in infrastructure spending as a means to foster job creation and economic recovery in the aftermath of COVID-19 presents a unique opportunity to accelerate Europe's transition towards climate neutrality. As both contributors to climate change and victims of its consequences, transport infrastructure assets are an illustrative example of the multiple angles greening can take throughout the different phases of an infrastructure's lifespan, from planning to construction, operation and decommissioning. The highly interdependent nature of these phases underscores the need for a holistic approach to greening of infrastructures. This article examines, in particular, the ability of infrastructures to serve as enablers for wider sectoral, but also cross-sectoral, greening, and argues that this function can and should be amplified by means of a conducive and coherent EU regulatory, financing and taxation framework, which engrains sustainability at its core.

Confronting the dual challenges of decarbonisation and economic recovery post-COVID-19

The free movement of people and goods across national borders is a fundamental freedom of the European Union (EU) and its single market. The transport sector contributes 5% to the European Gross Domestic Product (GDP) and directly employs around 10 million workers, making it decisive for economic development, as well as for the social well-being and cohesion of populations (European Commission, 2020). However, reaping these benefits depends on the existence of adequate infrastructure, which supports the provision of high quality and efficient transport services. Already back in 2011, the European Commission's Roadmap to a Single European Transport Area – Towards a competitive and resource-efficient transport system acknowledged that '*Infrastructure shapes mobility. No major change in transport will be possible without the support of an adequate network and more intelligence in using it. Overall, transport infrastructure investments have a positive impact on economic growth, create wealth and jobs, and enhance trade, geographical accessibility and the mobility of people. It has to be planned in a way that maximises positive impact on economic growth and minimises negative impact on the environment*'.

More recently, the European Green Deal set the ambition of transforming Europe into the world's first climate neutral continent by 2050: a commitment, which places a particular responsibility on the transport sector and the infrastructures it relies on. A collective 90% reduction in CO_2 emissions will need to be achieved by mid-century from the transport sector, which today accounts for a quarter of the EU's total greenhouse gas (GHG) emissions. The Commission's subsequent Sustainable and Smart Mobility Strategy reiterates that '*greening mobility must be the new license for the transport sector to grow*' (European Commission, 2020).

In parallel to facing growing pressures to decarbonise, the transport sector and its underlying infrastructure assets have undoubtedly been among the worst hit by the COVID-19 pandemic. Because of the crisis, significant public funds have been channelled towards struggling businesses, such as public transport operators, hit by persisting drops in ridership. While this has meant that less funding is available for spending on new projects, the pandemic recovery measures proposed by governments worldwide, have been characterised by a renewed interest in infrastructure spending as a means to boost economic growth. For instance, whereas US president, Joe Biden, has pledged to spend $2 trillion on roads, electricity grids and railways, the EU has announced that 30% of its €750 billion recovery fund will be dedicated to green projects, including renewable energy and electric vehicle recharging infrastructure. In fact, spending on climate-resilient infrastructure is found to create five times more jobs per $1 million invested than spending on fossil fuels (UNEP, 2021). The greening of infrastructure assets is thus not only a strategic post-COVID-19 recovery measure, but also presents a unique opportunity for governments to accelerate the transition towards climate neutrality.

Transport infrastructure and its tight link to the environment

Transport infrastructure, be it publicly or privately owned, consists of the physical structures, such as highways, railways, bridges, tunnels, airports and ports, among others, which enable the provision of transport services, vital to facilitating, sustaining, or improving the

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social condition of living (Hossain, 2019). In addition, infrastructure can encompass the facilities necessary for the propulsion and refuelling of transport vehicles, as well as the coordination, monitoring and management of transport to ensure safe operations and the transfer of passengers and freight (European Commission, 2017). In other words, transport infrastructure is an integral part of the overall transport system, regardless of the transport mode in question.

The construction of new infrastructure, the upgrading of existing but also the eventual decommissioning of infrastructure, entail significant investment, often rely on the use of carbon-intensive materials, and lead to negative impacts on the environment, such as health-damaging air- and noise pollution, the release of CO_2 emissions, the generation of waste, as well as damage to local wildlife habitats and water bodies. While the distinction between the GHG emissions attributable to the different phases of an infrastructure's lifetime may not always be straightforward, it should be noted that the vast majority of emissions arise from the operation of the infrastructure, i.e., emissions stemming from vehicles using the infrastructure in question (European Commission, 2017).

At the same time, their fixed nature makes infrastructures particularly prone to the consequences of climate change. To recall, the Intergovernmental Panel on Climate Change (IPCC) estimates that if GHG emissions continue on a business-as-usual trajectory, global sea-levels could rise by one meter by the end of this century (IPCC, 2019). This, in turn, could entail particularly high risks for airports, many of which are located near large bodies of water. In fact, according to the World Resources Institute, 80 airports worldwide could be underwater if current emission trends continue. It goes without saying that such a scenario would have detrimental socio-economic and connectivity implications. The environmental and climatic impacts of infrastructures, coupled with their particular vulnerability to the consequences of climate change, underscore the need to incorporate sustainability and resilience throughout the entire lifecycle of transport infrastructures.

The different angles to the greening of transport infrastructure

Those infrastructures, which are conducive towards a zero-emission transport sector will have to be enhanced (e.g., bolstering public transport and micro-mobility infrastructure), while other, polluting infrastructures, will have to be restructured or entirely replaced by new types of infrastructures, which are in line with the net-zero emissions trajectory.

There are multiple angles to the greening of transport infrastructure. Firstly, greening may focus on measures to minimise the emissions embedded in construction and arising from maintenance. This, in turn, may take the form of using less CO_2-intensive, recycled and recyclable materials, boosting the energy efficiency of physical assets, and the installation of photovoltaic (PV) facilities onsite, among others. Subsequently, greening measures can also be applied at the end of an infrastructure's lifespan to ensure that its decommissioning has a minimal impact on the environment. Some ageing infrastructure, such as oil and gas platforms, wells and pipelines, for instance, can be repurposed for CO_2 transport and storage, thereby possibly helping to reduce the hefty upfront costs linked to the development of Carbon Capture and Storage technology. Furthermore, the integration of circular economy principles in the initial design process can later enhance resource recovery during decommissioning. Conversely, poorly designed infrastructure can lead to high long-term maintenance or replacement costs during operation and may have implications for decommissioning (UNEP, 2021). This interdependence between the different life phases of infrastructure assets calls for a holistic approach to their planning, financing and regulation.

What is more, infrastructures can have a much larger, albeit indirect, contribution towards overall emission reductions by inducing their users to shift towards more sustainable modes and practices. While highways, for instance, cannot be considered 'green' infrastructures per se, they can help advance broader decarbonisation objectives if linked to a credible sustainability plan. Carefully designed road charges, for example, can serve as an instrument to stimulate the uptake of zero-emission trucks, and conversely, to discourage polluting ones. Furthermore, highways and core networks can be equipped with electrical charging points to promote the uptake of electric mobility. The ongoing review of the Commission's Alternative Fuels Infrastructure Directive (2014/94/EU) offers a significant opportunity to ramp up the deployment of an interoperable publicly accessible recharging infrastructure, along the trans-European transport network (TEN-T), urban and sub-urban areas, with a view to reaching the targeted 1 million public recharging points by 2025 (European Commission, 2019).

In a similar fashion, airports can provide synergies for the entire aviation value chain, from ground handlers to airlines, suppliers of sustainable aviation fuels (SAFs), and innovative technologies manufacturers. Though indirectly, airports can stimulate the uptake of new aircraft technology related to electrification or hydrogen by securing the appropriate airport infrastructure, associated services, and, not the least, by setting the right incentives. To this end, airports can make use of several instruments at their disposal to incentivise cleaner and quieter aircraft, including airport charges, incentives, operational rules, and slot regulations. Many airports are already modulating the charges paid by airlines based on environmental criteria, for example, by reducing charges for aircraft producing less noise and emitting fewer air pollutants (Finger, Serafimova and Montero, 2021). This ability of infrastructures to serve as 'enablers' for wider sectoral, but also cross-sectoral, greening can and should be amplified through an overarching EU regulatory, financing and taxation framework, which, in turn, is discussed below.

Linking investment decisions to robust sustainability indicators

Their capital-intensive nature, coupled with the long operational lifetimes of transport infrastructure, means that regulatory and investment decisions taken today will have implications for the decades to come. Indeed, the built environment is constrained in how quickly it can change. This is further complicated by the fact that different transport modes and infrastructures have different life spans (Rodrigue, 2020). To put things into perspective, while it could be possible to renew the bulk of the car fleets with more efficient vehicles within a decade, road infrastructure could take as much as a quarter of a century to replace (Rodrigue, 2020). In the spending-cautious aftermath of COVID-19, this places a particular responsibility on investors and infrastructure planners to ensure their decisions not only improve the quality and resilience of the transport system, but also help to advance the EU's climate and sustainability objectives.

All new infrastructure construction, expansion and decommissioning will have to be clearly justified and preceded by comprehensive environmental impact assessments. The planning phase for new infrastructure has till now primarily focused on the emissions stemming from the initial construction phase, whereas the lifecycle GHG emissions, including those arising from operations, maintenance and subsequent decommissioning of infrastructure, have not been consistently factored in (European Commission, 2017). The inclusion of lifecycle emissions is key to securing the most accurate assessment of infrastructure projects' environmental performance. Here, it is also essential to distinguish between short- and long-term considerations pertaining to infrastructure-related investments. In other words, whereas infrastructure construction projects can be particularly emission-intensive in the short run, they can deliver substantial emission reductions in the long run. One illustrative example of this is high-speed rail, which is likely to grow in significance as the aviation sector undergoes restructuring and short-haul flights are increasingly replaced by rail. Under most circumstances, investment in high-speed rail reduces GHG emissions from traffic compared to a situation where the line was not built, but the reduction may initially be small, and it could take decades for it to compensate for the emissions caused by construction.

In view of this, the definition of common international rules for assessing the environmental performance of infrastructure projects is of crucial importance in guiding scarce financial resources towards 'green investments' and, equally important, in preventing 'stranded assets'. A first step in this regard was already taken in the EU, with the entry into force of Regulation (EU) 2020/852 (the so-called 'Taxonomy Regulation'), which seeks to provide uniform criteria for companies and investors to determine whether an economic activity is to be deemed 'environmentally sustainable'. The Taxonomy covers activities responsible for up to 80% of the EU's GHG emissions. As such, it may play an important role by setting performance thresholds for these activities, thereby informing investors' decisions and preventing greenwashing (Schuetze and Stede, 2020).

Having said that, it is of utmost importance that a robust and science-based approach is applied in establishing the criteria, which the Commission is set to finalise in the coming months. This, in turn, will be instrumental in determining whether pending EU and national fiscal recovery packages foster the development of a more integrated, smarter and sustainable mobility system. A number of existing EU funding programmes, such as the Connecting Europe Facility (CEF) and the Cohesion Funds, including the European Regional Development Fund, already support the construction of transport infrastructure between and within EU countries. It is equally critical that this public funding supports the development of climate-proof infrastructure projects.

Local authorities, in particular, are central investors in green infrastructure, such as buildings, transport, water and waste. While private sector investment and technical expertise will be increasingly needed to close the infrastructure gap, public policy and procurement of infrastructure, have a key role in channelling investment into sustainable infrastructure projects and creating positive impacts on the ground. Today's procurement practices and tender specifications, however, do not always provide the necessary incentives for industry actors to invest in zero-emission technologies and infrastructures. The recast of EU regulatory frameworks to introduce minimal environmental standards will be key. More specifically, the shift away from procurement practices which prioritise the lowest-cost bid will be needed towards ones that consider life-cycle costing, including the costs of environmental emissions and other externalities over the entire infrastructure lifecycle. Furthermore, the Commission's ongoing efforts to develop a common EU framework for sustainable urban mobility indicators (SUMI), stands to not only enable cities to better evaluate the performance of their mobility systems, benchmark and replicate best practices, but also ensure that funding is channelled towards sustainable mobility projects.

Getting users and polluters to pay the true environmental cost

The cost of providing transport infrastructure is paid either directly through user charges or indirectly through taxation. In closed systems, namely railways and aviation, transport users pay for the use of infrastructure as a part of their overall transport charge (e.g., ticket price). For open systems, such as road, on the other hand, there is either no direct infrastructure charge or the infrastructure charge is levied directly to the user in the form of a toll.

There is a long-standing agreement that transport charges and taxes must be restructured so as to ensure the implementation of the 'polluter-pays' and 'user-pays' principles. The Commission's recent Sustainable and Smart Mobility Strategy sets out that all external costs of transport within the EU shall be covered by the transport users at the latest by 2050. The provision of cost-reflective price signals is considered the most effective incentive mechanism to influence more sustainable transport user choices. Such incentives can include carbon pricing, taxation, and infrastructure charging but should be complemented by improved information to users (European Commission, 2020). Pricing can facilitate the switch to cleaner vehicles, optimise capacity utilisation, and manage demand, thereby reducing congestion during peak hours. Adequately designed infrastructure charging (e.g., road tolls) can foster the creation of a level playing field between the different modes and fuels while generating a source of revenue for the public budget for the cross-financing of railways and other green infrastructures.

Notwithstanding, infrastructure charging, financing and taxation frameworks in the EU today fall short of promoting decarbonisation. While best practices can be observed, infrastructure charging approaches are not homogeneous across modes or countries, whereas some European countries are not imposing any road charges at all (European Commission, 2017). The ongoing revision of the Eurovignette Directive (1999/62/EC) is an opportunity to address this by putting in place a uniform approach to road charging Europe-wide. Smart, distance-based road charging, with varied rates for the type of vehicle (based on CO_2 performance, air pollutants) and the time-of-use, can effectively incentivise efficient choices, manage traffic and reduce congestion (European Commission, 2020).

While green infrastructure projects may be linked to lower operational costs, they often entail higher upfront costs, which, in turn, raises questions pertaining to how these additional costs of greening should be financed. The concept of charging for environmental purposes can be unpopular, and social acceptability issues can risk hampering fiscal reforms in the road sector for instance, as these oftentimes result in a disproportionate burden for the working and middle classes. The introduction of charges will thus have to be preceded by careful planning and design, complemented by awareness-raising campaigns among taxpayers as well as measures to enhance transparency and accountability in revenue use.

Cross-sectoral policy coherence

The design and implementation of coherent, cross-sectoral policies can enable infrastructures to stir the greening beyond their own sector. One illustrative example of such cross-sectoral greening is the installation of electric charging infrastructure in buildings, which entails close interactions between several sectors, namely transport, buildings and energy. The latest revision of the Energy Performance of Buildings Directive (2018/844/EU) introduced new provisions to ensure that parking spaces in residential and commercial buildings are progressive-

ly equipped with recharging points for electric vehicles. This stands to offer synergies for the progressive greening of all three sectors by encouraging the uptake of cleaner mobility, optimising energy efficiency in buildings, and reinforcing electricity grids.

Transport infrastructure and energy networks have historically been designed independently yet are wholly interdependent for many years of subsequent operation. Sector coupling is increasingly observed both within sectors (e.g., Mobility-as-a-Service) as well as across sectors (e.g., the coupling of transport and energy with the growing penetration of electricity and hydrogen-based powertrains). These trends bring about additional challenges related to regulatory approaches and regulatory bodies and call for the enactment of appropriate incentive schemes, be these financial or reputational, so as to ensure that infrastructure is designed in a way that allows it to interact synergistically with its environment. In particular, within the transport sector, improvements in inter-modality, interoperability, and integration of transport systems would facilitate the greening of the transport by favouring a shift to the most appropriate mode, reducing congestion, and improving efficiency and coordination in the use of the infrastructure.

One key challenge to the greening of infrastructures will be to ensure a systemic approach and coherence across the different EU legislative pieces, from the EU taxonomy and State aid guidelines to ongoing efforts to internalise the external costs of transport and implement effective charging for infrastructure use, among many others. The future regulatory framework needs to reflect the fact that transport infrastructures are complex systems of interrelated facilities and assets, which, in turn, has important implications for the assessment and regulation of their sustainability performance.

Digitalisation can provide a means to better coordinate these increasingly complex and interrelated systems, and as such facilitate sector coupling. Importantly, digital tools in transport can enable more flexibility and better operational practices thereby optimising the utilisation of existing capacity. For example, smart mobility systems which make efficient use of data on mobility patterns and integrate multiple transport options, including both individual mobility and mass transit, can help to improve network management, traffic congestion, accessibility and environmental performance. This, in turn, can also help to reduce investment needs into new physical infrastructure and support infrastructure greening objectives.

Conclusions

The greening of transport infrastructures can strengthen systems' resilience to climate change and support the transition to a low carbon economy, while also stimulating economic growth. In view of this, the increased appetite for infrastructure spending in the aftermath of COVID-19 presents a strategic opportunity for policymakers and investors to accelerate Europe's transition towards climate neutrality.

A range of greening measures can be applied throughout the typically long lifetimes of infrastructure assets, including the reduction of emissions embedded in construction and maintenance, those stemming from infrastructures' operations, but also at the end phase of infrastructures' lifespan, when they are undergoing decommissioning. Though possibly decades apart, the different phases – design, construction, operation and decommissioning – are highly interdependent and thus need to be regulated holistically.

Infrastructures can play a pivotal role in overall emission reductions by supporting their users as well as other operational stakeholders along the value chain in their greening efforts. This ability of infrastructures to serve as 'enablers' for wider sectoral, but also cross-sectoral, greening needs to be amplified by means of a conducive EU regulatory, financing and taxation framework, which engrains sustainability throughout the entire lifecycles of infrastructures.

All new infrastructure construction, expansion and decommissioning will have to be preceded by comprehensive environmental impact assessments, which take into account lifecycle GHG emissions. To this end, the development and coherent application of common science-based rules for the measurement and assessment of infrastructures' environmental performance will be paramount in stirring investments towards climate-neutrality compliant projects. In line with this, cost-reflective pricing and charging will be key to informing both investor and consumer decisions. Transport charges and taxes will have to be restructured so as to ensure the internalisation of external costs in a socially just manner. Last but not least, all of these policies and regulations will have to be implemented in a coherent manner, which reflects the growing coupling within and between sectors, and allows for mutually-reinforcing greening efforts.

References

European Commission (2020), *Recovery Plan for Europe*, https://ec.europa.eu/info/strategy/recovery-plan-europe_en; accessed on 8 February 2020

European Commission (2019), *The European Green Deal*, 2019 (Brussels: European Commission)

European Commission, Research & Innovation (2017), *Transport Infrastructure Expert Group Report*, 2017 (Brussels: European Commission)

European Commission (2020), *Sustainable and Smart Mobility Strategy – putting European transport on track for the future*, 2020 (Brussels: European Commission)

Finger, M., Serafimova, T., and J. J. Montero-Pascual, (2021), *The role of airports in the European Green Deal*, Policy Briefs, 2021/02, Florence School of Regulation, Transport, Retrieved from Cadmus, European University Institute Research Repository

Intergovernmental Panel on Climate Change (2019), *Summary for Policymakers*, https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/03_SROCC_SPM_FINAL.pdf

Md. Faruque Hossain, *Chapter Seven - Best Management Practices in Sustainable Design and Build: Building, Energy, Roads, Bridges, Water and Sewer* (2019); Pages 419-431

OECD, *Green Growth and Transport*; http://www.oecd.org/greengrowth/greening-transport/greengrowthandtransport.htm; accessed on 12 February 2021

Rodrigue, J. P. (2020), 'The Lifespan of Main Transport Assets' in *The Geography of Transport Systems* (New York: Routledge) The Geography of Transport Systems, The lifespan of Main Transport Assets

Rodrigue, J. P. (2020), 'Transportation, Sustainability and Decarbonization' in *The Geography of Transport Systems* (New York: Routledge)

Schuetze, F. and Stede, J., (2020), '*EU Sustainable Finance Taxonomy – What Is Its Role on the Road towards Climate Neutrality*?', DIW Berlin Discussion Paper No. 1923

United Nations Environment Programme (2021), *International Good Practice Principles for Sustainable Infrastructure. Integrated*, Systems-Level Approaches for Policymakers. Nairobi

World Resources Institute (2020), Resource Watch Blog; https://github.com/resource-watch/blog-analysis/tree/master/blog_021_airports_affected_by_sea_level_rise/Final%20Results; accessed on 8 February 2021

Greening Infrastructures: Airports' Role and Responsibility

André Schneider*

This paper demonstrates the importance of infrastructures, and more specifically, airports, in the fight against climate change. The impact of infrastructures does not limit itself to their own operations, but also to their capacity to influence and shape the behaviours of their users.

Introduction and context

Achieving our goals in the fight against climate change is important and the need for action becomes more and more pressing, especially when we see how difficult it is to keep up with our commitments made under the Paris Agreement. Infrastructures play a crucial role in this challenge, as they often influence and shape our behaviours and hence can have an important impact on the reduction of greenhouse gas emissions. Examples of infrastructures that will shape our future behaviours and which are capable of reducing greenhouse gas emissions are infrastructures for mobility, energy-producing infrastructures, but also buildings, among many others. However, we should not forget in our fight against climate change that also other environmental impacts have to be looked at like noise and biodiversity. Furthermore, we should keep in mind the social impact of such measures and, notably, how we can avoid increasing social imbalance through our changes to make our society less impactful on the climate. In conclusion, it will be very important that, through our actions, we secure a good balance between all aspects of sustainable development, namely between the social, environmental and economic impacts.

Nevertheless, infrastructures and their operators can and must play a major role in reducing greenhouse gas and other emissions. Infrastructures can play a role in three dimensions:

1. By reducing greenhouse gas emissions related to the infrastructures and their operations;

2. By inciting and assisting greenhouse gas reduction in the use of the infrastructure;

3. Finally, by reducing greenhouse gas emissions by influencing the behaviours of their users by inducing a greenhouse gas reducing use of the infrastructure.

Before further laying out how airports can play a crucial role that can be played by infrastructures, let me give another example, energy production infrastructures. In this specific case, the first dimension would be to ensure already in the building process a reduction of greenhouse gas emissions and also to use energy production methods that reduce as much as possible the emission of greenhouse gases (for example by producing energy either using solar or wind energy sources instead of fossil energy sources). For the second dimension, this will be achieved by assuring a competitive offering of lower greenhouse gas emission energy and by assuring and supporting the societal understanding of the importance to prioritise this energy over fossil energy. Finally, the third dimension could be achieved by launching an energy efficiency programme that supports and assists the consumers of the energy provided by this infrastructure to use it more efficiently and hence reduce its impact on the environment by using less energy. As demonstrated through this simple example, this is nothing new nor untested, but we need to replicate these three dimensions with all infrastructures and their operators.

Hence, it is important to understand and recognise that infrastructures and their operators must and will play a major role in our endeavour to reduce greenhouse gas emissions and that we need to plan, develop and operate all these infrastructures in this spirit. This simply implies that infrastructures are not only here to offer their service, but they need to take a role of leadership to not only reduce greenhouse gas emissions in their own operations but also shape how they get used and the behaviour of their users. Otherwise, it will become extremely difficult to meet our binding goals in reducing greenhouse gas emissions to mitigate the impact of climate change and subsequently, safeguard the possibility to live in a sustainable way on our earth for the generations to come.

Greening infrastructures – airports' role and responsibility

Now let us apply these principles to an airport and illustrate with the example of Geneva Airport how this could be implemented and what results can be achieved. In a

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first part, we will describe the actions Geneva Airport has taken to reduce its greenhouse gas emissions in its direct operations, whereas in the second part we will look at how Geneva Airport incentivises airlines to contribute to the reduction of greenhouse gas emissions.

Reducing greenhouse gas emissions in the airports' operations

Geneva Airport has started over the past decades a global programme to reduce its environmental impact, which includes noise as well as CO_2 emissions. This programme will culminate in a CO_2 net-zero objective before 2050 and return to the noise impact levels of 2000 by 2030 at the latest. The programme is composed of the following elements:

1. **Buildings' energy efficiency**: Since 2016, Geneva Airport is only constructing new buildings that generate more energy than they consume; examples are our noise absorber and our new east wing for intercontinental flights.

2. **Energy consumption**: We will prioritise the energy use for essential needs; we will continuously increase our energy efficiency; and we will move towards the use of renewable energy. These efforts have enabled us to reduce our energy consumption by 26.4% compared to 2006. We will achieve 100% renewable energy consumption for our infrastructures by 2026 by using geothermal energy, by replacing all our heating and cooling by heat pumps using water from the lake located nearby, and by buying 5GWh per year of solar energy. Furthermore, we will be generating solar energy at the airport covering an overall surface of 55'000 square meters.

3. **Mobility airside**: We are upgrading our fossil energy-based buses for passengers by equipping them with electric motorisation (10 buses today with an addition of two more electrified buses per year). We are also targeting to replace the airside vehicles with electrically motorised ones (currently 29% of them are either electric or hybrid). We are also participating in the investments of our partners to support them in doing the same. As an illustration, today one of our ground handlers has electrified 50% of their vehicles.

4. **Mobility**: We are also promoting the use of sustainable mobility to reach the airport, and currently over 50% of our passengers come by sustainable mobility, whereas we target 45% of our employees to do so. In order to achieve these targets we are offering buses for passengers and employees for late night and early morning hours, where there is no public transport. Furthermore, we are offering each arriving passenger a free ticket for a journey with the public transport system of Geneva.

5. **Energy support for airplanes**: We have introduced direct availability of electricity on an important number of parking positions to avoid the use of the planes' engines to generate electricity. We are also rolling out heat pumps directly at the parking positions to provide cold and heat to the planes during their turnaround time, again to avoid using the planes' engines to do so.

Furthermore, in preparation of our net-zero emission objective, Geneva Airport is offsetting since 2017 its CO_2 emissions and has this certified by the Airport Carbon Accreditation 3+ certification issued by the Airports Council International (ACI).

Incentivising greenhouse gas emission reductions by the airlines

Currently, there are only four options available to advance the reduction of greenhouse gas emissions by airlines that can be measured and incentivised by airports. These are:

1. Increasing the load factor (% of seats occupied in the plane) of the flights;

2. Using the last generation of planes with CO_2 emission reductions of up to 20%;

3. CO_2 compensation of the airline of their operations; and finally

4. Using Sustainable Aviation Fuel (SAF).

However, we need also to keep in mind that CO_2 emissions are not the only concern for which airports wish to incentivise improved operations by the airlines; we do also have a concern about noise emissions of the planes. Fortunately, the last generation of planes, examples are the Airbus 220 (former Bombardier C series and the Airbus 319, 320 and 321 NEOs for short to medium-haul flights and Boeing 787 and Airbus 350 for long-haul

flights), are not only offering a substantial reduction in noise (up to 40%) but also in fuel consumption and hence also in CO_2 emissions (up to 20%). This fact allows airports to develop incentivising policies that simultaneously address noise and greenhouse gas emissions.

The next question is what are the means an airport has to incentivise any of the above four options? To answer this question we need to better understand the nature and the contractual basis of the relationship between airlines and airports. First, in order to start flying into an airport an airline has to obtain a slot for landing and take-off. The airline will obtain these for level 3 congestion airports, from an independent coordinator. These slots can specify conditions for their availability like type of airplane or passenger capacity available at a certain moment. Then, the airport will define airport charges for the use of the airport infrastructure. These charges have to be negotiated and agreed with the airlines, whereby a direct relationship by costs generated by the use or by the providing of infrastructure will be necessary for the use. These two mechanisms are highly regulated to avoid any undue influencing of the market by airports and hence offer in the current context of regulations only limited opportunities to incentivise the reduction of noise or greenhouse gas emissions. Nevertheless, there are still some opportunities in this framework like in the context of noise taxes, where our system, which is in place since the beginning of 2018, has taxes adapted to the noise level and is hence favouring last generation planes. This has already facilitated the change of noisier and higher emission planes with last generation planes (one example was the replacement of an Airbus 330 by a Boeing 787).

Nevertheless, this situation can be addressed by combining the tax system with its limitations stemming from the regulatory framework, by incentive schemes. At Geneva Airport, we have implemented such schemes to generate incentives with financial returns on the airport taxes based on aspects like use of new airport types or load factors. These incentive schemes have been added to the airport tax proposal at the beginning of our last negotiations. These schemes have been part of the airport tax agreement negotiated with the airlines and the regulator, and have been accepted during the last quarter of 2020. To illustrate this, here is an example of the impact of such an incentive scheme: if an airline increases its movements of last generation aircrafts from 10% to 30%, they can obtain a return of their landing fees as paid according to the tax regulations of 30%. This incentive plan has already generated interest to increase the presence of last generation airplanes in the locally present fleet of one of the airlines operating at the Geneva Airport.

We are also prospectively in discussion to add to these incentive schemes a recognition of airlines offsetting their CO_2 emissions and in the long run the use of SAF.

Finally, airports can also introduce actions to reduce greenhouse gas emissions or noise impact in their operating rules. Geneva Airport did not provide slots for take-offs after 10pm. This is also because 95% of the passengers fly to European destinations, which do not require take-offs after 10pm. But in the context of Geneva Airport's strategy to develop its intercontinental connectivity, we have introduced an allowance for last generation wide-body planes (currently represented by the Airbus 350 and the Boeing 787) for take-off after 10pm. Currently we have already one airline, Ethiopian Airlines, that uses this possibility with its B787 Dreamliner and a departure at 10h45pm.

Finally, we believe that the current slot system should be extended to allow the further limitation of the use of slots to emission-related criteria, like limitations to certain types of planes or permitted emission levels for certain slots, and also to the need to develop more qualitatively the connectivity of an airport. This last point seeks to avoid excessive competition on certain destinations, creating too many movements for one destination with lower load factors and hence increasing again the emissions per passenger.

In conclusion, this paper should have demonstrated how infrastructures, in our case airports, can actually reduce the emissions of their own operations but also facilitate the reduction of emissions by their users and operators. This should further exemplify the importance of the role of infrastructures to contribute in the fight against climate change.

Greening of Railway Infrastructure: Designing a timely and orderly Transition

Alain Quinet*

Greening trains and railway infrastructure assets will provide enormous benefits for society at large. However, Infrastructure Managers need to follow a progressive approach: actions need to be deployed over time in the most cost-effective way, depending on the portfolio of clean technologies available and of the life cycle of assets.

Railways are broadly perceived as the most sustainable form of mass transport for both passengers and freight. Compared to other modes, railways generate low CO_2 emissions and air pollutants, save energy and space, thus reducing the pressure on natural resources, habitat and biodiversity.

When considering external transport costs, a recent EC study shows that overall rail traffic scores better for both passenger and freight transport than road and air traffic. According to the *Handbook on the external costs of transport (EC, 2019a)*, external costs linked to greenhouse gas emissions, local air pollution, noise, habitat damage and biodiversity, as well as the costs of congestion and crashes, sum up in the EU to almost €900 billion annually, or the equivalent of almost 7% of EU GDP. These external costs vary greatly depending on the transport mode: Road transport accounts for 83% of such negative externalities, whereas the contribution of rail is smaller than 2%.

Nonetheless, the environmental impact of railways must still be improved for three different reasons:

- Business: Railways must demonstrate to their passengers and freight clients that they are fully engaged in the decarbonisation of transport;
- Acceptability: Railway systems run through urban areas, providing a wide range of benefits. Nonetheless, noise emerges as a public health and political concern in some Member States and generates substantial opposition to increases in rail freight. Noise emissions, therefore, need to be reduced in order for increased traffic to be accepted by the public, especially for freight and high-speed lines;
- Regulation: Railways must demonstrate that they are committed to complying with more stringent European and national regulations concerning soil, water pollution, vegetation management and protection of habitat and biodiversity and, more generally, to reduce the environmental footprint of works.

In this context, rail infrastructure managers (IMs) can "green" railways by providing a decarbonised and silent infrastructure to railway undertakings (part I), increasing the capacity of their networks (specifically where there is a potential for further modal shift (part II)) and by reducing the environmental footprint of infrastructure works (part III).

These actions can bring considerable environmental benefits for society at large. However, three main obstacles need to be overcome: some clean technologies are not mature enough or are unavailable; some measures come at a relatively high cost, making the case for investment more difficult. Moreover, the high cost must not endanger the competitiveness of the railways, otherwise, the benefits of the railways in terms of sustainability may be outweighed.

Here lies the main challenge for IMs: finding the right balance between environmental benefits and costs. Providing green assets yields huge benefits for society at large, but IMs need to follow a progressive approach based on the merit order of greening actions: starting with the low-hanging fruit; defining a trajectory of actions considering the life cycle of assets, minimising the cost of retrofitting, and fostering innovation when technologies (e.g., hydrogen) are not mature enough to be deployed.

Greener assets

IMs are both asset managers and traffic managers: they maintain the infrastructure, provide train paths and

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manage rail traffic. They can contribute to the railway system's greening by acting on the two residual external costs of railway infrastructure in operation: carbon emissions resulting from powering trains and noise.

A low carbon infrastructure

The European Green Deal (EC, 2019b) calls for a reduction of 90% in transport CO_2 emissions, in order for the EU to become a climate-neutral economy by 2050.

In 2018, rail accounted for only 0.4% of transport CO_2 emissions and 2% of transport energy consumption in EU27. Moreover, rail is the only transport mode to have reduced its CO_2 emissions almost continuously since 1990, while carrying about 11,2% of freight and 6,6% of passengers on all modes (EC, 2020a).

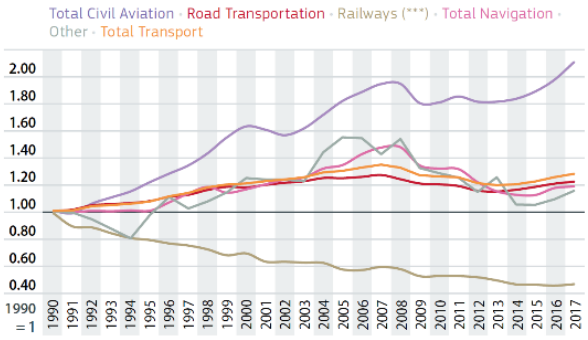

Figure 1: Evolution of greenhouse gas emissions by transport mode in the EU

Source: European Commission (2019): EU Transport in Figures. Statistical Pocketbook 2019.

It should be remembered that railways were not originally climate-friendly: they appeared during the industrial revolution and were heavy users of coal. The progressive greening of railway infrastructure comes from two fundamental trends: electrification and development of low carbon sources of electricity while also showing the highest energy efficiency among all transport modes.

The total length of the EU27 rail network in 2018 was around 201 000-line km. About 56% of the lines carrying 80% of traffic are electrified, which practically means that all mass transit lines are electrified. Electrified trains, however, are not necessarily green by default, depending on the electricity generation mix in the specific country of operation. In some countries where electricity generation is very carbon-intensive, it may be misleading to claim that electrified trains have zero operating CO_2 emissions. In other countries where electricity is sourced from nuclear power or natural sources, such as wind or solar energy, operating CO_2 emissions will be significantly lower. However, with the EU's long-term energy strategy in mind, the electricity generation mix in Europe is expected to become greener.

This leaves the issue of diesel trains open. Their elimination raises important economic and financial questions. Electrifying existing lines is a very costly way to decarbonise the transport system: it requires huge investment and further maintenance costs while providing limited additional revenues as the electrification does not increase the capacity on the network per se. New technologies such as batteries are emerging, which allow for partial electrification of a line for short distances and the use of hydrogen for long distances.

Infrastructure will need to adapt progressively following the merit order of actions:

- the area of relevance of traditional electrification should be limited to freight lines with a high potential of traffic;
- partial electrification using batteries to avoid the high cost of electrification for forward-stations and tunnel sections is a viable alternative, but only for short and medium distances given available technologies;
- for longer distance electrification based on hydrogen should be considered in the coming decades. Some promising pilot-tests have already been carried out in Germany and the Netherlands. However, the deployment costs are still too high when taking into account production, distribution costs (e.g., hydrogen refueling stations) and retrofitting costs of rolling stocks.

Silent routes

Railways are rightly considered as one of the greenest modes of public transport and benefit as such from the support of the public. However, they face growing concerns from local communities concerning noise emissions. This paradox is particularly true in urban or specific geographic areas (e.g., Rhine Valley in Germany): although the benefits of railways in those areas are sig-

nificant in reducing air pollution and congestion, noise emerges as a major obstacle to the development of traffic.

Noise could historically be considered a pure NIMBY (*Not in my backyard*) issue: the opposition of people living geographically close to infrastructure, which delivers more significant benefits for society at large. Historically, local opposition could be dealt with using a mix of state prerogatives and compensation for damages and losses in land values. Still, the issue nowadays is much broader: railways are more and more a mass transit system, running intensively through urban and noise-sensitive areas, thereby increasing the number of people exposed to noise. According to the latest data reported under the Environmental Noise Directive, around 100 million people in the EU are exposed to average sound levels of 55 decibels (dB) or higher during the day, evening and night from road traffic noise. Railways are the second most important source of noise, with a total of nearly 20 million people exposed (EU, 2017).

Although modern electric passenger trains running on well-maintained tracks are relatively quiet, older freight wagons equipped with cast iron brake blocks can pose a significant noise issue, as many freight services are operated at night. Here again, the environmental benefits of noise reduction come at a cost that needs to be minimised and efficiently shared between the infrastructure and the rolling stock: finding an optimal combination of track components (e.g., soft rail pads) and improved rolling stock, retrofitting freight wagons with less noisy brakes. The reduction of noise at the source (trains) is a more efficient and less intrusive way of addressing the matter than adapting the infrastructure (e.g., erecting noise barriers). Furthermore, noise barriers sometimes create a visibility barrier for rail passengers as well as nearby residents and can attract vandalism and graffiti. The revised *Noise Technical Specification* for Interoperability has defined an efficient compromise with the banning of "noisy" freight wagons from some of the busiest rail freight routes as of December 2024.

Increasing capacity to allow for a modal shift in favour of rail

To meet the objectives of the European Green Deal, rail will have to take up a bigger share of passenger and freight transport. As detailed in the ProRail policy paper (2019), an ambitious policy agenda will be needed. This calls for careful cost-benefit analysis as rail infrastructure implies high fixed costs.

The case for cost-benefit analysis

Cost-Benefit Analysis (CBA) allows the selection of relevant options by assessing the socio-economic value added by projects or public policies and ranking them. The practice of CBA has a long-standing history, dating back from the end of the 19th century. It needs, however, to play a bigger role in the policymaking process of climate action.

In the context of climate action, the key parameters are the value of time and the so-called shadow price of carbon, which reflects the value put by society on measures aimed at avoiding the emission of one ton of CO_2. Whereas a market price is based on the trading price for a service or a product, a shadow price is the price that reflects the full value to society. In France, a first set of values for the shadow price of carbon was defined by a specific commission on this topic (Quinet, 2008), with a recommendation of €100/t CO_2 in 2030. Given the new objective of carbon neutrality, a second commission (Quinet, 2019) recommended considering a shadow price of carbon of €250/t CO_2 in 2030. This means that all actions which deliver an abatement cost below this reference should be considered as they efficiently contribute to the net-zero emissions target. Actions that deliver abatement costs above this reference should be considered as relevant to fight climate change (but may be justified by other considerations).

A portfolio of cost-effective actions

A modal shift from road or air to rail requires both an improvement in cost-competitiveness and an increase in the capacity offered by the railway network. This needs to be cost-effective: there is no need to increase capacity everywhere, hoping for an increase in demand. One should instead focus on congested areas and lines: In 2018, the EU27 network had an intensity of use of 18.2 thousand train kilometres per line kilometre. The most intensively used networks in 2018 were those in western Europe, particularly the Netherlands, which has an intensity of use of 50.6 thousand train kilometres per line kilometre. The total length of track that was declared to be congested in EU27 affected 2 261 kilometres, including 1 339 kilometres along rail freight corridors (EC, 2021).

In this context, it may be, at times, necessary to build new lines. This may be the case when a high-speed line between two metropolitan areas can induce a significant shift from

road and air to rail or when a new freight line is needed to bypass a metropolitan area. In these cases, maximising the environmental benefit goes hand in hand with maximising the commercial and financial objectives: the more traffic you capture, the more environmental benefits you get.

Looking at the socio-economic advantages of a development project, a wide range of benefits need to be considered because a costly new line cannot be justified simply on the ground of climate benefits. In this respect, a distinction needs to be drawn between passenger and freight traffic.

The high investment costs of a new high-speed line (about 25 Million € per km) cannot be justified by climate benefits alone, and broader socio-economic benefits need to be considered. Time savings remain the principal advantage as they provide a 'double dividend': a welfare benefit as well as climate benefits when they deliver a shift from air and road to rail. Overall, the climate benefits of an HSL project account for about 10% of the investment costs.

The picture appears to be more favourable for freight transport for two reasons: investment costs for new freight lines are significantly lower than for new high-speed lines (5 million €/km compared to 25 million €/km for a high-speed line) and decarbonising freight transport delivers larger climate benefits because the emissions from a freight train are superior to the emissions from a passenger train and freight trains frequently operate on long distances.

In most cases, entirely new infrastructure is not a cost-effective choice. A portfolio of alternative options is available to increase traffic thanks to digitalisation and better interoperability:

- Digital technologies can increase both punctuality and infrastructure capacity on existing lines. For instance, in France, the number of train paths between Paris and Lyon will increase from 13 to 17 per hour thanks to the retrofit of the high-speed line with ERTMS level 2;

- More than half of total rail freight is across borders, making the competitiveness of rail freight very sensitive to interoperability and operational difficulties between national rail networks. Passenger traffic is still mostly domestic, with only 7% of it crossing borders in 2018. The interoperability of technologies, traffic management systems and timetabling, with priority given to international trains, can play a key role in fostering long-distance traffic for both passengers and freight across European countries.

The case for carbon pricing

A transport network is and will always be multimodal. But modal shift in favour of rail is necessary to decarbonise mobility. Where passengers are concerned, modal shift can come from a time gain of an HSL between big cities or road congestion within urban areas, but for other types of traffic on conventional lines, the time gains are less relevant. Carbon pricing - or regulation dedicated to reducing air pollution - are essential to sustain the competitiveness of railways compared to other modes.

Despite longstanding policy commitments for efficient carbon pricing in transport progress has been limited. As flagged in the communication on Sustainable and Smart Mobility Strategy (EU, 2020b), the "polluter-pays" principle needs to be implemented in all transport modes. Enlarging the scope of the European Emissions Trading Scheme (ETS) to transport or implementing an EU-wide eco-tax on trucks would be the most efficient way to level the playing field and to reap the carbon benefits of rail, and notably rail freight.

Reducing the environmental footprint of infrastructure works

In the context of the urgent need to decarbonise our transport systems, rail is expected to expand its reach and capacity. Across Europe, existing lines are predicted to get busier and new lines are planned, and with this growth, there is a risk to biodiversity.

Track maintenance and works carried out by IMs impact the environment globally and locally. For a significant part of day to day activities, IMs don't have clean options that are nearly as cheap as their polluting counterparts. Reducing the environmental footprint of activities and notably of works requires a long-term strategy.

The carbon footprint of works

Besides the CO_2 emissions from powering trains, IMs carbon emissions come from a wide range of business activities. These include direct emissions stemming from road fleet vehicles and buildings (scope 1 and 2 emissions) and indirect emissions generated by the supply

chain (scope 3 emissions). Indirect emissions include 'embodied carbon' in products (for example, from the energy required to extract raw materials, manufacture the materials into a product, and transport the product to the site), and onsite contractors using machinery and equipment to design, build, maintain and renew the assets. A specific feature of IMs is that the indirect emissions represent a major part of total emissions.

The construction of a new line is indeed responsible for massive CO_2 emissions, especially in certain circumstances such as large tunnel sections. This is also the case, to a lesser extent, with renewal investments. In the first place, it should be recognised that a large part of these emissions is inevitable given the lack of carbon-free technologies to produce materials such as cement and steel.

Most importantly, the reference to scenarios to assess the impact of works needs to be carefully designed to avoid misleading conclusions. True, the 'payback' period in which lower carbon emissions delivered by a modal shift once a new line is in operation offset the higher carbon emissions during the construction period can be long (depending on the traffic), but the relevant question is to consider the alternative scenarios: should we inflict congestion costs to passengers in dense areas, build a road or reinforce urban sprawl rather than density?

Nonetheless, reducing the carbon footprint of infrastructure works is a requirement. It should be based on a two-pronged approach:

- The companies which supply materials for work and projects are critical. IMs spend billions of euros each year buying materials. Environmental considerations need to be addressed in the early stages of procurement and given a high priority and appropriate weighting in the assessment of tenders.

- A life cycle approach implementing circular economy, focusing on the reuse and recycling of materials (tracks, ballast, crossings), is a very cost-effective way to reduce both maintenance costs and carbon emissions.

The local footprint of infrastructure works

The biodiversity challenge is distinct from the climate challenge. Increased traffic provides climate benefits but can degrade ecosystems through land consumption, landscape fragmentation, barrier effects, soil pollution and waste. These can threaten the viability of sensitive populations and alter ecosystem dynamics. Moreover, biodiversity impacts are diffuse and are more difficult to quantify and monetise, thus harder to incorporate in a cost-benefit analysis.

IMs understand that railway infrastructure should be part of the natural landscape, becoming a 'green network' integrating vegetation management, protection of habitat and biodiversity. While the focus was traditionally on the environmental impact of large-scale greenfield projects, IMs are now seeking comprehensive solutions that can halt and reverse the loss of biodiversity.

The most promising avenues concern:

- the eco-design of renewal and development projects, based on a comprehensive assessment of the infrastructure's life cycle, from construction and use through to maintenance;

- a more circular economy, where the railway extracts fewer virgin resources from the planet, keeps materials and resources in circulation and waste to an absolute minimum;

- The transition from herbicide based to non-herbicide-based vegetation control.

Carrying out these policy actions should not be based only on compliance with stringent norms and regulations but include an environmental management system to support the rise of awareness among the organisation's staff on environmental protection and local-level concertation to design specific solutions.

Conclusion

Greening trains and railway infrastructure assets requires actions which need to be deployed over time in the most cost-effective way depending on the portfolio of clean technologies available and of the life cycle of assets to minimise retrofitting costs.

Greening trains and railway infrastructure assets are and will be a team effort. IMs must work with passenger and freight operating companies that run their services as investments must be coordinated between IMs and Railway Undertakings. The teamwork extends into collaborative planning with municipalities and other providers of passenger transport (such as cities) as well as

freight buyers. IMs must work with their supply chain as a major part of CO_2 emissions come from materials.

All these efforts carried out for the benefits of society at large need to be sustained by public regulation: selecting the policy actions with the best cost-benefit ratio and putting a price on carbon emissions are key to deliver a smooth and efficient transition to sustainable rail networks.

References

European Commission (2017) - Report from the Commission to the European Parliament and the Council on the implementation of the environmental noise directive in accordance with article 11 of directive 2002/49

European Commission (2019a) – Handbook on the external costs of Transport

European Commission (2019b) - Communication from the Commission to the European Parliament, the European Council, the Council, the European economic and social Committee and the Committee of the Regions - The European Green Deal

European Commission (2020a) - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions- Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future - Commission staff working document

European Commission (2020b) - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions- Sustainable and Smart Mobility Strategy – Putting European Transport on Track for the Future.

European Commission (2021) - Report from the Commission to the European Parliament and the Council seventh monitoring report on the development of the rail market under article 15(4) of directive 2012/34/EU of the European Parliament and of the Council

ProRail (2019) – An ambitious Policy Agenda Paper

Quinet A. (2008) - La Valeur tutélaire du carbone. Centre d'analyse stratégique, Rapports et documents N° 16. Paris: La Documentation française

Quinet A. (2019). La valeur de l'action pour le climat. France Stratégie, Rapport

Greening Railway Stations: The Italian Experience towards intermodal Hubs

Valerio Birindelli, Lorenzo Radice*, Nadia Bert and Germano Guglielmi**

Railway stations are a central element in transportation systems. In Italy, major railway stations are currently undergoing a profound transformation. They are no longer just a single-purpose place where trains stop to load or unload passengers. They are becoming people-centred hubs where visitors can do much more than just catching a train.

Introduction

Railway stations are a central element in transportation systems and may become pivotal with the implementation of the European Green Deal. In this article, we will look at the Italian "Station and City Plan" developed by the national railway infrastructure manager and reflect upon how it fits into the wider context of the greening of infrastructure assets. First, we will present the definition of sustainable transport and EU (European Union) strategy in this field. Then, we will focus on the change that Italian railway stations are currently undergoing, moving from single-use railway stations to intermodal hubs and poles of attraction. In particular, we will present the current developments at the Roma Termini station. Moving from this example, we will analyse the toolbox at the disposal of the Italian railway infrastructure manager and look at how railway stations are evolving. Finally, we look ahead and mention some elements that will be essential for the implementation of the strategy for a sustainable evolution of the railway station.

The context: from the early definition of sustainable development to the European Green Deal

The need to define and develop a sustainable transport system emerged with the idea of **sustainable development** in the late 1980s. Its definition, by the Brundtland Commission (1987), is a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In other terms, mutually reinforcing elements of economic, environmental and social policy have to be exploited to achieve **continuous improvements in living quality for both current and future generations**.

Sustainable development has been adopted as the overarching long-term goal of the European Union (EU), set out in the Treaties of Maastricht and Amsterdam. As such **the EU has taken the lead in the international sustainability agenda**. The EU and its Member States have not only agreed upon specific targets and projects, they have also adopted several all-comprehensive strategies involving the engagement of the stakeholders operating in various sectors. Its wide set of policy initiatives for Europe to become climate neutral in 2050, the "European Green Deal" (European Commission, 2019) is just the latest step in a thirty-year journey. To reach the climate neutrality goal, the European Commission states that all transport modes (road, rail, aviation, and waterborne transport) will have to contribute to the reduction in greenhouse gas emissions and become more sustainable. Achieving sustainable transport means **putting users first and providing them with more affordable, accessible, healthier and cleaner alternatives to their current mobility habits**. In particular, the 2020 "Sustainable and Smart Mobility Strategy" (European Commission, 2020a) lays the foundation for how the EU transport system can achieve its green and digital transformation and become more resilient for future crises.

Against this background, **rail plays a crucial role** being projected to grow significantly by 2050 both in terms of passenger transport and in terms of rail freight activity (European Commission, 2020b). In particular, **train stations are expected to evolve as part of the new mobility system and to take on a much wider range of roles than in the past**. Thanks to the EU initiative "2021 European Year of Rail", a variety of activities will put rail in the spotlight throughout 2021 across the continent. They will do this to encourage rail-use by both citizens and businesses, but also to contribute to the EU Green Deal goal of becoming climate-neutral by 2050.

The concept: from the railway station to the multimodal hub

In Italy, **Rete Ferroviaria Italiana** (RFI), the railway infrastructure manager, plays a **leading role in the evolution**

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of the national transport system and, intrinsically, in the development of major **sustainable mobility initiatives**. Indeed, RFI's main tasks converge on the ultimate objective of increasing the attractiveness and accessibility of railway transport: those tasks, note, are that of guaranteeing fair and non-discriminatory access to the national railway infrastructure; ensuring safe circulation to all railway undertakings; and providing efficiency and development of the network. To this end, its investment strategy aims: at strengthening and developing the network; at improving its performance (in terms of safety, speed, capacity, etc.), and at constructing, managing and promoting integrated and intermodal connections and systems that maximise accessibility to railways for both passengers and freight.

On the passenger side the definition and implementation of the "Station and City Plan" is of key importance. This plan aims at **transforming passenger terminals into intermodal hubs and poles of attraction** for the development of the hinterland, so they can better respond to environmental, economic and social challenges (see Figure 1 - Rete Ferroviaria Italiana, 2020).

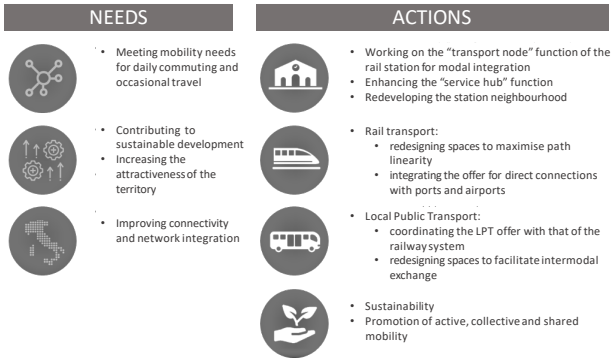

Figure 1: From the railway station to the multimodal hub

The new railway station becomes:

- An integrated Mobility-as-a-Service (MaaS) hub with spaces and services capable of ensuring the faster, easier, more intuitive and fluid transition from one means of transport to another;
- The **vital centre of the smart city**, an integral part of the urban structure and even a driving force for the redevelopment of abandoned, marginal or unattractive areas.

This means satisfying the mobility needs of commuters, tourists and smart-workers in a safe way. It is imperative to enhance the accessibility and attractiveness of the station area, at the same time as favouring modal rebalancing for accessing the station.

Case study: Roma Termini

In 2018, the FS Italiane Group (with its companies RFI, Grandi Stazioni Rail and FS Sistemi Urbani) started an important planning and design process to **improve the Roma Termini terminal and the surrounding area** to complement the strategic works co-financed by the Italian Ministry of Infrastructure and Transport. The construction of an elevated tunnel is presently underway that, in addition to various services for travellers, features a parking lot made of two elevated bridge platforms above the tracks. The subsequent construction of a photovoltaic panel system of about 10,000 square meters is planned: according to the pre-feasibility analysis, it is estimated that it will produce a saving of about 400 tonnes CO_2 per year.

Furthermore, on 23 December 2020, the FS Italiane Group, together with Rome municipality (Roma Capitale), opened a tender **for re-designing the main square in front of the Roma Termini train station** (Piazza dei Cinquecento). According to the tender rules (FS Sistemi Urbani, 2020), the participating projects had to achieve high standards of environmental, social and architectural sustainability, transforming the square in line with the guidelines of the SUMP (Sustainable Urban Mobility Plan)[1] of the city of Rome. On the one hand, the proposals were to enhance the relationship between the station and the historical, monumental and archaeological elements present in the area. On the other, they were to: integrate traditional services with alternative mobility systems; organise better public and private parking; and improve safety conditions. The initiative marks a crucial step in the regeneration of the square and, indeed, of the entire urban area of Roma Termini.

At the celebrations for its seventieth anniversary (Roma Termini new building was inaugurated on 20 December 1950), the new Roma Termini is a symbol of the desire to restart after the pandemic with an outstanding development plan.

The toolbox: stakeholder engagement, methodological analysis, and "nature-based solutions"

[*] "A Sustainable Urban Mobility Plan is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life. It builds on existing planning practices and takes due consideration of integration, participation and evaluation principles"(Rupprecht Consult, 2019).

To transform railway stations into intermodal hubs and new poles of attraction, RFI's commitment builds on the **"Stakeholder Engagement" process**. This involves the direct involvement of company stakeholders in implementing ideas in close partnership (Global Reporting Initiative – GRI). Indeed, in the case of railway stations, this means that RFI works together with the municipalities in which the stations are located; and that it creates a regular dialogue with institutional and social actors in the city to align its needs with societal needs and expectations with long-term sustainability in mind. In fact, 2020 saw the consolidation of several initiatives where Ministries, Regions and Municipalities worked together with RFI, to promote the centrality of railway stations and their sustainable integration with cities.

In addition, to better classify its stations, RFI developed a **new methodology**, mapping the mobility on offer from both railway services and other transport services in a given area. Moreover, the analysis not only looked at routes and frequencies. It also focused on road networks and pedestrian and cycle paths; on the potential for shared mobility services; on the parking dynamics; and of the circulation regulation and control system. Using this new approach, each station in the Italian network has been classified as one of eight predefined clusters (four referring to the macro-area of "metropolitan railway" and four to the "hinterland service"). This has been done while **taking into consideration its level of interconnection and integration** with public transport and its attractiveness potential. This clustering will help set up the new development actions for the stations. This will further enhance not only the aspects most closely linked to rail transport, but also those relating to intermodality and general services for travellers so that the stations can shine as transport hubs and poles of attraction.

A core element in the RFI's approach to transforming stations is that of operating according to criteria and solutions for ensuring the **sustainability of the buildings and their operations**. This is very much in line with international standards: "LEED protocol" for the design, construction and management of energy-sustainable buildings; "Envision Protocol", for the assessment of the environmental sustainability of the designed works. This strategic approach allows for planners to take full advantage of the climate and context in which the intervention is located, working past the old Business-As-Usual approach, and **implementing "Nature-Based Solutions" (NBS) strategies**[2]. With stations, this means, in particular: the design of spaces and services for greater social inclusion; the development of a methodology for energy diagnosis; buildings water and energy efficiency; the use – where possible – of recyclable or, in any case, sustainable materials according to the Life Cycle Assessment; the continuous improvement of the quality of the spaces taking into account air, water, nutrition, fitness, physical and mental comfort factors; the development of a monitoring and management system for the new features applied to Smart Energy Management already to be found in stations; the introduction of green elements (planted green areas), improving the microclimatic conditions near the station; the reduction of pollutants through a filter/barrier effect for both outdoor and indoor environments; and the reduction of noise pollution.

Conclusions: goals and future perspectives

Transforming the station into an efficient integrated mobility hub – that is also in line with the guidelines of the SUMPs – demands a perspective shift. There needs to be a **new centrality** given, on the one hand, **to the needs of travellers and citizens**, on the other, **to the multimodal context** and to overall station accessibility. At the same time, the inclusion of new services and functions in the station and a higher quality environment in the surroundings can ensure greater attractiveness for the station itself, while improving the safety and liveability of the spaces available to travellers and the general urban context. Therefore, the RFI has identified specific interventions to pursue the aforementioned methodology, in addition to its traditional tasks:

- increasing pedestrian spaces, ensuring simpler, more fluid and more attractive itineraries;
- creating safe bicycle lanes that connect the station to the cycle network and the main attractions of the city while providing services such as bike stations and workshops;
- making local public transport lines more efficient;
- promoting shared mobility;
- optimising and regulating the presence of parking areas;
- supporting the installation of e-charging stations;

[*] "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions" (European Commission).

- offering info-mobility tools, a technology that is increasingly able to reduce overall travel times.

To track evaluate the evolution – qualitative and quantitative – of intermodality around the railway stations through time, the RFI developed the "movement monitoring system". This is already in place and will be key for the assessment of different interventions.

References

Community of European Railway and Infrastructure Companies (2019), *Rail's priorities for the European Green Deal* (Brussels: Community of European Railway and Infrastructure Companies).

European Commission (2019), *Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal*. COM(2019) 640 final, 11.12.2019 (Brussels: European Commission).

European Commission (2020a), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Sustainable and Smart Mobility Strategy – putting European transport on track for the future*. COM(2020) 789 final, 09.12.2020 (Brussels: European Commission).

European Commission (2020b), *Commission Staff Working Document Accompanying the document: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Sustainable and Smart Mobility Strategy – putting European transport on track for the future*. COM(2020) 789 final, SWD(2020) 331 final, 09.12.2020 (Brussels: European Commission).

FS Sistemi Urbani (2020), *FS Italiane e Roma Capitale: al via concorso per riqualificazione Piazza dei Cinquecento Stazione Termini*. https://www.fssistemiurbani.it/content/fssistemiurbani/it/in-primo-piano/news-ed-eventi/2020/12/23/fs-italiane-e-roma-capitale--al-via-concorso-per-riqualificazion.html

Global Reporting Initiative (2020) https://www.globalreporting.org/

Rete Ferroviaria Italiana (2020), *Il Piano Commerciale. Edizione Febbraio 2020*. (Roma: Rete Ferroviaria Italiana)

Rupprecht Consult (editor) (2019), *Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan*, Second Edition. (Cologne: Rupprecht Consult)

Greening of Ports: Sailing the green Course?

Sergi Sauri*, Christa Sys** and Thierry Vanelslander***

Maritime shipping and ports are important contributors to air emissions. Legislation is available at various policy levels, but more solutions are needed that are in a further stage of development, taking into account also the economics of the various involved actors.

Introduction

European ports are key gateways for the European economy and global trade. Next to this, they also accommodate passenger transport as well as cruise and tourism activities. Furthermore, ports are home to industrial activities and play a key role as energy hubs with energy commodities representing a substantial part of traffic volumes.

Notwithstanding the critical role that ports play, the environmental sustainability of port activities is a growing concern for port stakeholders, policy makers and local communities. Shipping and port activities affect the natural environment and have a negative impact on human health and marine ecosystems. Harmful effects of port activities include air emissions, noise and water pollution, congestion and waste generation, among others. Environmental issues arise from vessel and cargo handling operations, hinterland transport modes, port development and industrial activities in ports. A substantial part of the externalities of port operations results from shipping.

This contribution gives an overview of the current situation with respect to emission problems in shipping and ports, as well as a state of policy-making on the matter.

Air emissions from shipping

Emissions from ships represent the primary source of air pollution in the majority of ports (Eyring et al., 2009, Mueller et al., 2011, and Wang et al., 2020, for instance). Furthermore, port emission inventories show that most of these emissions occur at berth and while manoeuvring. Accompanied by considerable fuel consumption, marine transport produced 1.056 million tons of CO_2 in 2018, representing 2.89% of the global CO_2 emissions (IMO, 2020). In addition to this greenhouse gas (GHG), maritime fleets also emit a considerable amount of other pollutant emissions such as NOx and SOx: according to Deng (2021), between 2014 and 2018, annually:

- NOx emissions increased from 19 million tons to 20.9 million tons
- SOx emissions increased from 10.2 million tons to 11.3 million tons.

Moreover, most shipping emissions (CH4, CO, CO_2 and NOx) are expected to grow fourfold up to 2050.

The regulation of shipping emissions is insufficient, slow and complex due to the fact that maritime transport is, by nature, an international activity. Companies in the sector demand maximum uniformity and stability in rules and regulations in order to ensure a level playing field for the industry and to allow for planning and scheduling of their investments over time. For that reason, emissions from international shipping are regulated at the international level by the International Maritime Organisation (IMO) under the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). The regulations for the Prevention of Air Pollution from Ships (Annex VI) seek to minimise airborne emissions and their contribution to local and global air pollution, as well as other environmental problems.

MARPOL Annex VI lays out global progressive reduction standards for emissions of SOx, NOx and particulate matter (PM) and defines emission control areas (ECAs) to help further reduce emissions of those air pollutants in designated sea areas. At the moment, only the MARPOL provisions on SOx emissions are covered by EU law. Directive (EU) 2016/802, known as the 'Sulphur Directive', regulates SOx emissions from ships. This Directive integrates the sulphur emission standards defined in the MARPOL Annex VI, which set stricter sulphur limits for marine fuel in SECAs (0,10%) and sea areas outside SECAs (3,50%), since 2015. The latter limit is further strengthened since 2020 through a global

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0,5% sulphur cap on marine fuels. On 1 January 2020, the Sulphur Directive also introduced a 0,1% maximum sulphur requirement for fuels used by ships at berth in EU ports and a 1,50% for passenger ships operating on regular services to or from any EU port in sea areas outside the SECAs. The sulphur limit for vessels at berth in EU ports has been the critical element in reducing SOx emissions, to the extent that these emissions are no longer a priority for action in EU ports. Furthermore, the last report on implementation and compliance with the sulphur standards for marine fuels set out in Directive (EU) 2016/802 (European Commission, 2018) reports a significant reduction of sulphur dioxide concentrations in regions bordering the SOx-ECA.

However, emissions of PM and NOx from international ships are not regulated by the EU. The IMO designated the North and the Baltic seas as 'Nitrogen Oxides Emission Control Areas' (NOx-ECAs) in July 2017. This implies that an engine installed on a ship constructed after 1 January 2021 that operates in the Baltic Sea or the North Sea has to comply with the 'Tier III' engine requirements laid out in MARPOL Annex VI. Since this regulation only addresses new ships built after 2021 and only those ships operating in a NOx-ECA, it is not expected that there will be any significant short- or medium-term improvement in NOx emissions in the EU.

So far, only one Member State has put forward a measure to address NOx emissions from (domestic) shipping. In 2008, Norway created a NOx Fund as an instrument to reduce NOx emissions from shipping (and a number of other sectors) and as an alternative to the existing NOx tax. Companies joining the NOx fund pay a fee to the organisation, instead of the fiscal NOx state tax, in order to incentivise participation. In return, affiliated companies can apply for and get NOx funding for NOx reduction measures, and the industry commits to certain obligations in the form of emission ceilings. Recently, shipping companies have claimed that the taxation of CO_2 has undermined efforts towards NOx reductions. In January 2018, Norway removed the exemption from the national CO_2 tax of liquefied natural gas (LNG) as fuel on ships and increased the tax on NOx to €500 per tonne of CO_2. This has caused LNG to be more expensive with a knock-on effect on the NOx fund investments for LNG fuelled ships, whose business has been affected. This is a clear example of how energy taxation can influence investments in the greening of maritime transport.

Since IMO regulations do not specifically consider ship emissions in ports, regulations at the regional level (EU Sulphur Directive, California CARB) and industry (voluntary) initiatives have taken over the role of addressing shipping emissions in ports and particularly at berth. It should be noted that these two regulatory attempts have two very different approaches. The EU Sulphur Directive imposes an emissions limit at berth while not imposing any technical solution to reduce them. Meanwhile, the California regulation has favoured the connection of vessels to grid-based shore power and only, in some cases, allows other (approved) alternative emission reduction measures.

The Marine Environment Protection Committee (MEPC, 2011), a committee of the IMO, did make amendments to the MARPOL 73/78. From 1 January 2013, the Energy-Efficient Design Index (EEDI) and the Ship Energy Efficient Management Plan (SEEMP) became mandatory for all vessels over 400 gross tonnes. These systems attempt to further enhance the reduction of greenhouse gas emissions.

The EEDI is a benchmark on the energy efficiency set to reduce exhaust gas on newly-built vessels. It is a non-prescriptive measure that helps the industry decide which technologies should be installed on a specific ship design. When the emission of CO_2 is above this benchmark, the design of the vessel has to be changed.

The SEEMP is an operational measure that helps the shipping company improve the energy efficiency of its operations in existing vessels. The SEEMP shows how energy savings can be made in four steps: planning, implementation, monitoring and self-evaluation.

MEPC (2011) also discusses other possibilities of reducing greenhouse gas emissions, such as market-based mechanisms. These mechanisms put a price on greenhouse gas emissions, consequently giving economic incentives to the industry to invest in vessels and technologies with low emissions. The generated revenue can be used to limit climate change (IMO, 2011). These mechanisms could include:

- A levy on vessels that do not meet the EEDI standard;
- A levy on all greenhouse gas emissions coming from all types of vessels;

- A global emission trading system;
- A penalty on trade and development;
- A rebate mechanism for a market-based instrument for international shipping.

(IMO, 2010).

These are two new measures: the technical requirement to reduce carbon intensity, based on a new Energy Efficiency Existing Ship Index (EEXI), and the operational carbon intensity reduction requirements, based on a new operational carbon intensity indicator (CII). In a recent publication, Rutherford et al. (2020) concluded that the EEXI would only marginally reduce CO_2 from the 2030 fleet, but it would be more impactful if evaluated at higher engine loads.

With regards to GHG emissions from shipping, following the Paris Climate Agreement in 2015 in which shipping was not included, and under the pressure of the EU, the IMO adopted an initial Green House Gas (GHG) Strategy in April 2018. This GHG-Strategy sets out two objectives taking 2008 as a baseline year.

- The first target aims to reduce the average carbon intensity (CO_2 per tonne-mile) by at least 40% by 2030 while aiming for 70% by 2050.
- The second target aims to reduce total GHG emissions from shipping by at least 50% by 2050 and hopes for the phasing out of such emissions as soon as possible within this century.

The strategy and its targets will be reviewed in 2023, based on information gathered from its Data Collection System and from a fourth IMO GHG study undertaken in 2019.

The EU also laid out general decarbonisation goals with a target reduction of GHG emissions of 80% below 1990 levels by 2050 and milestones of 40% cuts by 2030 and 60% by 2040. Since all sectors are expected to contribute, the EU has put forward the following measures:

- The EU 'MRV' regulation
- The EU ETS Directive: The Emission Trading Scheme (ETS)

It can be expected that if a shipowner is forced to take measures to fulfil new criteria, they will opt for the solutions that are the least costly. There are three reasons why it could be argued that investing in new technologies, to reduce the EEXI could be problematic due to too much uncertainty:

- The effectiveness of the new technology is unknown or not yet proven;
- The actual fuel consumption of a ship is related to the total propulsion system, including external effects. Therefore, the technologies' effectiveness depends not only on the total propulsion system but also on external effects;
- The high volatility in the bunker fuel price and the unknown development of the bunker price make investments in new technologies more risky.

Solutions for shipping and the role of ports

Driven by the EU Directive 2014/94/EU on the deployment of alternative fuels infrastructure, EU ports are making substantial investment efforts to develop Liquefied Natural Gas (LNG) bunkering facilities. In addition, several EU ports (a.o. Gothenburg, Hamburg, Bremen, Rotterdam and Barcelona) promote the use of LNG through important rebates in the port dues charged to ships.

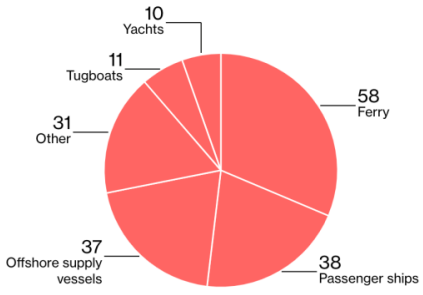
The carbon intensity of fuels needs to be assessed from well to tank in accordance with standards based on life cycle assessment. This will enable biofuels and synthetic fuels to be accounted for as carbon-neutral while preventing the use of zero-carbon fuels made by carbon-intensive processes (e.g., hydrogen produced from natural gas) (DNV, 2020). Key aspects to study are the potential to re-use LNG infrastructure for biogas and requirements for the supply of other well-to-propeller zero-carbon fuels.

One of the measures adopted by ports to reduce local air emissions from ships in ports is the provision of Onshore Power Supply (OPS) technologies, also called Cold Ironing or Alternative power supply. Vessels equipped with OPS can turn off their auxiliary engines and replace power generated onboard the ship with electricity generated onshore. The European Alternative Fuels In-

frastructure Directive sets out that OPS shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by the end of 2025 unless there is no demand costs are disproportionate to the benefits, including environmental benefits.

However, electricity produced from the combustion of marine fuel on board ships is tax-exempt. But, when ships at berth are plugging into the shore-side electricity system, they have to pay taxes applied to electricity. OPS electricity can be tax-exempted for a limited period as laid down in Article 19 of Directive 2003/96 (Energy Taxation Directive). Since 2011, Sweden, Germany and Denmark have been provided with a permit to temporarily apply a reduced rate of taxation to shore-side electricity for ships. Recently, other countries, such as Spain, have joined the exemption. However, the reduction is often insufficient. The EU port sector is therefore calling for a permanent EU-wide tax exemption for the use of shore-side electricity under the Energy Taxation Directive.

Likewise, the EC should explore the impact of marine battery technology in ships (vessels' lithium batteries / battery-powered / electrified vessels) on OPS solutions. In hybrid vessels, batteries are charged at sea using the vessel's main engines and used while at berth to reduce emissions in the port. For more extended port stays, batteries may be charged using shore-side power. To date, only a small number of battery-powered vessels are in operation, but several initiatives are underway to push those figures higher.



Source Maritime Battery Forum, DNV GL
Electric, plug-in hybrid, and hybrid vessels

Figure 3. Battery-powered vessels either in operation or under construction around the world (2018)

OECD/ITF (2018) analysed the existing port incentives schemes as drivers of change in the greening of maritime transport with the following conclusions:

- Port incentives should have a more mandatory character and be harmonised to some extent in terms of green ships definitions to allow shipping companies to benefit from them;
- A more robust application of the polluter pays principle is needed, in line with the principles of EU environmental law;
- Efforts should be made to improve the measurement and assessment of the impact of port incentive schemes on shipping emissions.

Greening port operations

While a lot of attention usually goes to ships in the greening debate on maritime supply chains, ports' operations should also be considered when talking about port greening (Vanelslander and Sys, 2020). Growing port activities themselves come with an environmental burden that needs to be mitigated through a more sustainable and efficient operational model.

The World Ports Sustainability Program (WPSP) of the International Association of Ports and Harbours (IAPH) is an international initiative of eleven leading ports (Antwerp, Barcelona, Gothenburg, Hamburg, Le Havre, Long Beach, Los Angeles, New York & New Jersey, Rotterdam, Vancouver and Yokohama) that are working on plans to reduce CO_2 emissions from shipping and ports and improve air quality. Examples of initiatives taken by ports listed under the initiative involve:

- upgrade existing environmental sensors set with new sensors;
- develop a Port Environmental Performance IT platform that will receive real-time data from the sensor networks and existing operating systems in each port (i.e., PCS);
- decrease port traffic congestion and reduce CO_2 emissions from trucks;
- optimise vessel calls before and after port closure due to bad meteorological conditions;
- predict air quality and noise levels and generate notifications to government institutions when certain emission levels will be exceeded;

- predict how ship-to-shore crane productivity will be affected by waves, currents and wind and sending warnings 48 hours in advance to vessels calling;

- inform shippers about the real emissions generated by their shipments in door-to-door transport chains.

Conclusions

Several adverse environmental effects, as well as strategies and policies to tackle them, have been pointed out in the previous sections. Following the 2019 Green Deal Strategy of the European Commission, it is important to have an overview of strategies and practices pursuing economic growth paired with green objectives and to aid in knowledge sharing and identification of the tools in pursuing similar objectives by other ports and authorities and adjusting them to their specificities.

While there are regulatory recommendations at the global level, implementations at the EU country level are uneven and still slow. The multitude of stakeholders involved in reducing emissions from ships and the maritime sector's international scale make common or similar regulation at the European level difficult. Short-term challenges should focus on extending technological advances in fuels and port energy supply facilities to the maritime and port sector, respectively.

References

DNV-GL (2020) Energy transition outlook 2020, Maritime Forecast 2050

Deng, J., Wang, X., Wei, Z., Wang, L., Wang, C., Chen, Z. (2021) A review of NOx and SOx emission reduction technologies for marine diesel engines and the potential evaluation of liquefied natural gas fuelled vessels, *Science of The Total Environment*, 766, https://doi.org/10.1016/j.scitotenv.2020.144319

European Commission (2019) European Green Deal. COM (2019) 640

Eyring, V.; IsaksenI, S.A.; Berntsen, T.; Collins, W.J.; Corbett, J.; Endresen, O.; Grainger, R.G.; Moldanova, J.; Schlager, H.; Stevenson, D.S. (2009) Transport impacts on atmosphere and climate: Shipping. Atmos. *Environ.* 44, 4735–4771

IMO (2020) Fourth IMO GHG study 2020, IMO, London

IMO (2011) Mandatory energy efficiency measures for international shipping adopted at IMO environment meeting

MEPC (2011) 62nd session, https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MEPC-62nd-session.aspx

Mueller, D., Uibel, S., Takemura, M. et al. (2011) Ships, ports and particulate air pollution - an analysis of recent studies. *J Occup Med Toxicol* 6, 31. https://doi.org/10.1186/1745-6673-6-31

OECD/ITF (2018), Reducing shipping GHG emissions: lessons from port-based incentives

Rutherford, D., X. Mao, and B. Comer, (2020) Potential CO_2 reductions under the Energy Efficiency Existing Ship Index. Working Paper 2020-27. International Council on Clean Transportation.

Vanelslander, T. & Sys, C. (Eds) (2020) *Maritime Supply Chains*. Elsevier.

Wang, L., Peng, C., Shi, W., & Zhu, M. (2020). Carbon dioxide emissions from port container distribution: Spatial characteristics and driving factors. *Transportation Research Part D: Transport and Environment*, 82, 102318

networkindustries quarterly

Network Industries Quarterly, Vol. 23, issue 2, 2021 (June)

"Building and Governing EU Networks"

Presentation of the next issue

The EU's basic objective is to create a Single European Market as a tool for political integration. This objective is being transposed into all economically relevant sectors.

In the infrastructures, this objective translates into the unbundling of the network industries into a monopolistic infrastructure on the one hand and a market for services delivered on the basis of these infrastructures on the other.

On the basis of these unbundled infrastructures at the national level, the EU aims at creating interconnected infrastructures which offer full interoperability for all the services provided on these infrastructures. This aim is being implemented in a systematic way in electricity ("copper-plate Europe"), in railways ("Single European Railway Area") and in air transport ("Single European Sky"). One could add to this road infrastructures and perhaps telecommunications infrastructures, even though unbundling does not take place there.

Of course, the implementation of this idea progresses differently in the different infrastructures, owing to technological specificities, national interests, and funding requirements, among others. In this NIQ we will look at electricity, rail and air EU-wide infrastructures, how they have developed, whether they make progress, and what obstacles they encounter. In the last paper, we will also explore whether this idea of an EU-wide infrastructure can also apply to digitalisation.

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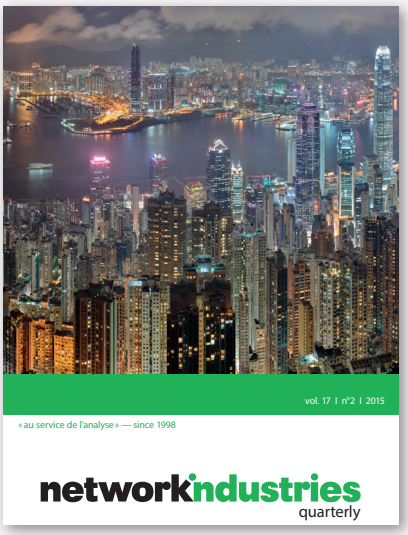

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