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Identifying key priorities in support to the EU Macro-regional Strategies implementation

An ex-ante assessment for the Adriatic-Ionian and Alpine regions focusing on clean growth in transport and bioenergy

Muntean, M., Van Dingenen, R., Monforti-Ferrario, F., Scarlat, N., Janssens-Maenhout, G., Hjorth, J., Bernabei, C., Skoniezki, P., Norcini Pala, A., Coppola, P., Vizcaino Martinez, P., Jacobs-Crisioni, C., Lavalle, C., Kompil, M., Armengaud, A., Trozzi, C., Contini, D., Twrdy, E., Psaraftis, H., De Gennaro, M., Paffumi, E., Martini, G., Marelli, L., Giuntoli, J., Ntziachristos, L., Antoniou, C., Meyer, M., Santa, U., Rroco, E., Motola, V., Cosic, B., Rutz, D., Ziron, M., Weissinger, A., Camia, A., Martinov, M., Jelavic, V., Garbolino, E.

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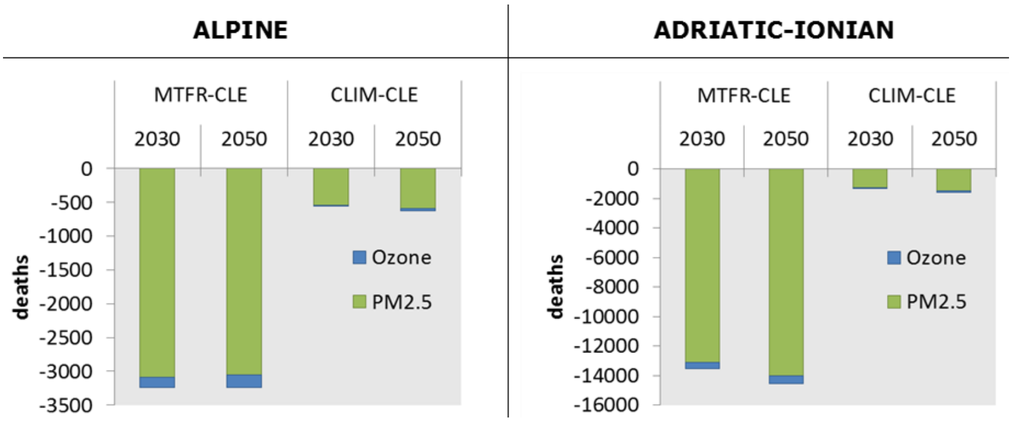

Contact information
Name: Marilena Muntean
Email: marilena.muntean@ec.europa.eu

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Contents

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Authors

Marilena Muntean[1], Rita Van Dingenen[1], Fabio Monforti-Ferrario[1], Nicolae Scarlat[2], Greet Janssens-Maenhout[1], Jens Hjorth[3], Cesare Bernabei[4], Patrick Skoniezki[5], Arianna Norcini Pala[6], Pierluigi Coppola[7], Pilar Vizcaino Martinez[8], Chris Jacobs-Crisioni[8], Carlo Lavalle[8], Mert Kompil[8], Alexandre Armengaud[9], Carlo Trozzi[10], Daniele Contini[11], Elen Twrdy[12], Harilaos N. Psaraftis[13], Michele de Gennaro[14], Elena Paffumi[14], Georgio Martini[14], Luisa Marelli[14], Jacopo Giuntoli[14], Leonidas Ntziachristos[15], Constantinos Antoniou[16], Maren Meyer[17], Ulrich Santa[17], Evan Rroco[18], Vincenzo Motola[19], Boris Cosic[20], Dominik Rutz[21], Marco Ziron[22], Alexander Weissinger[23], Andrea Camia[24], Milan Martinov[25], Vladimir Jelavic[26], Emmanuel Garbolino[27]

[1]European Commission, Joint Research Centre (JRC), Directorate for Energy, Transport and Climate, Air and Climate Unit, Via E. Fermi 2749, I-21027 Ispra (VA), Italy
[2]European Commission, Joint Research Centre (JRC), Directorate for Energy, Transport and Climate, Energy Efficiency and Renewables Unit, Via E. Fermi 2749, I-21027 Ispra (VA), Italy
[3]European Commission, Joint Research Centre (JRC), Directorate for Energy, Transport and Climate, Air and Climate Unit (JRC-ISPRA-EXT), Via E. Fermi 2749, I-21027 Ispra (VA), Italy
[4]Directorate-General for Regional and Urban Policy (DG REGIO), Competence Centre Macro-regions and European Territorial Cooperation, Brussels, Belgium
[5]EUSALP AG4 Lead Team, European Region Tyrol-South Tyrol-Trentino, Austria
[6]Rete Autostrade Mediterranee (RAM) S.p.a, Italy
[7]Università degli Studi di ROMA "Tor Vergata", Italy
[8]European Commission, Joint Research Centre (JRC), Directorate for Growth and Innovation, Territorial Development Unit, JRC Knowledge Centre for Territorial Policies, Via E. Fermi 2749, I-21027 Ispra (VA), Italy
[9]Air PACA, Région de Marseille, France
[10]Techne Consulting srl, Italy
[11]Istituto di Scienze dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche, Italy
[12]University of Ljubljana, Slovenia
[13]Technical University of Denmark
[14]European Commission, Joint Research Centre (JRC), Directorate for Energy, Transport and Climate, Sustainable Transport Unit, Via E. Fermi 2749, I-21027 Ispra (VA), Italy
[15]Aristotle University Thessaloniki, Greece
[16]Technical University of Munich, Germany
[17]Agency for Energy South Tyrol – CasaClima, Leader EUSALP Action Group 9[18]Agricultural University of Tirana, Albania
[19]ENEA, Italy
[20]University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Croatia
[21]WIP Renewable Energies, Germany
[22]ARPAV, Italy
[23]Bioenergy2020+ GmbH, Austria
[24]European Commission, Joint Research Centre (JRC), Directorate for Sustainable Resources, Bio-Economy Unit, JRC Knowledge Centre for Territorial Policies, Via E. Fermi [27]49, I-21027 Ispra (VA), Italy
[25]University of Novi Sad, Faculty of Technical Sciences, Serbia
[26]EKONERG, Zagreb, Croatia
[27]MINES ParisTech, France

Abstract

The emissions from transport and residential sectors have significant shares in total emissions of Europe. In this study, we identified key priorities in support to the EU Macro-regional Strategies implementation based on an ex-ante assessment focusing on two EU macro-regions: Adriatic-Ionian (AIR) and Alpine (ALP).

Firstly, we analysed how different sectors contribute to air pollution in the ALP and AIR regions and to predict future pollution levels under different emission scenarios such as Current Legislation (CLE), Maximum Technically Feasible Reduction (MTFR), and Climate Mitigation (CLIM) by using the TM5-FASST air quality and impact model. It was found that the residential sector is the main contributor to anthropogenic PM2.5 emissions and it will remain so also beyond 2050 under the CLE scenario while the transport sector remains the major contributor to NOx emissions until 2030, with a significant and growing contribution from shipping in the AIR region. Primary PM2.5 has almost reached its technical reduction limit but secondary PM2.5 still has a large reduction potential. MTFR measures on road transport and shipping emissions can generate an annual health benefit from PM2.5 and ozone of 750 (ALP) + 2950 (AIR) avoided premature mortalities in 2050 of which 64% from shipping emission reductions. The potential health benefits from all sectors under MTFR (ALP + AIR) amounts to 16,800 avoided premature deaths annually in 2030 (3250 + 13550). The potential health benefits from Climate mitigation (ALP + AIR) amounts to 2200 avoided premature deaths annually in 2050 (620 + 1580), however CLIM policies due to fuel switch to biomass also cause air quality trade-off in the domestic sector leading to an estimated number of 360 extra premature deaths annually in 2050 in AIR.

Secondly, the experts in the transport sector from these regions have pointed several areas of improvement. Increased intermodality, combining road, rail and maritime ship transport can have important benefits in both regions. In the ALP, moving from trucks to rail could considerably reduce the environmental impacts of transport by reducing emissions of CO2 and air pollutants and could help to solve traffic congestion problems. In the AIR, many countries use outdated technologies for on-road freight transport, causing large environmental impacts. A modal shift e.g. to electric rail or maritime shipping can thus give particularly large positive environmental benefits for this region. The potential drawbacks of a modal strengthening the role of railway and ship transport are primarily related to the increased complexity, the costs of the necessary infrastructures and the risk of increased air pollution in some port cities due to ship emissions. For traffic on roads, infrastructure development is a key element to move towards more sustainable transport. Electrification of road transport generates emissions reductions when the electricity generation is also clean and attention should be given to the charging infrastructure development. Fleet renewal of trucks and ships and use of cleaner fuels will contribute to clean growth in transport. However, fleet renewal is a costly measure and difficult to implement in poor countries; consequently, the measures that proved to be effective in other countries may not be beneficial or even applicable in these countries. One important obstacle in implementing the provisions of EU macro-regional strategies is the disparity between countries within the macro-regions. Further, some countries in ALP and AIR are not part of EU and may present limitations in international trade and security agreements.

Finally, the experts in the field highlighted the fact that bioenergy is an important opportunity for ALP and AIR regions. Because of potential environmental threats, its clean deployment is an issue to be carefully addressed through appropriate policies and regulatory acts. An example is the impact on regional air pollution of small and medium scale traditional appliances and domestic boilers. Improved efficiency and best available technologies need to be strongly supported with both market strategies and effective controls. On the other side of the supply chain, sustainable collection of feedstock has to be assured through the appropriate management of the forest stocks and accounting for the actual climate mitigation benefits, without forgetting the increasing demand of biomass from other industrial sectors in a bio-economy framework.

1 Introduction

In the last half a century, air quality has significantly improved in Europe thanks to the adoption of more and more stringent regulations and the deployment of appropriate technologies. Nevertheless, significant room for improvement still remains as far as some sectors and some geographical areas are concerned.

This report focuses on two sectors, transport and domestic biomass burning, and two geographical areas: the Adriatic-Ionian (AIR) and Alpine (ALP) regions. These specific combinations of sectors and areas have been chosen on the basis of two separate rationales. Sectors have been identified because of the actual emissions amount and their growth perspectives: atmospheric emissions both from the transport sector and from biomass combustion by the residential sector, in particular from old and inefficient biomass heating systems, are significant throughout Europe (EEA, 2016). Traffic in Europe is increasing, (COM501, 2016) while biomass is and will remain a major source for renewable energy in the EU and is key to reaching targets on renewable energies in several countries (COM860, 2016). The geographical areas have been selected because of their specific policy deployment context: indeed, both the Adriatic-Ionian and Alpine regions are the subject of an EU "macro-regional strategy" as defined in COM357 (2014) and COM366 (2015) respectively.

The main idea behind macro-regional strategies is that common programs and exchange of competences should in principle lead to a smoother and more efficient management of issues that are trans-boundary in nature, such as for instance air quality and its impact on human health. Although air quality is not always directly addressed in the European Union Strategy for Alpine Region (EUSALP) and in the European Union Strategy for Adriatic-Ionian Region (EUSAIR) documents, macro-regions have identified policy areas supporting sustainable economic growth e.g. to switch to low emissions and energy efficient vessels (COM357, 2014) or investing in research and innovation to support a shift to advanced low carbon technology (COM0366, 2015; EURLAP, 2016) that also reduce the impact of emissions on air quality and health.

This report is a contribution to policy design in the selected macro-regions driving the attention on air pollution and its causes. Indeed, specific challenges, which require joint efforts, such as air pollution and health, could be further addressed through macro-regional strategies that are valuable instruments to tackle transboundary issues. The scientific groups from the EC/JRC, experts from the Alpine (ALP) and Adriatic-Ionian (AIR) macro-regions and DG REGIO, explored the cross-border issues related to clean growth in transport and bioenergy that are key elements for sustainable development. Their findings, which are presented in this report, provided additional insights on the challenges/priorities in these two macro-regions.

In Europe, sustainable development and emissions mitigation are supported by measures included in EU legislation and also in recent initiatives such as the "Europe on the Move" package, "European Strategy for Low-Emission Mobility" and "Clean Energy For All Europeans". These framework policy drivers are differently considered in the macro-regional sectorial contexts.

For **transport**, in the EUSAIR, the main challenges are related to significant infrastructure deficit, little multi-modal transport development and an increasing maritime traffic congestion, which lead to significant level of emissions from shipping and ports, harming air quality and human health. A strategic asset for the AIR is its location at a major European cross-road, which could be exploited by improving land-sea connectivity and intermodal transportation (COM357, 2014). For the ALP, as a transit region, a major issue is the increase in traffic volumes with a large share of freight transport for which a harmonised regulation framework is missing. Measures promoting sustainable transport such as shifting traffic from road to rail focusing are needed to improve air quality, which is poor in some areas and would benefit from increased synergy between mobility-environment planning at macro-regional level (COM0366, 2015); efforts are envisaged to develop an Alpine transport and environmental policy (EURLAP, 2016).

For **energy**, in the EUSAIR, interconnection of energy grids remains inadequate impeding profitable exploitation of renewable energy sources (COM357, 2014). In the EUSALP, the self-generation of energy is encouraged by promoting the development of renewable energy specific to this macro-region, but with a consequent impact on air quality from using different types of combustion in the heating sector. The energy sector should also focus on reducing air pollution by supporting the implementation of Air Quality Plans and National Air Pollution Control Programmes (COM0366, 2015; EURLAP, 2016). In EUSALP, meeting the energy demand sustainably, securely and affordably is an important challenge.

In this report, after a scene setting introduction, an overall view of the air pollution related challenges in the two targeted macro-regions is provided in Chapter 3. There, we describe the levels of anthropogenic emissions in both EUSALP and EUSAIR and provide an insight on the impacts on air quality and on human health of ECLIPSE emissions scenarios in which different policy options are considered. This analysis, based on the outcomes of a state-of-the-art modelling exercise, shows that, although the uncertainty in present and future emissions is relatively large, transport and residential sectors play a major role in the areas and, accurate data and information from countries within both macro-regions are important for the estimation of the effectiveness of the measures discussed.

Further, JRC acted as a facilitator for knowledge and expertise sharing/exchange between countries; two workshops were organized to identify priorities and efficient practices in both macro-regions. The aim was to encourage the sharing of knowledge, which could support countries in their efforts to apply suitable/best practices and consequently reduce the disparities related to knowledge and research capacities and close the gap between potential and achievable emission reductions.

The findings presented in Chapters 4 (transport), 5 (bioenergy with a focus on residential sector) and 6 (knowledge management) of this report are based on the presentations and the discussions at these workshops and constitute the core knowledge on which conclusions presented in Chapter 6 are based.

2 Scene setting

According to the Treaty, regional development is an objective of the European Union and the territorial dimension is the heart, the identity, “la raison d'être" of the Cohesion Policy. Taking into account this aspect and following a proposal of the European Commission, Macro-Regional Strategies (MRS) have been endorsed as an integrated framework by the European Council, becoming a powerful tool for the implementation of the European Union Policies in regions with common challenges and opportunities.

So far, four MRSs have been launched: the first one, the European Union Strategy for the Baltic Region (EUSBR) was adopted in 2009 with the participation of eight countries (Sweden, Denmark, Estonia, Finland, Germany, Latvia, Lithuania and Poland) with the aim of preserving the good status of the Baltic Sea.

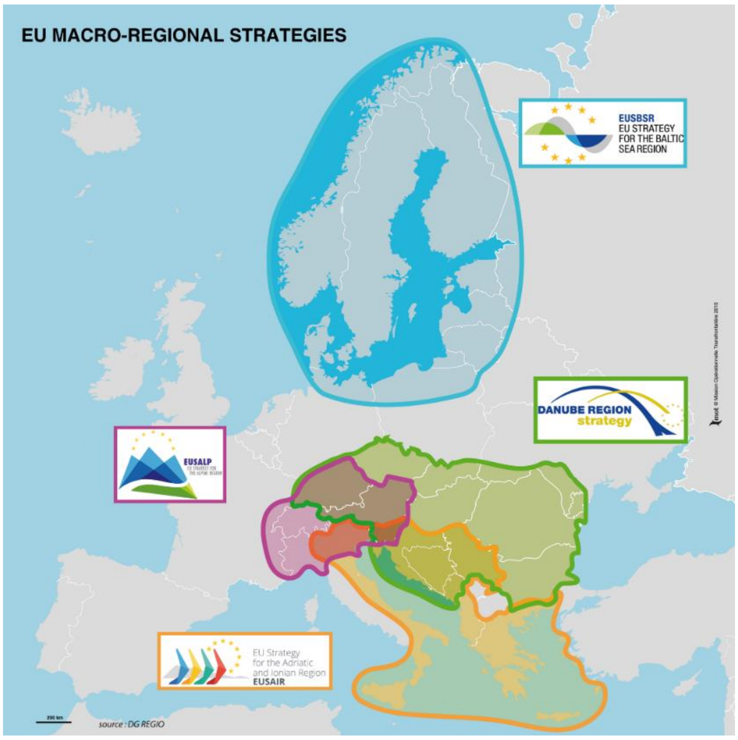
In 2011 was adopted the one of the Danube Region or EUSDR including fourteen countries (nine EU Member States: Germany, Austria, Hungary, Czech Republic, Slovak Republic, Slovenia, Bulgaria, Romania and Croatia and five non-EU countries: Serbia, Bosnia and Herzegovina, Montenegro, Ukraine and Moldova).

In 2014 was adopted the Adriatic-Ionian (EUSAIR) Strategy with four EU Member States: Croatia, Greece, Italy, Slovenia and four non-EU Countries: Albania, Bosnia and Herzegovina, Montenegro, and Serbia to develop a joint maritime strategy for the Adriatic and Ionian Seas.

In 2015, the Alpine (EUSALP) Strategy was endorsed including seven countries, five EU (Austria, France, Germany, Italy and Slovenia) and two non-EU (Liechtenstein and Switzerland) for the growth of a region that is dynamic and innovative but that is also environmentally fragile and needs to be preserved.

The areas covered by the EU macro-regional strategies are illustrated in Figure 1.

Figure 1. Baltic, Alpine, Adriatic-Ionian and Danube EU macro-regions



Source: DG REGIO.

No new legislation or bureaucracy would be introduced by the adoption of the MRSs, while the budget would be the one, which is already, planned for the Territorial Cohesion with the contribution of cross pillar Union Programs enhancing synergies.

The strength of the MRSs stems in that it encompasses geographical areas that have an important common denominator, being it, a sea like for the Baltic Strategy or a river like the Danube Strategy, without paying attention if the country is or is not member of the European Union creating ties that will help integrate non-Members to the Union. Additionally, and very importantly the Strategies create connection and synergies between different fields of development like environment, transport, energy, research, etc. This is true for all fields of development, but it assumes a very important aspect in the case of transport and energy. For transport, the development of European Core Corridors of the Trans European Transport Network (TEN-T and its information system TENtec([1])) needs to be integrated into each region by a capillary network of connections that would ensure access to the main stream. For energy, important aspects to be addressed are interconnection of energy grid and access to clean and affordable energy while sustainable criteria are respected taking into account region/country specificity. Many more aspects that are important can be mentioned like supporting synergies particularly for transport, energy and environment developments as these policy pillars need to keep into account the development of each other if the scope of a sustainable growth is to be achieved. Additional related information can be found on the official site of the European Commission and in particular in DG-REGIO([2]), DG-MOVE([3]) and DG-ENER([4]) ones.

In this study, for Alpine and Adriatic-Ionian macro-regions only, we identified key priorities based on the existing situation in support to the implementation of these two EU macro-regional strategies. The aim was to focus on clean growth in transport and bioenergy sectors; contributors to this work are researchers and policy makers from the JRC, DG REGIO, and universities, research institutes and other authorities from these macro-regions including Priority Area coordinators and Action Group leaders. In this report are presented the findings of the JRC evaluation of impacts of air pollutant emissions in current legislation (CLE), advanced technology implementation (MTFR) and climate mitigation (CLIM) scenarios on air quality and human health; this analysis highlights the contributions of emissions from transport and combustion in domestic activities in Alpine and Adriatic-Ionian macro-region on air quality and health. Further, challenges in clean growth in transport sector and those in bioenergy([5]) are discussed; the views and achievements of the researchers from these macro-regions and from the JRC were streamlined as scientific findings in support to the actions in EUSAIR and EUSALP as presented by the Priority Area coordinators and Action Group leaders. Final conclusions include the main findings and recommendations.

([1]) TENtec acts as a bridge to Member States ministries and other key stakeholders (DG REGIO, DG ENV, EIB and neighbouring countries) and includes support for transport modelling of future policy and budgetary scenarios, briefings, the mapping of TEN-T/CEF co-funded projects and other layers (alternative fuels, secure and safe parking etc.), http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/index_en.htm

([2]) https://ec.europa.eu/info/departments/regional-and-urban-policy_en

([3]) https://ec.europa.eu/info/departments/mobility-and-transport_en

([4]) https://ec.europa.eu/info/departments/energy_en

([5]) annex 1 includes info about the presentations and documents of the two Workshops (transport, bioenergy).

3 Exploratory impact assessment of air pollutant emissions in CLE, MTFR and Climate mitigation scenarios on air quality and human health

Air quality is an important environmental and social issue with a strong trans-boundary character. Morbidity and premature mortality due to air pollution are associated with significant economic costs (Holland, 2014). At the same time it is a complex problem, posing multiple challenges in terms of management and mitigation of harmful pollutants from various sources and sectors. Ambient pollution by airborne fine particles with a diameter below 2.5 micrometer (PM2.5) is an important cause of premature death and ill health worldwide. Breathing polluted air has been linked to lower respiratory infections like pneumonia, cardiovascular disease – including ischemic heart disease and stroke – some cancers, and chronic respiratory diseases such as Chronic obstructive pulmonary disease (COPD).

According to a recent WHO survey in the frame of the "Health Risks of Air Pollution in Europe" (HRAPIE) project, the major pollutant emission source categories posing an emerging health risk are road transport, space heating and air conditioning and shipping (WHO, 2013).

Because of their specific climatic and geographic conditions, these sectors are particularly relevant for the Alpine and Adriatic-Ionian macro-regions, due to:

- The location of important Mediterranean harbours and shipping routes
- The vicinity of the Po Valley as hotspot for industry and road transport emissions, subject to specific meteorological conditions enforcing high winter time pollutant levels
- The role of the Alpine region as a transit region
- The wide-spread use of solid biofuel (biomass) for residential heating

In this chapter we will explore a set of air pollutant emission scenarios for the next decades (until 2050) and their impacts on pollutant levels and health impacts, with a focus on the Alpine (ALP) and Adriatic – Ionian (AIR) macro- regions.

3.1 The TM5-FASST air quality and impact model

We use JRC's TM5-FASST reduced-form global air quality model to evaluate the resulting pollutant concentrations and exposure metrics, as well as the impacts of air pollutants on human health. Although the TM5-FASST model does not provide detailed city-level exposure information, the over-all country or region-averaged attribution gives already a useful indication on how specific sectors are contributing to the pollution levels, thus providing a general framework for policy guidance.

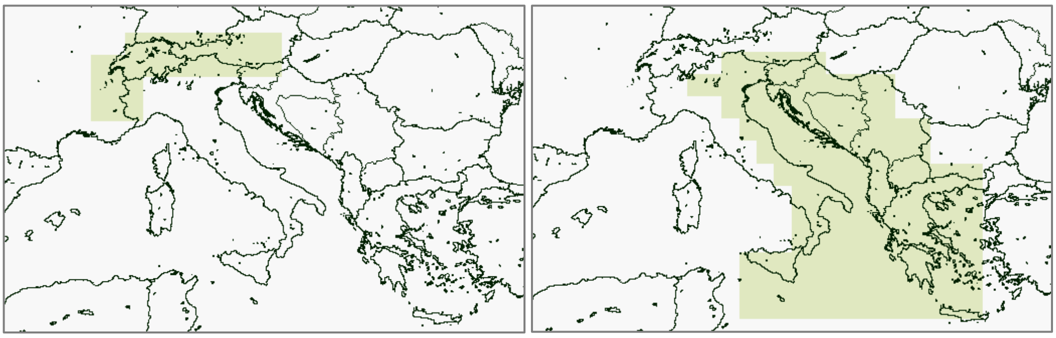
The model is described in detail in Van Dingenen et al. (2015) and Crippa et al. (2017). In brief, TM5-FASST calculates global grid maps of air pollutant concentrations and metrics at a resolution of 1°x1°, from given annual pollutant emission strengths, aggregated over each of 56 continental source regions as well as from total international shipping and aviation. The reduced-form TM5-FASST model has been previously applied in several assessments (Cohen et al., 2017; Kuylenstierna et al., 2011; OECD, 2016; Rao et al., 2016, 2017; Riahi et al., 2012; The World Bank, The International Cryosphere Climate Initiative, 2013). The TM5-CTM model, from which the TM5-FASST emission-concentration sensitivities were derived, has been described and documented in literature (Krol et al, 2005; Huijnen et al., 2010). The model results have been evaluated in model inter-comparison exercises, using in-situ, satellite and sun-photometer measurements (Textor et al. 2006, de Meij et al., 2006, Vignati et al., 2010, Van Dingenen et al., 2009).

For the present analysis we created 2 custom receptor areas corresponding to the ALP and AIR regions respectively (Figure 2) for which we will present population-weighted pollution levels and impacts, using emission scenarios described in the next section.

Population exposure was estimated by overlaying the pollution maps with gridded population projections, prepared in the context of the Global Energy Assessment (2012).

Health impacts from PM2.5 are calculated as the number of annual premature mortalities from five causes of death: ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), stroke, lung cancer and acute lower respiratory airways infections (ALRI) using the age-averaged Integrated Exposure-Response functions (IER) developed by Burnett et al. (2014), and applied in e.g. the 2010 Global Burden of Disease (GBD) study. Ozone health impacts are calculated as mortalities from respiratory disease according to Jerrett et al. (2009) and the Global Burden of Disease 2010 assessment (Lim et al., 2012).

Figure 2. Custom receptor areas in TM5-FASST corresponding to ALP (left) and AIR (right) macro-regions



Source: JRC.

3.2 Emission scenarios

Our analysis is based on sectorial pollutant emission scenarios developed by IIASA in the framework of the ECLIPSE FP7 project (Stohl et al., 2015; available on-line at http://www.iiasa.ac.at/web/home/research/researchPrograms/air/ECLIPSEv5a.html). The ECLIPSE emission set was created with the GAINS model (Amann et al., 2011) which provides emissions of long-lived greenhouse gases and short-lived pollutants in a consistent framework.

For the European Union, the current legislation (CLE) scenarios are consistent with assumptions used in the NEC revision (Amann et al., 2015). Globally gridded (0.5°x0.5°) pollutant and pollutant precursor emissions are available for SO2, NOx, NH3, NMVOC, BC, OC, PM2.5, PM10, CO and CH4. The ECLIPSE scenarios describe a few possible futures for emissions of short-lived pollutants until 2050. We consider the following scenarios: current legislation (CLE), Maximum Technically Feasible Reduction (MTFR) and Climate mitigation policies combined with CLE air quality policies (CLIM). CLE is the reference scenario, while MTFR represents the (end-of-pipe) air pollution mitigation potential, and CLIM informs about potential air quality co-benefits or trade-offs of climate mitigation policies, through the reduction of greenhouse gas emissions. The following sector disaggregation is available: energy (ENE), industry (IND), solvent use (SLV), transport (TRA), residential and commercial fuel combustion (DOM), agriculture (AGR), open burning of agricultural waste (AWB), waste treatment (WST), international shipping (SHP).

A detailed description of the ECLIPSE scenarios are given by Amann et al. (2013) and Klimont et al. (2017); in sections 2.2.1, 2.2.2 and 2.2.3 we report the major features of the scenarios considered.

3.2.1 Baseline Scenario (CLE)

In this scenario existing legislation is implemented but there is no assumption made as to how such legislation can develop further in the coming decades. From that perspective, this scenario can be considered as a rather conservative case but on the other hand it assumes that control technologies deliver expected reductions and that perfect enforcement of the laws is implemented in the modelling time horizon. Key sectors include combustion of solid fuels in the residential sector for heating and cooking, transportation with specific focus on high-emitting diesel vehicles and off-road machinery, open burning of agricultural residue, and selected industrial processes in the developing world, e.g., coke ovens, brick kilns.

3.2.2 Maximum reduction scenario (MTFR)

In this scenario the best available technology is applied to all source sectors. We refer to this scenario as maximum technically feasible reduction (MTFR). It was developed for 2030 and 2050 based on activity data as in the CLE case, but assuming implementation of technologies with lowest emission factors (as defined in GAINS). It further assumes no introduction of non-technical measures that would improve resource efficiency and lead to a significant change of energy balance. The scenario includes delays on the implementation of best technologies in some developing regions.

3.2.3 Climate mitigation scenario (CLIM)

Achieving climate mitigation goals is associated with important changes in the energy system that transitions to lower use of fossil fuels and consequently reduction in emissions of air pollutants. This scenario considers the changes in co-emissions of all substances associated with the CO2 reduction case that achieves the 2°C target. The macroeconomic and energy use projections underlying this scenario originate from the International Energy Agency (International Energy Agency, 2012) while the assumptions on environmental, specifically air pollution, policy are the same as used in the CLE scenario. This scenario follows a global CO2 trajectory similar to RCP2.6 (Van Vuuren et al., 2011) and in view of the outcome of the COP21 in Paris where 195 countries adopted the first universal climate agreement, such scenarios become even more relevant.

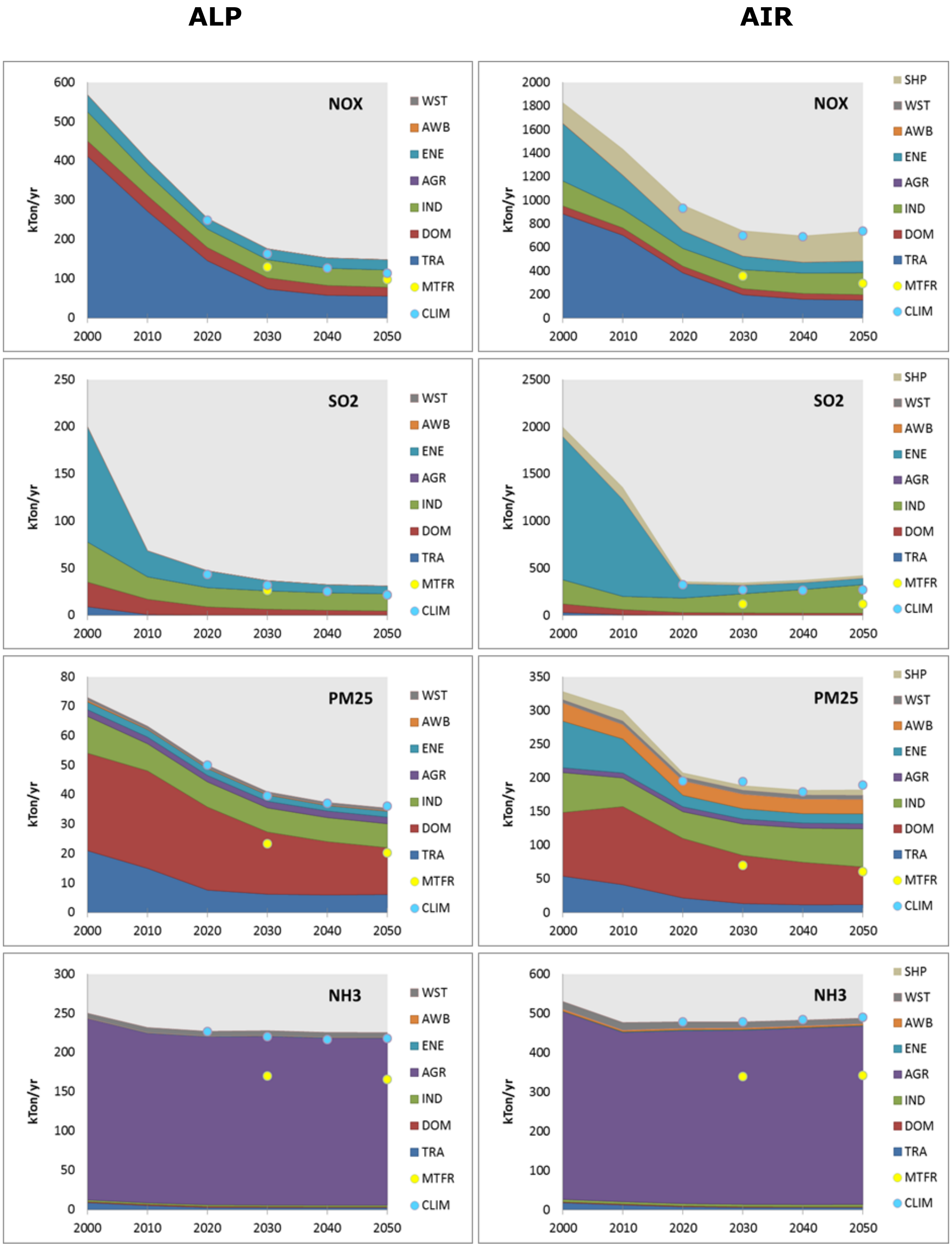
3.2.4 Pollutant emission trends

Figure 3 shows CLE emission time trends, by sector, of the major health-relevant pollutant in the macro-regions ALP and AIR respectively, for the masked grid cells shown in Figure 2. Under CLE, as expected, we observe a marked downward trend by 2030 for most pollutants, except for NH3 which is an important contributor to PM2.5 under the form of ammonium nitrate and ammonium sulphate (Maas et al, 2016). The transport sector remains the major contributor to NOx emissions till 2030, with a significant and growing contribution from shipping in the AIR region, while the domestic sector (i.e. residential fuel combustion) is the dominant contributing sector to primary PM2.5. The blue and yellow dots show the total emissions for the CLIM (2020 to 2050) and MTFR (2030 and 2050) scenarios, respectively.

The sectorial contributions to the emission reductions under the MTFR and CLIM scenarios are shown in Figure 4 for NOx and PM2.5. In the ALP region, the major mitigation potential (as shown on the MTFR scenario) lies in the surface transport, industry and energy sectors linked to their dependence on fossil fuels. This applies as well to the AIR region, but due to shipping in the Adriatic Sea, 50% of the total NOx mitigation potential is already available in the shipping sector only.

PM2.5 emission reductions via technical measures (i.e. in the MTFR scenario) can be achieved mostly in the domestic sector in the ALP region. In the AIR region, agricultural waste burning and industrial processes, together with the residential sector, have most potential for emission reductions via technical improvements.

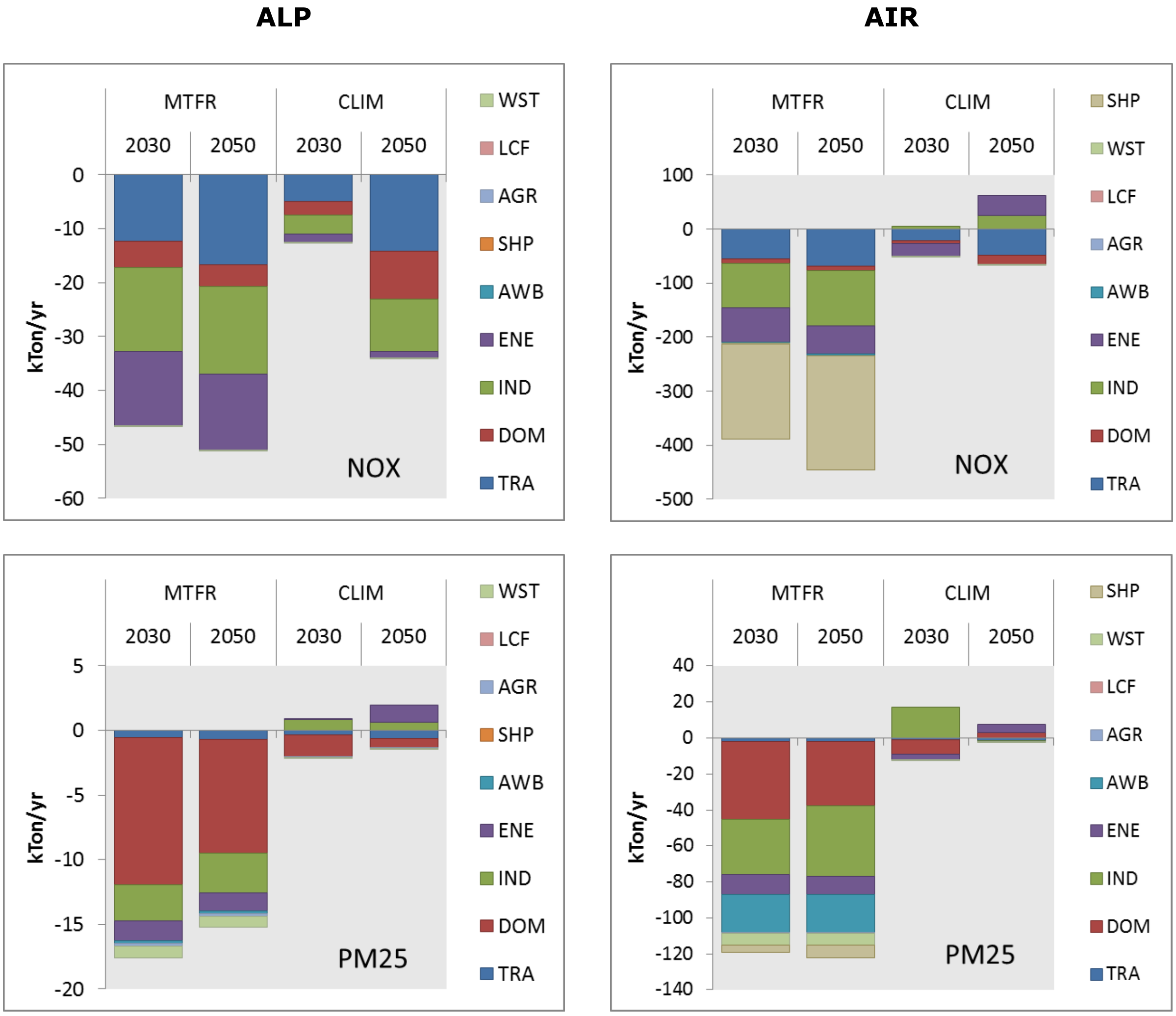
Figure 3. Major pollutant emission trends by sector under CLE for the ALP (left) and AIR (right). Dots indicate the total of all sectors for the MTFR (yellow) and CLIM (blue) scenarios respectively



Source: JRC elaboration of ECLIPSE V5a gridded emission set (http://www.iiasa.ac.at/web/home/research/researchPrograms/air/ECLIPSEv5a.html).

The link between fossil fuel combustion and NOx emissions creates a potential significant co-benefit from greenhouse gas mitigation measures under the CLIM scenario. In particular in ALP, climate mitigation efforts in the transport, industrial and power generation sectors, will substantially reduce NOx emissions by 2050, but much less so for PM2.5 due to the introduction of biofuel as climate mitigation measure. In the Adriatic-Ionian region, climate mitigation does not significantly contribute to NOx and PM2.5 emission co-benefits. In fact a trade-off in PM2.5 emissions is even expected in 2030 and throughout 2050.

Figure 4. Mitigation potential (as annual emission strength) by 2030 and 2050 for the ALP (left) and AIR (right) macro-regions, under MTFR and CLIM scenarios, relative to CLE for the same year



Source: JRC elaboration of ECLIPSE V5a gridded emission set (http://www.iiasa.ac.at/web/home/research/researchPrograms/air/ECLIPSEv5a.html).

3.3 Pollutant concentrations and impacts

The emissions of air pollutants described in the previous section are dispersed through the atmosphere and undergo chemical reactions, resulting in atmospheric concentrations of particulate matter (consisting of a mixture of primary and secondary PM2.5) and ozone. We use the JRC tool TM5-FASST to estimate the resulting pollutant concentration levels associated with the emission scenarios described above. Given the prominent role of the transport and residential sectors in the regional pollutant emissions, we will focus on those sectors. Note that we apply the global emission scenarios, hence the reported concentrations are not only a consequence of the regional in-situ emissions but also affected by long-range transport. Figure 5 shows 1°x1° resolution grid maps of PM2.5 attributed to road transport, shipping and residential burning respectively under CLE for the year 2000, as well as the maximal 6-monthly running mean of daily maximum hourly ozone (M6M) contribution from the same sectors.

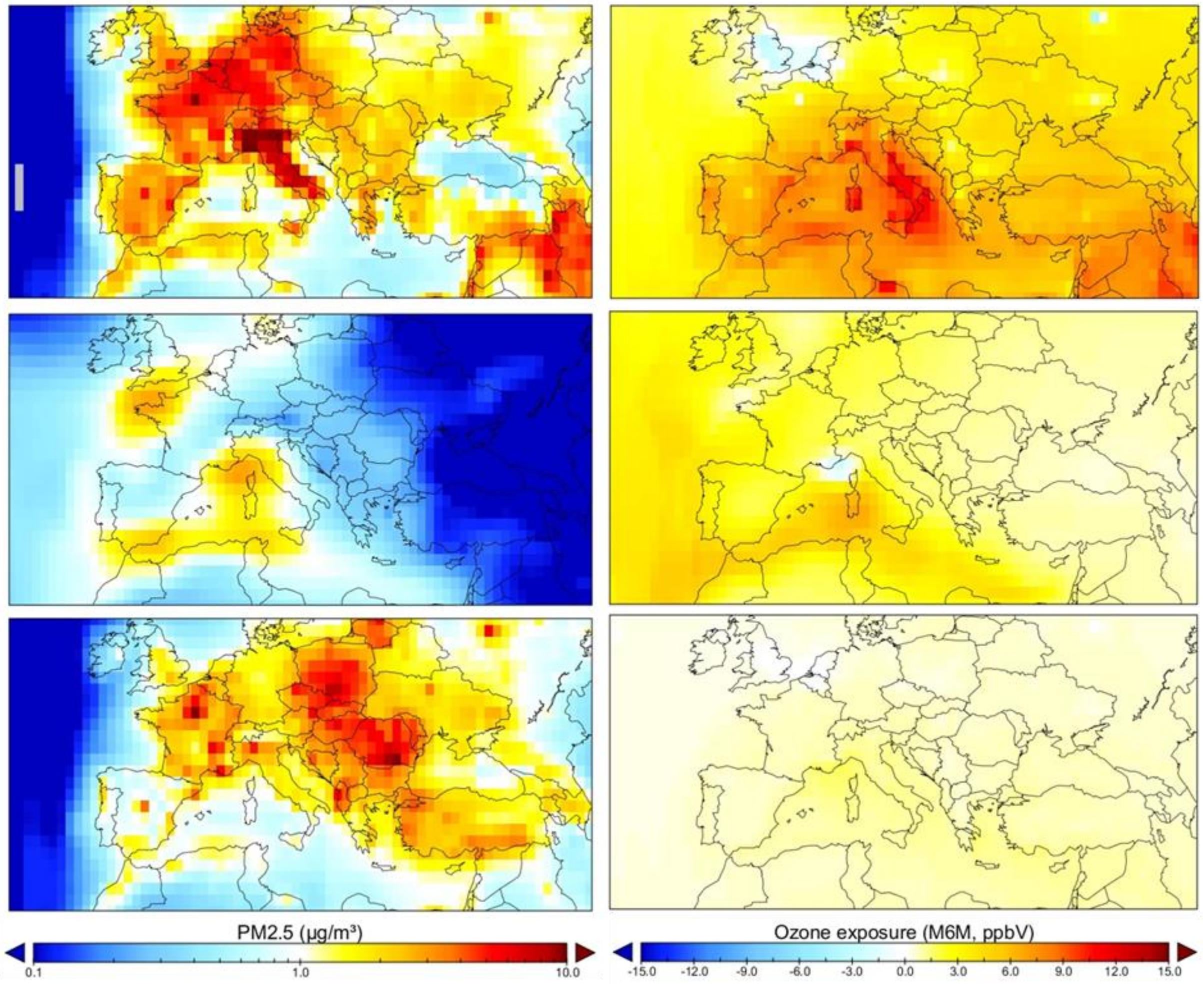
PM2.5 from transport is high over most of North-Western Europe, and in Italy, with marked hot-spots over large urbanized areas and the entire Po Valley north of the Alps. International shipping has a major influence in the Western Mediterranean basin and the North Sea, related to the density of shipping routes (Strait of Gibraltar, North Sea

Channel) and the location of large ports (Marseille, Genoa). The residential sector is relatively strongly contributing to PM2.5 in Eastern and Central Europe.

The transport sector is the major contributors to ozone, in particular over the coastal areas of the Mediterranean basin.

It has to be noted that the spatial distribution of PM2.5 within a country from individual sectors with a high primary PM2.5 contribution, like transport and the domestic sector, is biased towards areas with high total PM2.5 emissions (from all sectors), and hence the apparent urban hot spots from the residential sector are likely to be artefacts of the reduced-form approach used in TM5-FASST. In the following we will therefore only discuss region-averaged concentrations and metrics.

Figure 5. PM2.5 concentrations (left) and ozone exposure metric (right) attributed to road transport (top), international shipping (middle) and the residential sector (bottom) under the CLE scenario, for the year 2000



Note: the excess of NOx leads to titration and reduction of O3, which explains negative contributions.

Source: JRC analysis of ECLIPSE V5a CLE scenario.

3.3.1 Pollutant concentration trends under CLE

Table 1 summarizes the population-weighted PM2.5 concentrations, relative shares of the selected sectors, as well as the trend until 2050 for the ALP and AIR regions as defined by the masks shown in Figure 2 for the CLE scenario. In Europe, the CLE baseline already includes advanced air quality control policies, resulting in a significant decline in total PM2.5. In particular technical measures in the (surface) transport sector are expected to a strong decline both in absolute concentrations and in share in total PM2.5, from 22% in 2000 to 9% or less in 2030. The absolute contribution from shipping is more or less equal in both regions where it should be noted that the shipping contribution in the ALP region is mainly coming from the densely populated regions near Marseille and Genoa. Because of the general downward trend in total PM2.5 towards 2050, the relative share of the shipping sector more or less doubles from 2000 to 2050. The share of the residential sector reaches a peak value in 2020 in both regions (17% in ALP, 20% in AIR) and slightly decreases afterwards to 11% and 14% respectively.

Table 1. Mean total anthropogenic PM2.5 (population-weighted) and sectoral contributions from 2000 to 2050 under the CLE scenario for the ALP and AIR macro-regions. The values in brackets show the share in the total PM2.5.

Year	TOTAL PM2.5 (µg/m³)	TRANSPORT PM2.5 (µg/m³)	SHIPPING PM2.5 (µg/m³)	RESIDENTIAL PM2.5 (µg/m³)
	ALPINE REGION			
2000	16.2	3.6 (22%)	0.5 (3%)	2.3 (14%)
2020	11.2	1.2 (11%)	0.5 (4%)	1.8 (17%)
2030	10.2	0.8 (8%)	0.5 (5%)	1.4 (14%)
2040	9.9	0.7 (7%)	0.5 (5%)	1.2 (13%)
2050	9.9	0.7 (7%)	0.6 (6%)	1.1 (11%)
	ADRIATIC-IONIAN REGION			
2000	21.0	4.7 (22%)	0.6 (3%)	2.5 (12%)
2020	13.5	1.7 (13%)	0.5 (4%)	2.8 (20%)
2030	12.3	1.0 (9%)	0.5 (4%)	2.2 (18%)
2040	12.0	1.0 (8%)	0.6 (5%)	1.9 (16%)
2050	12.1	1.0 (8%)	0.6 (5%)	1.7 (14%)

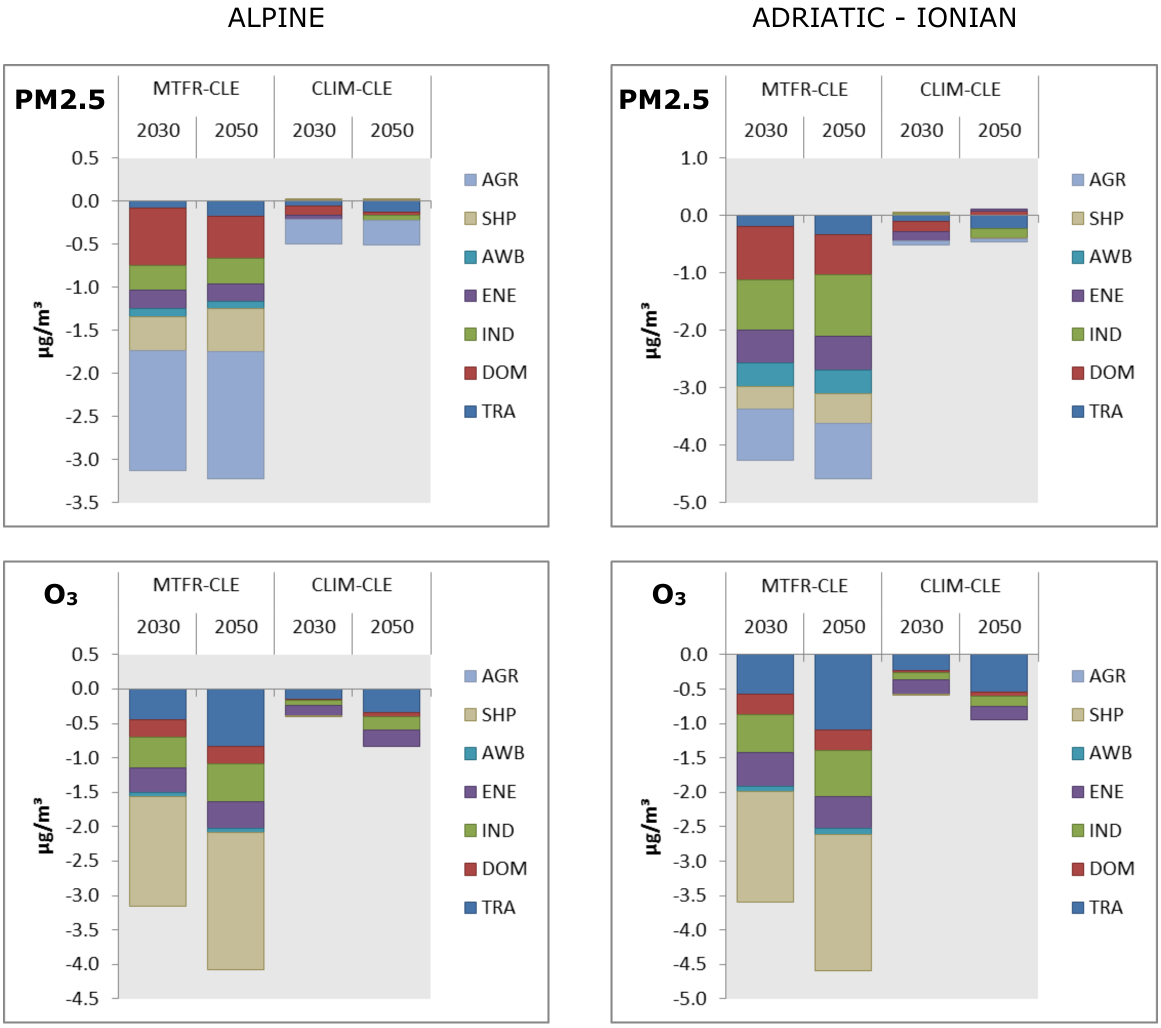
Source: JRC analysis.

3.3.2 Pollutant reduction potential under MTFR and CLIM scenarios

The MTFR emission controls would lead to a substantial improvement in PM2.5 and ozone levels. Figure 6 shows the mitigation potential, broken down by sector, by the years 2030 and 2050 for ALP and AIR. The margin for improvement is higher in AIR (total reduction in PM2.5 with 4 to 5 µg/m³ versus 3 µg/m³ for ALP) because of the less stringent timing of measures implementation in the CLE baseline for central Europe. In the ALP region, where intensive agriculture activities in the nearby Po Valley lead to strong ammonia emissions, the agricultural sector is the largest potential contributor to the improved air quality, followed by the domestic sector and shipping. The latter may be surprising at first sight as no (international) shipping emissions are happening from within the ALP region. However, long range transport from nearby Mediterranean harbours is affecting the densely populated areas at the south-western edge of the Alpine region. As described in annex 2, the alleged contribution of the agricultural sector to reduction in PM2.5 is in fact a combination of purely agricultural emissions of ammonia and nitrogen oxides emissions from fossil fuel combustion in other sectors. Regarding ozone exposure, the largest reduction potential beyond CLE for both regions comes from NOx emission reductions in the shipping sector.

Climate mitigation efforts (under CLE air quality implementation) due to the reduction of fossil fuel use lead to small net co-benefits in PM2.5 and ozone.

Figure 6. Reduction in population-weighted PM2.5 concentration (top) and ozone exposure metric M6M (bottom) in 2030 and 2050 compared to CLE for the same year. Left: Alpine macro-region, Right: Adriatic – Ionian macro-region

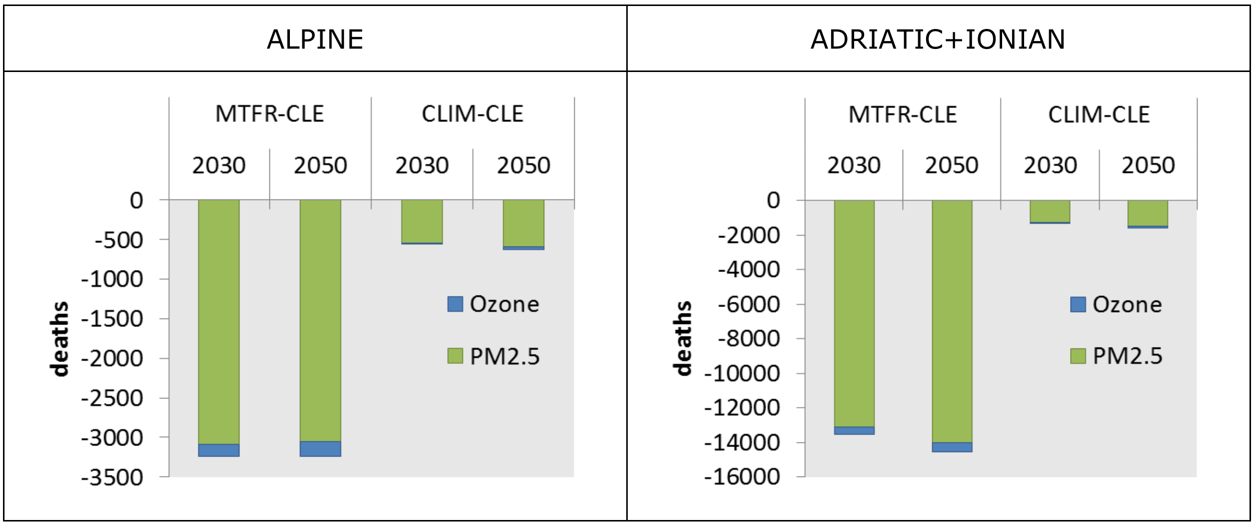


Source: JRC elaboration of ECLIPSE V5a scenarios.

3.3.3 Avoided premature mortalities from air pollution

Finally we evaluate the potentially avoided health risk under MTFR and CLIM scenarios relative to CLE. Figure 7 shows the estimated total avoided mortalities (all sectors) for ALP and AIR. The break-down by sector for both regions is given in Table 2. Most of the avoided impact is due to reduction in PM2.5, because of the inherent higher relative risk associated to the respective exposure levels. It has to be noted that a recent study by Turner et al. (2016) has reassessed the long-term health impact from ozone exposure, resulting in a factor 2 higher ozone-related mortality than the assessment based on Jerrett et al (2009) used here.

Figure 7. Reduction in premature deaths attributable to air pollution in 2030 and 2050 (PM2.5 and ozone) under MTFR and Climate mitigation scenarios, relative to CLE for the same year



Source: JRC analysis.

Table 2. Change in total annual premature mortalities from PM2.5 and ozone for MTFR and CLIM scenarios, relative to CLE from all sectors, and share of the change by sector. Numbers in red indicate a trade-off (i.e. an increase in mortalities from the associated sector).

ALPINE									
		ALL	TRA	DOM	IND	ENE	AWB	SHP	AGR
		# of deaths	Fraction by sector						
MTFR-CLE	2030	-3240	3%	21%	9%	7%	3%	14%	42%
	2050	-3240	6%	15%	10%	6%	3%	17%	43%
CLIM-CLE	2030	-556	13%	21%	0%	11%	-2%	0%	57%
	2050	-624	28%	7%	11%	-2%	0%	-2%	57%

ADRIATIC + IONIAN									
		ALL	TRA	DOM	IND	ENE	AWB	SHP	AGR
		# of deaths	Fraction by sector						
MTFR-CLE	2030	-13544	5%	21%	20%	14%	9%	10%	20%
	2050	-14523	8%	15%	23%	13%	9%	12%	20%
CLIM-CLE	2030	-1317	22%	38%	-9%	39%	-1%	-1%	12%
	2050	-1583	63%	-23%	47%	-7%	1%	2%	16%

Source: JRC analysis.

In the ALP region, the MTFR scenario leads to about 3,200 annual extra avoided premature mortalities (compared to CLE) by 2030 and 2050. For the AIR region, around 14,000 annual premature deaths could potentially be avoided by applying best available technology. In the ALP region, most benefit could be obtained from technological emission reduction measures in the agricultural sector accounting for more than 40% of the additional health benefits under MTFR compared to CLE (however taking into account that its impact is actually a combination of mostly TRA and AGR, see annex 2, followed by the residential sector (DOM), accounting for 21% (in 2030) to 15% (in 2050) of the potential benefit. In the AIR region, the residential, agricultural and industry sectors contribute about equally in the year 2030 (round 20% each), whereas by 2050 AGR and maintains its share while IND and TRA increase by 3% each and DOM decreases its share by 6%.

It has to be noted that both regions would significantly benefit from a reduction in shipping emissions following MTFR (1600 avoided annual deaths in AIR and 460 in ALP by 2050).

Co-benefits from climate mitigation are relatively small (600 and 1500 avoided premature deaths in ALP and AIR respectively by 2050). We note in particular the trade-off from DOM and ENE sectors in 2050, due to the projected change in the fuel mix with a larger contribution from biomass leading to higher emissions of primary PM2.5.

A simplified version of the TM5-FASST tool with output aggregated at regional level is available at http://tm5-fasst.jrc.ec.europa.eu/.

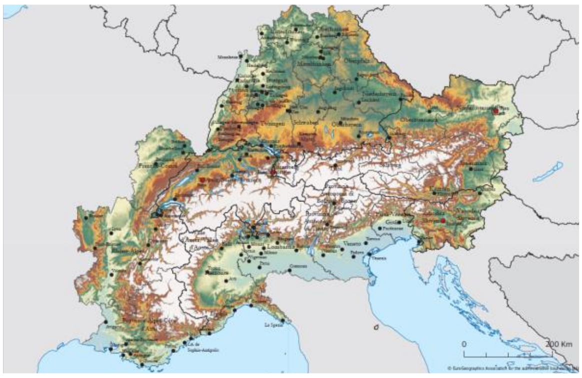
4 Challenges of clean and efficient transport in the Alpine and Adriatic-Ionian regions

In this section, first, the priorities and actions in the EUSALP and EUSAIR for transport sector are presented. Further, the focus is on the challenges covering intermodality, accessibility and reduction of emissions from ship and road transport; case studies are included. A summary of discussion and other issues are presented in annex 10.

4.1 EUSALP and EUSAIR: priorities and actions for transport sector

The Alpine area is an extremely sensitive area with rare landscapes and habitats, unspoiled areas, intact cultural historic landscapes and nature protection zones located at the heart of the European continent. These areas (see Figure 8) are valuable because of their material advantages, such as contribution to the purification of water and air, maintain biodiversity, protection against dangers, and alleviation of climatic impacts, like for example floods etc. There are also non-material benefits, for example stress reduction, leisure time recreation and enjoyment of nature, sense of identity and home, etc. for the individual and society as a whole. The EU Strategy for the Alpine Region EUSALP, launched in January 2016, addresses these issues in nine Action Groups. The overall objectives of EUSALP are to promote sustainable economic and social prosperity of the Alpine Region through growth and jobs creation, by improving its attractiveness, competitiveness and connectivity while preserving the environment and ensuring healthy and balanced ecosystems.

Figure 8. Alpine area and Alpine EU macro-region

ALPINE area	ALPINE EU macro-region
	

Source: EC/SWD, 2016.

Under the 2nd Strategic Objective of EUSALP, the partners focus on the most important challenges and opportunities concerning mobility and connectivity. The Alpine Region suffers from the negative social and environmental impacts of transalpine transport, reinforced by the specific geographic conditions. There are several major transport corridors crossing the Alps, resulting in all kinds of traffic emissions. Transport is one of the main causes of climate change. Almost thirty percent of all greenhouse gas emissions in the Alps can be attributed to transport, and both passenger and freight traffic volumes are rising continuously.

Road transport in particular causes negative externalities such as air pollution, noise and traffic congestion. This makes mobility one of the biggest challenges for the social, economic and ecological development of the Alpine Region. A coordinated approach giving way to a coherent strategy is required to tackle these challenges in order to ensure a sustainable development for the Alps. Therefore, transport needs to be made more efficient and environmentally friendly by promoting intermodality and interoperability and coordinated modal shift policies. Modal shift can improve air quality, result in CO2 reduction, it makes roads safer, keeps the region attractive for tourism and hence helps the local economies, and reduces congestion on roads (time savings for local economies). The EUSALP Action Group 4 Mobility (AG4) addresses the need for sustainable mobility solutions by promoting intermodality and interoperability in passenger and freight transport (AG4, 2017). This action group offers a platform to coordinate and harmonise the activities of Alpine regions and states for a sustainable transport and mobility system. Its mission is to build a common understanding of transport policy and mobility, to define common objectives and to launch specific activities and projects. In January 2016, the AG4 lead was awarded to the European Region Tyrol-South Tyrol-Trentino, which mandated the task to its member Tyrol for the following three years.

The AG4 gathers today 26 representatives of provinces/regions (see Table 3), national states and the civil society, meeting three times per year.

Table 3. EURLAP: framework for cooperation.

5 National States:	France, Germany, Italy, Slovenia and Switzerland
15 Regions and Provinces:	Bavaria, Burgenland, Carinthia, Central Switzerland with Ticino, Friuli Venezia Giulia, Liguria, Piedmont, Salzburg, South Tyrol, Styria, Trento, Tyrol, Veneto, Valle d'Aosta, Vorarlberg
3 Observers:	European Commission, Alpine Convention, Alpine Space Programme
3 Members in Advisory role:	CIPRA International, CEI Central European Initiative, EUROCHAMBRES

In order to address the most important challenges and opportunities concerning mobility in the Alpine macro-region, the AG4 works towards the following objectives:

- To promote inter-modality and interoperability in passenger and freight transport in particular by removing infrastructure bottlenecks, bridging missing links, coordinating timetables and interconnecting transport information as well as modernizing infrastructure. The AG4 is addressing this objective by focusing on infrastructure for sustainable transport in passenger- and combined transport as well as interconnecting public transport systems, focusing on operations and information and ticketing services.
- To support the modal shift from road to rail. The Alpine regions are particularly sensitive to negative environmental and social impacts caused by the excessive traffic flow of freight and passenger transport through the Alps. In order to tackle this challenge the AG4 promotes the harmonization and implementation of modal shift policies with a focus on toll systems.
- To develop cooperation and greater integration between the existing bodies and structures in the field of transport. The close collaboration of the AG4 with different actors involved in the transport and mobility sectors of the Alpine Regions guarantees an improved coordination and ensures consistency between existing initiatives in order to avoid duplications and encourage the alignment of funding. Strong links have already been established with the Alpine Convention, the Suivi de Zurich Process, as well as the iMONITRAF! network.

The AG4 Work Plan was finalized in March 2017 and defines the priorities and detailed activities to be tackled by members in the period 2016 to 2019; the implementation initiatives that correspond to the above mentioned priority topics are listed below.

Cross-topic initiatives (A): 1. Development of recent estimates for external costs in mountain areas, 2. Development of a common target system for AG4, 3. Public acceptance of modal shift (infrastructure and policy instruments)

Implementation of modal shift policies with a focus on toll systems (B): 1. Extension of Toll Plus proposal to other EUSALP AG 4 members, 2. From Toll Plus to an integrated incentive system for modal shift, 3. Link between pricing systems and the use of innovative technologies. The objective action is to build a common understanding for coordinated modal shift policies and develop a harmonised pricing system (extension of Toll Plus proposal to Alpine corridors) to reduce environmental and social impacts of transalpine freight transport.

Infrastructure for sustainable transport (C): 1. Infrastructure for passenger transport (supplementary rail connections), 2. Infrastructure for combined transport (terminals). The objective of this action is to remove infrastructure bottlenecks in passenger and freight transport for improved connectivity and accessibility in the Alpine region, strengthening regional transport systems and the use of public transport.

Interconnecting public transport systems (D): 1.Interconnecting public transport operation, 2. Interconnecting public transport information and ticketing. The objective of this action is to bridge missing links in passenger transport by integrating transport systems across national and regional borders, focusing on operations and information and ticketing services for improved interoperability and intermodality.

The AG4 organizes meetings to discuss the implementation of the Work Plan, and annual Mobility Conferences offering a platform for dissemination and interaction with the wider public, stakeholders, the press as well as the political level.

The Adriatic and Ionian EU macro-region includes four member states (Italy, Croatia, Greece and Slovenia) and four non-EU countries (Albania, Montenegro, Serbia and Bosnia Herzegovina) as illustrated in Figure 9.

Figure 9. Adriatic and Ionian EU macro-region

Source: EC/SWD, 2016.

The European Council approved the European Union strategy for the Adriatic and Ionian region (EUSAIR) in October 2014. It aims at promoting the economic and social well-being in the Adriatic and Ionian macro-region, by fostering employment, improving its appeal, competitiveness and connectivity while protecting the environment and ensuring the safety and balance of the seacoast ecosystems. The EUSAIR includes four thematic pillars and crosscutting issues such as capacity building, research and innovation and SMEs development. The governance mechanism of this strategy has two levels: 1. political level represented by the Governing Board, which coordinates the work of the four Thematic Steering Groups that are in charge of implementing the EUSAIR Action Plan through the identification of measures and projects of macro-regional added value, and 2. the technical level represented by the Thematic Steering Groups.

Pillars address the core challenges and opportunities identified as being of central importance for the Adriatic-Ionian region. Topics and related specific objectives represent the main areas where the macro-regional strategy can contribute to improvements. The topics are addressed by different actions carried out by countries and stakeholders; these actions are included in an action plan, in which the projects are presented by way of examples to stimulate further initiatives, as the Strategy progresses and as new ideas emerge, and to illustrate what is needed.

Pillar 2 "Connecting the Region", has as objective to improve connectivity within the Region and with the rest of Europe in terms of transport and energy networks. This requires thorough coordination of infrastructure works and improved operation of transport and energy systems between the countries in the Region (EUSAIR, 2017).

The Transport Subgroup Group (TSG2) of Pillar 2 was established in November 2016; it selects priority actions and approves measures, project proposals, specific criteria, and the list of labelled projects. TSG2 includes "Transport" and "Energy" subgroups. The topics addressed by TSG2-Transport subgroup are: 1. Maritime transport that focuses on maritime safety and security and competitive regional intermodal port system and 2. Reliable transport networks and intermodal connections with the hinterland for freight and passengers.

Priority actions for maritime transport:

- Improving and harmonizing traffic monitoring and management by implementing an integrated Adriatic and Ionian common VTMIS, the related alerting system and the common training and certification schemes of the operators.
- Developing ports, optimizing port interfaces, infrastructures and procedures/operations by establishing a common framework for the development of: 1. Internal and external port infrastructures to support the ports' intermodality and related Short Sea Shipping transport by aligning them with TEN-T requirements, 2. Single Window systems allowing exchange of information between the ship and the competent authorities and operators for streamlining administrative procedures (e.g. customs clearance, phytosanitary controls, etc.), 3. Green shipping solutions as the necessary facilities for bunkering with alternative fuels (LNG) and cold ironing in Adriatic-Ionian ports.

Priority actions for Intermodal connections:

- Developing the Western Balkans transport network by supporting the TEN-T extension (Networks and Corridors) to the WB - taking into account the so-called "Berlin process" - by identifying and developing infrastructure projects aimed at complementing the networks with intermodal and strategic links improving the connectivity in the Adriatic Ionian region.
- Developing motorways of the sea by Identifying transnational IT tools for tracking and tracing of ITUs (Intermodal Transport Units) using MoS (Motorways Of the Sea) in the Adriatic Ionian region, supporting intermodality through its integrated with inland terminals and port / inland operators and improving last mile connections.
- Cross-border facilitation by 1. Adoption of common administrative procedures at border crossings (e.g. for security, phytosanitary and custom controls) and implementation of small and target scale investments and joint training programmes, 2. Facilitation and implementation of rail services (passengers and freight) and

simplification of crossing border procedures among Member State and non-UE countries.

The actions of Pillar 2 crosscutting issues supporting TSG2-Transport are removing barriers for the mobilization of cross border investments in transport, and development of a joint lifelong plan and training tools.

Four project categories are considered for the selection of projects with macro-regional relevance considers: 1. Last-mile connections (rail and road) [project cluster: Cross border, hinterland, last mile connections], 2. Intermodality and accessibility within the port nodes [project clusters: Motorways of the sea and Ports development], 3. Smart & Green solutions (land and seaside) [project cluster: LNG], 4. Maritime and Inland shipping security and sustainability [project clusters: Inland waterways, Motorways of the sea and LNG]. The specific criteria are 1. Finalization of the infrastructural interventions on the TEN-T axis, 2. Interconnection between the main TEN-T axis and the nodes, with a particular attention to last mile connections, 3. Reinforcing the role of ICT in order to overcome current infra and info structural gaps, 4. Interoperability and intermodality between different modes of transport, 5. Promotion of green transport solutions (land and sea side) and 6. Safety and security solutions in transport. The selected projects, included in clusters, are consistent with both general and specific criteria, having a macro-regional impact. The list is open to additional projects and integration, which will be elaborated in the future as soon as other measures/projects will be identified and labelled by TSG2.

4.2 Intermodality and accessibility indicators

There is a need to focus and develop intermodal transport in Europe since, for example, for inland waterways transport there are no significant improvements in modal share and navigability conditions since 2001, despite the funding allocated and investments (ECA, 2015). In this section, we present the actions to promote inter-modality and interoperability in passenger and freight transport in particular by removing infrastructure bottlenecks, bridging missing links, coordinating timetables and interconnecting transport information as well as modernizing infrastructure in Alpine macro-region. However, intermodality and green solutions in transport are on the agendas of both EUSALP and EUSAIR. Accessibility and air quality thematic indicators are also presented for Europe.

4.2.1 Intermodality in passenger transport: good practices

The AG4 of the EUSALP is addressing this objective by focusing on infrastructure for sustainable transport in passenger and combined transport as well as interconnecting public transport systems, focusing on operations and information and ticketing services. For passenger transport, intermodality is addressed in the Work Plan in particular under activity D2 "Interconnecting public transport information and ticketing". This activity aims at harmonising, across regional and national borders, the different existing but in many cases not interoperable information, tariff and ticketing systems. This should enable passengers to get coherent information about their journeys, to buy tickets valid for all operators along their entire itineraries and update themselves online about real-time information on possible delays and, if necessary, about travel alternatives. The objective of this activity is to connect the different existing platforms to create an integrated travel information system in the EUSALP territory, facilitating interoperability of the different information systems in order to provide better connectivity to travelers, both inhabitants of the Alpine region and tourists. The overarching aim is to promote sustainable modes of transport, facilitating door-to-door mobility and making public transport and soft modes more attractive versus the individual motorised transport. The outcome should be a common journey planning system for the Alpine region that includes real-time information as well as touristic information where possible, providing travelers with comprehensive information about sustainable means of transport across and beyond regional and national borders. This would entail the provision of real-time information through a single portal for the territory of EUSALP, including last mile solutions (public transport, walking, cycling, bike rentals, taxi, on-demand transport etc.). Developing this activity in the frame of EUSALP can serve as a pilot to be enlarged at a larger scale on an EU-wide dimension, connecting passenger information systems and providing cross-border, multimodal door-to-door solutions.

4.2.2 Intermodality in freight transport: good practices

The activity "Infrastructure for combined transport (terminals)" (ALP/AG4, C2) focuses on intermodality in freight transport with the objective to improve efficiency of logistics systems through appropriate infrastructure for combined transport. The principle of combined transport is that long-distance, mainly international transport of goods is subdivided into a long-distance transport part on rail (or another sustainable mode) and intraregional collection and distribution of goods for the last mile, which is the shorter distance, carried out on road. The hubs of such logistic chains are multimodal terminals (or ports), typically at a central location within a region. Overall, combined transport is more sustainable than transport on road only, however time and cost of transhipment are obstacles against this form of transport, as well as the fact that it pays off only if there is a sufficient bundling of goods along the railway section.

Measures can comprise all components relevant for the logistic chain, i.e. improving infrastructure and operation and applying smart technologies, as to achieve a selection of proposals: 1. Increasing capacity of rail-road terminals and their accesses, both on rail and on road, 2. Optimising transhipment procedures in the terminals, 3. Controlling and monitoring the whole transport chain by means of smart ITS technology.

This activity foresees to establish a methodology to determine, in every particular case, if such improvement of logistic chains would be socio-economically and environmentally justified. The corresponding targets shall be in line with the overall target system developed in activity "Development of a common target system for AG4" (A2). This methodology shall be applied on the examples collected from AG4 members, so far, and on possible additional projects, with the goal to assess if they are worth to be implemented, from a socio-economic view.

4.2.3 Accessibility and air quality: thematic indicators

Territorial developments such as urbanisation affect air quality directly, for example through increased intensity of activities but also indirectly, for example through changes in transport demand; complex tools are needed to evaluate the impacts of territorial changes on air quality.

The JRC develops a complex territorial modelling system for clean and efficient transport policies. It can simultaneously produce quantitative outputs related to policy goals such as improving accessibility and improving air quality; the Land-Use-Based Integrated Sustainability Assessment (LUISA) modelling platform (see description in annex 3) is set up to execute ex-ante impact assessments of EC policies with a territorial impact. The projected territorial patterns cover all EU Member States and several Western Balkan countries at a detailed geographical resolution (100m), typically until 2050.

It can be argued that one of the challenges of transport policies lies in the conflict between the opportunities offered by fast transport systems, and the negative air quality effects that fast transport modes may have. To measure the effects of any policy on interaction opportunity, a wide range of accessibility-related indicators is available in the LUISA platform. Some of those indicators describe opportunity, namely potential, daily and location accessibility (Jacobs-Crisioni et al. 2016), other indicators describe urban form efficiency, namely average travelled distances and ease of access to public transport facilities (Jacobs-Crisioni et al. 2015). Yet others describe quality of life aspects, such as distance to modelled facilities, or network efficiency.

Within the environmental domain, several indicators regarding air quality are derived based on primary LUISA outputs. As a first step, EU-28 wide maps of pollutants of main concern are derived from land use regression models; for a detailed description please refer to Vizcaino et al. (2017). These models are developed using proxies of pollution (distribution and intensity of human activities, population density, proxies of traffic levels, and terrestrial emissions disaggregated from different GAINS scenarios) as independent variables and have been fitted using values of concentration measured in monitoring stations as dependent variable. By combining resulting maps of levels of pollution with maps of population, it is also possible to derive levels of population exposed to concentrations over limits established by current legislation. The availability of spatially explicit projected input variables allows also for forecasting trends of pollution under different emission-reduction scenarios. An illustrative example of the usefulness of the LUISA model platform in general and of the air quality model in particular for ex-ante evaluation of regional, national or supranational policies is shown in Figure 10. It presents results of annual average NO2 concentration in Europe for 2010 (left), and for 2030 under different scenarios of NOx emissions, with high (center) and moderate (right) emission reductions from the GAINS model (IIASA, 2016).

Figure 10. Maps of NO2 annual average concentrations in 2010 (left) and 2030, under the PRIMES 2013 REF-CLE (centre) and ECLIPSE v5 Baseline Scenario (CLE) (right) scenarios of emission.

Source: JRC analysis.

In all cases, maps of concentrations follow patterns of distribution related to urban and industrial activities, population density and traffic intensity. Regional hot spots of concentrations are located in several areas in Europe with high industrial or traffic levels, and these areas will remain the places at highest risk in the future. At a local scale, redistribution of population and traffic intensity will play an important role in the levels of concentration and population affected.

4.3 Reduction of emissions from ship transport

The emissions from navigation (shipping) are significant in the Mediterranean Sea (EEA, 2013). As mentioned also in Chapter 3 of this report, these emissions affect the air quality and human health in the areas covered by EUSALP and EUSAIR.

In this Chapter, we present case studies related to emissions of ships in ports located in Alpine and Adriatic-Ionian macro-regions, green ports and maritime shipping, and lessons learned from the Northern European SECA area for the Ro-Ro sector.

4.3.1 Emissions of ships in ports

Air pollution is nowadays recognized as the first environmental health hazard (Lelieveld et al, 2015); among the different air pollutants, fine particulate matter (PM2.5) constitute the major risk factor. Numerous anthropogenic activities and natural phenomena contribute to the atmospheric budget of fine particles. Recently, new studies have emerged, reporting associations with both short-term and long-term exposure to NO2.

There was a general consensus to update the current WHO Air Quality Guidelines for NO2 based on the amount and quality of the new evidence from different studies, which might result in a numerical recommendation below the current annual guideline value (WHO, 2015; WHO, 2017). Studies already made in Mediterranean urban areas highlighted the importance of secondary organic aerosol formation (Lelieveld et al. 2002, 2012; Minguillon et al., 2016); the influence of shipping emissions is suspected to be significant, especially in the Western Mediterranean basin (Marmer et al., 2009), their overall impact on urban air quality is still barely known.

There is a large number of ports in Europe, often with big cruise terminals, that are fully integrated into the city. Therefore, in port emissions contribute to background pollutants concentrations on large areas of the city to which emissions from road traffic are added, leading to the exceedance of air quality limits, particularly for nitrogen oxides. Considering that this activity sector will significantly grow in a near future (EEA, 2013), this issue must be addressed to develop efficient abatement policies. Air pollution and its impact on the development of coasts is a common matter for the major Mediterranean harbour zones. On the other hand, maritime transport regulations are a cross-border issue being mainly ruled by the International Maritime Organization and the EU at the European level. Hence, air pollution derived from maritime transport must be addressed through a transnational approach.

4.3.1.1 Case studies of ship emission impacts in ports in the Adriatic-Ionian and Alpine macro-regions

The European project APICE (Common Mediterranean strategy and local practical Actions for the mitigation of Port, Industries and Cities Emissions) has focused/worked on emissions mitigation by bringing together five main Mediterranean ports (Venice, Genoa, Marseille, Thessaloniki, Barcelona), both from a scientific and a policy perspective, and has expressed main common features in the Common Transnational Strategy (see http://www.apice-project.eu/). This planning document is the result of putting together the common measures of the five local action plans.

Another European project, CAIMAN (Cruise and passenger ship Air quality Impact Mitigation Actions, http://www.medmaritimeprojects.eu/section/caimans) is dealing with the impact of passenger ships in the same five ports. Within this project it was found that considering air quality limits set by the current European legislation in order to protect human health, the hourly nitrogen dioxide (NO2) concentrations are those of major concern among all air pollutants emitted by passenger ships. The shift to a passenger ship fleet with engines fuelled by Liquefied Natural Gas (LNG) was found to be a very effective air quality mitigation scenario for the foreseen growing emissions in maritime touristic traffic. In general terms, it was concluded that European and international policies on fuels, engine technologies and ship emission abatement, by acting on a wider domain, could be very effective in the mitigation of negative impacts on public health and the environment; on the contrary, local regulations on these issues could penalize single harbours that try to reduce ship impacts on a local scale. Nonetheless, planning strategies on the local scale could be more effective in implementing specific mitigation actions, such as displacement of ship terminals or manoeuvring routes, which could significantly reduce the population exposure.

Specifically for **Adriatic and Ionic Sea ports,** two projects were concluded. These projects were focused on in-port ships impact on local air quality in four port-cities (Venice, Brindisi, Rijeka, and Patras): “Contribution of Emission Sources on the Air quality of the Port-cities in Greece and Italy” (CESAPO, Interreg Greece-Italy 2007-2013, www.cesapo.upatras.gr) and “Pollution Monitoring of ship emissions: an Integrated approach for harbours in the Adriatic basin” (POSEIDON, Programme MED 2007-2013, http://www.medmaritimeprojects.eu/section/poseidon Poseidon (2015)). The analysis was performed using a comparable approach in the different areas that integrates emission inventory analysis, measurements and dispersion modelling (Merico, 2017).

The emission inventories for the four port-cities indicated that maritime emissions of particulate matter and NOx are comparable with those of road traffic. Considering the increasing trend of maritime traffic in the next years, it follows that this pollution source needs to be taken under serious consideration in the area by national and regional governments and by the European authorities.

The impacts of ship traffic in the four port-cities are summarised in Figure 11. The impact on PM2.5 concentrations vary between 0.4% and 7.8% while that on PM10 ranges between 0.3% and 5.8%. The impact is larger (between 6% and 26%) on ultrafine particles number concentrations (PNC, including ultrafine particles with diameter less than 100 nm). Particles of this size are currently not considered in the European and national legislations and there is a limited amount of available data, however, concentrations of such particle sizes are a better metric for evaluating the impact of this type of pollution source and for monitoring the inter-annual trends in the future (Merico, 2016; Donateo, 2014).

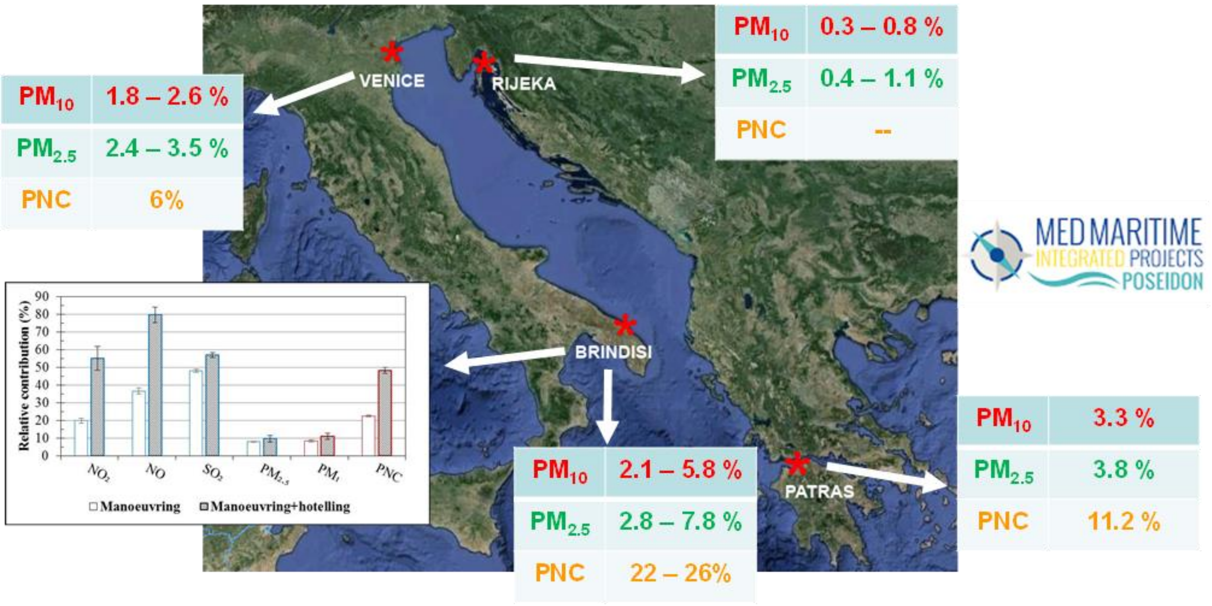
The impact on gaseous pollutant concentrations (NOx and SO2) is 3-5 times larger than that on PM2.5 and PM10. At short distance from the harbour the impact on NO concentration is larger than that on NO2 (a parameter included in air quality legislation standards). However, modelling indicates that at higher distances from the harbour NO is oxidized to NO2, so that maritime emissions could impact significantly on NO2 concentrations in urban areas located near harbours. Impact on total PAHs concentrations (gas plus particulate phases) was between 60% (Brindisi) and 80% (Venice). The impact on gaseous phase PAHs is larger than that on particulate phase (Donateo, 2014; Contini, 2011; Gregoris, 2016). In Venice, shipping impact on metals contained in PM10 was also relevant, ranging from 24% to 35% (Gregoris, 2016).

The analysis performed showed that the use of low-sulphur content fuels in ships has proven to be efficient in reducing the impact on primary particles concentration, in addition to SO2 concentrations and sulphates, also as consequence of local regulation in specific ports (Cesari, 2014; Contini, 2015). However, it had a limited effect on other pollutants like NOx, metals and PAHs. Future actions in the Adriatic-Ionian macro-region and/or at European level could concern the improvement of the international legislation or guidelines to curb ship emissions of these pollutants.

Impact of pollutants released by harbour-related activities (hoteling, loading, unloading of ships) represents an important share of the impact of maritime activities on air pollution (Figure 11). Development and application of guidelines and legislations specific for logistic management of harbours could be important for local air quality in port-cities. This suggests the importance of consolidating a network, at international scale in the Adriatic-Ionian macro-region, among the local and environmental authorities, the research institutions and the public to foster common, large scale, actions for curbing air pollution impact of maritime transport while still maintaining competitiveness in economic, commercial and tourist development of the coastal areas.

Specifically for **Ligurian and Balearic Sea ports,** similar studies were performed. Air pollution for several Italian ports and possible control measures were studied by Techne Consulting. The Ravenna and Taranto Adriatic-Ionian ports are included in the national study while the Genoa, La Spezia and Savona ports are included in the Liguria regional study; the emissions reductions in ports allow to obtain a very important contribution to reduce overall urban emissions (see annex 4). In Marseille, the port has experienced a strong increase in both container transport and passenger transport; the studies performed by AirPACA provide an insight on population exposure related to NOx from ship emissions. The findings are presented in annex 4.

Figure 11. Estimates of the relative contributions of ship to measured concentrations at the four different towns. PNC represents the particle number concentrations (size range 0.01 – 1 µm)



Source: Merico et al. (2017).

4.3.1.2 Green port development: a case study

In Sustainable Ports - A Guide for Port Authorities (PIANC, 2014), "Green Port" is defined as a port in which the port authority and port users pro-actively and responsibly develop and operate, based on an economic green growth strategy. Lam and Notteboom (2012) indicate impacts caused by ports in three groups: air pollution, water pollution and the maintenance and upgrading of port infrastructure, causing a high impact on marine ecosystems due to dredging and civil works. The problems are also emissions from ships, from port equipment and port operations, and from seaborn trade handled in the ports (Gibbs at all 2014). They propose actions for reducing these emissions by using green ships, by vessel speed reduction and by on shore power supply.

To achieve the concept of development for green port it is necessary to integrate environmentally friendly methods of port activities, port operations and management.

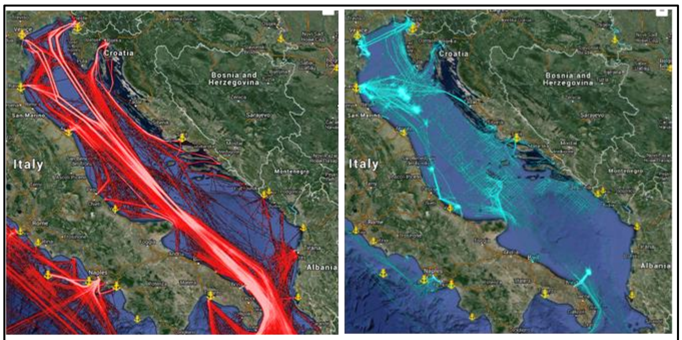
Port of Trieste, Venice, Koper and Rijeka are members of North Adriatic Ports Association (NAPA). The geographical position of these ports is crucial since they are on the Adriatic Baltic Corridor and Mediterranean Corridor.

As illustrated in Figure 12, the traffic in Adriatic Sea is very intensive and most of the ships are directed to the ports of the North Adriatic.

Special attention has to be given to the Port of Trieste, with the biggest oil terminal in the Adriatic and to the Port of Koper, with the biggest container terminal. Even though the total cargo throughput has increased, the number of ships is smaller (see annex 5). This means that ships that are now coming to those ports, are much bigger than they were in the past, which is why ports have to be prepared for that by purchasing new equipment and dredging (Twrdy et al, 2013).

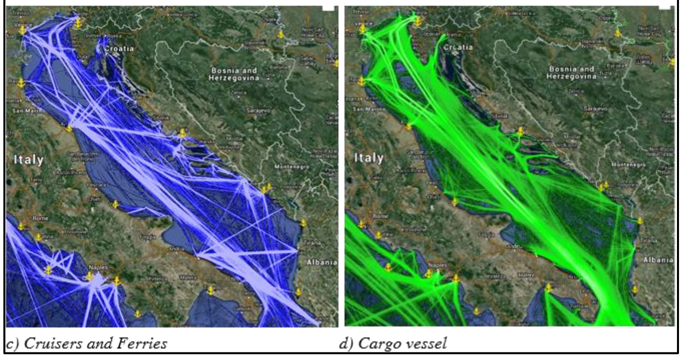
Development of transport and logistics sector in this part of Europe depends mostly on the NAPA ports as one of the most important creators of traffic flows. The economic effects of port activity are reflected in direct surroundings and wider environment, as ports present a generator for economic development. For the application of the „Green Port" concept it is necessary to include the term „green" growth in the port development of all these ports. Therefore, there is a need for the implementation of policies relevant for reduction of the emissions of harmful substances to the atmosphere and to the sea, the appropriate landscape design with trees that absorb the noise and pollution, use of renewable energy for port operations and activities (solar, wind, energy from the sea), and recycling.

Figure 12. Traffic in Adriatic Sea for the period 16.7.2015 – 31.7.2015



a) Tankers

b) Service vessels



c) Cruisers and Ferries

d) Cargo vessel

Source: Perkovic et al. (2016a).

Some of the ports have already put a lot of effort in this direction, the most successful is the Port of Koper as they develop some new technological solutions for environmental protection, prepare research in areas involving technology and ecology, with particular emphasis on renewable energy sources, natural resources, waste management solutions and the preservation of marine and coastal ecosystems.

4.3.2 Emissions from maritime shipping

4.3.2.1 Logistical and environmental considerations in container shipping

Reduction of emissions of air pollutants from shipping is a main issue in the Adriatic and Ionian Region and, as discussed in previous sections, also of relevance to the Alpine Region. The classical breakdown of measures to reduce maritime emissions divides such measures into the following three major classes:

- Technological measures include more efficient engines, ship hulls and propellers, cleaner fuels, alternative fuels, devices to trap exhaust emissions, energy recuperation devices, "cold ironing" in ports, various kites, and others.
- Logistics-based (tactical or operational) measures include speed optimization, optimized weather routing, optimal fleet management and deployment, efficient supply chain management, and others that impact the logistical operation.
- Market-based measures (MBMs). These can be a levy on fuel, an Emissions Trading Scheme (ETS) or others.

Regarding CO2 emissions, a break down from the world commercial fleet by ship type-size combination (Psaraftis and Kontovas, 2009) is presented in annex 6; fleet data is from the IHS Fairplay database and the base year is 2007 (45,620 commercial ships accounted for).

According to this analysis, containerships are the top CO2 emitters in the world fleet. This is perhaps something to be expected, given the relatively high design speeds of these vessels (20-26 knots) as opposed to those carrying bulk cargoes (13 to 15 knots) and given the nonlinear relationship between speed and fuel consumption and hence emissions. What is perhaps not so obvious to expect and can be seen in annex 6 is that just the top tier category of container vessels (712 vessels of 4,400 TEU and above) are seen to produce 110.36 million tonnes of CO2 emissions, which is higher than the 106 million tonnes produced by the entire crude oil tanker fleet (2,028 vessels). This means that if ship speed were to be reduced, perhaps uniformly across the board, or even selectively for some categories of vessels, emissions would be reduced too.

Reducing speed could also have important side benefits: cost reduction is one, and helping a depressed market in which shipping overcapacity is the norm these days is another. In that sense, reducing ship speed may conceivably be a 'win-win' proposition. In Giovannini and Psaraftis (2017), a model was developed for a fixed route containership scenario which, among other things, incorporates the influence of freight rates, along with that of fuel prices and cargo inventory costs into the overall decision process, including ship speed, frequency of service and number of ships deployed. The objective to be maximized is the operator's average daily profit. Illustrative runs of the model are made on three existing services. CO2 emissions of the fleet are also computed. An important contribution of the model is that service frequencies different from the standard assumption of one call per week were also considered. Even though this is well outside the current spectrum of practices in the liner sector, the potential benefits of an enlarged set of alternatives as regards frequency were investigated. In that sense, it was shown that the cost of forcing a fixed (weekly) frequency can sometimes be significant. This cost is attributed either to additional fuel cost if the fleet is forced to sail faster to accommodate a frequency that is higher than the optimal one, or to lost income if the fleet is forced to sail slower to meet a lower than optimal frequency.

Turning now from ships to intermodal, relevant references that explore win-win solutions for the intermodal transport chain include, among others, EU FP7 project SuperGreen on green corridors (www.supergreenproject.eu), and a recent book on green transportation logistics (Psaraftis, 2016).

4.3.2.2 The implications of sulphur regulations in the Northern European SECA area for the Ro-Ro sector: lessons learned

The idea of turning the Mediterranean into a Sulphur Emission Control Area (SECA) is widely discussed. Panagakos et al. (2014) investigated some possible scenarios regarding impacts on emissions and modal share. In this context it may also be useful to look at the experiences obtained within the Northern European SECA.

The RoRoSECA project was a project whose main objective has been to identify and assess possible technical, operational, regulatory and financial measures for the mitigation and reversal of the negative repercussions of environmental legislation to the market shares of RoRo shipping in Northern Europe. The project's main sponsor was the Danish Maritime Fund, with the Orient's Fund providing supplementary funding.

Before the introduction of new limits for the content of sulphur in marine fuels within the European Sulphur Emission Control Areas (SECAs) as of 1/1/2015, gloom and doom was the industry mood: there was wide concern that RoRo and other short sea shipping companies operating in these SECAs would face substantial additional costs, which would put their routes and services at risk. In fact, some companies shut down some of their routes, in anticipation of the new regime. IMO's MARPOL Annex VI and EU Directive 2012/33/EU (amending Council Directive 1999/32/EC) stipulate, among other things, a 0.1% limit in the sulphur content of marine fuels, or equivalent measures (such as scrubbers) limiting the percent of SOx emissions to the same amount. As low-sulphur fuel (Marine Gas Oil-MGO or Marine Diesel Oil-MDO) is substantially more expensive than Heavy Fuel Oil (HFO), there is little or no room within the RoRo companies current margins to absorb such additional cost. Unlike its deep-sea counterpart, in short-sea shipping a freight rate increase may induce shippers to use land-based alternatives (mainly road). A reverse shift of cargo would go against the EU policy to shift traffic from land to sea to reduce congestion, and might ultimately (under certain circumstances) increase the overall level of CO2 emissions along the entire supply chain.

Things turned out differently however: the significant and largely not anticipated drop in fuel prices after mid-2014 alleviated and to some extent masked the impact of the new legislation. Still, and as fuel prices can rise again, the same questions and concerns pertain. After two years of research, and in collaboration with DFDS, the RoRoSECA project developed a set of tools that can help both RoRo companies and policy makers address the following issues (among others):

- What is the economic impact of the new legislation?
- What is the environmental impact of the new legislation?
- What may be possible modal shifts?
- What measures can the RoRo operator take to mitigate and reverse the situation?
- What policy measures are deemed the most appropriate?

This project has been the first attempt to examine the effects of the new SECA limits, and the project managed to dissect them from the record low fuel prices that were observed in the last two years. The main conclusions of the project can be summarized as follows.

- Maritime shares actually increased due to observed low fuel prices
- Maritime shares would have increased further if HFO were still allowed
- Maritime shares would drop if fuel levels returned to 2014 levels
- Slow steaming may be a good mitigation measure, but reducing speed is limited by logistical constraints. In 2016 certain routes actually sped up.
- Frequency of sailing service can be used to improve load factors
- Swapping vessels in some routes can help with load factors
- Investing in scrubbers critically depends on fuel prices and level of subsidies
- The freight rate is the most important component for the shipper, as opposed to transit time, which was deemed not so important
- Typical annual cost for full mitigation of adverse effect is 2M€ per route
- Policy measures are sensitive to fuel price
- BAF (Bunker Adjustment Factor), eco-bonus, and internalization of external costs have similar effects

Potential users of the models developed by DTU include RoRo operators, intermodal operators, other short sea shipping companies operating in ECAs, and maritime policy makers including the EU. For more details see Zis and Psaraftis (2017). All results of this project can be found at www.roroseca.transport.dtu.dk/dissemination.

4.4 Reduction of emissions from road transport

Reduction of emissions from road transport is on the agenda of policy makers in the two macro-regions. In this section we focus on different options such as electrification, technology, and biofuels; the findings in some case studies are also presented. The framework for developing official emissions inventories is described in annex 9.

4.4.1 Electrification of road transport

In order to enable transport emissions reduction in Europe and to meet the Kyoto protocol objectives, the EC White Paper 2011 sets the de-carbonisation of transport as a priority, defining ten goals to be achieved over the next twenty to forty years (EC, 2011a). This calls for major changes for future mobility, as outlined by the Strategy and Action Plan for creating an Energy Union (EC, 2015b) and the European strategy for low-emission mobility (EC, 2016), resulting in a significant de-carbonisation of transport to reach the 60% greenhouse gas emissions reduction set between 1990 and 2050. Big data is among the most promising research trends of the decade, drawing attention from every segment of the market and society. Applying customised analyses the multi-layers data approach can lead identifying non obvious relations among large amount of data, generating the basis for an integrated approach for policy assessment and governance.

TEMA (Transport tEchnology and Mobility Assessment platform) (De Gennaro et al., 2016) is a flexible and modular big data platform developed by JRC, based on GPS mobility data and natively interfaced with GIS-based digital geographic mapping systems. It aims at harnessing the potential of big data in support to transport policy, performing a wide-range of mobility analyses, characterising the driving behaviour of the vehicles at a regional level and investigating the potential of innovative vehicle technologies nested in complex transportation systems. The platform is natively interfaced with the JRC STU-VELA laboratories and experimental programme on HEVs (Hybrid Electric Vehicles) and EVs (Electric Vehicles) and is designed to serve real-world vehicle emission applications too, having being used in the frame of driving and evaporative gaseous emissions from conventional fuel vehicles and eco-innovation technologies assessments. This tool can support smart city and smart region policies in the frame of low carbon mobility and sustainable transport systems development(6); additional details about the tool and examples of applications are provided in annex 7. Pictorial examples of the applications of TEMA are illustrated in Figure 13 and 14.

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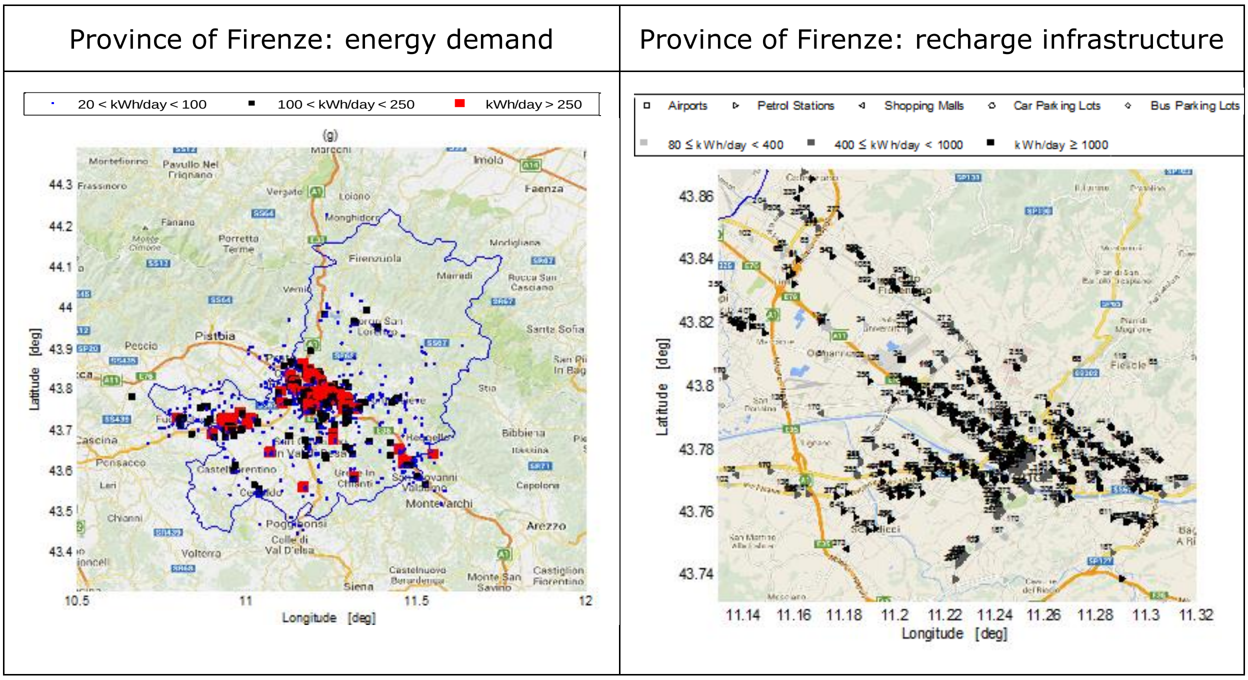
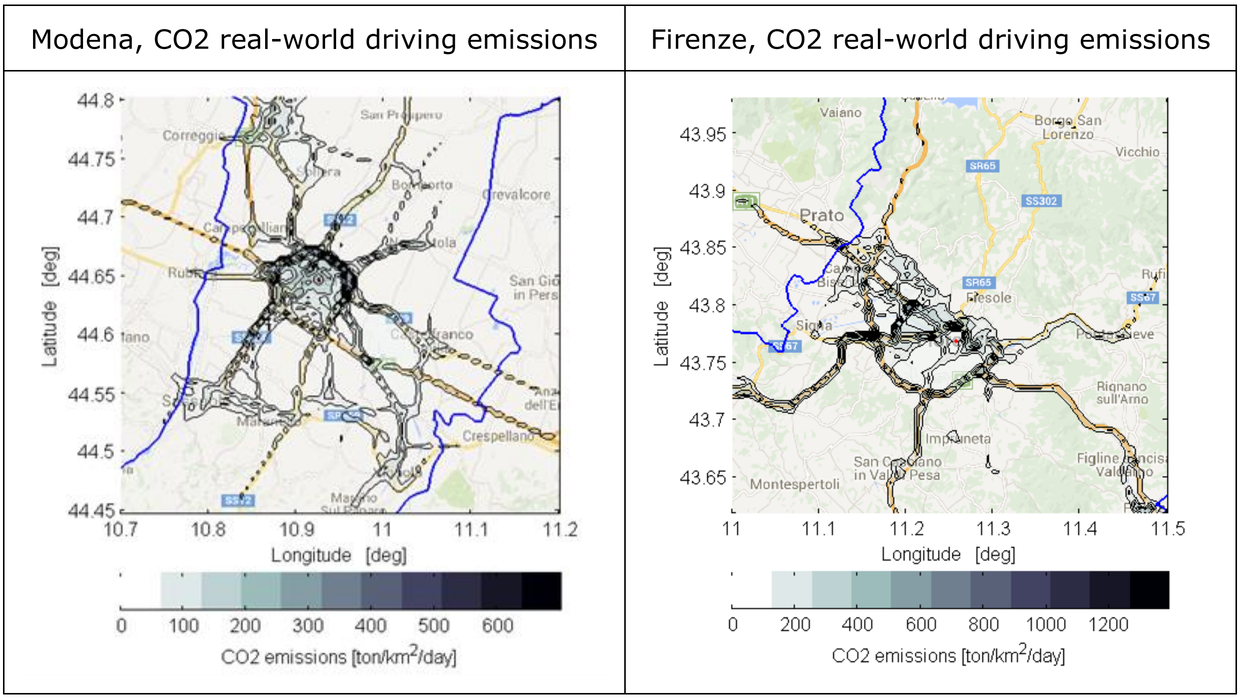
(6) Link to on-line resources (if applicable): MIDAS repository http://midas.jrc.it/discovery/midas/#showmetadata/model/207 and scientific publications

Figure 13. Extract from the geo-referenced energy demand results, province of Firenze, (left). Recharge infrastructure needed to sustain the demand (right)



Source: JRC.

Figure 14. Extract from the geo-referenced CO2 real-world driving emissions, province of Modena (left) and province of Firenze (right)



Source: JRC.

For AIR and ALP macro-regions, the ELITE JRC project (EVIAC work package), supports e.g. the Lombardia (Italy) province in assessing the impact of the car sharing initiative implemented in Milan city. Car sharing in Milan is part of the national Initiative Car Sharing (ICS) system supported by the Ministry of the Environment.

4.4.2 Technology options to decrease emissions and fuel consumption

The area covered by the EUSALP and EUSAIR macro-regions presents some unique characteristics. With the exception of some countries around the Alpine region (e.g. Switzerland, Austria, Germany and Italy), the rest of the countries involved comprise small nations with limited resources and poor economies. Some of these countries do not belong to the EU and may present limitations in international trade and security agreements. As a result, transport of goods and people is often discontinuous, slow and inefficient. Also, policies on greening up energy and achieving environmental targets agreed in the EU context are not automatically applicable for the region. As a result, measures of recognized effectiveness elsewhere may not be beneficial or even applicable to some parts, especially of the EUSAIR region.

Despite limitations, in assessing possible options for decreasing emissions and fuel consumption, one needs to consider a systems-approach rather than individual measures. In a systems approach, agents controlled on a centralized level and not people decisions may offer environmental benefits. These include infrastructural changes, including Information and Communication Technologies (ICT) and Intelligent Transportation Systems (ITS) and improved fuels. In a study conducted within the EU28 framework (Papadimitriou, et al. 2016), introduction of ICT and ITS, together with improved biofuels led to up to 18.6% reduction in CO2 emissions in 2030, over the baseline. ICT included traffic-adaptive traffic lights (UTC), variable speed limits, green navigation and adaptive cruise control (ACC) for passenger cars. This dropped to -17% if UTC and ACC were removed from the scenario. Green navigation and variable speed limits in motorways are relatively easy and not exceptionally costly to implement. Also, biofuels included improved production pathways which are within the EU central policies for sustainability of fuels. Hence, CO2 emissions and fuel consumption may be decreased without considering vehicle technology replacement. Such scenarios and assessment of their effectiveness need to be conducted in the EUSALP and EUSAIR regions.

If reductions in the emissions of air pollutants are required, then definitely introduction of new vehicle technologies needs to be considered. However, there are two caveats in proposing such an approach. Vehicle replacement is a costly measure often not accessible to private and public users of transportation services. For several of the countries of the region, new registrations in their majority comprise second-hand vehicle imports, rather new car sales. Hence, proposing the introduction of new vehicle technologies may be expected to have limited effectiveness in real terms, because of the slow fleet turnover and the high share of second-hand registrations. The second caveat is related to the effectiveness of Euro standards as such. It is well known that up to the first generation of diesel Euro 6 (Euro 6a&b), the reductions in NOx promised were not reached in reality. Hence, proposing that captive fleets of passenger cars (e.g. taxis) and light commercial vehicles (e.g. delivery vans) are replaced with latest diesel technology is no guarantee that actual benefits will be delivered in real terms. Although it is expected that Euro 6c and beyond will be able to deliver actual reductions, this is yet to be confirmed.

A second option to achieve reductions in PM and NOx levels is diesel vehicle retrofits with DPF and/or DPF+SCR systems. These have been proven effective in reducing PM by up to 80% and NOx by up to 70% for urban buses. Reductions in PM by DPF for smaller vehicles may be even higher. Several regions in the world, including Asian megacities with significant air quality problems have initiated and support vehicle retrofitting programmes. Although technical difficulties are always present in such retrofits, still the emission reductions reached are very significant so that to counterbalance any technology risks.

In every environmental measure considered, enforcement and surveillance are very important components that are often neglected. Without mechanisms to make sure that emission control technologies remain on board and operational, through inspection and maintenance programmes, any potential measure is deemed to fail. Several of the countries in the region are known of having an ineffective public sector, also often prone to corruption. This is often against effective enforcement. Hence, retrofits are also deemed to fail in delivering environmental benefits, unless a reliable inspection, maintenance and enforcement system is put in place.

It should also be stated that electric vehicles may not be a good option for a number of countries in the region. Table 4 attempts a comparison of CO2 emissions of a conventional diesel vehicle and a corresponding electric car of the same segment, when upstream emissions are also concerned. It is clear the electric vehicles result in much higher CO2 emissions, because of the use of coal in producing electricity. Scientific studies (Yu and Stuart, 2017; Razeghi et al. 2016), looking into ambient NO2 concentrations in cities where coal is used for power production demonstrate that the introduction of electric vehicles may actually aggravate the problem. As several of the countries in the region have not planned aggressive GHG reductions for electricity production in the years to come, it is very uncertain if electric vehicles will be a positive option for the environment or not. Information on carbon intensity is provided in Table 4.

Carbon intensity data are from EEA for EU28 countries and IEA for the rest, BMW i3, energy consumption: 13.1 kWh/km, and BMW 114d assuming (JEC, 2014) 95 gCO2/km from combustion, increased by ~10% to account for upstream emissions.

Table 4. Carbon intensity.

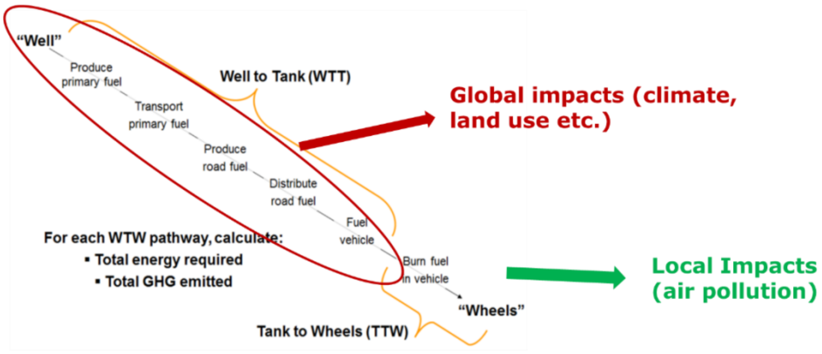
Region	**Carbon Intensity gCO_2/kWh**	**BMW i3 EV gCO_2/km**	**BMW 114d Diesel gCO_2/km**	**Improvement (%)**
Austria	60.1	7.9	105	92
Greece	830	109	105	-3.8
Bosnia & Herzegovina	1326		105	-65%
Serbia	1548		105	-93%

4.4.3 Biofuels in transport

The climate change reduction, security of energy supply and economic and rural development are the three pillars of EU biofuel policy. The overall goal of this policy is sustainable development targeting environmental, social and economic aspects. In Renewable Energy Directive (RED), the 2020 target for renewable energy in transport is 10% and the Energy and climate package post-2020 calls for a range of alternative fuels for 2030, with special focus on 2nd generation and 3rd generation biofuels (mainly from waste and residues). Further, the proposal for amending RED for post-2020 (COM767, 2016) includes target for a minimum share of advanced biofuels and gradual reduction of crop-based biofuels share.

Environmental and climate impacts of biofuels must be assessed over the entire life-cycle of the fuels in use (see Figure 15) with different regulatory frameworks for Well-To-Tank (WTT) and Tank-to-Wheel (TTW) emissions.

Figure 15. Life-cycle of the fuels in use with different regulatory frameworks for WTT and TTW



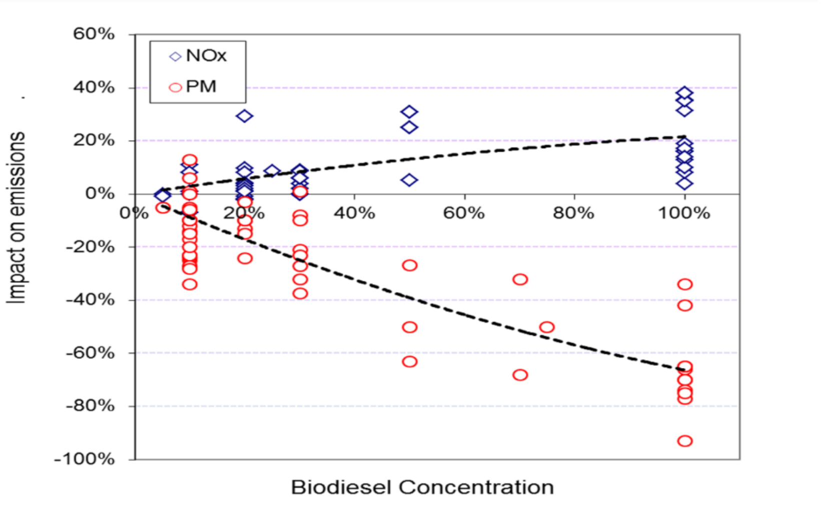
Source: WG transport, 2017.

Bioenergy systems can influence directly and indirectly local and global climate through a complex interaction of perturbations including: CO2 from biomass combustion, influence on land use and land management, substitution of fossil fuels, impacts on agriculture/wood markets, and climate response.

Well-To-Tank emissions. The threshold for minimum GHG savings for biofuels and bioliquids in RED is 50% from 2017 with respect to fossil fuels replaced; a simplified attributional life-cycle assessment methodologies is used to calculate the total GHG emissions in which only direct emissions from the production of biofuels are considered, which are named "supply-chain" emissions. Because of the limitation of the method the impacts were assessed only in the energy sector.

Tank-to-Wheel (tailpipe) emissions. As illustrated in Figure 16, depending on the biodiesel concentration the increases of NOx emissions could reach up to 20% and PM reductions > 60%.

Figure 16. NOx and PM emissions related to biodiesel concentration



Source: WG transport, 2017.

Biofuels represent one of the few options to reduce CO2 emissions in transport, in particular for aviation. Environmental concerns on 1st generation biofuels lead to the need for transition to advanced biofuels (mainly from waste and residues). However, further research are needed in this area including on sustainability, e.g. to approach economic feasibility, 2nd generation biofuels require huge scale-up and/or cheap sources of sustainable feedstock (straw). Regarding emissions, there are potentials for CO2 reductions and climate benefits vs fossils in the WTT part (supply-chain) and the tailpipe emissions reduction are important for urban air quality with trade-offs between some effects e.g. PM and NOx as illustrated in Figure 16.

4.4.4 Case studies

4.4.4.1 Passenger cars: Reducing transport externalities in times of growth

Economic prosperity and transport externalities are directly linked. Therefore, in times of growth, the negative impacts of transport are exacerbated, and special attention is needed to reduce them. The Alpine Region is a unique region, which benefits from the European Union initiatives, but also national legislation and initiatives. For example, at the federal level, Germany has recently issued a Climate Action Plan (CAP, 2017) (2020/2050 horizons); some key directions include more efficient vehicles, more electric vehicles, heavy goods vehicle (HGV) tolls, more hybrid vehicles, and focus on improving rail infrastructure to drive a shift to rail.

Recognizing that electric mobility is clearly going to play an increasing role in the foreseeable future, the German National Platform for Electric Mobility (CIEVG, 2015) focusses on the anticipated need for more charging infrastructure (and electric distribution infrastructure) for more electric vehicles and includes: (i) 10,000 charging station program, (ii) building regulations and tenancy law, (iii) changes in the tax law, (iv) energy law and calibration regulations, and (v) central roll-out planning for the DC fast charging infrastructure in Germany.

Germany needs to walk a fine line between supporting its automotive industry and reducing pollution in cities. Munich(7) and Stuttgart both suffer from NOx levels higher than EU guidelines, but these cities are also home to many German automakers. In the aftermath of the Diesel emissions scandal, German cities with strong automaker presence propose bans on diesel vehicles to control NOx and PM pollution(8). At the same time, German automakers agree to introduce cleaner diesel engines. Many smaller cities in the south of Germany are also very active with related activities. For example, Freiburg defined itself as a "Green City"(9), with activities including being a pilot city for the GREENCYCLE project(10), the support of the Sustainability Center Freiburg and a general focus on compact development, quality public transport, cycle paths, etc. Tübingen uses blue as its colour, with its „Tübingen Macht Blau" initiative(11), which is a broader environmental campaign, with a transport component (e.g. a subsidy scheme for replacing old scooters with electric ones). Of course, many other cities have similar programs, such as Low-emission zones (LEZ) ("Umweltzone"), shared vehicle schemes, electric vehicle charging infrastructure and extensive bike path networks, but it is important to highlight the initiatives of the smaller cities that may have fewer resources.

This is all supplemented by external initiatives, such as (i) the EU-Strategy for the Alpine Region (EUSALP) and (ii) the Alpine Space programme, which is a European transnational cooperation programme for the Alpine region. Alpine Space provides a framework to facilitate the cooperation between economic, social and environmental key players in seven Alpine countries, as well as between various institutional levels such as: academia, administration, business and innovation sector, and policy making (http://www.alpine-space.eu).

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(7)https://www.bloomberg.com/news/articles/2017-06-14/bmw-s-hometown-munich-mulls-diesel-ban-to-fight-air-pollution

(8)https://www.reuters.com/article/us-germany-emissions-bavaria/bavaria-agrees-anti-pollution-steps-with-bmw-audi-man-idUSKBN19J1QO

(9)http://www.freiburg.de/pb/site/freiburg_mundenhof/node/372840/Len/green_city.html (accessed 5.11.2017)

(10)http://www.alpine-space.eu/projects/greencycle/en/home (accessed 5.11.2017)

(11)http://www.tuebingen.de/tuebingen-macht-blau/ (accessed 5.11.2017)

A number of projects either directly focusing on mobility or indirectly affecting it have been developed already within this framework. For example, the ASTUS project(12) aims to help local authorities to identify and implement long term solutions in both mobility and spatial planning to reduce the CO2 impacts linked to daily trips in the Alps. e-MOTICON(13) aims to support Public Administrations in ensuring homogeneous development of electric mobility (e-mobility), deploying an innovative transnational strategy of integration among spatial planning, innovative business models and technologies, sustainable mobility patterns, energy efficiency instruments and policies enabling large diffusion of Electric Charging Stations (E-CS) and wider interoperability.

Looking into the future, one should consider what mix of measures are needed, in order to achieve the desired objectives (funding, reduce pollution, congestion). Furthermore, with the emergence of electric vehicles, one should consider that such vehicles are not a panacea, as they "escape" the oil-tax, while not necessarily reducing emissions (depends on where the electricity is coming from). Still, while they may have limited environmental impacts, they have other external costs (congestion, parking, crashes). On the other hand, emerging mobility services (ride-sharing, vehicle-sharing, transportation network (Uber-type) services) may "replace" many conventional vehicles, so perhaps they should obtain a special status, reflecting this. Finally, as automated vehicles are coming closer to reality, the implications of these should also be considered.

4.4.4.2 Freight transport: Clean and Efficient? Or Clean vs. Efficient?

The movement of goods within the EU is increasing, because of mainly three factors: the EU monetary union and market liberalisation, the evolution of EU internal markets, and the EU enlargement towards the east. The transport of goods to or from, as well as within and through, the Alpine area may be the most controversial topic of Alpine transport. Based on not very recent data (most data in this section come from the 2007 Alpine Convention (AC, 2007), a total of more than 190 Mio tonnes were transported by road and rail across the Alpine arc in 2004, accounting for 57% of the total traffic across the Alps. It is easy to realize that such flows create a significant stress to the Alpine transport infrastructure, as well as its fragile environment. Trends in freight transport show an overall increase, which will likely continue in the coming decades, and -with the exception of Switzerland- this increase will ceteris paribus occur predominantly in road freight transport. In fact, the volume of long distance traffic expressed in number of vehicles has historically increased at an annual average rate of about 5%.

The Alpine main ridge can be crossed on French, Swiss, Italian or Austrian territory. Regarding the tonnage by Alpine crossing country, Switzerland had the biggest percentage increase between 1999 and 2004, both on rail and on road. Austria featured the highest absolute increase, while on French Alpine crossings, road transport volumes stagnated and rail transport decreased. When looking at national differences in modal split, the data reveal significant differences within the Alpine region. It is interesting to note that the modal split between rail and road is 64% to 36% in Switzerland, whereas the railway holds shares of only 31% in Austria and 14% in France._Between 1999 and 2004, rail traffic (in tonnes) decreased by 30% on northern French crossings, whereas rail traffic through Swiss crossings increased by 21%.

According to the 2007 Alpine Convention (AC, 2007), "in order to redress this situation, rail freight must offer competitive and efficient services. The sector needs to respond to the customer needs, by ensuring that it provides adequate rail infrastructure capacity and that levels of investment in rolling stock are increased". This underlines the major issue with rail transport today. It is perceived by the shippers as inferior, and therefore is not the go-to mode for most shipments. Carrot-and-stick measures can support and strengthen a desirable mode, but if they are alone, they cannot be sufficient in the long run.

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(12)http://www.alpine-space.eu/projects/astus/en/home (accessed 5.11.2017)
(13)http://www.alpine-space.eu/projects/e-moticon/en/about (accessed 5.11.2017)

Therefore, it is not sufficient for rail transport to be environmentally superior to road traffic, but it also needs to appeal to other aspects, including making business sense. Cost can also not be a main driver. There is inherent friction within rail transport (as opposed to truck transport), as often rail is limited by the reach and capacity of the railroad network, the frequency of the trains, the location and availability of transtainer equipment at the stations, the capacity of the loading yards. An example of clever exploitation of the advantages of the train is the “rolling motorway” (Rollende Landstrasse, ROLA) trains that carry trucks along the Alps, which have been rather successful, as they allow truckers to cross the Alps, in spite of restrictions in traffic, but also in driving time regulations.

Information and Communication Technologies (ICT) can provide a very valuable instrument in reducing the friction and opaqueness sometimes associated with rail transport. Other solutions could relate to better support for smaller cargo units (less than container), as well as better connection with last-mile delivery. Technologies to reduce the friction of transferring a container between a track and a rail wagon at ad-hoc locations could considerably increase the catchment area of rail passing through Alpine territories.

One important programme that aims at improving rail market share is Shift2Rail (Shift2Rail, 2005), with a focus on innovation to deliver better trains and infrastructure at a lower cost. This will drive a shift in passenger and freight transport towards trains. The initiative’s key targets are

- Cutting the life-cycle cost of railway transport by as much as 50%;
- Doubling railway capacity; and
- Increasing reliability and punctuality by as much as 50%.

Of course, the topography of the Alpine region imposes significant restrictions, which require major capital investment in the form of rail tunnels, in order to achieve such goals. Therefore, major rail tunnels are being developed in the Alps, including the Gotthard Base Tunnel and Lötschberg Base Tunnel in Switzerland and the Brenner Base Tunnel and the Semmering Base Tunnel in Austria.

One major reason for construction of these tunnels is to shift freight traffic from trucks to trains. These tunnels upgrade many slow mountain segments of the Trans-European Transport Networks (TEN-T). The Gotthard Base Tunnel opened in 2016 and is projected to move 180–260 freight trains per day and the Lötschberg Base Tunnel opened in 2007, but is still only half complete (portions of single-track), while the Austrian tunnels are scheduled to open in 2026. Clearly, such time-horizons require a lot of foresight and long-term planning to be effective.

4.4.4.3 Air Quality plan: Preparatory study for Pescara-Chieti costal area

In the last years European Union air quality directives that have been introduced require Member States to divide their territory into zones related to air quality standards. The directives also require Member States to adopt plans and programs inside zones when air quality standards are not respected. Italian legislation delegates air quality planning activities to the regions.

In Abruzzo region three zones have been defined: the Pescara-Chieti agglomeration, a zone with higher anthropic pressure, and a zone with lower anthropic pressure. In the Pescara-Chieti agglomeration nitrogen dioxide (NO2) concentrations exceed the annual limit, particulate matter with diameter less than 10 micron (PM10) concentrations exceed the daily limit while benzo(a)pyrene concentrations are near the annual limit. In addition ozone (O3) concentrations are above the target value in large areas of the region.

The following air quality planning activities have been carried out in the Abruzzo Region in the last years under contract of Regione Abruzzo Dipartimento Opere Pubbliche, Governo del Territorio e Politiche Ambientali, Servizio Politica Energetica, Qualità dell Aria, SINA for updating of Air Quality Protection Plan:

- multiyear emission inventory (by source for main sources and at municipal and 1km x 1km scale for other sources);
- specific road traffic, airport, port, vegetation emissions models;
- emission projection model implemented with inventory base year and projections at 5, 10, 15 years in different scenarios:
- air quality models applications with CHIMERE (LMD, 2017) and CALPUFF (Scire et al, 2000) in different scenarios.

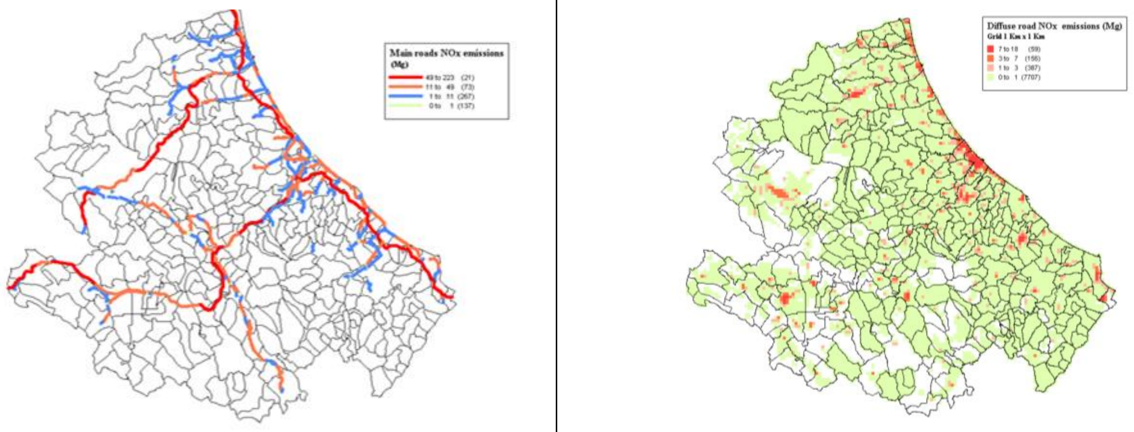
The emission inventory follows the SNAP classification of activities and EMEP/EEA emission factors for main air pollutants (NOx, SOx, NMVOC, CO, PM10, PM2.5, NH3), heavy metals, benzene, PAHs, POPs, dioxins and greenhouse gases (CO2, CH4, N2O). The sources have been classified as: 1. Point, stationary sources whose emissions exceed fixed thresholds (i.e. 5 tons/year of NOx or PM10, SOx, NMVOC), 2. Line, the main roads, railways, and 3. Area, the main ports, airports, landfills, storage areas.

The methodology to compile road traffic emissions inventory is reported in annex 8 and uses very detailed data from traffic regional modelling, highway counts and EMEP/EEA methodology (EMEP/EEA, 2016) to estimate fuel consumptions and emissions. The procedure has been calibrate with statistical data on regional fuels sales.

Emissions from transport have been evaluated as line sources (Figure 17a) while diffuse emissions have been evaluated at regional level, allocated to cities using population and then to 1 km grid using land use maps (Figure 17b); these emissions have been used as input for CHIMERE air quality model application (Figure 17c).

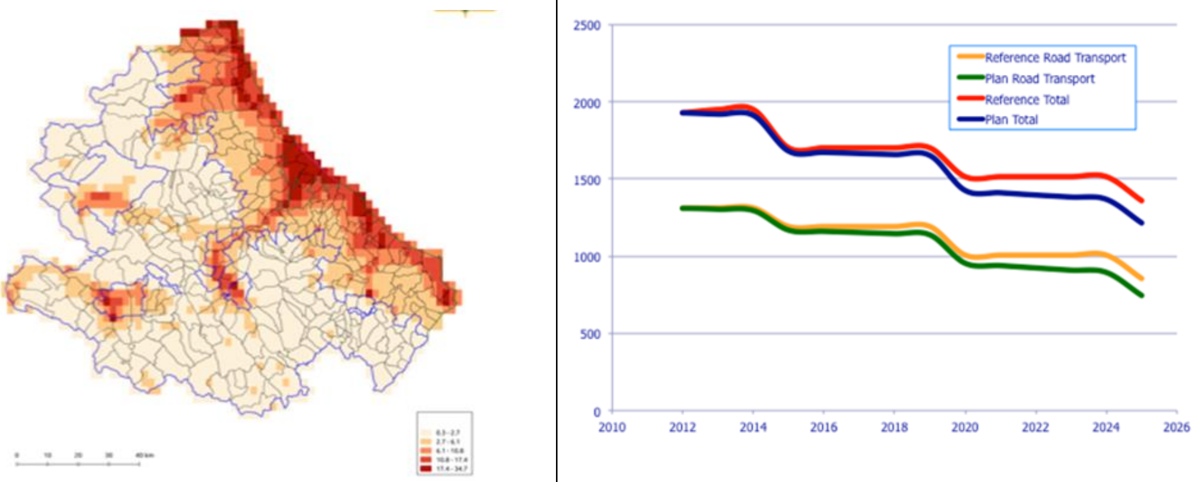
The planning activity includes a Business As Usual (BAU) and a Plan Scenario (PS). BAU Scenario include socio-economical and technology trends and all already planned and approved measures while Plan Scenario include general regional measures and the following specific measures for the agglomeration Pescara – Chieti: 1. Reduction of urban and suburban traffic (4% by 2020 and 10% by 2025), 2. Support for replacing existing stoves and fireplaces with advanced stoves and fireplaces or pellet stoves (target of 10% of installations replaced by 2025), 3. Reduction of the emissions of nitrogen oxides of selected industrial combustion plants in the area. The effect of plan on traffic emissions is reported in Figure 17d.

Figure 17. Emissions (a, b), concentrations (c) and benefits of implementing reduction measures on traffic emissions (d) in Abruzzo region



a) Line emissions [Mg]

b) Diffuse emissions [Mg]



c) NO2 annual mean [µg/m^3]

d) Benefits of implementing the measures in PS on traffic emissions [Mg]

Source: Regione Abruzzo, 2017.

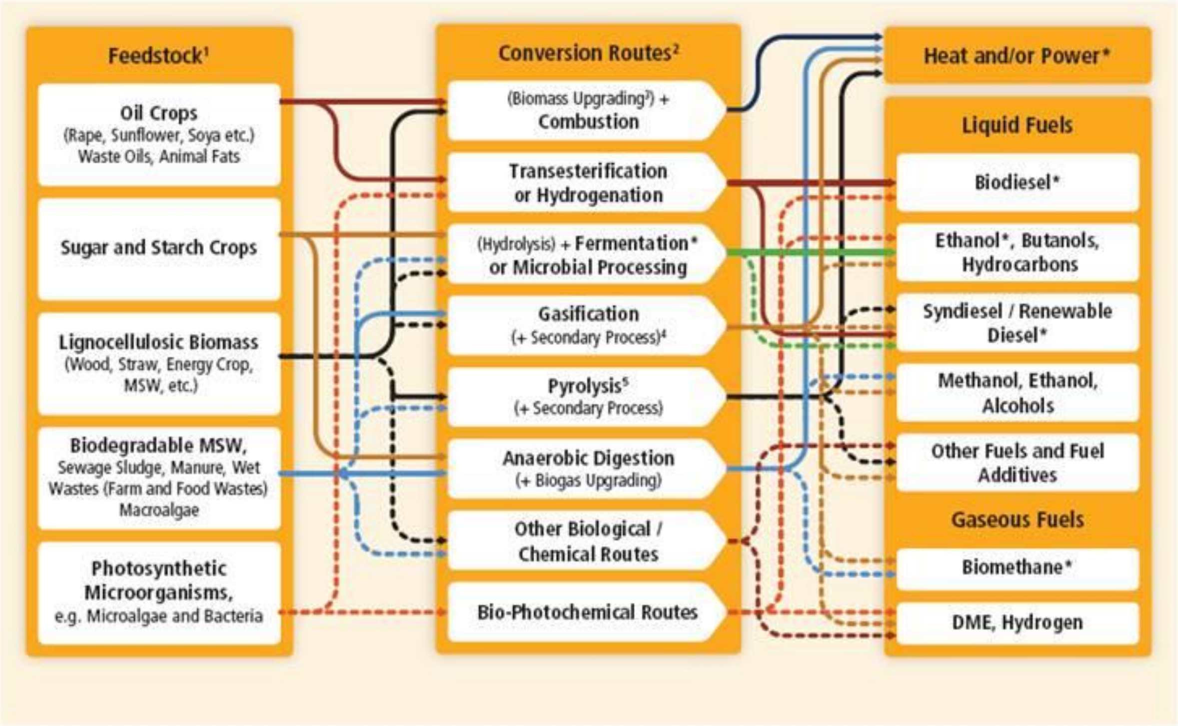
5 Clean growth in bioenergy in the Alpine and Adriatic-Ionian regions

Feedstock availability and sustainability, feedstock and technologies coupling, conversion technologies for a clean bioenergy deployment, bioenergy and air quality are discussed in this Chapter with special focus on EUSALP and EUSAIR countries; a summary of issues and possible key priorities is presented in annex 14.

5.1 Bioenergy in the frame of the EUSALP and EUSAIR macro regional perspective

Bioenergy is defined as the conversion of material of biological origin (biomass) into energy. Bioenergy is a quite complex matter because of its diversity. Biomass originates from many types of either liquid, solid or gaseous feedstock: firewood, energy crops, wastes, residues, wood chips, pellets, briquettes, industrial liquors, biogas etc. It can provide different end products such as power generation, heating and cooling, and biofuel for transport. Conversion routes are also diverse, such as the possible conversion plants sizes, ranging from small domestic pellet boilers to large scale biomass-fed power plants (Figure 18).

Figure 18. Bioenergy supply chain



Source: IPCC (2011).

In the EU, bioenergy is a key component of the ongoing transition to decarbonisation, with a contribution to the Final Energy Consumption moving from 62 Mtoe in 2005 to 108 Mtoe in 2015 and expected to reach 140 Mtoe in 2020.

Similarly, European macro-regions are also deeply relying on bioenergy resources to decrease their dependency from fossil fuels and to decrease their GHG emissions.

For instance, yearly final energy consumption of the EUSALP territory amounts to approximately 2200 TWh. About 43% of the final energy consumption takes place in the heating sector, 32% in the transport sector and 25% covers the electricity demands. The

EUSALP action plan supports the further deployment of local and renewable energy production in the Alpine region. Particular emphasis lays on wind and solar power, biomass and geothermal energy.

The bioenergy dilemma.

According to EUSALP action plan, renewable energy potentials "must be developed in a balanced way, taking into account ecological, economical and land use issues and considering social trade-offs." Indeed, bioenergy deployment, similarly to most renewable energy sources, has to take place in a proper context and has to be balanced with appropriate measures aiming at minimizing the unintended negative impacts and enhancing environmental, climatic and societal benefits.

In order to achieve this goal, all the steps of the bioenergy production chain depicted in Figure 18 must be appropriately handled. Possible key priorities for such a handling, which resulted from the discussions between experts, are presented in this section and in the annex 14, while in the immediate a short introduction to the relevant aspects of EUSALP and EUSAIR activities will be given.

Macro-regional strategies provide a framework for cooperation, coordination and consultation between and within states and regions. At the same time, macro-regional strategies depict an opportunity for greater regional cohesion and a more coordinated implementation of European sectorial policies in transnational territories that are confronted with common challenges and opportunities. The EU Strategy for the Alpine region (EUSALP) is the fourth macro-regional strategy that was endorsed by the Council in 2015. It covers a territory inhabited by 80 million people and includes 48 regions from seven countries of which five countries are EU member states, namely, Italy, Austria, Germany, France, Slovenia, Switzerland and Liechtenstein.

Since 2016, nine thematic Action Groups composed of regional and national representatives carry out activities and projects that support the realization of these objectives. EUSALP Action Group 9 has the mission "to make the territory a model region for energy efficiency and renewable energy" and falls under the third policy area "environment and energy" that has the objective to develop a more inclusive environmental framework and to develop a strategy for renewable and reliable energy solutions for the future. Action Group 9 has 19 members from 17 states and regions/provinces of the EUSALP. The activities pursued by Action Group 9 back the implementation of the Energy Union Package that strives for more energy security, an integrated European energy market, an increase of energy efficiency, decarbonization of the economic sector and support of research, innovation and competitiveness in Europe. In particular, Action Group 9 pursues the following objectives:

- To make Alpine building sector more energy efficient and sustainable.
- To support economic actors, especially SME, to become more energy efficient
- To support the expansion of local renewable energy sources in line with environmental and landscape protection standards
- To promote smart grids towards an intelligent energy system in the Alps
- To foster the exchange of good policies and Macro-regions are then a natural context to discuss the horizontal issues linked to clean energy.

Biomass for heating and cooling increasingly replaces CO2 emission intense fossil fuels in the European and Alpine residential sector. This shift to more CO2 emission-neutral sources, however, has, in the case of solid woody biomass, repercussions e.g., on air quality. Therefore, the EUSALP action plan promotes an increase in the use of local energy resources to expand energy self-sufficiency and to reduce climate and environmental impacts at the same time.

Apart air quality, other issues should be further investigated within the EUSALP context, for example:

- sustainable forest management and sustainable supply chains including non-energetic use of biomass as for instance the use of local wood in the Alpine construction sector
- climate impacts of a growing bioenergy sector and its role for effective climate change mitigation
- energy production out of waste
- roll-out of biomass micro grids / co-generation esp. in spoiled landscapes of the Alpine and pre-Alpine area and in the context of district heating in urban areas
- overcome challenges that regard use of innovative technologies to reduce the negative impacts on the environment (air quality) and on health
- improvement of energy efficiency of existing district heating networks (i.e. biomass quality and storage conditions)
- sharing of local, regional and national good practices in regulating the biomass sector including energy planning
- development of an Alpine resource conflict management for biomass.

Last but not least, bioenergy issues are cutting across different sector policies such as energy, transport, environment, climate, innovation and economic policies. Due to this complex-multidimensional character, EUSALP calls for future bioenergy policy development in the Alpine region being increasingly coordinated and drafted in a cross-sectoral and transnational/regional manner. Some of these issues were indeed discussed during the workshop, with reciprocal benefit of experts and EUSALP representatives.

In the EUSAIR action plan(14) specific actions are foreseen for a better integration of the energy market to pave the way to further deployment of renewable resources. Moreover, the countries in South–East Europe, as signatories of the Energy Community Treaty, have embarked on a path of energy market reforms and regional integration aiming at increasing energy efficiency, promoting renewable energy production and consumption, stimulating energy infrastructure development and creating a well-functioning South–East European energy market.

5.2 Feedstock availability and sustainability in perspective

Feedstock availability and mobilization is a basic crucial starting point for any assessment of biomass exploitation. When dealing with multi-national assessment, the main challenge consists in data harmonization among EU and neighbouring countries. Based on a mix of remote sensing and statistical data JRC has developed a set of availability maps such as the ones shown in Figure 19.

Moreover, biomass is a sparse resource, with a relatively low spatial density and needs to be collected, pre-processed and transported to transformation sites (e.g., power plants or digesters) large enough to allow profitable economies of scale. For this reason, the assessment of technical (i.e., collectable) potential has been complemented with an analysis of the feedstock mobilization and the related costs in order to provide a picture the actual economically feasible biomass mobilization (Figure 20).

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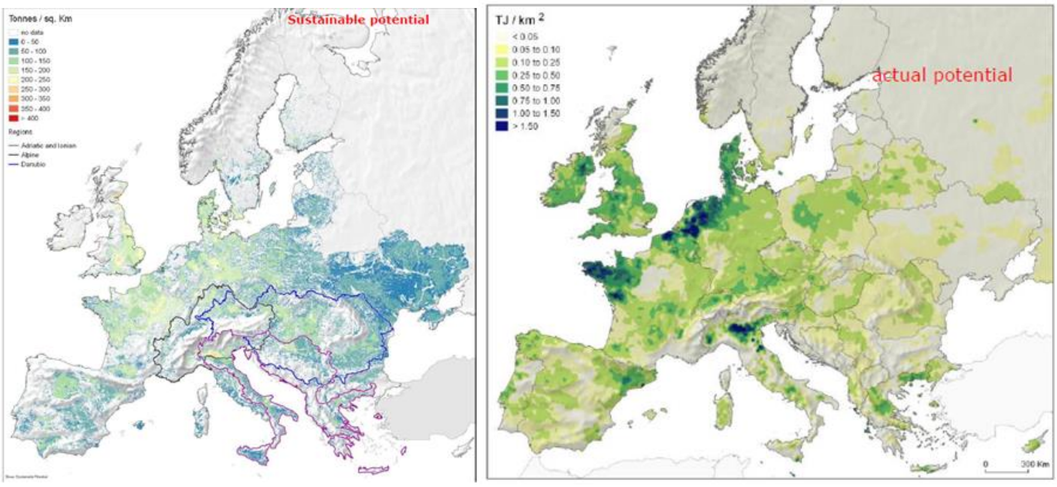
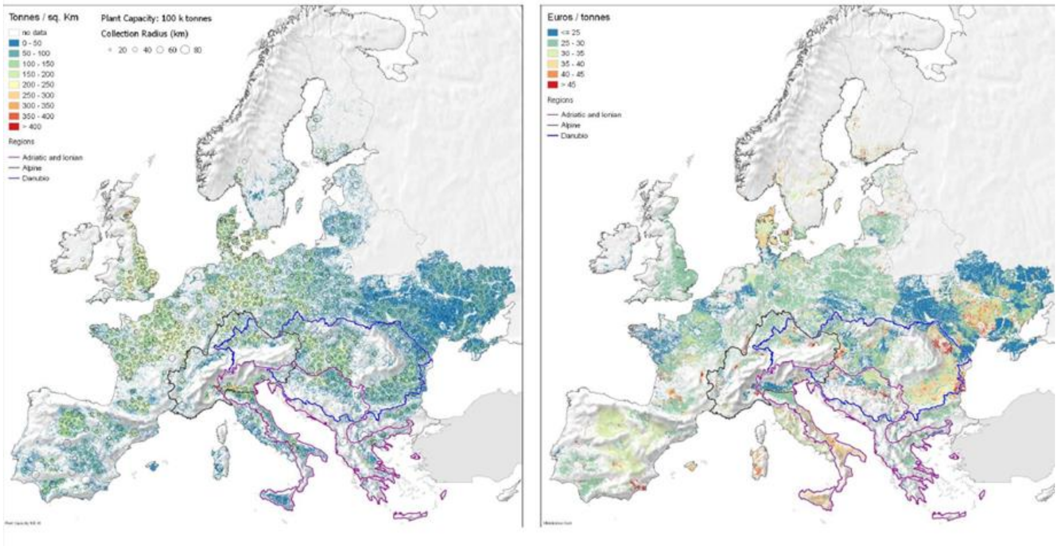
(14)SWD(2014) 190 final, Action Plan, accompanying the document "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS concerning the European Union Strategy for the Adriatic and Ionian Region.

Figure 19. Crop residues (left) and biogas (right) technical potential in Europe



Source: JRC.

Figure 20. Mobilization needs (left) and costs for crop residues in Europe

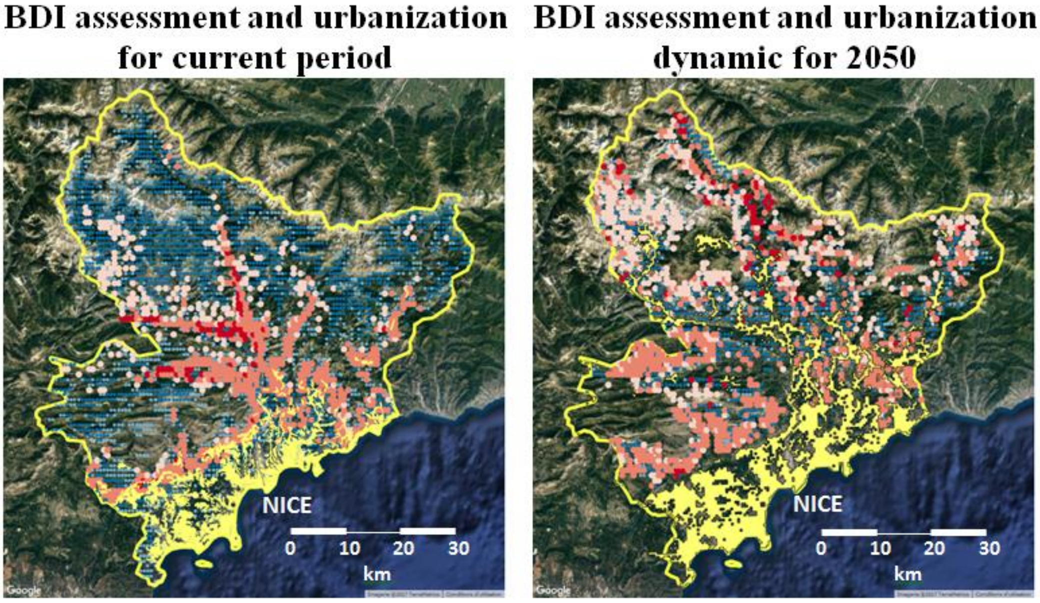


Source: JRC.

Nevertheless, potential evaluation should also take into consideration the reality of an evolving climate and the need of anticipating climate change effect on biomass productivity and vegetation structure. As an example, thanks to the use of a geoprospective approach Garbolino et al. (2017) have assessed the potentiality of biomass production and availability for energy systems based on woody biomass. The methodology takes into account the impact of the global warming on the Net Primary Productivity (NPP) and the vegetation structure towards 2050, and the assessment of urban dynamic in order to identify the future areas of energy demand (see the methodology description in annex 11).

Results show that Mediterranean forest may be more vulnerable due to the increase of temperatures that may affect the mortality of the trees and shrubs, and the structure of the ecosystems due to the colonization of more xerophilous species in the inner valleys and hills. In some parts of the Alpes-Maritimes (French Riviera), these changes may affect the biomass production and, in consequence, the availability of the resource for the supply chain (see the comparison present vs 2050 of the suitability of the territory for the production of wood in annex 11). The current development of the urbanization in the valleys and in the central part of the territory, which will be emphasized in the future, raises the question of the sustainability of energy systems based on woody biomass in such areas due to the potential risk of the increase of trees mortality, changes in vegetation structure with less trees and NPP decrease. At the opposite, in the mountain areas, the NPP will increase and the dynamic of trees would be suitable to the development of forests. But these areas are mainly located in protected zones where few activities are tolerated. These results underline the difficulty and complexity of a sustainable development of wood energy supply chain in Mediterranean territories, and the need of a strategy to face these potential problems.

Figure 21. Comparison of urban areas in 2015 and potential urban development for 2050 (in yellow) and the Biomass Development Index (BDI) level for the two periods



Source: Garbolino et al. (2017).

The model shows that for the current period, the most interesting areas for wood production are located close to the dense urban areas, at a distance around 10 to 20km which seems acceptable in terms of costs for the transportation and the preparation of the biomass. In 2050, the urban development should colonize the inner valleys but the most favourable areas for wood production should be located in the north part of the territory, which is farther from the dense urbanized areas localized in the coastal strip (Figure 21). Because some areas will be urbanized in the inner valleys of the territory, the supply chain should move close to these urbanized zones, next to the wood production localities. But, there are some limitations of such assumption due to the presence of protected areas like the National Park of the Mercantour (north part of the territory) and the Regional Park of the "Préalpes d'Azur" (south-west part of the territory).

An appropriate planning should then start from evaluating of climate change impacts on the resource of biomass (wood and bushes) in order to assess the sustainability of the development of the supply chain and deeply investigate GHG emissions and capture due to forest management techniques in order to underline the best practices to ensure the lowest GHG emission and developing the formation, awareness and control related to the best practices in forestry activities;

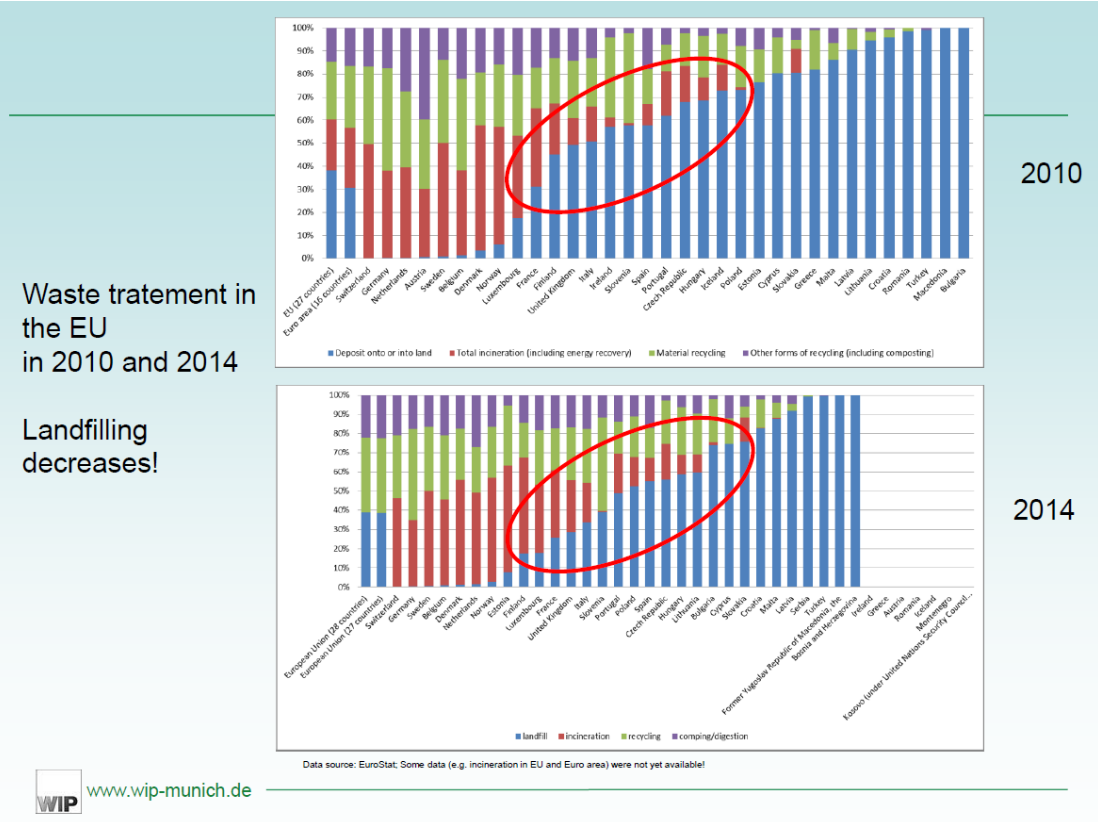
On a more practical side, policy makers should also encourage the regrouping of forest parcels due to the problem of fragmented forest areas (from the administrative point of view with a lot of owners) in order to help the management of such areas and assessing the potential development of urban areas in order to identify the potential places of energy consumption for the future, and to optimize the development of proximity activities of the supply chain (carbon balance optimization).

5.3 Coupling feedstock and technologies

Urban solid waste and aerobic digestion.

Among the emerging combinations of feedstock and transformation technology, a special attention is deserved at the continental level by anaerobic digestion of organic waste. Indeed in EU, still today, a large fraction of bio-waste (organic fractions of municipal solid waste (MSW) including food waste) goes to landfills. In 2010 it was estimated that 40% of biowaste went to landfills (EU, 2010). In some Member States, this waste is almost completely landfilled, whereas in some other countries, landfilling of biowaste is already phased out. Estimates show that about one-third of Europe`s 2020 targets for renewable energy in transport could be met by using biogas produced from bio-waste (including food waste), and around 2% of the EU`s overall renewable energy target could be met if all bio-waste were turned into energy (EC, 2010). Modern and environmentally friendly waste management is still not introduced in many European cities and regions, including several countries of the Alpine and Adriatic-Ionian Regions. Waste collection and landfilling in European countries is presented in Figure 22.

Figure 22. Waste collection and landfilling in European countries



Waste tratement in the EU in 2010 and 2014

Landfilling decreases!

Data source: EuroStat; Some data (e.g. incineration in EU and Euro area) were not yet available!

Source: Dominik Rutz, WIP using EuroStat Data.

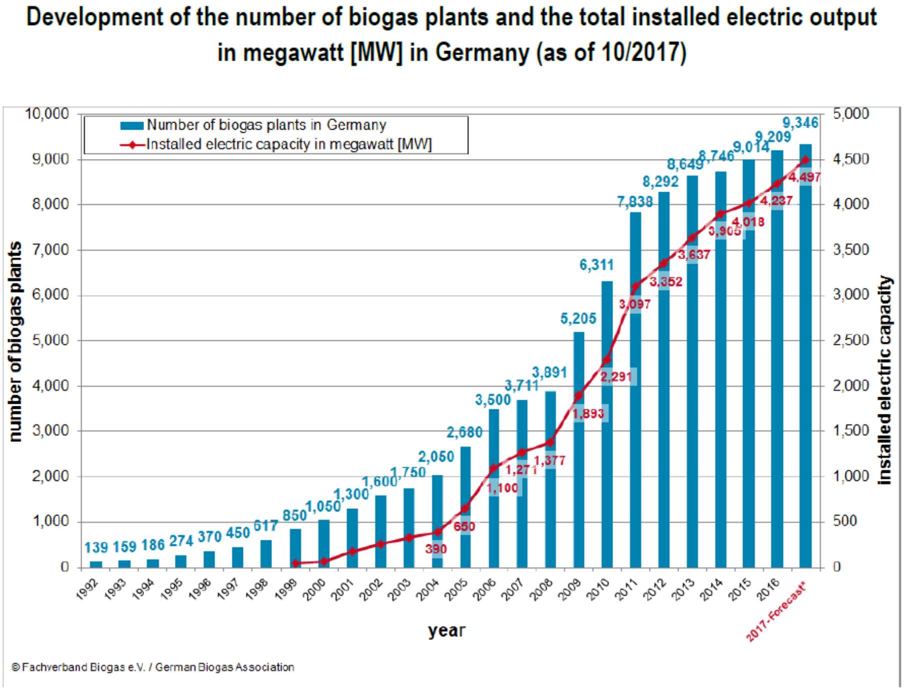
The waste management (collection) and the treatment (conversion) options are closely interrelated. Today different systems are applied for the collection of biowaste, either source-separated or not: 1. Dedicated biowaste collection from industries (e.g. food and beverage industries) by special containers and trucks; 2. Dedicated biowaste collection from wholesalers and retailers by special containers, bins and trucks; 3. Source separated biowaste in different bins; 4. Source separated biowaste in different plastic bags; 5. Mixed collection of biowaste and remaining household waste with centralised mechanical-biological treatment (MBT); 6. Mixed collection of biowaste and remaining household waste.

The type and origin of the waste as well as the collection system influences the quality of the waste which is of importance for the further processing. The processing can include the following options: 1. Anaerobic digestion, 2. Composting, 3. Incineration and 4. Landfilling.

The use of bio-waste for anaerobic digestion (AD) is a key technology to overcome various challenges in Europe and abroad (Rutz et al. 2014, 2016a, 2016b, 2016c, 2017), namely waste recycling, sustainable waste treatment and renewable energy production.

As an example of the ongoing developments, the biogas sector evolution in Germany is presented Figure 23.

Figure 23. Biogas sector evolution in Germany



Source: Fachverband Biogas (https://www.biogas.org/edcom/webfvb.nsf/id/DE_Branchenzahlen/$file/17-10-13_Biogasindustryfigures-2016-2017.pdf).

As a matter of recommendations for the Alpine and Adriatic-Ionian Regions, it has to be noticed that several countries, regions, cities or municipalities have not yet introduced proper waste management for bio-waste. From the environmental view, source separated collection should be introduced and the digestible fraction used for Anaerobic Digestion, in order to increase the share of bioenergy generation.

5.4 Conversion technologies for a clean bioenergy deployment

5.4.1 Appropriate and balanced technology mix: the example of Italy

The choice of appropriate technologies all along the bioenergy supply chain is crucial in pursuing a clean deployment of bioenergy potential, especially where biomass provides a relevant share of energy consumption, like in Italy.

Water-cooled, vibrating grate (VG) boilers is the common choice technology for bioenergy produced using solid biomass as feedstock in Italy. Typical power generation burns wood residues with a low heating value (LHV) of about 13.8 MJ/ kg, and with 30% humidity, for a capacity plant of the order of 10 MWe. Nevertheless, fluidized bed and bubbling fluidized-bed combustion (BFBC) boilers for solid biomass are today's commercial technologies that ensure high efficiency, low emissions and high fuel flexibility but require high initial investments for larger scale applications, over 20 MWt.

The Organic Rankine Cycle (ORC) technology is also a way to convert heat into electricity and its main applications consist in distributed electricity generation and heat recover including renewable heat sources, better suited for smaller plant size 20-2000 KWel with the technical possibility to reach also larger size as 15MW. Pyrolysis and gasification technology are also promising in terms of efficiency and emission control capabilities, but still in early stage of market penetration.

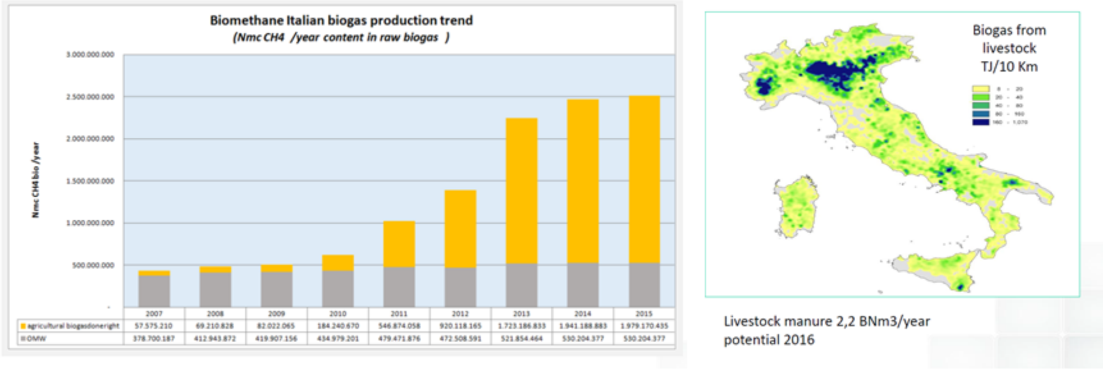
Whenever possible, Combined Heat and Power (CHP) should be preferred as the overall efficiency of biomass-based CHP plants for industry or district heating ranges from 70%-90%. Continued improvements in CHP technology have enabled a new generation of plants that offer advanced steam parameters and high efficiency, circulating fluidized bed combustion (CFBC) boilers offer a further option for biomass-fired CHP; the district heating in northern Italy, and the high efficiency heat production in Italy and its growth potential are presented in annex 12.

From the domestic heating side, high efficiency biomass (pellet and wood chip) stoves and boilers have increased in the last years, with 1.3 M new units installed in 2013 to more than 1.7 M new units in 2016, mostly stoves; the driver for this penetration is the possibility for the householders to use the 65% of cost afforded to purchase the high efficiency stove or boiler, and get the equivalent reduction on personal income tax in 10 years.

Like in Germany, a special attention in Italy is devoted to biogas. Biogas is one of the technologies that can provide in the long run positive returns in terms of decarbonization of energy and agriculture sectors. At the same time, the biogas refineries favour emission mitigation in the energy system, carbon storage via creation of carbon negative systems, synergy for agriculture and organic waste management, biogas refinery could be even more fundamental sector of bioeconomy and circular economy.

In 2015 Italy had an installed capacity of 450 MW biogas electricity output, realized exploiting agricultural residues and OMW (organic municipal solid waste) and producing biogas 2.5 Gm³/year. It has been estimated that, thanks to a combination of crop rotation and integrated use of organic waste stream, it would be possible to reach 8 Gm³/year in 2030. The biogas trend and potential for biogas from manure in Italy is presented in Figure 24.

Figure 24. Biogas trend and potential for biogas from manure in Italy



	2007	2008	2009	2010	2011	2012	2013	2014	2015
🟨 agricultural biogasdoneright	57.575.210	69.210.828	82.022.065	184.240.670	546.874.058	920.118.165	1.723.186.833	1.941.188.883	1.979.170.435
▨ OMW	378.700.187	412.943.872	419.907.156	434.979.201	479.471.876	472.508.591	521.854.464	530.204.377	530.204.377

Source: CIB, 2017; ENEA, 2017.

Techniques for upgrading biogas from anaerobic digestion and landfills are developing quickly, and are currently dominated by technologies for absorption (water scrubbing, amine scrubbing, physical scrubbing with organic solvents) and pressure swing adsorption (PSA), which offer similar performance and involve similar investment costs. The simplicity and reliability of water scrubbing has made this the option of choice in many applications. Membrane separation and organic scrubbers technics are commercially applied today. Cryogenic technology is a further option that is suited for combination with biomethane liquefaction. The information and data provided in this section are from the following data sources CIB (2017), GSE (2016), GSE (2017b), IEA (2017), IEA (2016b) and CR (2017).

5.4.2 The bio-refinery concept: obtaining the maximum from biomass

In order to maximise the use of all biomass components from farming to final products and to reduce the use of fossil resources, the integration of different conversion technologies into one single facility called bio-refinery is desired. Bio-refinery is defined as "the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat)" (de Jong et al., 2017). Elements of the bio-refinery concept are already used in sugar, wood, bioenergy, biofuels and biochemical industry. The bio-refinery can be based on a single process for the production of different products but in many cases, several different processes are combined in order to produce value-added products. Which process will be implemented in bio-refinery depends on feedstock composition, complexity and chemical characteristics of feedstock as well as on required spectrum of final products. The wood-based bio-refineries are one of the most promising solutions for sustainable and economic viable utilisation of limited wood resources for the production of different value-added products. Wood biomass offers great potential for production of different products needed for energy and chemical sector and presents one of the main solutions for reaching bio-based future economy.

The most promising pathways for using wood biomass as a feedstock for bio-refineries are (van Ree and de Jong, 2014): 1. bio-refinery in the pulp and paper industry using wood chips for production of electricity and heat, crude tall oil, red-oil, turpentine, crude sulphate, paperboard, pulp; 2. bio-refinery in the wood industry using residues and wood chips for production of electricity and heat and pellets; 3. bio-refinery using wood chips for production of electricity and heat, Fischer-Tropsch biofuels and wax.

Except for pulp and paper industry, another very promising industry for application of the bio-refinery concept is sawmill industry. The sawmill industry is one of the biggest wood consumer for the production of different wood-based products and at the same time high consumer of heat for drying final products and electricity for machine operation. High usage of wood resulting in the high generation of different wood residues which are usually used in boilers or CHP units for production of own heat and in some case these residues are sold on the market for heating. Nowadays, due to the high price of wood feedstock, many sawmill companies are trying to diversified product portfolio and at the same time to increase utilisation efficient of wood feedstock. This is mainly achieved through usage of sawmill residues for heat and electricity generation but also for pellet production leading to increase in heat consumption produced from own boiler units.

Recommendations for the Alpine and Adriatic-Ionian Regions: 1. Implementation of the bio-refinery concept can significantly increase sustainability of the region and efficient resource utilisation; 2. The bio-refinery concept can be applied on any industry which produces different type of residues which are suitable for application in different energy, chemical and similar process; 3. The bio-refinery concept gives opportunity to mountain areas to increase economic benefit and efficiently utilisation of forest and agricultural resources; 4. Through application of the bio-refinery process for district heating and cooling systems local air quality can be improved due to higher air quality limitation from large units compared to small stoves for households.

5.5 Bioenergy and air quality – case studies from EUSALP and EUSAIR countries

Putting bioenergy in operation while keeping attention on its impacts implies the need for careful planning and implementing appropriate monitoring measures in order to cope with the related impacts, in particular with the important impacts on air quality.

5.5.1 Improving technologies

Domestic woodstoves for heating and cooking are deeply rooted in the Alpine culture. However, due to incorrect combustion of wood fine particulates matter and harmful hydrocarbons are liberated, leading to increased pollutant concentrations in the air; in some areas even above legal target values. In particular, settlements with a high amount of small and manually operated wood-burning stoves are confronted with poor air quality. Adverse weather conditions, such windless periods, as well as geographic locations such as valley floors exacerbate these effects.

In **Serbia**, the most of used appliances for bioenergy production belong to simple conventional stoves, cookers and boilers, characterized by low efficiency and high pollutants emission. Although the presence of over twenty boilers, stoves and cookers manufacturers in the country, a lot of appliances are self-made, or produced by local handcrafters. One of the prime requests of the buyers is to get appliance as cheap as possible that usually implies lower efficiency and higher pollutants emission rate. Some manufacturers, especially of appliances for wooden biomass, provide advanced solutions, but these are mostly exported to EU and other countries.

The emission limits for domestic combustion appliances fixed in Serbian legislation are presented in Table 5.

Table 5. Emission limits for domestic combustion appliances in Serbia.

Pollutant	Fuels	Thermal Power (kW_{th})	LVP (mg/Nm^3)
Particulate Matter (PM)	Coal	≥4	90
	Wood, excluding wooden briquettes and pellets	≥4	100
	Wooden briquettes and pellets	≥4	60
Carbon Monoxide (CO)	Coal and Wood, excluding wooden briquettes and pellets	4-500	1000
	Wooden briquettes and pellets	4-500	800
	Coal and Wood, wooden briquettes and pellets	≥500	500

Source: Anonymous. 2016.

Legislation regulates emissions and emissions measurements; there is a national decree imposing emission limits for wooden biomass appliances almost identical to those applied in Germany. Unfortunately, measurement of emissions in practice and certification of appliances are not defined to be obligatory. Currently, there is no certified laboratory for such measurements, but two are in a process of preparation. Nevertheless, all CEN and

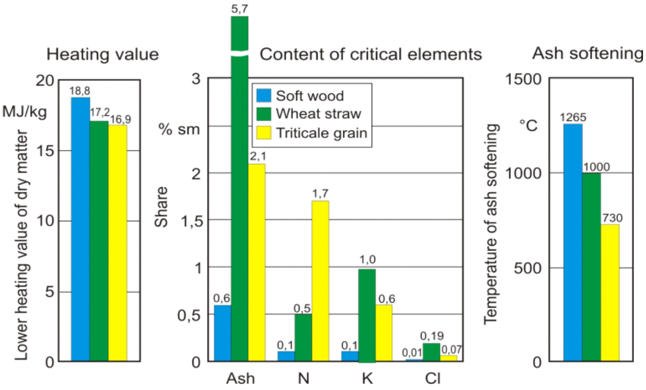
EN standards related to biomass use as a fuel are adopted as national, including most important EN 303.5.

Currently there are three institutions qualified for measurement of airborne pollutions, but neither one is equipped for constant measurements of emissions caused by biomass combustion. A positive example in this field is the ongoing project within EU Danube Transnational Programme titled: "Transnational Cooperation to transform knowledge into marketable products and services for the Danubian sustainable society of tomorrow (Made in Danube)". The project includes Pilot Activity BIOFUELS, which is in line with biomass combustion and air quality issues. Idea of the project is to support innovative solutions in the Danube region, by bringing innovators and manufactures in contact. One of mentioned challenges is reduction of flue gas pollutants for small boilers and stoves, especially for agro biomass. Another initiative worth to mention is the just submitted application of the LIFE project CONSPIRO – Breathing Together for Local Air Quality that includes development of low-cost pollution monitoring scheme as well.

Generally, for all countries, it would be of interest to introduce trade-off between global warming issue (reduction of GHG emission) and air pollution mitigation by utilization of biomass for residential heating.

For Serbia and some of EUSAIR countries, it would be of interest to develop appliances and practice of sustainable use of agro biomass for small units, residential heating. This is a big challenge due to higher content of critical elements and ash characteristics in comparison with wooden biomass. The Comparison of combustion characteristics for wood, straw and triticale grain is presented in Figure 25.

Figure 25. Comparison of combustion characteristics for wood, straw and triticale grain



Source: Hartmann, H. (2013).

For Serbia, but some EUSAIR countries as well, it would be of interest to perform: 1. Improvement of appliances, and replacement of old with new and advanced types; 2. Improvement of agro biomass fuels, content and form, for better combustion and lower emissions; 3. Introduction of obligatory (compulsory) testing of appliances for biomass combustion; 4. Development of new, low-cost, solutions aimed to obtain reduction of pollutants emission and incentives for their application; 5. Quantification of airborne pollutants caused by biomass combustion. Development of method and purchase of adequate equipment.

Burning biomass in boilers and stoves is the main source of PM emission also in a few cities in northern **Croatia**, in the City of Zagreb, Slavonski Brod and Osijek. These towns are implementing Air Quality Improvement Plans, although the important issue is that in northern Croatia, where air pollution by PM exceeds limit values, the contribution from transboundary transport is higher than contribution from domestic sources. How much the implementation of the new NEC directive will decrease pollution is not yet known for certain, and further research and investigation is needed.

5.5.2 Regulations and controls

In the **Po Valley**, where during the cold seasons, the air quality is one of the most relevant issues, the bio-power plants emissions may also contribute negatively. To control the emissions of a bio-power plant supplied by solid biomass both primary and secondary measures should be taken into account as briefly described in Table 6.

Table 6. Primary and secondary measures for a bio-power plant supplied by solid biomass.

Primary measures	Secondary measures
• Solid biomass quality control (woody chips size and origin) • Elemental analysis of the solid biomass • Moisture content control • Operational written procedures for start up and shut down and trained plant operators • Start up and shutdown optimisation to reduce pollutant emissions • A minimum technical load should be set • Automatic feed rate control air/solid biomass related to pollutant emissions • Auxiliary burners • Combustion chamber temperature control • Residence time optimisation • Operational written procedures for emergency shutdown • Partially burned solid biomass displacement from the combustion chamber in case of emergency shutdown	• Efficient particulate control equipment (for example well designed bag filter, made by temperature resistant material) • NO_x reducing strategies (for example: staged combustion, temperature reduction, SNCR and SCR) • Post combustion chamber • The emission control equipment should be in service during transient phase too

Source: Adapted from "Air Pollution Engineering Manual" Air and waste management association, Wiley, 2000 (http://eu.wiley.com).

The air quality issue in the Po Valley is inducing the regulators to legally impose stricter ELV (Emission Limit Value) for the bio-power plants supplied by solid biomass. To fulfil the legal obligation of stricter ELV, the implementation of primary and secondary measures can be economically unviable, especially for residential applications and small-scale plants supplied by solid biomass. Furthermore, the complexity of the emission control measures requires well-trained operators and effective maintenance plans, not easily implementable in small-scale plants and residential applications. In particular, the Adriatic-Ionian and Alpine regions could consider to: 1. Implementing Best Available Technologies (BAT) for industrial applications of biomass for medium and small-scale plants (under 50 Mw_{th}). The BAT should also consider local air quality issue; 2. In order to use the bioenergy resources, the enriched biogas can be supplied to small-scale plants and residential applications by the existing gas network, or it can be used in the automotive sector; (good examples of enriching technologies of biogas are still present in Veneto and commercially available); 3. The use of enriched biogas for residential applications determines a more effective preventing policy of air pollution, avoiding not easily implementable measures needed for the solid biomass; 4. In order to produce biogas, a challenging research could be the anaerobic digestion of pre-treated woody biomass; 5. Bioenergy in the context of the low carbon economy.

5.6 Status and perspective of bioenergy in the frame of national decarbonisation strategies

When taking a more general view, bioenergy finds its place in the plans for decarbonizing national economies. Some case studies from both EUSALP and EUSAIR will be presented, showing how different national frameworks consisting e.g., in different feedstock availability, industrial structure, incentives and legislative approaches are reflected in bioenergy deployment.

- Croatia

In the energy sector, Croatia is on its way to reach the target of 20% of renewable energy until 2020. In recent years the share of renewables has been even higher than 20%; new corrected statistical data shows that the share is 29% in 2015 (Eurostat, 2017a). In the year 2015 the biomass production was mostly firewood (81%), other biomass and waste accounted for 16%, biogas 2% and biofuels 1%. In total consumption of 55,2 PJ, 88% are used in the residential sector, 8% for energy transformations, 2% for industry, 2% for transport and less than 1% for services (Eurostat, 2017b). Croatia is producing biomass pellets and briquettes, but the export is considerably higher than domestic use; in 2015 the 89% of the pellets and 66% of the briquettes produced were exported (Eurostat, 2017c).

Production of electricity from biomass is subsidized by feed in tariffs. Now (September 2017) there are 36 MW of CHPs using solid biomass and 35 MW of CHPs using biogas (CEMO, 2017a), and for 2020 the target is set on 120 MW and 70 MW respectively (CEMO, 2017b).

Croatia has also started to work on the preparation of its Low Carbon Strategy(15) (LCS), and the draft White Book has passed public consultation in August 2017.The LCS refers to all economic sectors and human activities, and is particularly relevant for the energy sector, industry, traffic, agriculture, forestry and waste management. The Strategy operates horizontally, and takes precedence over sectorial strategies but will be operationally implemented through specific sectors. LCS goals will be met by applying cost-effective measures, primarily those measures that enhance productivity and employment, as well as measures that contribute to modernization and equal territorial development, while at the same time decreasing social differences. The preparation of LCS involved the application of many simulations and optimization models, simulation of numerous scenarios, all of them aggregated the integral planning model package, dealing with GHG and non-GHG gases, and with calculation of health impact costs and new jobs creation. The draft LCS outlines three scenarios: the Referent Scenario (NUR) that represents the application scenario of the already existing regulation, and two transition scenarios towards low-carbon economy: The Gradual Transition Scenario (LC1) and the Strong Transition Scenario (LC2). In its National Integrated Climate Energy Plan, Croatia will present its final political ambition.

Biomass is an important renewable energy source for Croatia, having a large share in the residential sector, as traditional fuel in rural areas. In the future, the perspective will be using the best available technologies and substitution of bark wood consumption with pallets and biogas. The main challenges in the future are increasing the biomass available

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(15)https://esavjetovanja.gov.hr/Econ/MainScreen?entityId=5575 for supply but with continuation of sustainable forest management that has a long hundred year old tradition, and improving air quality in some urban areas. Croatia is facing a challenge with the GHG 'no-debit' rule in the LULUCF sector, coming from Paris agreement and European Union LULUCF GHG accounting regulation under the 2030 climate framework policy.

In Croatia 41% of the territory is covered by forests, and the forestry sector has great natural and economic value with an important social dimension background. About 36% of the total Croatian terrestrial territory is under the Natura2000 protection, posing a challenge for forest management and restricting the economic exploitation activities. Applied forest management methods in Croatian forests have relatively low economic effects, but they guarantee long-term sustainability.

The Republic of Croatia has continuous significant greenhouse gases removals by sinks in the LULUCF sector; in the year 2015 the sink was 21% of total GHG emission (NIR2017). Croatia believes that the new criteria and guidelines for determining forest reference levels under the LULUCF directive will take into account national circumstances, such as post war circumstances impacting forest management during the reference period in Croatia.

Currently there are growing positive actions that are being implemented, use of modern biomass boilers in buildings (schools, other public buildings), efficient biomass CHP plants and use of heat, plans for production of advanced biofuels for transport.

The main challenge is finding a way for biomass production and utilization to contribute to economic growth and creation of new jobs. In this general bio-economic challenge, the following issues will be of importance for Croatia: 1. Increasing the intensity of forest harvesting while preserving carbon sink and meeting the 'no-debit' rule by new LULUCF accounting; 2. Increasing the usage of agricultural waste biomass and fast rotation copies biomass; 3. Supporting the usage of best available technologies and enforcing implementation measures in cities that have excessed air pollution with PM due to biomass burning in the residential sector where coordinated action of local and national authorities is essential; 4. Improving data and statistics on the biomass chain (production, supply, consumption) and building a LULUCF information system.

- Italy

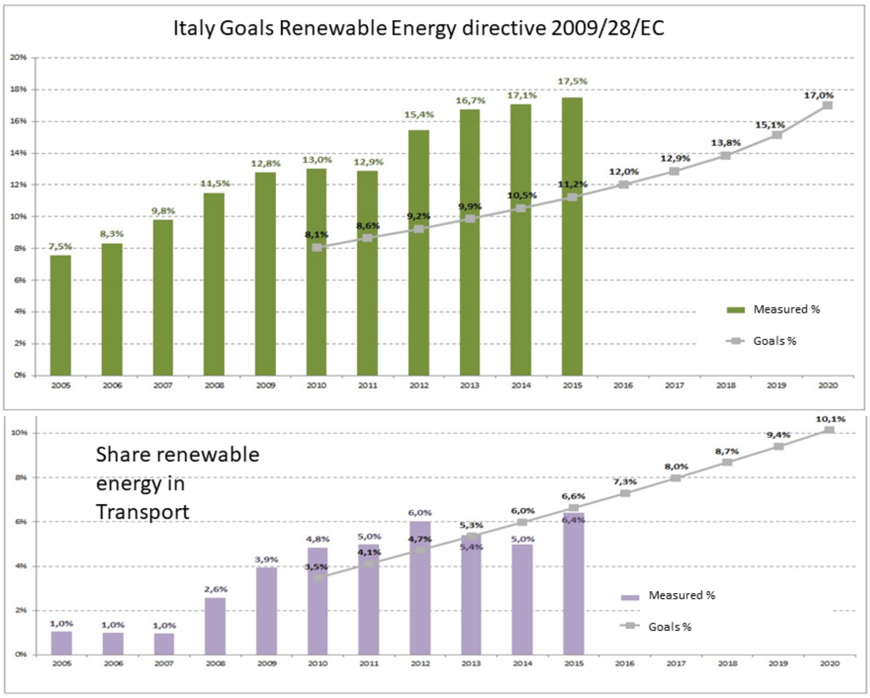
According to the Renewable Energy Directive (RED), Italy has a 2020 target of 17% of gross final energy consumption being produced by Renewable Energy Sources (RES). The National Renewable Energy Action Plan (SIMERI, 2017) monitoring shows that in 2015 renewable Heating and Power sectors are both performing above trajectory target, while in transport Italy is struggling to cope with the sectorial final target of 10% of RES in transport fuel by 2020 (Figure 26).

In 2014, renewable energy consumption in Italy 2014 reached about 1136 PJ, almost half which, around 518 PJ consisted in Bioenergy. Most of the bioenergy consumed in Italy came from solid feedstock (375 PJ). The second largest item consumed is biogas (69 PJ) followed by biodiesel (44 PJ), renewable municipal waste (34 PJ), other liquid biofuels (30 PJ) and charcoal (2 PJ). Bioenergy consumption in Italy increased more than fifteen fold from 1990 to 2013, from 0.6% to 8.5% of the final energy consumption, and changed in nature as in 1990 bioenergy originated only from solid biomass and accounted for just 34 PJ (see annex 13). In 2016 there were 2747 Power and Combined Heat & Power (CHP) bioenergy plants operating in Italy, totalling 4128 MW installed power actually producing around 19509 GWh. Between 2015 and 2020 1200 GWh of additional bioelectricity are foreseen to come in grid out of the additional 8000 GWh production planned for total renewable energy. As of 2016, only 40 MW of new bioenergy capacity were on stream, with 175 M€ in new bioenergy investment, of which 100 M€ for plants under 500 KW. Demand for existing biomass plants repowering was very weak.

The main national schemes supporting Bioenergy in Italy, applied for the past installations and still running for the beneficiary plants until the incentive expiration are:

1. Green Certificate scheme for all RES other than PV (over 15 years); 2. Feed in Tariff scheme for all RES other than PV with a capacity up to 1 MW (over 15 years). For the new plants the main incentives currently available are: 1. New feed-in Tariff and sliding feed-in Premiums systems through registries and auction (over the plant lifetime); 2. Fiscal incentive (tax credit). The new Fiscal incentive schemes have simplified the purchase, accessible by all renewable non-programmable power plants and for other power plants up to 10 MW and allows the operator to have the energy injected into the grid retired by GSE, who is responsible for bidding the energy into the market; 3. Net Metering, accessible by renewable power plant and CHP power plants up 200 kW (extended up to 500 kW in 2015). It provides to the producers an economic contribution in order to pay back a part of the cost of purchased energy. The value of the contribution is determined on the basis of an economic valorization of the energy injected into the grid.

Figure 26. Renewable energy deployment in Italy vs. National Renewable Energy Action Plans forecast



Source: SIMERI, 2017.

The overall Bio electricity incentive support in 2016 amounted to around 2.8 Billion Euros, and while from 2015 to 2020 about 2300 GWh bio electricity production will see expiring their incentives, new Bio electricity production for around 1200 GWh will be incentivized.

Regarding bioheat, in 2016 consumption reached 6800 Ktoe representing 8% share in the total heat energy consumption. Heat generated in CHP plants contributed for around 33000 GWh, and it is expected to reach the value of 49000 GWh in 2023, a potential considered economically feasible in the current conditions. The shift towards bioheat is pushed by the "conto termico" incentive, available at the national level in order to promote the substitution of existing heating systems with biomass-based installations, along with the installation of heat metering systems in the case of plants with a thermal output higher than 200 kW with maximum permitted 2000 KW per plant. The incentive level varies depending on the type of the plant, source, capacity and location of the installation. The total national cap is set at € 700 million in the case of private individuals and € 200 million in the case of public administration.

While for Electricity and heat Italy is performing well above the plan, in 2015 biofuel blending was 28% less than planned with a gap of 583 Ktoe. A mandatory quota for "advanced biofuels" has been also introduced, as well planned to 1.2% in 2018 and increasing to 2% in 2022.

Finally, it is worth mentioning terms of bioenergy contribution to the green economy: the bioelectricity production sector in 2016 employed about 20.000 full time equivalent with a value around 2.1 billion euros/year including new investment, operational and maintenance. For the bio heating sector, stoves and boilers sectors has a value of 850 Meuros/year with 5500 full time equivalent employees. It has also to be considered that bioenergy supply chain is partially embedded in other sectors such as agriculture and livestock farming, waste management (organic fraction), import export (fire wood, pellet, biofuel) vendors and transport. Economic statistics in these sectors are usually not analysed to evaluate the bioenergy related contribution, but it is anyway possible to assume the bioenergy value in terms of value and jobs is higher than what stated. The information and data provided in this sections are also from other data sources such as GSE (2016).

- Serbia

In the Republic of Serbia, according to the National Renewable Energy Action Plan (NREAP), the biomass potential makes about 60% of all renewables, i.e. about 3.4 Mtoe. This potential seems to be technically, not sustainable, and, according to rough estimation, the sustainable potential should be 10 to 20% lower, what means about 2.9 Mtoe. About 1.3 Mtoe is currently used, corresponding to about 45% of sustainable potential. The unused potential share is dominated by agricultural biomass, with around 1 Mtoe. So, it has the biggest potential for further expansion of utilization.

According to the Action Plan (Anonymous. 2013), the share of biomass utilization for sector heating&cooling is about 31 %, which is significant. More than 95 % is used for residential heating in small appliances, up to 50 kW of nominal thermal power. The Bioenergy in the NREAP of Republic of Serbia is summarized in Table 7.

Table 7. Bioenergy in the NREAP of Republic of Serbia: a) Gross Final energy consumption, total and per sector, in 2009 and 2020. Scenario with no additional energy efficiency, b) Renewable sources in heating and cooling sector.

(a)

Year	**GFEC (ktoe)**	**Electricity (ktoe)**	**Share (%)**	**Heating/cooling (ktoe)**	**Share (%)**	**Transport (ktoe)**	**Share (%)**
2009	9149.7	3079	33.6	4144	45.3	1926	21.1
2020	10330.6	3425	33.2	4231	40.9	2675	25.9

(b)

Source	**2009 (ktoe)**	**2020 (ktoe)**
Geothermal	5	10
Solar	0	5
Biomass	1054	1152
Solid biomass	1054	1142
Biogas	0	10
TOTAL	1059	1167
Of which DH	0	25
Of which households	994	1001

Source: Anonymous, 2013.

- Albania

As far as Albania is concerned, presently (data of 2015), renewable energy resources in Albania cover 33% of the total energy consumption. The main renewable energy sources are hydro-energy and fire wood. There are also attempts to produce biofuel (for 2015, 33 Ktoe were reported), but for the moment this is based on imported raw materials while the product is exported to Italy. In July 2017 a plant for energy production from municipal wastes started operation with a capacity of 2.8 MW.

In bioenergy production, fire wood is the main source exploited in the country. Residues from wood processing and olive processing (olive cake) are also used for energy production mainly through combustion.

Due to the agricultural situation, very small farm size, relatively low yields and high agricultural input prices, the production costs, especially of less labour intensive cops, are higher than in many other countries. This situation, combined with the lack of incentives for bioenergy production makes the cultivation of energy crops not realistic.

The use of firewood as the main heating source, especially in the villages and in colder regions, combined with the insufficient replacement of the consumed wood with new forests, has contributed to a sharp decrease of the forests stock in the last 20 years. Then, in this forest situation the use of fire wood should become under control, and there are no real possibilities in increasing it. Another possibility to increase bioenergy production in Albania could be based on planting of fast growing trees in abandoned areas and in other agricultural areas as windbreakers. For this purpose, there is a need of support from the governmental structures.

In this framework the future of bioenergy production in Albania could develop only through low cost raw materials. These raw materials could be identified in the agricultural residues and livestock manure. Taking also in consideration the sustainability of agricultural production and the maintenance of the soil fertility, the best approach should be the use of these residues for biogas production. After gaining biogas the organic material could be used again in agriculture as manure.

Fruit trees residues from pruning are actually used in small amounts through direct burning. There exist real possibilities to use this organic material in much higher scale for energy production through pelleting.

A study was undertaken to establish bioenergy production in Albania (Rroco et al., 2009). In this study not only the situation of the agricultural production, was taken into account, but also the actual use of agricultural residues from the farmers and the situation of soils regarding soil organic matter and in general soil fertility. In this study the coefficient of potential use of agricultural residues for bioenergy production were calculated. According these calculations there are real possibilities to produce over 107 Ktoe/year, from this almost 90 Ktoe/year as biogas from agricultural residues and manure. Due to the fragmentation of the agricultural surface and the great number of farms the best solutions should be small scale biogas plants.

A new plant with a capacity of 3.8 MW, aimed at producing bioenergy from urban waste is planned to enter in operation this year and the projections, according the "Renewable Energy National Action Plan" show that up to 2020 the amount of biodegradable waste will reach more than 60000 m3. Differential collection of urban waste, which for the moment is done in very small amounts, would strongly support this process and decrease energy production costs.

Overall, the use efficiency of the present bioenergy production is very low: fire wood is used in heating private buildings in mostly obsolete facilities and there is very small diffusion of pellets. In Albania the industrial capacities for pellet production reach 225000 tons year-1, but due to lack of raw material this capacity is used for just between 10-20%. There is also lack of facilities for pellet use and the product is mainly exported.

On summary: 1. Albania has real capacities in increasing bioenergy production from agricultural residues, but an intelligent use of this resources is needed in order to preserve soil fertility; 2. There is a need to improve marketing channels for bioenergy production; 3. It is necessary to improve the efficiency of energy use from firewood and industrial residues using better burning facilities.

5.7 The JRC for bioenergy and growth

JRC has been active in research addressing the "clean growth" bioenergy paradigm under several points of view, entering in the scientific debate on several of the points discussed in the workshop.

The environmental sustainability pillar of bioenergy has been addressed by the JRC in support of the definition of the EC proposal for the recast of the Renewable Energy Directive (COM767, 2016). The JRC has been studying the greenhouse gas (GHG) emissions performance of biofuels and bioenergy pathways since many years. For instance the work carried out in the frame of the discussion about the Indirect Land Use Change (ILUC) caused by biofuels exploitation was crucial in defining the 2015 amendment of the Renewable Energy Directive (Directive 2015/1513/EC). More recently, the JRC has investigated the climate change mitigation potential of forest bioenergy. The results of these analyses fed into the EC impact assessment on bioenergy sustainability (EC/SWD/418, 2016).

This work has highlighted that, when looking at the carbon performance of bioenergy, the modelling approach must be consistent with the specific goal set for the analysis. For instance, for regulatory needs, simplified life-cycle methodologies are based on accounting for GHG emissions encountered along the supply-chain of each bioenergy commodity. This methodology is suitable to benchmark various pathways on a common scale so to exclude the pathways which are inefficient or with highest impacts. This approach is used in the Recast of the Renewable Energy Directive to calculate the GHG savings of biofuels and bioenergy pathways (Annex V-VI).

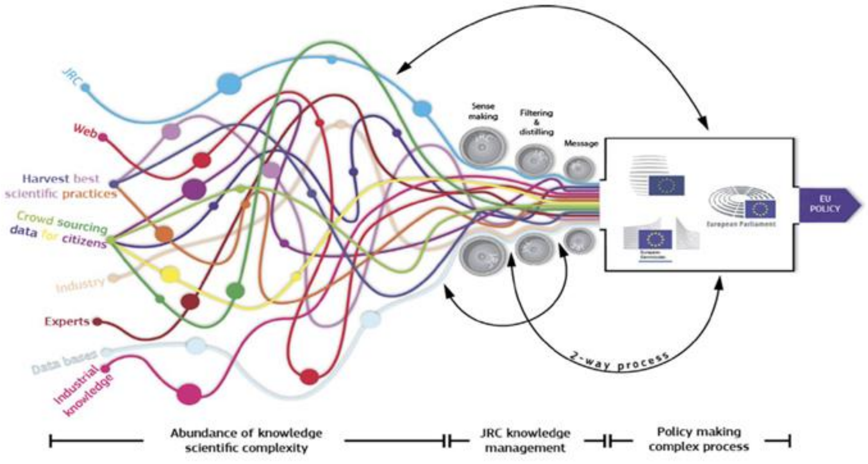
However, when the goal is to perform a strategic assessment of the potential climate change mitigation of specific commodities or policy choices, the modelling approach needs to change. In addition to the supply-chains GHG emissions, also biogenic-CO2 emissions should be accounted, and alternative uses of biomass (or land) need to be considered. The results of this strategic approach show that the assumption of "carbon neutrality" of bioenergy (i.e. the assumption that bioenergy does not contribute to the net atmospheric increase of CO2 because the same amount of CO2 released by the combustion of biomass is absorbed again by the re-growth of the biomass feedstock) is not generally true. Instead, actual GHG reductions depend strongly on: i) time horizon considered; ii) type of feedstock; iii) forest management (past, present and forecasted); iv) alternative uses of biomass; v) fossil source substituted; vi) end-use efficiency; vii) effects on non-energy economic sectors.

Generally speaking, wood residues use results in a GHG benefit in most cases, while sawnwood, stumps and coarse deadwood do not provide GHG benefits in policy relevant time-horizons. As far as pulpwood is concerned, a case-by-case evaluation is necessary. Moving to a systemic approach, the majority of EU forest-based bioenergy currently delivers benefits in terms of GHG emission savings; however in the future, actual benefits will strongly depend on the scale of demand and supply. In any case, forest management strategies have been, are and will remain crucial for defining the overall GHG performance.

Finally, it is essential to notice that the environmental performance of bioenergy is not limited to GHG emissions and climate change; impacts on air pollution, land use, and biodiversity and ecosystem services should be evaluated as well to provide a holistic impact assessment.

Bioenergy is an aspect of the wider concept of bio-economy, in which biomass is seen as a valuable resource providing added value to several industrial sectors. Already in 2012, the European Commission has put in place a bioeconomy strategy and a related Action Plan (COM (2012) 60) aiming to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection.

Figure 27. The concept of knowledge management to support policy making in the JRC Knowledge Centres



Source: JRC.

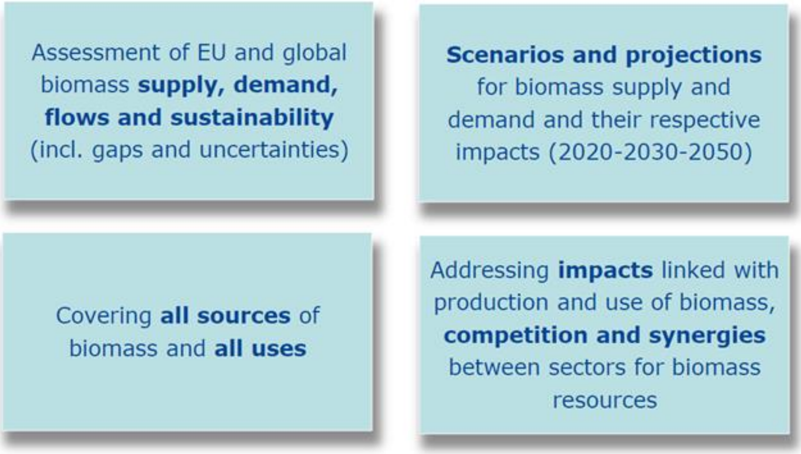
JRC has recently started the process of setting up a first group of thematic knowledge centres with the mandate of "creating, collecting and making sense of collective scientific knowledge for better EU policies" including the Bioeconomy Knowledge Centre (Figure 27).

The scope of the BKC is manifold: promoting synergies among EU policies, improving the knowledge base for policies by means of quality controlled and fit for purpose data and setting up an ICT platform (https://biobs.jrc.ec.europa.eu/) providing a common repository for data, information and knowledge. The BKC is also expected to facilitate the creation of a "Community of Practice" ensuring continuous knowledge exchange among experts from EC services, external organizations and stakeholders from the many disciplines and areas of the bioeconomy.

Finally, it is worth mentioning the effort of JRC in providing a consistent picture of biomass supply and demand at the EU level following a specific mandate from the European Commission services, the so-called JRC biomass study (Figure 28).

Among the different aspects targeted in the study, it is worth citing the preparation of complete Sankey diagrams detailing the flows of biomass through the different sectors and uses in the EU and its members States (Figure 29).

Figure 28. Scope of the JRC biomass study



Assessment of EU and global biomass **supply, demand, flows and sustainability** (incl. gaps and uncertainties)

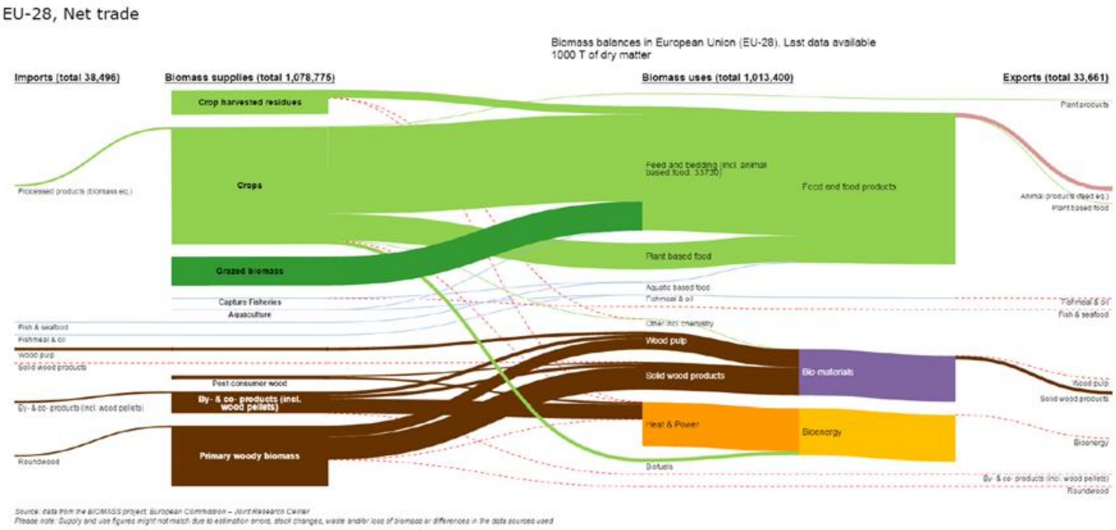
Scenarios and projections for biomass supply and demand and their respective impacts (2020-2030-2050)

Covering **all sources** of biomass and **all uses**

Addressing **impacts** linked with production and use of biomass, **competition and synergies** between sectors for biomass resources

Source: JRC.

Figure 29. Sankey diagram of EU biomass flows



Source: JRC.

6 Steps towards management of knowledge

End 2016 the Commission adopted and published a communication, C6626 (2016), that sets out a corporate strategy on data, information and knowledge management. It might be useful to provide a definition of the terminology with

- data as the raw facts, events, measurement points or statics
- information which adds the context, conditions, quality to the data points
- knowledge which links the information; knowledge is needed to find the storyline and answer to a question.

The Information Management Steering Board (IMSB) at the European Commission was established with all the directorates general to develop and guide actively corporate data, information and knowledge management policy. The IMSB included in the 2017 work programme of the European Commission the following four actions:

- To improve information retrieval and delivery (including the establishment of info responsibilities, corporate governance and system interoperability)
- To work together and sharing information and knowledge (including the mapping of knowledge, enabling collaborations and linking people)
- To maximise the use of data for policy-making (including the development of scientific data analysis capacities, exploitation of big data and tools and infrastructure for data analytics)
- To create a culture of knowledge sharing and learning (aiming at an organization that is information aware and willing to learn).

Recognising the strategic value of data, info and knowledge, the Joint Research Centre took measures to make knowledge management an important activity, reflected in its mission to “manage and make sense of collective, scientific knowledge for better EU policies”. The 2016 reorganization underlined the knowledge management importance at the JRC with a horizontal knowledge management directorate, bringing together the knowledge units of the knowledge production directorates (see an example in annex 15).

Knowledge management related to macro-regions could focus on including best practices, tools, science supporting green solutions, integrated approaches and outstanding achievements of different projects.

7 Conclusions

The findings presented in this report can be summarized as follows:

1. **The preliminary analysis of available emission scenarios** for the next decades, with a focus on the Alpine and Adriatic–Ionian regional as receptor has shown that:

- Under the baseline CLE scenario, the residential sector is and remains (beyond 2050) the major contributor to anthropogenic primary PM2.5 emissions, both in ALP and AIR.
- Under CLE, the road transport sector is the major contributor (until 2040) to emissions of NOx both in ALP and AIR.
- The residential sector currently contributes 14% of (total, i.e. primary and secondary) PM2.5 concentration, up to 20% in 2020, then decreasing to 11% (ALP) and 14% (AIR) in 2050. Present-day road transport is responsible for 22% of exposure to PM2.5 in ALP and AIR, reducing its share to 8% or less in 2050.
- Primary PM2.5 emission control has almost reached its technical limit, but secondary PM2.5 has still a large reduction potential through NOx and NH3 controls using MTFR technologies.
- Potential health benefits from all sectors under MTFR (ALP + AIR): minus 16,800 premature deaths annually in 2030 (3250 + 13550).
- Potential health benefits from Climate mitigation (ALP + AIR): minus 2200 premature deaths annually in 2050 (620 + 1580).
- CLIM policies due to fuel switch to biomass also cause AQ trade-off in the domestic sector leading to 360 extra premature deaths annually in 2050 in AIR.
- PM2.5 from shipping contributes 3% to total PM2.5 in 2000. Absolute concentration under CLE does not decrease by 2050, while its share increases to 5-6% for both regions (CLE).
- MTFR measures on road transport and shipping emissions can generate an annual health benefit from PM2.5 and ozone of 750 (ALP) + 2950 (AIR) avoided premature mortalities in 2050 of which 64% from shipping emission reductions.
- Climate measures in the road-transport sector can generate a co-benefit of 1200 avoided air-quality related mortalities by 2050.
- Emissions from the agricultural sector on the one hand and mainly transport and energy sectors on the other hand contribute in a complex but significant way to total PM2.5 exposure: under CLE ammonium salts contribute to total anthropogenic PM2.5 with 57% in 2000 to 65% in 2050 in AIR and 71% to 73% in ALP.

2. Clean growth in transport

a) Intermodality aspects in Alpine and Adriatic–Ionian macro-regions

For 2nd Strategic Objective of EURLAP, the partners focus on the most important challenges and opportunities concerning mobility and connectivity. The Alpine Region suffers from the negative social and environmental impacts of transalpine transport, reinforced by the specific geographic conditions; road transport in particular causes negative externalities such as air pollution, noise and traffic congestion. These issues are addressed by Action Group 4 Mobility, which promotes inter-modality and interoperability, supports the modal shift from road to rail, and_develops cooperation.

Pillar 2 "Connecting the Region" of EUSAIR, has as objective to improve connectivity within the Region and with the rest of Europe in terms of transport and energy networks. The Transport Subgroup Group TSG2 includes "Transport" and "Energy" subgroups. The TSG2-Transport subgroup of TSG2/Pillar 2 is focusing on topics related to maritime transport, maritime safety and security and competitive regional intermodal port system in particular, and topics related to reliable transport networks and intermodal connections with the hinterland for freight and passengers.

- Intermodality and green solutions in transport are on the agendas of both EUSALP and EUSAIR.
- Intermodality in passenger transport could be improved e.g. for EURLAP by providing real-time information through a single portal for the territory of this macro-region, including last mile solutions (public transport, walking, cycling, bike rentals, taxi, on-demand transport etc.).
- Intermodality in freight transport could be improved by implementing combined transport (divided in long-distance and last mile); every particular case should be analyzed, if such improvement of logistic chains would be socio-economically and environmentally justified.
- The modal split between rail and road is 64% to 36% in Switzerland, whereas the railway holds shares of only 31% in Austria and 14% in France; between 1999 and 2004, rail traffic (in tonnes) decreased by 30% on northern French crossings, whereas rail traffic through Swiss crossings increased by 21%. In Greece, 80% of freight transport is conducted by road; rail is insignificant and maritime too little, given the vicinity of major Greek cities with the sea. In Slovenia, the share of transit freight flows on highways is almost 70%.
- Territorial modelling platform (LUISA) allows for the exploration of several policy alternatives e.g. for clean and efficient transport policies. Accessibility and air quality thematic indicators were developed for all EU Member States and several Western Balkan countries.

b) Reduction of emissions from ship transport

- Ship traffic in the Adriatic and Ionic Seas is intense and the area has several important ports, e.g. Trieste and Venezia in Northern Italy.
- Ship emissions in ports give an important contribution to air pollution in many European cities. Case studies of ports in the Adriatic and Ionian area show that maritime emissions of particulate matter and NOX can be comparable to those of road traffic. The contribution of harbours to the concentration levels of NO2 found in urban air is of particular concern. One study found that the contribution of ship emissions to ultrafine particles was particularly important. The use of low-sulphur content fuels by ships in ports has proven to be efficient in reducing primary particles concentration, in addition to SO2 concentrations and sulphates
- 'Cold ironing', i.e. connection of the ships to the land based electrical grid during their stay in port, is found to have a great potential for reduction of ship emissions during the hoteling phase in ports. Development and application of guidelines and legislations specific for logistic management of harbours could be important for local air quality in port-cities.
- A sustainable development of ports must be focused on the balance between environmental issues and economic benefits. Enlargement of the port area must be in accordance with environmental standards. All new investments in infrastructure could present a positive effect on welfare and ecological protection of air. The green port concept implies less carbon emissions and require that new equipment is in compliance with this goal.
- Container ships are the top-emitters in the world fleet. Several options are available for reduction of these emissions. Reducing ship speed is one of these, it could also have important side benefits: cost reduction, and helping a depressed market in which shipping overcapacity is the norm these days. However, as speed reduction may have important logistical ramifications, one should be careful on how such a

measure might be implemented, so as to achieve maximum benefit to society and avoid possible market distortions.

- Before the introduction of new limits for the content of sulphur in marine fuels within the Northern European Sulphur Emission Control Area (SECA) as of 1/1/2015 it was widely feared within the shipping industry that this would bring their services at risk due to the higher cost of low-sulphur fuel compared to heavy fuel oil. However, due to a strong drop in fuel prices, the maritime transport share actually increased after the introduction of new sulphur limits. If oil prices turn to 2014 levels, a reduction in the maritime transport share is expected. For what concerns a possible Mediterranean ECA a prior case study seems to provide positive clues but further analyses are needed.

c) Reduction of emissions from road transport

- Electrification of road transport enables transport emissions reduction in Europe. TEMA platform aims at investigating the potential of innovative vehicle technologies nested in complex transportation systems at a regional level. This tool can support smart city and smart region policies in the frame of low carbon mobility and sustainable transport systems development.
- If electric mobility is going to play an increasing role in the future, attention should be given to the need for more charging infrastructure.
- Electric vehicles are only as clean as the energy source that charges them; if this comes from renewables, it could be beneficial for environment but if it comes from a coal plant, it might lead to an overall increase in harmful emissions elsewhere.
- Advanced biofuels represent (vs fossil fuel) one of the few options to reduce CO2 emissions in transport but for air quality it comes with trade-offs between some effects.
- With the exception of some countries (e.g. Switzerland, Austria, Germany and Italy), the rest of the countries in ALP and AIR macro-regions comprise small nations with limited resources and poor economies; measures of recognized effectiveness elsewhere may not be beneficial or even applicable to some countries, especially of the EUSAIR region.
- Some of these countries in ALP and AIR macro-regions do not belong to the EU and may present limitations in international trade and security agreements.
- Measures to reduce CO2 emissions and fuel consumption include infrastructural changes, including Information and Communication Technologies and improved fuels.
- Fleet renewal is required to reduce air pollutants. This is a costly measure often not accessible to private and public users of transportation services; for several of the countries of the AIR macro-region, new registrations in their majority comprise second-hand vehicle imports, rather new car sales. Diesel vehicle retrofit is more accessible and proved to be effective for PM and NOx emissions reductions.
- The effectiveness of Euro standards should be confirmed e.g. the reductions in NOx promised for first generation of diesel Euro 6 were not reached in reality.
- European Union air quality directives require Member States to divide their territory into zones related to air quality standards, therefore the emissions and their impacts on air quality should be evaluated. Member States have to adopt plans and programs inside zones when air quality standards are not respected; in this study are presented the steps and results for Abruzzo region. Official emissions inventories for all sources, including transport, are developed by country experts that are members of the Task Force on Emission Inventories and Projections (TFEIP), which operates under the Convention of Long-range Transboundary Air Pollution (CLRTAP).

3. Clean growth in bioenergy

— Overcome challenges that regard use of innovative technologies to reduce the negative impacts on the environment (air quality) and on health.

There is consensus in pointing air quality as a major issue related to the present and future bioenergy deployment in the area. Domestic heating sector is particularly critical, because of the wide use of very simple, obsolete an inefficient devices. Clearly a technological switch to cleaner and more efficient boilers or other structural solutions such as district and centralized heating are needed. Tools for boosting appropriate technologies include incentives, quality labels, motivating producers and reducing time to market for new appliances, without neglecting the effective enforcement of strict and legally binding emission controls.

— Sustainable forest management and sustainable supply chains including non-energetic use of biomass.

Although sustainable forest management is already a reality since centuries, in several European areas, illegal logging is still an issue, especially in rural areas, driven by inefficient wood burning. From a technological point of view, the biorefinery concept could play an important role in optimizing wood resources exploitation.

— Climate impacts of a growing bioenergy sector and its role for effective climate change mitigation

Research is ongoing on the actual mitigation effectiveness of solid biomass when a full life cycle approach is taken. At the same time, an appropriate assessment of mid-term climate impacts should always be performed when planning a further exploitation of wood resources in climate sensitive areas.

— Energy production out of waste

Waste is probably a largely neglected resource, in its diverse formats: urban waste, agricultural residues and by-products (e.g., manure and crop residues) and industrial bio-waste (e.g., sawmill residues). Transformation patterns such as aerobic digestion sound very promising and biogas chain development is already priority in several countries.

— Roll-out of biomass micro grids / co-generation esp. in spoiled landscapes of the Alpine and pre-Alpine area and in the context of district heating in urban areas

District heating probably still needs additional legislative and economic impetus to reach the level at which it could provide the expected important benefits. Micro-grid optimisation could profit of blending biomass with other renewable energy technologies in line with the prosumer concept, with multiple small suppliers on the network.

— Improvement of energy efficiency of existing district heating networks

Energy efficiency in district heating should be seen as a double faced issue: from the supply side, maximum effort should be devoted to decrease as much as possible energy losses during feedstock transformation, again deploying the most appropriate technologies. From the demand side, energy efficiency of houses consuming biomass has to be improved, through e.g., the improvement of thermal insulation, with a positive impact on the reduction of the energy (heat) demand and feedstock mobilization needs.

— Sharing of local, regional and national good practices in regulating the biomass sector including energy planning

Appropriate regulatory design could benefit of exchange of information on e.g., emission standards and controls, proper implementation of better technologies, sustainable management of forests and other biomass resources.

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List of abbreviations and definitions

AIR	Alpine macro-region
ALP	Adriatic and Ionian macro-region
COPD	Chronic Obstructive Pulmonary Disease
WHO	World Health Organization
TM5-FASST	FAst Scenario Screening Tool
IHD	Ischemic heart disease
ALRI	Stroke, lung cancer and acute lower respiratory airways infections
IER	Integrated Exposure-Response functions
GBD	Global Burden of Disease
NEC	National Emission Ceilings Directive (2016/2284/EU, Directive 2001/81/EC)
ECLIPSE	Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants, FP7-Environment project
IIASA	International Institute for Applied Systems Analysis
GAINS	Greenhouse Gas and Air Pollution Interactions and Synergies model
CLE	Reference (current legislation) scenario
MTFR	Maximum Technically Feasible Reduction scenario
CLIM	Climate mitigation policies combined with CLE air quality policies scenario
IEA	International Energy Agency
MRS	Macro-Regional Strategies
IMSB	Information Management Steering Board
EDGAR	Emissions Database for Global Atmospheric Research
AG4	Action Group 4 Mobility of EUSALP
TSG2	Transport Subgroup Group of the EUSAIR
KCTP	The Knowledge Centre for Territorial Policies of the JRC
LUISA	Land-Use-Based Integrated Sustainability Assessment modelling platform
JRC	Joint Research Centre of the European Commission
SECA	Sulphur Emission Control Area
RoRo	Roll-on/roll-off ships are vessels designed to carry wheeled cargo, such as cars, trucks, semi-trailer trucks, trailers, and railroad cars, that are driven on and off the ship
TEMA	Transport tEchnology and Mobility Assessment platform
TFEIP	Task Force on Emission Inventories and Projections
CLRTAP	Convention of Long-range Transboundary Air Pollution
EMEP	European Monitoring and Evaluation Programme
AEIG	EMEP/EEA Air Emissions Inventory Guidebook
CHP	Combined Heat and Power
RED	Renewable Energy Directive

List of figures

List of tables

Annexes

Annex 1. Working documents

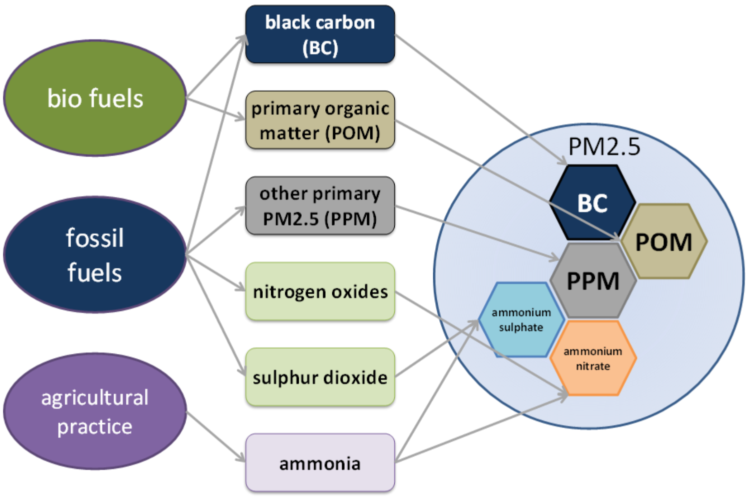
The presentations, extended abstracts and the outcome of the panel discussion of the workshop/working group meeting on "Clean Growth in bioenergy in the Alpine and Adriatic-Ionian regions". 9-10 October, Ispra, Italy, 2017 – are available (access to the documents upon request) at http://edgar.jrc.ec.europa.eu/working_group_bioenergy_2017.php. The presentations, extended abstracts and the outcome of the panel discussion of the workshop/working group meeting on "Challenges of clean and efficient transport in the Alpine and Adriatic-Ionian regions", 12-13 October, Ispra, Italy, 2017 – are available (access to the documents upon request) at http://edgar.jrc.ec.europa.eu/working_group_transport_2017.php.

Annex 2. Agricultural contribution to PM2.5

Note on the agricultural contribution to PM2.5: Ambient PM2.5 consist of a complex mixture of chemical components from various sources, combustion processes and sectors (see figure below). The contributions to PM2.5 by individual sectors shown in Figure 6 indicate a prominent role for the agricultural sector as a result of ammonia (NH3) emissions leading to the formation of ammonium nitrate or sulphate in fine particulate matter. In reality, for ammonia to be bound as ammonium in PM2.5 there is a complex partitioning mechanism in play between gas and particulate phase, depending on the availability of nitric acid and sulphuric acid which are products from nitrogen oxides (NOx) and sulphur dioxide (SO2) chemical conversion respectively.

In the past decades, SO2 emissions (mainly from industry and power plants) have decreased more than those of nitrogen oxides (mainly from transport). Therefore, ammonium nitrate has become the major ammonium salt in particulate matter in several agriculture-intensive areas in Europe, in particular in the Netherlands and Northern Italy which are at the same time also hotspots for NOx emissions. Being a result of ammonia and NOx emissions, the ammonium nitrate component in PM2.5 cannot be solely attributed to agricultural emissions. Furthermore, the impact of an emission reductions in a single sector (agriculture or transport) may be little effective if the corresponding pollutant is not the limiting factor. For instance, in areas where more ammonia is available than can be bound by nitrate or sulphate, ammonia emission reductions will initially not result in PM2.5 reductions but will only lead to a reduction in excess gas-phase ammonia. In such conditions, a reduction of NOx emissions would more efficiently reduce ammonium nitrate in PM2.5.

The schematic of how different sources contribute to the mix of primary and secondary components in PM2.5 (source: JRC) is presented here.

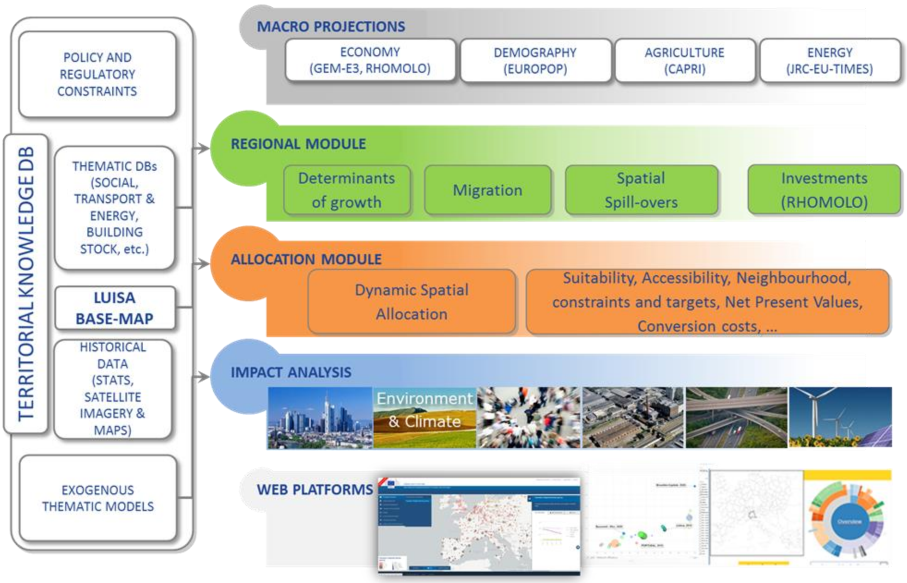


Annex 3. LUISA modelling platform

Within the European Commission the Land-Use-Based Integrated Sustainability Assessment (LUISA) modelling platform is set up to execute ex-ante impact assessments of EC policies with a territorial impact. That modelling platform allows for the exploration of several policy alternatives, and how they differ from developments that occur in a business as usual case. The platform's aim is to provide integrated assessments, taking into account across the economic, social and environmental domains. It can simultaneously produce quantitative outputs related to policy goals such as improving accessibility and improving air quality. As such, it is a useful tool to map the impacts of current trends on air quality, and to evaluate the impacts of potential air quality related policies.

The LUISA platform can be divided into three main elements: a comprehensive territorial knowledge base, advanced analytical and modelling modules, and production and visualization of territorial indicators. The LUISA modelling modules allocate (in space and time) the demand and supply of resources, the location choices of human activities, and infrastructure and its effects on location choice. A complete overview of the LUISA model platform structure and derived tools is presented in Figure 30; for a detailed description please refer to (Jacobs-Crisioni et al. 2017).

Figure 30. Overall structure of the LUISA platform



Source: JRC.

The projected territorial patterns cover all EU Member States and several Western Balkan countries at a detailed geographical resolution (100m), typically until 2050. The data and indicators produced by LUISA are publicly accessible in the Territorial Dashboard (https://data.jrc.ec.europa.eu/tc/t-board/).

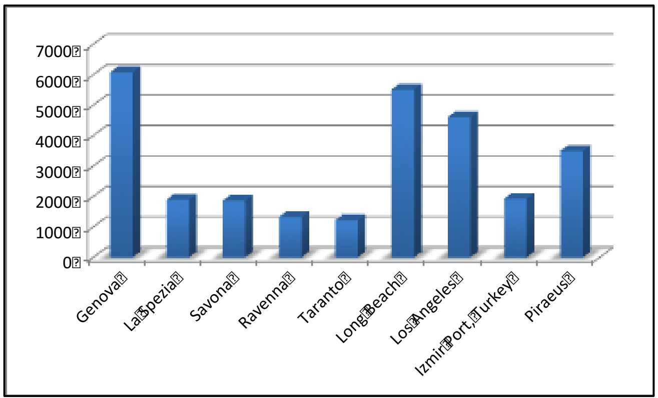
Annex 4. Air pollution in Ligurian and Balearic Sea ports

Air pollution in several Italian ports and possible control measures were studied by Techne Consulting (I) under a research contract with ENEA (Italian National agency for new technologies, energy and sustainable economic development), in the frame of a convention ENEA – Italian Ministry for Environment and Territory and Sea (Trozzi et al, 2012) and of a specific contract by Liguria Regional administration (Techne Consulting, 2014; Trozzi, 2017).

The Ravenna and Taranto Adriatic-Ionian ports are included in the national study while the Genoa, La Spezia and Savona ports are included in the Liguria regional study. The Liguria region is a narrow strip of heavily populated land between the sea and the Alps with many highways, three large harbours including the largest Italian port, an airport, three power stations, a refinery, a steel mill; the ports are fully immersed in the urban areas with no possibility of relocation of facilities.

Ships fuel consumptions and emissions are evaluated by dock, ship, and ship operation using as input data the time spent by each ship in each operation of hoteling by dock and of manoeuvring. Specific fuel consumptions and emission factors are retrieved from EMEP/EEA guidebook (Trozzi, 2016). For the Liguria case study data are retrieved and emissions are estimated also for land based activities (Oil product loading/unloading, Dry dock activities, Aggregate handling and storage, Service vehicles handling, Vehicles in transit). In Figure 31 the emissions estimates for the areas are compared with some international results.

Figure 31. Nitrogen oxides emissions estimate in port [Mg] from various studies

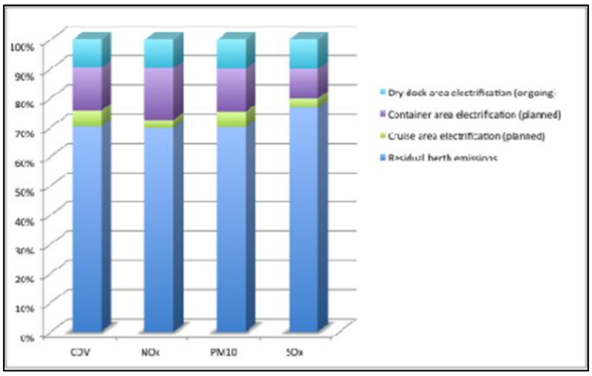


Source: Trozzi, 2012; Trozzi et al, 2017; Starcrest Consulting Group (2016a; 2016b); Kilic and Tzannatos, 2014; Saraçoğlu et al, 2013.

The nitrogen oxides emissions can be reduced by connecting of the ships to the land based electric network during their stay in port allowing ships to turn off their auxiliary engines in such a way that all the engines of the ship can be switched off in port.

Net emissions are reduced because land-based electricity generation complies with emission standards more stringent than those for ship engines. Emissions reduction (see Figure 32) are evaluated, with a very conservative approach, comparing emissions from ships with emissions from land based electricity production from fossil fuels computed with average national emission factors; only ships stops with a duration greater than a threshold value (2 hours), chosen based on technical times of connection and disconnection, have been taken into account.

Figure 32. Potential reduction of nitrogen oxides emissions in Genoa port with cold ironing



Source: Techne Consulting, 2014.

A land-based power source, transmission system, and related infrastructures are required to provide electricity to a hoteling marine ship. An electrical cable system is required to bring shore-side power to the ship during hoteling.

From the Liguria regional study it is possible to conclude that emissions from ships at dock are the most relevant ones in port and can represent one very important source in the city.

From analysis of cold ironing there is evidence of the great potential of this solution for reducing emissions: between 750 to 4700 tons per year in port for nitrogen oxides, nearly 400 tons for the largest cruise terminal in the national study (in city centre). There are no major technical obstacles to development of actions while the major constraint is the cost that ship-owners will have to face for the adaptation of on-board systems.

A coordinated European approach to carry out initiatives that allow owners to use the service of "cold ironing" in different ports is a priority while a reduced rate of electricity tax applied to electricity directly provided to vessels at berth in a port can give an economic incentive to the use of shore-side electricity(16). The emissions reductions in ports allow to obtain a very important contribution to reduce overall urban emissions (up to 40% of urban emissions of nitrogen oxides in the regional study).

In Marseille, the port has experienced a strong increase in container transport over the last 20 years (+58% from 1995 to 2014) and an even more dramatic increase in passenger transport, particularly due to the strong increase in the number of cruise ship passengers coming to Marseille (+73% from 2007 to 2016). The increase in cruise ship traffic is also seen in other Mediterranean ports like Barcelona and Venice.

The strongest impact of ship emissions on air pollution in the urban area of Marseille is found to be on NO2 (see Figures 33 and 34).

Figure 34 (left) shows that about 12% of the population is exposed to an annual concentration exceeding 10% of the NO2 annual AQL. These inhabitants are mainly located close to the port area. In the meantime, 100% of the population is exposed in the whole area to values exceeding 10% of the hourly NO2 AQL, as revealed in Figure 15 (right).

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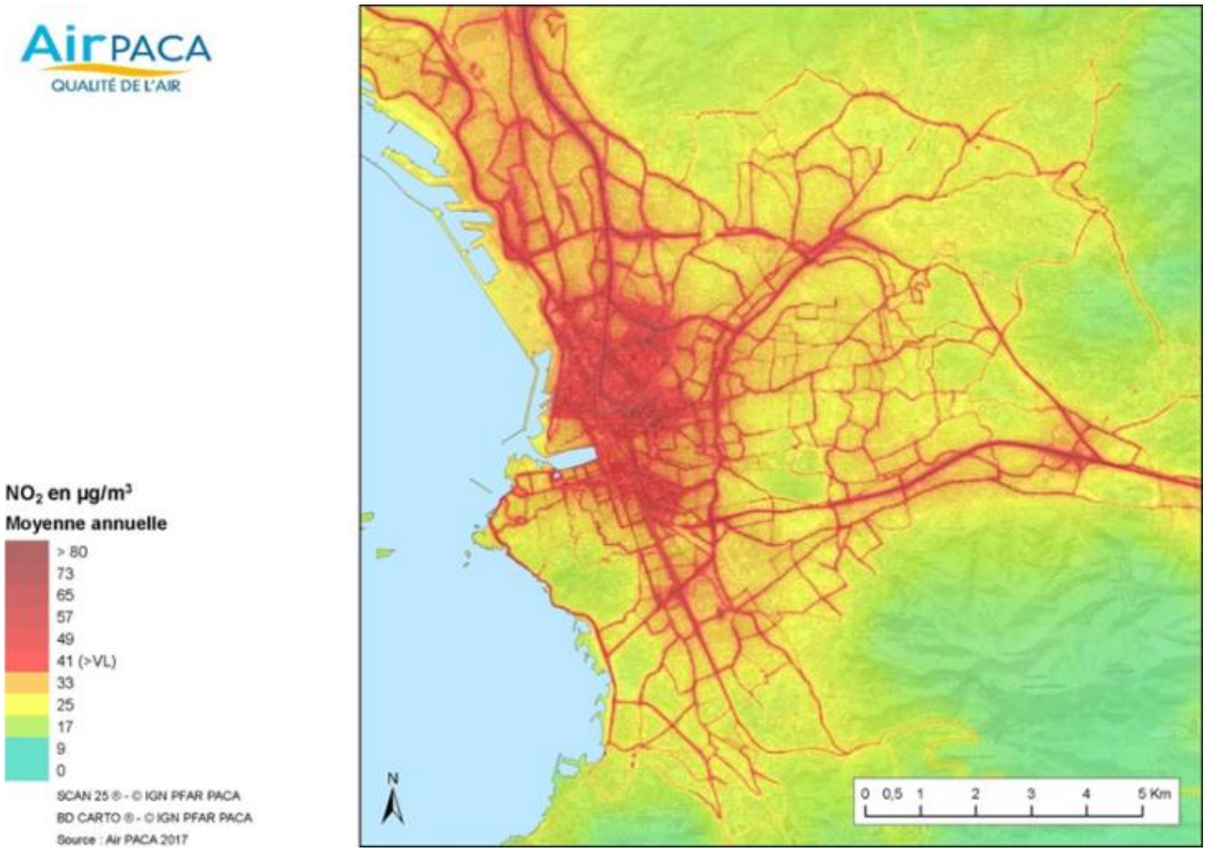
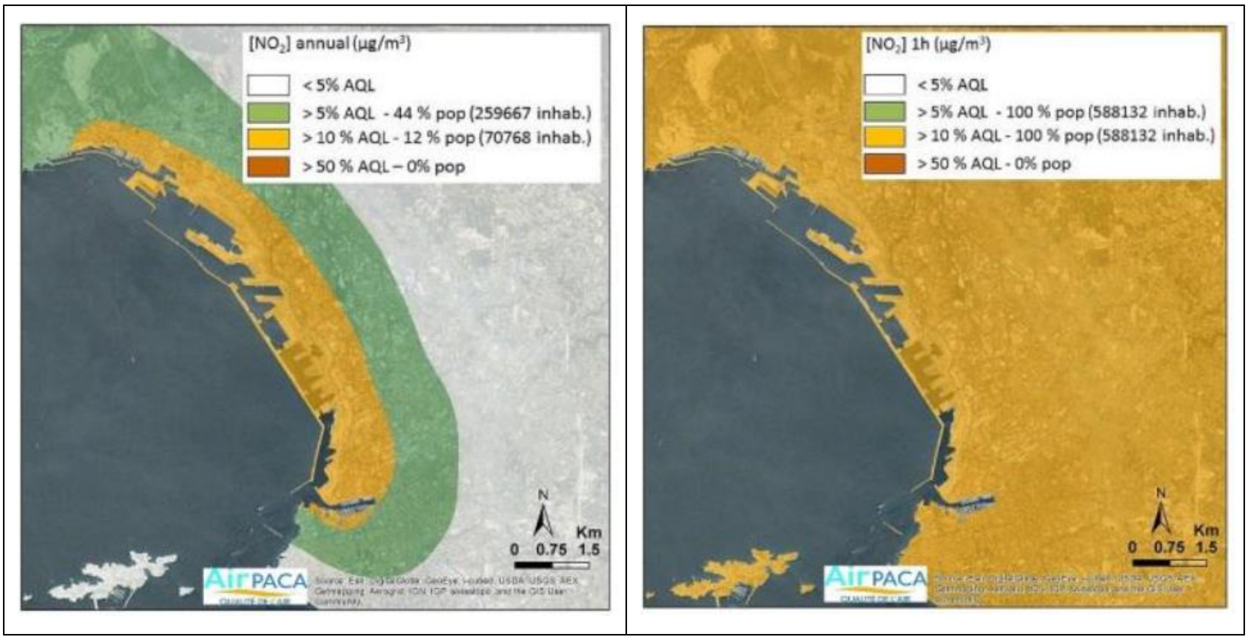
(16) See at some European Commission Council Implementing Decisions (EC,2014a; EC, 2014b; EC, 2015a) authorising Sweden, Germany and Denmark to apply a reduced rate of electricity tax to electricity directly provided to vessels at berth in a port ("shore-side electricity") in accordance with Article 19 of Directive 2003/96/EC (EC, 2003).

Figure 33. Annual mean NO2 concentrations Marseilles, 2013



Source: AirPACA.

Figure 34. Population exposure with respect to (left) annual NO2 concentrations and (right) the NO2 hourly AQL at present time (2013)

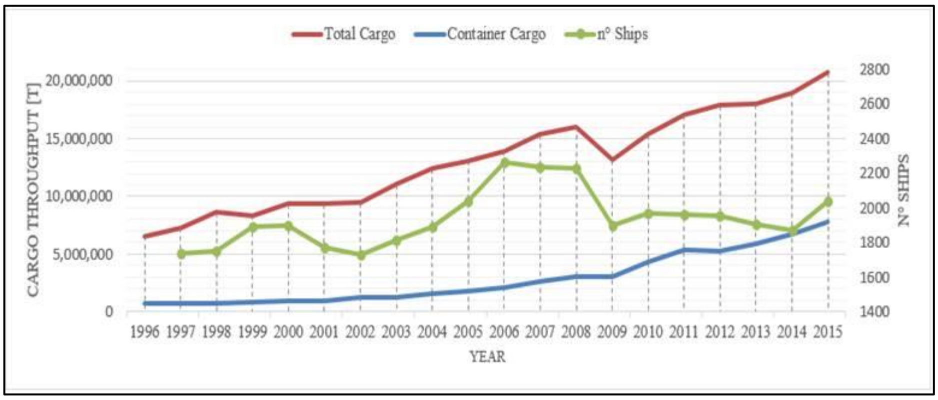


Source: Cruise and passenger ship air quality impact mitigation actions, CAIMANS Project, Med Maritime integrated Projects, http://www.medmaritimeprojects.eu/section/caimans/outputs.

Annex 5. Green port development

Ports are under pressure from the seaside but also from the landside. Growth of global trade, increasing sizes of vessel and the needs to modernize port facilities are the key reasons for urgent investments in ports. Port development can have a negative impact on the surrounding area, which is why sustainable or green port development is important. With increased concerns about the environmental impact due to the development of ports, a research in the field of ecological issues in ports and port management policies in relation to green port development (Peris-Mora et al., 2005; Gupta et al., 2005; Darbra et al., 2009, Nebot et al., 2017) has been done. It was concluded that green ports has become an important issue and a critical part of sustainable supply chain management research and that there is a need for innovative solutions for sustainable port development.

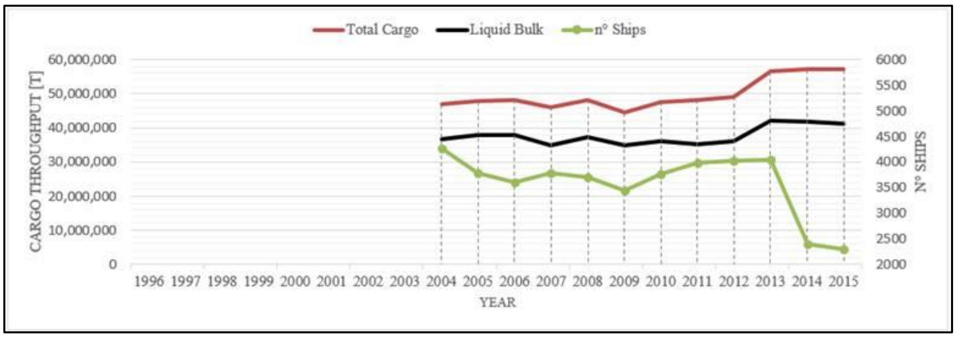
Figure 35. Number of ships and throughput in Port of Koper



Source: Perkovic et al. (2016b).

New green ports must be in harmony with the ecosystem, but also prepared to change for innovative solutions in operational, technical and economic dimensions, if they don't want to lose cargo, throughput and competitive position on market. For example, in Adriatic special attention should be given to the Port of Trieste, which is the biggest oil terminal, and to the Port of Koper that has the biggest container terminal. Even though the total cargo throughput has increased, the number of ships is smaller (see Figure 35 and 36). This means that ships that are now coming to those ports are much bigger than they were in the past, which is why ports have to be prepared for that by purchasing new equipment and dredging (Twrdy et al, 2013).

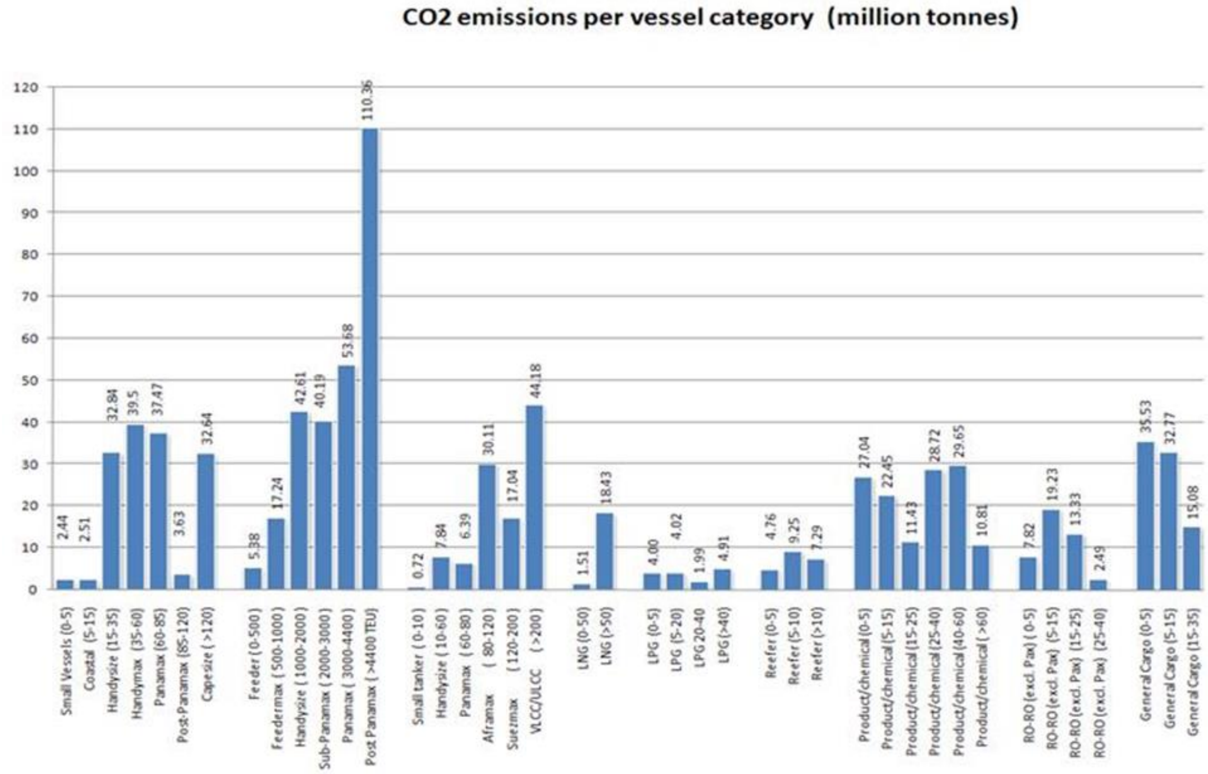
Figure 36. Number of ships and throughput in Port of Trieste



Source: Perkovic et al. (2016b).

Annex 6. CO2 emissions from the world commercial fleet by ship type-size

Figure 37. CO2 emissions, world fleet, 2007



Source: Psaraftis and Kontovas (2009).

Annex 7. Transport tEchnology and Mobility Assessment platform (TEMA)

TEMA includes four macro-modules:

— Travel behaviour: statistical mobility processing module;

— E-mobility: HEVs/EVs simulation module, EVs usability in urban environment and modal shift; Energy spatial and time analysis module, GIS-based spatial distributions of energy demand and offer; Optimised customer-driven recharging infrastructure design based of points of interest (POI); V2G (Vehicle To Grid) applications;

— Vehicles' emissions: Evaporative emissions simulation module; Cold start and driving emissions simulation module; GIS-based spatial distributions of emissions; Utility factor for PHEVS (Plug-in Hybrid Electric Vehicles) and BEVs (Battery Electric Vehicles);

— In-vehicle battery durability and performance, in support to the UNECE (United Nations Economic Commission for Europe) electric vehicle and environmental regulatory activities in the frame of the EVE-IWG (Electric Vehicle and Environment Informal Working Group).

Practical, evidence-based examples of the applications of TEMA.

TEMA has been used for supporting the European development of low-carbon road transport policies in the areas of:

— quantification of the real world potential of deploying electrified vehicles within urban areas accounting for different electric vehicles penetration shares under different technological and infrastructural constraints, (De Gennaro et al., 2014a; Paffumi et al., 2015) in support to the Strategy and Action Plan for creating an Energy Union;

— quantification and geo-referencing the shift from oil to electric energy and the impact on the electricity distribution grid from the deployment of EVs (De Gennaro et al., 2014b), in support to the deployment of alternative fuel and low-carbon vehicles;

— design of a customer-driven smart recharge infrastructure and tailored V2G application in public areas (De Gennaro et al., 2015; Paffumi et al., 2016) in support to the Directive for deployment of alternative fuels infrastructure and the Energy Union;

— evaluation of the driving and evaporative real world emissions from the current fleet of conventional vehicles and the gaseous emissions reduction potential from the introduction of new vehicle technologies (Martini et al., 2014; De Gennaro et al., 2016) in support to the development of effective transport regulations in the areas of real world driving and gaseous evaporative emissions and the need of revising the current regulation on evaporative emissions;

— evaluation of the Utility Factor (UF), based on collected vehicle activity data to evaluate the real world conditions of use of plug-in hybrid electric vehicles, in support to the assessment of the type approval regulation for plug-in hybrid vehicles (Paffumi et al., submitted);

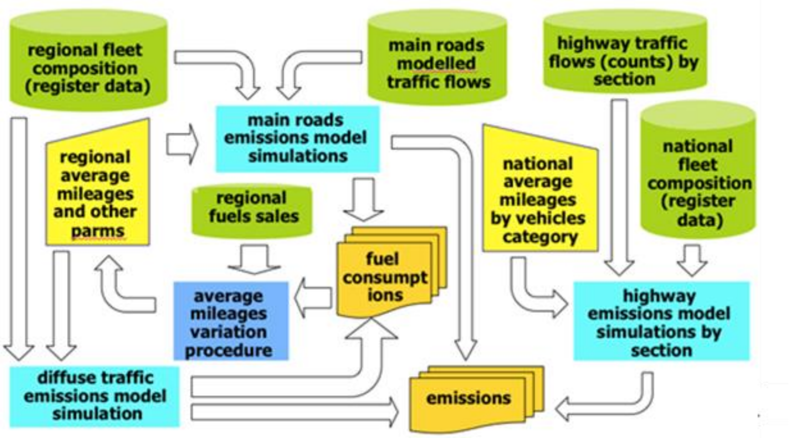
— evaluation of in-vehicle battery durability and performance, in support to the UNECE electric vehicle and environmental regulatory activities (UNECE, 2016)

— support to the eco-innovation technologies assessments, evaluating CO2 savings of innovative technologies on passenger vehicles, and defining simplified calculations and methodologies applicable at European level;

— evaluation of the future market competition and new business opportunities offered by the diverse scenarios considered (De Gennaro et al., 2015).

Annex 8. Methodology to compile road traffic emissions inventory

Figure 38. Methodology to compile road traffic emissions inventory



Source: Techne Consulting.

Annex 9. Official emissions inventories for transport sector

The Task Force on Emission Inventories and Projections (TFEIP) operates under the Convention of Long-range Transboundary Air Pollution (CLRTAP). TFEIP annually reports to the European Monitoring and Evaluation Programme (EMEP) Steering Body and together with several other task forces and centres contributes to improving the environmental reporting of the Parties to the Convention.

The TFEIP comprises four different expert panels focusing on respective part of the emission inventorying methodologies. The four expert panels include (a) combustion and industry, (b) transport, (c) agriculture and nature, and (d) a cross-cutting theme on projections.

The expert panel on transport coordinates the work on the methodologies to calculate emissions from transport sources. These include aviation, road transport exhaust and non-exhaust sources (tyre, brake and road wear), maritime, railways, inland navigation, and non-road mobile machinery. These methods, together with the corresponding emission factors and relevant activity data are in detail described in the EMEP/EEA Air Emissions Inventory Guidebook (AEIG).

In particular the expert panel on transport has the following responsibilities: 1. Collect and review available information on activities, emission factors and methodologies; 2. Consider the significance of each source and identify needs to sub-divide or merge source categories or new categories that have to be added; 3. Update the AEIG to reflect developments within the sector, in terms of methodology and emission factors; 4. Support AEIG users with the use and interpretation of the methods; 5. Identify the need for further research or study to improve the methodology; 6. Encourage the exchange of information between experts.

Recent activities of the expert panel on Transport are shown in the following Table 8.

The expert panel on transport and the AEIG may offer a useful forum for exchange of information and with assistance on the activities of EUSALP and EUSAIR. First, it comprises experts from countries in the two regions who are responsible for the inventorying of emissions. Second, this comprises an open forum for exchange where information and data can be freely circulated and where help can be sought for to address specific environmental or data limitation problems. Participation in the TFEIP is open and discussions on the expert panel on transport and the plenary are held annually and can be followed after registering to TFEIP.

Table 8. Recent activities of the expert panel on Transport.

Sector	**Activities**
Road	COPERT 5 Emission factors for diesel Euro 6 Efficiency improvements for latest vehicle technologies Heavy metals from lube oil consumption Method to grid emissions
Shipping	Implementation of AIS data for inventorying Emission factors for Tier 3 Black carbon emission factors
Aviation	Complete new chapter prepared by Eurocontrol New ICAO emission factors for late engine technologies Extended list of pollutants, including NMVOC Spreadsheets for calculation of emissions per aircraft type

Source: TFEIP (https://tfeip-secretariat.org/expert-panels-transport/).

The expert panel on transport and the AEIG may offer a useful forum for exchange of information and with assistance on the activities of EUSALP and EUSAIR. First, it comprises experts from countries in the two regions who are responsible for the

inventorying of emissions. Second, this comprises an open forum for exchange where information and data can be freely circulated and where help can be sought for to address specific environmental or data limitation problems. Participation in the TFEIP is open and discussions on the expert panel on transport and the plenary are held annually and can be followed after registering to TFEIP.

Annex 10. Transport: discussion and other issues

The experts from Alpine and Adriatic and Ionian EU macro-regions discussed during the panel session how to support clean growth in freight transport focusing on a few topics such as intermodality, emission control areas for maritime transport, fleet renewal and fuel substitution, opportunities, research/innovation and other issues.

Since freight transport is not as attractive for investors as the transport in larger urban areas, it was found that some tools should be efficiently used in supporting clean growth in freight transport. For example, promoting projects focused on specific problems and engaging the private sector by providing incentives to start-ups to activate themselves and develop ideas for these macro-regions. This could give an impetus to future developments e.g. appropriate solutions demonstrated via pilot projects. Creating networks of scientists and stakeholders (e.g. public administrations), promoting bilateral collaboration between countries and multilateral collaboration, including the regions, civil society and economic stakeholders are essential to get consensus towards an integrated approach. However, the key priority for freight transport is investing in infrastructure; therefore, the needs are more political and budgetary in nature.

How can intermodality be encouraged and improved?

From the discussion, it came out that the intermodality could be encouraged and improved by providing a set of instruments and tools in support to an efficient and sustainable intermodal logistic service, by developing a relevant infrastructure and by introducing efficient IT support that will enable the required level of operational efficiency, flexibility and ease-of-use. Coordinated modal shift policies are required focusing on improving the framework conditions, including interoperability, for rail freight transport and intermodality. Further, the internalization of external costs is an important element, which is being tackled in the revision of the Eurovignette Directive.

Experts agreed that intermodality should be seamless and end-to-end. Further, cost evaluation/comparison is essential; consequently, competitiveness and effectiveness are two important pillars of promoting intermodality.

The potential benefits of a modal shift in transport identified by the participants in this working group are: 1) decreasing the negative effects of road freight transport on environmental and road infrastructure deterioration, for countries with substantial transit freight flows in particular; 2) strengthening the role of rail and maritime transport in the (intermodal) supply chains. The Alpine Region suffers from the negative social and environmental impacts of transalpine transport, due to the geographic conditions (narrow valleys). In this region, moving from trucks to rail could considerably improve emissions of air pollutants and CO2, noise and safety and help to solve traffic congestion problems. Higher capacity combined transport terminals, railway tunnels (for transalpine transport) and an extension of railway infrastructure overall would be most pertinent. The experts appreciated that, quantifying these benefits correctly can make a big difference in informing and guiding policy. The Adriatic and Ionian macro-region comprises a number of small nations that are often not even under the same trade or other associations; this means that transit traffic becomes difficult with frequent border control checks. Modal shifts with the use of rail and maritime transport may contribute in lifting these bans, hence contributing to overall financial and environmental benefits and faster transport. Moreover, most of these countries use outdated vehicle technologies for on-road freight transport with large impacts to the environment. A modal shift, e.g. to electric rail or maritime shipping will have significant benefits on a relative scale, compared to these in Northern EU.

The potential drawbacks of a modal shift in transport mentioned during the discussion are: 1) concerns about air quality impacts for the cities that will have to carry the additional burden in their ports; 2) increase in transport logistic services complexity and cost; 3) the high costs of railway transport; 4) barriers to connect the last mile. The legal framework and taxation need to be adapted to encourage modal shift to rail. Economic challenges affect especially regional transport and local economies. Rail is often not the most efficient mode for shorter distances (below 300 km). Therefore, exemptions and special regulations for regional transport are needed (see also current revision of Eurovignette Directive).

The disparity between countries could be an important obstacle in international transport and to further development of an intermodal freight transport system that would enable efficient and customer-oriented intermodal services. Consequently, working plans differentiated by countries are seen as possible solutions.

Can the Mediterranean Sea (including Ionic and Adriatic Seas), become Emission Control Areas for SO2 and NOx?

It was agreed that technically, it would be possible and a reduction of emissions of the main pollutants is expected with a benefit in air quality mainly in coastal areas and in coastal towns. The argument against this choice is mainly economic, regarding the costs of shipping that could cause a reduction of commercial and tourist (cruises) traffic in these Seas. These measures will have a negative influence on the competitive position of ports in these regions and in the EU market.

What types of fleet renewal (trucks and ships) and fuel substitution could contribute to clean growth in freight transport?

The experts appreciated that electric trucks could presumably offer a cleaner alternative, for the Alpine macro-region in particular, solving partial aspects of the problem. Furthermore, electric vehicles are only as clean as the energy source that charges them; if this comes from renewables, it could be beneficial for environment but if it comes from a coal plant, it might lead to an overall increase in harmful emissions elsewhere.

Regarding fuel substitution, the use of low-sulphur fuels has already proven to reduce emissions from ships and to improve local air quality not only for SO2 but also for primary and secondary particulate matter. Reduction on NOx emissions and concentrations could likely be obtained using retrofitting of the engines of ships. The use of the much cleaner fuel LNG (Liquid Natural Gas) will need extensive infrastructural investments not only on ship but also in harbours. Regarding trucks the best option is likely to encourage economically the substitution of old trucks with new diesel trucks having more efficient engines. Introduction of new propulsion systems for trucks and ships (electric propulsion) and using alternative fuels (such as LNG for ships) could contribute to clean growth in freight transport; the infrastructure requirements to support such changes in the Alpine and Adriatic-Ionian regions would predominantly be focused on supplying the fleet with alternative fuels. In addition, the network of urea sales needs to be expanded for smooth operation of SCR equipped trucks.

An issue is the fact that some countries from these macro-regions often become the dump yard of vehicles in Northern EU after their useful life has been exhausted e.g. in Greece practically no new trucks are being sold, only second hand ones and the companies have limited capacity for renewal. Furthermore, 80% of freight transport in Greece is conducted by road. Rail is insignificant and maritime too little, given the vicinity of major Greek cities with the sea. It is clear that both road vehicle infrastructure needs to be modernized and improvement in logistics to transfer part of the activity in railways and shipping. The rail network in particular requires significant modernization in collaboration with neighbouring countries.

Opportunities for encouraging clean growth in freight transport

The experts from the two macro-regions appreciated that it would be beneficial to implement the staged/hierarchical delivery of goods, for example instead of having full trucks go to every village to deliver small amounts of goods use suitably distributed centers/logistics centers. The additional friction that is induced could be eliminated by using advanced communication technologies. For rail transport, transhipment of containers from a train to a truck and vice versa without the need for a dedicated infrastructure requires only a simpler infrastructure on the truck that moves the container over, this could considerably increase the reach of the rail into the direct deliveries to various remote areas.

A few actions were identified: 1) the rail network needs to be expanded, following same technical specifications between countries, to the degree possible; rail needs to reach all major ports in the area; 2) road freight transport needs to operate under Eurovignette; 3) logistics need to consider green footprint.

The experts agreed on the fact that also the situation of non-road machinery should be investigated. It was mentioned that there is a limited amount of data on their energy consumption and operations. The experts recommended that the data and information have to be collected before bringing in new policies.

Research and innovation

The experts from the two macro-regions agreed that further research and investigations are needed on monitoring and management of the environmental risks of transport in an integrated perspective, and for characterising the impacts of shipping on specific pollutants like black carbon, particles, particularly ultrafine particles (number of particles) and PAHs. Equally important is enhancing and promoting the development of integrated monitoring networks based on harbour activity information, territorial data, air quality measurements and modelling that would allow a better air quality assessment both in space and in time and the development of knowledge-based transport policies.

A modern and sustainable transport in the two macro-regions implies investigation and evaluation of potential impacts for establishing an Emission Control Area for maritime transport and identifications of needs for intermodal transport. Further actions should focus on reducing of noise emissions of freight trains and rail infrastructure, efficient handling and distribution of goods, and optimizing intermodality in freight transport for which beside travel time and cost more attention should be given to the factors that really influence the choice of a traveller/shipper.

Experts of the panel found that, for example, there have been only limited projects between institutes in the Balkan region addressing transport and emission problems. More studies between research institutes and the administration in the area, involving Greece, FYROM, Albania, Serbia, Croatia, Bosnia-Herzegovina, Montenegro and Slovenia are required.

Innovative and good practices are of utmost importance for the further developments to maintain the level competitiveness. Experts provided example of projects in Munich (freight delivery), in Slovenia (low emission and electric vehicles) and in South East of France (electric mobility).

Points of reflection and other issues

A point of discussion was on the need on further research on emissions of fine particles (number) from ships. Safety and the impact of noise should also be taken into account.

An important issue that was underlined and identified as a priority is the interoperability between EU countries and non-EU countries; the EU Single Window environment for customs, which is focused on customs formalities and involves stakeholders dealing with cross-border movement of goods, is useful but further improvements are needed.

The experts pointed out that the electronic commerce will evolve in the future and its impact on transport should be investigated.

Public perception of the changes in the infrastructure e.g. for LNG is crucial for new investments and business attractiveness. For Adriatic and Ionian Seas, it was also mentioned that tanker accidents can lead to serious environmental pollution; the pipeline to reduce the quantities of liquids in bulk transported by tanker ships should be investigated as a possible solution.

Pros and cons for considering establishing a Mediterranean Sulphur Emission Control Area (SECA) and a Nitrogen Emission Control Area (NECA) have been discussed. Regarding reduction of emissions from ships, the experts highlighted the need of actions on how to enforce the regulations e.g. on verification of the actual sulphur content of the fuel in use in ships, the efficiency of emissions control system etc.

When fleet renewal is considered for emissions reduction, the fact that the lifetime of ships and lifetime of trucks are very different should be taken into account.

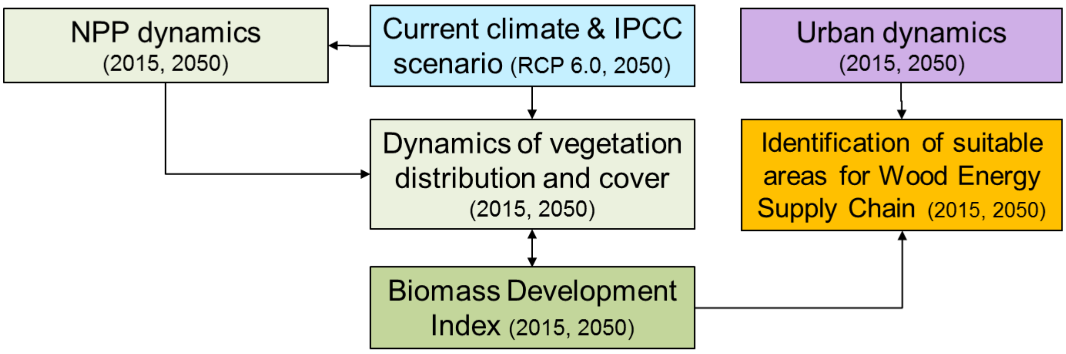
Of interest for policy makers could be also a comparison between the impacts of two policy options: increase mobility vs decrease mobility.

It was concluded that for further developments in transport, the synergy policy ↔ infrastructure development ↔ intermodality ↔ business (market) ↔ green transport should be analysed for finding the best solutions.

Annex 11. Climate change effect on biomass productivity

Methodology

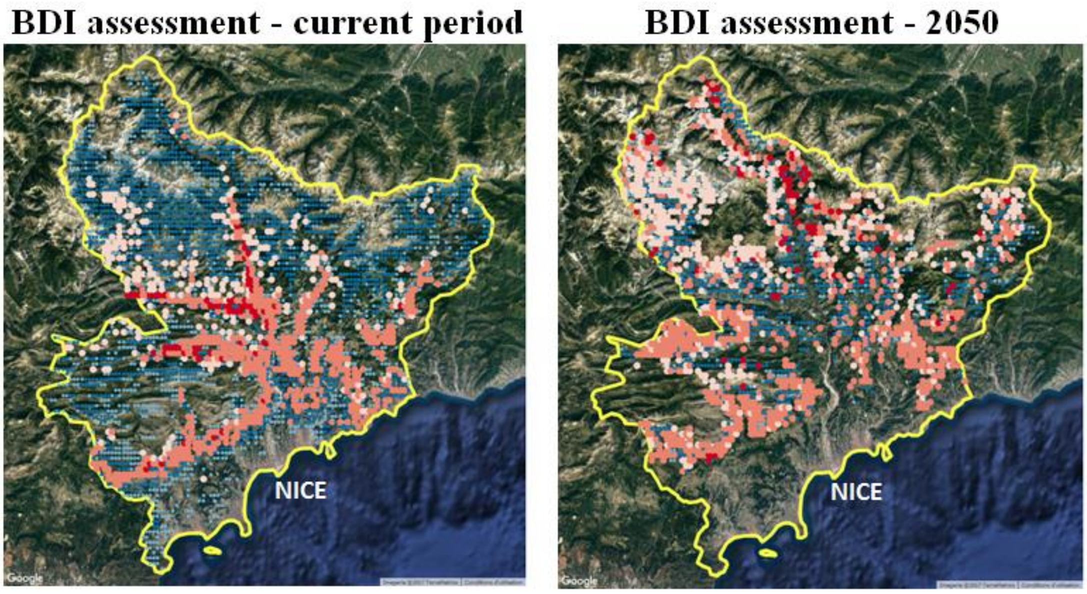
Figure 39. Methodological steps for assessing climate-driven changes in forest productivity and urban dynamics towards 2050



Source: Garbolino et al. (2017).

Results

Figure 40. Comparison between the suitability of the territory for the production of wood for the current period and 2050.

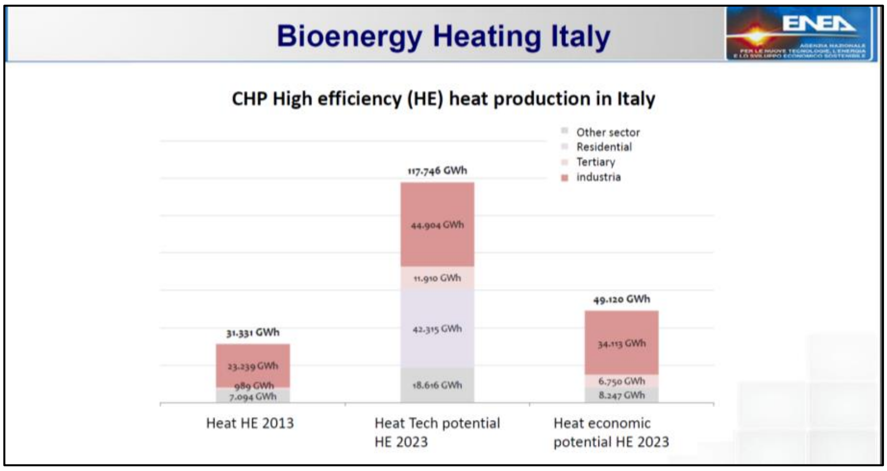


Source: Garbolino et al. (2017).

Annex 12. High efficiency heat production in Italy

The high efficiency heat production in Italy and its growth potential is presented in Figure 41.

Figure 41. High efficiency heat production in Italy and its growth potential



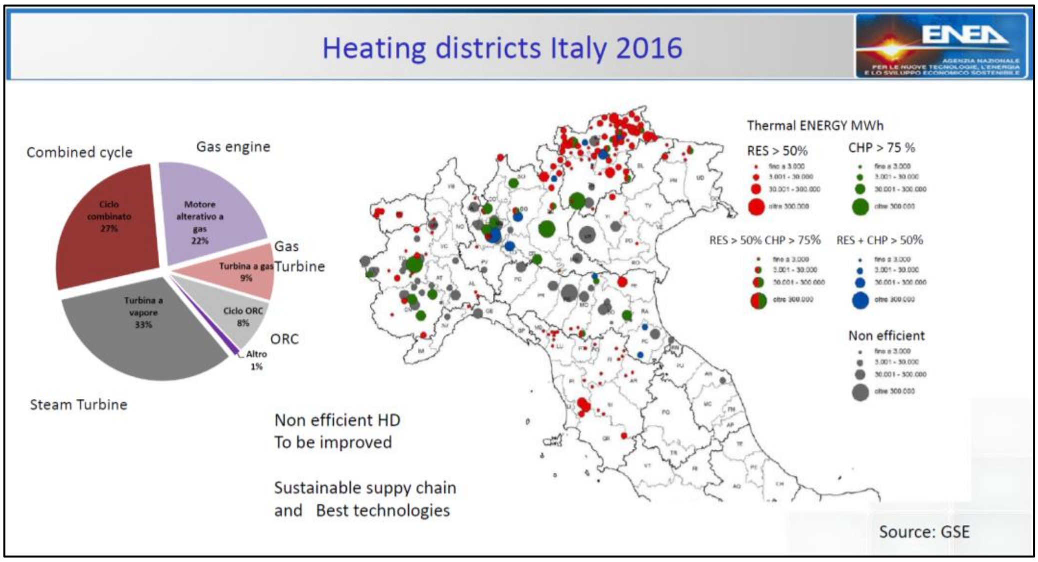
Bioenergy Heating Italy

CHP High efficiency (HE) heat production in Italy

Source: GSE, 2017a.

Another way to optimize biomass use in the energy sector, often in conjunction with CHP itself, is the District Heating (DH) concept. In Italy in 2015, DH plants used 2235 GWh/year of heat from renewable sources: 33% was produced with steam turbine, 27% with combined cycle, 22% with gas engine, 9% gas turbine and 8 % through ORC. It is estimated feasible to add around 3700 GWh/year production, with the possibilities to reach 6000 GWh/year until 2023. CHP and Heating Districts are largely installed in Northern East Italy because of average lower temperature and local fiscal incentives. The district heating in northern Italy is presented in Figure 42.

Figure 42. District heating in northern Italy



Heating districts Italy 2016

Non efficient HD
To be improved

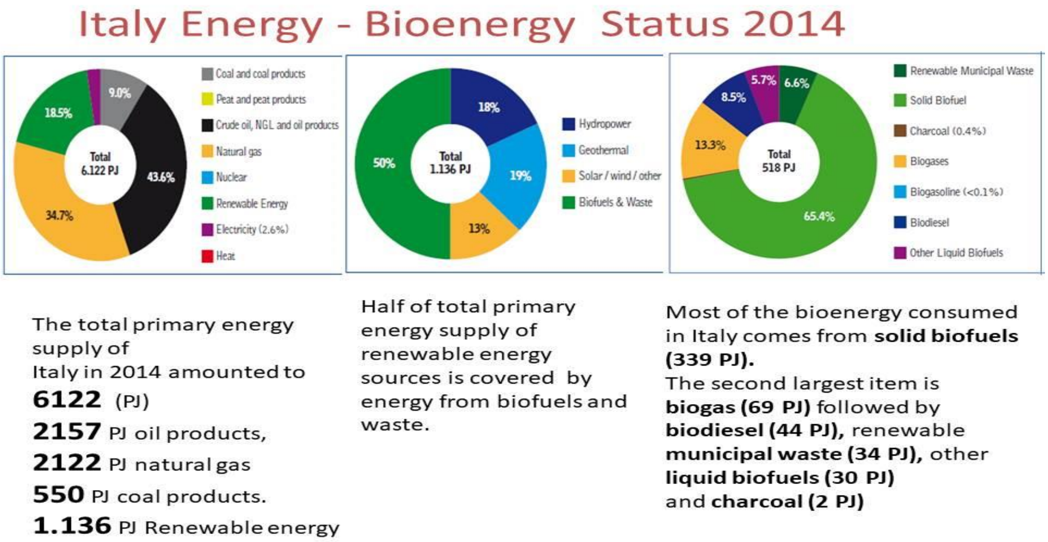
Sustainable suppy chain
and Best technologies

Source: GSE

Source: GSE, 2017a.

Annex 13. Bioenergy deployment in Italy in 2014

Figure 43. Bioenergy deployment in Italy



Italy Energy - Bioenergy Status 2014

The total primary energy supply of
Italy in 2014 amounted to
6122 (PJ)
2157 PJ oil products,
2122 PJ natural gas
550 PJ coal products.
1.136 PJ Renewable energy

Half of total primary energy supply of renewable energy sources is covered by energy from biofuels and waste.

Most of the bioenergy consumed in Italy comes from **solid biofuels (339 PJ).**
The second largest item is **biogas (69 PJ)** followed by **biodiesel (44 PJ),** renewable **municipal waste (34 PJ),** other **liquid biofuels (30 PJ)** and **charcoal (2 PJ)**

Source: IEA, 2016a.

Annex 14. Paving the way for clean bioenergy

Issues and policy priorities

From the technological point of view, Best Available Technologies (BAT) are urgent to be spread around the small and medium scale bio-power plants. This should be achieved through market measures to encourage development of new advanced technologies and reducing the risk of return of investment, but in some cases command and control measures will still be indispensable. Research and development for clean growth needs to be intensified, thus creating new and improved equipment on the market to replace old technologies by clean bioenergy systems.

Market governance through appropriate taxation and incentivation schemes is also seen as a priority need. CO2 taxes are missing in most of the countries and even support for the use of fossil fuel is provided in various forms.

In the specific case of biogas, a very promising bioenergy source, it was noticed that, although much of the biogas production in Germany is based on maize silage as feedstock, there are no incentives to diversify and increase the sustainability of energy crops for biogas production. For instance, instead of planting only corn on a plot, improved farming practices including mixtures with other crops (intercropping - e.g. sunflower, fabaceae, etc.) should be promoted.

Illegal logging must be prevented especially in rural areas where there is a huge demand for heating and residential heating based on biomass makes sense at local level.

Finally, there is the need to carry out more detailed impact assessments of Short Rotations Coppice (SRC) and Short Rotation Forestry (SRF) which could improve biomass potential for energy uses, in the context of the Common Agriculture Policy (CAP) and the effort for greening the agriculture.

Issues in feedstock mobilization include the separate waste collection of the organic fraction of municipal solid waste, which is still not implemented in many regions and a better estimation of biomass available for supply. Unnecessary competition for biomass for energy use should be avoided.

There is also a need for the harmonisation of EU 2030 LULUCF policy and biomass deployment, a requirement which seems to be addressed in the new proposal for RES directive, that will ensure that the production of wood fuel continues to be sustainable and that any LULUCF emissions are accounted for in the country of biomass production.

Finally, a major communication problem exists: since some years, "bioenergy" in general is seen in the public as a sensitive issue, and led to a negative perception on bioenergy, as many negative news were distributed. The image of bioenergy must be improved with providing good examples on bioenergy use and promoting best practices.

Role of technological improvements in air pollution mitigation

Focusing on the major issue of air pollution, mitigation by technological improvement, plays a major role in air pollution control, yet not within an immediate time scale, given the fact that old technologies have an impact on indoor air quality and pollution and people might lack knowledge to operate safely old stoves.

Among the many technologies available that could play a role in air pollution mitigation, low emission stoves and heating boilers as well as larger systems and CHP systems based on combustion or gasification in various ranges offer a significant potential. There are also possibilities for technology improvements for small-scale biomass combustion, including staged combustion (two or more stages) and post treatment of exhaust gases (flue).

Additional technologies to optimise the operation of these systems with other renewable energy technologies are the key to a higher market acceptance: technologies for micro-grid optimisation in heat and power sector should also be supported, in line with the prosumer concept, with multiple small suppliers on the network.

Finally, from the demand side, the increase of energy efficiency of houses using biomass, through the improvement of thermal insulation can contribute to the reduction of the energy (heat) demand and to the reduction of air pollution.

Biomass combustion in residential sector

Most of the biomass combustion systems are very simple, obsolete, appliances, with very low efficiency (and thus high biomass consumption) and high emission of pollutants. . For this reason there is a big challenge to replace old systems with improved, high efficiency systems to reduce especially the organic and particulate matter emissions.

On technology switch, the use of more efficient boilers could contribute to significant emission reduction. One measure, especially for manually operating appliances, could be utilization of heat accumulator avoiding the operation at partial load of appliances.

Limitations of use for the residential heating with solid biomass in certain areas (such as the Po valley) also need to be introduced. Limitations should be also put on the installation of fossil fuel based heating systems, especially if based on heating oil and coal, e.g., though a CO2 tax.

Encouraging the implementation of methods/advanced technologies

Fast success in operation is the major challenge for modern technologies, not only with fast time-to-market, but especially terms of a high number of applications. As long as these new systems are not in operation replacing old systems the effect on air quality is zero.

Increasing public awareness on the availability of improved technology solutions and their advantages in comparison with old technologies is absolutely necessary in the very fragmented market of domestic heating appliances. On the other side, it is also necessary to motivate the manufacturers to develop their emission reduction concepts and to integrate them into final marketable products. There is a high risk of development, high development costs and market acceptance is very important and that must be considered.

From the regulatory point of view, legal requirements are needed to control emissions from biomass combustion, at the same time it should be ensured that this is not a too high barrier that would lead to increasing investments in fossil heating systems. Several alternative solutions are also available to increase the advantages provided by economies of scale, including District Heating systems and high efficiency and high capacity boilers in centralised heating systems. Experts also agreed that all technologies can be improved, but the key challenge is not the technology, but political will and legislation; here innovation is needed.

Opportunities of clean bioenergy to rural development

Clean bioenergy is a major issue and has a big potential for contributing to rural development, including on diversifying an intensifying economic activities and the employment, offering local jobs for equipment manufacturers and operation and maintenance. Bioenergy shows in particular a strong relation to employment effects and regional added value. Bioenergy provides additional income for local producers, farms and especially in jeopardized rural areas.

Efficient tools to support research in clean growth in bioenergy and additional research needs

A combination of tools is preferred to be used to support research in clean growth in bioenergy, mainly: Supporting projects focused on specific problems as bioenergy research is a very practical field, Creating networks of scientists and stakeholders (e.g. public administrations) and Promoting bilateral collaboration between countries. Additional research is needed to further support the development of clean technologies and to optimise a combined use of all renewable energy systems in regional and decentral systems in microgrids.

Innovative and good practices

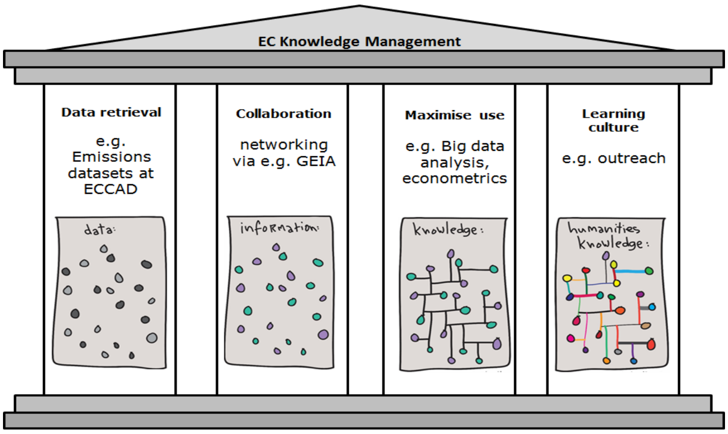
There exist already many good practices, e.g. for biomass combustion, CHP, biogas production and biofuels for the transport sector. Projects are also dealing with finding out the best methods to motivate people to replace old stock (in the field of biomass combustion) and to motivate companies to change to renewable energies.

Other opportunities for increasing biomass use include the use of modern biomass boilers in buildings (schools, other public buildings), efficient biomass CHP plants and the use of heat, plans for production of advanced biofuels (including those produced from waste and residues) for transport.

Annex 15. Management of knowledge

The management of knowledge concept applies also to the Directorate of Energy, Transport & Climate, in which the Air & Climate unit contributes with knowledge production. In the same Directorate, the Knowledge for Energy Union unit contributes with knowledge management (see Figure 44).

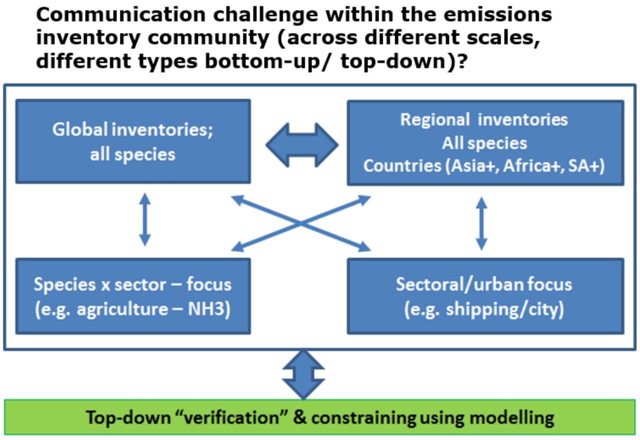
Figure 44. Information management at the European Commission (EC)



Source: WG bioenergy (2017); WG transport (2017).

As an example, the Emissions Database for Global Atmospheric Research (EDGAR([17])) of EC-JRC (2011) includes a huge amount of data of very different sources, ranging from energy statistics to industrial and agricultural products and land-use. The database is maintained with annual updates of CO2 emissions datasets and less frequent updates of all air pollutants. The geographical mapping and analysis of the emissions allows to identify hot spots that needs monitoring and the econometric evaluation of emissions trends reveals insights in emission drivers. These are results of knowledge production. The documentation and archiving and dissemination with user support and training seminars remain activities which fit under knowledge management and has been transferred to a project of the Knowledge for Energy Union unit.

Figure 45. Overview of the variety of emission inventories (mainly static, some developing towards a dynamic information tool)



Source: GEIA session 1 overview discussion (2017).

([17])http://edgar.jrc.ec.europa.eu/

With the open access policy, the EDGAR data are all publicly available and documented with papers, recently also submitted to the Earth System Science Data journal for living databases. The EDGAR website is visited by many users and hundreds of thousands of data downloads from the datasets, now at the JRC data-portal have been counted. The data are of increasing importance to those countries which lack capacity or underwent a capacity cut and which are in need of first estimates of activity data, emission factors, technology shares, emissions or spatial distribution. In particular the last item has shown to be of great interest for certain regions. In collaboration with the Task Force for Emissions Inventory and Projection, the EDGAR team has been organizing also several trainings on emission gridding and provided an online tool for transport and buildings sector. These are part of the effort sharing decision sectors and need spatial proxy data contrary to the point sources which are reported under the European Pollutant Release Transfer Register. The variety of emission inventories is illustrated in Figure 45.

With the interest of DG REGIO in some areas of Europe where sharing knowledge and best practices are considered useful, the EDGAR team contributed with emission gridmaps for these areas, which are subject to errors caused by the spatial distribution, local practices, region-specific superemitters or use of non-sold fuel (Muntean et al., 2017). A discussion with regional experts highlights that these aspects are key for the continuous improvement and capacity build-up. A living database, which is encouraged by the Earth System Science Data journal, is needed to avoid the loss of (detailed) knowledge and was chosen for contributions from the EDGAR team (Janssens-Maenhout et al., 2017).

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